

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INTEL CORPORATION.
Petitioner

v.

DEMARAY LLC
Patent Owner

Patent No. 7,381,657

**DECLARATION OF DR. VIVEK SUBRAMANIAN
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 7,381,657**

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I, Vivek Subramanian, declare as follows:

I. INTRODUCTION

1. I have been retained as an independent expert consultant in this proceeding before the United States Patent and Trademark Office (“PTO”) regarding U.S. Patent No. 7,381,657 (“the ’657 patent”) (Ex. 1001).¹ I have been asked to consider whether prior art references disclose or suggest the features recited in claims 1-21 (“the challenged claims”) of the ’657 patent. My opinions are set forth below.

2. I am being compensated at a rate of \$650/hour for my work in this proceeding. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

¹ In this Declaration, I refer to exhibits that I understand are to be attached to the petition for *Inter Partes* Review of the ’657 patent.

II. BACKGROUND AND QUALIFICATIONS

3. My qualifications are stated more fully in my curriculum vitae, which is attached as Ex. 1003. Below is a summary of my education, work experience, and other qualifications.

4. I received a bachelor's degree summa cum laude in electrical engineering from Louisiana State University in 1994. I received M.S. and Ph.D. degrees in electrical engineering, in 1996 and 1998, respectively, from Stanford University.

5. Throughout the course of my education, including my B.S., M.S., and Ph.D. degrees, I was involved in deposition technology for thin films, including sputtering technology, and more specifically reactive sputter technology. For example, during my PhD, I performed research on the deposition of films of metals, oxides, and semiconductors via sputtering, including Aluminum, Tungsten, Tungsten Silicide, Titanium, Titanium Nitride, and Silicon Dioxide.

6. After completing my Ph.D., I held multiple appointments simultaneously between 1998 and 2000. I served as a Consulting Assistant Professor in the Electrical Engineering Department of Stanford University. I also served as a Visiting Research Engineer in the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley, where my research

focused on 25nm metal oxide semiconductor field effect transistor (MOSFET) design and fabrication. I worked on technologies for high-performance transistor processes, and I published several papers as a direct outcome of this technology development. As part of my research work both at Berkeley and at Stanford during this period, I performed research on the use of sputtering and reactive sputtering.

7. During the same period, I also served as a founder and member of technical staff of Matrix Semiconductor, a startup company that developed high-density nonvolatile memories. At Matrix, I led much of the process development effort to develop a new type of memory. We made extensive use of sputtering and reactive sputtering in this work, and I led much of the process development in this regard. Matrix was subsequently acquired by Sandisk.

8. In 2000, I became an assistant professor at the University of California, Berkeley in the Department of Electrical Engineering & Computer Sciences. In 2005, I was promoted to the position of tenured Associate Professor, and in 2011, I was promoted to full Professor. In 2018, I became a full Professor of Microtechnology at EPFL in Switzerland, where I lead the Laboratory for Advanced Fabrication Technologies (LAFT). The lab focuses on the development and application of advanced additive fabrication techniques for realizing precision

microelectronic and electromechanical systems. As of 2020, I have completed my move to EPFL and have therefore converted to an adjunct appointment at Berkeley.

9. Starting in 2004, I was a founding technical advisor for Kovio. Under my leadership, Kovio re-focused on RFID and RF anti-theft systems. I led the development of Kovio's first commercial RFID tag product, including the design of both the tag and the reader. My involvement with Kovio ended with Kovio's acquisition by Thin Film Electronics ASA, but Kovio continues to focus on this area.

10. I co-founded Locix Inc. in 2014. Locix develops and sells a range of wireless-enabled products, including proprietary Wi-Fi-based RF localization systems and sub-GHz low-power wireless sensor networks. As CTO of Locix, I led the development of the entire Locix RF product portfolio. I continue to be involved with Locix on a regular basis.

11. I have authored or co-authored over 200 technical papers in international journals and conferences and have been named an inventor or co-inventor on more than 50 patents, many of which cover aspects of thin film deposition and devices based on the same, including use of sputtering and reactive sputtering in this regard.

III. MATERIALS REVIEWED

13. The opinions contained in this Declaration are based on the documents I reviewed, my professional judgment, as well as my education, experience, and knowledge regarding systems and processes for sputtering-based deposition of films on substrates.

14. In forming my opinions expressed in this Declaration, I reviewed the following materials:

Ex. 1001	U.S. Patent No. 7,381,657
Ex. 1004	Prosecution History of U.S. Patent No. 7,381,657
Ex. 1005	U.S. Patent No. 6,342,134 to Barber et al.
Ex. 1006	U.S. Patent No. 6,485,602 to Hirose
Ex. 1007	U.S. Patent No. 5,651,865 to Sellers
Ex. 1008	A. Belkind et al., <i>Pulsed-DC reactive sputtering of dielectrics: Pulsing parameter effects</i> (2000)
Ex. 1009	U.S. Patent No. 4,464,223 to Gorin
Ex. 1010	U.S. Patent No. 6,132,564 to Licata
Ex. 1011	U.S. Patent No. 5,942,089 to Sproul
Ex. 1012	U.S. Patent No. 6,352,629 to Wang
Ex. 1013	S. Gibilisco, <i>Handbook of Radio & Wireless Technology</i> (1999)

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Ex. 1014	J. Joo, <i>Low-temperature polysilicon deposition by ionized magnetron sputtering</i> (2000)
Ex. 1015	B. Chapman, <i>Glow Discharge Processes</i>
Ex. 1016	U.S. Patent No. 4,579,618 to Celestino
Ex. 1017	International Publication No. WO 02/23588 to Quon
Ex. 1018	International Publication No. WO 01/6300 to Johnson
Ex. 1019	U.S. Patent No. 6,695,954 to Hong
Ex. 1020	U.S. Patent No. 6,153,068 to Ohmi
Ex. 1021	U.S. Patent No. 4,846,920 to Keller
Ex. 1022	U.S. Patent No. 6,911,351 to Kidoguchi
Ex. 1023	U.S. Patent No. 5,302,882 to Miller
Ex. 1024	Pinnacle Plus+ 10KW (325-650 Vdc) Master/Slave AE Bus, DeviceNet, MDXL User, UHF Output User Manual (March 2005)
Ex. 1025	The Advanced Energy MDX Magnetron Drive, Advanced Energy Industries, Inc. (March 1993)
Ex. 1026	Pinnacle 10x6 kW DeviceNet, MDXL User 5702063-C, User Manual, (May 2000)
Ex. 1027	U.S. Patent Publication No. 2002/0027249 A1 to Takemura
Ex. 1028	U.S. Patent Publication No. 2002/0144889 to Tao
Ex. 1029	E. Dogheche, <i>Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering</i> , <i>Applied Physics Letters</i> (1999)
Ex. 1030	U.S. Patent No. 6,506,686 to Masuda

Ex. 1031	K. Nam, <i>A study on the high rate deposition of CrN films with x controlled microstructure by magnetron sputtering</i> , Surface & Coatings Technology (2000)
Ex. 1032	D. Mattox, <i>Handbook of Physical Vapor Deposition (PVD) Processing – Film Formation, Adhesion, Surface Preparation and Contamination Control</i> (1998)
Ex. 1033	U.S. Patent No. 5,830,327 to Kolenkow
Ex. 1034	U.S. Patent Publication No. 2001/0041252 to Laird
Ex. 1035	M. Ruske, <i>Properties of SiO₂ and Si₃N₄ layers deposited by MF twin magnetron sputtering using different target materials</i> , Thin Solid Films (1999)
Ex. 1036	W. Sproul, <i>High-rate reactive DC magnetron sputtering of oxide and nitride superlattice coatings</i> (1998)
Ex. 1037	U.S. Patent Publication No. 2003/0029563 to Kaushal
Ex. 1038	U.S. Patent No. 6,627,323 to Nagaraj
Ex. 1039	I. Safi, <i>A novel reactive magnetron sputtering technique for producing insulating oxides of metal alloys and other compound thin films</i> (2000)
Ex. 1040	U.S. Patent No. 6,001,227 to Pavate
Ex. 1041	S. Wolf et al., <i>Silicon Processing for the VLSI Era</i> , Vol. 1 (2000)
Ex. 1043	U.S. Patent Publication No. 2001/0031383 to Sakawaki
Ex. 1044	U.S. Patent No. 4,895,631 to Wirz
Ex. 1045	U.S. Patent No. 7,041,391 to Ando
Ex. 1046	U.S. Patent No. 6,984,550 to Yamazaki
Ex. 1047	A. Billard, <i>Low-frequency modulation of pulsed d.c. or r.f. discharges for controlling the reactive magnetron sputtering process</i> , Surface & Coatings Technology (1996)

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Ex. 1048	P. Kelly, <i>The deposition of aluminum oxide coatings by reactive unbalanced magnetron sputtering</i> (1996)
Ex. 1049	U.S. Patent No. 7,247,227 to Hanson
Ex. 1050	U.S. Patent No. 7,391,072 to Forbes
Ex. 1051	International Publication No. WO 96/06203 to Seeley
Ex. 1054	U.S. Patent No. 5,331,218 to Moody
Ex. 1056	U.S. Patent No. 6,409,965 to Nagata
Ex. 1057	U.S. Patent No. 6,284,110 to Sill
Ex. 1058	U.S. Patent No. 5,148,133 to Zennamo
Ex. 1059	P. Kelly et al., <i>Reactive pulsed magnetron sputtering process for alumina films</i> (2000)
Ex. 1060	U.S. Patent Application No. 09/145,323 to Miller et al.
Ex. 1061	U.S. Patent No. 4,960,651 to Pettigrew
Ex. 1062	Pinnacle 20 kW DeviceNet, MDXL User 5702199-A, User Manual, (April 2001)
Ex. 1063	U.S. Patent No. 6,010,583 to Annavarapu
Ex. 1065	Pinnacle Plus Pulsed DC Power Supply Data Sheet (April 1999)
Ex. 1067	Pinnacle Plus 10kW User 5702269-B, User Manual, (June 2002)
Ex. 1068	Japanese Patent Publication No. JPH10102247A to Aokura and certified English translation of JPH10102247A
Ex. 1069	U.S. Patent Application Publication US 2001/0047838 to Segal

I also considered any other documents and materials I refer to in this Declaration.

15. My opinions contained in this declaration are based on the documents I reviewed and my knowledge and professional judgment. My opinions have also been guided by my appreciation of how a person of ordinary skill in the art would have understood the state of the art, the prior art, and the claims and the specification of the '657 patent at the time of the alleged invention, which I discuss below.

16. I have been asked to initially consider that the time of the alleged invention of the '657 patent was around 2002 (including and up to March 16, 2002), which corresponds to the filing date of the parent application for '657 patent. (Ex. 1001, Cover.)

17. Based on my experience and expertise, it is my opinion that certain references disclose and/or suggest all the features recited in challenged claims of the '657 patent, as I discuss in detail below.

IV. PERSON OF ORDINARY SKILL IN THE ART AND THE TIME OF THE ALLEGED INVENTION

18. I am familiar with the level of ordinary skill in the art regarding the '657 patent as of what I understand to be around the claimed priority date of March 16, 2002. Considering the '657 patent, the technology, the educational level and experience of workers in the field relating to the patent, and problems and solutions in that field (e.g., processes and related systems for sputtering deposition of films on substrates), and drawing on my own experience, I believe a person of ordinary skill in the art at the time of the alleged invention (around March 16, 2002) would have had a Master's degree in Electrical Engineering or Material Science (or an equivalent subject) and at least two years of relevant experience, or a Bachelor's degree in Electrical Engineering or Material Science (or an equivalent subject) and at least four years of relevant experience. Relevant experience in the context of the '657 patent refers to experience with sputtering deposition of films on substrates, as referenced in the '657 patent. (See '657 patent (Ex. 1001) at 1:10-14, 2:45-47.)

19. My opinions in this Declaration regarding the '657 patent and the prior art (including the state of the art) are from the perspective of one of ordinary skill in the art as I defined above, during the relevant timeframe (e.g., the time of the alleged invention), which I discussed above as being around March 16, 2002.

V. TECHNICAL BACKGROUND

20. Below, I present a brief overview of certain aspects of systems and processes relating to the sputtering deposition of films on substrates prior to and at the time of the alleged invention for the '657 patent. The functionalities and concepts I describe below in this technical background section reflect the state of the art that a person of ordinary skill in the art would have had knowledge of and understood prior to and at the time of the alleged invention of the '657 patent. I rely on, and incorporate as applicable (even if not expressly mentioned below in Section IX), the following disclosures and opinions to support my opinions in this Declaration, including those opinions relating to how the prior art discloses and/or suggests the challenged claims of the '657 and how and why a person of ordinary skill in the art would have been motivated to consider and combined the disclosures and suggestions from that prior art as I explain below in Section IX. The concepts below would have been within the knowledge and mindset of a person of ordinary skill in the art at the time.

A. Sputter Deposition

21. Sputter deposition, which was also often known as just “sputtering,” is a film deposition technique that takes place in a plasma process chamber, where a target is bombarded with gas ions, such as noble/inert gas (e.g., argon) ions. (Ex.

1007, 1:19-21; *see also* Ex. 1032, 6; Ex. 1041, 5-10 (discussions regarding the physics of sputtering).) Those of ordinary skill in the art understood that ionized gas was (and is) also known as a plasma. (Ex. 1041, 3-4 (disclosing that a plasma is a “partially ionized gas”).) In a sputtering process, the gas ion bombardment mechanically frees atoms of the target material, and the target material is then deposited, forming a film on a substrate placed in the plasma chamber. (Ex. 1007, 1:21-23.) Argon was known generally as the gas of choice for sputtering processes because “it is easily available (hence low in cost), and its mass is a good match to those of the elements most frequently sputtered (Al, Cu, Si, and Ti).” (Ex. 1041, 8; *see also* Ex. 1032, 7 (“typically argon...is used for inert gas sputtering since it is a relatively inexpensive inert gas”).)

22. Many types of target materials (e.g., element, alloy, or compound) were known and available for sputter deposition processes, which allowed for diverse fields of applications. (Ex. 1032, 18 (disclosing that one of the advantages of sputtering deposition is that the method is capable of sputtering “element, alloy, or compound” materials); *see also id.*, 19-20 (disclosing a list of exemplary target materials available for sputtering for various fields of applications, e.g., semiconductor devices, optical coatings, and wear/erosion-resistant coatings ...

etc.); Ex. 1011, 3:58-60). For example, single element targets made of aluminum or silicon were well known before March 2002. (*See e.g.*, Ex. 1005, 6:42-50.) It was also well known that a target may be made of an alloy, which contained, for example, both aluminum and silicon. (*See e.g.*, Ex. 1034, ¶[0027].) It was also known that an alloy target may also include rare-earth ions, such as yttrium. (Ex. 1036, 6; Ex. 1069, ¶¶[0041]-[0048].) Furthermore, oxides of yttrium-containing alloy such, as yttria-stabilized zirconia (YSZ), were known to be widely used as a thermal-barrier coating for its high-temperature capability. (Ex. 1038, 1:30-35.) Also, a person of ordinary skill in the art would have appreciated and known that an aluminum oxynitride layer (AlN_xO_y), deposited using a “reactive” sputtering technique (which I discuss in the next section below), was used in manufacturing displays, particularly useful for “blocking moisture and oxygen” and “to prevent impurity...from entering” semiconductor devices in the displays and the film also has other useful properties including “a high thermal conductivity, a heat radiation effect, and a very high light transmitting property.” (Ex. 1046, 19:34-39.)

23. Typical sputtering systems were also known to include a substrate holder, upon which a substrate is positioned to face the target for film deposition. (*See, e.g.*, Ex. 1005, FIG. 2 (disclosing a substrate platen 115, upon which a substrate

110 is positioned).) A wide range of substrate materials were known to be used, including, for example, silicon, quartz, sapphire, aluminum oxide (*id.*, 3:63-65), or a piece of steel (Ex. 1011, 3:56-58). Additionally, those of ordinary skill in the art were aware, would have appreciated, and understood the benefits of monitoring and controlling the temperature of the substrate (via for example temperature control circuits or the like) to obtain a high-quality sputter deposited film (Ex. 1029, 2) and that the temperature can be controlled with a high accuracy (Ex. 1030, 1:33-40 (disclosing temperature control within a plasma environment with an “accuracy of $\pm 5\text{ }^{\circ}\text{C}$), 1:60-67 (disclosing temperature control within a plasma environment with “a high accuracy of $\pm 2\text{ }^{\circ}\text{C}$).)

B. Reactive Sputter Deposition

24. A reactive sputtering process differs from the above discussed sputtering process as it introduces one or more reactive gases (e.g., oxygen or nitrogen) in addition to the noble/inert gas (e.g., argon). (Ex. 1005, 2:5-7.) Typically, the reactive gases were known to have low atomic masses and known to be not as effective in sputtering. Therefore, a heavier noble/inert gas, such as argon, was known to be used in the reactive sputtering process to sputter the target material. (Ex. 1032, 8.)

25. The reactive gas reacts with the target material to produce a film that is sputtered onto the substrate. (Ex. 1005, 2:5-8; *see also* Ex. 1007, 1:7-11.) Reactive sputtering can be used for forming insulating layers, such as oxides or nitrides of a metal, by using a metallic or conductive target and an oxygen or nitrogen-containing reactive gas. (Ex. 1007, 1:11-14.) For example, a layer of aluminum oxide film may be formed by using an aluminum target and an oxygen-containing reactive gas. (*Id.*, 1:27-29; *see also id.*, 1:29-37 (describing that other types of target materials and reactive gases may be used).)

26. One issue associated with reactive sputtering that those of ordinary skill in the art would have understood and appreciated was the buildup of insulating materials on the target surface, which was also known as “poisoning” of the target that may significantly reduce the sputtering rate and causes arcing on the target. (Ex. 1007, 1:45-47; *see also* Ex. 1005, 2:37-43; Ex. 1048, Abstract.) It was therefore known to use a pulsed DC power supply (discussed further below) to reduce such arcing.

C. Power Supplies Used for Reactive Sputtering

27. It was known by those of ordinary skill in the art prior to March 2002 to use in such reactive sputtering systems a power supply connected to the target to apply a bias in order to create a plasma and to facilitate sputtering. (*See, e.g.*, Ex.

1005, 6:6-8, FIG. 2; Ex. 1007, 9:32-37, FIG. 12.) Such skilled persons would have understood that a continuous (i.e., non-pulsed) DC power supply was typically not suitable for reactive sputtering because, once the target surface reacts with the reactive gas and forms an insulating layer (a “poisoned” target), charges buildup on the insulated target surface lead to arcing and also prevent bombardment/sputtering of the surface (e.g., ceasing or significantly hindering the sputter deposition process). (Ex. 1008, 1; *see also* Ex. 1007, 6:2-5 (discussing arcing’s deleterious effects on the target); Ex. 1032, 3.) Those of ordinary skill in the art at the time understood that such issues can be resolved through the use of a pulsed DC power supply, which reverses its negative bias to the positive bias periodically in order to discharge poisoned/insulated target surface, preventing arcing and allowing the ion bombardment to continue (once the pulse flips back to the negative bias). (Ex. 1008, 1.) For example, a typical waveform of a pulsed DC power supply is shown in Figure 1 of *Belkin*, which I annotate below.

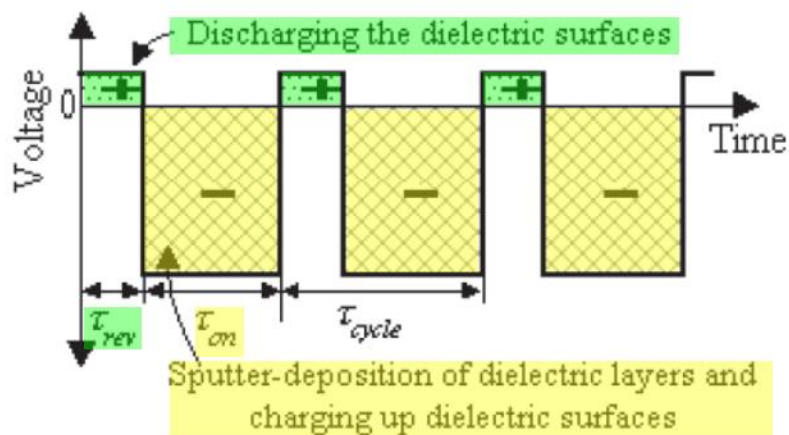


Figure 1. Pulsed voltage used to power a cathode

(Ex. 1008, FIG. 1 (annotated).) As Belkin explains (which was consistent with the knowledge of a person of ordinary skill in the art) , during the “on-time” pulses (τ_{on}), i.e., negative pulses (highlighted in yellow), positive ions of the gaseous plasma bombard the negatively-biased target and the sputter-deposition process proceeds. (*Id.*, 1, FIG. 1; see also *id.*, 4 (“Sputtering takes place only during the on-time”).) Also, during these on-time pulses, positive charges accumulates on the insulating layer formed on the target surface (as a result of the reactive gas reacting with the target). (*Id.*) In order to discharge such an accumulation of charges and avoid arcing, “reverse” or “off-time” pulses (τ_{rev} or τ_{off}), i.e., positive pulses (highlighted in green), are applied to the target to dissipate the positive charges accumulated at the insulated/poisoned target surface. (*Id.*, 2.) Therefore, it was known by those of

ordinary skill in the art that by alternating the pulses between a negative bias (sputtering while accumulate charges) and a positive bias (ceasing sputtering while dissipating charges), the reactive sputtering process may proceed with arcing events substantially reduced. (*Id.*; see also Ex. 1007, 3:39-62 (applying a bias to the target that alternates between negative and positive biases to prevent arcing); Ex. 1032, 3-5 (same); Ex. 1036, 4 (same).)

28. The use of such pulsed DC power supplies for reactive sputtering processes was known and available before March 2002. For example, *Belkin* discloses using pulsed DC power supplies, including those manufactured by Advanced Energy (e.g., the MDX-10 unit that is combined with a pulsed generator Sparcle-V or the PinnaclePlus unit). (Ex. 1008, 1 (“The pulsed DC power was applied to the cathode [target] using a DC power supply, model MDX-10 by Advanced Energy Industries (AEI), pulsed generator Sparcle-V (AEI), and also by PinaclePlus unit (AEI)”); see also Ex. 1001, 5:46-48 (disclosing use of the PinnaclePlus unit as an example); Ex. 1011, 6:7-11 (disclosing use of the MDX unit and the Sparcle unit to generated a pulsed DC power); Ex. 1048, 2 (same).)

29. It was also known before March 2002 to use in reactive sputtering systems an RF power supply that was coupled to the substrate holder to, for example,

control the quality of the sputter deposited film formed on the substrate. (Ex. 1005, 6:29-31, FIG. 2; Ex. 1011, 6:12-16, 7:19-20, FIG. 1.) A person of ordinary skill in the art would have understood that such known RF frequency ranges ranged from near 1 MHz to tens of MHz, and that a frequency of 13.56 MHz was typically used in a plasma system RF power supply as it was one of the frequencies allocated for industry use by the Federal Commission of Communication at the time of the alleged invention. (Ex. 1009, 3:7-11; *see also, e.g.*, Ex. 1010, 9:13-15 (disclosing application a RF bias to a substrate “in the range of from about 0.2 to 80 MHz, for example, at 13.56 MHz”); Ex. 1011, 5:10-17 (disclosing application of a RF bias to a substrate with a “radio frequency source of 13.56 MHz”); Ex. 1012, 4:61-64 (same).

D. Filter(s)

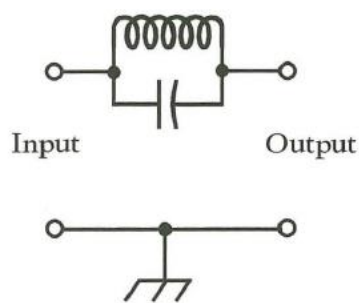
30. Filters were commonly used in plasma process chambers to isolate one power source from another. For example, *Hirose* discloses that it was known by placing a filter circuit between a plasma process chamber and a local RF power supplies, the filter circuit can effectively block the electrical signal of the remote RF power supply from the local power supply (when the filter circuit is set or tuned to block at the operating frequency of the remote RF power supply). (Ex. 1006, 1:44-52; *see also id.*, 4:9-16:21.) Such a filter configuration allowed supplies of power

to the plasma chamber “under an optimum condition.” (*Id.*, 1:62-67.) As an additional and similar example, *Ohmi* discloses using band eliminators, which are “band rejection filters, and suitably set in such a manner that only radio frequency power having desirable frequencies are applied to the respective electrodes connected, so that the applied radio frequencies are not affect one another.” (Ex. 1020, 4:26-30.)

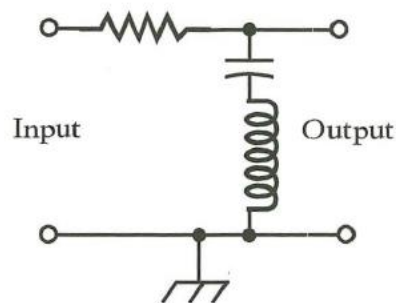
31. In addition to isolating RF power supplies, the use of filters was known to also isolate a continuous DC or a pulsed DC power supply from other power source(s) in such systems. For instance, *Joo* informed those skilled in the art at the time of the use of a plasma chamber with a bipolar pulsed DC power supply and a 2 MHz RF power supply, where a low-pass filter (comprising essentially a capacitor and an inductor) is placed between the plasma chamber and the pulsed DC power supply “to cut off interference” from the 2 MHz RF power supply. (Ex. 1014, 3, FIG. 1.) Similarly, *Hong* informed such skilled persons that “an RF blocking filter, when designed properly, can eliminate or reduce substantially RF current flowing to the DC source.” (Ex. 1019, 6:60-62.) Likewise, *Ohmi* discloses uses of a filter between an AC power supply and a DC power supply were known. (Ex. 1020, 2:61-3:6.)

32. A person of ordinary skill in the art would have been well aware of the designs and types of filter circuits that achieved features mentioned above. In fact, such a skilled person would have been knowledgeable in the types of available filter circuits, the configuration, design, and implementation of such filter circuits to achieve the filtering of signals depending on the application of such power supplies in sputtering systems. For example, it was known that common filter circuits included a combination of resistor(s) (R), inductor(s) (L), and capacitor(s) (C), which were also known as the RLC circuits, or simply the LC circuits. (Ex. 1013, 3-9 (describing that various types of filters are comprised of LC circuits); *see also* Ex. 1006, FIGS. 1 and 10; Ex. 1014, FIG. 1.) Band-rejection filters, one of the commonly known filters, were designed to pass energy at all frequencies, except a certain frequency or those within a certain range of frequencies. (Ex. 1013, 4-5.)

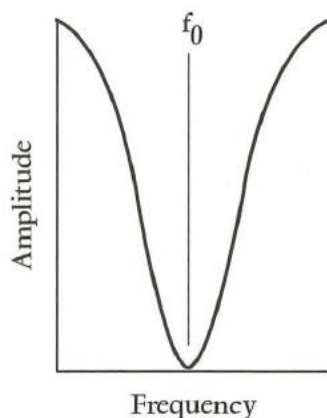
33. The 1999 Gibilisco, *Handbook of Radio & Wireless Technology* (“*Gibilisco*”) (Ex. 1013) provides a description of known concepts relating to such filter circuits (consistent with the knowledge of a person of ordinary skill in the art at the time). Below I provide a copy of exemplary circuits provided by *Gibilisco*.



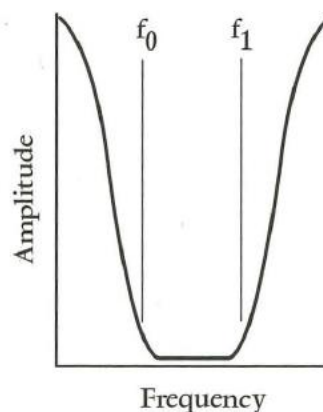
E.



F.



G.



H.

(Ex. 1013, 5.) A person of ordinary skill in the art would have understood (consistent with that shown above) that a band-rejection filter can be tuned to have a different blocking bandwidth such that the filter can block a range of frequencies centered on an operating frequency. (See *e.g.*, *id.*, FIG. 2-9(G) (corresponding to a narrow band-rejection filter that blocks frequency f_0), FIG. 2.9(H) (corresponding to a wide band-rejection filter that blocks a range of frequency between f_0 and f_1); see also *id.*, 5-6.) A band-rejection filter having a narrow frequency response was also known as the

narrow band-rejection filter, or a notch filter, because of its V-shaped or notch-like frequency response. (*Id.*, 6.)

34. A person of ordinary skill in the art would have had the knowledge and capability to design and implement such filter circuits to filter target frequencies according to the application of the filter circuit. For example, such a skilled person would have understood that by adjusting the circuit parameter(e.g., capacitance, inductance, and/or resistance), the LC circuits/filters can be set to impede a certain frequency or a band of frequency. (Ex. 1013, 4-6; *see also id.*, 3-9.) As an example, *Celestino* discloses using a filter comprised of an inductor and a capacitor, where the inductor has a value of 1.38 μh and the capacitor has a value of 100 pf, that is “intended to attenuate the 13.56 MHz signal.” (Ex. 1016, 4:20-27.) Likewise, *Hirose* discloses a filter comprised of essentially an inductor and a capacitor, where the inductor has a value of 2.5 μh and the capacitor has a value of 2000 pf, to attenuate a 2 MHz signal. (Ex. 1006, 4:48-51.)

35. A person of ordinary skill in the art would have also appreciated and understood that the benefit of using a filter in sputtering systems that use a DC power supply and a RF power supply. In particular, it was well known that in such arrangements, preventing signals from the RF power supply from reaching the DC

power supply, would protect the DC power supply. In fact, the manufacturer of known DC power supplies available before March 2002 that were designed for use in plasma processes recommended the use of an RF filter for such purposes. For example, in 1993, the manufacturer provided a warning requiring a RF filter to be placed between its continuous DC power supply and the target/chamber. (Ex. 1025, 23 (“An RF filter must be placed between the dc output and the chamber because 13.56 MHZ can damage the typical dc magnetron power supply”).)

DC Sputtering with RF Bias



WARNING! You must place an ac blocking filter in series with the output of the dc power supply if your system uses a dc power supply in combination with an ac power supply that has an output frequency greater than 50 kHz.

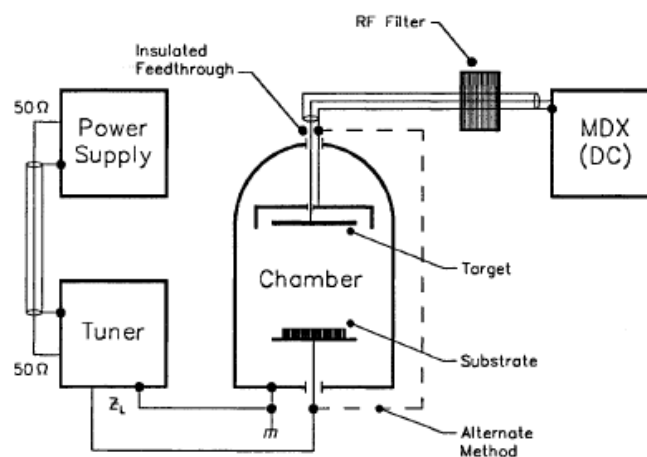


Figure 1- 5. Typical configuration for dc sputtering with RF bias.

(Ex. 1025, 23 (top), 24 (Figure 1-5).) Further, in 2000, the same manufacturer provided a similar caution for its Pinnacle 10X6 kW DC power supply. (Ex. 1026, 116.)



CAUTION:

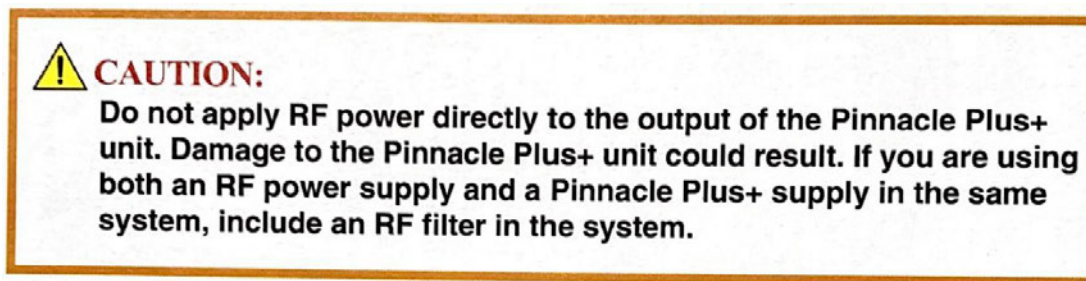
Do not apply RF power directly to the output of the Pinnacle unit. Damage to the Pinnacle unit could result. If you are using both an RF power supply and a Pinnacle supply in the same system, include an RF filter in the system.

36. Advanced Energy provided similar guidance in April 2001, regarding its Pinnacle 20kW power supply, and the Pinnacle Plus+ 10kW (a pulsed DC power supply)² supply in June 2002. (Ex. 1062, 134 ((April 2001) “CAUTION: Do not

² The '657 patent identifies a Pinnacle Plus 10K as an example of a type of DC power supply that can be used to provide the pulse DC voltage signals in its disclosed system, which would have been previously available. (Ex. 1001, 5:46-50 (“Pulsed DC power supply 14 can be any pulsed DC power supply, for example an AE Pinnacle Plus 10K by Advanced Energy, Inc.”).) A Pinnacle Plus data sheet shows specifications similar to that described in the '657 patent for that unit. (Ex. 1065, 2 (describing a “10kW” power, a frequency range (up to 350 kHz), reverse voltage (“10% of the operating voltage”), and reverse time (“400 nsec to 5μsec (variable)”)); Ex. 1001, 5:46-55 (describing that with the disclosed “Pinnacle plus 10K” supply, “up to 10kW of pulsed DC power can be supplied at a frequency of between 0 and 350 KHz” and “[t]he reverse voltage is 10% of the negative target voltage”, and that “the reverse time on this embodiment of power supply 14 can be adjusted between 0 and 5 μs”).)

apply RF power directly to the output of the Pinnacle unit. **Damage** to the Pinnacle unit could result. *If you are using both an RF power supply and a Pinnacle supply in the same system, include an RF filter in the system*"); Ex. 1067, 141 (June 2002) "CAUTION: Do not apply RF power directly to the output of the Pinnacle Plus+ unit. **Damage** to the Pinnacle Plus+ unit could result. *If you are using both an RF power supply and a Pinnacle Plus+ supply in the same system, include an RF filter in the system*".)

37. Again, in 2005, the same manufacturer continued its guidance for the PinnaclePlus 10kW that if "using both an RF power supply and a Pinnacle Plus+ supply in the same system, include an RF filter in the system." (Ex. 1024, 151 (excerpt below).)



38. The cautions highlighted above are consistent with the understandings of a person of ordinary skill in the art regarding the use of DC power supplies in a sputtering system with an RF power supply prior to March 2002. Such a skilled person would have appreciated and understood the concerns associated with a

plasma system having a DC power supply and an RF power supply and appreciated the benefits of considering and using a filter to block the frequency or frequencies associated with the signals provided by the RF power supply from damaging the DC power supply. Thus, while Ex. 1024 is dated in 2005, a person of ordinary skill in the art would have understood that the cautions and concepts disclosed in Ex. 1024 (like the others I highlighted above) are consistent with the knowledge of such a person regarding the use of such power supplies at the time of the alleged invention for the '657 patent.

VI. THE '657 PATENT

A. Description

39. The '657 patent describes the “deposition of oxide and oxynitride films and, in particular, [the] deposition of oxide and oxynitride films by pulsed DC reactive sputtering.” (Ex. 1001, 1:11-13.) The claimed apparatus is made up of components that were well known to a person of ordinary skill in the art before the alleged invention. For example, a pulsed DC power supply providing alternating negative and positive voltages to the target (known), an RF bias power supply coupled to the substrate (known), and a filter coupled between the pulsed DC power supply and the target (known), as I explain below. (See Sections V, IX.)

40. Figure 1A of the '657 patent, below, shows a reactor apparatus 10 that “includes target 12 which is electrically coupled through a filter 15 to a pulsed DC power supply 14. (*Id.*, 5:25-26.) The apparatus 10 also includes substrate 16 that is capacitively coupled to electrode 17 and which is coupled to an RF power supply 18. (*Id.*, 5:32-34.)

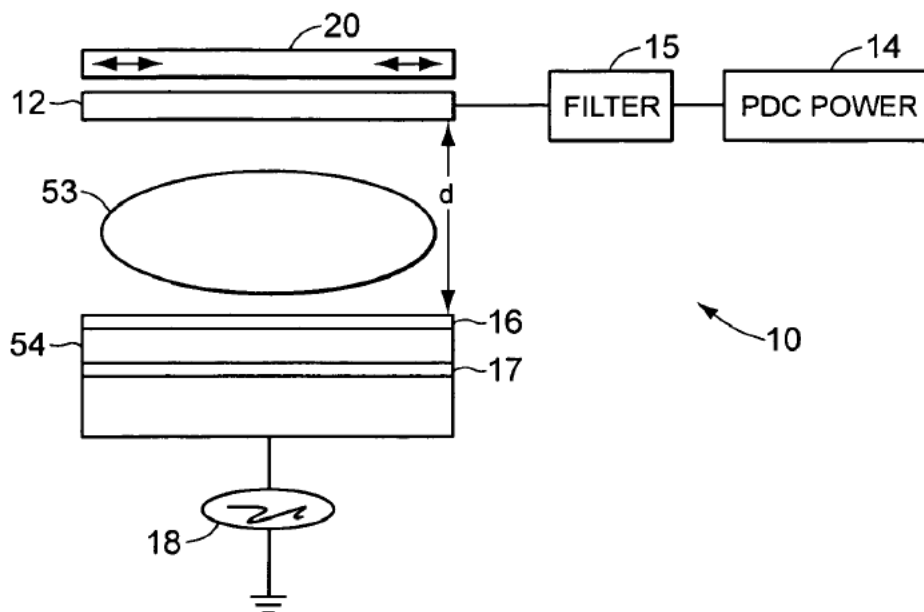


FIG. 1A

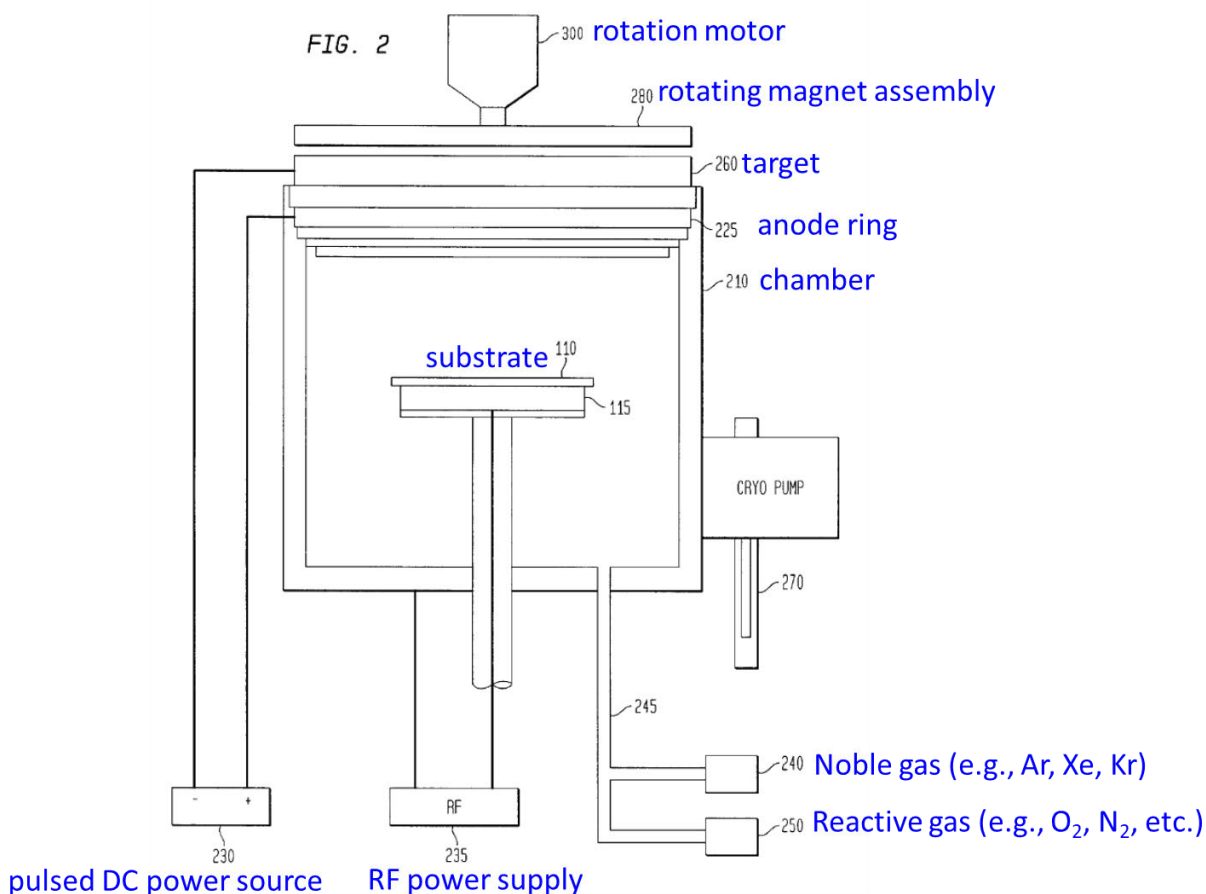
(*Id.*, Figure 1A.)

41. During operation of the reactor pulsed DC power is supplied to the target 12 and RF power is supplied to the substrate 16. (*Id.*, 5:21-24.) The pulsed DC power supplied to the target creates plasma 53. (*Id.*, 5:31-32.) The RF power supplied to the substrate prevents the creation of columnar structures in the film deposited on the substrate. (*Id.*, 6:3-6, 9:57-67.) Filter 15 prevents the bias power from the RF power supply 18 from coupling into the pulsed DC power supply 14. (*Id.*, 5:56-57.)

VII. OVERVIEW OF THE PRIOR ART

A. *Barber*

42. *Barber* generally relates to a system and a process for depositing high-quality films based on “a pulsed DC reactive sputtering process.” (Ex. 1005, 5:62-63.) *Barber* discloses with reference to Figure 2 a rotating magnetron sputtering apparatus. (*Id.*, 5:67-6:3, FIG. 2.)



(Ex. 1005, FIG. 2 (annotated).)

43. The system includes a plasma chamber 210 that operates in a reduced pressure, and also includes flow control sources 240 and 250 (i.e., process gas sources) and a cryo pump with a throttle valve 270. (Ex. 1005, 6:4-13; *see also id.*, 2:1-2.) The gas pressure within the chamber is regulated by valve 270 and by the flow control sources 240 and 250 (*id.*, 6:27-29), where flow control source 240 introduces a noble gas (for example, Ar, Xe, and Kr) and flow control source 250 introduces a reactive gas (or example, O₂, N₂, etc.) into the chamber (*id.*, 6:8-12). The gases are supplied via gas delivery port 245. (*Id.*, 6:13.)

44. The system also includes a pulsed DC power source 230, a target 260, and an anode ring 225, where pulsed DC power source 230 applies a bias across target 260 and anode ring 225 (where the target 260 and the anode ring 225 collectively serve as a pair of electrodes) to ionize the noble gas, forming a plasma. (Ex. 1005, 6:6-11 (“The electric potential applied to the electrodes may be controlled by a pulsed DC power source 230”), 7:30-34; 8:49-52 (“argon (the noble gas) is introduced into the chamber, preferably at the lowest value at which a plasma can be maintained”).) The ions of the noble gas bombard target 260 and eject atoms of the target material (e.g., aluminum). (*Id.*, 7:30-34 (“As the deposition process is carried out, a pulsed DC voltage is applied across the pair of electrodes (the target

and anode ring) that are positioned within the sputtering chamber so that ions from the noble gas impinge upon the target material and eject atoms therefrom.”); *see also id.*, 2:1-5 (describing known sputtering deposition techniques involving ion bombardment of a target that eject atoms of the target material onto a substrate), 6:42-46 (disclosing use of aluminum target.) The freed atoms of the target material react mostly at the target with the reactive gas (e.g., nitrogen) and are subsequently deposited on a substrate 110 within the chamber to form a film, such as the AlN film discussed above. (*Id.*, 7:34-36; *see also id.*, 8:44-9:22.) The system also includes a radio frequency (RF) power supply 235 that applies a bias voltage to a substrate platen 115, upon which substrate 110 is positioned, to control the property of the deposited film. (*Id.*, 6:15-17, 6:29-31.)

45. The reactive sputtering system further includes a rotating magnet assembly 280 which forms a magnetic field over the target surface facing the substrate 110 to increase the efficiency of the sputtering process. (Ex. 1005, 6:17-27.) In particular, *Barber* discloses:

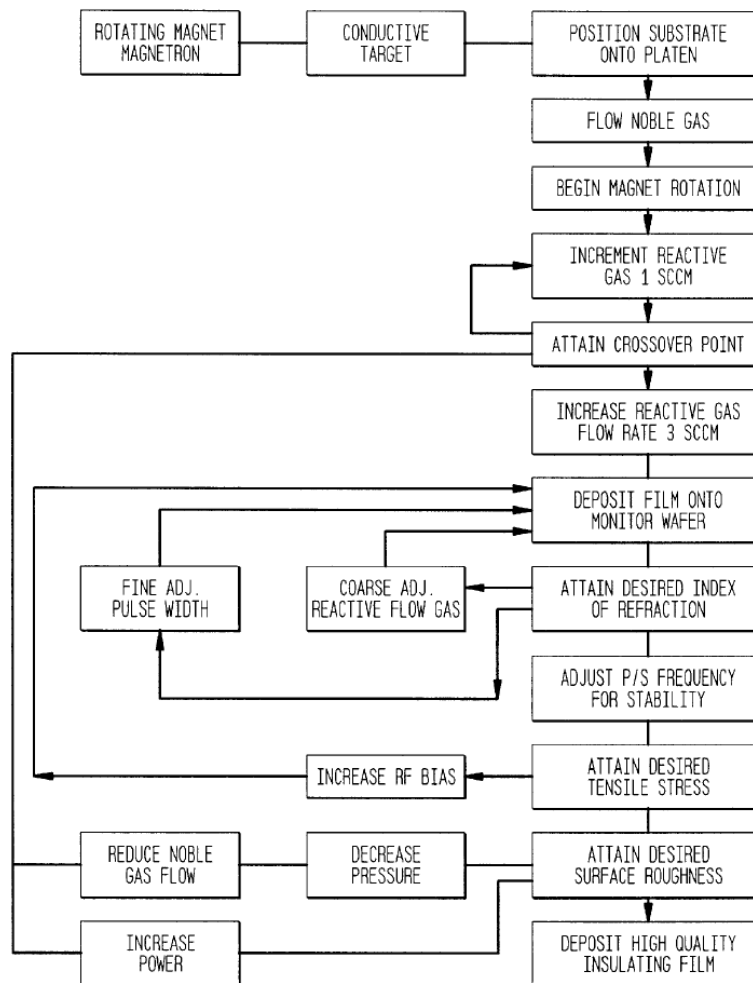
The target material 260 is mounted adjacent a rotating magnet assembly 280 which includes a magnet array to produce a magnetic field to penetrate the target material 260 and form an arc over its surface facing the substrate

110. A rotation motor 300 causes the rotating magnet assembly to rotate about an axis of rotation with respect to the target 260. The magnetic field generated across target 260 helps to confine free electrons near the surface of the target. The increased concentration of ions excited by these electrons at the target surface increases the efficiency of the sputtering process.

(*Id.*, 6:17-27.)

46. *Barber* also discloses a process flow for depositing high quality piezoelectric film (e.g., AlN) and oxide film (e.g., silicon dioxide or SiO₂) based on the features of the reactive sputtering system described above. (Ex. 1005, Figure 5, 7:1-2; *see also id.*, 8:43-9:22 (exemplary process for depositing an AlN film based on the process disclosed in Figure 5), 9:23-10:11 (exemplary process for depositing a silicon dioxide film based on the process disclosed in Figure 5).) *Barber* discloses, among other things, depositing both an AlN film and a SiO₂ film and refers to the AlN film as a piezoelectric film (Ex. 1005, 3:56-57, 6:42-46) and the SiO₂ film as an insulating film (*id.*, 7:65-8:4, 9:25).

FIG. 5



(Ex. 1005, FIG. 5.) As shown in Figure 5 above, the process flow includes steps for controlling gas flows to attain a “cross-over point” of a reactive sputtering process and adjusting various parameters (such as pulsed width and power of the pulsed DC power supply, and RF bias) to obtain desired film properties in order to deposit a high quality film. (Ex. 1005, 7:19-29, 7:36-50, 7:59-64; *see also id.*, 7:1-8:12.)

47. For instance, *Barber* explains that in order to reach the “cross-over point” the noble gas is introduced and then reactive gas is introduced incrementally into the chamber:

The noble gas is introduced into the sputtering chamber, and then the reactive gas is added so that it reacts with a portion of the target material. The reactive gas is introduced incrementally into the sputtering chamber so that the flow rate of the reactive gas is maintained at a rate corresponding substantially to, but greater than, the flow rate at the cross-over point. A film is thus deposited on the substrate as the chamber is maintained just above the cross-over point. Immediately below (less than 3 sccm) the cross-over point will result in a metallic film. Above the cross-over point, the deposition rate decreases for at least 20 sccm and until the target is totally poisoned, becomes an insulator, and a plasma can no longer be maintained.

(*Id.*, 7:17-27.) Furthermore, *Barber* explains that “[t]he cross-over point for the flow of a reactive gas into the sputtering chamber is determined with appropriate settings to the pulse frequency and pulse width.” (*Id.*, 7:14-17.)

48. In fact, *Barber* discloses that “[m]aintaining the flow rate near the cross-over point is effective in optimizing the deposition conditions.” (*Id.*, 7:36-38.)

This is because that “the target will continue to be conductive while depositing a coating on the substrate, and poisoning of the target itself is controlled.” (*Id.*, 7:38-40.) Additionally, *Barber* discloses that various other aspects of the process may be managed to improve the deposition rate and overall quality of the deposited films, for example:

the relevant parameters of the process may be monitored and adjusted, considering that the deposition rate is inversely proportional to the amount of reactive gas, the power supply pulse width, and the deposition pressure, and is directly proportional to the power. The deposition rate is unaffected by the power supply frequency. The index of refraction is inversely proportional to both the amount of reactive gas and the power supply pulse width.

(*Id.*, 7:40-50.)

49. These deposition parameters may be adjusted to achieve an optimal deposition rate for producing films having the desired index of refraction. (*Id.*, 7:51-54.) “Using monitor wafers, the index of refraction of the deposited coating can be monitored and adjusted to achieve a desired index of refraction for the coating,” which may “comprise a coarse adjustment with reactive gas, followed by a fine

tuning with pulse width.” (*Id.*, 7:54-59.) Furthermore, in order to deposit high-quality films:

The current and/or voltage can be monitored and frequency adjusted to achieve a stable waveform. The pulse width of the DC voltage can be adjusted to improve the homogeneity of the film or coating formed on the substrate. The DC power can be increased or the pressure or flow rate reduced to improve the surface roughness for the film.

(*Id.*, 7:59-54; *see also id.*, 8:64-9:2, 9:42-45.)

B. *Hirose*

50. *Hirose* discloses “a plasma processing apparatus” that utilizes two power supplies of different frequencies. (Ex. 1006, Abstract.) *Hirose* discloses with reference to Figure 10 below that it was known in such systems to utilize a filter to isolate one power supply from the other. (*Id.*, 1:30-67, FIG. 10.)

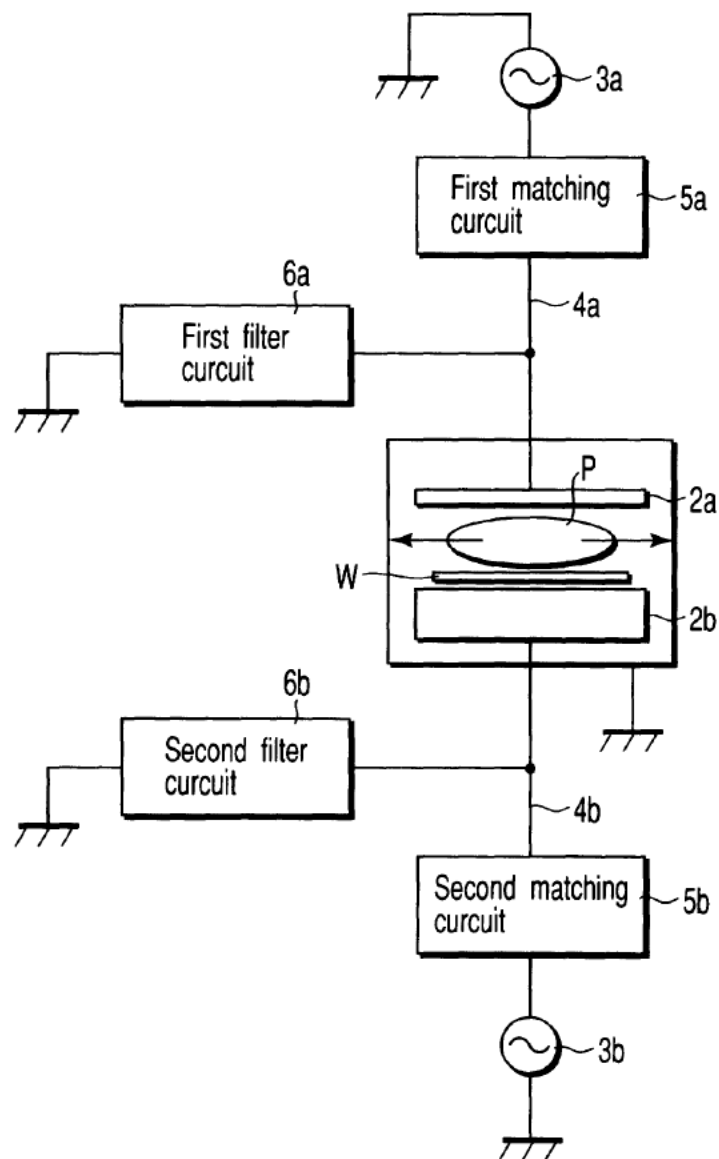


FIG. 10 PRIOR ART

(Ex. 1006, FIG. 10.) The prior art plasma processing apparatus comprise:

upper and lower electrodes **2 a** and **2 b**, and first and second high-frequency power supplies **3 a** and **3 b**. The upper and lower electrodes **2 a** and **2 b** are arranged parallel facing each other in a processing chamber **1**. The first and second high-frequency power supplies **3 a** and **3 b** supply these upper and lower electrodes **2 a** and **2 b** with first and second high-frequency powers having different frequencies.

(Ex. 1006, 1:30-39.) Furthermore, *Hirose* discloses that the prior art apparatus uses a filter, having **a fixed circuit constant** that is “set to a value resonating with a high frequency to be filtered,” to isolate one power supply from the other:

The first power supply line **4 a** connects with **a first filter circuit 6 a** as a return circuit. This filter circuit **6 a** has a fixed circuit constant and attenuates a second high-frequency component. The second power supply line **4 b** connects with **a second filter circuit 6 b** as a return circuit. This filter circuit **6 b** has a fixed circuit constant and attenuates a first high-frequency component. In the first and second filter circuits **6 a** and **6 b**, **each circuit constant is set to a value resonating with a high frequency to be filtered.**

(*Id.*, 1:44-52.) As such, by attenuating the frequency from the other power supply, *Hirose* discloses that “[t]he first and second high-frequency power supplies 3 *a* and 3 *b* supply respective high-frequency powers to the upper and lower electrodes 2 *a* and 2 *b* **under an optimum condition.**” (*Id.*, 1:62-67.)

51. *Hirose* additionally discloses embodiments where the filters, while still being capable of isolating different power supplies, the optimum resonance point of the filters can be modified, e.g., to adjust plasma process conditions. For example, *Hirose* describes with reference to Figure 1 a plasma processing apparatus 10 that includes a chamber 11 and two electrodes: an upper electrode 12 and a lower electrode facing each other. (*Id.*, 3:45-50.) The upper electrode 12 is connected to a first high-frequency power supply 14 via a first power supply line 16 and a first matching circuit 17. (*Id.*, 3:51-54.) The lower electrode 13 is connected to a second high-frequency power supply 15 via a second matching circuit 19. (*Id.*, 3:54-56.) This lower electrode 13 also functions as a chuck top for mounting a processing object W, such as a semiconductor wafer. (*Id.*, 3:56-58.) A plasma P is generated in an atmosphere of process gas supplied between the upper and lower electrodes 12 and 13. (*Id.*, 3:59-63.)

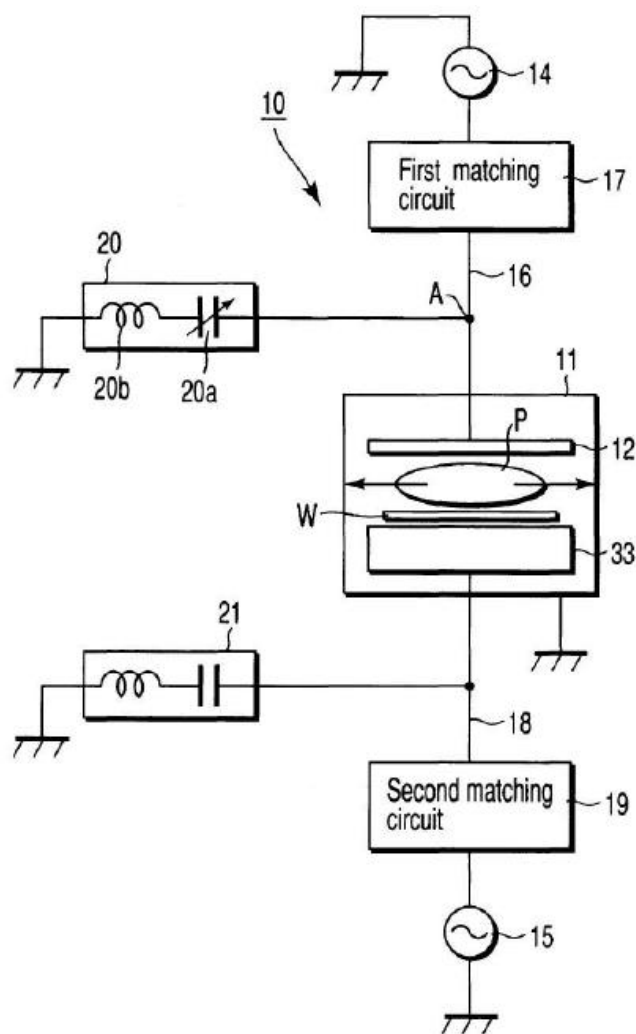


FIG. 1

(Ex. 1006, FIG. 1.)

52. Similar to its discussed conventional technologies (Ex. 1006, 1:30-67, FIG. 10), *Hirose* discloses utilizing a first filter circuit 20 that is placed between first power supply 14 and upper electrode 12 to “**selectively filter[] a high-frequency**

current output from the second high-frequency power supply 15 for preventing the current from reaching the first high-frequency power supply 14.” (*Id.*, 4:9-16.) To isolate the other power supply, *Hirose* also discloses using a second filter circuit 21 to prevent a high-frequency current from the first high-frequency power supply 14 from reaching the second high-frequency power supply 15. (*Id.*, 4:16-21; *see also id.*, 5:63-6:4.)

53. Different from its discussed conventional technologies that use filters of a **fixed** circuit constant (Ex. 1006, 1:45-47), *Hirose* discloses embodiments where the circuit constant of the filters may be **varied**, by changing the values of the inductor and the capacitor, to change the resonance point thereof to adjust plasma process conditions. (*Id.*, 2:45-51, 6:2-4, 6:9-12, 7:20-30; *see also id.*, FIGS. 7-9.) The resonance point of the filter corresponds to the frequency the filter is designed to isolate. (*Id.*, 5:7-10, 8:34-38 (“a resonance point most attenuating high-frequency power depends on” the disclosed equation that associates the values of the inductor and capacitor constituting the filter circuit).) *Hirose* explains that in each of these filters (e.g., first circuit filter 20) is “an LC series resonant circuit” that include a capacitor and an inductor. (*Id.*, 4:11-13; Fig. 1 (elements 20b, 20a).) To show the effectiveness of the filters, *Hirose* shows that the voltage waveform is distorted when

the filter is removed. (*Id.*, 4:45-67 (indicating that the waveform is measured at Point A of Figure 1, which is between an electrode and a power supply), FIGS. 2-4.)

VIII. CLAIM CONSTRUCTION

54. I understand that when considering the meaning of patent claims, one must consider the language of the claims, the specification, and the prosecution history of the patent. I also understand that claim terms are typically given their ordinary and customary meanings as would have been understood by a person of ordinary skill in the art at the time of the invention for the patent. For the '657 patent, as I explained above in Section IV, the relevant time that I have been asked to consider is around March 16, 2002. For purposes of my opinions in this declaration, I have been asked to consider the challenged claims under their plain and ordinary meanings as understood by a person of ordinary skill in the art at the time of the alleged invention, and I have applied such understandings in my analysis of the '657 patent and the prior art.

**IX. THE PRIOR ART DISCLOSES OR SUGGESTS ALL RECITED
FEATURES OF CLAIMS 1-21 OF THE '657 PATENT**

55. In my opinion, the prior art discussed below discloses and/or suggests the limitations of claims 1-21.³

**A. *Barber* in view of *Hirose* Discloses and/or Suggests the Limitations
of Claims 2-4, 6, 8, 10-12, and 21**

1. Claim 2

**a) Claim 2[a] “A method of depositing an insulating
film on a substrate, comprising:”**

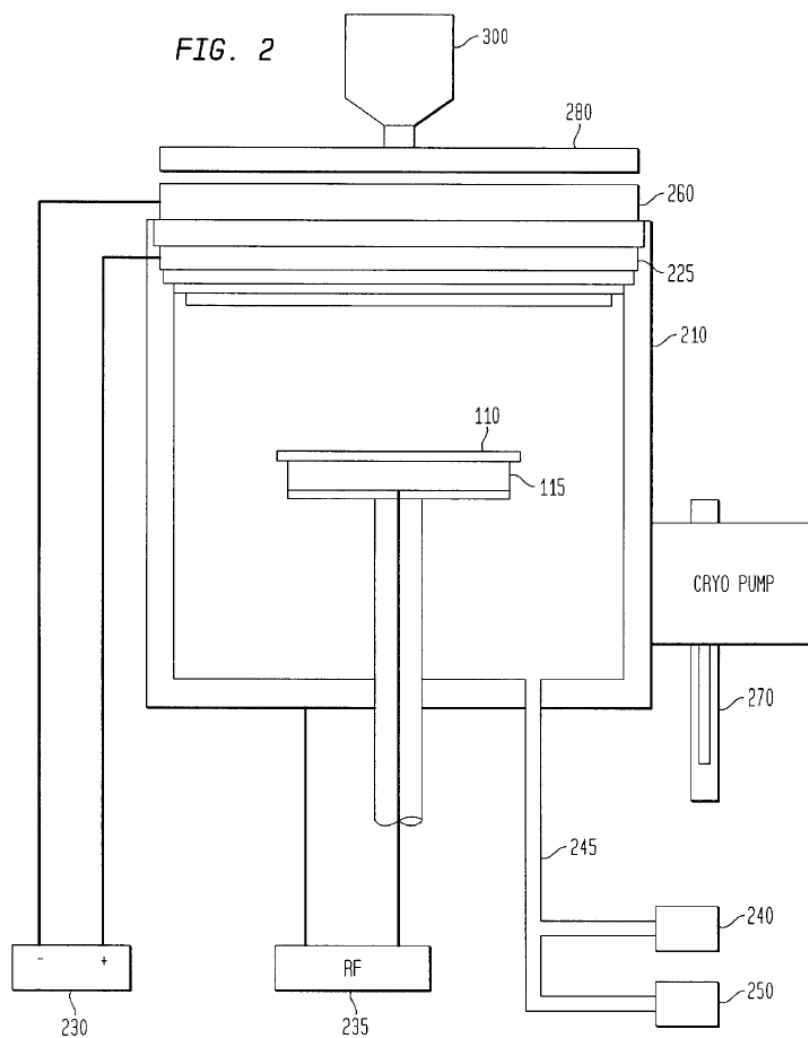
56. I understand that this limitation is a preamble of the claim and I have been asked to assume that it is limiting. Under such an assumption, it is my opinion that *Barber* discloses a “method of depositing an insulating film on a substrate.” For

³ In this section (Section IX), I refer to exhibits other than those identified prior art reference(s) that disclose and/or suggest the claimed limitations. Such exhibits reflect the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

example, *Barber* discloses a process for depositing a piezoelectric film formed of aluminum nitride (AlN). (Ex. 1005, Abstract, 1:15-19, 4:31-34, 6:42-46, 8:44-9:22; *see also id.*, 5:62-67.) A person of ordinary skill in the art would have understood that an AlN film like that disclosed by *Barber* is an “insulating film” as claimed because AlN was known to be an insulating material. (Ex. 1005, 2:50-52 (“insulating films (including piezoelectric films)”); Ex. 1022, 38:63-67 (disclosing forming an “**insulating film**...of aluminum nitride (AlN)” by “sputtering in an argon atmosphere by using metallic aluminum and nitrogen as material sources”)⁴.) Indeed, *Barber* explains that once the metal target material (e.g., aluminum) reacts with a reactive gas (e.g., nitrogen), it “becomes an insulator.” (Ex. 1005, 7:26-29; *see also id.*, 6:58-62.) Furthermore, *Barber* discloses that the piezoelectric film is deposited on a substrate. (Ex. 1005, 5:67-6:3 (disclosing, referring to Figures 1 and 2, deposition of a piezoelectric film 120 on substrate 110), 7:23-25.) *Barber* also discloses depositing AlN and silicon dioxide on a monitor wafer. (*Id.*, 8:44-48, 9:25-31.)

⁴ The emphasis I provide in this Declaration are added unless I note otherwise.

57. According to *Barber*, the piezoelectric layer may be deposited by a reactive sputtering process using a system described with reference to Figure 2. (Ex. 1005, 5:67-6:3, FIG. 2.)



(*Id.*, FIG. 2.) *Barber*'s system includes a plasma chamber 210 that operates in a reduced pressure, and further includes flow control sources 240 and 250 and a cryo

pump with a throttle valve 270. (*Id.*, 6:4-13.) The gas pressure within the chamber is regulated by valve 270 and by the flow control sources 240 and 250 (*id.*, 6:27-29), where flow control source 240 introduces a noble gas (e.g., Ar, Xe, and Kr) and flow control source 250 introduces a reactive gas (e.g., O₂, N₂, etc.) into the chamber (*id.*, 6:8-13).

58. The system also includes a pulsed DC power source 230, a target 260, and an anode ring 225, where pulsed DC power source 230 applies a bias across target 260 and anode ring 225 (which collectively serve as a pair of electrodes) to ionize the noble gas, forming a plasma. (Ex. 1005, 6:4-11 (“The electric potential applied to the electrodes [i.e., target 260 and anode ring 225] may be controlled by a pulsed DC power source 230”), 7:30-34; 8:49-52.) The ions of the noble gas bombard target 260 and eject atoms of the target material (e.g., aluminum). (*Id.*, 7:30-34; *see also id.*, 2:1-5 (describing known sputtering deposition techniques involving ion bombardment of a target that eject atoms of the target material onto a substrate), 6:42-46 (disclosing use of aluminum target).) The freed atoms of the target material react mostly at the target with the reactive gas (e.g., nitrogen) and are subsequently deposited on a substrate 110 within the chamber to form a film, such as the AlN film discussed above. (*Id.*, 7:34-36; *see also id.*, 8:44-9:22.) The system

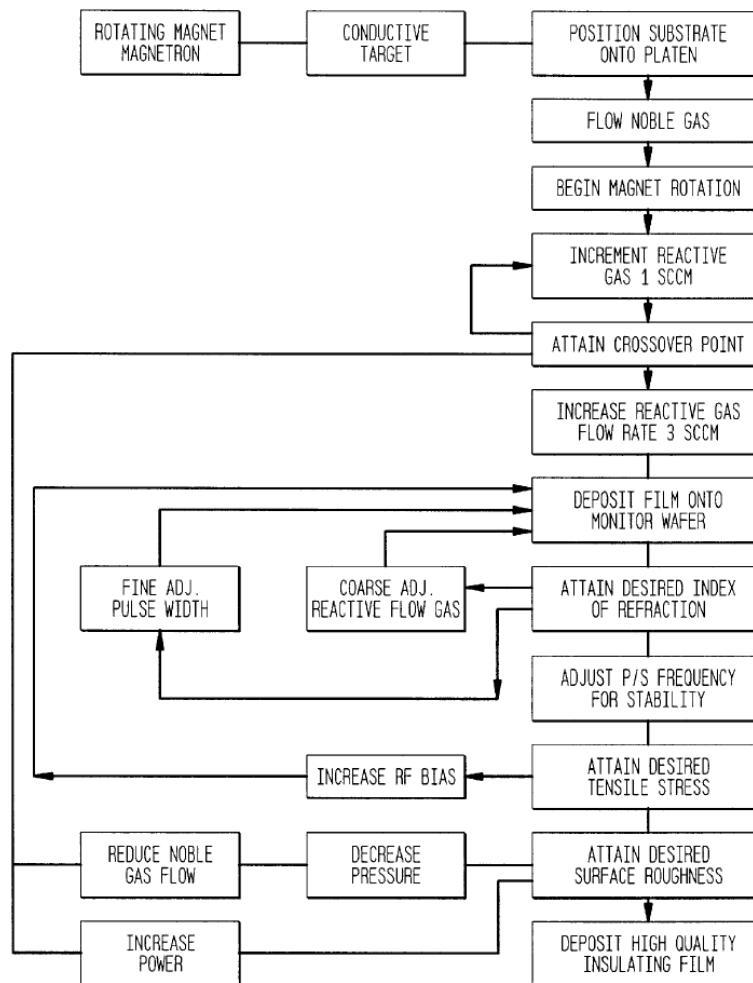
also includes a radio frequency (RF) power supply 235 that applies a bias voltage to a substrate platen 115, upon which substrate 110 is positioned, to control the property of the deposited film. (*Id.*, 6:15-17, 6:29-31.)

59. *Barber's* system also includes a rotating magnet assembly 280 that forms a magnetic field over the target surface facing the substrate 110. (Ex. 1005, 6:17-21.) A rotation motor 300 rotates magnet assembly 280 about an axis respect to target 260. (*Id.*, 6:21-23.) The magnetic field generated across target 260 increases concentration of ions at the target surface and thus increases the efficiency of the sputtering process. (*Id.*, 6:23-27.)

60. *Barber* also discloses a process flow for depositing high quality piezoelectric film (e.g., AlN) based on the features of the reactive sputtering system described above. (Ex. 1005, Figure 5, 7:1-2; *see also id.*, 8:43-9:22 (exemplary process for depositing an AlN film based on the process disclosed in Figure 5), 9:23-10:11 (exemplary process for depositing a silicon oxide film based on the process disclosed in Figure 5).) *Barber* discloses, among other things, depositing both an AlN film and a silicon dioxide (SiO₂) film and refers to the AlN film as a piezoelectric film (Ex. 1005, 3:56-57, 6:42-46) and the SiO₂ film as an insulating film (*id.*, 7:65-8:4, 9:25). A person of ordinary skill in the art would have understood

that an AlN piezoelectric film (like that described by *Barber*) was a known insulator, and thus *Barber*'s AlN piezoelectric film is an "insulating film" like that claimed. (See *e.g.*, Ex. 1022, 38:63-67 ("Thereafter, the side faces of the ridge 31A and the dummy ridges 31B and areas therebetween are covered with ***an insulating film 35 of aluminum nitride (AlN)*** by the ECR sputtering in an argon atmosphere by using metallic aluminum and nitrogen as material sources").) As I discuss below for claim element 2[e], the SiO₂ film in *Barber*, while an insulating film, is also an "oxide material" that is deposited on the substrate 110 before the AlN film. (See my discussions in Section IX.A.1.f.)

FIG. 5

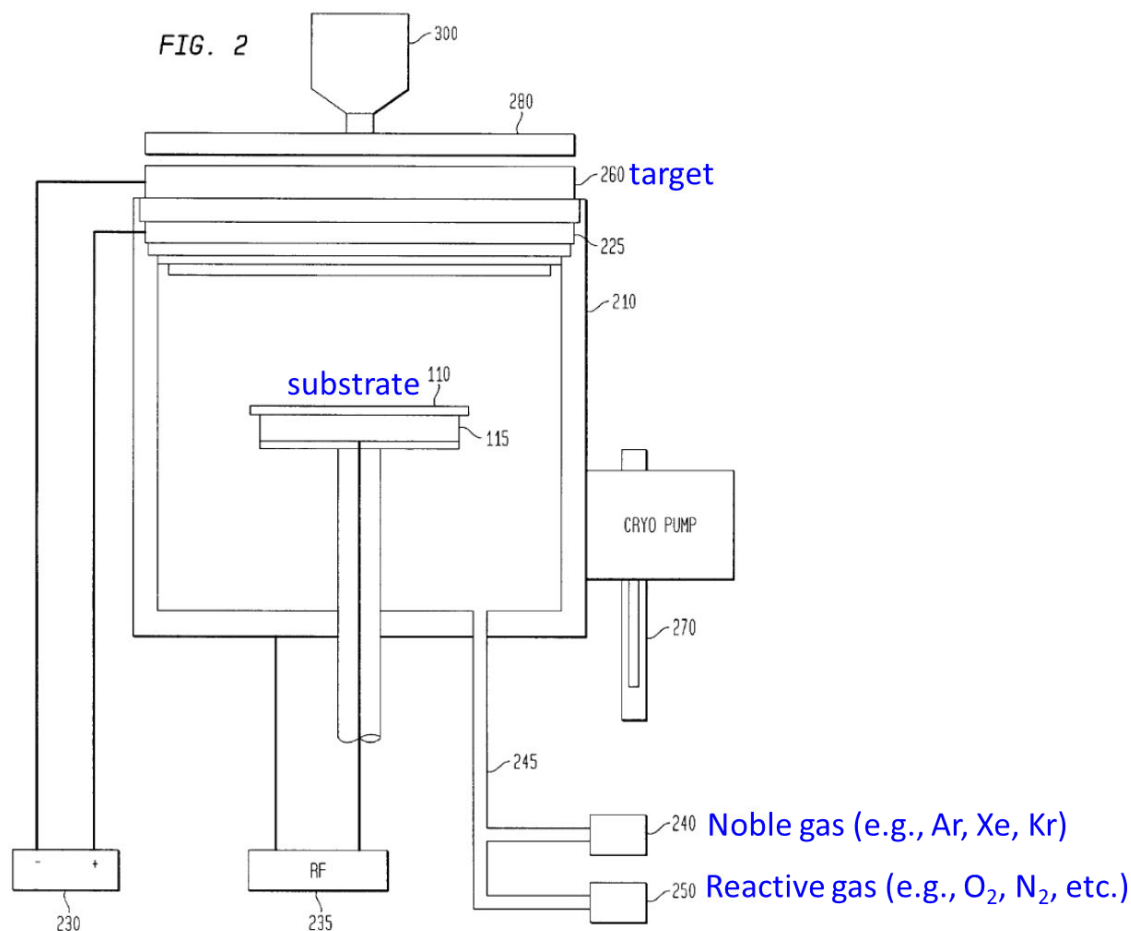


(*Id.*, FIG. 5.) The process flow includes steps for controlling gas flows to attain a “cross-over point” of a reactive sputtering process and adjusting various parameters (such as pulsed width and power of the pulsed DC power supply, and RF bias) to obtain desired film properties in order to deposit a high quality film. (Ex. 1005,

7:19-29, 7:36-50, 7:59-64; *see also id.*, 7:1-8:12.) (See my discussions in Sections VII.A, IX.A.1(b)-(f) (describing *Barber*'s method that are applicable to this claim.)

b) Claim 2[b] “providing a process gas between a target and a substrate;”

61. In my opinion, *Barber* discloses “providing a process gas between a target and a substrate,” as claimed. For example, *Barber* discloses providing a noble gas and a reactive gas (which collectively, or at least one of the noble gas (e.g., argon) or the reactive gas (e.g., nitrogen, oxygen), correspond to the claimed “process gas”) into chamber 210 between target 260 and substrate 110 for film depositions. (Ex. 1005, 6:8-13.) Substrate 110 is positioned in chamber 210 and is “disposed such that it is in communication with the target and gasses within the chamber.” (*Id.*, 6:14-17; FIG. 2.)



(*Id.*, FIG. 2 (annotated with labels).) Target 260 is bombarded by the ionized noble gas and reacts with the reactive gas. (Ex. 1005, 2:1-9, 6:6-11, 7:30-36; 8:45-52.) In this way, *Barber* discloses “providing a process gas between a target and a substrate.” Therefore, it is my opinion that *Barber* discloses this claim limitation.

- c) **Claim 2[c] “providing pulsed DC power to the target through a narrow band rejection filter such that the voltage on the target alternates between positive and negative voltages;”**

62. In my opinion, *Barber* in view of *Hirose* discloses and/or suggests this limitation, which I explain below in separate parts.

- (1) **“providing pulsed DC power to the target...such that the voltage on the target alternates between positive and negative voltages;”**

63. In my opinion, *Barber* discloses providing pulsed DC power to the target such that the voltage on the target alternates between positive and negative voltages. Namely, *Barber* discloses a pulsed DC power source 203 that provides an electrical potential to target 260, which alternates between positive and negative values. (Ex. 1005, 6:4-8, 8:45-48.)

64. *Barber* describes applying **positive** DC pulses to target 260 at a certain pulse frequency. (Ex. 1005, 2:21-26 (disclosing “pulse width of the **positive** portions of the applied voltage is adjusted” to tune the property of the deposited film as described in the Miller application), 7:14-17 (“The cross-over point for the flow of a reactive gas into the sputtering chamber is determined with appropriate settings to the pulse frequency and pulse width.”), 8:45-48 (setting pulse frequency and pulse width), 8:66-9:3 (adjusting frequency), 9:17-22 (disclosing in the embodiment for

depositing AlN that “pulsed DC power may be adjusted as described in the above-referenced Miller application”).) *Barber* also explains that the “**reverse**-bias pulse width” of the pulsed DC power supply may be adjusted for tuning the property of the deposited film and that “increasing the pulse width also lowers the deposition rate.” (*Id.*, 9:6-11; *see also id.*, 9:48-53.) A person of ordinary skill in the art would have understood that *Barber*’s reference to a “reverse-bias” pulse refers to the pulse of a **positive** bias, which is consistent with how the ’657 patent discusses this feature and with how a person of ordinary skill in the art would have understood the concept and features at the time. (Ex. 1001, 5:50-51 (“The **reverse** voltage is 10% of the negative target voltage.”); 5:39-43 (describing that the positive bias period as the “**reverse** time”); Ex. 1008, 1-2 (describing with reference to Figure 1 that the duration of applying a **positive** bias to the target is the “off-time”), 3 (disclosing that the “off-time” is also called “**reverse** time”)⁵.)

⁵ I refer to Ex. 1008 here to demonstrate the state of the art understood by a person of ordinary skill in the art at the time of the alleged invention.

65. *Barber*'s disclosure that "increasing the [reverse] pulse width also **lowers the deposition rate**" is consistent with a person of ordinary skill in the art's understanding that positive pulse periods are off-times for sputtering process (i.e., little or no deposition occurs during positive voltage pulse periods). This is also consistent with the descriptions that are provided in the '657 patent. (Ex. 1001, 10:57-58 ("if the reverse time is too long, the deposition rate will decrease").)

66. A person of ordinary skill in the art would have understood that in addition to the positive bias (that I discuss above), *Barber*'s pulsed DC power supply 203 necessarily provides a negative bias to the target such that the voltage on target 260 alternates between negative and positive voltages. Such a person of ordinary skill in the art would have known and understood that for a sputtering process to operate, a negative bias must be applied to the target at times in a DC-based sputtering system (e.g., like that disclosed in *Barber*) because that is what is needed to attract the positively-charged gas ions in the plasma created in the sputtering chamber to cause deposition on the substrate. Such a skilled person would have had such an understanding because it was known and understood at the time that for deposition to ultimately occur, the positively-charged gas ions must be attracted and accelerated towards a negatively-biased target to knock off the target material for

film deposition. (Ex. 1005, 7:30-34; *see also id.*, 2:1-5 (describing known sputtering deposition techniques involving ion bombardment of a target that eject atoms of the target material onto a substrate).) A person of ordinary skill in the art would have known that this would not (and does not occur) if the target is only positively biased. This understanding is consistent with the known concepts according to Coulomb's Law, which provides that like charges repel and opposite charges attract. (*See e.g.*, Ex. 1007, 3:8-16 (disclosing the known concept that "positive argon ions are accelerated towards" the negatively-biased target), 3:39-41 ("negative dc voltage that is applied to the target is interrupted periodically by reverse-bias pulses of appositive dc voltage relative to the anode"), 3:53-54 (describing that a "negative" voltage at the target is the "normal" sputtering voltage).)⁶

67. Therefore, in my opinion, a person of ordinary skill in the art would have understood that biasing a target only with a positive voltage does not sputter the target, which is an understanding consistent with *Barber's* "reverse-bias"

⁶ I refer to Ex. 1007 to demonstrate the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

disclosures that I explained above. (*See also* Ex. 1008, 1-2 (describing with reference to Figure 1 that the period when the target is negatively biased is called “on-time” and the period when the target is positively biased is called “off-time”), 4 (disclosing that “[s]puttering takes place **only** during the on-time”).)

68. A person of ordinary skill in the art would have also understood that *Barber*’s disclosures of adjusting a “**reverse**-bias pulse width” of the pulsed DC power supply for tuning the property of the deposited film and “increasing the pulse width [would lower] the deposition rate” (*see e.g.*, Ex. 1005, 9:6-11, 9:48-53), to be in context of the required and known aspects of also using a negative bias to facilitate sputtering for depositing film on substrate 110. Accordingly, while *Barber* does not expressly state that supply 230 provides a negative bias to target 260 in addition to the positive bias, in context of *Barber*’s disclosures and the understandings of a person of ordinary skill in the art, such a skilled person would have understood that *Barber*’s pulsed DC power supply 230 necessarily provides a **negative** bias to target 260 during its disclosed reactive sputtering process in order to attract the positively charged gas ions (e.g., ionized argon, Ar^+ , as disclosed in *Barber*) to facilitate the bombardment of the target material for deposition to occur on substrate 110. Also, because target 260 serves as an electrode that receives voltage from pulsed DC

power supply 230 (Ex. 1005, 6:4-8), a person of ordinary skill in the art would have understood that the voltage on target 260 necessarily alternates between the positive and negative voltages provided by pulsed DC power supply 230, as I explained above. Thus, a person of ordinary skill in the art would have understood that in *Barber's* process, the target 260 must be necessarily negatively biased to attract the positive ions that are required to facilitate the reactive sputtering process that is disclosed by *Barber*, and, as disclosed in *Barber*, the bias on the target is reversed, i.e., from the negative to the positive, in pulses of a finite width to achieve desired film property. A person of ordinary skill in the art would have understood that without such negative bias functionalities, *Barber's* system would not perform the sputtering process to deposit film on substrate 110 as disclosed.

69. Therefore, in my opinion, *Barber* discloses “providing pulsed DC power to the target...such that the voltage on the target alternates between positive and negative voltages” at a certain pulse frequency because target 260 serves as an electrode that receives such voltage (Ex. 1005, 6:4-8, 8:45-48).

70. My opinion is consistent with the *Miller* application, which is incorporated by reference in *Barber*. (Ex. 1005, 2:14-26, 8:44-9:22.) In particular, *Barber* discloses that *Miller* is incorporated in *Barber* by reference.

A pulse DC sputtering method for efficiently depositing thin films of piezoelectric materials such as aluminum nitride (AlN), e.g., with improved control over the direction and delivery of the reactive gas, is described in U.S. patent application Ser. No. 09/145,323, to Miller et al., “Pulse DC Reactive Sputtering Method for Fabricating Piezoelectric Resonators,” filed Sep. 1, 1998, assigned to the present assignee and **incorporated herein by reference**. In Miller et al., the quality of the piezoelectric films is improved with the techniques used to deposit the films, i.e., the pulse width of the positive portion of the applied voltage is adjusted based on its effect on the desired film constituency, stress, and texture.

(*Id.*, 2:14-26.) *Barber* also discloses applying *Miller*’s teaching to deposit insulating films, such as AlN.

The pulsed DC power may be adjusted as described in the above-referenced Miller application, incorporated herein, to enhance the desired [AlN] film constituency, stress, and texture through more efficient reaction by the reactive gasses.

(*Id.*, 9:17-22.)

71. As to *Miller*, it discloses that it was known in the art that:

One specific type of reactive sputtering that often is used in, e.g., silicon processing methods, is **pulse DC reactive sputtering**. Since the target insulating film is **an insulator (e.g., AlN)**, the noble gas ions tend to accumulate on its surface, reducing the sputter rate and ultimately terminating the sputter process. In pulse DC reactive sputtering, **the electric potential formed between the cathode and the anode in the chamber is reversed periodically to prevent charge accumulation on the target insulating film**. More specifically, the **positive** portion of the applied voltage neutralizes accumulation of the noble gas ions on the surface of the target insulating film, and the **negative** portion of the applied voltage, if sufficient, causes ions from the noble gas to impinge upon the target insulating film formed on the target material, physically removing ions thereof and allowing them to accumulate on the substrate. This forms the deposited layer or coating.

(Ex. 1060, 4:24-5:5.) *Miller* further discloses that

Embodiments of the invention include the steps of providing a target material such as aluminum within the sputtering chamber, positioning a substrate such as silicon within the sputtering chamber, providing a noble gas such

as argon into the sputtering chamber, directing a reactive gas such as nitrogen within the sputtering chamber, **applying a pulsed DC voltage across the electrodes within the sputtering chamber sufficient to cause ions from the noble gas to impinge upon the thin insulating layer (e.g., AlN) formed on the target material, physically removing ions thereof and allowing them to accumulate on the substrate.** According to embodiments of the invention, the pulse width of the **positive** portion of the applied voltage is adjusted based on its effect on the desired film constituency, stress, and texture.

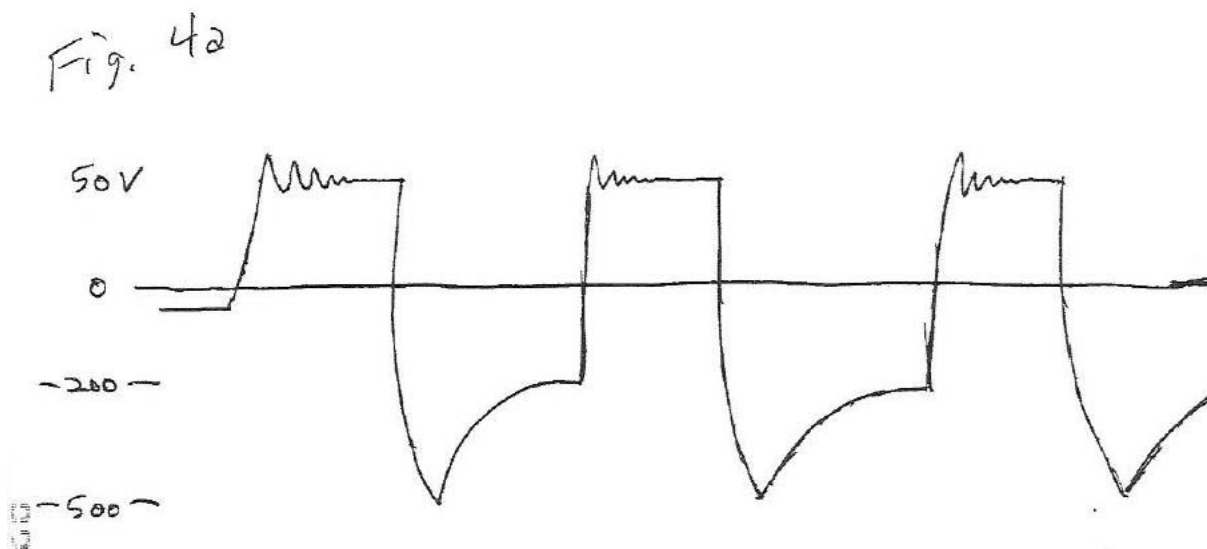
(*Id.*, 6:2-11.)

Embodiments of the invention include piezoelectric resonators with improved piezoelectric film quality and control of methods for making such piezoelectric resonators using pulse DC reactive sputtering for the deposition of thin films of piezoelectric material on substrates. Embodiments of the invention are based on the realization that **varying or adjusting the pulse width of the positive portion of the applied DC voltage** improves the control and crystallinity of the deposited piezoelectric material.

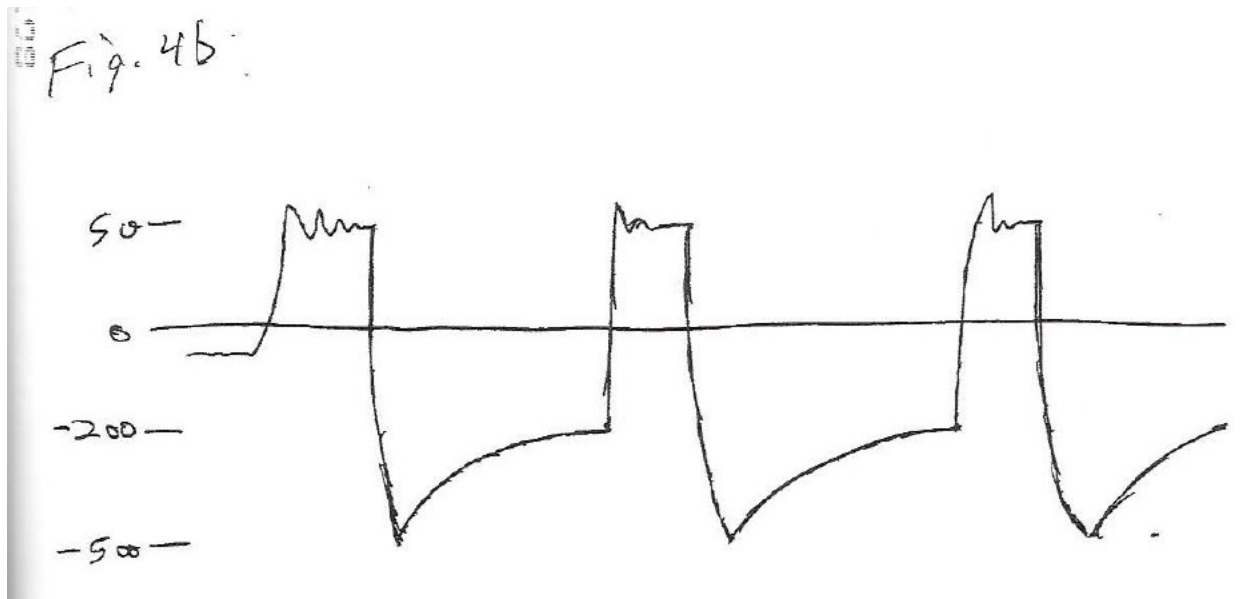
(*Id.*, 7:6-11.)

[P]ulse DC reactive sputtering arrangements provide a **periodic positive DC voltage across the electrodes 220, 225 separated by periods in which a negative voltage potential exists across the electrodes and target sputtering occurs.** The application of this periodic positive voltage pulse is done for a number of reasons, as discussed hereinabove, including to improve film texture and increase piezoelectric response.

(*Id.*, 11:23-28; *see also id.*, 8:14-10:22, 11:14-12:14.) Furthermore, *Miller* discloses with reference to Figures 4a and 4b that the pulsed DC voltage applies to the target alternates between positive and negative voltages. (*Id.*, 12:15-30; *see also id.*, 6:26-29.)



(*Id.*, FIG. 4a.)



(Id., FIG. 4b.)

72. Accordingly, as I discussed above, it is my opinion that *Barber* discloses and/or inherently discloses “providing pulsed DC power to the target...such that the voltage on the target alternates between positive and negative voltages.” (See my discussions in Sections VII.A and IX.A.1(a).)

**(2) [providing pulsed DC power to the target]
“through a narrow band rejection filter [such
that ...]” ;**

73. In my opinion, *Barber* in view of *Hirose* discloses and/or suggests providing pulsed DC power to the target “through a narrow band rejection filter” such that the voltage on the target alternates between positive and negative voltages.

74. *Barber* discloses that electrical characteristics of the pulsed DC power supply should be monitored or adjusted “to achieve a stable waveform.” (*Id.*, 8:66-9:2 (“The voltage-current of the magnetron should be monitored and if necessary, the frequency should be adjusted to achieve a stable waveform.”); *see also id.*, 7:59-60 (“[t]he current and/or voltage can be monitored and frequency adjusted to achieve a stable waveform.”).) According to *Barber*, electrical characteristics of the pulsed DC power supply are important parameters to monitor, adjust, and stabilize in order to obtain high quality films. For example, *Barber* discloses that performing reactive sputtering at the “cross-over point” is “effective in optimizing the deposition conditions” (Ex. 1005, 7:36-40) and that the “cross-over point” is determined based on electrical characteristics of the pulsed DC power supply, i.e., “appropriate settings to the pulse frequency and pulse width” thereof (*id.*, 7:14-17). *Barber* also discloses that the voltage and current parameters can also be monitored to arrive at the “cross-over point” for film deposition. (*Id.*, 8:54-59.) Likewise, *Barber*

discloses that because “the deposition rate is inversely proportional to...the power supply pulse width...and is directly proportional to the power,” these “relevant parameters of the process may be monitored and adjusted” to “improve the deposition rate and overall quality of the deposited films.” (*Id.*, 7:41-47; *see also id.*, 7:60-67 (disclosing that by adjusting the pulse width and power of the pulse DC bias film quality may be improved).) (*See also* my discussions in Section VII.A.)

75. While as I explained above, *Barber* necessarily discloses alternating the voltage on the target between positive and negative voltages like that recited in the claim, *Barber* does not expressly disclose providing such pulsed DC power “through a narrow band rejection filter.” However, in my opinion, a person of ordinary skill in the art would have been motivated to modify *Barber*’s system to include a narrow band rejection filter, in light of the disclosures and suggestions in *Hirose* and the knowledge of the state of the art known to such a skilled person at the time in order to protect the DC power supply 230 and allow it to provide un-interfered pulsed DC power having a stable waveform to optimize film depositions.

76. Such a skilled person at the time would have had reasons to consider and implement such a modification especially since *Barber*’s system includes, in addition to pulsed DC power supply 230 coupled to target 260, a RF power supply

235 that applies a bias voltage to a substrate platen 115. (Ex. 1005, 6:29-31, 9:12.)

A person of ordinary skill in the art would have understood that these two power supplies operate at different frequencies, where the pulsed DC power supply operates at, for example, 100 kHz (*id.*, 8:45-48) and RF power supply 235 operates at a radio frequency. Such a skilled person would have understood that such RF frequency ranges at the time ranged from near 1 MHz to tens of MHz, and that a frequency of 13.56 MHz was typically used in a plasma system RF power supply as it was one of the frequencies allocated for industry use by the Federal Commission of Communication at the time of the alleged invention. (Ex. 1009, 3:7-11; *see also*, *e.g.*, Ex. 1010, 9:13-15 (disclosing application a RF bias to a substrate “in the range of from about 0.2 to 80 MHz, for example, at 13.56 MHz”); Ex. 1011, 5:9-17 (disclosing application of a RF bias to a substrate with a “radio frequency source of 13.56 MHz”); Ex. 1012, 4:61-64 (same)⁷

⁷ I refer to Exs. 1009-1012 to demonstrate the state of the art known to a person of ordinary skill in the art at the time of the alleged invention. *See also* my discussions above in Section V.

77. A person of ordinary skill in the art contemplating the implementation of *Barber*'s system and process would have been motivated to consider the issues relating to *Barber*'s configuration and look to guidance from their knowledge and other sources relating to the use of power supplies in similar systems. For example, *Hirose* discloses "a plasma processing apparatus" that utilizes two power supplies of different frequencies. (Ex. 1006, Abstract.) *Hirose* discloses that it was known in such systems to utilize a filter to isolate one power supply from the other (*id.*, 1:30-67, FIG. 10) and additionally discloses embodiments where the filters, while still being capable of isolating different power supplies, the optimum resonance point of the filters can be modified, e.g., to adjust plasma process conditions.

78. In particular, *Hirose* describes with reference to Figure 1 a plasma processing apparatus 10 that includes a chamber 11 and two electrodes: an upper electrode 12 and a lower electrode facing each other. (Ex. 1006, 3:45-50.) The upper electrode 12 is connected to a first high-frequency power supply 14 via a first power supply line 16 and a first matching circuit 17. (*Id.*, 3:51-54.) The lower electrode 13 is connected to a second high-frequency power supply 15 via a second matching circuit 19. (*Id.*, 3:54-56.) This lower electrode 13 also functions as a chuck top for mounting a processing object W, such as a semiconductor wafer. (*Id.*,

3:56-58.) A plasma P is generated in an atmosphere of process gas supplied between the upper and lower electrodes 12 and 13. (*Id.*, 3:59-63.)

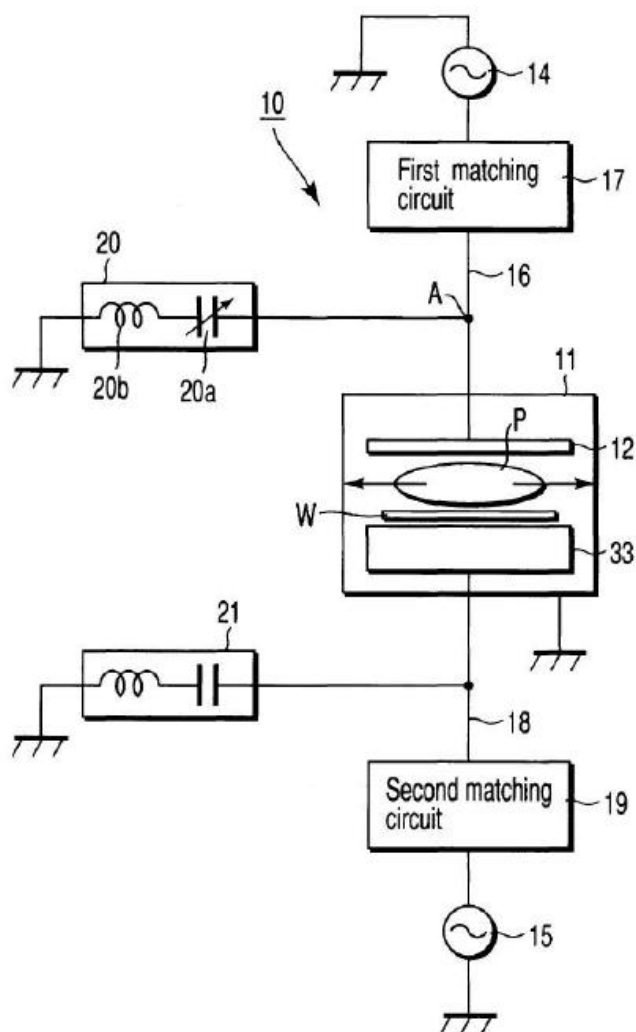


FIG. 1

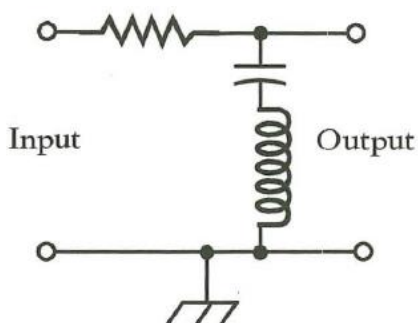
(Ex. 1006, FIG. 1.)

79. Similar to its discussed conventional technologies (Ex. 1006, 1:30-67, FIG. 10), *Hirose* discloses utilizing a first filter circuit 20 that is placed between first power supply 14 and upper electrode 12 to “**selectively filter[] a high-frequency current output from the second high-frequency power supply 15 for preventing the current from reaching the first high-frequency power supply 14.**” (*Id.*, 4:9-16.) To isolate the other power supply, *Hirose* also discloses using a second filter circuit 21 to prevent a high-frequency current from the first high-frequency power supply 14 from reaching the second high-frequency power supply 15. (*Id.*, 4:16-21; *see also id.*, 3:45-4:38, 5:63-6:4.)

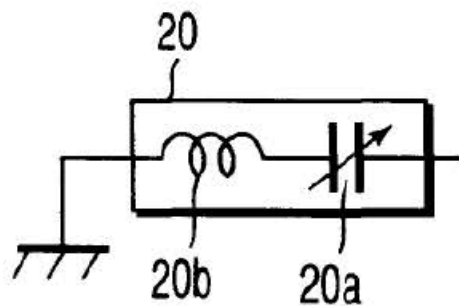
80. Different from its discussed conventional technologies that use filters of a **fixed** circuit constant (Ex. 1006, 1:45-47), *Hirose* discloses embodiments where the circuit constant of the filters may be **varied**, by changing the values of the inductor and the capacitor, to change the resonance point thereof to adjust plasma process conditions. (*Id.*, 2:45-51, 6:2-4, 6:9-12, 7:20-30; *see also id.*, FIGS. 7-9.) The resonance point of the filter corresponds to the frequency the filter is designed to isolate. (*Id.*, 5:7-10, 8:34-38 (“a resonance point most attenuating high-frequency power depends on” the disclosed equation that associates the values of the inductor and capacitor constituting the filter circuit).) *Hirose* explains that in each of these

filters (e.g., first circuit filter 20) is “an LC series resonant circuit” that include a capacitor and an inductor. (*Id.*, 4:11-13; Fig. 1 (elements 20b, 20a).) To show the effectiveness of the filters, *Hirose* shows that the voltage waveform is distorted when the filter is removed. (*Id.*, 4:45-67 (indicating that the waveform is measured at Point A of Figure 1, which is between an electrode and a power supply), FIGS. 2-4.) (See also my discussions above in Section VII.B.)

81. While *Hirose* does not expressly state the type of filter used in its system (e.g., whether the filter is a low-pass, high-pass, band-pass, or band-rejection filter), it is my opinion that a person of ordinary skill in the art would have understood that *Hirose*’s filters were well-known **band-rejection filters**. This understanding is consistent with that described in *Gibilisco* (which I discussed above in Section V). (Ex. 1006, 4:9-16; Ex. 1013, 4-6; see also *id.*, 5 (Figure 2-9(F) disclosing a filter like that disclosed in *Hirose*).)



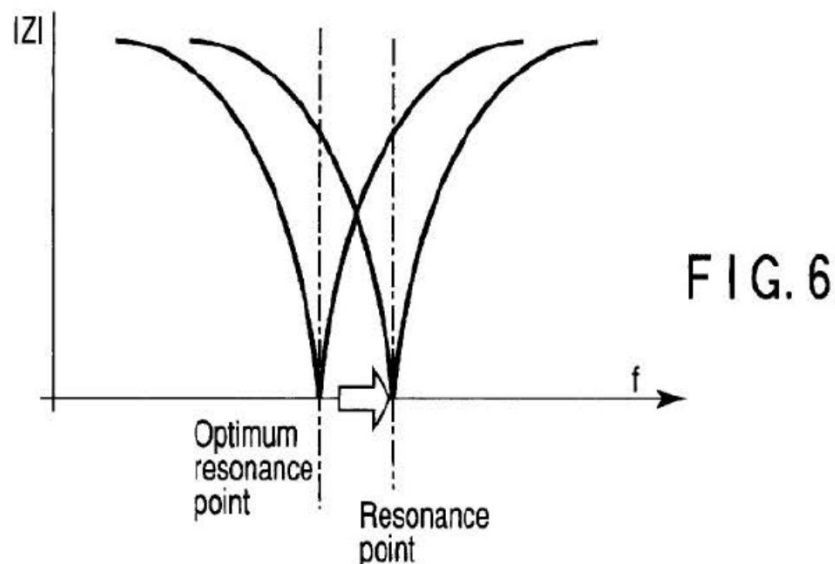
(Ex. 1013, Figure 2-9(F))



(Ex. 1006 (*Hirose*), Fig. 1 (excerpt))

According to Figure 6 of *Hirose*, the band rejection filter has a very narrow frequency response, as suggested by the pointy and V-shaped curve shown in the figure. Thus, in context of *Hirose*'s disclosures and based on the knowledge of a person of ordinary skill in the art, such a person of at the time would have understood that the band rejection filter disclosed in *Hirose* is so tuned such that it rejects a narrow band of frequency, i.e., a narrow band rejection filter or known as a notch filter (a name given by its V-shaped or notch-like frequency response), consistent with how it is designed to isolate a specific frequency (*id.*, 5:7-10, 8:34-38; compare Ex. 1013, 5 at FIG. 2-9(G) (describing a “sharp response...occurs at or near a single resonant frequency”) with Ex. 1006, FIG. 6 (similar)). While *Hirose* describes that “FIG. 6 shows a decrease in the sputter rate” (Ex. 1006, 3:24), a person of ordinary skill in the art would have understood that such description refers to the end result

of lowering the filter's capacitance and/or inductance value. (See, e.g., Ex. 1006, 5:7-10 (disclosing that the resonant frequency is inversely proportional to the square root of the product of the capacitance and inductance values); 4:62-5:6 (disclosing that by lowering the filter's capacitance value the resonant frequency of the filter is increased and the sputtering rate is reduced).)



(Ex. 1006, FIG. 6.)

82. In my opinion, based on the knowledge of a person of ordinary skill in the art at the time (*see also e.g.*, my discussions above in Section V) and the disclosures and suggestions in *Hirose*, a person of ordinary skill in the art would have understood that *Hirose* describes the use of a **narrow band-rejection filter** to

block electrical current of a remote power supply (e.g., second high-frequency power supply 15) from reaching a local power supply (e.g., first high-frequency power supply 14) in a plasma process system, which is placed between the local power supply and an electrode of the plasma system.

83. Based on such disclosures and understandings, in context of the disclosures of *Barber*, a person of ordinary skill in the art considering the implementation of the sputtering process disclosed in *Barber* would have been motivated to modify *Barber*'s system to incorporate a narrow band rejection filter such that the filter prevents the RF signal from source 235 from affecting DC power supply 230 during the process. As I explained below, this understanding is applicable also even if *Hirose* is somehow determined not to disclose a **narrow** band rejection filter, because in my opinion, a person of ordinary skill in the art would have been motivated to use such a filter for the same reasons that I explain in this section. That is, consistent with the reasons I discuss here, a person of ordinary skill in the art would have been similarly motivated to configure the filter to be implemented in *Barber*'s system (as I explain below) to be a narrow band rejection filter to ensure the appropriate frequency or frequencies associated with RF power supply 235 are isolated from DC power supply 230.

84. In my opinion, a person of ordinary skill in the art would have had reason to consider the teachings and suggestions of *Hirose* because of their similarities in operating components and the environment operated therein described in these references. For example, a person of ordinary skill in the art would have appreciated that *Barber* and *Hirose* use similar hardware components to perform plasma-based processes, such as a plasma processing chamber having multiple power supplies operating in different frequencies. Similarly, a person of ordinary skill in the art would have appreciated that *Hirose*'s power supply 14 biases upper electrode 12 and its power supply 15 biases a wafer holder or electrode 33 (*see, e.g.*, Ex. 1006, FIG. 1) is similar to *Barber*'s pulsed DC power supply 230 that biases target 260 and its RF power supply 235 that biases a substrate platen 115 (*see, e.g.*, Ex. 1005, FIG. 2).

85. Furthermore, *Hirose* suggested and disclosed to those of ordinary skill in the art at the time that filters were known to be useful to block electrical current of a remote power supply in plasma process systems, which would have been beneficial in the sputtering system as disclosed in *Barber*. (*See, e.g.*, Ex. 1006, Abstract ("The present invention concerns a **plasma processing apparatus** for processing a processing object by applying two types of high-frequency power with

different frequencies to generate plasma.”), 1:44-67 (the admitting prior art discloses using filters in a “**plasma processing apparatus**”).) While *Hirose* uses a reactive ion etch system, such a system was one of the known plasma processing systems available at the time, and describes its system *as examples*. (Ex. 1006, 3:67-4:2 (“An ion component in the plasma is introduced to the surface of a semiconductor wafer W for performing, *say*, reactive ion etch (RIE).”), 6:46-48 (same).) Thus, consistent with *Hirose*’s disclosures, a person of ordinary skill in the art would have understood that the use of a filter would have also been useful in other plasma process systems, such as *Barber*’s system. (Ex. 1006, 8:1-8.) In fact, a person of ordinary skill in the art would have understood that a RIE system is very similar to a sputtering system, e.g., *Barber*’s system, and both RIE and sputtering systems would have benefited from *Hirose*’s teachings. (Ex. 1015, 3 (“[r]eactive ion etching systems...are essentially converted sputtering systems.”); Ex. 1057, 1:16-34 (describing that RIE and sputtering processes are “similar”), 1:56-58 (“Electronically isolating certain system components with respect to RF energization is desirable when using RF power in **sputtering** and **etching**,” “[o]therwise, the plasma may be altered, adversely affecting the **sputtering or etching process**”); Ex. 1010, 9:23-34 (describing the known understanding that etching (for pre-deposition

cleaning purposes) and sputtering deposition can be performed in the same plasma chamber by having different power supply settings).⁸ Such disclosures are consistent with the knowledge of a person of ordinary skill in the art at the time.

86. In my opinion, a person of ordinary skill in the art would have recognized these similarities and appreciated the benefits of using an RF narrow band rejection filter to protect the pulse DC power supply and also reduce interference. For instance, because it was known that such a filter would have been able to “selectively filter[]” a specific frequency of electrical current that is generated by the RF power supply (Ex. 1006, 4:9-16), a person of ordinary skill in the art would have understood that using a narrow band rejection filter in *Barber’s* system as I explained above would have helped *Barber’s* pulsed DC power supply provide a stable waveform to the target so as to optimize film depositions by reducing or eliminating electrical interference from the RF power supply. A person of ordinary skill in the art would have also understood that implementing such a filter would

⁸ I refer to Exs. 1010, 1015, and 1057 to demonstrate the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

have been beneficial as it would have reduced or eliminated interferences or noise on the electrical characteristics (e.g., power, current, voltage, pulse frequency, and/or pulse width) of the pulsed DC power supply that are monitored or adjusted in order to attain the optimal process point (the cross-over point). Thus, such a skilled person would have appreciated that through a filter, the pulsed DC power signals provided by the DC power supply 230 in *Barber's* system—with the intended bipolar pulses and other pulse characteristics—would have been properly applied to the target 260 to facilitate reactive sputtering processes that depend on these electrical characteristics.

87. Consistent with such understandings, a person of ordinary skill in the art would have been similarly motivated to configure/tune the filter used in the above-discussed *Barber-Hirose* modified system/process to be a narrow-band rejection filter to block the specific frequency of the RF power supply (e.g., 13.56 MHz). A person of ordinary skill in the art would have understood a narrow band rejection filter was a type of band rejection filter, which were known to suppress parasitic signals or to reduce interference. (Ex. 1013, 5 (“A common example of a band-rejection filter is a *parasitic suppressor* used in high-power RF amplifiers”), 6 (disclosing that “[t]he notch filter is extremely convenient for reducing interference”

caused by other signals and that the notch filter, also known as a narrow band rejection filter, shares a similar circuit configuration with a type of band rejection filter shown in the figures).)

88. A person of ordinary skill in the art would have recognized from *Hirose* (and based on their knowledge of such circuits) that the specific frequency to block in the *Barber-Hirose* system may be configured using known design concepts (e.g., modifying the capacitor and inductor components of the filter, and would have motivated to do so such that it would block the appropriate RF frequency corresponding to the RF power supply 235 in *Barber* for the reasons I discuss in this Declaration. (See, e.g., Ex. 1006, 5:7-10, 8:34-38; Ex. 1013, 6 (“[t]he frequency is adjustable, so that the deep null can be tuned to any frequency within the receiver passband”).) In my opinion, a person of ordinary skill in the art would have had the capability and knowledge to configure and implement such a filter in *Barber*’s system (located in connection with DC power supply 230) and would have expected such configurations to operate properly (and been able to address any design issues with implementing it in *Barber*’s system) so that it would have achieved the purpose of filtering the appropriate RF frequency signal from RF power supply 235.

89. A person of ordinary skill in the art would have understood that configuring a filter in the modified *Barber-Hirose* system and process I discussed above to block a specific frequency (or a narrow band of frequencies) would have been a known choice among a limited number of options in frequency filter design that were available and known to such a skilled person at the time. For example, such a skilled person would have appreciated that choosing to reject a specific frequency (or narrow band of frequencies) depending on the bandwidth of the RF power supply 235 selected in *Barber's* system would have been a known way to achieve the benefits suggested and discussed above by *Hirose* and understood by a person of ordinary skill in the art at the time. (See *e.g.*, Ex. 1023, 7:51-61 (disclosing that in plasma systems “the type of filter is a mere design choice” and “[t]he filter will **necessarily be designed to reflect the frequency of operation**”); Ex. 1013, 4-5 (disclosing two types of band-rejection filters, as shown in FIG. 2-9(E) and in FIG. 2-9(F)); 6 (disclosing that a notch filter is a type of band-rejection filter, specifically, a narrow-band rejection filter that can be implemented using the circuit shown in FIG. 2-9(E)); Ex. 1006, FIGS. 1 and 6 (disclosing that filter circuit 20, similar to FIG. 2-9(F) of Ex. 1013, is a narrow band rejection filter or a notch filter); Ex. 1057, 7:23-34 (disclosing that a narrow band rejection filter or a notch filter can be created

using different components/configurations); Ex. 1058, 1:64-2:1 (notch filter bandwidth modified based on Q factor.); *see below* Section IX.G (discussions that a person of ordinary skill in the art would have been motivated to configure the narrow band-rejection filter, e.g., its bandwidth, in the *Barber-Hirose* system to address the frequency spread of RF supply 235 in light of *Sill*.) Because *Barber* describes the use of a pulsed DC power supply and that its waveform would have determined the deposited film quality, a person of ordinary skill in the art would have been motivated to configure that filter as a narrow-band rejection filter to minimize the impact the filter would have on the pulsed DC waveform (i.e., would not have significantly degraded the pulsed DC waveform signal through the effect of filtering) while still protecting the DC power supply 230 from the specific RF frequency signals of the RF power supply 235. (Ex. 1016, 4:20-27 (disclosing an example of a notch filter or a band rejection filter that is “intended to attenuate the 13.56 MHz,” which “provides the required isolation”).)⁹

⁹ I refer to Exs. 1013, 1016, 1023 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

90. The use and benefits of filters in plasma systems and processes to block interference/current from one power supply from another power supply was known to a person of ordinary skill in the art at the time, and thus would have been in the mind of such a skilled person when considering *Barber's* system and processes. (See *e.g.*, Ex. 1014, 3, FIG. 1 (describing use of a filter coupled to a bipolar pulsed DC power source to “cut off interference” from a RF power source operating at 2 MHz); Ex. 1016, 3:53-63 (describing the use of a filter to isolate a 100 kHz power supply and a 13.56 MHz power supply in a plasma reactor so “the high frequency power [to] be largely prevented from reaching the low frequency power supply to prevent damage”); Ex. 1017, 16:20-29 (describing the use of a “low frequency band-reject filter 324 which blocks power at 2 MHz to [an] electrode”); Ex. 1018, 24:29-32 (describing use of a band rejection filter to reject a certain frequency); Ex. 1019, 6:60-62 (describing the use of “an RF blocking filter, when designed properly, can eliminate or reduce substantially RF current flowing to the DC source”), 7:40-42 (explaining the RF blocking filter “is constructed, in a conventional matter, of impedance such as capacitors and inductors, to block transmission of RF power” to a DC voltage source); Ex. 1020, 2:61-3:6 (describing use of a filter between an AC power supply and a DC power supply), 4:26-31 (describing use of “band eliminators

(B.E.) 108-110,” which “are band-rejection filters, and suitably set in such a manner that only radio frequency power having desirable frequencies are applied to the respective electrodes connected, so that the applied radio frequencies are not affect one another”); Ex. 1021, 7:66-8:2 (describing that “[t]he notch filter 60 comprises an inductor 62 connected in parallel to a capacitor 64, with the resulting notch filter designed to be in resonance with the RF drive frequency of approximately 13.56 MHz”); Ex. 1010, 6:40-41 (“The power supply 20 is preferably connected to the cathode assembly 17 [which includes target 16] through an RF filter 22.”).)¹⁰

91. In addition as I mentioned above, a person of ordinary skill in the art would have had additional reasons to contemplate and implement a narrow band rejection filter in *Barber*’s system in light of *Hirose* and the knowledge of such a person at the time. For instance, such a skilled person would have understood at the time that where a DC power supply (like that described by *Barber*) is used in a system with an RF power source, a filter would help prevent the RF power from the

¹⁰ I refer to Exs. 1014, 1016-1021 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

RF power supply from damaging the DC power supply, whether internal or external to the DC power supply. This understanding is consistent with the known configurations of pulse DC power supplies that is exemplified in the '657 patent. For instance, the '657 patent does not limit the pulse DC power supply to any particular type, but it does identify an example of such a power supply. (Ex. 1001, claim 2, 5:46-48 (“[p]ulsed DC power supply 14 can be any pulsed DC power supply, for example an AE Pinnacle plus 10K by Advanced Energy, Inc.”).) A person of ordinary skill in the art would have known at the time that use of such a power supply (and others like it) in a system with an RF power supply required a filter in order to prevent damage to the DC power supply.

92. For instance, in 1993, the same manufacturer of the pulse DC power supply that is exemplified in the '657 patent (Advanced Energy) informed those skilled in the art of the need to include a filter at the output of a DC power supply when such power supplies were used in a system with an RF power supply. (Ex. 1025, 23 (“An RF filter must be placed between the dc output and the chamber *because 13.56 MHZ can damage* the typical dc magnetron power supply”).)

DC Sputtering with RF Bias



WARNING! You must place an ac blocking filter in series with the output of the dc power supply if your system uses a dc power supply in combination with an ac power supply that has an output frequency greater than 50 kHz.

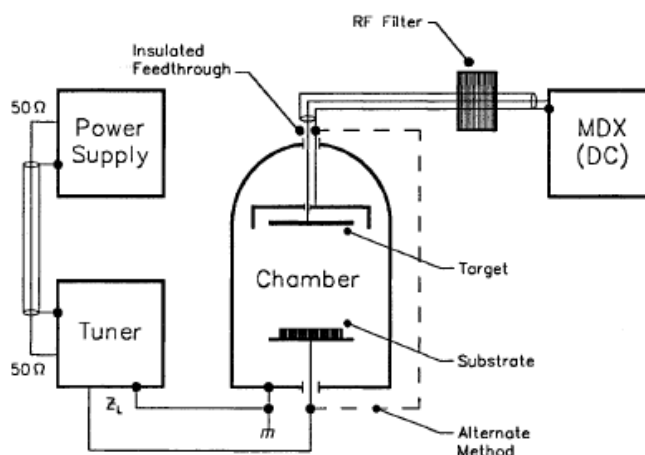


Figure 1- 5. Typical configuration for dc sputtering with RF bias.

(Ex. 1025, 23 (top), 24 (Figure 1-5). (See also my discussions above in Section V.D.)

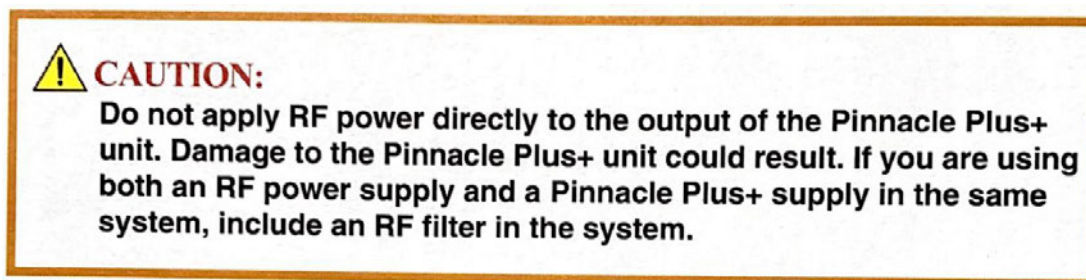
93. The same manufacture continued its cautions to those skilled in the art in the early and mid-2000s that use of such DC power supplies in a system with an RF power source required use of a filter.

94. As I explained above in Section V.D, Advanced Energy (a manufacturer that a person of ordinary skill in the art would have been familiar with)

provided guidance about using RF filters with DC power supplies in sputtering systems in April 2001, regarding its Pinnacle 20kW power supply, and the Pinnacle Plus+ 10kW (a pulsed DC power supply) supply in June 2002. (Ex. 1062, 134 ((April 2001) “CAUTION: Do not apply RF power directly to the output of the Pinnacle unit. **Damage** to the Pinnacle unit could result. *If you are using both an RF power supply and a Pinnacle supply in the same system, include an RF filter in the system*”); Ex. 1067, 141 (June 2002) “CAUTION: Do not apply RF power directly to the output of the Pinnacle Plus+ unit. **Damage** to the Pinnacle Plus+ unit could result. *If you are using both an RF power supply and a Pinnacle Plus+ supply in the same system, include an RF filter in the system*”).) (See also Ex. 1026, 116 (“CAUTION: Do not apply RF power directly to the output of the Pinnacle unit. Damage to the Pinnacle unit could result. *If you are using both an RF power supply and a Pinnacle supply in the same system, include an RF filter in the system*”).)

95. Again, in 2005, the same manufacturer continued its guidance for the PinnaclePlus 10kW that if “using both an RF power supply and a Pinnacle Plus+

supply in the same system, include an RF filter in the system.” (Ex. 1024, 151 (excerpt below).)¹¹



96. Recall that the '657 patent identifies a Pinnacle Plus 10K as an example of a type of DC power supply that can be used to provide the pulse DC voltage signals in its disclosed system, which would have been previously available for the inventors to identify it in their specification of the '657 patent. (Ex. 1001, 5:46-50

¹¹ I refer to Exs. 1024-1026, 1062, 1065, and 1067 to demonstrate the state of the art known to a person of ordinary skill in the art at the time of the alleged invention. As I explained above in Section V.D, although Ex. 1024 is dated in 2005, a person of ordinary skill in the art would have understood that the cautions and related concepts disclosed in Ex. 1024 are consistent with the knowledge of a person of ordinary skill in the art concerning such power supplies at the time of the alleged invention.

(“Pulsed DC power supply 14 can be any pulsed DC power supply, for example an AE Pinnacle Plus 10K by Advanced Energy, Inc.”).) A Pinnacle Plus data sheet shows specifications similar to that described in the ’657 patent for that unit. (Ex. 1065, 2 (describing a “10kW” power, a frequency range (up to 350 kHz), reverse voltage (“10% of the operating voltage”), and reverse time (“400 nsec to 5μsec (variable)”)); Ex. 1001, 5:46-55 (describing that with the disclosed “Pinnacle plus 10K” supply, “up to 10kW of pulsed DC power can be supplied at a frequency of between 0 and 350 KHz” and “[t]he reverse voltage is 10% of the negative target voltage”, and that “the reverse time on this embodiment of power supply 14 can be adjusted between 0 and 5 μs”).) This information is consistent with how a person of ordinary skill in the art would have understood the Pinnacle Plus power source identified in the ’657 patent (e.g., that the exemplified system was a known pulse DC power supply having such characteristics).

97. Like the ’657 patent, *Barber* does not limit the type of pulse DC power supply to use in its system. Thus, a person of ordinary skill in the art would have had reason to consider known pulse DC power supplies when contemplating the implementation and configuration of *Barber*’s system. Likewise, such a skilled person would have considered and appreciated the known design concepts and

cautions that come with use of the use of a pulse DC power supply in a plasma system where an RF power supply was being used, like that described by *Barber*.

98. For example, a person of ordinary skill in the art would have had reasons to consider the designs or availability of known DC power supplies at the time, and would have likewise had reason to consider features associated with pulse DC power supplies from known manufacturers at the time, including Advanced Energy, Inc. (Ex. 1001, 5:46-48; *see also* Ex. 1008, 1 (“The pulsed DC power was applied to the [target] using a DC power supply, model MDX-10 by Advanced Energy Industries (AEI), pulsed generator Sparcle-V (AEI), and also by a PinnaclePlus unit (AEI)”); Ex. 1011, 6:7-11; Ex. 1048, 2 (disclosing use of “an Advanced Energy SPARC-LE unit, which was connected in series with the existing Advanced Energy MDX” to provide pulsed DC power for reactive sputtering), 3 (Table 1).) And in doing so, such a person of ordinary skill in the art would have been aware of the design constraints and cautions that were known to come with use of such supplies (or similar ones) in a system that also uses an RF power supply, like that described by *Barber*. With such knowledge, as I explained above, and motivated by *Barber*’s concern to provide a stable waveform for deposition, a person of ordinary skill in the art would have reasons to include a narrow band rejection filter

between the output of pulse DC power supply 230 and the target 260 to prevent the RF power from the RF power supply 235 from damaging the DC power supply 230, while also reducing interference for producing a stable waveform for efficient deposition. Indeed, a person of ordinary skill in the art would have recognized from *Hirose*'s disclosures that that use of a narrow band rejection filter provides a stable waveform. (See Ex. 1006, Fig. 2 (waveform without filter), Fig. 3 (waveform with filter), 3:4-10, 4:57-61.) Providing these features while protecting the pulse DC power supply 230 would have been consistent with achieving *Barber*'s goal of providing a stable waveform so as to achieve optimal film deposition. (Ex. 1005, 7:59-60 (“[t]he current and/or voltage can be monitored and frequency adjusted to achieve a stable waveform.”), 8:66-9:2 (“The voltage-current of the magnetron should be monitored and if necessary, the frequency should be adjusted to achieve a stable waveform”).) And as I explained above, a person of ordinary skill in the art would have found that configuring such a filter in the *Barber-Hirose* combined system as a narrow band rejection filter would have likewise benefited the system, especially where the RF power supply was selected to provide power at a commonly used frequency known to damage such DC power supplies (e.g., 13.56 MHz). (Ex. 1025, 23.)

99. Therefore, in my opinion, a person of ordinary skill in the art would have been motivated by the benefits of using a narrow band rejection filter between the pulsed DC power supply 230 and the target electrode 260 in *Barber*'s system to block the frequency signals of RF power supply 235. (*See also* Section V.) Such an implementation would have been achieved through use of known circuit component, design, and relevant engineering skills available to such a skilled person at the time. In fact, a person of ordinary skill in the art would have understood and appreciated that the above-described combination would have involved known technologies (e.g., the known use of a pulsed DC power supplies and a RF power supply in a plasma system like that described in *Barber* and a narrow band-rejection filter that blocks a local power supply from a remote power supply as described and/or suggested in *Hirose* and the knowledge of a person of ordinary skill in the art, as exemplified by the state of the art documentation I referenced above) according to known processes and techniques (e.g., known circuit design and relevant engineering skills to implement a narrow band rejection filter in such a plasma system) that would have resulted in a system and process that provides a pulsed DC power supply 230 that produces a DC bias through a narrow band-rejection filter

such that the voltage of the target in *Barber*'s alternates between positive and negative voltages without interference from the RF power supply 235.

100. Accordingly, for the reasons I discuss above (*see also* my discussions in Sections V, VII, and IX.A.(c)(1)), a person of ordinary skill in the art would have been motivated to modify *Barber*'s system as I explained above, and as a result the *Barber-Hirose* combination that I discussed above discloses and/or suggests "providing pulsed DC power to the target through a narrow band rejection filter such that the voltage on the target alternates between positive and negative voltages."

d) Claim 2[d] "providing an RF bias that corresponds to the narrow band rejection filter to the substrate; and"

101. In my opinion, *Barber* in view of *Hirose* discloses and/or suggests this limitation for reasons similar to those that I explained above for claim elements 2[a] and 2[c]. For example, I discuss above how *Barber* discloses "RF power supply 235 applies a bias voltage to the substrate platen 115" (Ex. 1005, 6:29-31) and that "RF bias is applied to the substrate to control tensile stress" of the deposited film (*id.*, 9:12). I also discussed above how and why a person of ordinary skill in the art would have modified *Barber* to include a narrow-band rejection filter that blocks the frequency of the RF power supply. (*See* my discussions in Section IX.A.1(c).) Accordingly, for the reasons disclosed here and in Sections IX.A.1(a) and IX.A.1(c),

a person of ordinary skill in the art would have been motivated to configure the modified *Barber* system and process such that RF power supply 235 would provide an RF bias to the substrate, where the RF bias that corresponds to the narrow band rejection filter to protect the DC power supply 230 from damage while also assisting in providing as stable waveform. Accordingly, for those same reasons, the *Barber-Hirose* combination discloses and/or suggests the claimed “providing an RF bias that corresponds to the narrow band rejection filter to the substrate.”

e) Claim 2[e] “providing a magnetic field to the target;”

102. In my opinion, *Barber* discloses using a rotating magnet assembly 280 to “produce a magnetic field to penetrate the target material 260 and form an arc over its surface facing the substrate 110,” where “[t]he magnetic field generated across target 260 helps to confine free electrons near the surface of the target.” (Ex. 1005, 6:17-27, 8:66-9:2.) Thus, a person of ordinary skill in the art would have understood that *Barber* discloses “providing a magnetic field to the target,” which such a person would have recognized would have been implemented in the combined *Barber-Hirose* system and process for the reasons I discussed above. (See my discussions in Section IX.A.1(c).) Thus, in my opinion, the *Barber-Hirose* combination that I discuss above for the earlier elements of claim 2 discloses and/or suggests this limitation.

- f) **Claim 2[f] “wherein an oxide material is deposited on the substrate, and the insulating film is formed by reactive sputtering in a mode between a metallic mode and a poison mode.”**

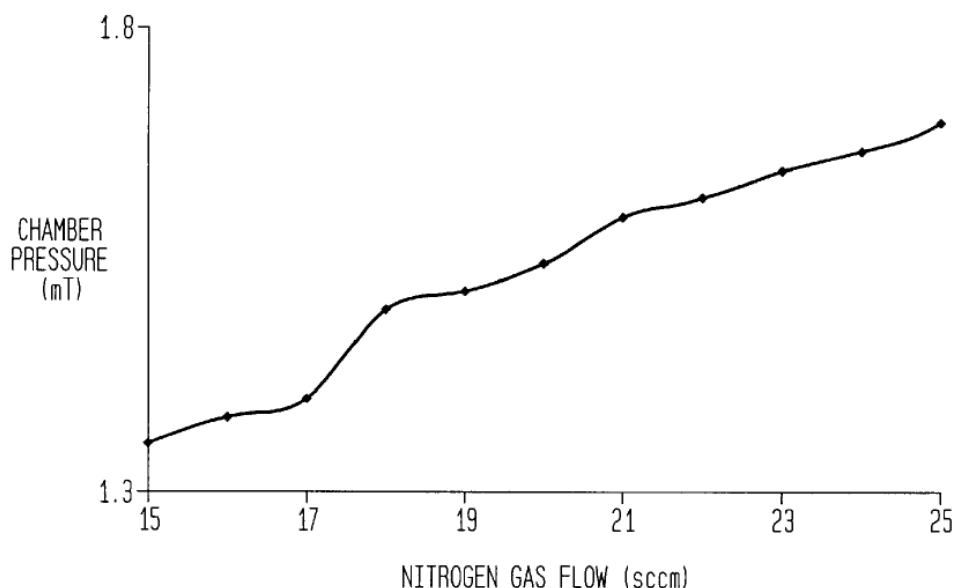
103. I explained above how *Barber* discloses depositing a silicon dioxide layer (the claimed “oxide material”) on the substrate, and then forming on that oxide material the aluminum nitride (the claimed “insulating film”) is formed thereon by reactive sputtering at a reactive gas flow rate that corresponds substantially to the cross-over point (“a mode between a metallic mode and a poison mode”). (See my discussions in Section IX.A.1(a).)

104. *Barber* also discloses with reference to Figure 1 depositing an oxide material layer, such as silicon dioxide (the claimed “oxide material”), on a substrate 110, and then deposit a piezoelectric material, such as aluminum nitride, which is also an insulator (the claimed “insulating film”). (Ex. 1005, 3:44-55 (disclosing forming piezoelectric layer 120 on layers 125 that are deposited on substrate 110), 3:56-57 (disclosing that piezoelectric layer 120 is an aluminum nitride layer), 4:24-26 (disclosing that layers 125 are insulating layers) 7:65-8:5 (disclosing that insulating layers 125 are made of silicon dioxide films, an oxide material); *see also id.*, Abstract.)

105. In addition, *Barber's* AlN deposition process discloses and/or suggests “the insulating film is formed by reactive sputtering in a mode between a metallic mode and a poison mode” in three ways as I discussed below.

106. **In the first way that *Barber* discloses this limitation,** *Barber* in the context of Figure 3 describes depositing an AlN film by performing a reactive sputtering process *in a metallic mode and such process continued into a poison mode*. Because such a reactive sputtering process extends continuously from the metallic mode to the poison mode, *Barber* discloses forming an insulating film by reactive sputtering “in a mode **between a metallic mode and a poison mode.**” For instance, *Barber* discloses depositing an AlN film first at a low reactive gas flow rate and then at a high flow rate to obtain a “cross-over curve.”

FIG. 3



(*Id.*, FIG. 3.) For example, *Barber* discloses that:

At low flow of reactive gas (to the left of the graph), all the nitrogen is being reacted with **metallic** aluminum so introduction of small amounts of nitrogen does not increase the chamber pressure. As the gas flow is increased, gas is present in the chamber that cannot react with metal, and the unreacted gas causes an increase in pressure in the chamber. At a very high flow rate (to the right of the graph), the target material becomes fully [sic] “**poisoned**” or coated with the reaction product (AlN) such that any further gas admitted into the chamber will not

react with target material and will directly contribute to a pressure increase.

(*Id.*, 6:51-62, 8:45-48 (depositing AlN on a monitor wafer to obtain the “cross-over curve”).) *Barber* discloses that this “cross-over curve” as shown in Figure 3 above, describes:

a behavior of a **metallic** target fully consuming reactive gas to the behavior of a fully **poisoned** target.”

(*Id.*, 6:63-67.) Thus, the reactive sputtering process disclosed in *Barber* with reference to Figure 3 necessarily includes a mode between the metallic mode and the poison mode. Therefore, in my opinion, *Barber* discloses “the insulating film is formed by reactive sputtering in a mode between a metallic mode and a poison mode” in this first way.

107. In my opinion, *Barber* discloses this limitation in a **second way** with reference to Figure 5. *Barber* discloses reactive sputtering AlN by “maintain[ing] at a rate corresponding substantially to, but greater than, the flow rate at the cross-over point” to “optimiz[e] the deposition conditions.” (Ex. 1005, 7:19-25, 7:36-38 (“Maintaining the flow rate near the cross-over point is effective in optimizing the deposition conditions”), FIG. 5; *id.*, 6:32-37 (“A high-quality film may be achieved

with this apparatus, and various parameters can be applied to optimize the processing conditions. Applicants have discovered a method comprising optimization of the reaction parameters to achieve a high-deposition rate and correct index of refraction.”), 7:1-8:12.)

108. *Barber* explains that the “cross-over point” is “defined as the point at which a pressure increase in the chamber **210** becomes non-linear with the flow of reactive gases, and this point reflects a **reactive gas flow rate that strongly effects a reaction with the target material.**” (*Id.*, 6:37-42.) Near that point, “**target will continue to be conductive** while depositing a coating on the substrate, and **poisoning of the target itself is controlled.**” (*Id.*, 7:34-40.) In my opinion, because this “controlled” poisoning indicates a mode where the **poisoned** target surface is continuously sputtered/removed to expose the **metallic/conductive** surface for reactive sputtering (i.e., depositing an AlN film) in such mode, a person of ordinary skill in the art would have understood that *Barber* discloses reactive sputtering AlN “in a mode between a metallic mode and a poison mode.” (Ex. 1008, 3-4 (“In addition to these stable [oxide/poison and metallic] modes, the target...can be maintained also in an intermediate mode...by employing a closed-loop control

system”), Ex. 1059, 3-4 (disclosing that controlled or partial poisoning is “between the metallic and poisoned regimes”).)

109. I have been asked to consider a scenario in which *Barber* does not expressly disclose controlling the reactive sputtering process at or closely above/below the “cross-over point.” Under that scenario, a person of ordinary skill in the art would have been motivated to implement such feature. Therefore, in my opinion, *Barber* discloses and/or suggests reactive sputtering AlN (“insulating film”) “in a mode between a metallic mode and a poison mode” in a **third way**. In particular, *Barber* discloses depositing “near the cross-over point,” for example, at a flow rate corresponding substantially to, but 3 sccm greater than, the cross-over point. (Ex. 1005, 7:19-23, 7:34-40, FIG. 5.) *Barber* additionally discloses adjusting the flow rate to “improve the deposition rate” (*id.*, 7:40-50, 7:51-8:9) and the “deposition rate is inversely proportional to the amount of reactive gas” (*id.*, 7:44-45).

110. It is my opinion that a person of ordinary skill in the art would have been motivated to reduce the flow rate (i.e., towards the cross-over point) to improve deposition rate, consistent with *Barber*’s goal of achieving high-deposition rate. (Ex. 1005, 6:32-37, 7:40-42, 7:51-8:9.) Additionally, because *Barber* explains that

depositing at 3 sccm below the “cross-over point” produces metallic films (*id.*, 7:23-29), a person of ordinary skill in the art would have been motivated to adjust the gas flow to be **within 3 sccm below/above the “cross-over point,” including at such point**, in order to adjust the deposition rate while depositing AlN. In my opinion, A person of ordinary skill in the art would have had a reasonable expectation of success implementing such feature because *Barber* itself already discloses the capability of controlling flow rate to achieve high-deposition rate and the ability to attaining the cross-over point and operating near such point by adjusting the process parameters discussed in the context of Figure 5. (FIG. 5, 7:1-8:9, 8:59-63.) Accordingly, *Barber* discloses and/or suggests “the insulating film is formed by reactive sputtering in a mode between a metallic mode and a poison mode.”

111. I have been asked to consider a scenario where claim 2[f] is read to require that the “insulating film” is formed by the “oxide material.” In that scenario, a person of ordinary skill in the art would have been motivated to implement such feature.

112. As I discussed below in claim 3 (see below for my discussions in Section IX.A.2), a person of ordinary skill in the art would have been motivated to use an aluminum target and an oxygen-containing process gas to form an insulating

film in the combined *Barber-Hirose* system and process. And as I explained, such process forms an insulating film, namely, aluminum oxide, that is useful for various applications. For example, as I discussed below, a person of ordinary skill in the art would have understood that aluminum oxide was useful for forming an insulator used in various semiconductor devices, such as memory devices, and was known to be useful for forming a barrier layer in a flat panel display circuit. (Ex. 1050, Abstract (disclosing the use of aluminum oxide (Al_2O_3) as an insulator in a memory device); Ex. 1049, Abstract (disclosing the use of aluminum oxide as a barrier player in flat panel display devices).) (See below for my discussions in Section IX.A.2.)

113. As I also discussed below in claim 3, a person of ordinary skill in the art would have found it beneficial to deposit the aluminum oxide (insulating) film by “reactive sputtering in a mode between a metallic mode and a poison mode” because it would have optimized deposition conditions, for depositing insulating films, as I discussed above. This is true particularly given that *Barber* also aims to provide high-quality insulating films and such processes were known by a person of ordinary skill in the art. (Ex. 1005, 7:65-67 (“optimizing the processing conditions for depositing the **insulating** layers”), Ex. 1008, 3-4 (target maintained “in an intermediate mode” for **oxide** sputtering), Ex. 1059, 3-4 (depositing **aluminum**

oxide in “between the metallic and poisoned regimes”).) Therefore, under this scenario (requiring the “insulating film” is formed by the “oxide material”), *Barber* discloses and/or suggests “an oxide material is deposited on the substrate, and the insulating film is formed by reactive sputtering in a mode between a metallic mode and a poison mode” because the aluminum oxide is “an oxide material” that is deposited on the substrate in *Barber*’s modified process/system, and the aluminum oxide is also “an insulating film” that is formed “by reactive sputtering in a mode between a metallic mode and a poison mode” according to *Barber*’s modified process as I discussed above.

114. Beyond the fact that *Barber* uses the same phrases, i.e., metallic mode and poison mode, as the ’657 patent to describe reactive sputtering processes, *Barber*’s descriptions of “metallic mode” and “poison mode” in its disclosure are consistent with those of the ’657 patent. For example, *Barber*’s metallic mode is characterized by a low reactive-gas flow, which results a substantially metallic target and deposited film during reactive sputtering. (Ex. 1005, 6:51-55 (“Referring to FIG. 3, the characteristic pressure-flow curve shows two asymptotic regimes. At low flow of reactive gas (to the left of the graph), **all the nitrogen is being reacted with metallic aluminum so introduction of small amounts of nitrogen** does not

increase the chamber pressure”), 6:63-67 (“The plot of pressure versus reactive gas flow (as in FIGS. 3 and 4) shows a ‘cross-over curve’ from the **behavior of a metallic target fully consuming reactive gas** to the behavior of a fully poisoned target showing increasing pressure with further admission of reactive gas”), 7:25-26 (“Immediately below (less than 3 sccm) the cross-over point will result in **a metallic film.**”).) *Barber*’s descriptions of “metallic mode,” such as those discussed above, are consistent with the “metallic mode” described in the ’657 patent. For example, the ’657 patent discloses that:

Reactive sputtering from a metal or metallic alloy target **12** can be characterized by two modes of operation. **In the first mode, which is sometimes referred to as the ‘metallic mode’ the surface of target 12 is substantially metallic. This mode is characterized by a small addition of reactive gas** to the inert gas flow of apparatus **10** as well as a higher impedance magnetron discharge. It is also characterized by incomplete oxidation of film deposited on substrate **16** and therefore higher index films. As the proportion of reactive to inert gas is increased, the sputter voltage at target **12** begins to fall at constant power.

(Ex. 1001, 11:27-37; *see also id.*, 11:51-57, 17:6-15.) As to the poison mode, *Barber*'s poison mode is characterized by a higher reactive-gas flow, resulting a formation of compound (e.g., AlN or Al₂O₃) on the target surface (e.g., Al), where—depending on the reactive gas flow rate—the compound may be removed/sputtered as quickly as it is formed (not necessarily exposing the metallic target surface as it may depend on whether the target surface has a compound coating at the start of the sputtering as a person of ordinary skill in the art would have understood) or the compound may form faster than being removed/sputtered (and having a reduced sputtering/deposition rate). For example, *Barber* discloses that:

“As the gas flow is increased, gas is present in the chamber that cannot react with metal, and the unreacted gas causes an increase in pressure in the chamber. At a very high flow rate (to the right of the graph), **the target material becomes filly [sic] “poisoned” or coated with the reaction product (AlN)** such that any further gas admitted into the chamber will not react with target material and will directly contribute to a pressure increase. The plot of pressure versus reactive gas flow (as in FIGS. 3 and 4) shows a “cross-over curve” from the behavior of a metallic target fully consuming reactive gas to the

behavior of a fully poisoned target showing increasing pressure with further admission of reactive gas”

(Ex. 1005, 6:55-67.) *Barber* also explains that:

The noble gas is introduced into the sputtering chamber, and then the reactive gas is added so that it reacts with a portion of the target material. **The reactive gas is introduced incrementally** into the sputtering chamber so that the flow rate of the reactive gas is maintained at a rate corresponding substantially to, but greater than, the flow rate at the cross-over point. A film is thus deposited on the substrate as the chamber is maintained just above the cross-over point. Immediately below (less than 3 sccm) the cross-over point will result in a metallic film. **Above the cross-over point, the deposition rate decreases for at least 20 sccm and until the target is totally poisoned, becomes an insulator, and a plasma can no longer be maintained.**

As the deposition process is carried out, a pulsed DC voltage is applied across the pair of electrodes (the target and anode ring) that are positioned within the sputtering chamber so that ions from the noble gas impinge upon the target material and eject atoms therefrom. Freed atoms of the target material react mostly at the target with the

reactive gas to form a coating on the substrate. Maintaining the flow rate near the cross-over point is effective in optimizing the deposition conditions; the target will continue to be conductive while depositing a coating on the substrate, and **poisoning of the target** itself is controlled. Additionally, various other aspects of the process may be managed to improve the deposition rate and overall quality of the deposited films. For example, the relevant parameters of the process may be monitored and adjusted, considering that **the deposition rate is inversely proportional to the amount of reactive gas**, the power supply pulse width, and the deposition pressure, and is directly proportional to the power. The deposition rate is unaffected by the power supply frequency. The index of refraction is inversely proportional to both the amount of reactive gas and the power supply pulse width.

(*Id.*, 7:17-50.) *Barber*'s descriptions of poison mode, such as those discussed above, are consistent with the "poison mode" described in the '657 patent. For example, the '657 discloses that:

At slightly higher oxygen flow during deposition, the oxide layer on target **12** forms a continuous layer and the voltage of target **12** during deposition falls rapidly to the range of about 190 to about 270 Volts, indicating complete

coverage of the surface of target **12** with an oxide that is at least as thick as the material removed during one scan of the magnetron. Under this condition, **the rate of oxide formation on the surface of target 12 equals or exceeds the rate of sputter removal of the surface of target 12 by the moving magnetron 20. This condition is sometimes referred to as the ‘poisoned mode’.**

(Ex. 1001, 11:66-12:9; *see also id.*, 10:44-50 (“The ratio of O₂/Ar gas flow can be set at a value to ensure that target **12** is operating within a **poison mode**. The poison mode is defined as the ratio where the oxide is etched from the surface of target **12** as fast as the oxide layer is formed.”), 13:7-8, 17:7-15). A person of ordinary skill in the art would have recognized that such features, as claimed, would have been implemented in the combined *Barber-Hirose* system and process for the reasons indicated above, and the combination discloses/suggests this limitation. (Section IX.A.1(c).)

2. Claim 3

- a) **“The method of claim 2 wherein the target is a metallic target and the process gas includes oxygen.”**

115. In my opinion, *Barber* discloses and/or suggests “the target is a metallic target and the process gas includes oxygen.” For example, *Barber* discloses a system (with reference to Figure 2) that provides various process gases, including reactive

gases, e.g., nitrogen and oxygen, etc., and noble gas, e.g., argon, etc. for film deposition. (Ex. 1005, 6:8-13.) *Barber* also describes examples using either an aluminum target with nitrogen or a silicon target with oxygen to deposit insulating films. (Ex. 1005, 6:42-50, 8:44-10:11.) While *Barber* does not expressly disclose using an aluminum target and an oxygen-containing process gas to form an insulating film, in my opinion, a person of ordinary skill in the art would have been motivated to implement such a process in the combined *Barber-Hirose* system and process.

116. A person of ordinary skill in the art would have been motivated to implement such a film deposition process with various types of metallic targets (such as aluminum) and an oxygen-based process gas because it would have added to the versatility of *Barber*'s reactor system. *Barber* does not limit its materials or system processes, but rather expressly provides for variations in the types of target materials and gases that can be implemented. (Ex. 1005, 1:18-20 ("The invention is particularly useful in fabricating...semiconductor devices"), 6:8-13, 6:42-50.) A person of ordinary skill in the art would have had reason from the disclosures and suggestions of *Barber* and the knowledge of such processes at the time to use a metallic target, such as aluminum, with an oxygen-based process gas for its

deposition processes depending on the application of the system (e.g., the type of substrate being formed). For example, a person of ordinary skill in the art would have appreciated that using aluminum (which is disclosed by *Barber*) with an oxygen-based process gas (also disclosed), would have produced aluminum oxide films in *Barber*'s system/process. (Ex. 1007, 8:50-51 (disclosing that "a practical example of a reactive sputtering system" is to use "Al to produce Al_2O_3 "); Ex. 1060, 4:1-17 (disclosing that in DC reactive sputtering aluminum targets may be used and "suitable coatings include, e.g., oxides such as aluminum oxide... and nitrides..."))¹² A person of ordinary skill in the art would have understood at the time that aluminum oxide was useful for forming an insulator used in various semiconductor devices, such as memory devices, and was known to be useful for forming a barrier layer in a flat panel display circuit. (Ex. 1050, Abstract (disclosing the use of aluminum oxide (Al_2O_3) as an insulator in a memory device); Ex. 1049, Abstract (disclosing the use of aluminum oxide as a barrier player in flat panel display devices).) Thus,

¹² I refer to Exhibits 1007, 1046, and 1060 to demonstrate the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

a person of ordinary skill in the art would have found it beneficial to use a metallic target (e.g., aluminum) with an oxygen-based process gas in the combined *Barber-Hirose* system and process as it would have improved and expanded the uses and applications of *Barber's* modified process and system, and also provided the capability to produce aluminum oxide, which was well known as useful in various aspects of semiconductor manufacturing processes. Such an implementation would have been consistent with the applications and uses of *Barber's* invention. (Ex. 1005, 1:17-19 (“[t]he invention is particularly useful in fabricating...semiconductor devices.”).)

117. Furthermore, in my opinion, a person of ordinary skill in the art would have found it beneficial to deposit the aluminum oxide (insulating) film by “reactive sputtering in a mode between a metallic mode and a poison mode” because it would have optimized deposition conditions, for depositing insulating films, as I discussed above in claim 2. (Section IX.A.1(f) (claim 2(f)).) This is true particularly because that *Barber* also aims to provide high-quality insulating films and also because that processes for depositing aluminum oxide using reactive sputtering were known by a person of ordinary skill in the art at the time of the alleged invention. (Ex. 1005, 7:65-67 (“optimizing the processing conditions for depositing the **insulating**

layers”), Ex. 1008, 3-4 (target maintained “in an intermediate mode” for **oxide** sputtering), Ex. 1059, 3-4 (depositing **aluminum oxide** in “between the metallic and poisoned regimes”); Ex. 1060, 4:1-17 (disclosing that in DC reactive sputtering aluminum targets may be used and “suitable coatings include, e.g., oxides such as aluminum oxide... and nitrides...”)).

118. A person of ordinary skill in the art would have understood and appreciated that the above-described modification would have involved known technologies (e.g., a known use of reactive sputtering technology and known materials and gases like that described in *Barber*) according to known processes (e.g., known use of an oxygen process gas to form an oxide layer) that would have resulted in a foreseeable system and process that provides the use of an aluminum target with oxygen to form an aluminum oxide film. Moreover, such a skilled person, with their knowledge and capabilities, would have reasonably expected the above modification to operate correctly and without detracting from *Barber*’s aim to provide quality deposition films and would have had the capability to address any design issues associated with such an implementation. Accordingly, the *Barber-Hirose* modified system and process above discloses and/or suggests that “the target is a metallic target and the process gas includes oxygen.”

3. Claim 4

- a) “The method of claim 2 wherein the target is a metallic target and the process gas includes one or more of a set consisting of N₂, NH₃, CO, NO, CO₂, halide containing gasses.”**

119. In my opinion, *Barber* discloses that the target is a metallic target and the process gas includes one or more of a set consisting of N₂, NH₃, CO, NO, CO₂, halide containing gasses. For example, I explained above for claim element 2[a] that *Barber* discloses using an aluminum target with a nitrogen-containing (N₂) process gas to form an AlN layer. (Ex. 1005, 6:51-67; see my discussions in Section IX.A.1(a).) Thus, in my opinion, *Barber* discloses this limitation, which a person of ordinary skill in the art would have implemented in the *Barber-Hirose* modified system/process for the reasons I explained above for claim 2. (See my discussions above for claim 1 in Section IX.A.1.)

4. Claim 6

- a) “The method of claim 2 wherein the magnetic field is provided by a moving magnetron.”**

120. In my opinion, *Barber* discloses the magnetic field is provided by a moving magnetron. For example, *Barber* discloses using a rotating magnetron to provide a magnetic field to the target. (Ex. 1005, 5:67-6:3 (disclosing with reference to Figure 2 “a **rotating magnetron** sputtering apparatus”).) *Barber* further discloses

that such magnetron (rotating magnet assembly 280) “produce a magnetic field to penetrate the target material 260 and form an arc over its surface facing the substrate 110,” where “[t]he magnetic field generated across target 260 helps to confine free electrons near the surface of the target,” where rotating motor 300 causes rotating magnet assembly 280 to rotate. (*Id.*, 6:17-27.) Thus, in my opinion, *Barber* discloses this limitation, which a person of ordinary skill in the art would have implemented in the *Barber-Hirose* modified system/process for the reasons I explained for claim 2. (See my discussions above for claim 2 in Section IX.A.1.)

5. Claim 8

a) “The method of claim 2 wherein the process gas includes a mixture of Oxygen and Argon.”

121. In my opinion, *Barber* discloses and/or suggests this limitation. As I explained in Section IX.A.2 (for claim 3) above, a person of ordinary skill in the art would have been motivated to use an aluminum target with an oxygen-containing process gas to form an aluminum oxide film. (Section IX.A.1(2).) Furthermore, a person of ordinary skill in the art would have also been motivated to introduce a noble gas, such as argon, into the process chamber along with oxygen, as the noble gas, once ionized, would have facilitated sputtering of the target by “imping[ing] upon the target material and eject[ing] atoms therefrom.” (Ex. 1005, 7:30-36.)

Additionally, a person of ordinary skill in the art would have been motivated to use argon as the noble gas in the sputtering process as *Barber* already discloses using it to sputter an aluminum target (Ex. 1005, 8:49-51) and it was known to be a relatively inexpensive and commonly-used noble gas. (Ex. 1032, 7.) Given that both oxygen and argon would have been introduced in the process chamber of *Barber*, a person of ordinary skill in the art would have understood that the “process gas” in *Barber*’s process would have included a mixture of oxygen and argon. Thus, in my opinion, *Barber* discloses this limitation, which a person of ordinary skill in the art would have implemented in the *Barber-Hirose* modified system/process for the reasons I explained for claim 2. (See my discussions above for claim 2 in Section IX.A.1.)

6. Claim 10

a) “The method of claim 2 wherein the process gas further includes nitrogen.”

122. For the reasons I explained in Section IX.A.3 (claim 4), *Barber* (as modified in light of *Hirose*) discloses that the process gas further includes nitrogen. For instance, I explain how *Barber* discloses using an aluminum target with a nitrogen-containing (N₂) process gas to form an AlN layer. (Ex. 1005, 6:51-67; see my discussions above for claim 4 in Section IX.A.3.) Thus, in my opinion, *Barber* discloses this limitation, which a person of ordinary skill in the art would have

implemented in the *Barber-Hirose* modified system/process for the reasons I explained for claim 2.

7. Claim 11

- a) **“The method of claim 2 wherein providing pulsed DC power to a target includes providing pulsed DC power to a target which has an area larger than that of the substrate.”**

123. In my opinion, *Barber* discloses and/or suggests this limitation. For example, a person of ordinary skill in the art would have understood that, based on the drawing of Figure 2 in *Barber*, *Barber* discloses or suggests that the target has an area larger than the substrate. (Ex. 1005, FIG. 2 (showing target 260 larger than substrate 110).) In addition, a person of ordinary skill in the art would have understood that using a target that has an area that is larger than that of the substrate would have improved uniformity of the deposited film. (See *e.g.*, Ex. 1041, 11 (disclosing that “the target diameter is made larger than the wafer diameter to improve thickness uniformity” and “[a]s an example for 200-mm (8 in) wafers, the target diameter is typically 330 mm (14 in)”).) Thus, a person of ordinary skill in the art would have been motivated to provide a target area that is larger than that of the substrate, consistent with that disclosed or suggested in Figure 2 of *Barber*, to improve the film deposition uniformity. Thus, in my opinion, *Barber* discloses this

limitation, which a person of ordinary skill in the art would have implemented in the *Barber-Hirose* modified system/process for the reasons explained for claim 2. (Section IX.A.1.)

8. Claim 12

a) “The method of claim 2, further including uniformly sweeping the target with a magnetic field.”

124. In my opinion, *Barber* discloses this limitation. For example, *Barber* discloses “[a]s the [film deposition] process begins, the magnet rotation begins and is stabilized at a level sufficient to **achieve uniform target erosion.**” (Ex. 1005, 7:11-13.) As a person of ordinary skill in the art would have understood and consistent with *Barber*’s disclosure, the region where the target is exposed to the magnetic field is preferentially sputtered or eroded due to an increased ion concentration caused by the magnetic field. (Ex. 1005, 2:27-30 (“Magnetron sputtering systems are known in which magnetically-enhanced targets are used to **confine the plasma discharge along a particular path and enhance the flow of target material**”) 6:23-27 (“The magnetic field generated across target 260 helps to confine free electrons near the surface of the target. The **increased concentration of ions excited by these electrons at the target surface increases the efficiency of the sputtering process.**”).) Accordingly, given that the magnetic field provided by

the magnetron is able to achieve uniform target erosion, a person of ordinary skill in the art would have understood that *Barber* discloses “uniformly sweeping the target with a magnetic field,” which would have been implemented in the *Barber-Hirose* modified system/process for the reasons that I explained for claim 2. (See my discussions above for claim 2 in Section IX.A.1.)

9. Claim 21

a) “The method according to claim 2, wherein the RF frequency is about 2 MHz.”¹³

125. In my opinion, *Barber* in view of *Hirose* discloses and/or suggests this limitation. As I discussed above in Section IX.A.1(c)(2), a person of ordinary skill in the art would have been motivated to configure/tune the filter used in the above-discussed *Barber-Hirose* modified system/process to be a narrow-band rejection filter to block the specific frequency of the RF power supply. (See my discussions

¹³ Claim 2 does not recite an “RF frequency.” . However, for purposes of this proceeding, I was asked to assume that “RF frequency” relates to the “RF bias” provided in claim 2.

at Section IX.A.1(c)(2).) For similar reasons, a person of ordinary skill in the art would have been motivated to configure the RF supply 235 in *Barber*'s system to operate in accordance with the application of *Barber*'s process. Such a skilled person would have appreciated that Configuring RF source 235 to provide signals at 2 MHz would have been an option among known available options in the choice of design that a person of ordinary skill in the art at the time would have considered. In fact, *Hirose* discloses a "second high-frequency power supply 15" that operates at 2 MHz. (Ex. 1006, 4:42-45; Ex. 1010, 9:13-16 (disclosing a RF power supply "operat[ing] in the range of from about 0.2 to 80 MHz").) A person of ordinary skill in the art would have been aware of filter implementations that blocked 2 MHz RF power. (See e.g., Ex. 1014, 3, FIG. 1 (describing use of a filter coupled to a bipolar pulsed DC power source to "cut off interference" from a RF power source operating at 2 MHz); Ex. 1017, 16:20-29 (describing the use of a "low frequency band-reject filter 324 which blocks power at 2 MHz to [an] electrode").¹⁴ Further, in my opinion,

¹⁴ I refer to Exs. 1014 and 1017 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

a person of ordinary skill in the art would understand that the '657 patent does not provide any disclosure that would have led such a skilled person to understand the disclosure to provide any special or critical features associated with the use of a 2MHz frequency. (See *e.g.*, Ex. 1001, 5:57-60.) Thus, for reasons similar to that I explained above for claim 2, a person of ordinary skill in the art would have been motivated to implement an RF supply 235 having a common frequency and configure/tune the above-discussed filter implemented in the *Barber-Hirose* combined system/process to block the 2 MHz signal. (See my discussions at Section IX.A.1(c).) Accordingly, the *Barber-Hirose* combination discloses and/or suggests this limitation.

B. *Barber* in view of *Hirose* and *Dogheche* Discloses Claims 5 and 7

1. Claim 5

a) “The method of claim 2 wherein the target is a ceramic target.”

126. In my opinion, *Barber* in view of *Hirose* and *Dogheche* discloses and/or suggests this limitation. For example, while *Barber* discloses use of an aluminum target and a silicon target (Ex. 1005, 6:42-50), it does not expressly disclose the use of a ceramic target. However, a person of ordinary skill in the art would have been motivated to implement such a feature in *Barber*'s modified system in view of

Dogheche and the knowledge of such a skilled person at the time. (See my discussions above for claim 2 in Section IX.A.1.)

127. *Dogheche* discloses depositing an AlN film on a substrate using a reactive sputtering technique. (Ex. 1029, 2 (disclosing that “AlN films were deposited by...magnetron sputtering” using aluminum target with argon and nitrogen as process gasses).) A person of ordinary skill in the art would have appreciated that instead of using an aluminum target as disclosed in *Barber* (Ex. 1005, 6:42-46), *Dogheche* additionally discloses using an aluminum nitride (AlN) target in a nitrogen-containing process gas to deposit a high-quality AlN film. (*Id.* 2 (Table I), 4 (“aluminum nitride target.”).) Because AlN was known as a ceramic material, a person of ordinary skill in the art would have understood that *Dogheche* discloses use of a ceramic target in reactive sputtering processes. (Ex. 1047, 2 (disclosing that examples of ceramic materials include “AlN”).) *Dogheche* discloses that such film is “of increasing interest for a large number of applications in microelectronic field” and “is a promising material for integrated optics in the ultraviolet (UV) region, i.e., laser diode, detectors, and fabrication of high frequency surface acoustic wave (SAW) devices.” (Ex. 1029, 2-3.) Furthermore, *Dogheche* discloses that, by maintaining the temperature of the substrate, “the best texture [of

the AlN film] is obtained” in its process. (*Id.*) Based on the teachings and suggestions of *Barber* and *Dogheche*, a person of ordinary skill in the art would have been motivated to modify the *Barber-Hirose* reactive sputtering system such that the system includes using an AlN ceramic target for depositing high-quality AlN films.

128. A person of ordinary skill in the art would have appreciated and recognized the benefits of such an implementation because it would have expanded *Barber*’s system and process capability to use an additional target material to deposit high-quality AlN films, which were known to be of interest in a large number of applications in microelectronic field. Also, such a skilled person would have recognized that AlN targets could have also been used to deposit other useful films such as an aluminum oxynitride layer (AlN_xO_y). (Ex. 1046, 19:28-34, 19:34-39 (disclosing the deposited films are useful in the semiconductor fabrication and have various useful properties).)¹⁵ Thus, in my opinion, a person of ordinary skill in the art would have been motivated to include the AlN ceramic target so as to implement

¹⁵ I refer to Ex. 1046 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

such a process particularly when the process gas (i.e., argon and nitrogen) used in *Dogheche* to form the AlN film are already available for use in *Barber*'s chamber and that *Barber* discloses that "[t]he invention is particularly useful in fabricating acoustic resonators and semiconductor devices." (Ex. 1005, 1:17-19, 6:8-13.) Furthermore, a person of ordinary skill in the art would have appreciated that such an implementation would have been consistent with *Barber*'s goal to "achieve a maximum texture for the piezoelectric films [i.e., the deposited AlN film]" of high quality. (Ex. 1005, 5:10-12; 5:24-49.)

129. A person of ordinary skill in the art would have had the capability to implement such a modification and would have done so with a reasonable expectation that such an implementation would have performed as expected, especially since the use of a ceramic target in a system or process like that disclosed in *Barber* would have been known to such a skilled person at the time. (See Ex. 1046, 19:28-34 (disclosing use of an AlN target in reactive sputtering); Ex. 1060, 13-14 (claims 1 and 6, disclosing that in pulsed DC reactive sputtering a target material may be AlN).) (See also Ex. 1001, 2:25-28 (the '657 patent acknowledging that use of "ceramic targets" are known).) In fact, a person of ordinary skill in the art would have understood and appreciated that the above-described combination

would have involved a combination of known technologies (e.g., a known use of reactive sputtering technology like that described in *Barber* and a known use of an AlN ceramic target like that described in *Dogheche*) according to known processes (e.g., known use of reactive sputtering system to deposit films, e.g., a high-quality AlN by using an AlN ceramic target with certain known process gases) to provide a system that deposits high-quality films proven useful for various applications. Thus, for the reasons I discuss above and those I explain for claim 2, *Barber* in view of *Hirose* and *Dogheche* discloses and/or suggests this limitation. (See my discussions above in Section IX.A.1.)

2. Claim 7

a) “The method of claim 2 further including holding the temperature of the substrate substantially constant.”

130. In my opinion, *Barber* in view of *Hirose* and *Dogheche* discloses and/or suggests “holding the temperature of the substrate substantially constant.” As I discussed above, *Barber* discloses depositing an aluminum nitride (AlN) film on a substrate using a sputtering technique. (See my discussions above in Section IX.A.1(a); Ex. 1005, 6:42-46.) *Barber* also discloses that the substrate is placed on a substrate platen. (Ex. 1005, 6:14-17, FIG. 2.) Although *Barber* does not appear to expressly disclose “holding the temperature of the substrate substantially

constant,” a person of ordinary skill in the art would have been motivated to implement such a feature in the *Barber-Hirose* process in view of *Dogheche* and the knowledge of such a skilled person at the time.

131. As I explained above, *Dogheche* discloses depositing an AlN film on a substrate using a sputtering technique. (Ex. 1029, 2 (disclosing “AlN films were deposited by radio-frequency...magnetron sputtering on Si/SiO₂ substrates”).) *Dogheche* further discloses that the “substrate temperature was maintained at a low temperature of 400 °C” during deposition of the AlN film. (*Id.*) Based on the disclosures of *Barber* and *Dogheche*, a person of ordinary skill in the art would have been motivated to modify the reactive sputtering process similar to as disclosed in *Barber* such that the process holds the substrate temperature substantially constant at an optimal film deposition temperature, such as 400 °C.

132. A person of ordinary skill in the art would have found it beneficial to control the temperature of the substrate, upon which the AlN is deposited, to be substantially at determined temperature (e.g., 400 °C or other temperature appropriate for the type of deposition process performed). A person of ordinary skill in the art would have recognized that as described by *Dogheche*, at 400 °C and with a certain nitrogen content “the best texture [of the AlN film] is obtained.” (Ex. 1029,

2.) Thus, a person of ordinary skill in the art would have found configuring the *Barber-Hirose* process to maintain the temperature of the substrate 110 substantially constant would benefit the process as discussed by *Dogheche* which teaches how to obtain the best film texture. (*Id.*) A person of ordinary skill in the art would have appreciated that such features would have been consistent with *Barber*'s goal to "achieve a maximum texture for the piezoelectric films [i.e., the deposited AlN film]" of high quality (Ex. 1005, 5:10-12; 5:24-49; Ex. 1060, 10:9-13 (disclosing that in pulsed DC reactive sputtering systems "variables...are managed in an attempt to improve the deposition rate and the overall quality of the deposited films without sacrificing too much from either," such variables include, e.g., "substrate temperature").)

133. A person of ordinary skill in the art would have had the skills to configure the above modification and would have reasonably expected that implementing such a temperature control process in a plasma process environment like as disclosed in *Barber* would have properly provided a mechanism for controlling the temperature of the substrate especially given that similar implementations were known at the time. (See e.g., Ex. 1030, 1:33-40 (disclosing temperature control within a plasma environment with an "accuracy of $\pm 5^{\circ}\text{C}$ "), 1:60-

67 (disclosing temperature control within a plasma environment with “a high accuracy of ± 2 °C).)¹⁶ Also, a person of ordinary skill in the art would have understood and appreciated that the above-described combination would have involved a combination of known prior art technologies (e.g., a known use of sputtering technology like that described in *Barber* and a known process and related components for holding the substrate temperature substantially constant to achieve quality films, like that described in *Dogheche*) according to known methods (e.g., known method of maintaining the substrate temperature to achieve a film of high quality and texture) to yield the predictable result of a process that is capable of depositing an aluminum nitride film of high quality. Therefore, the *Barber-Hirose-Dogheche* combination discussed above discloses and/or suggests this limitation.

¹⁶ I refer to Ex. 1030 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

C. *Barber* in view of *Hirose* and *Safi* Discloses and/or Suggests the Limitations of Claim 9

1. Claim 9

- a) “The method of claim 2 wherein the Oxygen flow is adjusted to adjust the index of refraction of the film.”**

134. In my opinion, *Barber* in view of *Hirose* and *Safi* discloses and/or suggests this limitation.¹⁷ As I discussed above for claims 2[f] and 3, *Barber* discloses and/or suggests using an aluminum target with an oxygen-containing process gas for forming an aluminum oxide film. (See my discussions above in Sections IX.A.1(f) and IX.A.2.) Although *Barber* does not expressly disclose adjusting the oxygen flow to adjust the index of refraction of the aluminum oxide film, a person of ordinary skill in the art would have been motivated to implement such a feature in the combined *Barber-Hirose* process in view of *Safi*.

¹⁷ While claim 2 does not recite “oxygen flow” to relate to the claimed “the Oxygen flow” recited in claim 9, I nonetheless have been asked to assume that claim 9 refers to “[] oxygen flow” in the first instance. Therefore, my opinions for claim 9 are based on that assumption.

135. For example, *Safi* discloses a sputtering process that utilizes an aluminum target with an oxygen-containing process gas to deposit aluminum oxide films. (Ex. 1039, 9 (disclosing forming “Aluminum oxides” with Al magnetron and oxygen).) *Safi* additionally discloses setting the oxygen flow rate (amongst other parameters) to a certain value such that the aluminum oxide film has a “refractive index” value of 1.67 that is “comparable with the best reported results.” (*Id.*) Based on the disclosures and suggestions of *Barber* and *Safi*, a person of ordinary skill in the art would have been motivated to adjust the flow rate of the oxygen such that the deposited film has a certain index of refraction.

136. A person of ordinary skill in the art would have found it beneficial to adjust the index of refraction by adjusting the oxygen flow during film deposition. Indeed, a person of ordinary skill in the art would have understood that various film properties, including index of refraction, were known to be adjusted based on reactive gas flow rate to obtain a desired and/or customized film. (Ex. 1011, 5:22-30 (disclosing with reference to Figures 4 and 5 (i.e., process data associated with oxygen partial pressure and flow rate during deposition of an aluminum oxide film) various physical parameters of the film, including “index of refraction,” can be “customized” by correlating the process data with, e.g., index of refraction); 5:30-

33 (disclosing that “[b]y controlling the sputtering process to such data points..., the desired custom film may be sputtered applied to a substrate”).¹⁸ As a person of ordinary skill in the art would have also understood and consistent with *Safi*’s disclosure and suggestions, different optical properties, such as various refractive indices “are of great interest in optical applications.” (Ex. 1039, 10.) Therefore, a person of ordinary skill in the art would have been motivated to adjust the index of refraction by adjusting the oxygen flow during film deposition in order to different refractive indices for different optical applications.

137. A person of ordinary skill in the art had the skills and capability to implement the above described modification in the *Barber-Hirose* system/process and would have done so with an expectation that such an implementation would have properly operated as intended (consistent with that discussed above.) In fact, in my opinion, a person of ordinary skill in the art would have understood and appreciated that the above-described combination would have involved a

¹⁸ I refer to Ex. 1011 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

combination of known technologies (e.g., a known use of reactive sputtering technology like that disclosed and/or suggested in *Barber* to deposit aluminum oxide and a known use of adjusting oxygen flow rate like that described in *Safi*) according to known processes (e.g., known use of adjusting oxygen flow rate to obtain a film of a certain index of refraction) to yield what would have been a foreseeable process that deposits a film of a certain refractive index based on the oxygen flow rate. Thus, as I mentioned, such a skilled person would have had the knowledge and capabilities to implement the above discussed modification, and would have done so with the expectation that the modified system would have properly adjusted the oxygen flow to adjust the index of refraction of the film as I discussed above.

D. *Barber* in view of *Hirose* and *Aokura* Discloses and/or Suggests the Limitations of Claims 12 and 13

1. Claims 12 and 13

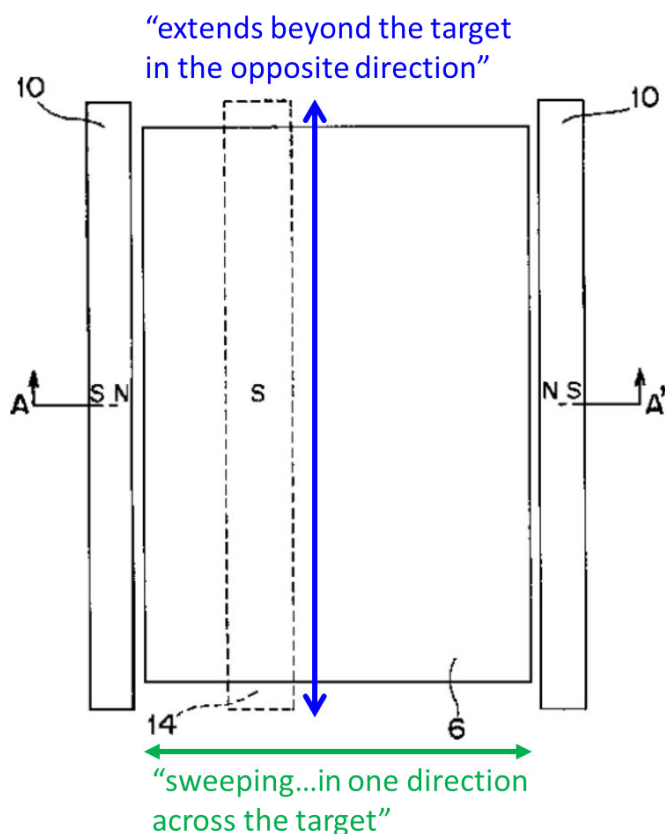
- a) [12] “The method of claim 2, further including uniformly sweeping the target with a magnetic field.”
- b) [13] “The method of claim 12 wherein uniformly sweeping the target with a magnetic field includes sweeping a magnet in one direction across the target where the magnet extends beyond the target in the opposite direction.”

138. In my opinion, *Barber* in view of *Hirose* and *Aokura* discloses and/or suggests this limitation. As I explained above for claim 12, *Barber* discloses a

rotating magnet assembly that uniformly sweeps the target with a magnetic field. (See my discussions above in Section IX.A.8 (claim 12); Ex. 1005, 7:11-13.) I have been asked to consider a scenario in which “uniformly sweeping” in claim 12 is read to require linear sweeping. Since *Barber* does not expressly disclose such features of claim 12 under such scenario or that the magnet uniformly sweeps the target with a magnetic field by “sweeping a magnet in one direction across the target where the magnet extends beyond the target in the opposite direction,” as recited in claim 13, it is my opinion that a person of ordinary skill in the art would have been motivated to implement these features in the combined *Barber-Hirose* system/process in view of *Aokura* .

139. *Aokura* discloses a magnetron sputtering apparatus/process. (Ex. 1068, ¶[0001].) A magnet 14 sweeps a target 6 with a magnetic field, where magnet 14 sweeps in a direction across target 6 and extends beyond target 6 in the opposite/perpendicular direction. (*Id.*, (Ex. 1068, ¶¶[0002] (disclosing that “[m]agnetron sputtering methods, which use a permanent magnet or electromagnet...to form a magnetic field near a target”), [0012] (disclosing with reference to Figure 1 “magnet 14 is provided with a movement mechanism that moves on the rear side surface of the target 6 in a direction orthogonal to the

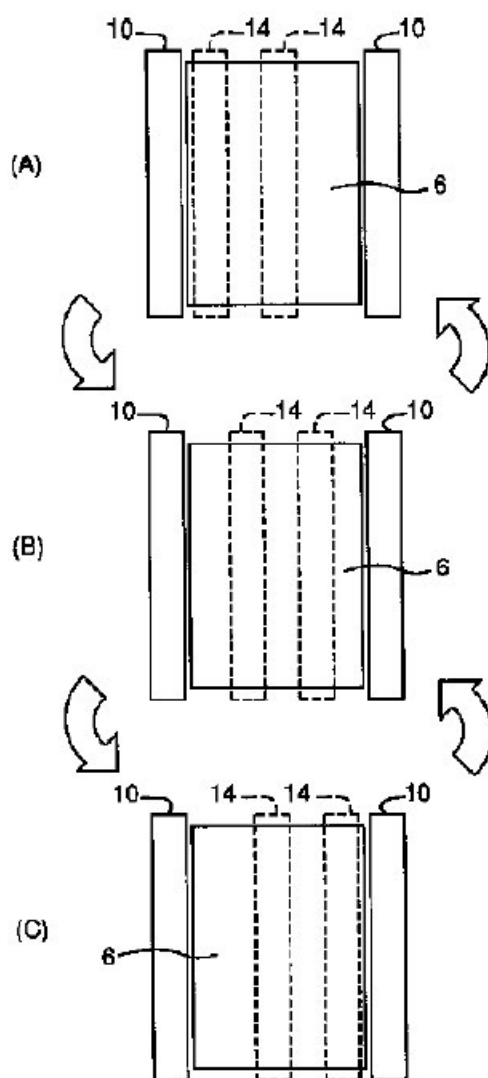
longitudinal direction of the target 6” and fixed magnets 10 are provided along the edges of the target), [0013] (disclosing the same with reference to Figures 1-4), [0014] (disclosing application of magnetic field to target 6)), FIGS. 1-5).



(Ex. 1068, Fig. 2 (annotated.) Aokura explains that such a scanning mechanism and process provides uniform erosion/sputtering of a target in a magnetron sputtering apparatus/process. (*Id.*, ¶¶[0003], [0013] (“temporally make the plasma density approximately balanced”), [0014], [0015] (plasma density on the target surface is “temporally balanced, and...the erosion portion 6a of the target 6 is approximately

uniform, greatly increasing the efficiency use of material”), [0016] (similar embodiment with two sweeping magnets), FIG. 7.)

【 7 】



(*Id.*, Fig. 7 (showing sweeping magnets that move in linear fashion across target 6 where each magnet 14 extends beyond the target 6, similar to that described above for Fig. 2 (single magnet).) Thus, a person of ordinary skill in the art would have understood *Aokura* to disclose a process of sweeping a target with a magnetic field by sweeping a magnet in one direction across the target where the magnet extends beyond the target in the opposite direction.

140. In light of the knowledge of a person skilled in the art at the time, and the teachings/suggestions of *Barber* and *Aokura*, such a person would have been motivated to modify the combined *Barber-Hirose* reactive sputtering system to uniformly sweep the target with a magnetic field by sweeping the magnet in one direction across target 260 where the magnet extends beyond target 260 in the opposite direction in order to ensure uniform magnetic field sweeping of the target.

141. A person of ordinary skill in the art would have appreciated and recognized that targets that were used for reactive sputtering at the time had different shapes for various reasons, such as to accommodate to the shape of the substrate for improving film uniformity or by design choices based on different applications. (See *e.g.*, Ex. 1032, 14 (disclosing “[c]onformal targets, which conform to the shape of the substrate, may be used to obtain uniform coverage over complex shapes”), 349

(disclosing “[targets] may have to be of some predetermined shape to fit supplied fixture or be conformal to the substrate shape” and “may have tiles of several materials”).) Rectangular or circular target shapes were common. (Ex. 1068, ¶[0012] (“rectangular target”); Ex. 1011 (6:1-3 (“Two nominally 5"x15" rectangular MRC Inset targets”); Ex. 1031, 2 (“magnetron sputtering of a rectangular” metallic target); Ex. 1033, 1:32-35 (“circular” target); Ex. 1041, 11 (“aluminum circular-planar-magnetron target”).)¹⁹

142. A person of ordinary skill in the art would have been motivated to modify the sweeping action and/or shape the magnet used in the *Barber-Hirose* system based on the shape of the target 260 to improve the uniformity and efficiency of target erosion. (Ex. 1033, 3:10-15 (disclosing the use of an “apple-shaped” target to “produce uniform coatings and erosion over the **entire** surface of the target”).)²⁰

¹⁹ I refer to Exs. 1011, 1031, and 1041 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

²⁰ I refer to Ex. 1033 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

The disclosures associated with *Aokura*'s sweeping arrangement and techniques (and those known in the art at the time) would have guided a person of ordinary skill in the art to modify the magnet sweeping techniques/components in the *Barber-Hirose* system as I explained above in order to improve sputtering and deposition rate as well as uniformity of target erosion, particularly when using rectangular target like that of *Aokura*. (See *e.g.*, Ex. 1068, ¶¶[0002]-[0003], [0012], [0013] (“it is desirable that the magnet 14 moves with uniform velocity in order to temporally make the **plasma density approximately balanced**”), [0014], [0015] (plasma density on the target surface is “temporally balanced, and...the erosion portion 6a of the target 6 is **approximately uniform, greatly increasing the efficiency use of material**”); Ex. 1031, 2 (describing a mechanism similar to *Aokura* “for high erosion efficiency”).)

143. Also, to maximize the number of uses of the target, a person of ordinary skill in the art would have been motivated to adjust the size of the magnet in the *Barber-Hirose* system to ensure that the entire volume of the target, including the edges of the targets, are sputtered/eroded for film deposition purposes. This was a concept known to those of ordinary skill in the art at the time. (See *e.g.*, Ex. 1033, 1:48-54 (disclosing altering the shape of the target erosion profile to “increase the

number of substrates a target can coat before the target must be replaced”).) This would reduce/eliminate regions on the edge of target 260 that are not properly sputtered, which would have extended the life of the target, as guided by *Aokura*. (Ex. 1068, ¶[0015] (increase target utilization efficiency.) For example, a person of ordinary skill in the art would have appreciated and thus had reason to at least ensure that the size of the magnet is at least the same or slightly larger than the target in *Barber*’s system to reduce or eliminate the regions on the edge of the target that are not sputtered as it would have extended the life of the target.

144. A person of ordinary skill in the art had the skills and capability to implement the above described modification in the *Barber-Hirose* system/process and would have done so with an expectation that such an implementation would have properly operated as intended (consistent with that discussed above.) In fact, in my opinion, a person of ordinary skill in the art would have understood and appreciated that the above-described combination would have merely involved a combination of known prior art technologies (such as the known use of reactive sputtering technologies like that described in *Barber* and a known use of a magnet like that described in *Barber* and *Aokura*) according to known methods (e.g., known use of a magnet to expose a target with its magnet field) to yield the predictable

result of a process that provides a process, where a magnet uniformly sweeps the target with a magnetic field by sweeping the magnet in one direction across the target and the magnet extends beyond the target in the opposite direction to promote efficient sputtering and deposition.

145. Thus, in my opinion, the combined *Barber-Hirose-Aokura* system and process discloses the limitations of claims 12 and 13.

E. *Barber* in view of *Hirose* and *Segal* Discloses and/or Suggests the Limitations of Claims 14-18

1. Claims 14 and 15

- a) [14] “The method of claim 2 wherein the target is an alloyed target.”
- b) [15] “The method of claim 14 wherein the alloyed target includes one or more rare-earth ions.”

146. In my opinion, *Barber* in view of *Hirose* and *Segal* discloses and/or suggests these limitations. As I discussed in Section IX.A.2 (claim 3) *Barber* discloses using an aluminum target and a silicon target. (See my discussions above in Section IX.A.2 (claim 3); Ex. 1005, 6:42-50.) *Barber* does not expressly disclose using an alloyed target including one or more rare-earth ions. Nevertheless, in my opinion, a person of ordinary skill in the art would have been motivated to implement an alloyed target that includes one or more rare-earth ions in the combined *Barber-*

Hirose system/process in view of *Segal* and knowledge of such a person of ordinary skill in the art.

147. At the time of the alleged invention, a person of ordinary skill in the art would have understood that various types of target materials, such as element, alloy, or compound, were known to be used in sputtering systems like that described by *Barber*. (Ex. 1032, 18 (sputtering deposition is capable of sputtering “element, alloy, or compound” materials), 19-20.) Thus, a person of ordinary skill in the art would have considered and contemplated various target materials (including alloys) in the *Barber-Hirose* system to enhance its versatility in depositing different films. For example, *Segal* discloses aluminum alloy targets that are formed by using the equal channel angular extrusion (ECAE) method and the type of alloy targets are useful for manufacturing flat-panel displays, including LCDs. (Ex. 1069, Abstract, ¶¶[0002] (“In particular applications, the invention pertains to methods of utilizing equal channel angular extrusion (ECAE) to deform an aluminum-comprising mass in forming a physical vapor deposition (PVD) target for use in the manufacture of flat panel displays (FPDs), such as, for example, liquid crystal displays (LCDs).”), [0003]-[0005], [0037], [0041].)

ECAE can enable a decrease in the grain size of high purity aluminum and aluminum alloys used for the

manufacture of LCDs by at least a factor of three compared to conventional practices.

(*Id.*, ¶[0041].)

148. *Segal* discloses such alloy target, having a decreased and fine grain size, contains aluminum and non-aluminum materials, including silicon (Si) and/or rare earth elements, e.g., yttrium (Y) and scandium (Sc) (*Id.*, ¶¶[0041] (“aluminum alloys”), [0045]; *see also id.*, ¶¶[0010], [0042]-[0048], claims 1, 4-5, 14-15.) A person of ordinary skill in the art would have understood that Y and Sc are both rare earth elements, for example. For instance, *Segal* explains that these non-aluminum materials can, for example, comprise:

one or more elements selected from the group consisting of Ge, Group IIA elements, Group IIIA elements, Group VIA elements, Group VA elements, Group IIIB elements, Group IVB elements, Group VIB elements, Group VIII elements, and **Rare Earth elements**. Alternatively, the dopant materials can comprise one or more of Ac, Ag, As, B, Ba, Be, Bi, C, Ca, Cd, Ce, Co, Cr, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, In, Ir, La, Lu, Mg, Mn, Mo, N, Nb, Nd, Ni, **O**, Os, P, Pb, Pd, Pm, Po, Pr, Pt, Pu, Ra, Rf, Rh, Ru, S, Sb, **Sc**, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Ti, Tl, Tm, V, W, **Y**, Yb, Zn and Zr.

(*Id.*, ¶[0045].)

149. A person of ordinary skill in the art, based on the teachings of *Barber* and *Segal*, would have found it beneficial to use aluminum-alloy targets in the combined *Barber-Hirose* system. As expressly taught in *Segal*, a person of ordinary skill in the art would have understood that such alloy targets of fine grain size are structurally stable and homogeneous (Ex. 1069, ¶¶[0010], [0015] (disclosing that “fine grain size and stable microstructures” in targets are desired), [0041], [0051]-[0052], [0058]) and thus would have “improve[d] thin film uniformity, sputtering yield, and deposition rate, while reducing arcing” (*id.*, ¶[0007]), consistent with *Barber*’s goal (Ex. 1005, 2:66-3:13). For example, *Segal* explains that:

Various works demonstrate that **three fundamental factors of a target can influence sputtering performance. The first factor is the grain size of the material**, i.e. the smallest constitutive part of a polycrystalline metal possessing a continuous crystal lattice. Grain size ranges are usually from several millimeters to a few tenths of microns; depending on metal nature, composition, and processing history. It is believed that ***finer and more homogeneous grain sizes improve thin film uniformity, sputtering yield and deposition rate, while reducing arcing.*** The second factor is target

texture. The third factor is the size and distribution of structural components, such as second phase precipitates and particles, and casting defects (such as, for example, voids or pores). These structural components are usually not desired and can be sources for arcing as well as contamination of thin films.

(Ex. 1069, ¶[0007].)

150. *Segal* also explains that the stability of the target is provided by adding “at least the minimal amount” of non-aluminum materials (Ex. 1069, ¶[0044]), such as Si and/or rare earth elements (*id.*, ¶¶[0045], [0071], [0077] (alloy of Al and Si), [0079] (alloy of Al and Sc)). Accordingly, a person of ordinary skill in the art would have been motivated to use an alloy target in the *Barber-Hirose* system to improve sputtering processes and deposited films.

151. Furthermore, a person of ordinary skill in the art would have recognized additional benefits of using alloy targets as they were known to be useful in various application, e.g., for depositing low-emissivity glass coatings (Ex. 1034, Abstract, ¶[0025] (Si-Al alloy); Ex. 1035, 1-2 (Si-Al alloy)) and for depositing thermal-barrier coating (Ex. 1036, 6 (yttrium-containing alloy), Ex. 1037, ¶[0053], Ex. 1038, 1:30-35). Thus, person of ordinary skill in the art would have been motivated to use an

alloy target to provide further versatility in the application of *Barber's* modified system.

152. A person of ordinary skill in the art would have a reasonable expectation of success in implementing alloy targets (including those containing rare-earth ion(s)) especially since they were used in the industry at the time as discussed above and known to be used in reactive sputtering processes. (Ex. 1034, ¶[0025], Ex. 1035, 1-2; Ex. 1036, 6.) Moreover, a person of ordinary skill in the art would have had the skill to implement, and expectation of success in achieving, the above modification, because, for example such an implementation would have involved the application of known technologies (e.g., known sputtering technology (*Barber*) and materials (e.g., alloy targets, including rare-earth ion containing alloy target (*Segal*)) according to known methods (e.g., known sputtering techniques to deposit coatings and use of different alloy targets) to yield the predictable result of a process that deposits various types of films from an alloy or rare-earth ion containing alloy target as discussed above.

2. Claim 16

- a) “The method of claim 14 wherein the alloyed target includes Si and Al.”**

153. In my opinion, *Barber* in view of *Hirose* and *Segal* discloses and/or suggests these limitations (“the alloyed target includes Si and Al”) for similar reasons for claim 14, which shows the use of an Al and Si alloyed target in the asserted combination. (See my discussions above in Section IX.E.1 (claim 14); see also e.g., Ex. 1069, ¶¶[0045], [0077].)

3. Claim 17

- a) “The method of claim 14 wherein the alloyed target includes one or more elements taken from a set consisting of Si, Al, Er, Yb, Zn, Ga, Ge, P. As, Sn, Sb, Pb, Ag, Au, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Th, Dy Ho, Tm, and Lu.”**

154. For the reasons that I explained above for claims 14 and 16, *Barber* in view of *Hirose* and *Segal* discloses and/or suggests these limitations (“the alloyed target includes one or more elements taken from a set consisting of Si, Al, Er, Yb, Zn, Ga, Ge, P. As, Sn, Sb, Pb, Ag, Au, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Th, Dy Ho, Tm, and Lu”) for similar reasons for claim 14, which shows the use of an Al and Si alloyed target in the asserted combination. (See my discussions above in Sections IX.E.1-2 (claims 14 and 16); see also e.g., Ex. 1069, ¶¶[0045], [0077].)

4. Claim 18

a) “The method of claim 14 wherein the alloyed target is a tiled target.”

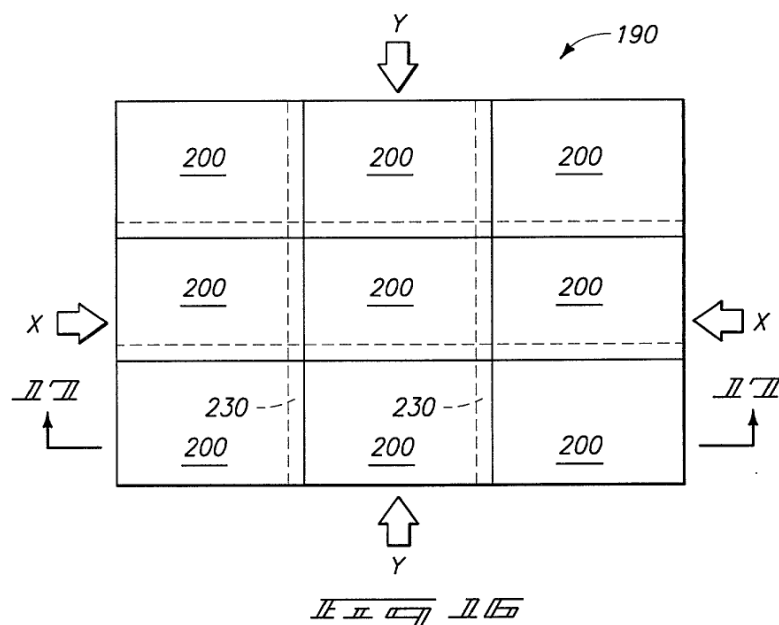
155. In my opinion, *Barber* in view of *Hirose* and *Segal* discloses and/or this limitation. *Barber* does not disclose an alloyed tiled target, but a person of ordinary skill in the art would have been motivated to implement such features in the above-discussed *Barber-Hirose-Segal* system/process (claim 14) in view of *Segal* and the knowledge of a person of ordinary skill in the art at the time.

156. Section IX.E.1 above explains why a person of ordinary skill in the art would have been motivated to implement an alloyed target in view of *Segal* and the state of the art knowledge at the time. In addition to those reasons, a person of ordinary skill in the art would have been further motivated to use a **tiled** alloyed target like that described by *Segal*. (Ex. 1069, Fig. 16, ¶[0075] (target of “a tiled assembly”).)

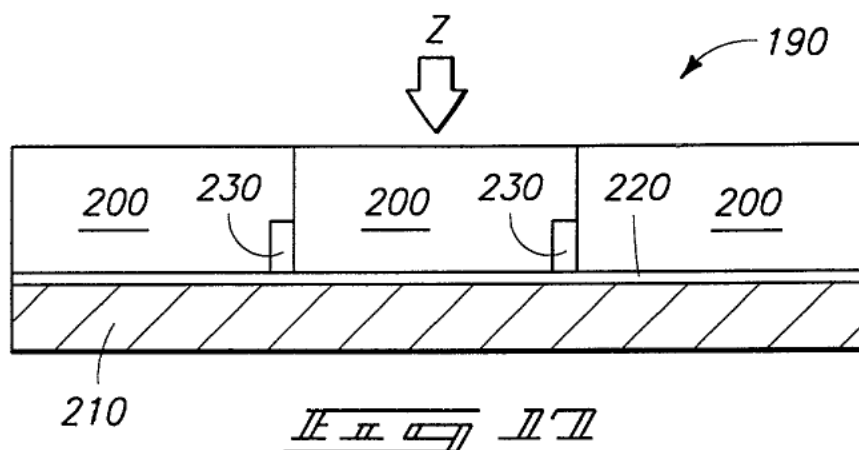
A particular application of the invention is directed to the manufacture of targets of especially large size. FIGS. 16 and 17 display this aspect of the invention. In FIGS. 16 and 17, the construction of a target **190** in the form of a tiled assembly is provided. Such comprises joining two or more billets **200** of identical shape, dimensions and processing history to a backing plate **210**, machining the

surface of the resulting assembly, and fabricating the final
target **190**....

(*Id.*, ¶[0075].)



(*Id.*, FIG. 16.)



(*Id.*, FIG. 17.)

157. A person of ordinary skill in the art would have appreciated the benefits of tiled targets as *Segal* expressly teaches that it “present[s] several advantages for the production of very large targets” (i.e., use of “current equipment,” “known methods,” and “easily adaptable to any future evolution of the size of...targets”) and would have offered a broader range of applications of *Barber*’s modified system. (Ex. 1069, ¶[0076]; Ex. 1035, 5 (disclosing that the tiled target has a “reduced brittleness...and the possibility to provide larger tile sizes”).) Thus, consistent with the reasons above for claim 14, a person of ordinary skill in the art would have been motivated to use a tiled alloy target (as known in the art demonstrated by *Segal* and the state of the art) for achieving a larger target size (which would have improved film uniformity as discussed in Section IX.A.7 (claim 11)) and expanded the fields

of use and applications of *Barber*'s modified system/process. (Ex. 1069, ¶[0006] ("LCD targets are quite large in size..., and are expected to become bigger in the figure," which "present[s] challenges to the development of tooling and processing for fabrication of suitable aluminum-comprising targets"); Ex. 1049, Abstract (disclosing the use of aluminum oxide as a barrier player in flat panel display devices).)

158. A person of ordinary skill in the art would have had understood and appreciated that the above-described modification would have merely involved a combination of known prior art technologies (e.g., a known use of sputtering technology like that described in *Barber* and a known use of tiled alloy targets like that described in *Segal*) according to known methods (e.g., known use of reactive sputtering technique to deposit coatings and use of alloyed tiled targets) to yield the predictable result of a process that deposits a film for use in different types of applications as suggested by *Segal*. Given such understandings and knowledge, a person of ordinary skill in the art would have been capable of implementing the above modification to *Barber*'s combined system/process and would have done so with the expectation that the use of a tiled alloy target would produce quality films for various applications in line with *Barber*'s goal.

F. *Barber* in view of *Hirose*, *Segal*, and *Sakawaki* Discloses and/or Suggests the Limitations of Claim 19

1. Claim 19

- a) “The method of claim 18 wherein each tile of the tiled target is formed by prealloy atomization and hot isostatic pressing of a powder.”**

159. In my opinion, *Barber* in view of *Hirose*, *Segal*, and *Sakawaki* discloses and/or suggests claim 19. While *Segal* discloses forming its tiled alloyed targets using extrusion (Ex. 1069, Abstract), a person of ordinary skill in the art would have understood the various available techniques for forming such targets. As such, a person of ordinary skill in the art would have been motivated to form each tile of the tiled target implemented in the *Barber-Hirose-Segal* process/system by prealloy atomization and hot isostatic pressing of a powder, especially in view of *Sakawaki*.

160. *Sakawaki* relates to providing alloyed targets used in sputtering processes. (Ex. 1043, ¶[0015] (disclosing an “film is formed through sputtering by use of a sputtering gas containing nitrogen or...oxygen”), ¶¶[0069]-[0070] (disclosing such film is formed through sputtering using an alloy target).) *Sakawaki* additionally discloses a method to manufacture alloy targets by first producing an

alloy powder using a “gas-atomization method” (*id.*, ¶[0072]) and then by performing a “hot isostatic processing (HIP)” on the alloy powder to form an alloy target (*id.*). As such, a person of ordinary skill in the art would have understood that *Sakawaki* discloses forming a target by “prealloy atomization and hot isostatic pressing of a powder.”

161. As discussed, the *Barber-Hirose-Segal* combination discloses and/or suggests use of a tiled alloyed target. (Sections IX.E.1, E.4.) Based on the teachings and suggestions of *Barber*, *Segal*, and *Sakawaki*, a person of ordinary skill in the art would have been motivated to modify the *Barber-Hirose-Segal* combination such that each tile of the tiled target is formed by prealloy atomization and hot isostatic pressing similar to the processes described by *Sakawaki*. While *Segal* promotes its specific extrusion processes for forming the tiled alloyed targets, its processes are based on highly pure aluminum with certain amounts of dopant materials (e.g., Ex. 1069, ¶[0054].) In modifying the combined *Barber* system/process (as discussed for claims 14 and 18), a person of ordinary skill in the art would have appreciated the various options available for forming such an alloyed target, and thus would have contemplated various amounts of materials used to form the alloy (not necessarily being limited to the specific amounts exemplified by *Segal*.) As such, a person of

ordinary skill in the art would not have been deterred by such features in *Segal* in considering and implementing other processes for forming the tiled alloyed target in the combined *Barber*'s system/process (like that described by *Sakawaki*) given the motivation gleaned from *Segal* (and the state of the art) would have been the consideration and implementation of an alloyed tiled target, and the options available in terms of the make-up of such an alloy for purposes of forming a desired film on the substrate in *Barber*'s system. (Ex. 1034, ¶¶[0024]-[0027] (Si/Al targets with ~8% Al); Ex. 1035, 2 (Si/Al (~10%) alloyed tiled target); Ex. 1036, 6 (disclosing “[o]xides of titanium, zirconium, hafnium, chromium, magnesium, silicon, yttrium, tantalum, and an alloy of zirconium and yttrium have all been successfully deposited using this technology.”)) Additionally, *Segal* acknowledges benefits of continuing use of “hot processing,” similar to disclosed in *Sakawaki*, as it is known to “healing pores and voids, and for eliminating other casting defects.” (Ex. 1069, ¶[0015].)

162. A person of ordinary skill in the art would have recognized the benefits of such a modification because prealloy atomization and HIP processes were known to produce high-performance and high density alloy targets of uniform quality that improves sputtering processes. (Ex. 1063, 1:42-45 (uniform target composition improves substrate yield), 1:56-63 (“advantageous to fabrication a sputtering target

that is a homogeneous composition”), 1:66-2:46 (disclosing a process similar to *Sakawaki* that produces “a high performance, high density [alloy] sputter target” by using “an inert-gas atomization process” and a “hot isostatic pressing” process).) Indeed, as a person of ordinary skill in the art would have understood, the quality of the deposited films “depends on the quality of the sputtering target, which in turn depends on the quality of its fabrication” and the “target composition and structure” is “important in achieving a high performance, high density” film. (Ex. 1063, 1:23-30 (“Metals to be deposited on a semiconductor substrate are removed from the sputtering target by a plasma. **The quality of the resultant semiconductor substrate depends on the quality of the sputtering target supplying the material, which in turn depends on the quality of its fabrication.** The fabrication of the sputtering target, in particular the target composition and structure, is important in achieving a high performance, high density substrate”); *id.*, 1:31-45 (“Improperly fabricated sputtering targets have several undesirable features such as low density, the presence of intermetallic compounds, and a non-uniform composition. Low density sputtering targets are undesirable because they cause outgassing during pumpdown, where air trapped in the target either increases the time for the desired level of vacuum to be reached, or prevents the necessary vacuum from being reached

at all, thus reducing uptime of the target. Additionally, impurities in the air trapped in the target can contaminate the film. Intermetallic compounds are brittle and may result in sputtering target failure during fabrication or operation. A non-uniform composition of the sputtering target is undesirable because it reduces the substrate yield, since the non-uniform composition is reproduced on the film coating the substrate.”), 1:56-64 (“It would be **advantageous to fabricate a sputtering target that is a homogeneous composition** of an unreacted aluminum and non-aluminum metal and that contains greater than about 2% to 5% by weight of aluminum. This would be sufficient to allow formation of an aluminum layer around the non-aluminum metal. Therefore, a **high quality, high performance, substantially uniform sputtering target, and an efficient method of fabricating such a target, is needed.**”).)

163. Additionally, a person of ordinary skill in the art would have understood that a variety of alloy materials can be formed into an alloy target. (Ex. 1034, ¶¶[0024]-[0027] (Si/Al targets with ~8% Al); Ex. 1035, 2 (Si/Al (~10%) alloyed tiled target); Ex. 1036, 6 (disclosing “[o]xides of titanium, zirconium, hafnium, chromium, magnesium, silicon, yttrium, tantalum, and an alloy of zirconium and yttrium have all been successfully deposited using this technology.”);

Ex. 1056, 6:6-11, 6:12-7:21.) Accordingly, a person of ordinary skill in the art would have been motivated to combine a target fabrication process similar to as disclosed in *Sakawaki* to form high-performance and high-density alloy targets to improve the quality of the deposited film, consistent with the common goal as disclosed in *Segal* and *Barber*. (Ex. 1069, ¶[0007] (disclosing that homogenous target material “improve[d] thin film uniformity, sputtering yield, and deposition rate, while reducing arcing” and “defects (such as...voids or pores)” are not desired); Ex. 1005, Abstract (disclosing a “high quality” sputter-deposited film).)

164. A person of ordinary skill in the art would have a reasonable expectation of success in implementing such a modification especially since tiled alloy targets formed based on the HIP process were in use in the industry at the time. (Ex. 1035, 5; Ex. 1032, 15 (“A single target may be used to deposit alloys and mixtures by having different areas of the target be of different materials[,]” for example “the mosaic target may have tiles of several materials”), 16 (use of the HIP process for “producing the most dense sintered [target] product”); Ex. 1061, 14:55-64 (disclosing “[a] number of target tiles manufactured [using the HIP process] can be butted together to fit any size of magnetron”); Ex. 1063, 4:49-58.) A person of ordinary skill in the art would have also appreciated that prealloy atomization and

hot isostatic pressing were conventionally known to produce targets with high-density. (Ex. 1032, 16 (“hot isostatic pressing (HIP) produc[es] the most dense sintered product”); Ex. 1043, ¶[0072] (prealloy atomization and HIP processes are both “conventionally known”).)

165. A person of ordinary skill in the art would have understood and appreciated that the above-described combination would have involved a combination of known prior art technologies (e.g., a known use of tiled and alloyed targets in reactive sputtering technology like that described in the *Barber-Hirose-Segal* combination and a known use of forming an alloy target based on a known process to produce high-density targets and high quality films that described in *Sakawaki*) according to known methods (e.g., known method of forming an alloy target described in *Sakawaki*) to yield the predictable result of a process that produces each tile of a tiled target by prealloy atomization and hot isostatic pressing of a powder in order to produce high-density targets and high quality films.

G. *Barber* in view of *Hirose* and *Sill* Discloses and/or Suggests the Limitations of Claim 20

1. Claim 20

- a) “The method according to claim 2, wherein the narrow band-rejection filter has a bandwidth of about 100 kHz.”**

166. In my opinion, *Barber* in view of *Hirose* and *Sill* discloses and/or suggests this limitation. As I explained above for claim element 2[c] in Section IX.A.1(c)(2) (claim 2(c)(2)), the *Barber-Hirose* combination discloses and/or suggests “providing pulsed DC power to the target through a narrow band rejection filter such that the voltage on the target alternates between positive and negative voltages.” (See my discussions above in Section IX.A.1(c)(2).) In addition to the reasons I discuss above for claim 2 (narrow band rejection filter) (Section IX.A.1(c)), a person of ordinary skill in the art would have been motivated to adjust the bandwidth of the narrow band rejection filter (similar to that described in *Hirose* (Ex. 1006, 4:9-16, FIGS. 1 and 6) and Section IX.A.1(c)(2)) based on the frequency spread of RF power source 235 that the filter in the combined system is designed to block, as was known at the time. (Ex. 1054, 1:13-19 (“Notch filters are used in analog-signal manipulating circuits for rejecting a particular signal frequency, or narrow range of frequencies. Conventional notch filters have a center or primary

rejection frequency w , and a **quality factor Q, which when high corresponds to a narrow filter bandwidth and when low corresponds to a relatively wide bandwidth.**”), 4:14-16 (Q factor depends on filter circuit components); Ex. 1058, 1:64-2:1 (“In order to achieve sharper skirts, the notch filter must have a high Q (Quality Factor), i.e., **the bandwidth is minimized by optimization of the Q of the notch filters' inductors and capacitors.** In most applications, the Q of the notch filter can be improved by utilizing inductors having larger winding diameters with larger diameter wire.”.) In my opinion that a person of ordinary skill in the art would have thus been motivated to implement the same features in the combined *Barber-Hirose* system and process in light of the disclosures and suggestions of *Sill* and the knowledge of such a person at the time.

167. For example, *Sill* discloses use of RF power supply in a sputtering system. (Ex. 1057, 4:24-28 (disclosing with reference to Figure 2 a “power supply 28” that outputs a RF signal).) *Sill* also discloses designing and implementing a band-rejection or a notch filter to block the RF power supply’s signal at its operating frequency. (*Id.*, Abstract (disclosing modifying “[a] passive first-order band reject, or notch filter characteristics” such that “a high impedance is created for” a radio frequency).) *Sill* explains that by tuning the values of the capacitors, inductors,

and/or resistors of the filter, such filter can be designed and implemented to block a specific frequency and a certain bandwidth. For example, *Sill* discloses a formula (correlating the resonant frequency with values of the capacitors and inductors) that can be used to determine the specific frequency to block, e.g., 13.56 MHz, based on the values of the capacitors and inductors. (*Id.*, 4:66-5:12, FIG. 4.) Furthermore, by adjusting the values of the resistors, the bandwidth of the filter can be modified, for example, from tens of Hz to several MHz, including the claimed “bandwidth of about 100 kHz,” by tuning the filter circuitry. (*Id.*, 5:17-21 (disclosing that “increase[ing] the impedance” by adding turns to the coil results in “a narrower bandwidth”), 5:48-60 (disclosing resistors of the filter “control[s] the peak impedance and bandwidth” of the filter); *see also id.*, 5:61-6:12, FIG. 6 (disclosing the correlation between the resistor values and the bandwidth of the filter).) Based on the knowledge of a person of ordinary skill in the art at the time, and the disclosures and suggestions of *Barber* and *Sill*, a person of ordinary skill in the art would have been motivated to modify the *Barber-Hirose* reactive sputtering system such that narrow band-rejection filter in the modified system has a bandwidth of about 100 kHz.

168. A person of ordinary skill in the art would have had reason to consider *Sill*’s disclosures because, while the *Barber-Hirose* combination discloses a formula

for selecting a specific frequency for a filter (Ex. 1006, 5:8-10 (disclosing the same formula as in *Sill* at 5:50)), the combination does not expressly teach how to adjust the bandwidth of the filter, which *Sill* does. A person of ordinary skill in the art would have recognized and appreciated the benefits of designing and configuring the *Barber-Hirose* system to provide specific bandwidth ranges given *Sill* explains that the RF frequency may have a certain spread, and with proper “design choice” desired filter bandwidth can be implemented. (Ex. 1057, 5:65-6:12 (“Design choice, such as choice of [filter component] with appropriate resistive characteristics, may be made for the desired peak impedance and width of band reject characteristics.”); *see also id.*, 7:23-44 (disclosing various known options in filter designs to modify the filter characteristics).)

169. Armed with such knowledge, a person of ordinary skill in the art would have recognized that using an RF supply 235 with a particular frequency spread (such as 100 kHz) would consequently drive the design and implementation of the filter in the combined system for the reasons I explained above for claim 2. (See my discussions above in Section IX.A.1(c).) Thus, a person of ordinary skill in the art would have been motivated to design the bandwidth of the filter in the *Barber-Hirose* system and process to be about the same to ensure that the entire or

substantial portion of the RF signal around its operating frequency is blocked from the pulsed DC power supply, as I discussed above for claim 2. (See my discussions in Section IX.A.1(c)(2).) Selecting and/or designing the filter with a 100 kHz frequency spread would have been a known design choice that would have been within the capability and knowledge of a person of ordinary skill in the art at the time, especially in light of the disclosures of *Sill*. (*Id.*) A person of ordinary skill in the art would have understood that the '657 patent provides no disclosures concerning any importance or criticality associated with a 100 kHz bandwidth or the RF power supply. (Ex. 1001, 5:58-65 (the '657 patent uses known and commercially available RF power supply).) Accordingly, in my opinion, a person of ordinary skill in the art would have been motivated to configure the *Barber-Hirose* filter to block frequency signals within a 100 kHz band of the RF supply 235 frequency.

170. A person of ordinary skill in the art would have understood and appreciated that the above-described combination would have merely involved a combination of known technologies (e.g., a known use of a narrow band-rejection filter or a notch filter in the *Barber-Hirose* combination and a known use of a notch filter in *Sill*) according to known processes (e.g., known method of adjusting the bandwidth of the filter in *Sill*) to yield the foreseeable result of a process that uses a

narrow band-rejection filter that is tuned to have a particular bandwidth that is applicable to the processes that the *barber* system may be applied, which would have included for example a bandwidth of about 100 kHz.

171. Thus, the combined *Barber-Hirose-Sill* system and process discloses and/or suggests the limitations of claim 20.

H. *Barber* in view of *Hirose* and *Sellers* Discloses and/or Suggests the Limitations of Claim 1

1. Claim 1

a) Claim 1[a] “A method of depositing a film on an insulating substrate, comprising:”

172. I understand that this limitation is a preamble of the claim and I have been asked to assume that it is limiting. Under such an assumption, it is my opinion that *Barber* discloses “[a] method of depositing a film on an insulating substrate, comprising.” As discussed above in Section IX.A.1(a), *Barber* discloses depositing an insulating film (AlN) on a substrate. (Ex. 1005, Abstract, 1:15-19, 4:31-34, 6:42-46, 8:43-9:22; *see also id.*, 5:62-67; Section IX.A.1(a).) *Barber* further discloses that the disclosed substrate may be fabricated with aluminum oxide or quartz. (Ex. 1005, 3:63-65.) A person of ordinary skill in the art would have understood that these substrate materials are insulating materials. (Ex. 1027, ¶[0065].) In fact, the ’657 patent acknowledges that aluminum oxide is an insulating material. (Ex. 1001,

4:51-54.) Thus, *Barber* discloses this limitation. (See also citations and analysis for *Barber* for claim element 2[a] in Section IX.A.1(a); analysis below for claim elements 1[b]-1[f].)

b) Claim 1[b] “providing a process gas between a conductive target and the substrate;”

173. As I discussed above for claim element 2[b], *Barber* discloses providing a process gas (e.g., noble gas and a reactive gas (collectively, or at least the reactive gas (e.g., nitrogen) a “process gas”)) between a target 260 and a substrate 110. (Section IX.A.1(b); Ex. 1005, 2:1-9, 6:6-17, 7:30-36; 8:45-52 (describing how target 260 is bombarded by ionized noble gas and reacts with reactive gas), FIG. 2.) *Barber* explains that target 260 can be made of aluminum, which a person of ordinary skill in the art would have understood to be conductive. (Ex. 1005, 6:42-46, 7:36-40 (disclosing providing a process gas flow near the cross-over point and the “target will continue to be **conductive** while depositing a coating on the substrate, and poisoning of the target itself is controlled.”).) Thus, a person of ordinary skill in the art would have understood that *Barber* discloses providing a process gas between a conductive target and the substrate like that recited in this limitation.

- c) **Claim 1[c] “providing pulsed DC power to the target through a narrow band rejection filter such that the target alternates between positive and negative voltages;”**

174. *Barber* in view of *Hirose* discloses and/or suggests this limitation for the same reasons I explained above for claim element 2[c], which recites similar limitations as recited in claim element 1[c]. (See my discussions and analysis above in Section IX.A.1(c).)

- d) **Claim 1[d] “providing an RF bias at a frequency that corresponds to the narrow band rejection filter to the substrate;”**

175. In my opinion, *Barber* in view of *Hirose* discloses and/or suggests this limitation for the same reasons explained above for claim element 2[d], which tracks similar language recited in claim element 1[d]. (See discussions and analysis above in Section IX.A.1(d).) My analysis above in Sections IX.A.1(c) and (d), explain why a person of ordinary skill in the art would have been motivated to modify *Barber*’s system and process to include use of a narrow-band rejection filter that blocks signals at the *frequency* provided the RF power supply 235. (See my discussions and analysis above in Sections IX.A.(c)-(d) (discussing implementation of a narrow-band rejection filter block a specific frequency, depending on the type RF supply used (e.g., 13.65 MHz, or another appropriate value).) Therefore, in my

opinion, the *Barber-Hirose* combination discloses “providing an RF bias at a frequency that corresponds to the narrow band rejection filter to the substrate,” as recited in this claim element.

e) Claim 1[e] “providing a magnetic field to the target; and”

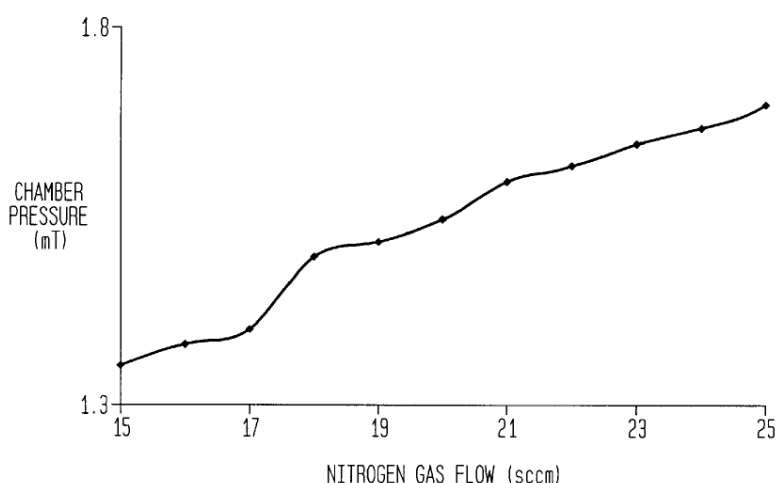
176. *Barber* discloses this limitation for the same reasons above for claim element 2[e], which include limitations similar to the features recited in claim element 1[e]. (See my discussions and analysis above in Section IX.A.1(e).) And for similar reasons that I discuss above, a person of ordinary skill in the art would have recognized that such features would have been implemented in the combined *Barber-Hirose* system and process as discussed above for claim element 1[c]. (See my discussions and analysis above in Section IX.H.1(c).)

f) Claim 1[f] “reconditioning the target; wherein reconditioning the target includes reactive sputtering in the metallic mode and then reactive sputtering in the poison mode.”

177. In my opinion, *Barber* in view of *Hirose* and *Sellers* discloses and/or suggests this limitation. I explained above for claim element 2[f] how *Barber* discloses two process regimes (which correspond to the claimed “metallic mode” and the “poison mode”) in a reactive sputtering process for depositing an aluminum

nitride film using an aluminum target. (See my analysis above in Section IX.A.1(f);
see also Ex. 1005, 6:51-67; FIG. 3.)

FIG. 3



(Ex. 1005, FIG. 3.)

178. *Barber* discloses increasing the gas flow from a low flow rate (“metallic mode”) to a high flow rate (“poison mode”) while performing reactive sputtering in each mode (*id.*, 6:55-58) (thus disclosing reactive sputtering in the metallic mode and **then** reactive sputtering in the poison mode) (See my discussions and analysis above in Section IX.A.1(f).) But, *Barber* does not expressly disclose doing so during “reconditioning [of] the target.” It is my opinion, however, that a person of ordinary

skill in the art would have understood that such processes were known in the art and thus would have been motivated to modify the above *Barber-Hirose* system and process to include “reconditioning” the target in the same manner, especially in light of *Sellers* and the knowledge of a person of ordinary skill in the art at the time of the alleged invention.

179. A person of ordinary skill in the art would have understood that *Sellers* discloses using a pulsed DC power supply to perform reactive sputtering to deposit aluminum compounds, such as aluminum nitride or aluminum oxide, using an aluminum target. (Ex. 1007, 3:4-31, 3:39-44, 4:37-58, 4:61-63.) *Sellers* further disclosed to a person of ordinary skill in the art at the time that when the aluminum target is exposed to the atmosphere, the disclosed pulsed DC sputtering technique can be used to “sputter[] off oxides and impurities with little or no damage to the target and without arcing. (*Id.*, 9:1-12.) *Sellers* explains that this process is known as the target “condition[ing]” process. (*Id.*, 9:2-4 (“This technique can also be employed prepare or ‘condition’ an aluminum target which has been exposed to the atmosphere.”).) A person of ordinary skill in the art would have also understood that such target conditioning process in *Sellers* is also known as the “burn-in” process commonly used to decontaminate the target following its exposure to the

atmosphere or contaminants. (Ex. 1028, ¶¶[0010]-[0011] (disclosing that “the sputtering chamber...must be vented to the atmosphere to permit cleaning or routine maintenance” and that “[a]fter the chamber...has been exposed to atmosphere, and before proceeding with deposition, decontamination processes [such, as burn-in] must be performed”).)²¹ The ’657 patent uses the term “burn-in” interchangeably with the “reconditioning” process. (Ex. 1001, 20:53-55 (“The recondition process (or burn in) consists of...”)).)

180. Based on the knowledge of a person of ordinary skill in the art and teachings and suggestions of *Barber* and *Sellers*, it is my opinion that a person of ordinary skill in the art would have been motivated to modify the combined *Barber-Hirose* process to include a target reconditioning process, similar to the processes suggested and/or disclosed in *Sellers* and that was known by such skilled persons at the time, in order to promote and ensure quality films are provided during deposition processing of substrate 110. A person of ordinary skill in the art would have

²¹ I refer to Ex. 1028 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

appreciated, as disclosed in *Sellers*, that during reactive sputtering, the sputtered material (e.g., aluminum nitride) “not only coats the...substrate, but also coats other surfaces including walls of the chamber.” (Ex. 1007, 3:32-35.) As such, a person of ordinary skill in the art would have recognized that after multiple film deposition processes like those contemplated by *Barber*, the sputtering chamber would have eventually been vented to the atmosphere to permit cleaning of coatings on the chamber wall or routine maintenance in between multiple film depositions. (Ex. 1028, ¶¶[0010]-[0011].) A person of ordinary skill in the art would have also understood that such a cleaning or maintenance process would have exposed *Barber*’s aluminum target left in the chamber to the atmosphere and containments. (Ex. 1028, ¶[0010].) Such a skilled person at the time would have understood that any target that was so exposed prior to use in *Barber*’s chamber would likewise be subject to potential contamination.

181. Thus, such a person of ordinary skill in the art would have been motivated to implement a decontamination process to recondition the target 260 in between multiple film depositions to ensure it was clean of impurities for subsequent deposition runs in the chamber. A person of ordinary skill in the art would have understood that such processes were known in the art (as demonstrated by *Sellers*)

and would have appreciated the benefits of such processes to sputter off impurities with little or no damage to the target and without arcing. (Ex. 1032, 15 (disclosing performing “pre-sputtering and conditioning before sputter deposition begins”), 17 (“Generally, the surface of the sputter target is initially covered with a layer of oxide or contaminants and may be pre-sputtered before deposition begins”); Ex. 1040, 12:4-8 (disclosing that “[d]uring burn-in, the plasma is used to remove any remaining contaminants from the target surface while dummy wafers pass through the sputter chamber”); Ex. 1041, 13-14 (“Pre-sputtering of targets is done to clean their surfaces prior to film deposition. Once the target surface is clean, sputter deposition onto product wafers can take place.”); Ex. 1051, 16:26-29 (disclosing a two-step pre-sputtering process that includes a first step being “a standard pre-sputtering procedure...to burn off any surface contaminants” and a second step where “the target is conditioned by introducing” oxygen).)²²

²² I refer to Exs. 1032, 1040, 1041, and 1051 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention

182. A person of ordinary skill in the art would have further understood that reconditioning the target after/between deposition runs in *Barber*'s modified system would ensure that the film deposited on the substrate 110 in subsequent deposition runs would contain the desired composition without inclusion of unwanted contaminants and impurities, which would have been consistent with *Barber*'s goal of forming high quality films by optimizing processing conditions. (*Id.*; Ex. 1005, 6:32-34.)

183. Having been motivated to recondition target 260 for the reasons above, a person of ordinary skill in the art would have also been motivated to perform such reconditioning by using the metallic mode-poison mode process described by *Barber*. A person of ordinary skill in the art would have been so motivated given that *Barber* describes reactive sputtering in the metallic mode and then in the poison mode (as discussed above for claim 2[f]) the purpose of the cross-over curve is for "optimizing the deposition conditions." (Ex. 1005, 7:1-5, 7:36-39; *id.*, 8:45-46.) A person of ordinary skill in the art would have recognized that *Barber* describes a "first step" of "determining the cross-over curve on a monitor wafer" (*Id.*, 8:45-46), which would have included reactive sputtering of the target 260. A person of ordinary skill in the art would have understood that *Barber*'s use of a "monitor

wafer” is to allow the metallic mode-poison mode reactive sputtering process to occur to identify the optimal conditions for subsequent deposition runs with substrate 110 for production of semiconductor devices.

184. Moreover, consistent with that known in the art (and described by *Sellers*), a person of ordinary skill in the art would have appreciated and understood the benefits in conditioning the target 260 by using a reactive gas in the manner as described by *Barber* as it would have prepared the target surface to a condition that is similar to the condition where the reactive sputtering deposition would have occurred. (See *e.g.*, Ex. 1044, 5:58-6:3 (disclosing “especially advantageous to proceed, after the conditioning of the target surface is completed, by setting process parameters close to the working point as required for the needed coating properties by programming the timing of the influx of the reaction gas and steadily increasing it within a given adjustment period until a flow of the reaction gas is reached which approximately determines the level to be preset for at least one coating property”); see also Ex. 1045, 3:56-58 (disclosing a “pre-sputtering step for cleaning the Surface of the target 4 and for stabilizing discharge”), 4:29-35 (disclosing with reference to

Figure 2 that in the pre-sputtering process a reactive gas (oxygen) is used), FIG. 2.)²³ A person of ordinary skill in the art would have recognized, performing reactive sputtering in the metallic mode followed by the poison mode (as described by *Barber*) as I discussed above, would have prepared the surface of the target 260 to a condition similar to a condition where actual film deposition would occur with production substrates. This would have improved the controllability and stability of the film deposition process, which a person of ordinary skill in the art would have appreciated would have been consistent with *Barber*'s goals to provide quality films. (Ex. 1005, 7:1-5, 7:36-42.) For example, a person of ordinary skill in the art would have understood such concepts and benefits because such a conditioning process would have prevented or reduced the impacts of non-ideal, but foreseeable, process

²³ I refer to Ex. 1045 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

conditions, for example undesired variations in the composition of the process gases and arc discharges at the target. (Ex. 1044, 2:41-53.)²⁴ In addition, a person of ordinary skill in the art would have recognized that it was known to take advantage of a “bipolar nature of the target voltage” in a pulsed DC power supply-based sputtering system to sputter clean a target “between runs” (Ex. 1059, 4, 7) and that target cleaning improves “as the magnitude of the reverse voltage is increased (*id.*, 8).²⁵

185. To recondition the target with the reactive gas in the modified *Barber* system, a person of ordinary skill in the art would have performed such conditioning process initially with a lower reactive gas flow rate (corresponding to the metallic mode) and then incrementally increase the reactive gas flow rate to be slightly above the cross-over point (corresponding to the poison mode), similar to the film

²⁴ I refer to Ex. 1044 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

²⁵ I refer to Ex. 1059 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

deposition process as disclosed in *Barber*. (Ex. 1005, 8:49-63; Ex. 1044, 5:58-6:3; *see also* Ex. 1005, 7:1-8:2 (disclosing with reference to Figure 5 a film deposition process that incrementally increases the reactive gas flow).) A person of ordinary skill in the art would have understood that the above-discussed “reconditioning” process would not have been limited to the AlN reactive-sputtering process discussed above. In fact, a person of ordinary skill in the art would have been motivated and found it beneficial to apply the “reconditioning” process to, for example, aluminum oxide (Al_2O_3) reactive-sputtering process, which I discussed above in Sections IX.A.1(f) (claim 2(f)) and IX.A.2 (claim 3) for reasons discussed above. (Sections IX.A.1(f) (claim 2(f)) and IX.A.2 (claim 3).) Similar to the AlN reactive-sputtering process discussed above, reactive-sputtering process for aluminum oxide likewise include a reactive sputtering in a “metallic” mode and a “poison” mode. (Ex. 1059, 3-4, FIG. 3 (disclosing with reference to Figure 3, showing aluminum oxide reactive-sputtering process characteristics as the oxygen flow rate being varied, that such process may be operate in the “metallic” regime, “poisoned” regime, or a mode maintained “between the metallic and poisoned regions”).)

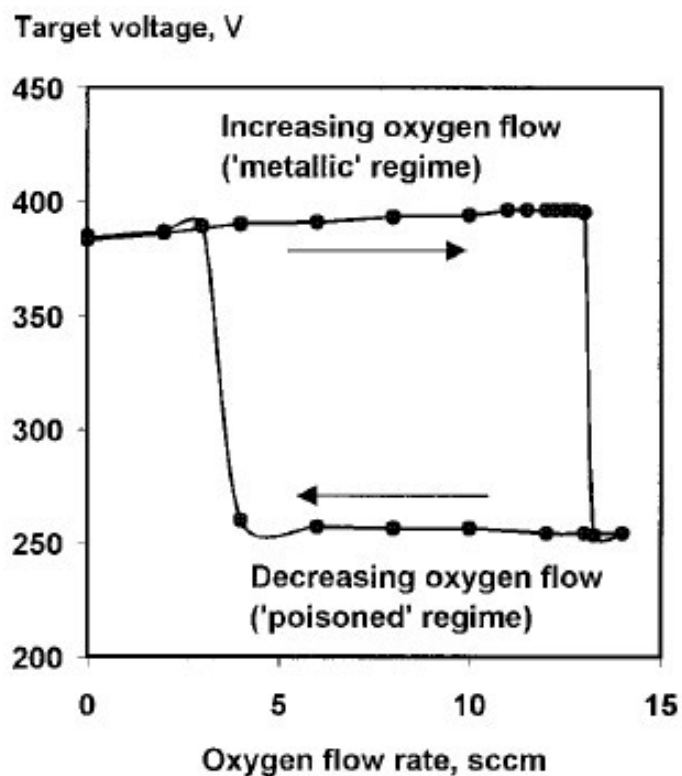


FIG. 3. Hysteresis behavior displayed during reactive sputtering of alumina.

(Ex. 1059,. FIG. 3.)

186. Accordingly, for the reasons above, a person of ordinary skill in the art would have been motivated to recondition target 260 using a process similar to that already provided for by *Barber* (e.g., metallic mode-poison mode reactive sputtering process) to ensure target 260 is reconditioned properly to allow the *Barber-Hirose* system to produce quality films on substrate 110. Thus, the combined *Barber-Hirose-Sellers* system and process discloses and/or suggests this limitation.

I. Each of the Above Prior Art Combinations in view of *Belkind* Discloses and/or Suggests the Claims of the '657 Patent

187. As I discussed above, Sections IX.A.-H. demonstrate how various combinations of prior art based on the *Barber-Hirose* combination disclose and/or suggest claims 1-21. (See my analysis and discussion above in Sections IX.A.-H.) My analysis and discussions above in Sections IX.A.-H. explain how *Barber* discloses the claimed aspects relating to providing pulsed DC power to the target such that the target alternates between positive and negative voltages associated with claim elements 2[c], 2[d] and 1[c]. (See my analysis and discussion above in Sections IX.A.1(c)-(d) and IX.H.1(c).) I have been asked to consider a scenario where *Barber* is read not to disclose the-above discussed “pulsed DC power” feature as I opined above. Under that scenario and in my opinion, a person of ordinary skill in the art would have been motivated to implement such a DC power supply to provide such features in light of *Belkind* and also in light of such person’s knowledge at the time of the alleged invention.

188. *Belkind* discloses the known use of pulsed DC power to perform reactive sputtering processes for depositing insulating layers. (Ex. 1008, 1 at Abstract (“Pulsed DC power is used for reactive sputtering of dielectrics”).) Additionally, *Belkind* explains that “providing pulsed DC power to the target...such

that the voltage on the target alternates between positive and negative voltages,” as claimed. For instance, with reference to Figure 1, *Belkind* describes pulsed voltages used to bias a target, where the voltage on the target alternates between positive and negative voltages. (Ex. 1008, 1-2, FIG. 1 (“Pulsed voltage used to power a cathode”).)

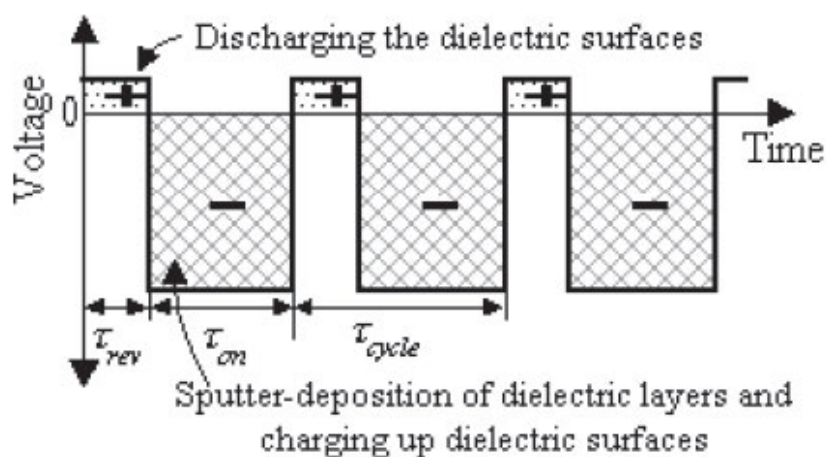
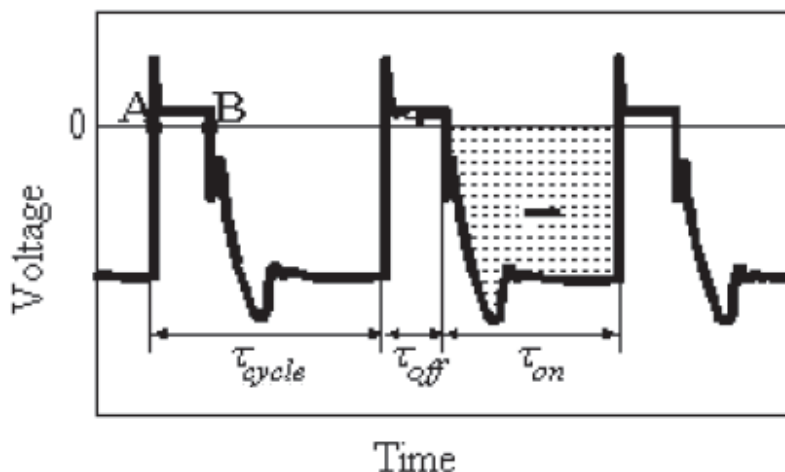


Figure 1. Pulsed voltage used to power a cathode

(Ex. 1008, FIG. 1.)²⁶ Likewise, with reference to Figure 3 *Belkind* discloses that the target voltage alternates between positive and negative voltages. (*Id.*, 2-3, FIG. 3.)



(Ex. 1008, FIG. 3.) *Belkind* further explains that “[t]he **pulsing parameters must satisfy certain conditions to avoid arcing.**” (*Id.*, 1.) In my opinion, based on the

²⁶ A person of ordinary skill in the art would have understood that *Belkind* uses the term “cathode” and “target” interchangeably (Ex. 1008, 1-2 (discussions of “cathode microarcing” and “microarcs are seen on the target surface”)), which is consistent with the understanding that in a sputtering system, the target serves as the cathode of a power supply (Ex. 1011, 3:61 (“The target 18 serves as a cathode”)).

knowledge of a person of ordinary skill in the art, and the disclosures and suggestions in *Barber* and *Belkind*, such a person would have been motivated to modify the *Barber-Hirose* system/process that I discuss above for claims 1 and 2, such that the system provided pulsed DC power to the target, where the voltage on the target alternates between positive and negative voltages, with reduced arcing.

189. A person of ordinary skill in the art would have understood that arcing is an undesired effect that may occur at the target surface when depositing an insulating film, such as AlN or Al₂O₃ films, which are disclosed in the *Barber-Hirose* combination as I discussed above. (See my discussions above in Sections IX.A.1 (claim 2) and IX.A.2 (claim 3); Ex. 1007, 6:2-5 (disclosing that arcing “creates deleterious effects on the target, such as pitting, flaking and cracking, as well as localities of extreme heat.”); Ex. 1008, 1 (“DC reactive sputtering of dielectrics is often accompanied with strong arcing”).)²⁷ *Belkind* explains that arcing is caused by accumulation of positive charges when the target is negatively biased, and, by

²⁷ I refer to Exs. 1007-1008 to describe the state of the art known to a person of ordinary skill in the art at the time of the alleged invention.

applying positive pulses, such accumulated charges can be dissipated to avoid arcing when two specific operating limitations are met. (Ex. 1008, 1 at Section 3.) In my opinion, a person of ordinary skill in the art would have recognized the benefits of modifying the *Barber-Hirose* based system/process as I noted above because *Belkind* explained to such a skilled person how to avoid target arcing by using **a bipolar pulsed DC power supply with two specific operating limitations**. Regarding the first operating limitation, *Belkind* teaches that the “**pulsing frequency** should be larger than a critical frequency...to avoid microarcing due to charge accumulation in a single on-time [or negative] pulse.” (*Id.*, 2.) As to the second operating limitation, *Belkind* teaches that the insulating film formed on the target surface “must be discharged completely during each off-time [or positive pulse],” which can be achieved by having a long-enough positive **pulse width** to discharge the target surface. (*Id.*; see also *id.*, 5.)

190. A person of ordinary skill in the art would have found *Belkind*’s disclosure helpful because, while *Barber* discloses adjusting the **pulse frequency** and **pulse width** of its pulsed DC power supply (Ex. 1005, 7:14-17), *Barber* does not discuss how to ensure these adjustments do not cause target arcing; an aspect that is disclosed by *Belkind* as I discussed above. Therefore, a person of ordinary

skill in the art, when implementing a system/process similar to the *Barber-Hirose* combination, would have been motivated to also consider and apply the concepts and teachings provided by *Belkind* to allow the DC power supply in the combined system to provide pulsed DC power to the target such that the voltage on the target alternates between positive and negative voltages with the two operating limitations discussed above in order to avoid arcing.

191. In my opinion, a person of ordinary skill in the art would have had a reasonably expected that such an implementation and modification would have provided such features as intended given such a person's knowledge at the time and the disclosures of *Barber* (including its discussions of reverse voltage and positive voltage functionalities as I discussed above for claim element 2[c]), *Hirose*, and *Belkind*. For example, a person of ordinary skill in the art would have appreciated that the pulsed DC power supply disclosed in *Belkind* was commercially available at the time of the alleged invention and used by various groups to deposit insulating films with reduced target arcing. (Ex. 1008, 1 (disclosing use of Advanced Energy's pulsed DC power supplies); Ex. 1011, 6:7-11 (disclosing use of Advanced Energy's pulsed DC power supply and "suppression of arcing on the target surface during sputtering"); Ex. 1059, 2-3 (disclosing that use of Advanced Energy's pulsed DC

power supply “significantly reduces the occurrences of arc events at the target”).) In fact, the '657 patent explains that the use of Advanced Energy type pulse DC power supplies were contemplated as exemplary supplies for its system. (Ex. 1001, 5:46-55.)

192. Additionally, a person of ordinary skill in the art would have understood and appreciated that the above-described combination would have merely involved a combination of known prior art technologies (e.g., a known use of a pulsed DC power supply that provides bipolar pulses like that disclosed in *Belkind*) according to known methods (e.g., known method to avoid target arcing by setting operation limitations of the power supply) that would have resulted in a foreseeable process and system that provides pulsed DC power to the target such that the voltage on the target alternates between positive and negative voltages with reduced target arcing.

193. Accordingly, for the reasons above, under the scenario where *Barber* is read not to disclose providing pulsed DC power to the target such that the target alternates between positive and negative voltages, a person of ordinary skill in the art would have been motivated to modify the *Barber-Hirose* system/process (including the additional modifications provided by the other identified prior art in

Sections IX.B-H) to implement such a DC power supply to provide such features in light of *Belkind* and the knowledge of a person of ordinary skill in the art at the time. My opinions in Sections IX.A-H are applicable to the combinations asserted above for the same reasons. Thus, the positions above in Sections IX.A-H remain applicable to demonstrate how each of the asserted combinations discloses and/or suggests the limitations of claims 1-21. (See Sections IX.A-H, which I incorporate here and are applicable for each of the following prior art combinations that I list below.)

194. For instance, in my opinion, a person of ordinary skill in the art would have had the same motivations, capabilities, and expectations discussed above to provide the above modification in the combined prior art combinations identified below, and therefore, for the same reasons discussed above and in the respective sections above for Sections IX.A-H, the *Barber-Hirose-Belkind* combination in view of the respective prior art discussed below, discloses and/or suggests the limitations of claims 1 and 2, and those of claims 3-21.

1. *Barber* in view of *Hirose* and *Belkind* Discloses and/or Suggests Limitations of Claims 2-4, 6, 8, 10-12, and 21

195. The *Barber-Hirose-Belkind* combination discloses and/or suggests claims 2-4, 6, 8, 10-12, and 21 for reasons similar to those discussed in Section IX.A.

The same analysis associated with the *Barber-Hirose* combination presented above for these claims in Section IX.A also applies here for the *Barber-Hirose-Belkind* combination discussed above in Section IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claims 2-4, 6, 8, 10-12, and 21 in Section IX.A.

2. *Barber* in view of *Hirose*, *Belkind*, and *Dogheche* Discloses and/or Suggests Limitations of Claims 5 and 7

196. The *Barber-Hirose-Belkind-Dogheche* combination discloses and/or suggests these claims for reasons similar to those I discussed in Section IX.B. The same analysis associated with *Dogheche* presented above for these claims in Section IX.C also applies here for the *Barber-Hirose-Belkind* combination discussed above in Sections IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claims 5 and 7 in IX.B.

3. *Barber* in view of *Hirose*, *Belkind*, and *Safi* Discloses and/or Suggests Limitations of Claim 9

197. The *Barber-Hirose-Belkind-Safi* combination discloses and/or suggests claim 9 for reasons similar to those discussed in Section IX.C. The same analysis associated with *Safi* presented above for claim 9 in Section IX.C also applies here for the *Barber-Hirose-Belkind* combination discussed above in Section IX.I. Thus,

my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claim 9 in IX.C.

4. *Barber* in view of *Hirose*, *Belkind*, and *Aokura* Discloses and/or Suggests Limitations of Claims 12 and 13

198. The *Barber-Hirose-Belkind-Aokura* combination discloses and/or suggests these claims for reasons similar to those discussed in Section IX.D. The same analysis associated with *Aokura* presented above for these claims in IX.D also applies here for the *Barber-Hirose-Belkind* combination discussed above in Section IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claims 12 and 13 in Section IX.D.

5. *Barber* in view of *Hirose*, *Belkind*, and *Segal* Discloses and/or Suggests Limitations of Claims 14-18

199. The *Barber-Hirose-Belkind-Segal* combination discloses and/or suggests these claims for reasons similar to those discussed in Section IX.E. The same analysis associated with *Segal* presented above for these claims in Section IX.E also applies here for the *Barber-Hirose-Belkind* combination discussed above in Sections IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for these claims in Section IX.E.

6. *Barber* in view of *Hirose*, *Belkind*, *Segal*, and *Sakawaki* Discloses and/or Suggests Limitations of Claim 19

200. The *Barber-Hirose-Belkind-Segal-Sakawaki* combination discloses and/or suggests claim 19 for reasons similar to those discussed in Section IX.F. The same analysis associated with *Sakawaki* presented above for these claims in Section IX.F also applies here for the *Barber-Hirose-Belkind* combination discussed above in Sections IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claim 19 in Section IX.F.

7. *Barber* in view of *Hirose*, *Belkind*, and *Sill* Discloses and/or Suggests Limitations of Claim 20

201. The *Barber-Hirose-Belkind-Sill* combination discloses and/or suggests these claims for reasons similar to those discussed in Section IX.G. The same analysis associated with *Sill* presented above for claim 20 in Section IX.G also applies here for the *Barber-Hirose-Belkind* combination discussed above in Sections IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claim 20 in Section IX.G.

8. *Barber* in view of *Hirose*, *Belkind*, and *Sellers* Discloses and/or Suggests Limitations of Claim 1

202. The *Barber-Hirose-Belkind-Sellers* combination discloses and/or suggests these claims for reasons similar to those discussed in Section IX.H. The

same analysis associated with *Sellers* presented above for claim 1 in Section IX.H also applies here for the *Barber-Hirose-Belkind* combination discussed above in Sections IX.I. Thus, my analysis regarding the discussed combination with *Belkind* as I discuss above is included with my analysis for claim 1 in Section IX.H.

X. CONCLUSION

203. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Vivek Subramanian

Dated: June 3, 2021

By: _____

Vivek Subramanian