

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FAVORED TECH CORPORATION,

Petitioner

v.

P2I LTD.,

Patent Owner

Case No. IPR2020-01198

Patent No. 10,421,876

DECLARATION OF GREGORY N. PARSONS, PH.D.

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I, Gregory N. Parsons, do hereby declare as follows:

I. INTRODUCTION

1. I have been retained on behalf of P2i Ltd. (“P2i”), and its counsel, Fitch Even Tabin & Flannery LLP, as an expert in this proceeding. I am personally knowledgeable about the matters stated herein and am competent to make this declaration.

2. I understand that Favored Tech Corporation (“Favored”) filed a Petition for *Inter Partes* Review regarding certain claims of U.S. Patent No. 10,421,876 (“the ’876 patent”) (Paper 1), which was accompanied by the Declaration of Dr. Karen Gleason (Ex. 1002).

3. I have been asked to investigate and opine on certain issues relating to the ’876 patent (Ex. 1001), and on issues relating Favored Tech’s petition for inter partes review of the ’876 patent. I understand that the Petition asserts the following grounds of unpatentability:

- Ground 1, which alleges obviousness of claims 1–3, 9, and 11–15 based upon Coulson-122 (Ex. 1004), Badyal (Ex. 1005), and Cohen (Ex. 1006);
- Ground 2, which alleges obviousness of claims 1–8 and 10–15 based upon Coulson-122, Badyal, and Holliday (Ex. 1007);
- Ground 3, which alleges obviousness of claims 1–4, 10, and 12–15 based upon Coulson-122, Badyal, and Padiyath (Ex. 1008);

- Ground 4, which alleges obviousness of claims 1–3, 5–8, and 11–15 based upon Coulson-122, Badyal, and Francesch (Ex. 1009); and
- Ground 5, which alleges obviousness of claims 1–3, 5–8, and 12–15 based upon Coulson-122, Badyal, and Tropsch (Ex. 1011).

4. I receive compensation for my time working on this matter, which is billed at an hourly rate of \$595 per hour, plus expenses. I have no financial interest in P2i or in the '876 patent, and my compensation is not dependent on the outcome of this proceeding. The conclusions I present are due to my own judgment.

5. For this declaration, I will first present my technical history and experience relating to plasma processing and thin film coating, and their relation to content within the '876 patent. I will then present my analyses and opinions relating to claims 1–15 of the '876 patent, including my analysis of the Petition and the declaration made by Petitioner's expert, Dr. Karen Gleason.

6. I base this declaration on the information currently available to me. To the extent that additional information becomes available, I reserve the right to continue my investigation and study, which may include reviewing documents and information that may be produced, as well as testimony from any depositions that may be taken.

II. BACKGROUND AND QUALIFICATIONS

Education and Professional Experience

7. My curriculum vitae (CV) is included at the end of this declaration. It includes a detailed record of my educational training, industrial experience, and professional activity and service. It also includes a list of my scientific publications and patents, including many related to the subject matter of this proceeding. I possess the training, education, knowledge, skills, and hands-on experience, to form an expert opinion and provide expert testimony in this matter.

8. Since earning my Ph.D., I have 30 years of professional experience in the fields of Physics and Chemical Engineering, including 3 years industrial experience as a Physics Post-doc at IBM T.J. Watson Research Center, Yorktown Heights NY, and 27 years academic experience as a faculty member in Chemical Engineering at North Carolina (NC) State University. The full 30 years has focused on thin film deposition reactions by plasma and thermally-excited reactions, including deposition of polymeric, inorganic, and combined organic/inorganic materials.

9. I received Bachelor of Arts degree in Physics from the State University of New York, College at Geneseo in 1980. Between 1980 and 1984, I worked as a Physics Research Technician at GTE Laboratories in Waltham, Massachusetts. I

received a Ph.D. in Physics from North Carolina State University in 1990. My Ph.D. research thesis described physical and chemical surface processes during Plasma Enhanced Chemical Vapor Deposition (PECVD) of hydrogenated amorphous silicon, and how those processes influenced the optical and electronic properties of the deposited films for solar cell applications.

10. For my postdoctoral training at IBM TJ Watson Research Center, I continued my study of PECVD reactions and electronic properties of thin films, particularly for applications in thin film transistors used in Active Matrix Liquid Crystal Displays. During my Post-doc, I invented a process for plasma enhanced area-selective deposition of silicon, and received an IBM invention award for my work.

Professional Background

11. My academic career began in 1992 when I joined North Carolina State University as an Assistant Professor of Chemical Engineering, and I have remained employed at NC State since then. I was promoted to Associate Professor with tenure in 1998, and I have been Full Professor from 2002 to the present. I was named as Alcoa Professor from 2009 to 2018, and in 2018 my title became Celanese Acetate Professor, a position I hold now. I also currently hold positions as Associate Faculty in the department of Physics and the department of Materials Science and

Engineering at NC State. Between 2012 and 2014 I also held the position of Visiting RTI Senior Fellow at Research Triangle Institute in Research Triangle Park, North Carolina.

12. As a professor at NC State, I have taken leadership roles in the university and in external professional activities, and received multiple awards for my research, teaching, and service scholarship. In 2001 I co-founded the annual International AVS Atomic Layer Deposition (ALD) Conference which now attracts more than 1,000 participants each year. I was elected Fellow of the American Vacuum Society in 2005, and served from 2011–2013 on the AVS Board of Directors. I am the recipient of an NSF Career Award, the Alcoa Foundation Distinguished Engineering Research Award, and a Semiconductor Research Corporation Invention Award. In 2006, I launched NC State's Nanotechnology Initiative and was Director until 2014. I am also an accomplished classroom teacher, being named to NC State's Academy of Outstanding Teachers in 2009. I am the 2014 recipient of NC State's RJ Reynolds Award, the College of Engineering's highest distinction for faculty research, teaching and service. In 2015 I received the ALD Innovation Award, the highest recognition of accomplishment in the ALD community, and in 2017 I received the NC State Alumni Distinguished Graduate Professorship Award. In 2016 I was selected as part of the inaugural class of the NC

State Research Leadership Academy, and I was elected and served as Academy Chair for 2019-2020 academic year.

13. I am also co-founder and co-owner of VaporPulse Technologies, begun in 2011 as a company providing service for thin film coatings by Atomic Layer Deposition, including materials as well as research and development support.

Research Field and Experience

14. Starting since graduate studies in the late 1980's up to the present, my research has focused on surface and gas-phase chemical mechanisms during thin film formation, modification, and removal by chemical vapor deposition and etching, including reactions during Plasma Enhanced Chemical Vapor Deposition, Atomic Layer Deposition, Plasma-ALD, Molecular Layer Deposition, Chemical Vapor Etching, and Atomic Layer Etching. A key feature of my work addresses means to control or guide fundamental surface reactions to achieve desired surface and film functionality for electronic, catalytic, energy conversion, and other applications.

15. My laboratory at NC State includes more than a dozen thin film deposition and etching reactor systems, all of which were designed and built by myself and my research students and group members. Reactors include small systems for focused surface testing on 2 cm x 2 cm size, up to larger systems capable

of coating on 12 in x 12 in flexible substrates and textiles. Unique expertise in my lab includes surface modification, coating, and analysis of polymers, in particular natural and synthetic polymers in fiber and textile formats. Our group provided the earliest report on ALD coating of textiles, including the effect of coating process and composition on polymer fiber surface energy and wetting. My group is also distinguished by our knowledge and expertise in the area of controlled thin film nucleation, and in the formation of metal-organic framework thin films. Scaling and shrinking of advanced nanoelectronic devices is beginning to rely on controlled nucleation during low-temperature area-selective deposition, where a thin film material of choice is formed only on part of an exposed surface while adjacent parts of the surface remain atomically clean, all while maintaining the reaction temperature to be less than 400°C. A recent study in our group produced more than 30 nm of TiO₂ on SiO₂ without measurable deposition on hydrogen-terminated silicon, a feat which is now a leading bench-mark in the field. Also, our group reported the first study of metal-organic framework thin films on polymer fibers showing rapid catalytic hydrolysis of soman, an active chemical nerve agent.

Scientific Publications

16. As shown in detail on my attached CV, I am the author of more than 270 scientific publications in the fields of physics and chemical engineering, and I

am a named inventor on 5 issued U.S. patents. I am regularly invited to present and discuss my work at scientific symposia and conferences, as well as academic institutions and industrial laboratories across the US and internationally.

17. The '876 patent concerns electronic or electrical devices having a protective coating obtained by exposing the device to a plasma comprising a monomer compound and a crosslinking reagent. I recognize this technology as being well within the sphere of my experience and expertise, and I understand the technology described in the '876 patent fully. I believe my expertise and education in this industry qualifies me to explain this technology and to address the issues of patent validity from the perspective of a person of ordinary skill in the art. I am qualified to submit expert analyses in this proceeding.

III. MATERIALS CONSIDERED

18. In forming my opinions, I have relied on information and evidence identified in this declaration, including the '876 patent, its prosecution history, the declaration of Dr. Karen Gleason, and other references listed as exhibits in Favored Tech's *inter partes* review petition and P2i's preliminary response.

IV. PERSON OF ORDINARY SKILL IN THE ART

19. I have been asked to address the issues from the perspective of a person of ordinary skill in the field relevant to the '876 patent at the time of the

invention, which I am informed is assumed to be June 9, 2015. Dr. Gleason contends that “a POSA at the time of the priority date for the ’876 patent would have had at least a bachelor’s degree in a field such as chemistry, physics, or chemical engineering, as well as at least two years of experience with plasma-polymerization techniques.” (Ex. 1002 ¶ 29.)

20. I agree with Dr. Gleason’s description of one of ordinary skill in the art, except that the use of “at least” with regard to education and experience renders the level of skill unclear. For the purposes of my opinions, I assume that a POSA would have had a bachelor’s degree in chemistry, physics, or chemical engineering and two years of experience with plasma polymerization techniques, with the understanding that “experience with plasma-polymerization techniques” should be interpreted include experience with plasma-enhanced chemical vapor deposition (PECVD) techniques. Dr. Gleason notes that the terms PECVD and plasma polymerization may be used interchangeably. (Ex. 1002 ¶ 12.)

21. I consider myself to have at least the credentials of a person of ordinary skill in the art. As a result of my education, academic experience, and industrial experience, I am familiar with the technology in the field of the ’876 patent and also with the state of that technology in June 9, 2015, the priority date for the ’876 patent. Throughout my career, I have worked with and supervised those of

ordinary skill in the art, and I am capable of addressing the issues from the perspective of such a person.

V. APPLICABLE LEGAL STANDARDS

22. As a technical expert, I am not offering any legal opinions. Rather I am offering technical assessments and opinions. In rendering my analysis, I have been informed by counsel regarding various legal standards for determining patentability. The standards provided by counsel that I was asked to apply in forming the opinions expressed in this declaration are summarized below.

23. The patent claims describe the invention made by the inventors and describe what the patent owner owns and what the owner may prevent others from doing. An independent claim sets forth all the requirements that must be met in order to be covered by that claim. A dependent claim does not itself recite all of the requirements of the claim but refers to another claim and incorporates all of the requirements of the claim to which it refers.

24. A claimed invention is unpatentable if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. In determining whether a claimed invention is obvious, one should consider the scope and content of the prior art, the

level of ordinary skill in the art, the differences between the claimed invention and the prior art, and whether the claimed invention would have been obvious to one of ordinary skill in the art at the time of the invention in light of those differences.

25. I understand a reference may be considered in an obviousness determination only when it is analogous to the claimed invention. A reference is analogous prior art if it is from the same field of endeavor, regardless of the problem addressed, or if the reference is not within the field of the inventor's endeavor, it is reasonably pertinent to the particular problem with which the inventor is involved. To determine the applicable field of endeavor, one must consider explanations of the invention's subject matter in the patent application, including the embodiments, function, and structure of the claimed invention.

26. When evaluating obviousness, one must not consider whether the claimed invention would have been obvious to a layman or to an expert. One must put oneself in the place of a person of ordinary skill at the time the invention was made and consider only what was known before the invention was made. One must avoid the temptation to read into the prior art the teachings of the patent at issue and guard against the use of hindsight. In other words, one should avoid using the challenged patent as a guide through the maze of prior art references, combining the right references in the right way so as to achieve the result of the claims at issue.

27. Obviousness should be considered in light of the problem facing the inventor(s) and the complexity of the alternatives for solving the problem. A patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. It is important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does. One should therefore also consider whether there was a teaching, suggestion or motivation to combine the references. The evaluation of a motivation to combine references allows recourse to logic, judgment, and common sense, but any such motivation to combine references must still avoid the improper application of hindsight. There must be some logical reason apparent from concrete evidence that justifies a combination of the references.

28. It is improper to combine references where the references teach away from their combination. A reference may be said to teach away when a person of ordinary skill would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the inventor. A reference teaches away, for example, if (1) the combination would produce a seemingly inoperative result, or (2) the references leave the impression that the

product would not have the property sought by the inventor or would no longer achieve the intended purpose(s) of the references being modified or combined.

29. I understand that the first step in determining validity is to properly construe the claims. Dr. Gleason has offered interpretations of one term found in the claims at issue. The claim construction principles that I have been asked to follow are summarized below.

30. The claim terms are given their ordinary and customary meaning, as would be understood by a person of ordinary skill in the art at the time of the invention. The person of ordinary skill is considered to read the words used in the patent documents with an understanding of their meaning in the field, and to have knowledge of any special meaning and usage in the field. The ordinary meaning of a claim term is its meaning to the person of ordinary skill after reading the entire patent, including the patent specification. The specification may reveal a special definition given to a claim term by the inventor, which then governs the meaning of the same term in the claims.

31. The claims themselves provide substantial guidance as to the meaning of claim terms, and the context in which a term appears in the claim can be highly instructive to its meaning. Difference among claims can also be a useful guide. For

example, the presence of a dependent claim that adds a particular limitation suggests that the limitation in question is not present in the independent claim.

32. The patent's prosecution history should also be considered, which includes the record of the proceedings before the U.S. Patent and Trademark Office and the prior art cited during the examination of the patent. The prosecution history may inform the meaning of the claim language by demonstrating how the inventor understood the invention and whether the inventor limited the invention in the course of prosecution, making the claim scope narrower than it would otherwise be.

33. My opinions regarding the meaning that a person of ordinary skill in the art would give to certain disputed claim terms are also addressed below.

VI. BACKGROUND TECHNOLOGY

35. Dr. Gleason makes several assertions regarding the background of technology and the knowledge and abilities of persons skilled in the art as of June 9, 2015. In some cases, Dr. Gleason, who is a person of extraordinary skill in the field of plasma polymerization, overstates the knowledge and abilities of a Person of Ordinary Skill (POSA).

36. For example, Dr. Gleason states in paragraph 27 that POSAs “would have known how to adjust plasma composition and reaction conditions to achieve desire properties in the polymer coating.” (Ex. 1002 ¶ 27.) In my opinion and based

on my experience, a POSA would have known how to adjust plasma composition and reaction conditions for known and established processes to achieve coatings with known properties, but would not have been able to simply achieve any desired property in a plasma coating, especially if the desired property was not previously known in the art. In the field of plasma polymerization, advancements are often made by highly educated and/or highly experienced researchers. (*See* Ex. 1001; Ex. 1004; Ex. 1005.)

37. A POSA would know that “plasma polymerization is a new material preparation process and is not a kind of polymerization.” (Ex. 2002 at ix.) In particular, “[t]he materials formed by plasma polymerization are vastly different from conventional polymers and constitute a new kind of material.” (*Id.*) A POSA would also know that plasma polymerization is a complex and highly system dependent process, and that changes to the reactor, the parameters used, or the monomers and other gaseous components used in the process can have drastic effects on plasma conditions and the resulting coating. (*Id.* ix–x.; Ex. 2003 (Guimond) p. S447–9, Fig. 3.) The nature of the substrate also affects the properties of the resulting coating, especially with thin film coatings. (Ex. 1004 at 3:9–12.)

38. I agree with Dr. Gleason at paragraph 36 that “[t]he plasma polymerization process creates complex branched and crosslinked molecular chains

due to partial fragmentation of the original monomer molecule” and that the “resulting structural complexity distinguishes plasma polymerization from molecular polymerization techniques in which monomer molecules combine through chemical reactions to form relatively uniform chains or networks of repeating monomer units.” (Ex. 1002 ¶ 36.)

39. As another example of the distinction between conventional polymerization and plasma polymerization, Yasuda is instructive:

To appreciate the uniqueness of plasma polymerization, it is useful to compare the steps necessary to obtain a good coating by a conventional coating process and by plasma polymerization. If one wants to coat a certain substrate with a conventional polymer, at least several steps are required: (1) synthesis of a monomer, (2) polymerization of the monomer to form a polymer or intermediate polymer to be further processed in a succeeding step, (3) preparation of coating solution, (4) cleaning and/or conditioning of the substrate surface by application of primer or coupling agent, (5) application of the coating, (6) drying of the coating, and (7) curing of the coating.

In coating by plasma polymerization, in contrast, all these functional steps are replaced by an essentially one-step process starting from a relatively simple gas that often is not considered a monomer for polymerization.

Polymers formed by plasma polymerization aimed at such a coating are in most cases highly branched and highly cross-linked. Such polymers are characteristically formed during plasma polymerization, although low molecular weight materials that are soluble in various solvents and noncohesive powders can also be formed (1).

Chemical reactions that occur under plasma conditions are generally very complex (2- 4) and consequently are nonspecific in nature. Such reactions are of merit when special excited states of molecules are required as intermediate states and cannot be achieved, or can be achieved only with great difficulty, by conventional chemical reactions. Thus, plasma polymerization should be recognized as a special means of preparing unique polymers that cannot be made by other methods rather than as a special way of polymerizing monomers.

(Ex. 2002 at 4–5.)

40. A POSA would also know that the structural complexity of materials made via plasma polymerization would be more useful for creating nanoscale protective coatings such as barrier layers than coatings made via conventional chemical reactions that have uniform chains. (Ex. 2002 at 5.) Plasma processes also require complex and expensive equipment, and if one could obtain the same materials via conventional polymerization methods, it would easier and more cost effective to use conventional methods. These distinctions between conventional polymerization and plasma polymerization provide reasons why a POSA would not

be motivated to look to references directed to conventional polymerization processes when looking to solve problems related to creating protective coatings using a plasma polymerization process.

41. I disagree with Dr. Gleason's statement in paragraph 53 that "plasma polymerization was known to proceed at least in part according to reaction pathways similar to those that occur following conventional activation techniques (like free-radical, solution-phase, or heat-based polymerization)." (Ex. 1002 ¶ 53.) A POSA would expect other reaction pathways to also occur. Further, a POSA would not reasonably have expected to predict the structure or properties of a plasma polymerized coating based on the use a particular crosslinker in a conventional polymerization process. Yasuda explains:

The plasma polymerization so far discussed is characterized by (1) the extensive fragmentation and/or rearrangement of a structural moiety or atoms in the starting material and (2) simultaneously occurring reactions involving many kinds of chemical species.

These phenomena are seldom found in conventional polymerizations, which can be recognized as molecular reactions. In other words, in conventional polymerizations, molecules of monomers are linked together with a minimum alteration of chemical structure of the monomer and the structure of a polymer can be well predicted from the structure of the monomer. In contrast, the structure of a polymer

formed by plasma polymerization cannot be predicted in this way. Perhaps the only sure prediction one could make would concern the elements constituting the polymer and, to a lesser extent, the elemental ratios.

This situation becomes clearer once we recognize the fact that plasma polymerization is not a regular "molecular polymerization."

(Ex. 2002 at 166–67.)

42. I disagree with Dr. Gleason's statement in paragraph 53 that "POSAs understood and expected that the same types of crosslinking reagents used for conventional polymerization would also work in plasma polymerization reactions." First, she doesn't explain what it means to "work". (Ex. 1002 ¶ 53.) Second, the references she cites to do not support her conclusion. For example, Badyal (Ex. 1005) does not suggest to a POSA that any crosslinker known in the polymer art would be effective to improve the durability of a plasma polymerized coating, as discussed below in my summary of Badyal. In addition, the Tarducci article (Ex. 2023 at 8725) is directed to pulsed plasma polymerization using only a single monomer at a time and does not discuss adding a crosslinker to a monomer.

43. As discussed above, coatings formed by plasma polymerization are not analogous to those formed in conventional polymerization processes. (Ex. 2002 at 2–3, 4–5, 166–7.) Combining a crosslinking reagent to another monomer in a

conventional polymerization process will lead to a different result than combining the same compounds in a plasma polymerization process. (Ex. 2002 at 166–7, 171.) Yasuda explains the difference between polymerizing two monomers in a conventional polymerization process vs. a polymerization process:

Another "atomic" feature of plasma polymerization is evident from the plasma codeposition of more than one monomer. In conventional molecular polymerization, copolymerization is governed by the monomer reactivity ratio, and a mixture of monomer A and monomer B in a 1: 1 ratio does not produce a 1: 1 copolymer of A and B, except in the special case of *azeotropic copolymerization*. This is due to the facts that the reactivities of two monomers differ depending on the chemical structures and that polymerization is very specific to the monomer structure and to the chain-carrying species. In contrast, the plasma polymerization of a mixture of two monomers nearly always yields polymers corresponding to azeotropic copolymerization, indicating the absence of specificity of monomers toward plasma polymerization.

(Ex. 2002 at 171.)

44. Further, plasma polymerization is inherently unpredictable and making changes to a process, such as by adding an additional compound, can have drastic effects. (Ex. 2003 at S4448–9, describing vastly different deposition results when NH_3 added to C_2H_4 in different ratios.) Yasuda explains:

Because of the atomic nature of the growth mechanism of polymer formation, plasma polymerization is highly system dependent. The fragmentation of molecules of a starting material or the rearrangement of molecular structure as visualized by diagnostic data based on the fragmentation products depends on the structure of the starting material and the conditions of plasma polymerization. Therefore, the selection of a monomer for an expected polymer requires a knowledge of the plasma polymerization conditions and of the atomic nature of the process under the conditions. This situation can be illustrated by the plasma polymerization of tetrafluoroethylene versus that of hexafluoroethane in the presence of H₂ gas. The details of this comparison are presented in Chapter 7, where ablation in plasma and the competitive nature of ablation and polymer formation are discussed.

(Ex. 2002 at 169) (emphasis added.)

VII. OVERVIEW OF THE '876 PATENT

45. I understand that the '876 patent is titled "Coatings." I understand the '876 patent arose from an international patent application filed December 15, 2016, which in turn claims priority back to a European patent application filed June 9, 2015.

46. The '876 patent states that the invention particularly relates to providing an electronic or electrical device or component thereof having a cross-linked polymeric coating obtained by exposing the device to a plasma comprising a

monomer compound and a crosslinking reagent. (Ex. 1001 at Abstract.) The '876 patent claims an electronic or electrical device (or electronic or electrical component thereof) having a protective coating obtained by exposing the device to a plasma comprising a particular monomer compound and crosslinking reagent. The '876 patent describes the difficulties in obtaining plasma-derived protective coatings on electronic devices, such as mobile phones. (Ex. 1001 at 1:20–2:6.) In particular, the desired coatings should have a high water contact angle (i.e., be highly hydrophobic) but also stable, tack-free, and resistant to smearing. (*Id.* at 1:20–2:6; 4:26–35.) The inventors described that when using the monomer 1H, 1H, 2H, 2H-perfluorooctyl acrylate (PFAC6) to form a plasma polymerized coating, applying lower power resulted in a more hydrophobic coating, but found the coating was unstable in the presence of water and was tacky and easily smeared. (*Id.* at 1:34–56.) They also found that applying higher powers created coatings that were more crosslinked and resistant to smearing but decreased the coating's hydrophobicity. (*Id.* at 1:47–67, 16:4–10, FIGS. 1 and 2.) Accordingly, the inventors recognized the process conditions required for producing tack and smudge-free protective coatings for electronic devices were limited and lacked sufficient hydrophobicity. (*Id.* at 2:1–6.)

47. The inventors discovered that they could obtain improved protective nanoscale coatings and also increase the range of suitable plasma processing conditions by adding particular crosslinking molecules to the monomer introduced during the plasma polymerization process. (*Id.* at 2:49–55.) The cross-linked copolymer protective coating could be obtained by low energy pulsed plasma processing and exhibited improved hydrophobicity while remaining tack and smudge-free. (*Id.* at 2:56–64, 16:58–17:19, compare FIGS. 2 and 4.) The '876 patent states that these properties make the coating “suitable for the coating of electronic devices to prevent the ingress of water-based liquids” to protect such devices from accidental damage. (*Id.* at 2:56–64.)

48. The '876 patent states that the coating formed according to the invention is a protective layer, in that it prevents damage by contact with water or other liquids, and may provide protective functionality by forming a liquid repellent layer and/or a physical barrier layer. (*Id.* at 3:8–11.) The '876 patent explains that a coating with a water contact angle (WCA) of at least 90 degrees is typically a water repellent layer. (*Id.* at 4:26–30.) The inventive coatings, particularly when thicker than 50 nm, act as physical barrier coatings, which provide a barrier to mass and electron transport and restrict diffusion of water, oxygen, and ions. (*Id.* at 3:3–11.) Accordingly, the coatings are particularly advantageous for protecting electronic

devices like mobile phones, including the internal electronic components thereof. (*Id.* at 1:5–13, 14:30–58.) The '876 patent explains that these barrier coatings are electrically insulating while remaining sufficiently compliant or alterable to allow electrical connections to be made to the device without needing to remove the coating, e.g., to allow the device to be connected to a charging cable. (*Id.* at 3:41–54.)

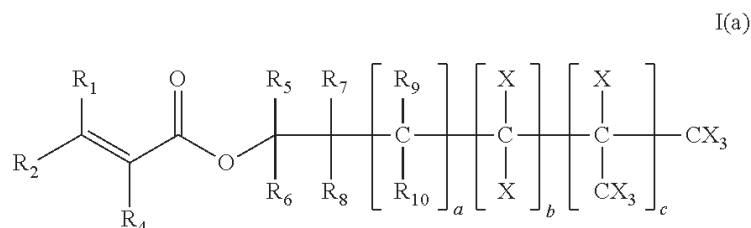
49. The '876 patent describes that electrical devices having the barrier coating will typically have an electrical resistance of at least 1×10^7 Ohms and allow the coated device to be submerged in water of up to 1m for 30 minutes while powered on, which is sufficient to pass the IPX7 test. (*Id.* at 3:55–4:6.) The inventors also discovered that the barrier coatings were significantly more electrically resistant than the coating formed without the crosslinking reagent. (*Id.* at 16:46–54, FIG. 5, 18:10–23.) Example 5 shows an increase in resistance of the coating from 2.1×10^7 to 9.2×10^9 Ohms when 10% DVA crosslinker was added to PFAC6 monomer. (*Id.* at 18:10–23.)

50. The '876 patent specifies a variety of monomers and crosslinkers that may be used. (*Id.* at 4:36–13:6.) Claim 1 is recited below:

An electronic or electrical device or electronic or electrical component thereof comprising a protective cross-linked polymeric coating on a surface of said device or component;

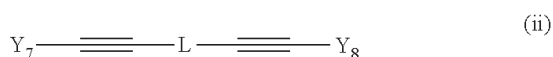
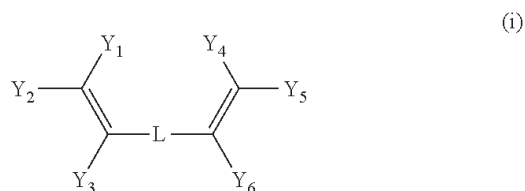
wherein the protective cross-linked polymeric coating is obtained by exposing said device or component to a plasma comprising a monomer compound and a crosslinking reagent for a period of time sufficient to allow formation of the protective cross-linked polymeric coating on a surface thereof,

wherein the monomer compound is a compound of formula I(a):



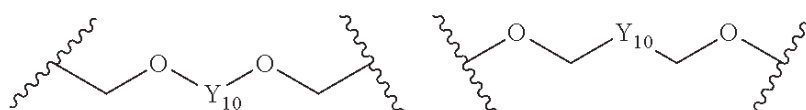
wherein each of R₁, R₂, R₄ and R₅ to R₁₀ is independently selected from hydrogen or an optionally substituted C₁-C₆ branched or straight chain alkyl group; each X is independently hydrogen or halogen; a is from 0-10; b is from 3 to 7; and c is 0 or 1;

and wherein the crosslinking reagent comprises two or more unsaturated bonds attached by means of one or more linker moieties and has a boiling point of less than 500° C. at standard pressure, the crosslinking reagent having one of the following structures:



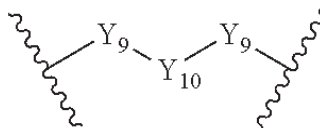
where Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 , Y_7 and Y_8 are each independently selected from hydrogen, optionally substituted cyclic, branched or straight chain C_1 - C_6 alkyl or aryl; and L is a linker moiety;

wherein for compound (i) L is of formula A having one of the following structures:



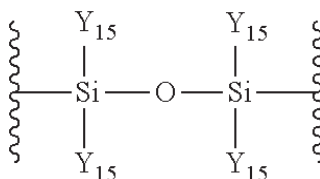
and Y_{10} is selected from optionally substituted cyclic, branched or straight chain C_1 - C_8 alkylene and a siloxane group;

or wherein for compound (i) L is of formula B having the following formula:



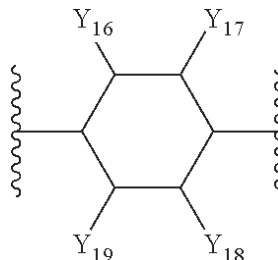
where each Y_9 is independently selected from, a bond, $—O—$, $O—C(O)—$, $—C(O)—O—$, $—Y_{11}—O—C(O)—$, $—C(O)—O—Y_{11}—$, $—OY_{11}—$, and $—Y_{11}O—$, where Y_{11} is an optionally substituted cyclic, branched or straight chain C_1 - C_8 alkylene; and

wherein Y_{10} has the following formula:



and each Y_{15} is independently selected from optionally substituted branched or straight chain C_1 - C_6 alkyl;

or wherein Y_{10} has the following formula:



and Y₁₆ to Y₁₉ are each independently selected from H and optionally substituted branched or straight chain C₁-C₈ alkyl or alkenyl.

51. As is evident from the patent specification and discussion above, the '876 patent's field of endeavor relates to plasma polymerized protective coatings. Claim 1 requires an electronic device having a protective coating, obtained by exposing the device to a plasma. (*Id.* at 18:26–36.) The Field of Invention in the '876 patent states “the present invention relates to protective coatings for electronic or electrical devices and components thereof, and methods for forming such coatings.” (*Id.* at 1:5–13.) Each example in the '876 patent similarly involves plasma polymerized protective coatings for electronic devices. (*Id.* at 15:40–16:54, 16:58–7:19.)

52. The '876 patent describes the problems that the inventors were addressing: obtaining protective coatings that did not smear, were tack free, but also had sufficient protective qualities suitable for electronic devices, including hydrophobicity and electrical resistance. (*Id.* at 1:15–2:6.) The inventors of the '876 patent were confronted with problems specific to plasma polymerization and

protection of electronic devices, and in particular with regard to plasma deposited coatings formed by PFAC8 and PFAC6. The problems described in the Background relate to the impact of power of the *plasma* on the nature of the polymer—a problem specific to plasma polymerization. (*Id.* at 1:20–21.) The power applied during plasma processing can affect the amount of fragmentation the monomer, impacting properties of the coating such as water contact angle and stability (e.g. resistance to smearing). (*Id.* at 1:20–33, 57–67.) After describing these problems, the '876 patent explicitly states “it is an aim to solve one or more of the above-mentioned problems with the prior art coatings.” (*Id.* at 2:5–7.) Accordingly, the inventors in the '876 patent expressly described the particular problems they were attempting to solve, all which related to plasma polymerized protective coatings for electronic devices.

53. From my review of the asserted prior art, it is my opinion that the claimed combination of monomers and crosslinking reagents were not previously known nor used in a plasma process to obtain a protective coating for an electronic device. It is also my opinion that claim 1 would not have been obvious to a person of ordinary skill in view of the asserted references.

VIII. CLAIM CONSTRUCTION

54. I understand that Dr. Gleason states that a POSA would have understood the term “halogen” in claim 1 to mean at least fluorine, chlorine, and

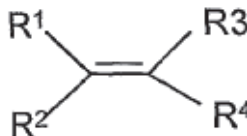
bromine. I agree.

IX. SUMMARY OF THE ASSERTED REFERENCES

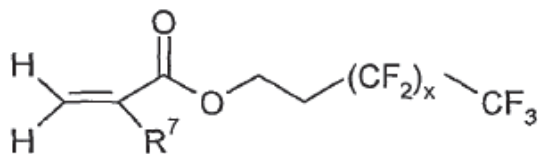
A. Coulson-122

55. Coulson-122 discloses an electronic device having a polymeric coating formed by exposing the device to a pulsed plasma composition that includes a particular formula of monomers. (Ex. 1004 at 3:20–34, claim 1.) Coulson-122 notes that plasma polymers had previously been used to coat fabric substrates, and describes the inventor's discovery that by utilizing a specific type of monomer under particular deposition conditions, a highly liquid repellent nano-coating could be deposited on an electronic device without affecting the operation of the device. (*Id.* at 2:32–3:18.)

56. Coulson-122 discloses that the monomer may have the following general structure:



(*Id.* at 3:20–25.) In a particular example, Coulson-122 discloses a monomer having the following structure:



where R^7 is hydrogen, C_{1-10} alkyl, or C_{1-10} haloalkyl and x is an integer from 1 to 9. (*Id.* at 12:13–21). When R^7 is hydrogen and x is 7, the monomer is 1H, 1H, 2H, 2H-heptadecafluorodecyl acrylate. (*Id.* at 12:21–22, claims 11 and 28.)

57. Coulson-122 teaches a polymeric coating is formed on an electronic device by exposing the device to a pulsed plasma including the disclosed monomer. (*Id.* at 3:20–25.) The device is exposed to the pulsed plasma for a sufficient period of time to allow a protective polymeric layer to form on the surface of the device. (*Id.* at 3:20–34, 4:1–3.) With regards to plasma polymerization, Coulson-122 describes, and a POSA would know, that “[t]he properties of the resultant coating can depend upon the nature of the substrate as well as the nature of the monomer used and conditions under which it is deposited.” (*Id.* at 3:9–12.)

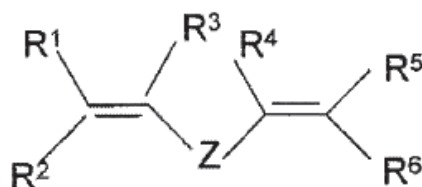
58. Coulson-122 does not disclose use of a more than a single monomer at a time, nor does Coulson disclose using a crosslinking reagent alone or in combination with the disclosed monomers in the pulsed plasma. (*Id.* at 7:19–24.)

B. Badyal

59. Badyal describes a method of coating a surface, such as a fabric, with a

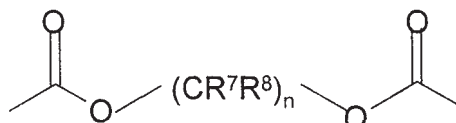
polymer layer which includes exposing the surface to a plasma comprising one or more organic monomeric compounds, at least one of which comprises two double bonds. (Ex. 1005 at 4:4–8.) The method forms a layer of cross-linked polymer on the surface of the fabric to form a water- and oil- repellant coating. (*Id.* at 1:3–5, 4:8–9, 6:10–12, 9:18–19.) Badyal states that “any solid substrate, such as fabric, metal, glass, ceramics, paper or polymers” may be coated, but Badyal focuses particular on fabric substrates. (*Id.* at Abstract, 1:14–19, 1:25–2:8, 2:31–3:2, 4:26–29, 9:28–34, 10:1–6, 11:22–24, claim 14.) Badyal discloses that such coatings applied to fabrics have sufficient durability to withstand washing. (*Id.* at 4:24–29.) Badyal discloses that durability means that the coating is sufficiently bonded to the fabric to withstand washing without being washed off. (*Id.* at 1:25–34.) Badyal never says that his coatings are protective. Further, just because a coating is durable on a fabric does not mean that the coating would be protective for an electronic device, or sufficient to withstand accidental dropping of an electronic device in water. Accordingly, a POSA reading Badyal would not expect that Badyal’s coatings would be suitable for electronic devices. Nor would a POSA understand from Badyal that plasma polymerization of a crosslinker in combination with PFAC8/PFMAC8 would improve the characteristics of the resulting coating applied to an electronic device.

60. Badyal discloses that a suitable crosslinking compound may be combined with an organic monomer in a plasma to improve the durability of a coating. (4:16-29.) Badyal describes that suitable crosslinking compounds have the following general formula (I):



where Z is a particular bridging group. (*Id.* at 5:1–5.) Badyal then describes in particular suitable substituents for R1-R6 and the bridging group Z. (*Id.* at 5:3–6:20.) Badyal describes that example of suitable bridging groups Z “are those known in the polymer art” and then goes on to describe that they include optionally substituted alkyl groups which may be interposed with oxygen atoms, and also include perhaloalkyl groups and perfluoroalkyl groups. Badyal then describes preferred examples as shown below:

In a particularly preferred embodiment, the bridging group Z includes one or more acyloxy or ester groups. In particular, the bridging group of formula Z is a group of sub- formula (II)

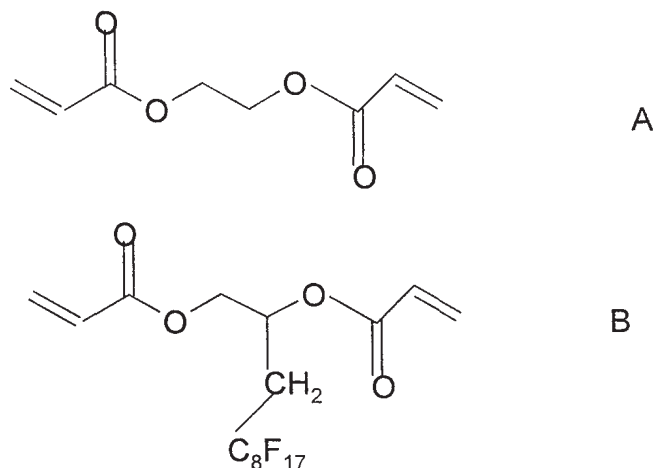


where n is an integer of from 1 to 10, suitably from 1 to 3, each R^7 and R^8 is independently selected from hydrogen, alkyl or haloalkyl.

Suitably R^1 , R^2 , R^3 , R^4 , R^5 , and R^6 are haloalkyl such as fluoroalkyl, or hydrogen. In particular they are all hydrogen.

Suitably the compound of formula (I) contains at least one haloalkyl group, preferably a perhaloalkyl group. This allows the formation oil repellent as well as water repellent coatings. This group is suitably located as a group R^7 or R^8 within the bridging group Z .

Thus particular examples of compounds of formula (I) include the following:



(*Id.* at 5:18–6:20.)

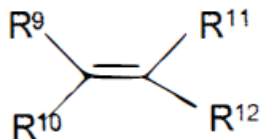
61. A POSA reading Badyal in its entirety would understand its disclosure of the crosslinking formula and bridging group Z would not be so broad as to include any known compound in the polymer art. Instead, Badyal's disclosure is focused on plasma polymerization for forming oil and water repellent coatings. Badyal teaches,

and a POSA would understand, that “[t]he success or otherwise of plasma polymerization depends upon a number of factors, including the nature of the organic compound.” (*Id.* at 2:26–28.) Badyal at first broadly discloses that the crosslinking compound used should have more than one double carbon-carbon bond, but then limits this broad description by stating that “suitable compounds with more than one carbon-carbon double bond . . . used in the plasma are suitably those which will yield cross-linked polymers having oil or water repellent properties.” (*Id.* at 4:4–21.) Accordingly, a POSA would understand that Badyal discloses that the suitable crosslinking compounds must be capable of forming a plasma-polymerized coating having oil or water repellent properties. Badyal then provides specific examples of suitable formulas and two particularly preferred compounds, as discussed directly above, which further suggests to a POSA a much narrower range of suitable reagents.

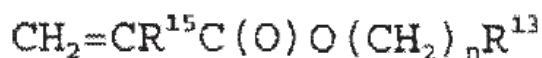
62. The particular bridging groups Z disclosed in Badyal, however, do not disclose the linker moiety “L” claimed in claim 1 of the ’876 patent. Of the only two specific examples of compounds A and B which satisfy formula (I), neither include the linker moiety claimed in the ’876 patent.

63. Badyal describes that other monomeric compounds that may be used in combination with the disclosed crosslinking compounds to form the coating,

including compounds having the following general formula:



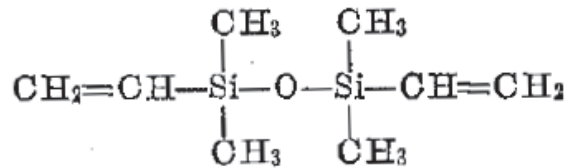
(*Id.* at 7:17–32.) Badyal describes that in one embodiment, the other monomeric compound may have the following formula:



where R^{13} is an alkyl or haloalkyl group and R^{15} is a hydrogen or C_{1-6} alkyl, such as methyl. (*Id.* at 7:26–27, 9:10–16.) Badyal describes that R^{13} is preferably a perfluoroalkyl group of formula $\text{C}_s\text{F}_{2s+1}$ where s is an integer. (*Id.* at 8:15–18.) When R^{13} is a perfluoroalkyl group of formula $\text{C}_s\text{F}_{2s+1}$ where s is 8 and R^{15} is a hydrogen, the monomeric compound is 1H, 1H, 2H, 2H-heptadecafluorodecyl acrylate (PFAC8). None of the secondary references (Cohen, Holliday, Padiyath, Francesch, or Tropsch) describe using a crosslinker with PFAC8.

C. Cohen

64. Cohen describes a monomer divinyltetramethyldisiloxane (DVTMDS or disiloxane) created by the inventor and polymerization products produced therewith. (Ex. 1006 at 1:15–20.) Cohen describes DVTMDS as having the formula:



(*Id.* at 1:27–30.)

65. Cohen does not disclose plasma polymerization processes to form protective coatings for electronic devices. It discloses how to formulate DVTMDS, as well as conventional polymerization processes to form copolymers using DVTMDS (*Id.* at 1:34–44, 2:70–3:50.) Cohen explains:

For example, the disiloxane with the other copolymerizable material may be dissolved in a suitable inert solvent, for example, an aromatic hydrocarbon solvent (such as benzene, toluene, xylene, etc.) and polymerization of the mixture effected. Another method which may be employed in preparing copolymers the instant claimed invention includes the preparation of an intimate mixture of the monomeric materials by preparing suspensions or emulsions of the disiloxane and the copolymerizable material in a liquid medium as, for example, water.

(*Id.* at 34–44.) As this passage reflects, Cohen discloses effecting polymerization in an inert solvent or in an emulsion.

66. Cohen discloses that copolymers made using DVTMDS may be used as a dielectric material in a capacitor, a cable or electrical coil impregnant, and a filling compound in potheads and cable joints. (*Id.* at 5:1–21.) Cohen does not

describe the use of DVTMDS with the specific monomers recited in claim 1 of the '876 patent.

67. In my opinion, a POSA would not look to Cohen to improve a plasma-formed protective coating for an electronic device. Cohen is not directed to the same field as the '876 patent, i.e., plasma polymerized protective coatings. Cohen also does not pertain to the particular problem that the inventors of the '876 were engaged with, i.e., improving plasma polymerized protective coatings for electronic devices.

D. Holliday

68. Holliday relates to curable insulating compositions for “dip coating electrical connectors and other conductors.” (Ex. 1007 at 1:12–15, 1:23–25, 2:16–21, 2:60–64.) Holliday describes that the compositions are particularly suitable for insulating underground secondary bus connectors used in the utility industry. (*Id.* 1:52–2:35.) Holliday describes various disadvantages with previously known molded, pre-shaped rubber insulating boots and sleeves, plastisol coatings, and thermosetting resin coatings for electrical connectors. (*Id.* at 1:26–51.) For example, molded insulations were expensive and lacked versatility, and plastisol coatings lacked sufficient electrical and heat distortion properties. (*Id.* at 1:63–2:16.) Holliday discloses a curable composition of polyolefin, polyvinylchloride and a

reactive allylic or vinylic monomer. (*Id.* at 2:39–42.) The composition is created by “forming an intimate admixture of the polymeric components of the composition and the reactive monomer” along with an optional curing agent, or is optionally cured using irradiation techniques. (*Id.* at 2:47–70.)

69. Holliday discloses that crosslinking allylic or vinylic monomers are employed in its dip coating compositions. (*Id.* at 3:21–54.) Among a list of approximately 52 possible monomers, Holliday includes diallyl-1,4,-cyclohexanedicarboxylate (DCHD) a suitable allylic monomer and 1,4-divinyl-oxybutane (also known as 1,4,-butanediol divinyl ether or BDVE) as a suitable vinylic monomer. (*Id.* at 3:34–35; 3:52–53.)

70. Holliday does not relate to plasma polymerization processes. Holliday also is unrelated to forming plasma derived protective coatings for electronic devices or otherwise. Holliday also does not describe the use of DCHD or BDVE with the specific monomers recited in claim 1 of the ’876 patent.

71. In my opinion, a POSA would not look to Holliday to improve a plasma-formed protective coating for an electronic device. Holliday is not directed to the same field as the ’876 patent, i.e., plasma polymerized protective coatings. Holliday also does not pertain to the particular problem that the inventors of the ’876 were engaged with, i.e., improving plasma polymerized protective coatings for

electronic devices.

E. Padiyath

72. Padiyath is entitled “Moisture Barrier Coatings” and relates to multi-layer barrier assemblies for the protection of a moisture or oxygen sensitive article, and particularly organic light emitting diode devices (OLEDs). (Ex. 1008 ¶¶ 2, 5.) The barrier assemblies include alternating diamond-like glass (DLG) layers and polymer layers, which may be crosslinked. (*Id.* ¶¶ 25, 30, 52.) Padiyath discloses two lists of possibilities for preferred and alternative monomers that can be used to form its polymer layers. (*Id.* ¶¶ 52, 54.) One of the monomers in the list of alternative monomers is cyclohexane dimethanol diacrylate esters. (*Id.* ¶ 54.)

73. Padiyath discloses forming polymer layers used in a multi-layer stack of the barrier assemblies by “crosslinking the layer to form the polymer in situ, e.g., by flash evaporation and vapor deposition of a radiation crosslinkable monomer, followed by crosslinking using, for example, an electron beam apparatus, UV light source, electrical discharge apparatus or other suitable device.” (*Id.* ¶¶ 52, 61.) Padiyath states that plasma polymerization may be employed “if it will provide a polymeric layer having a glassy state at an elevated temperature, with a glass transition temperature greater than or equal to that of HSPET.” However, Padiyath describes that “[m]ost preferably, the polymer layers are formed by flash

evaporation and vapor depositing *followed by* crosslinking in situ . . .” (*Id.* ¶ 61) (emphasis added.)

74. Padiyath fails to disclose use of the cyclohexane dimethanol diacrylate esters with the specific monomers claimed in ’876 patent and fails to suggest that the dimethanol diacrylate esters should be applied via a plasma in combination with another monomer. Accordingly, in my opinion, a POSA would not look to Padiyath to improve a plasma-formed protective coating for an electronic device.

F. Francesch

75. Francesch is an article entitled “Fabrication of Bioactive Surfaces by Plasma Polymerization Techniques Using a Novel Acrylate-Derived Monomer.” Francesch discloses the fabrication of bioactive surfaces using a new monomer pentafluorophenyl methacrylate (PFM) synthesized by the authors. (Ex. 1009 at 605.) The resulting coatings “leave the labile pentafluorophenyl group on the surface, enabling a rapid reaction with an amino-terminated biotin ligand and allowing layer-by-layer self-assembly of biotin-streptavidin.” (*Id.*)

76. Francesch describes that the novel PFM monomer can be deposited alone or can be copolymerized with 1,7-octadiene or 1,4-butanediol divinyl ether (BDVE) as crosslinkers to form the bioactive surface. (*Id.* at 606.) Such bioactive surfaces have application in tissue engineering and therefore are unrelated to

protective coatings for electronic devices. (*Id.* at 605, 610–11.) Francesch does not disclose or suggest the use of BDVE with the specific monomers claimed in the '876 patent.

77. In my opinion, a POSA would not look to Francesch to improve a protective coating for an electronic device. Francesch is not directed to the same field as the '876 patent, i.e., plasma polymerized protective coatings. Francesch also does not pertain to the particular problem that the inventors of the '876 were engaged with, i.e., improving plasma polymerized protective coatings for electronic devices.

G. Tropsch

78. Tropsch is entitled “Preparation of Polymers Comprising Peroxycarboxyl Groups” and as the title suggests, relates generally to processes for preparing polymers comprising peroxycarboxyl groups. (Ex. 1011 at 1:4–7.) Tropsch discloses it is an object of the invention to “provide a process for preparing polymers comprising peroxycarboxyl groups by reacting polymers comprising monoolefinically unsaturated dicarboxylic anhydride basic building blocks with hydrogen peroxide . . .” (*Id.* at 1:26–33.) Tropsch discloses that the polymers prepared according to the invention can be used in a wide range of applications, including as bleaches, disinfectants, and cleaners, and recites a variety of product

applications including acne remedies, tooth bleaches, cuticle softeners, and vaginal suppositories. (*Id.* 5:60–6:21.) Tropsch describes that the polymers can be crosslinked using “any suitable crosslinker[.]” and describes numerous classes and dozens of specific examples, including 1,6-hexanediol divinyl ether. (*Id.* at 3:47–54, 4:34–39.)

79. Tropsch is unrelated to plasma polymerization and protective coatings formed via a plasma. Tropsch also does not describe that 1,6-hexanediol divinyl ether could be employed in a plasma polymerization process, is suitable for forming coatings, or could be used with the specific monomer structures specified in claim 1 of the ’876 patent. In my opinion, a POSA would not look to Tropsch to improve a protective coating for an electronic device. Tropsch is not directed to the same field as the ’876 patent, i.e., plasma polymerized protective coatings. Tropsch also does not pertain to the particular problem that the inventors of the ’876 were engaged with, i.e., improving plasma polymerized protective coatings for electronic devices.

X. CLAIMS 1–15 ARE NOT OBVIOUS BASED ON THE COMBINATION OF COULSON-122, BADYAL, AND EACH OF COHEN, HOLLIDAY, PADIYATH, FRANCESCH, AND TROPSCH

80. I disagree with Dr. Gleason’s analysis and conclusion in paragraphs 114–214 (Ex. 1002 ¶¶ 114–214) that the subject matter of the challenged claims of

the '876 patent would have been obvious to a POSA based on the disclosures of Coulson-122, Badyal, Cohen, Holliday, Padiyath, Francesch, and Tropsch. I have concluded that Dr. Gleason has not shown that the challenged claims of the '876 patent cover subject matter that would have been obvious based on these references to a person skilled in the art at the time of the invention.

81. In my opinion, a POSA would not have been motivated to combine Coulson-122 and Badyal. First, a POSA would recognize that there are significant differences between preparing a protective coating for an electronic device and an oil or water repellent coating a fabric. In particular, electronic devices “are very sensitive to damage caused by liquids.” (Ex. 1004 at 1:10–11.) Coulson-122 acknowledges that “[c]ontact with liquids either in the course of normal use or as a result of accidental exposure, can lead to short circuiting between the electronic components, and irreparable damage to circuit boards, electronic chips etc.” (*Id.* at 1:11–15.) Accordingly, a protective coating for an electronic device needs to meet more stringent requirements than a coating for fabrics, which face few adverse consequences if the fabric is exposed to liquids. For example, a coating for electronics must be uniform, conformal, compliant, and sufficiently labile to retain its function during handling or bending (such as when a button is pressed). (Ex. 1001 at 3:40–54.). A POSA would not be motivated to look to a reference focused

on coatings that are particularly suited for providing oil and water repellency for fabrics when seeking guidance on how to satisfy the much more stringent protective requirements for electronic devices. A POSA would also understand that the properties of plasma polymerized materials are determined by the interactions between plasma exited species and the depositing film surface. Differences in the composition, uniformity and roughness of the substrate would also have an effect on the resulting coating. For example, POSAs would know that surface roughness effects hydrophobicity, and that coatings deposited on a naturally rough fabric would not necessarily produce the same hydrophobicity on a smooth electronic device surface.

82. A POSA would understand that crosslinked polymers tend to be more stiff and rigid compared to non-crosslinked polymers. Such rigidity is not always desirable for electronic devices. For example, Coulson-122 addressed the problem of protecting electronic devices, such as microphones, while also not having an “adverse impact on sound quality.” (Ex. 1004 at 2:11–12, 15.) Increased polymer rigidity caused by using a crosslinker may negatively impact the sound quality of electronic devices having microphones or speakers, such as mobile phones, discouraging a POSA from incorporating a crosslinker.

83. Other considerations would dissuade a POSA from adding a crosslinker

to the monomers disclosed in Coulson-122 or Badyal. The increased rigidity that can result from adding a crosslinker may be undesirable for movable components, such as buttons and switches, as movement could cause cracking which can compromise the coating. Further, Coulson-122 shows that a coating with oil- and water-repellant properties can be achieved without the need for a crosslinker. (*Id.* at 4:29–5:6.) A POSA would be motivated to achieve a more economical process. Accordingly, a POSA would be motivated to minimize the number of reagents and would not reach for additional, unnecessary reagents, especially considering such an addition could also negatively impact the performance of the coating. Adding more reagents also increases the complexity of a plasma polymerization process and presents additional challenges delivering multiple reactants uniformly. If reactants are not delivered uniformly, the resulting polymer will be non-uniform and can be non-conformal.

84. A POSA reviewing the Coulson-122 and Badyal references would understand that Coulson-122 was published more than 7 years after Badyal. Despite the references having overlapping inventors (Stephen Coulson), Coulson-122 never suggests that a crosslinker would improve a protective coating for electronic devices. A POSA therefore would be skeptical that the crosslinkers disclosed in Badyal would improve the protective coating for electronics disclosed in Coulson-

122 when Coulson-122 itself does not disclose or suggest incorporating Badyal's crosslinkers.

85. As discussed above, A POSA would not read Badyal's disclosure to be so expansive as to include crosslinkers of formula (I) having any bridging group Z known in the polymer art. Accordingly, Badyal would not have motivated a POSA to select a bridging group from any of the unrelated secondary references—Cohen, Holliday, Padiyath, Francesch, and Tropsch—instead of a “particularly preferred” group described by Badyal's formula (II). Further, none of the asserted secondary references (Cohen, Holliday, Padiyath, Francesch, or Tropsch) provide any disclosure or teaching that the crosslinking compounds identified by Petitioner would be suitable for use with the monomer compound recited in claim 1, or in particular with PFAC8 or PFMAC8, either in a conventional polymerization process, or in a plasma polymerization process. In addition, none of those crosslinking compounds are disclosed or suggested by Badyal. Accordingly, a POSA would lack motivation to combine the cherry-picked crosslinking compounds from the secondary references with the monomers disclosed in Coulson-122 or Badyal.

86. Cohen, Holliday, and Tropsch each fail to show their crosslinkers would yield crosslinked polymers having oil or water repellant properties when used

in plasmas so would not be suitable crosslinkers according to Badyal. Cohen does not describe using DVTMDS in a plasma nor does it describe that DVTMDS would be used to create crosslinked polymers having oil or water repellant properties. Instead, Cohen describes that copolymers made using DVTMDS could be used “alone or in combination with other insulating materials.” (Ex. 1006 at 5:2–7.)

87. Holliday also fails to describe that BDVE or DCHD could be used in plasma or to create polymer having oil or water repellant properties. Instead, Holliday describes using crosslinkers in compositions for “use in electrical insulating applications.” (Ex. 1007 at 1:22–23.)

88. Padiyath describes multilayer films including polymer and diamond-like carbon layers (Ex. 1008 ¶¶ 5–7, 25, 26, 52.) Padiyath teaches away from providing a single layer polymer coating, stating that multiple different layers of alternating inorganic layers separated by polymer coatings are required for superior barrier performance:

It is commonly accepted that *multiple inorganic layers separated by polymer coatings are needed to achieve superior barrier performance.* (Ex. 1008 ¶ 3) (emphasis added.)

Adding more layers may improve the lifetime of the assemblies by increasing their imperviousness to oxygen, moisture, or other

contaminants. Use of more or multiple layers may also help cover or encapsulate defects within the layers. (Ex. 1008 ¶ 26.)

Accordingly, Padiyath would lead a POSA away from forming a single layer coating as claimed in the '876 patent. For this reason, a POSA would not be motivated to combine Padiyath with Coulson-122 or Badyal.

89. Although Padiyath mentions plasma polymerization as one possible way to form the polymer layer, it does not suggest combining a monomer and a crosslinking reagent in a plasma as required in claim 1. Instead, Padiyath focuses on “crosslinking the layer to form the polymer in situ, e.g., by flash evaporation and vapor deposition of a radiation crosslinkable monomer, followed by crosslinking using, for example, an electron beam apparatus, UV light source, electrical discharge apparatus or other suitable device.” (Ex. 1008 ¶¶ 52, 61.) The process described in Padiyath leads away from applying a crosslinking reagent in combination with a monomer in the plasma by teaching a preference for crosslinking in-situ after polymer layers have already been formed.

90. Tropsch does not show using HDVE in a plasma nor does it describe that HDVE would be used to create crosslinked polymers having oil or water repellant properties.

91. Cohen, Holliday, and Tropsch each fail to teach use of the claimed

crosslinking reagent in connection with producing a protective coating for an electronic device via a *plasma* polymerization process. As discussed above, the structure of a coating obtained by plasma polymerization is inherently unpredictable, a POSA would not have a reasonably expected to succeed in combining the crosslinkers identified by Petitioner from these references with the monomers described in Coulson-122 and Badyal to produce a protective coating via a plasma polymerization process.

92. A POSA would not have a reasonable expectation of success in combining Padiyath with Coulson-122 and Badyal. Padiyath discloses a multilayer film including a crosslinked polymer layer. (Ex. 1008 ¶ 52.) Padiyath however does not describe the polymer layer as a barrier layer and, rather, refers to the layer as one layer in the multilayer stack of the barrier assembly. (*Id.* ¶ 51.) Padiyath teaches away from the claimed invention by stating multiple inorganic layers separated by a polymer layer are needed to achieve superior barrier performance. (*Id.* ¶ 3.) In reading, Padiyath a POSA would not expect successful barrier properties from the crosslinked polymer layer alone. Further, Padiyath fails to teach use of the claimed monomer compound and crosslinking reagent together in its polymer layer. Accordingly, even if a POSA would have been motivated to combine Padiyath with Coulson-122 and Badyal, they would not have a reasonable expectation of success

in arriving at the claimed invention of claim 1.

93. Francesch involves the fabrication of bioactive surfaces using plasma polymerization of a monomer, PFM, which is not disclosed in the '876 patent, with and without a crosslinker. (Ex. 1009 at 605.) Francesch does not describe that the crosslinker could be used to obtain a protective coating for an electronic device. Rather, Francesch focuses on properties such as the surfaces' ability to bind biological molecules. (*Id.* at 605, 610.) It does not discuss properties, such as water contact angle or resistance, which the '876 patent considers relevant to producing an effective protective coating for an electronic device. (Ex. 1001 at 3:55–4:35.) Francesch also fails to show use of the crosslinker with the claimed monomer compounds or it could be used to obtain a protective coating for an electronic device using those compounds. Accordingly, a POSA would not have a reasonable expectation of success in combining Francesch with Coulson-122 and Badyal to arrive at the invention of claim 1.

XI. CLAIMS 2–15 ARE NOT OBVIOUS BASED ON THE COMBINATION OF COULSON-122, BADYAL, AND EACH OF COHEN, HOLLIDAY, PADIYATH, FRANCESCH, AND TROPSCH

94. For the purposes of the preliminary response, I have not been asked to review the dependent claims 2–15 for any of the asserted grounds. However, claims 2–15 each depend from claim 1, and therefore include all of the limitations of claim

1. For at least the reasons stated with respect to claim 1 for each of the asserted Grounds, I have concluded that Dr. Gleason has not shown that the challenged claims of the '876 patent cover subject matter that would have been obvious based on the asserted references to a person skilled in the art at the time of the invention.

I hereby declare that all the statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further 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.

Dated: October 30, 2020

By: _____

Gregory N. Parsons, Ph.D.

GREGORY N. PARSONS, Ph.D.

Narrative:

Gregory Parsons is Celanese Acetate Professor of Chemical and Biomolecular Engineering at North Carolina State University. He received a Bachelor's degree in Physics from the State University of New York and a PhD in Physics in at NC State University studying Plasma CVD of Hydrogenated Amorphous Silicon. In 1990 he began a postdoc at IBM TJ Watson Research Center working on thin film transistor materials for flat panel displays, and joined NC State Chemical Engineering in 1992 as an Assistant Professor to explore surface reactions in thin film materials, including Atomic Layer Deposition. In 2001 he initiated the annual International AVS ALD Conference where he remains in active leadership. He has published more than 200 articles in reaction mechanisms during atomic layer deposition and molecular layer deposition, ALD on polymers and fibers, ALD for metal organic frameworks, reaction system scaling, ALD for energy storage and harvesting, as well as selective area ALD for advanced electronic devices. He was elected Fellow of the American Vacuum Society in 2005, and he served from 2011-2013 on the AVS Board of Directors. He is the recipient of an NSF Career Award, the Alcoa Foundation Distinguished Engineering Research Award, and a Semiconductor Research Corporation Invention Award. He is also an accomplished classroom teacher, being named to NC State's Academy of Outstanding Teachers in 2009. He is the 2014 recipient of NC State's RJ Reynolds Award, the College of Engineering's highest distinction for faculty research, teaching and service. In 2015 he received the ALD Innovation Award, the highest recognition of accomplishment in the ALD community, and in 2016 was named to the inaugural class of the NC State Research Leadership Academy.

Education

Post-doctoral Researcher, 1990-92, IBM T.J. Watson Research Center
Ph.D. Physics, May 1990, North Carolina State University
B.A. Physics, May 1980, State University of New York, College at Geneseo

Research and Employment Experience

2020 – : Associate Faculty, Department of Physics, NC State University
2018 – : Celanese Acetate Professor Dept. of Chemical and Biomolecular Eng., NC State Univ.
2009 – 2018: Alcoa Professor Department of Chemical and Biomolecular Eng., NC State Univ.
1993 – : Adjunct Faculty, Department of Materials Science and Eng., NC State University
2012 – 2014: Visiting RTI Senior Fellow Research Triangle Institute, RTP NC (half-time)
2002 – 2009: Professor, Department of Chemical and Biomolecular Eng., NC State Univ.
1998 – 2002: Associate Professor, Department of Chemical Engineering, NC State University
1992 – 1998: Assistant Professor, Department of Chemical Engineering, NC State University
1990 – 1992: Post-Doctoral Researcher, IBM T.J. Watson Research Center, Yorktown Heights, NY
1984 – 1990: PhD Student, Dept. of Physics, NC State University (Advisor: Gerald Lucovsky)

1980 – 1984: Research Technician, GTE Laboratories, Waltham Massachusetts

Litigation and Expert Experience

Consultation

2017-2018: Civil Action No. 1:16-cv-11249-WGY, Harvard University vs. Micron Technology Inc., US Patents Nos. 6,969,539, 7,507,848, 8,334,016.
2016: Harvard University vs. Global Foundries Inc., US Patents Nos. 6,969,539, 7,507,848, 8,334,016.
2016: TSMC Inter Partes Review Petition, U.S. Patent Nos. 6,521,911, 6,734,069.
2013-14 Ziptronix, Inc. v. OmniVision Technologies, Inc., et al., Case No. 4:10-cv-05525-SBA (EDL). U.S. Patent Nos. 7,387,944, 7,335,572, 7,553,744, 7,037,755, 6,864,585, 7,807,549, 7,871,898, 8,053,329, 8,153,505.
2011: International Trade Commission Investigation 337-TA-749 Regarding Certain LCD Devices

Trial

2011 Thomson Licensing v. Qisda et al., International Trade Commission Investigation 337-TA-749. Trial testimony on behalf of the plaintiff

Deposition

2011 Thomson Licensing v. Qisda et al., International Trade Commission Investigation 337-TA-749. Deposition testimony on behalf of the plaintiff

Reports

2017 Infringement upon U.S. Patent 6,969,539
Infringement upon U.S. Patent 7,507,848
Infringement upon U.S. Patent 8,334,016
2011 Infringement upon U.S. Patent 5,621,556
Infringement upon U.S. Patent 5,978,063
Validity of U.S. Patent 5,621,556
Validity of U.S. Patent 5,978,063

Web of Science: 273 publications, 7055 citations, h-factor = 46

Google Scholar: 9954 citations, h-factor = 54

Research interests: Semiconducting and electronic materials and devices. Atomic layer deposition of thin films. Electronic and photoactive materials and devices. Surface reactions in atomic and molecular layer deposition of inorganic and organic materials. Organic/inorganic interfaces and interface formation chemistry. Fundamental modeling and experiments of surface modification and deposition reactions.

Awards and Recognition

2019 Top Reviewer, ACS Chemistry of Materials
2018 Celanese Acetate Professorship
2017 Alumni Distinguished Graduate Professorship Award
2017 *AVS Journal of Vacuum Science and Technology* Most Valuable Reviewer
2016 Alumni Association Outstanding Research Award
2016 NC State Research Leadership Academy
2015 NC State Thank a Teacher Recipient
2015 International ALD Innovation Award
2014 RJ Reynolds Award for Research Teaching and Extension
2012 Visiting Senior RTI Fellow
2011 Named Nanotechnology Thought Leader by Nanowerk.com
(<http://www.nanowerk.com/news/newsid=21124.php>)
2009 Alcoa Professorship
2009 NC State Alumni Outstanding Teacher Award
2009 NC State Outstanding Teacher Award, Member, Academy of Outstanding Teachers
2008 Alcoa Foundation Distinguished Engineering Research Award
2006 Invited PhD Opponent, Helsinki University of Technology, Helsinki Finland
2005 AVS Fellow
2000 SRC Invention Award
1999 Alcoa Foundation Engineering Research Achievement Award
1996 NSF Faculty Early Career Development Award
1991 IBM First Patent Award
1989 Materials Research Society Student Research Award
1988 Elected to Sigma Pi Sigma, Physics Honor Society
1980 Geneseo Alumni Scholarship, highest physics GPA

Professional Society Memberships

American Institute of Chemical Engineering
American Vacuum Society
Sigma Pi Sigma: National Physics Honor Society

Service and Outreach

Professional Service

2018 – HERALD Grant Committee
2018 - American Vacuum Society, International Interactions Committee Chair
2017 – ALD Academy – Founder and Lecturer
2018 3rd Area Selective Deposition Workshop, Program Chair
2017 DTRA Science Review, Host and Organizing Committee

2015 - 2017 American Vacuum Society, Publications Committee Chair
 2013 - 2014 American Vacuum Society, International Interactions Committee Chair
 2010 - 2013 American Vacuum Society, Board of Directors
 2008 - 2010 NC Nanotechnology Commercialization Conference, Organizing Committee
 2001 - International Atomic Layer Deposition Conference, Program Committee
 2003 - 2010 Journal of Vacuum Science and Technology, Associate Editor
 2001 - 2010 Journal of Vacuum Science and Technology, Editorial Board,
 2003 International Atomic Layer Deposition Conference, Conference Chair
 2001 International Atomic Layer Deposition Conference, Conference Originator
 2000 - 2003 MRS Symposium Advisor, Symposium A, Amorphous Silicon Materials
 1999 - 2000 American Vacuum Society, Thin Film Division Chair
 1997 - 2000 American Vacuum Society, Thin Film Division Program Committee
 1997 - 1998 MRS Symposium Chair, Flat Panel Display Materials

University Service

2019 – 2020 Chair, NC State Research Leadership Academy
 2019 Chair, 2019 NC State University Research Symposium
 2018 – 2019 Chair-Elect, NC State Research Leadership Academy
 2017 – METRIC Magnetic Resonance User Committee
 2017 – COE representative, Plant Sciences Building Planning Committee
 2016 – 2018 Member, NC State Research Leadership Academy
 2012 – 2016 GAANN NEEM Scholarship PI
 2012 – 2015 University Liaison, Research Triangle Institute
 2006 – 2014 Nanotechnology Initiative, Director
 1995 – 2012 GAANN EIMat/NEEM Scholarship Committee
 2010 – 2011 Chancellor’s Research and Scholarship Strategic Planning Committee
 2010 – 2011 Vice Chancellor’s Research Facilities Steering Committee
 2009 – 2010 College of Textiles Faculty Search Committee
 2005 – 2009 Intellectual Property Committee
 2008 Vice Chancellor for Research and Graduate Studies Search Committee
 2005 – 2006 Nanotechnology Steering Committee

Department Service

2019 – 2020 Chair, Post-tenure Review Committee
 1995 – Undergraduate Advisor, Electronic Materials/Nanoscience Option
 2015 - 2016 Faculty Search Committee
 2010 – 2011 Faculty Search Committee, Chair
 2010 – 2011 Post-tenure Review Committee
 2008 – 2010 Graduate Student Recruiting Committee
 2009 – 2010 College of Textiles Faculty Search Committee
 2003 – 2006 Faculty Search Committee, Chair
 1999 – 2006 Faculty Search Committee
 2002 – 2003 Awards Committee
 1996 – 1999 Graduate Student Recruiting Committee, Chair
 1999 Centennial Campus Building Design Committee
 1993 – 1996 Graduate Student Recruiting Committee
 1995 COE Open House, ChE Organizer

Consulting

2011 - VaporPulse Technologies
1998 - National Science Foundation
2011 Thomson Licensing, Kirkland and Ellis LLP
2008 - 2010 Alditri Technologies
2005 Dow Corning
1998 Environmental Protection Agency
1997 - 1998 Becton Dickinson
1993 - 1994 Tokyo Electron

Journal Review Assignments

Reviewed many journals for:

American Chemical Society
Nature
Electrochemical Society
Elsevier
American Vacuum Society
American Institute of Physics

Outreach, Community Interactions, and Research Leadership

2017 – present: **ALD Academy:** In collaboration with Prof. Erwin Kessels at Eindhoven Technical University in The Netherlands, Parsons inaugurated the ALD Academy to provide tutorial lectures, free of charge (only asking for travel reimbursement), to groups or conferences interested in learning about ALD. To date, we presented lectures to several hundred participants in several locations in Europe, Asia and America.

2016 – present: **ASD Workshop:** Parsons worked with Annelies Delabie at IMEC in Belgium to found the annual Area-Selective Deposition (ASD) Workshop, attracting international academic and industrial researchers to discuss research in thin film nucleation and patterning. Parsons organized and chaired the 2018 ASD Workshop at NC State in Raleigh, attracting more than 150 participants.

2007 – present: **NC State NanoDays.** Parsons research group participates in NanoDays, bringing more than 3,000 K-12 teachers and students to NC State to see and learn about nanoscience and nanotechnology activities on campus. Parsons group members regularly contribute to other science and engineering K-12 and community events.

2008 – present: **Technology Translation and Entrepreneurship:** Parsons pushes technology transfer from his lab by working with former students to create start-up companies, including VaporPulse Technologies (2010-present) and Alditri Technologies (2008-2010). VaporPulse income grew substantially in 2015, and is engaged in several SBIR and private contracts.

2014 – 2015: **Research Triangle Institute Liaison to NC State University.** Parsons collaborated with Jackie Olich, RTI Director, University Collaborations, to promote the RTI Visiting Scholars Program and other interactions between RTI and NC State researchers. Position was transferred to Rick Liston in the NC State Office of Research, Innovation and Economic Development in January 2015.

2012 – 2013: **Visiting Senior Fellow at Research Triangle Institute and RTI Liaison to NC State University.** The position was created to improve NC State's communications with RTI, and to seek ways to improve research collaborations. As part of his role, Parsons worked with researchers in RTI's Solar Fuels Center, the Center for Aerosol and Nanomaterials Engineering and the Center for Materials and Electronic Technologies.

- 2013: ***RTI Visiting Scholars:*** As RTI Liaison, Parsons conceived and formally proposed development of RTI Visiting Scholars Program to RTI leadership. His program was accepted and announced to the North Carolina academic community in December 2013. The program provides funding for University faculty from the RTP region and elsewhere to partner with RTI researchers and build collaborations to address outstanding science and social challenges. The program continues with strong support.
- 2006 – 2014: ***Nanotechnology Initiative:*** Parsons conceived, secured funding and led the NC State Nanotechnology Initiative, designed to build external visibility in nanotech, coordinate and promote interdisciplinary nanotech research across the university, and develop outreach to the K-12 community. New nanotech research programs started at NC State during this time include an NSF Center for Chemical Innovation, the NSF Assist ERC, the DoE Power America Hub, the NSF Research Triangle Nanotechnology Network, and others. The Initiative also supported development of the NanoDays outreach program, led by Gail Jones in the NC State Dept of Education, which interacts with more than 2000 K-12 students and teachers from across NC every year.
- 2012: ***Governor's Luncheon:*** Invited by Governor Bev Purdue to discuss with other leaders ways to broaden commercial opportunities for new technologies.
- 2009: ***Pubic Lectures on Nanotechnology:*** Parsons presented eight public lectures regarding Nanotechnology and Society to groups including Raleigh Rotary Club (Dec. 8), NC State Faculty Scholars Forum (Oct. 12), NC Biotechnology Center Nano Summit (Oct. 8), Federation of Defense & Corporate Counsel (NY, NY, Sept. 11), Tech Transfer Interaction Meeting (July 30), NanoDays (April 24), NC Nanotech Commercialization Conf. (March 26), and the Sanford NC Rotary Club (March 17).
- 2008: ***NC Nanotech Commercialization Conference:*** Led by John Hardin in the North Carolina Department of Commerce, Parsons helped develop and promote the first North Carolina Nanotech Commercialization Conference to connect academics with industry leaders to address challenges in Nanotech Industries. The conference continues now as the Nanomanufacturing Conference, held in Greensboro in fall 2015.
- 1992 – present: ***Cross-Disciplinary Research:*** Led and/or promoted cross-disciplinary Research Center activity, including NCSU ERC for Advanced Electronic Materials Processing, SRC/SEMATECH Front-End-Processing Center, STC for Environmentally Friendly Solvents and Processes, the NC State Nanotechnology Steering Committee, and the NC State Nanotechnology Initiative. Parsons currently collaborates with Jacob Jones, Director of the Research Triangle Nanotechnology Network to attain equipment and build capacity for external research interactions.

Educational and Mentoring Contributions

Research Mentoring

Current research group: 10 PhD students, 1 Visiting PhD student, 2 Senior Researchers, 2 Postdocs, 4 BS students.

Graduated/Completed group members: 13 postdocs, 34 PhD, 6 MS, 68 BS, 2 High School students.

Former PhDs and postdocs in tenured or in tenure-track academic positions: 8, including positions at: University of Alabama, Tuscaloosa, University of Maryland, Baltimore County, North Carolina State University, James Madison University, and others.

Mentoring of underrepresented groups: Current and former group members (including graduate, undergraduate, postdocs and visiting scientists) total more than 130 individuals. These include 34 females, 4 African Americans and 1 Hispanic. I continue to seek opportunities within the University and elsewhere to recruit and support students and postdocs from underrepresented groups.

PhD Theses Directed

	Student	Start	Finish	Degree	Current Position
1.	Easwar Srinivasan	8/92	5/97	Ph.D.	Lam Research, Tualatin OR
	Thesis: Fundamental Surface Reactions in Amorphous Silicon Deposition				
2.	Tom Yang	8/93	9/98	PhD(ECE)	Unipac Optoelectronics, Taiwan
	Thesis: Full Self Aligned a-Si TFT's and TFT's on plastic substrates				
3.	Ashfaque Chowdhury	8/94	5/99	PhD	General Electric, Cleveland OH
	Thesis: In-situ Characterization of Plasma Deposition Processes				
4.	Tonya Klein	8/94	8/99	PhD	Associate Prof., U Alabama
	Thesis: Advanced Dielectrics for TFT's and for CMOS Devices				
5.	James J Chambers	8/95	7/00	PhD	AMD, Austin TX
	Thesis: Physical and Electrical Properties of Yttrium Oxide High-k Dielectrics				
6.	Atul Gupta	8/96	8/01	PhD	Varian Semiconductor, MA
	Thesis: Reactions in Silicon and Low Temperature SiO ₂ Deposition				
7.	Dong Niu	8/97	8/02	PhD	Lam Research, Tualatin OR
	Thesis: Chemical Vapor Deposition of High-k Dielectrics				
8.	Kevin Bray	8/97	8/02	PhD	K-Systems, Dayton Ohio
	Thesis: Surface Transport Processes During Deposition on Hydrogenated Amorphous Silicon				
9.	Jason Kelly	8/98	12/05	PhD	Commissioning Agents, Inc
	Thesis: Surface Reactions in high-k dielectric deposition				
10.	KeiJin Park	8/00	12/05	PhD	Samsung, Seoul Korea
	Thesis: Atomic Layer Deposition of Ru and Rh for metal gate electrode applications				
11.	Changwoong Chu	8/01	12/05	PhD	Samsung, Seoul Korea
	Thesis: Nanoscale electrode patterning and molecular electronic junction analysis				
12.	David Terry	8/00	5/06	PhD	Quality Chem. Labs, Wilmington NC
	Thesis: Atomic layer deposition of high-k dielectrics and metal gate electrodes				
13.	Kevin Hyde	8/03	8/07	PhD, Textiles	Glen Raven, SC
	Thesis: Layer-by-layer and atomic layer deposition of films on textile fibers				
14.	Sang Oh	6/03	12/07	PhD (MSE)	Lam Research, Fremont CA
	Thesis : In-situ analysis of low temperature metal ALD				
15.	Qing Peng	8/04	6/09	PhD	Univ. Alabama Tuscaloosa
	Thesis: Nanoscale Engineering of Materials with Supercritical Fluid and Atomic Layer Deposition				
16.	Jeong-Seok Na	8/04	7/09	PhD	Lam Research, Fremont CA

Thesis: Nanoscale Assembly for Molecular Electronics and In Situ Characterization During Atomic Layer Deposition

17. Joe Spagnola 6/05 5/10 PhD (MSE) 3M, Minnesota
Thesis: Polymer and Fiber Modification using Atomic Layer Deposition
18. Bo Gong 8/07 5/12 PhD Lam Research, Tualatin OR
Thesis: Reactions during Atomic Layer Deposition on Polymers
19. Kyoungmi Lee 8/08 8/13 PhD Postdoc MIT Dept of Chem Eng
Thesis: Atomic Layer Deposition on Cotton and ALD Nanosheets
20. Do-Han Kim 8/08 8/13 PhD Postdoc MIT Dept of Chem Eng
Thesis: ALD for Dye-Sensitized Solar Cells
21. Christina Devine 8/08 7/13 PhD US Patent Office, Wash DC
Thesis: ALD on Carbon Nanotubes and Mechanical Modification of Polymers
22. William Sweet 8/09 6/14 PhD Northrup Grumman, Baltimore MD
Thesis: Application of Conductive Thin Films and Selectively Patterned Metal Oxide Coatings on Fibers by Atomic Layer Deposition.
23. Sarah Atanasov 8/10 6/15 PhD Components Research, Intel, OR
Thesis: Substrate-Selective Growth and Organic / Inorganic Materials Integration by Atomic and Molecular Layer Deposition
24. Moataz Mousa 8/10 9/15 PhD ASM, Phoenix Arizona
Thesis: High Throughput Atomic Layer Deposition Processes: High Pressure Operations, New Reactor Designs, and Novel Metal Processing
25. Berc Kalanyan 8/09 12/15 PhD NIST, Gaithersburg MD
Thesis: Atomic Layer Deposition for Electronic Applications: Metal Interconnects, Conductive Textiles, and Photoelectrodes.
26. Halil Ibrahim Akyildiz 8/10 12/15 PhD, MSE (w/Jess Jur) Postdoc, NC State
Thesis: Formation of Organic-Inorganic Hybrid Materials by Sequential Vapor Infiltration
27. Junjie Zhao 8/11 4/16 PhD Postdoc - MIT Dept of Chem Eng.
Thesis: Metal-Organic Framework (MOF) Thin Films on Fibers Enabled by Atomic Layer Deposition (ALD)
28. Erinn Dandley Needham 8/12 6/16 PhD Intel, Portland Oregon
Thesis: Atomic Layer Deposition for the Modification and Creation of Nanomaterials
29. J. Zach Mundy 8/12 6/17 PhD BASF, New Jersey
Thesis: Deposition Processes for Multifunctional Nanocoatings on Polymers
30. Paul Lemaire 8/12 6/17 PhD Lam Research, Tualatin OR
Thesis: Atomic Layer Deposition and Controlling Film and Crystal Nucleation
31. James Daubert 8/12 6/17 PhD Northrup Grumman, Baltimore MD
Thesis: Atomic Layer Deposition for Electrochemical Applications: Energy Storage and Corrosion Protection.
32. Eric Stevens 8/13 5/18 PhD ASM, Phoenix, AZ
Thesis: From Novel Processes to Industrially Relevant Applications: Atomic Layer Deposition of Metal, Metal Oxide, and Metal Carbide Thin Films
33. Jennifer Ovental 8/13 6/18 PhD, with Saad Khan Micros, Durham, NC
Thesis: Methods and processes for molecular scale coupling of organic and inorganic materials
34. Mariah Ritz King 8/13 7/18 PhD, with Erik Santiso NC School of Science & Math
Thesis: Enhanced Materials Analysis Using Engineering Computational Tools for Applications in Electronics Fabrication and Surfactant Production

35.	Wenyi Xi	8/13	4/19	PhD	Postdoc – NC State
	Thesis: Thermal atomic layer etching and vapor phase infiltration for carbon materials synthesis				
36.	Dennis Lee	8/14	4/19	PhD	Postdoc - Johns Hopkins University
	Thesis: Chemical protective metal-organic framework thin films on fiber systems driven by atomic layer deposition				
37.	Heather Barton	8/15		PhD	
38.	Seung Keun Song	8/16		PhD	
39.	Amanda Volk	8/16		PhD	
40.	Siyao Wang	8/16		PhD	
41.	Holger Saare	8/16		PhD, Physics	
42.	Rachel Nye	8/17		PhD	
43.	Jung-Sik Kim	8/17		PhD	
44.	Leah Granger	8/17		PhD (with D. Brenner)	
45.	Sarah Smith	8/18		PhD	
46.	Hwan Oh	8/19		PhD	

MS Students

	Student	Start	Finish	Degree	Current Position
1.	Walter Bill Read	8/93	12/97	MS	Intel, Phoenix Arizona
	Thesis: Low Temperature Selective Area Deposition of Silicon				
2.	Chris Makosiej	8/96	5/99	MS	Schweiserhall, Inc., SC
	Thesis: Barrier Properties of Dielectric Films on Plastics				
3.	Powan Mehan	8/01	8/03	MS	
	Course-only MS				
4.	Tom Abatemarco	8/00	8/03	MS	
	Course-only MS				
5.	Dipak Barua	8/03	5/05	MS	PhD, NC State
	Thesis: Metal Deposition in Supercritical Fluids				
6.	Catherine Yingzhen Lu	8/10	5/12	MS	PhD at UT Dallas

Undergraduate Researchers

	<u>Start</u>	<u>Finish</u>	<u>Current Position</u>
1. Tim Anderson	9/94		5/97 Milliken
2. Steve Ellis	9/95		5/97 Motorola - grad school
3. Daniel Lloyd	1/95		5/96 Proctor and Gamble
4. Jeremy Bordeaux	5/96		1/97UNC Medical School
5. Chris Arthur	5/96	5/98	IBM East Fishkill
6. Andrew Lemonds	1/97	5/99	UT Austin Ph.D. program
7. Thumai Pham	8/98	5/99	Samsung, Texas
8. Kai Wang	1/99	12/99	UC Berkeley Ph.D. program
9. Bill Ketchie	1/00	12/01	UVA CHE Ph.D. program
10. Franklin Goldsmith	1/02	5/02	MIT ChE Ph.D. program
11. Leonard Nelson	8/00	5/02	Notre Dame Business School
12. Tammi Schmitt	5/01	5/02	Consultant, Greenville SC
13. Clint Smoke	8/01	5/02	
14. Scott Burnside	8/00	8/02	GlaxoSmithKline, RTP NC
15. Rob Ashcraft	8/00	8/02	MIT CHE Ph.D. program
16. Bryce Sturdevent	8/02	1/03	PhD Purdue
17. Justin Bennett	8/98	5/03	East Carolina U.
18. Kiel Chapman	1/03	5/03	
19. Jason Doub	1/02	5/04	ATMI Inc, Idaho
20. Joe Spagnola	1/03	5/04	Ph.D. MAT NCSU
21. Katherine Schadel	1/04	5/05	Ph.D. program MIT
22. Justin Hill	5/04	8/05	Ph.D. program UFlorida
23. Paige Auten	5/04	12/04	Ph.D. program Ga Tech
24. Erin D. Young	5/04	8/04	BS REU student
25. Michael Stewart	6/05	8/07	PhD, UC Santa Barbara
26. Linda Bruner	8/05	12/06	
27. Daniel Ruby	1/06	12/06	
28. Eric Petschke	5/06	8/06	Exxon Mobil
29. Zack Conrad	5/06	8/06	
30. Kimberly Ager	5/07	8/07	BS Penn State
31. Justin Wood	5/07	8/07	BS NC State
32. Ryan Van Gundy	10/05	5/08	Connecticut
33. Zach Nicholson	1/07	8/08	
34. Andrew Canton	1/08	8/08	
35. Kelly Roth	5/07	12/08	MS NCSU COT
36. Berc Kalanyan	5/08	8/08	PhD NC State
37. Christine Watson Link	1/07	12/08	PhD UCSB
38. Erin Green	8/08	12/08	
39. Chris Hanson	5/08	5/10	Exxon Mobil, Houston
40. Kai Presler-Marshall (high school student)	5/10	8/10	NC School of Sci and Math
41. Nicholas L. Abram (high school student)	9/10	1/11	Undergraduate, Stanford U.
42. Hanna Reese	1/10	8/10	PhD

43. Michael Carpenter	5/08	5/11	BS NC State
44. Shane Di Dona	8/08	5/11	MS NC State
45. D. Evan Piephoff	1/11	5/11	BS NC State
46. Mariah Woodroof	8/10	8/11	PhD Delaware
47. Barry Hiney	1/10	6/12	Peace Corps, Africa
48. Harshad Srinivasan	1/11	12/11	PhD NC State
49. Ashwin P. Srikrishna	1/11	5/12	BS ChE NCSU
50. Deon Bharrat	5/11	6/12	PhD MSE NC State
51. Nik Sigmon	1/10	5/13	
52. Sven Soltmann	5/11	5/13	BS Mech Eng
53. Michael Naclerio	5/12	12/12	BS Chem Eng
54. Trent Blevins	4/12	12/14	Employed in Raleigh
55. Matt Salmon	5/13	5/15	
56. Billy Nunn	8/13	5/15	PhD ChE Wisconsin
57. Omar Knio	10/13	5/15	PhD ChE GaTech
58. Clayton Shaffer	5/13	5/16	
59. Cailean Pritchard	8/13	5/15	RTI
60. Saif Hassan	10/13	5/17	
61. Allie Cox	8/14	5/16	
62. Hannah Gotsch	7/14	5/16	Industry position
63. Brent White	5/15	5/17	
64. Michael Hinkson	6/16	5/17	Duke MS Program
65. Ian Woodward	6/15	5/17	University of Delaware Chem Eng PhD Program
66. Parker Colbath	1/15	5/17	
67. Kraig Turner	10/16	5/17	
68. Grant Hill	6/14	5/18	
69. Antoine Gremaud	5/16	5/19	Peace Corps
70. Jovenal (Joe) Jamir	5/16	5/19	
71. Alexandra Davis	1/17	5/19	
72. Sara Bartczak	5/17	5/19	
73. Alex Lerner	8/18	8/21	
74. Christopher Downs	10/18	5/19	
75. Nick Carroll	9/19		
76. Andie O'Connell	9/19		
77. Devin Junkins	9/19		
78. Jimmy Donovan	9/19		

Post-Doctoral Researchers/Staff

	<u>Start</u>	<u>Finish</u>	<u>Subsequent Position</u>
1. D.H. Kim Postdoc	1/94	12/94	Faculty, Chonnam Univ. Gwangju, Korea
2. M. Fang Postdoc	1/96	11/96	Thomson Microelectronics
3. Laura Smith Postdoc	1/97	1/01	Staff Position, NSCU AIF
4. Bill Epling Postdoc	5/99	8/99	Assistant Prof, U. Alabama
5. Theodosia Gougousi Postdoc	5/01	8/04	Assistant Prof. of Physics UMBC
6. Elisa Rosa Postdoc	4/04	5/05	Brazil
7. Daisuke Hojo Postdoc	12/05	9/07	Tohoku University, Sendai, Japan
8. Giovanna Scarel Postdoc	8/07	8/09	Associate Prof., James Madison Univ.
9. Jesse Jur Res. Asst. Prof	9/08	12/10	Associate Prof, NCSU TECS
10. Kim Roberts Sr. Researcher	5/08	8/10	Director of Recruiting, NC State College of Eng.
11. Mark Losego Res. Assist. Prof	9/11	12/14	Assistant Prof., Ga Tech
12. Phil Williams Postdoc	1/13	3/15	BASF
13. Christopher Oldham Postdoc	9/09	12/14	Senior Researcher, NC State
14. Alexandra Brozena Postcoc	7/13	7/16	Founder/Editor, Advanced English Editing
15. Mike Mantini Res. Specialist	7/14	7/16	Specialty Trades Technician, NC State
16. Chris Oldham Sr. Researcher	1/15	12/18	VaporPulse Technologies Inc.
17. Cheng Cheng Research Assoc.	12/16	5/17	Applied Materials
18. Michael Fusco Postdoc	2/17	2/19	Wolfspeed, Durham NC
19. Ian Woodward Temp. Res. Asst.	5/17	4/18	University of Delaware Chem Eng PhD Program
20. Maryam Khazaei Visiting Postdoc	1/19	3/19	Intel, Phoenix Arizona
21. Wenyi Xie Postdoc	4/19		
22. Bruce Ash Research Assistant	4/19		

Thesis Committees (since 2009)

Student	Dept/Degree	Advisor
Hongping Yan	Physics PhD	Harald Ade
Paul Sujata	Physics PhD	Marco Bounjournon-Nardelli
Eun Chu (Julie) Oh	ECE PhD	Paul Franzon
Haiyan Liu	Chem Eng. PhD	Ruben Carbonell
Hyung Jun Koo	Chem Eng. PhD	Orlin Velev
Sumit Gangwal	Chem Eng. PhD	Orlin Velev
Feng He	Chem Eng. PhD	Fanxing Li

Recent Notable PhD Student and Postdoc Achievements and Recognition (since 2011)

2019	Amanda Volk: Featured “Student User Spotlight” interview on NC State’s AIF Website
2019	Holger Saare: Selected to participate in NSF/DOE Quantum Science Summer School
2019	Rachel Nye: Helen & Rolf Illsley Scholarship, Society of Vacuum Coaters Foundation
2018	Siyao Wang: Technical Merit Award, Nonwovens Institute Nov IAB Meeting
2018	Mariah King: Editor’s Pick in <i>Journal of Vacuum Science & Technology A</i>
2018	Dennis Lee: Honorable mention for microscopy, 2018 Envisioning Research contest
2018	Siyao Wang: Best Presentation Award, Nonwovens Institute May IAB Meeting
2018	Siyao Wang: 2 nd Prize, 10 th Triangle Soft Matter Workshop’s Art in Science Competition
2018	Wenyi Xie: Finalist, ALE Best Student Paper Award, ALD/ALE 2018, Korea
2018	Seung Keun Song, Finalist, ALD Best Student Paper Award, ALD/ALE 2018, Korea
2018	Dennis Lee: NC State Schoenborn Symposium, Vivian T. Stannett Fellow
2018	Rachel Nye: Honorable Mention, NSF Graduate Research Fellowship Program
2017	Dennis Lee: ACS Publications, “ACS Editors’ Choice” Recipient
2017	Junjie Zhao: Chinese Government Award for Outstanding Overseas Students
2016 – 2018	Mariah Ritz King: SRCEA Graduate Fellowship
2016	Zach Mundy: North Carolina State University’s Praxair Teaching Excellence Award
2016	Dennis Lee: 5th International Conference on Metal-Organic Frameworks & Open Framework Compounds, Student Support Award
2016	Junjie Zhao: NC State Schoenborn Competition, Runner-up: “Coupling ALD and MOFs”
2016	Dennis Lee: Korean-American Scientists and Engineers 6 th South-Atlantic Regional Conference, 1 st Place Outstanding Poster Award: “UiO-66-NH ₂ Assembly on ALD Oxide Surfaces using β -cyclodextrin and Cetyltrimethylammonium Bromide”
2015	Erinn Dandley, International ALD Conference, Student Award Finalist: “Wafer-Scale Vapor Infiltration Patterning”
2015	Berc Kalanyan: International ALD Conference, Best Poster Award: “Loading Effects during Tungsten Nucleation and Selective Area Deposition”
2015	Junjie Zhao: American Vacuum Society, Thin Film Division Student Award: “MOFs on Fibers using ALD Nucleation Layers”
2015	Eric Stevens: SRC TECHCON 2015: Best in Session Award

2015 Zach Mundy: The Nonwovens Institute Fall Industrial Advisory Board Meeting: Best Student Presentation

2015 Mariah Ritz: FOMMS 2015 Graduate Student Award

2015 Junjie Zhao: Best Paper Award using NCSU AIF Facilities: “Facile Conversion of Hydroxy Double Salts to Metal–Organic Frameworks Using Metal Oxide Particles and Atomic Layer Deposition Thin-Film Templates”

2014 James Daubert: North Carolina State University Certificate of Accomplishment in Teaching

2014 Alexandra Brozena: NSF AIR Pitching Contest, SBIR Phase II Grantees Conference: Third Prize

2014 Sarah Atanasov: Best Paper Award using NCSU AIF Facilities: “Improved Cut-Resistance of Kevlar® using Controlled Interface Reactions during Atomic Layer Deposition of Ultrathin (<50Å) Inorganic Coatings”

2013 James Daubert: U.S. Department of Education Graduate Assistance in Areas of National Need Fellowship

2013 Zach Mundy: U.S. Department of Education Graduate Assistance in Areas of National Need Fellowship

2013 William Sweet: International Atomic Layer Deposition Conference (ALD 2013), 1st place Best Poster Award: “Conductivity and Mechanical Properties of ALD Coated Nonwoven Fibers”

2013 Sarah Atanasov: Schoenborn Symposium, 3rd place poster award: “Nanoscale Modification of Kevlar via Atomic Layer Deposition for Enhanced Force Protection”

2012 Moataz Moussa: Schoenborn Symposium, 2nd place poster award: Effect of Temperature and Gas Velocity on Growth During Atomic Layer Deposition at Atmospheric Pressure”

2012 Sarah Atanasov: Annual AIChE Meeting - Materials Engineering and Sciences III Division, 1st place poster award: “Thermal Protective Properties of ALD Coated Fibers”

2012 Sarah Atanasov: International ALD Conference, Student Award: “Oxidative MLD of PEDOT”

2012 Junjie Zhao: AVS 59th International Symposium & Exhibition: First Place in Art Zone Contest

2011 Moataz Moussa: Local section of AVS MRS ASM meeting: 1st place award, oral presentation

2011 Christopher Oldham: NC State Chancellor’s Innovation Fund Award

2011 Christopher Oldham: Poole College of Management Leadership and Innovation Showcase, 1st place award

PhD Student Internships

2019	Siyao Wang	TE Connectivity, Fremont CA
2019	Heather Barton	Micross, Durham NC
2017	Mariah Ritz King	Micron Technology, Inc., Boise ID
2016 - 2017	Eric Stevens	IMEC, Leuven Belgium
2014	Junjie Zhao	Lam Research, Fremont CA
2012	Sarah Atanasov	Intel, New Mexico
2009	Bo Gong	Novellus, San Jose CA
2008	Joe Spagnola	IBM TJ Watson Research Center, NY

Research Group Outreach, Community Interactions, and Service (since 2012)

- 2018 Christopher Oldham: Volunteer judge, NC State Graduate Student Research Symposium, College of Engineering Division
- 2017 – Christopher Oldham: Co-Chair, Professional Development Task Force of the NC State Campaign Committee
- 2017 Parsons Group Service Day - Habitat for Humanity, May 20, 2017.
- 2017 Ian Woodward: Volunteer, NC Science Olympiad Elementary Event, Marbles Museum
- 2016 – Parsons Group – Volunteers, NC State NanoDays
- 2016 – Jenny Ovental: Undergraduate researcher mentor, NC State’s Parsons Group
- 2016 – Mariah Ritz King: High School Small Group Leader, Hope Community Church
- 2016 – 2017 Mariah Ritz King: Small Pack Leader, International Student Orientation, NC State
- 2016 – 2017 Heather Barton: Internal VP, Chem and Biomol Eng Graduate Student Association
- 2016 – 2017 Ian Woodward: Traditions Committee, Goodnight Scholars Program
- 2016 – 2017 Ali Stieglitz: Volunteer, The Lerner School’s Library
- 2016 Christopher Oldham: Volunteer, Raleigh School Preschool Maintenance Committee
- 2016 Eric Stevens: Volunteer, K-12 FTC Robotics Competition
- 2016 Eric Stevens: Weekly 3rd Grade Small Group Leader, Hope Community Church
- 2016 Ian Woodward: First-Year Mentor and Co-Chair of Shack-A-Thon Committee, Goodnight Scholars Program
- 2016 Ian Woodward: Team Member, Trinidad & Tobago Alternative Service Break, Trinidad
- 2016 Ian Woodward: Volunteer, NC Science Olympiad Raleigh Regional Competition
- 2015 – Jenny Ovental: Animal Foster, Wake County Animal Center
- 2015 – Jenny Ovental: Volunteer, Habitat for Humanity
- 2015 – 2016 Jenny Ovental: Recruiting Captain, Chem and Biomol Engineering Graduate Program
- 2015 – 2016 Jenny Ovental: Volunteer, Centennial Campus Middle School Science Fair
- 2015 – 2016 Ian Woodward: Executive Committee, Goodnight Scholars Program
- 2015 Christopher Oldham: Volunteer judge, Regional NC Science and Engineering Fair
- 2014 – Jenny Ovental, SPCA Dog Volunteer
- 2014 – James Daubert: NC State Representative, Research Triangle ECS Student Chapter
- 2014 – Mariah Ritz: Volunteer, Divorce Care for Kids (DC4K); Hope Community Church
- 2014 – 2016 Mariah Ritz: Volunteer judge, Science Fair at Centennial Campus Middle School
- 2014 – 2015 Mariah Ritz: Recruiting Captain, Chem and Biomolecular Engineering Graduate Program
- 2014 – 2015 Mariah Ritz: Social Chair, Chemical and Biomolecular Engineering Department
- 2013 - 2014 Erinn Dandley Needham: Recruiting Captain, Chem and Biomol Eng Graduate Program
- 2013 Alexandra Brozena: Volunteer judge, North Carolina 3A Regional Science Fair
- 2013 Junjie Zhao: Volunteer, AVS 60th International Symposium & Exhibition
- 2012 – Ali Stieglitz: Volunteer, Mitzvah Day, Jewish Federation of Durham-Chapel Hill
- 2012 Junjie Zhao: Volunteer, AVS 59th International Symposium & Exhibition
- 2008 – 2015 Ali Stieglitz: Volunteer event photographer, NC State NanoDays

Undergraduate Advising

- 2003 – Advisor, BS students in Nanoscience Option, ~15 students per year.
- 1995 – 2005 Advisor, BS students in Electronic Materials Option

Curricula Developed

- 2003 Nanoscience Option for Chemical Engineering Undergraduates
 - New curriculum to expand and replace the Electronic Materials Option

1995 Electronic Materials Option for Chemical Engineering Undergraduates

Courses Taught

CHE 205 "Chemical Process Principles", Spring, Fall 1993
CHE 225 "Chemical Process Systems", Spring 1994, 1995
CHE 311 "Transport Processes I" Fall 1995-2003, Spring 2005, Spring 2016
CHE 311H "Transport Processes I, Honors Level", Fall 2004 (*Developed course*)
CHE 315 "Chemical Engineering Thermodynamics I" Sp 2006, F 2006-2008
CHE 446 "Chemical Engineering Kinetics", Fall 2009 - 2014
CHE 460/560 "Chemical Processing of Electronic Materials" Sp1997-2004, F 2005, Sp 2008, '14, '16
CHE 495 "Seminar in Chemical Engineering" Spring 1994, 1995
CHE 596C "Fundamental Nano-scale Engineering", Spring 2005, 2007, 2009
CHE 598 "Chemical Processing of Electronic Materials", Fall 1994, Spring 1996
CHE 717 "Chemical Kinetics", Fall 2015, Fall 2017

Research Contributions

Patents Pending

<u>Filed</u>	<u>Docket/Application #</u>	<u>Title</u>
6/20/2017	10620-023WO1 PCT/US2017/038266	Metal-Organic Frameworks and Methods of Making and Use Thereof
1/23/2017	030871-9051-WO00 PCT/US2017/014607	Cellulose Acetate Aerogels
10/22/2016	16208-US 15/331,860	Deposition Process for Corrosion Protection of a Cooling Circuit
4/7/2015	1062.0008-EP 13857504.8	Assemblies and Methods of Stabilization

Disclosures Filed, Currently Active

<u>Filed</u>	<u>Case #</u>	<u>Title</u>
9/6/2016	17044	Electrochemical capacitors derived from cellulose diacetate: Effect of nitric acid, CO ₂ and ALD-based vapor metalation treatments on material and electrochemical performance
4/4/2016	16208	Nanoscale Passivation Coatings for Cooling Channels in Microwave Components
3/14/2016	16202	A Metal-Organic Framework for Broad-Spectrum Protection from Toxic Industrial Chemicals
10/22/2015	16081	Rapid Room-Temperature Synthesis of Metal-Organic Frameworks Using Layered Hydroxy Double Salts
6/25/2015	15291	Mechanically strong, reusable and compostable cellulose diacetate aerogels for oil/chemical spill cleanup

Patents Issued

2018	“Solar Water Splitting in a Molecular Photoelectrochemical Cell” Leila Alibabaei, Matthew Kyle Brennaman, Michael Norris, Gregory N. Parsons, Thomas J. Meyer, US Patent No. 10,119,197
2010	“Nano-structured photovoltaic solar cell and related methods”, Gregory N. Parsons, US Patent No. 7,655,860
2004	“Non-crystalline oxides for use in Microelectronic, Optical and other Applications”, G.N. Parsons and G. Lucovsky, US Patent No. 6,787,861.
2003	“High Dielectric Constant Metal Silicates Formed by Controlled Metal-Surface Reactions” G.N. Parsons, J.C. Chambers, M.J. Kelly, US Patent No. 6,521,911.
1992	“Pulsed Gas Plasma Enhanced Chemical Vapor Deposition of Silicon”, J. Batey, J. Boland and G.N. Parsons, US Patent No. 5,242,530.

2020

- 249 Barton, H. F.; Davis, A.; Parsons, G. N. The effect of surface hydroxylation on MOF formation on ALD metal oxides: MOF-525 on TiO₂/polypropylene for catalytic hydrolysis of chemical warfare agent simulants. *ACS Applied Materials and Interfaces*, **2020**, Just Accepted.
- 248 Dai, Z.; Lee, D. T.; Shi, K.; Wang, S.; Barton, H. F.; Zhu, J.; Yan, J.; Ke, Q.; Parsons, G. N. Fabrication of Freestanding Metal Organic Framework Predominant Hollow Fiber Mat and Its Potential Applications in Gas Separation and Catalysis. *Journal of Materials Chemistry A*, **2020**, DOI: 10.1039/C9TA11701F
- 247 Nye, R. A.; Kelliher, A.; Gaskins, J.; Hopkins, P.; Parsons, G. N. Understanding Molecular Layer Deposition Growth Mechanisms in Polyurea via Picosecond Acoustics Analysis. *Chemistry of Materials*, **2020**, DOI: 10.1021/acs.chemmater.9b0472
- 246 Xie, W.; Parsons, G. Thermal atomic layer etching of metallic tungsten via oxidation and etch reaction mechanism using O₂ or O₃ for oxidation and WCl₆ as the chlorinating etchant. *Journal of Vacuum Science & Technology A*, **2020**, DOI: 10.1116/1.5134430.

2019

- 245 Lee, D. T.; Jamir, J.D.; Peterson, G.W.; Parsons, G. N., “Protective Fabrics: Metal-Organic Framework Textiles for Rapid Photocatalytic Sulfur Mustard Simulant Detoxification” Matter 2019 DOI: 10.1016/j.matt.2019.11.005
- 244 SK Song, H Saare, GN Parsons, Integrated Isothermal Atomic Layer Deposition/Atomic Layer Etching Super-Cycles for Area-Selective Deposition of TiO₂ *Chemistry of Materials*, **2019**, 31, 4793–4804.
- 243 Natalie L. Pomerantz, Erin, E. Anderson, Nicholas P. Dugan, Nicole, F. Hoffman, Heather F. Barton, Dennis, T. Lee, Christopher J. Oldham, Gregory, W. Peterson, Gregory N. Parsons, “Air, Water Vapor, and Aerosol Transport through Textiles with Surface Functional Coatings of Metal Oxides and Metal-Organic Frameworks.” *ACS Applied Materials & Interfaces*, 2019, 11, 27, 24683
- 242 Fusco, M. A.; Oldham, C. J.; Parsons, G. N. Investigation of the Corrosion Behavior of Atomic Layer Deposited Al₂O₃/TiO₂ Nanolaminate Thin Films on Copper in 0.1 M NaCl. *Materials* **2019**, DOI: 10.3390/ma12040672
- 241 Dennis, L.; Jamir, J.; Peterson, G.; Parsons, G. N. Water-Stable Chemical-Protective Textiles via Euheudral Surface-Oriented 2D Cu-TCPP Metal-Organic Frameworks. *Small*, **2019**, DOI: 10.1002/smll.201805133
- 240 Parsons, G. N. Functional model for analysis of ALD nucleation and quantification of area-selective deposition. *Journal of Vacuum Science & Technology A* **2019**, DOI: 10.1116/1.5054285
- 239 Min, J. H.; Chen, Y. A.; Chen, I.T.; Sun, T. L.; Lee, D. T.; Li, C. J.; Zhu, Y.; O'Connor, B. T.; Parsons, G. N.; Chang, C. H. Conformal Physical Vapor Deposition Assisted by Atomic Layer Deposition and Its Application for Stretchable Conductors. *Advanced Materials Interfaces*, **2019**, DOI: 10.1002/admi.201801379

2018

- 238 Xie, W.; Khan, S.; Rojas, O.; Parsons, G. N. Control of Micro- and Mesopores in Carbon Nanofibers and Hollow Carbon Nanofibers Derived from Cellulose Diacetate via Vapor Phase Infiltration of Diethyl Zinc *ACS Sustainable Chemistry & Engineering* **2018**, DOI: 10.1021/acssuschemeng.8b02014

- 237 King, M. X.; Theofanis, P.; Lemaire, P. C.; Santiso, E.; Parsons, G. N. Ab initio Analysis of Nucleation Reactions during Tungsten Atomic Layer Deposition on Si(100) and W(110) Substrates. *Journal of Vacuum Science and Technology A* **2018**, DOI: 10.1116/1.5044740
- 236 Stevens, E. C.; Mousa, M. B. M.; Parsons, G. N. Thermal atomic layer deposition of Sn metal using SnCl₄ and a vapor phase silyl dihydropyrazine reducing agent. *Journal of Vacuum Science and Technology A*, **2018**, DOI: 10.1116/1.5055212
- 235 Cui, K.; Lemaire, P. C.; Zhao, H.; Savas, T.; Parsons, G. N.; Hart, A.J. Tungsten-Carbon Nanotube Composite Photonic Crystals as Thermally Stable Spectral-Selective Absorbers and Emitters for Thermophotovoltaics. *Advanced Energy Materials* **2018**, DOI: 10.1002/aenm.201801471
- 234 Dwyer, D.; Lee, D.; Boyer, S.; Bernier, W.; Parsons, G. N.; Jones, W. Toxic Organophosphate Hydrolysis using Nanofiber-Templated UiO-66-NH₂ Metal-Organic Framework Polycrystalline Cylinders. *ACS Applied Materials and Interfaces* **2018**, DOI: 10.1021/acsami.8b08167
- 233 Barton, H. F.; Davis, A. K.; Lee, D. T.; Parsons, G. N. Solvothermal Synthesis of MIL-96 and UiO-66-NH₂ on Atomic Layer Deposited Metal Oxide Coatings on Fiber Mats. *J. Vis. Exp.* **2018**, DOI: 10.3791/57734
- 232 Ives, R. L.; Oldham, C. J.; Daubert, J. S.; Gremaud, A. P.; Collins, G.; Marsden, D.; Bui, T.; Fusco, M. A.; Mitsdarffer, B.; Parsons, G. Corrosion Mitigation Coatings for RF Sources and Components. *IEEE Transactions on Electron Devices*, **2018**, DOI: 10.1109/TED.2017.2788379
- 231 Stevens, E.; Tomczak, Y.; Chan, B. T.; Sanchez, E. A.; Parsons, G. N.; Delabie, A. Area-Selective Atomic Layer Deposition of TiN, TiO₂, and HfO₂ on Silicon Nitride with inhibition on Amorphous Carbon. *Chemistry of Materials* **2018**, DOI: 10.1021/acs.chemmater.8b00017
- 230 Mousa, M. B. M.; Ovental, J. S.; Brozena, A. H.; Oldham, Khan, S. A.; C. J.; Parsons, G. N. Modeling and Experimental Demonstration of High-Throughput Flow-Through Spatial Atomic Layer Deposition of Al₂O₃ Coatings on Textiles at Atmospheric Pressure. *Journal of Vacuum Science and Technology A*, **2018**, DOI: 10.1116/1.5022077
- 229 Xie, W., Lemaire, P. C. and Parsons, G. N. Thermally Driven Self-Limiting Atomic Layer Etching of Metallic Tungsten Using WF₆ and O₂. *ACS Applied Materials and Interfaces* **2018**, DOI: 10.1021/acsami.7b19024
- 228 Tripathi, A.; Parsons, G. N.; Khan, S. A.; Rojas, O. J. Synthesis of organic aerogels with tailorable morphology and strength by controlled solvent swelling following Hansen solubility. *Scientific Reports*, **2018**, DOI: 10.1038/s41598-018-19720-4
- 2017**
- 227 Lee, D. T.; Zhao, J.; Oldham, C. J.; Peterson, G. W.; Parsons, G. N. UiO-66-NH₂ Metal–Organic Framework (MOF) Nucleation on TiO₂, ZnO, and Al₂O₃ Atomic Layer Deposition-Treated Polymer Fibers: Role of Metal Oxide on MOF Growth and Catalytic Hydrolysis of Chemical Warfare Agent Simulants. *ACS Appl. Mater. Interfaces* **2017**, DOI: 10.1021/acsami.7b15397.
- 226 Zhao, J.; Kalanyan, B.; Barton, H. F.; Sperling, B. A.; Parsons, G. N. *In Situ* Time-Resolved Attenuated Total Reflectance Infrared Spectroscopy for Probing Metal–Organic Framework Thin Film Growth. *Chem. Mater.* **2017**, DOI: 10.1021/acs.chemmater.7b03096.
- 225 Lemaire, P. C.; Parsons, G. N. Thermal Selective Vapor Etching of TiO₂: Chemical Vapor Etching via WF₆ and Self-Limiting Atomic Layer Etching Using WF₆ and BCl₃. *Chem. Mater.* **2017**, 29 (16), 6653–6665 DOI: 10.1021/acs.chemmater.7b00985.
- 224 Bagal, A.; Zhang, X. A.; Shahrin, R.; Dandley, E. C.; Zhao, J.; Poblete, F. R.; Oldham, C. J.; Zhu, Y.; Parsons, G. N.; Bobko, C.; Chang, C.-H. Large-Area Nanolattice Film with Enhanced

Modulus, Hardness, and Energy Dissipation. *Sci. Rep.* **2017**, 7 (1) DOI: 10.1038/s41598-017-09521-6.

- 223 Tripathi, A.; Parsons, G. N.; Rojas, O. J.; Khan, S. A. Featherlight, Mechanically Robust Cellulose Ester Aerogels for Environmental Remediation. *ACS Omega* **2017**, 2 (8), 4297–4305 DOI: 10.1021/acsomega.7b00571.
- 222 Duke, K. S.; Taylor-Just, A. J.; Ihrie, M. D.; Shipkowski, K. A.; Thompson, E. A.; Dandley, E. C.; Parsons, G. N.; Bonner, J. C. STAT1-Dependent and -Independent Pulmonary Allergic and Fibrogenic Responses in Mice after Exposure to Tangled versus Rod-like Multi-Walled Carbon Nanotubes. *Part. Fibre Toxicol.* **2017**, 14 (1) DOI: 10.1186/s12989-017-0207-3.
- 221 Daubert, J. S.; Wang, R.; Ovental, J. S.; Barton, H. F.; Rajagopalan, R.; Augustyn, V.; Parsons, G. N. Intrinsic Limitations of Atomic Layer Deposition for Pseudocapacitive Metal Oxides in Porous Electrochemical Capacitor Electrodes. *J. Mater. Chem. A* **2017**, 0 (25), 1–12 DOI: 10.1039/C7TA02719B.
- 220 Lemaire, P. C.; Lee, D. T.; Zhao, J.; Parsons, G. N. Reversible Low-Temperature Metal Node Distortion during Atomic Layer Deposition of Al₂O₃ and TiO₂ on UiO-66-NH₂ Metal Organic Framework Crystal Surfaces. *ACS Appl. Mater. Interfaces* **2017**, acsami.7b05214 DOI: 10.1021/acscami.7b05214.
- 219 Lee, D. T.; Zhao, J.; Peterson, G. W.; Parsons, G. N. Catalytic “MOF-Cloth” Formed via Directed Supramolecular Assembly of UiO-66-NH₂ Crystals on Atomic Layer Deposition-Coated Textiles for Rapid Degradation of Chemical Warfare Agent Simulants. *Chem. Mater.* **2017**, 29 (11), 4894–4903 DOI: 10.1021/acs.chemmater.7b00949.
- 218 Hilton, G. M.; Taylor, A. J.; Hussain, S.; Dandley, E. C.; Griffith, E. H.; Garantziotis, S.; Parsons, G. N.; Bonner, J. C.; Bereman, M. S. Mapping Differential Cellular Protein Response of Mouse Alveolar Epithelial Cells to Multi-Walled Carbon Nanotubes as a Function of Atomic Layer Deposition Coating. *Nanotoxicology* **2017**, 11 (3), 313–326 DOI: 10.1080/17435390.2017.1299888.
- 217 Daubert, J. S.; Hill, G. T.; Gotsch, H. N.; Gremaud, A. P.; Ovental, J. S.; Williams, P. S.; Oldham, C. J.; Parsons, G. N. Corrosion Protection of Copper Using Al₂O₃, TiO₂, ZnO, HfO₂, and ZrO₂ Atomic Layer Deposition. *ACS Appl. Mater. Interfaces* **2017**, 9 (4), 4192–4201 DOI: 10.1021/acscami.6b13571.
- 216 Lemaire, P. C.; King, M.; Parsons, G. N. Understanding Inherent Substrate Selectivity during Atomic Layer Deposition: Effect of Surface Preparation, Hydroxyl Density, and Metal Oxide Composition on Nucleation Mechanisms during Tungsten ALD. *J. Chem. Phys.* **2017**, 146 (5) 052811
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- 214 Kim, D. H.; Losego, M. D.; Peng, Q.; Parsons, G. N. Thin Films: Atomic Layer Deposition for Sensitized Solar Cells: Recent Progress and Prospects, *Advanced Materials Interfaces* **2016** 3 (21) DOI: 10.1002/admi.201670102
- 213 Zhao, J.; Lee, D. T.; Yaga, R. W.; Hall, M. G.; Barton, H. F.; Woodward, I. R.; Oldham, C. J.; Walls, H. J.; Peterson, G. W.; Parsons, G. N. Ultra-Fast Degradation of Chemical Warfare Agents

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- 212 Tovar, T. M.; Zhao, J. J.; Nunn, W. T.; Barton, H. F.; Peterson, G. W.; Parsons, G. N.; Levan, M. D. Diffusion of CO₂ in Large Crystals of Cu-BTC MOF, *Journal of the American Chemical Society*, **2016**, 138 (36), pp 11449-11452 DOI: 10.1021/jacs.6b05930
- 211 Wang, Z. T.; Zhao, J. J.; Bagal, A.; Dandley, E. C.; Oldham, C. J.; Fang, T. G.; Parsons, G. N.; Chang, C. H.; Wicking Enhancement in Three-Dimensional Hierarchical Nanostructures, *Langmuir*, **2016**, 32, pp 8029-8033 DOI: 10.1021/acs.langmuir.6b01864
- 210 Huang, L. J.; Li, G. Q.; Gurarslan, A.; Yu, Y. L.; Kirste, R.; Guo, W.; Zhao, J. J.; Collazo, R.; Sitar, Z.; Parsons, G. N.; Kudenov, M.; Cao, L. Y. Atomically Thin MoS₂ Narrowband and Broadband Light Superabsorbers, *ACS Nano*, **2016**, 10 (8), pp 7493-7499 DOI: 10.1021/acsnano.6b02195
- 209 Dandley, E. C.; Taylor, A. J.; Duke, K. S.; Ihrie, M. D.; Shipkowski, K. A.; Parsons, G. N.; Bonner, J. C. Atomic layer deposition coating of carbon nanotubes with zinc oxide causes acute phase immune responses in human monocytes in vitro and in mice after pulmonary exposure, *Particle and Fibre Toxicology*, **2016**, 13 (29), DOI: 10.1186/s12989-016-0141-9
- 208 Lemaire, P. C.; Zhao, J.; Williams, P. S.; Walls, H. J.; Shepherd, S. D.; Losego, M. D.; Peterson, G. W.; Parsons, G. N. Copper Benzenetricarboxylate Metal–Organic Framework Nucleation Mechanisms on Metal Oxide Powders and Thin Films formed by Atomic Layer Deposition, *ACS Applied Materials Interfaces*, **2016**, 8 (14), pp 9514-9522 DOI: 10.1021/acsami.6b01195
- 207 Dandley, Erinn C.; Lemaire, Paul C.; Zhu, Zhongwei; Yoon, Alex; Sheet, Lubab; Parsons, Gregory N., Wafer-Scale Selective-Area Deposition of Nanoscale Metal Oxide Features Using Vapor Saturation into Patterned Poly(methyl methacrylate) Templates, *Advanced Materials Interfaces*, **2016**, 3 (2) 1500431 DOI: 10.1002/admi.201500431
- 206 Kalanyan, B.; Lemaire, P. C.; Atanasov, S. E.; Ritz, M. J.; Parsons, G. N., Using Hydrogen to Expand the Inherent Substrate Selectivity Window During Tungsten Atomic Layer Deposition, *Chemistry of Materials*, **2016**, 28 (1), pp 117-126 DOI: 10.1021/acs.chemmater.5b03319
- 205 Atanasov, S. A.; Kalanyan, B.; Parsons, G. N. Inherent substrate-dependent growth initiation and selective-area atomic layer deposition of TiO₂ using “water-free” metal-halide/metal alkoxide reactants. *Journal of Vacuum Science and Technology A*, **2016**, 34: 01A148 (special issue on ALD) DOI: 10.1116/1.493848
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Other Publications:

12. Lucovsky, G.; Parsons, G. N.; Zeller, D.; Wu, K.; Papas, B.; Whitten, J.; Lujan, R; Street, R. A. “Spectroscopic detection of medium range order in hydrogenated amorphous Silicon, a-Si(H): applications in photovoltaics, thin film transistors and Si-based microelectronics” *Proceedings of 10th International Conference on Solid State Chemistry*, 44, 91-98 (2013).
11. C.M. Osburn, S.A. Campbell, A. Demkov, E. Eisenbraun, E. Garfunkel, T. Gustafsson, A.I. Kingon, J. Lee, D.J. Lichtenwalner, G. Lucovsky, T.P. Ma, J.P. Maria, V. Misra, R.J. Nemanich, G.N. Parsons, D.G. Schlom, S. Stemmer, R.M. Wallace, and J. Whitten “Materials and Processes for High k Gate Stacks: Results from the FEP Transition Center” *ECS Transactions*, 3 (3), 389 (2006).
10. G.N. Parsons, K.J. Park, J.M. Doub, M.J. Kelly, and T. Gougousi “Organic/Inorganic Integration: Ruthenium Atomic Layer Deposition on Self-Assembled Monolayers for Patterning and Work Function Tuning” *Proceedings of Semicon Korea* (2005).
9. C.M. Osburn, S.A. Campbell, E. Eisenbraun, E. Garfunkel, T. Gustafson, A. Kingon, D.-L. Kwong, J. Lee, G. Lucovsky, T.P. Ma, J.P. Maria, V. Misra, G. Parsons, D. Schlom, and S. Stemmer “Materials and Processes for High k Gate Stacks” *Semiconductor Fabtech 22nd edition* (2004)
8. L.L.Smith, K.Wang, R.Hernandez, D.T.Brown, and G. N. Parsons, "Selective Area Cell Adhesion on Amorphous Silicon Using Patterned Self-Assembled Monolayers" *Materials Research Society Symposium Proceedings*, Spring (2000).
7. J.J.Chambers and G. N. Parsons, "Yttrium Silicate Thin Films for Advanced CMOS High-k Gate Dielectrics" *Materials Research Society Symposium Proceedings*, Spring (2000).
6. Tonya Klein, Dong Niu, and Gregory Parsons, “Effect of Al, Ta, and O Precursors on Growth and Properties of Al₂O₃ and Ta₂O₅ Thin Films Deposited by Triode PECVD” *Materials Research Society Symposium Proceedings*, Spring (1999).

5. C.Wang, G.N.Parsons, E.C.Buehler, R.J.Nemanich and G.Lucovsky, "Substrate Temperature Dependence of the Raman Spectra for Microcrystalline Silicon Films Produced by Reactive Magnetron Sputtering" *Materials Research Society Proceedings* (1990).
4. G.N. Parsons, D.V. Tsu, and G. Lucovsky, "Chemical Reaction Pathways for the Deposition of Amorphous Silicon-Hydrogen Alloys by Remote Plasma CVD", *Materials Research Society Proceedings* Vol. 131 (1989).
3. G. Lucovsky, D.V.Tsu and G.N.Parsons,"Preparation of silicon dielectrics by remote plasma enhanced chemical vapor deposition", *AIP Conference Proc.* 167, AVS Series, ed. by G.W. Rubloff (1988).
2. G. N. Parsons and G. Lucovsky, "Estimation of Defect State Densities from Bulk Photoelectronic Properties of a-Si,Ge:H Alloys" *Materials Research Society Proceedings* Vol. 95 (1988).
1. E. Kamieniecki, G.N. Parsons "Characterization of Semiconductor Electrolyte systems by surface photovoltage measured capacitance" *Journal of the Electrochemical Society* 130 (8) C329-C329 (1983).

Invited Seminars and Research Presentations

2019

199. Gregory N. Parsons, "Modeling and Selectivity Loss During Coupled Deposition/Etching ASD Processes", International Area-Selective Deposition Workshop, Leuven Belgium, April 5, 2019
198. Gregory N. Parsons, "ALD Metal Oxide-Mediated MOF Thin Films for Chemical Agent Decontamination", Department of Chemistry, University of Oslo, Oslo Norway, March 7, 2019
197. Gregory N. Parsons, "Chemical Selectivity in Surface Deposition Reactions", Department of Chemical and Biomolecular Engineering, University of Texas at Austin, Austin TX, February 5, 2019

2018

196. Gregory N. Parsons, "Mechanisms for MOF Thin Films on polymer fibers via ALD metal oxides" International Metal Organic Framework Conference, Auckland, New Zealand, Dec. 11, 2018
195. Gregory N. Parsons, "ALD Future Prospects and Perspectives" International HERALD Summit, International Iberian Nanotechnology Laboratory, Braga Portugal, September 27, 2018
194. Gregory N. Parsons, "Adsorptive and Reactive MOF-Fiber Composites" DTRA Science Review, Harvard University, August 17, 2018
193. Gregory N. Parsons, "Research in Area Selective Atomic Layer Deposition and Atomic Layer Etching for Advanced Device Patterning" International Conference on Microelectronics and Plasma Technology, Incheon, Korea July 27, 2018
192. Gregory N. Parsons "Surface-Anchored Metal-Organic-Framework Films on Polymer Fibers", European MRS Conference, Strasbourg, France, June 20, 2018.
191. Gregory N. Parsons "Surface Reactions for Area-Selective Atomic Layer Deposition and Thermal Atomic Layer Etching of Metals and Dielectrics", IITC 2018 Selective Deposition Workshop, San Jose CA, June 4, 2018.
190. Gregory N. Parsons "Surface Reactions for Area-Selective Atomic Layer Deposition and Thermal Atomic Layer Etching of Metals and Dielectrics", ACS Annual Meeting, New Orleans LA, March 20, 2018.

189. Gregory N. Parsons “Chemical Selectivity in Surface Deposition Reactions”, Seminar, Department of Chemistry, Carlton University, Ottawa Ontario Canada, January 19, 2018.

2017

188. Gregory N. Parsons “Area-Selective Atomic Layer Deposition of Metals and Dielectrics” 2nd International Workshop on Atomic Layer Deposition: Russia 2017, Sept 25, 2017, St. Petersburg, Russia.
187. Gregory N. Parsons “Surface-Anchored Metal-Organic-Framework Films on Polymer Fibers”, International Workshop on Composites of Metal and Covalent Organic Frameworks: Fundamental Design & Applications, Granada Spain, September 14, 2017.
186. Gregory N. Parsons “Robust Surface-Anchored UiO-66-based Metal-Organic Framework Films on Polymer Fibers for Rapid Hydrolysis of Chemical Agents”, ACS Annual Meeting, Washington DC, August 20, 2017.
185. Gregory N. Parsons “Using Inherent Substrate Dependent Nucleation to Promote Selective-Area Atomic Layer Deposition” Applied Materials Workshop, San Jose California, July 14, 2017
184. Gregory N. Parsons “Using Inherent Substrate Dependent Nucleation to Promote Selective-Area Atomic Layer Deposition” American Chemical Society Symposium, San Francisco California, April 5, 2017
183. Gregory N. Parsons “Nucleation Reactions during ALD and MOF Thin Film Formation” Army Research Laboratory, Adelphi Maryland, March 27, 2017
182. Gregory N. Parsons “Reactions for Atomically-Precise Thin Film Materials” Lehigh University, Bethlehem Pennsylvania, February 21, 2017
181. Gregory N. Parsons “Surface Dependent Nucleation During ALD” Lam Research, Tualatin Oregon, February 1, 2017
180. Gregory N. Parsons “Surface Dependent Nucleation During ALD” University of Helsinki, Helsinki, Finland, January 12, 2016
179. Gregory N. Parsons “Surface Dependent Nucleation During ALD” Aalto University, Espoo, Finland, January 12, 2016

2016

178. Gregory N. Parsons “Using Inherent Substrate-Dependent Nucleation for Selective-Area ALD of Metals and Metal Oxides” Applied Materials Engineering and Technology Conference, Las Vegas NV, December 14, 2016
177. Gregory N. Parsons, Junjie Zhao, Dennis T. Lee, Heather F. Barton, Christopher J. Oldham, Howard J. Walls, Gregory W. Peterson “Atomic Layer Deposited Nucleation Layers for Cu-BTC and UiO-66 Based MOF Thin Films” Southeast Regional Meeting of the American Chemical Society, Columbia South Carolina, Oct. 24, 2016
176. Gregory N. Parsons “Using Inherent Substrate-Dependent Nucleation for Selective-Area ALD of Metals and Metal Oxides” Electrochemical Society Symposium, Honolulu Hawaii Oct 4, 2016
175. Gregory N. Parsons, Chase Beisel, Albert Keung, Douglas Call, “Computation with Living Cellular Systems” SRC Electronic/Biological Design Automation Workshop, Newcastle University, Newcastle upon Tyne, UK, August 19, 2016
174. Gregory N. Parsons “Selective ALD for Etch Free Patterning” SRC Project Review, Chicago, Ill, June 8, 2016.

173. Gregory N. Parsons, Berç Kalanyan, Sarah E. Atanasov, Paul Lemaire, Mariah Ritz, Eric Stevens, Chris Oldham and Erik Santiso “Nucleation and Selective-Area Atomic Layer Deposition of Metals and Metal Oxides” Area-Selective Deposition Workshop, IMEC, Leuven Belgium, April 15, 2016
172. Gregory N. Parsons “Atomic Scale Processing of Electronic and Chemically Functional Thin Films”, Department of Chemical Engineering, Georgia Institute of Technology, Atlanta, Georgia, March 9, 2016.
171. Gregory N. Parsons “Atomic Scale Processing of Electronic and Chemically Functional Thin Films”, Materials Science Institute, Washington University, St. Louis Missouri, January 29, 2016.
170. Gregory N. Parsons “Atomic Scale Processing of Electronic and Chemically Functional Thin Films”, Department of Chemistry, Wake Forest University, Winston-Salem North Carolina, January 20, 2016.

2015

169. Gregory N. Parsons, Junjie Zhao, Paul C. Lemaire, Christopher J. Oldham, Philip S. Williams, Howard J. Walls, and Gregory W. Peterson “Highly Adsorptive, MOF-Functionalized Nonwoven Fiber Mats for Hazardous Gas Capture Enabled by Atomic Layer Deposition”, Pacifichem Conference, Honolulu HI, Dec. 2015
168. Gregory N. Parsons “Selective-Area Atomic Layer Deposition of Metals and Metal Oxides”, Shanghai Thin Film Conference, Shanghai China, Oct 25, 2015
167. Gregory N. Parsons “Nucleation Reactions During ALD”, Russian ALD Conference, Moscow Russia, Sept 23, 2015
166. Gregory N. Parsons B. Kalanyan, S. E. Atanasov, E. Dandley, C. Needham, P. Lemaire, M. Ritz, E. Stevens, C. Oldham, E. Santiso “Selective-Area Atomic Layer Deposition of Metals and Metal Oxides by Modified Nucleation and ‘Inverse’ Polymer Patterning”, International ALD Conference, Portland Oregon, June 30, 2015
165. Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Moataz Mousa, Eric Stevens, Mariah Ritz, Erik Santiso “Selective ALD for Etch Free Patterning” SRC Review, Boulder Colorado, May 18, 2015
164. Gregory N. Parsons, Sarah Atanasov, Craig Needham “Water-Free Reactions for Selective Area ALD of Dielectrics” SRC Review, Boulder Colorado, May 18, 2015

2014

163. Gregory N. Parsons “Thin Film Materials: Deflecting Pauli’s Devil” RJ Reynold Award Lecture, NC State Univ. Raleigh NC, Nov. 24, 2014
162. Erinn Dandley, Z. Zhu, A. Yoon, L. Sheet, Gregory N. Parsons “Dielectric Nanopatterning Using Selective Sequential Vapor Infiltration” Lam Research Open House, Tualatin Oregon, Nov. 17, 2014
161. Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Philip Williams, Craig Needham, Paul Lemaire, Mariah Ritz, Erik Santiso, S. Clendenning, J. Roberts, A. Basu “Controlling Selective Area ALD of Metals and Metal Oxides without the use of Organic Blocking Layers” American Vacuum Society 61st Annual Symposium, Baltimore MD, Nov. 12, 2014
160. Gregory N. Parsons, “ALD Fundamentals and Applications”, NC State/Penn State Center for Dielectrics and Piezoelectrics Short Course, Raleigh NC, Nov. 5, 2014.

- 159 Gregory N. Parsons, Sarah E. Atanasov, Erinn C. Dandley, Craig Needham, Alexandra Brozena, Philip Williams and Christopher Oldham “New Applications and Ab-Initio Reaction Mechanism Analysis for ALD onto Polymer Fibers and Films” China ALD Conference, Shanghai China, Oct. 17, 2014
- 158 Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Moataz Mousa, Eric Stevens, Mariah Ritz, Erik Santiso “Selective ALD for Etch Free Patterning” SRC Review, Chicago Illinois, Sept. 23, 2014
- 157 Gregory N. Parsons, Sarah Atanasov, Craig Needham “Water-Free Reactions for Selective Area ALD of Dielectrics” SRC Review, Chicago Illinois, Sept. 23, 2014
- 156 Gregory N. Parsons, Berç Kalanyan, Sarah Atanasov, Philip Williams, Craig Needham, Moataz Mousa, Mariah Ritz, Erik Santiso “Nucleation and Selective Area Atomic Layer Deposition” Intel SRC Review, Ronler Acres Campus, Hillsboro OR, September 3, 2014
155. Gregory N. Parsons, “Evolving applications of ALD”, Israeli Vacuum Society Short Course, Weizmann Institute of Science, Rehovot, Israel, Sept 9, 2014.
154. Gregory N. Parsons, “ALD fundamentals and in-situ characterization”, Israeli Vacuum Society Short Course, Weizmann Institute of Science, Rehovot, Israel, Sept 9, 2014.
153. Gregory N. Parsons, “Atomic Layer Deposition for Photoelectrochemical Solar Cells and Photocatalysis”, Israeli Vacuum Society Annual Symposium, Herzlyia, Israel, Sept 8, 2014.
152. Gregory N. Parsons, “Studies on ALD nucleation and stabilizing dye bonding to TiO₂”, Telluride Surface Chemistry Conference, Telluride CO, July 30, 2014.
151. Gregory Parsons, Junjie Zhao, Paul Lemaire, Philip Williams, Christopher Oldham “Fiber/MOF Integration by ALD” ECBC Working Group, Northwestern University, Evanston Ill, July 15, 2014.
150. Gregory N. Parsons “Atomic Layer Deposition for Photoelectrochemical Water Splitting”, European MRS Meeting, Lille France, May 27, 2014.
149. Gregory N. Parsons “Atomic Layer Deposition for Photoelectrochemical and Dye Sensitized Solar Cells”, Korean ALD Meeting, Seoul Korea, April 10 2014.
148. Gregory N. Parsons “Selective Area ALD for Etch-Free Patterning”, SRC Seminar Webcast. March 20, 2014.
147. Gregory N. Parsons “Atomic Layer Deposition on Fibers and Textiles for Smart Materials Applications”, Smart Materials and Coatings Conference, Orlando Florida, Feb 26, 2014.
146. Gregory N. Parsons, Berç Kalanyan and Sarah Atanasov, “Selective Area Atomic Layer Deposition for Etch-Free Patterning”, Intel, Portland Oregon, Jan 9, 2014.

2013

145. Gregory N. Parsons and Erinn Dandley “Atomic Layer Deposition on Polymers and Extension to Selective Area ALD”, Lam Research Corporation, San Jose CA Dec 5, 2013.
144. Erinn Dandley and Gregory N. Parsons “Progress in Selective Area ALD using Polymer Infiltration”, Lam Research Corporation, San Jose CA Dec 5, 2013.
143. Gregory Parsons “Atomic Layer Deposition for Interface Control and Stabilization in Solar Photoelectrosynthesis Cells”, California Institute of Technology, Joint Center for Artificial Photosynthesis, Pasadena CA Nov 20, 2013.

142. Gregory Parsons and Mark Losego “Atomic Layer Deposition for Interface Control and Stabilization in Solar Photoelectrosynthesis Cells”, UNC Chapel Hill, Energy Frontier Research Center, Nov 15, 2013.
141. Gregory N. Parsons “Nanoscale Interface Engineering for Solar Energy Utilization”, NCSU/Brazil FAPESP Summit Meeting, Raleigh NC, Nov 12, 2013.
140. Gregory Parsons, Junjie Zhao, Mark Losego, Paul Lemaire, Philip Williams, Bo Gong, Sarah Atanasov, Trent Blevins, Christopher Oldham “Absorptive and Reactive Surfaces Enabled by Atomic Layer Deposition” DTRA Program Review, Belcamp MD, Oct 8, 2013.
139. Gregory N. Parsons, Berç Kalanyan and Sarah Atanasov, “Selective Area Atomic Layer Deposition for Etch-Free Patterning”, Applied Materials, San Jose CA, Oct 4, 2013.
138. Gregory N. Parsons, Berç Kalanyan and Sarah Atanasov, “Selective Area Atomic Layer Deposition for Etch-Free Patterning”, SRC Review, Chicago IL, Sept 10, 2013.
137. Gregory Parsons, “Research Directions in Molecular Layer Deposition”, Murarta Corporation Visit to Center for Dielectric and Piezoelectric Materials, Raleigh NC June 26, 2013.
136. Gregory N. Parsons “Releasing Hydrogen from Water using Nanoscale Materials and Sunlight” AC21 International Graduate Summer School, Kasetsart University, Bangkok, Thailand, June 3, 2013.
135. Gregory N. Parsons, "High Throughput Atmospheric Pressure Atomic Layer Deposition on Polymers and Fibers", University of Michigan Micro and Nano Manufacturing Workshop, Dearborn Michigan, May 22-23, 2013.
134. Gregory N. Parsons “Future of ALD – Electronics and Patterning”, DARPA ALD Workshop, Chicago Illinois, April 22, 2013.
133. Gregory N. Parsons “Vapor phase coating and modification of polymers”, Eastman Chemical, Kingsport TN, April 7, 2013.

2012

132. Gregory N. Parsons “Atomic Layer Deposition on Textiles”, Harvard University ALD Workshop, Harvard University, Cambridge MA, November 30, 2012.
131. Gregory N. Parsons “Nanoscale Surface Engineering by Atomic and Molecular Layer Deposition” Dept of Chemical Engineering, University of Southern California, Los Angeles CA, Oct 11, 2012.
130. Howard J. Walls, Marty Lail, and David S. Ensor (RTI International) Bo Gong, Christopher J. Oldham, Junjie Zhao, Gregory N. Parsons, (North Carolina State University), Gregory W. Peterson (Edgewood Chemical and Biological Center “Functionalized Nanofibers for Personal Protection Applications” American Association of Textile Chemists and Colorists, September 24, 2012
129. Gregory N. Parsons, “Opportunities and Issues in Nano-Energy Systems” Triangle Institute for Security Studies/ NC State Energy and Security Initiative Luncheon Series, Raleigh, Sept 17, 2012.
128. Gregory N. Parsons and Jesse S. Jur “Continuous Atmospheric Pressure Atomic Layer Deposition Process for Controlled Nanoscale Thin Film Coatings” CMMI Conference, Boston, July 9, 2013
127. Gregory N. Parsons and CJ. Oldham, “Atomic Layer Deposition on Fibers” Arden Fabrics Inc., Detroit MI, April 26, 2012.

126. Gregory N. Parsons, “Nanoscale Surface Engineering by Atomic Layer Deposition” Department of Nanoscience and Nanoengineering Engineering, UNCG, Greensboro, NC April 20, 2012.
125. Gregory N. Parsons, “Nanoscale Surface Engineering by Atomic Layer Deposition” Department of Chemical and Biomolecular Engineering, Vanderbilt University, Nashville TN, March 26, 2012.
124. Gregory N. Parsons and CJ. Oldham, “Atomic Layer Deposition on Fibers” TNO, Eindhoven, The Netherlands, March 22, 2012.
123. Gregory N. Parsons and CJ. Oldham, “Atomic Layer Deposition on Fibers” Levitech Inc., Almere, The Netherlands, March 21, 2012.
122. Gregory N. Parsons, “Progress and Opportunities in Atomic Layer Deposition and ALD Based Chemistry” Taiwan Vacuum Society Meeting, Taipei, Taiwan, January 2012.

2011

121. Gregory N. Parsons, “Surface Engineering of Sustainable Cellulosic Materials by Atomic Layer Deposition” Materials Research Society Fall Meeting, Boston MA, November 30, 2011.
120. Gregory N. Parsons, “Multifunctional Fiber Surfaces by Conformal Vapor Phase Coating” DTRA 2nd Skin Concept Workshop, Natick, MA August 4, 2011.
119. Jesse S. Jur, Bo Gong, Christopher Oldham, William J. Sweet III, Kyoungmi Lee, Joesph C. Spagnola, Gregory N. Parsons and Behnam Pourdeyhimi “ALD for Textiles” 2011 International Atomic Layer Deposition Conference, Boston MA, June 2011.
118. Gregory N. Parsons “Solar Fuels Materials and Devices using Atomic Layer Deposition” Department of Chemical Engineering, Northeastern Univ., Boston, Mar 17, 2011.
117. Gregory Parsons and Jess Jur “ALD at Atmospheric Pressure in a Flow-Tube Reactor” The Minerals, Metals & Materials Society Annual Symposium, San Diego CA, March 1, 2011
116. Gregory N. Parsons “Solar Fuels Materials and Devices using Atomic Layer Deposition” UNC Solar Energy Research Conference, Chapel Hill NC, Jan 14, 2011.

2010

115. Gregory N. Parsons, Jesse S. Jur “Atomic Layer Deposition on Polymers” ECS Annual Meeting, Las Vegas NV, October, 2010.
114. Gregory Parsons and Jess Jur “ALD at Atmospheric Pressure in a Flow-Tube Reactor” Baltic ALD/German ALD Conference, Hamburg, Germany, Sept 16, 2010
113. Gregory N. Parsons “Reactions during inorganic ALD on polymer fibers” Telluride Conference on Semiconductor Surfaces and Processes, July 2010.
112. Gregory N. Parsons “Molecular layer deposition of hybrid organic-inorganic films” Telluride Conference on Semiconductor Surfaces and Processes, July 2010.
111. Gregory N. Parsons “Thin Film Fundamentals and Emerging Applications” MeadWestVaco, Raleigh NC, May 5, 2010.
110. Jess Jur and Gregory Parsons “ Nanotechnology – Yesterday vs. Today vs. Tomorrow”, North Carolina Nanotechnology Commercialization Conference, Greensboro NC March 31, 2010

2009

109. Gregory N. Parsons “Atomic Layer Deposition and Nano-Engineered Surfaces” NC State College of Engineering Seminar on Advanced Materials and Manufacturing, Raleigh November 16, 2009.

108. Gregory N. Parsons “Modulation of Surface Wetting Phenomena on Fibrous Materials Using Atomic Layer Deposition” Dept. of Physics, James Madison University, Harrisonburg VA October 29, 2009.
107. Gregory N. Parsons, “Nanostructured Materials for Renewable Energy” 2009 US Dept of Energy Nanomanufacturing Review Meeting, Washington DC, Sept 15, 2009.
106. Gregory N. Parsons “Atomic Layer Deposition on Fiber Systems” 2009 International Atomic Layer Deposition Conference, Monterey CA, July, 2009.

2008

105. Gregory N. Parsons “Chemistry and Applications of Low Temperature Atomic Layer Deposition” Dept. of Materials Science, University of Texas at Dallas, Richardson TX, November 7, 2008
104. Gregory N. Parsons “Chemistry and Applications of Low Temperature Atomic Layer Deposition” Dept. of Chemical Engineering, Colorado School of Mines, Golden Colorado, October 3, 2008
103. Gregory N. Parsons “Chemistry and Applications of Low Temperature Atomic Layer Deposition” German ALD Conference, GerALD, Sept. 22, 2008, Halle, Germany.
102. Gregory N. Parsons “Chemistry and Applications of Low Temperature Atomic Layer Deposition” Dept. of Chemistry, University of Delaware, Sept 3, 2008
101. Gregory N. Parsons “Integrated Fiber Systems, Scientific Challenges and Approach Chemistry” Oak Ridge National Laboratory, Oak Ridge, TN, June 10, 2008.
100. Gregory N. Parsons “Fiber and Textile Surface Modification & Engineering” ACIMIT, Milan Italy, February 25, 2008.
99. Gregory N. Parsons “3D Surface Engineering of Bio/Organic Fiber Systems using Atomic Layer Deposition” University of Wisconsin, Madison, Materials Science Program, Madison, Wisconsin, February 7, 2008
98. Gregory N. Parsons “Atomic Layer Deposition for 3D Nano-Templating of Fiber and Textile Systems” Luna Innovations, Inc. Danville VA, January 18, 2008
97. Gregory N. Parsons “Atomic Layer Deposition Processes for Advanced Fiber and Textile Systems” Natick Army Soldier Systems Center, Natick, MA January 10, 2008

2007

96. Gregory N. Parsons “Nanotechnology Research at NC State University” Samsung Electronics, Suweon, Korea, Oct 31, 2007.
95. Gregory N. Parsons, Qing Peng, Jeong-Seok Na, G. Kevin Hyde, Xiao-Yu Sun, Joseph C. Spagnola, S. Michael Stewart, Ryan M VanGundy, Jennifer Ayres, Kusum L. Chandra, Richard J. Spontak, and Christopher B. Gorman, “Advanced Applications for Low-Temperature Atomic Layer Deposition” American Chemical Society Meeting, Boston MA, Aug 2007.
94. Gregory N. Parsons, Jeong-Seok Na, G. Kevin Hyde, S. Michael Stewart, Qing Peng, Ryan M VanGundy, Jennifer Ayres, Kusum L. Chandra, and Christopher B. Gorman, “Advanced Applications for Low-Temperature Atomic Layer Deposition” Atomic Layer Deposition Meeting, Seoul, Korea, May 18, 2007.
93. Gregory N. Parsons, “Interface Reactions for ALD of High Work Function Metals and High-k Dielectrics” Samsung, Seoul, Korea, May 17, 2007.
92. Gregory N. Parsons, “Engineering with Electronically Active Molecules” Rutgers University, Department of Chemistry and Physics, New Brunswick NJ, April 19, 2007.

91. Gregory N. Parsons, "Engineering with Electronically Active Molecules" NC State University, Physics Department, Raleigh NC, Jan 29, 2007.
90. Gregory N. Parsons, "Engineering with Electronically Active Molecules" University of Alabama, Chemical Engineering Department, Tuscaloosa AL, Jan 25, 2007.

2006

89. Joe Spagnola and Gregory N. Parsons, "Carbon Nanotube Integration for Interconnect Applications" SRC Review Meeting, Stanford University, San Jose CA, Aug 25, 2006.
88. Gregory N. Parsons, "Hierarchical Assembly of Single Molecule/Metal Junctions, and Temperature Dependent Characterization" Telluride Semiconductor Surface Chemistry Conference, Telluride CO, Aug 3, 2006.
87. Gregory N. Parsons, "Chemistry of Ruthenium ALD Integrated with Organic Monolayers" Telluride Semiconductor Surface Chemistry Conference, Telluride CO, Aug 1, 2006.
86. Gregory N. Parsons, "Stability of Low Temperature Thin Film Transistors on Plastic Substrates" Samsung, Seoul, Korea, July 28, 2006.
85. Gregory N. Parsons, Kie Jin Park, and S. Michael Stewart "Understanding the Process Window in Oxygen-Based Noble Metal Atomic Layer Deposition" 2006 Atomic Layer Deposition Conference, Seoul, Korea, July 25, 2006.
84. J.C. Spagnola and G.N. Parsons "Carbon Nanotube Lateral Alignment on Nanoscale Electrodes" Semiconductor Research Corp., RTP NC May 8, 2006.
83. G.N. Parsons "Interface Formation Reactions in Inorganic and Organic Electronics" Departmental Seminar, University of Colorado, Boulder CO, Jan 24, 2006.

2005

82. G.N. Parsons, D.B. Terry, K.J. Park "PMOS Gate Metals by Atomic Layer Deposition" SRC Project Review, Raleigh NC Nov 7, 2005.
81. G.N. Parsons "Materials and Interfaces for Improved Low Temperature OLED Barriers" Dow Corning, Midland Michigan, October 2005.
80. G.N. Parsons "Atomic Layer Deposition of High Workfunction Metals for PMOS Gate Electrode Applications" University of Tokyo, Tokyo Japan, Sept. 12, 2005.
79. G.N. Parsons "Atomic Layer Deposition of High Workfunction Metals for PMOS Gate Electrode Applications" SSDM Meeting, Kobe Japan, Sept. 15, 2005.
78. G.N. Parsons "Batch and Alternating Layer Deposition of Metal and Metal Oxide films from Precursors in sc-CO₂ Solution" Micell Inc, April 11, 2005.
77. G.N. Parsons "A Biomimetic Self Assembled Solar Cell" DARPA Nanopower Meeting, Washington DC March. 2005.
76. G.N. Parsons "ALD Metals and reactions at metal/dielectric interfaces" Gate Stack Working Group, Austin Texas, Feb 14, 2005.
75. G.N. Parsons, "Organic/Inorganic Materials for Transistor Devices" Samsung Electronics, Seoul, Korea Feb 3, 2005.
74. G.N. Parsons, K.J. Park, J.M. Doub, M.J. Kelly, and T. Gougousi "Organic/Inorganic Integration: Ruthenium Atomic Layer Deposition on Self-Assembled Monolayers for Patterning and Work Function Tuning" SEMICON Korea, Seoul, Korea Feb 2, 2005.

73. G.N. Parsons “Organic/Inorganic Integration: Ruthenium Atomic Layer Deposition on Self-Assembled Monolayers for Patterning and Work Function Tuning” Hanyang University, Seoul, Korea Feb 1, 2005.

72. G.N. Parsons “Research in Thin Film Electronic Materials” MCNC RTP NC Jan 5, 2005.

2004

71. G. N. Parsons “*Ru Atomic Layer Deposition and Work function tuning for Advanced Gate Electrodes*” Semiconductor Research Corporation Annual Review, Raleigh NC November 2004.

70. G. N. Parsons “*Selective Area Ru Atomic Layer Deposition for Advanced Gate Electrodes*” International Atomic Layer Deposition Conference, Helsinki Finland, Aug 16-18, 2004.

69. G. N. Parsons and T. Gougousi, “*Metal and Oxide Deposition by Solvent Enhanced Chemical Fluid Deposition*” STC Industry Advisors Meeting, Chapel Hill NC April 15, 2004.

68. G. N. Parsons “*Surface Reactions in High-k and Gate Electrode Deposition*” SEMATECH Gate Stack Meeting, Austin, TX March 8, 2004.

2003

67. G. N. Parsons “*Selective Area Ru Deposition for Advanced Gate Electrodes*” Semiconductor Research Corporation Annual Review, Raleigh NC November 18, 2003.

66. G. N. Parsons “*Activity in Organic Photovoltaics*” Dupont Central Research, November 6, 2003.

65. G.N. Parsons “*In-Situ Studies during Atomic Layer Deposition*” Advanced Metallization Conference, Montreal Canada, October 20, 2003.

64. G.N. Parsons “*Stability of High-k Dielectrics*” SEMATECH Gate Stack Meeting, Austin, TX May 2003.

63. G.N. Parsons “*Hybrid Silicon/Molecular Electronics*” APS March Meeting, Austin Texas, March 2003.

2002

62. G. N. Parsons “*Applications of Atomic Layer Deposition to High-k Dielectrics*” ALD Conference 2002, Seoul Korea, September 2002.

61. G.N. Parsons “*Surface Reactions in Silicon and High-k Thin Film Deposition*” Semiconductor Surface Chemistry Conference, Telluride Colorado, July 29, 2002.

60. Bruce Gnade, University of North Texas, Tayo Akinwande, Massachusetts Institute of Technology, Gregory Parsons, North Carolina State University, Sigurd Wagner, Princeton University, R. Shashidhar, Naval Research Laboratory “*Active Devices on Fiber: The Building Blocks for Electronic Textiles*” International Interactive Textiles for the Warrior Conference, Natick Soldier Systems Center, Natick MA July 2002

59. S. Stemmer¹, D. Klenov¹, Z. Chen¹, J.-P. Maria², A. I. Kingon², D. Niu³, G. N. Parsons³, “*Electron Energy-Loss Spectroscopy of Alternative Gate Dielectric Stacks*” ¹Department of Mechanical Engineering and Materials Science, Rice University, ²Department of Materials Science and Engineering, North Carolina State University, ³Department of Chemical Engineering, North Carolina State University. Microscopy and Microanalysis Conference, 2002

58. G. N. Parsons “Engineering Challenges in Molecular Electronics” Dow Chemical, RTP NC, May 13, 2002.

57. G. N. Parsons “Kinetics of Low Temperature Silicon Plasma Deposition” Eindhoven Technische Universiteit, Eindhoven, The Netherlands, January 14 2002.

56. G. N. Parsons "Silicon/High-k Interface Reactions" IMEC, Leuven Belgium, January 15 2002.
- 2001**
55. G. N. Parsons "Silicon/High-k Interface Reactions" SEMATECH Gate Stack Meeting, Raleigh NC, Nov 8 2001.
 54. G. N. Parsons "Silicon/High-k Interface Reactions" Motorola APRDL, Austin TX, October 19, 2001.
 53. G. N. Parsons "Silicon/High-k Interface Reactions" University of North Texas, Denton TX, October 18, 2001.
 52. G. N. Parsons "Silicon/High-k Interface Reactions" Texas Instruments, Dallas TX, October 17, 2001.
 51. G. N. Parsons "Silicon/High-k Interface Reactions" International Workshop on Device Technology, Porto Alegre Brazil, Sept. 5 2001.
 50. G. N. Parsons, J. Hauser, V. Misra, D. Feldheim, C. Grant, D. Bocian "Hybrid Silicon/Molecular Electronics Processing" NSF Nanoscale Science and Engineering Centers Reverse Site Visit, Washington DC, May 30 2001.
 49. G. N. Parsons "Kinetics of Interface Reactions During High-k Deposition on Silicon" SEMATECH Gate Stack Meeting, Austin TX, May 22 2001.
 48. G. N. Parsons "Kinetics of Interface Reactions During High-k Deposition on Silicon" American Physical Society March Meeting, Seattle Washington, March 2001.
- 2000**
47. G. N. Parsons "Kinetic Processes During High-k Dielectric Deposition on Silicon" Torrex Corporation, Santa Clara CA, November 2000.
 46. G. N. Parsons "Advanced Interfacial Layers" Semiconductor Research Corporation Annual Review, Raleigh NC November 2000.
 45. G. N. Parsons "Molecular and Nanoparticle Electronics" National Nanofabrication Users Network Interest Meeting, Raleigh NC, November 2, 2000.
 44. G. N. Parsons "Nanotechnology and Nanoelectronics" NASA IAC Meeting, Hillsborough, NC Sept 19, 2000
 43. G. N. Parsons "Issues in Advanced Gate Stacks" LSI Logic, Santa Clara, CA July 31, 2000
 42. G. N. Parsons "Kinetic Processes During High-k Dielectric Deposition on Silicon" IBM TJ Watson Research Center, Yorktown Heights, NY July 12, 2000.
 41. G. N. Parsons "Kinetic Processes During High-k Dielectric Deposition on Silicon" Lucent Bell Laboratories, Murray Hill NJ, July 11, 2000.
 40. G. N. Parsons "Effect of Oxide and Nitride Interface Layers on Si Consumption Reactions During High-k Metal Oxide Deposition on Si" SEMATECH Gate Stack Working Group Meeting, Austin TX, June 2000.
 39. G. N. Parsons "Formation of Yttrium silicate on Silicon" Materials Research Society High-k Workshop, New Orleans LA, June 2000.
 38. G. N. Parsons "Biocompatible electronic surfaces" ECE Nano-technology Seminar Series, NC State University, May 2000.
 37. G. N. Parsons "Formation of Yttrium silicate on Silicon" Symyx Technologies Inc., Santa Clara California, April 2000.

36. G.N. Parsons "Low Temperature Amorphous Silicon – Surface Reactions and Novel Applications" Ecole Polytechnique, Paris France, April 2000.

1999

35. G.N. Parsons "Very low temperature plasma enhanced deposition of electronic insulating thin films", Materials Research Society Spring Meeting, San Francisco, Mar. 2000.
34. G. N. Parsons "Interface formation reactions in high-k metal oxide deposition on silicon" SRC Program Review, Raleigh NC Nov. 1999.
33. G. N. Parsons "Surface Reactions in Very Low Temperature (<150°C) Hydrogenated Amorphous Silicon Deposition, and Applications to Thin Film Transistors" International Conference on Amorphous and Microcrystalline Semiconductors, Snowbird UT, Aug. 1999.
32. J. Crowley and G. N. Parsons "Progress in Low Temperature Materials for TFT's, and Future Display Research" Biannual TFT Workshop, San Jose CA, May 21, 1999.
31. G.N. Parsons "Low temperature plasma deposition of silicon" First Annual NSF CAREER PI Meeting, Washington DC, January 1999.

1998

30. T.M.Klein and G. N. Parsons "Triode PECVD of Tantalum Pentoxide and Aluminum Oxide thin films", SRC Program Review, Raleigh NC, November 1998.
29. G. N. Parsons "Low Temperature Silicon Crystallization" Dept. of Physics Seminar, UNC Charlotte, Charlotte NC, Sept. 1998
28. G.N. Parsons "Surface Reactions in Low Temperature Silicon Deposition: Theory and Experiment" Telluride Surface Chemistry Conference, Telluride CO, August 1998.
27. G. N. Parsons, "Chemical Processes for Low Temperature Electronic Materials", DARPA Information Exchange Conference, Washington D.C., March 23, 1998.

1997

26. G. N. Parsons, "Low Temperature TFT's on Plastic", DARPA/EPRI Workshop, Dayton Ohio, December 11, 1997.
25. G. N. Parsons, "Silicon Thin Film Deposition Reactions for Large Area Electronics on Plastics", Chemical Engineering Dept. Seminar, Cornell University, Sept 15, 1997.
24. G. N. Parsons, "Thin Film Materials for Bistatic Micro-Mechanical Smart Systems and Displays" Dept. of Materials Science and Engineering, NC State University, Sept. 24, 1997
23. G. N. Parsons, "Real-time process sensing and analysis for plasma deposition" Novellus Inc., San Jose CA, Oct. 22, 1997.
22. C. S. Yang, C. A. Arthur, W. W. Read, E. Srinivasan, and G. N. Parsons, "Self-Aligned and Full-Self-Aligned Thin Film Transistors (TFT's) Using Plasma Enhanced Selective Area Deposition of In-Situ Doped Microcrystalline Silicon," poster presentation for NSF ERC Review, June 1997.
21. G.N.Parsons, "Real time sensing and analysis of plasma deposition processes" Novellus Corp., San Jose, CA, October 1997.
20. G.N. Parsons "Thin Film Materials for Bistatic Micro-Mechanical Smart Systems and Displays" Dept. of Materials Science and Engineering, NC State University, Sept. 24, 1997.
19. G.N. Parsons "Silicon Thin Film Deposition Reactions for Large Area Electronics on Plastics" Dept. of Chemical Engineering, Cornell University, Sept. 15, 1997.

18. G.N.Parsons "Reaction sensing and analysis for electronic materials on plastic substrates" Becton Dickenson Research Center, Research Triangle Park, NC, June 3, 1997.
17. G.N. Parsons "Full Self Aligned TFT Processes for AMLCD's" American Vacuum Society Southeast Regional Conference, Oak Ridge Tenn, May 1997.
16. E. Srinivasan and G.N. Parsons "Plasma enhanced chemical vapor deposition of amorphous and microcrystalline silicon for thin film transistor applications" at Lawrence Livermore National Laboratory, CA, April 1997.
15. G.N. Parsons "Full Self -Aligned TFT Formation and Performance" at Xerox PARC, Palo Alto, CA, March 1997.
14. G.N. Parsons "Full Self -Aligned TFT Formation and Performance" at Lawrence Livermore National Laboratory, Livermore, CA, March 1997.
13. G.N. Parsons "Full Self -Aligned TFT Formation and Performance" at Silicon Light Machines, Inc., Sunnyvale, CA, March 1997.
12. G.N. Parsons "Manufacturable High Performance TFT's" at DARPA IEC, March 1997.
11. G.N. Parsons "Progress on TFT fabrication" at DARPA/EPRI Workshop, Palo Alto, CA, January 1997.

1996

10. G.N. Parsons "Interface and Heterostructure Formation for Thin Film Transistor Applications" at NC State/Univ. of Berlin joint workshop, Raleigh, Dec. 9, 1996.
9. G.N. Parsons "Very Low Temperature Inorganic Thin Film Deposition Compatible with Polymeric Substrates" at the NCSU/Hoechst Celanese Polymer Workshop, Nov. 1996.
8. G.N.Parsons, "Selective Deposition of Silicon" Materials Research Society Spring Meeting San Francisco, CA, April 10, 1996
7. G.N. Parsons "Progress toward High Performance TFT's" DARPA/EPRI Workshop, Washington DC, April 15, 1996
6. G.N. Parsons "Progress Toward Manufacturable High Performance TFT's" DARPA Information Exchange Conference Washington DC, April 17, 1996

1995

5. G.N. Parsons "Controlled Surface Chemistry in Plasma CVD: Applications to High Performance Thin Film Electronics" Dept. of Physics, University of North Carolina Chapel Hill, March 1995
4. G.N. Parsons "Controlled Surface Chemistry in Plasma CVD: Applications to High Performance Thin Film Electronics" Dept. of Materials Science and Engineering, N.C.State University, Feb. 1995

1994

3. G.N. Parsons, "Selective Microcrystalline Silicon Deposition for TFT/LCD Applications" Materials Research Society Fall Meeting, Boston MA, Nov. 1994.
2. G.N. Parsons, "Thin Film Transistor Requirements For High Performance Active Matrix Liquid Crystal Displays" Energy Conversion Devices Inc, Troy MI, November 1994.

1991

1. G.N. Parsons "Selected Area Nucleation and Bond Strain Relaxation in Silicon PECVD Using Time Modulated Silane Flow" Symposium for Dry Processing, Tokyo Japan, October 1991.

Technology Licensing and Transfer

2010 – VaporPulse Technologies
2008 – 2010 Alditri Technologies
2006 SolarAmp

Current Research Projects

1. Surface Adsorption and Spectroscopic Analysis Instrument Suite for Synthesis of Novel Catalytic Metal-Organic Framework Thin Films
US Army – Army Research Office (DURIP), 5/2017 – 10/2018
This project seeks to substantively expand the scientific equipment at NC State to create, synthesize and characterize adsorptive and reactive thin film MOF materials, and educate research students in the field of chemically reactive surfaces.
2. Innovative Materials for Microwave Tubes, Phase II and Phase II Option
US DoE, STTR with Calabazas Creek Research Inc., 3/2016 – 3/2019
Develop new tools to enable corrosion protection coatings to be integrated into microwave tubes.
3. Functional and Reactive Surfaces Enabled by ALD
US Army – Army Research Office, 6/2013 – 6/2019
This project addresses the need for new approaches to form conformal and high quality metal organic frameworks (MOF) thin film.
4. Multi-Modal Energy Flow at Atomically Engineered Interfaces
US Army – Army Research Office (with J. Maria and D. Brenner), 7/2016 – 7/2019
Explore fundamental physics and chemistry of shock-induced energy transfer at the nanoscale in organic/inorganic interfaces.
5. Intrinsically Microporous Nonwovens
The Nonwovens Institute, 1/2017 – 12/2019 (with S. Khan)
This project will explore polymers of intrinsic microporosity (PIMs) as a new class of high surface area nonwovens (exceeding 500 m²/g), where the backbone of the starting spun-melt polymer provides intrinsic microporosity (i.e. pores < 2 nm) directly within the nonwoven fiber, without the need for porous additives.
6. Ultra Barriers on Flexible Polymer Based Packaging Materials for Stabilizing Combat Rations by Atomic Layer Deposition
US Army, Natick Soldier Systems Center, 4/2016 – 1/2020
We are working to define metrics and fabrication options for barrier coatings by atomic layer deposition for food packaging required by the US Army.
7. Orthogonal Dielectric/Metal Selective Area Atomic Layer Deposition
Semiconductor Research Corp., 2/2017 – 1/2020
The main goal of our work is to advance fundamental understanding of selective nucleation. We will characterize unwanted surface products and understand how to avoid and/or remove them while expanding selective growth.
8. Advanced Metal Thin Film Nucleation During Atomic Layer Deposition
NSF (with E. Santiso) 7/2017 – 6/2020
The overall goal of this project is to expand fundamental understanding of vapor/surface chemical reaction mechanisms leading to new nanoscale elemental metal, semimetal and metalloid thin films by thermal atomic layer deposition (ALD).
9. Nucleation and Growth PEDOT Thin Films for Capacitor Device Systems
Center for Dielectrics and Piezoelectrics (with E. Dickey) 7/2018 – 6/2020

The overall program goal is to evaluate nucleation and growth of poly(3,4-ethylenedioxythiophene) (PEDOT) via oxidative Molecular Layer Deposition (oMLD) as a route to improve all-solid-state, high-surface-area, mesoporous electrolytic capacitors.

10. Smartphone-Based Leaf Volatile Profiling for Noninvasive Diagnosis of Plant Pathogens
USDA (with Q. Wei) 3/2019 – 3/2021

This project is expected to provide an economically vital, field-deployable, and noninvasive solution for early diagnosis of various important plant diseases or monitoring of abiotic stresses with a high degree of detection sensitivity and specificity.

11. Area-Selective Initiated-Molecular Layer Deposition of Polymers
Semiconductor Research Corp. 1/2019 – 12/2021

The main goal of our work will be to advance fundamental understanding of nucleation and area-selectivity during vapor-phase nucleation and deposition of polymers.

12. Phase II IUCRC North Carolina State University: Center for Dielectrics and Piezoelectrics
NSF 3/2019 – 2/2024

This internationally-recognized research center is dedicated to improving the science and technology of dielectric and piezoelectric materials and their integration into components/devices.

Pending Research Projects

1. Atomic and Molecular Layer Deposition for Capacitor Device Systems

Private Industry

We propose to understand, develop and demonstrate atomic layer deposition, ALD, and molecular layer deposition, MLD techniques for creation of thin film materials for advanced capacitor applications and related systems of interest to the sponsor.

2. Reactive Porous Surfaces, Thin Films and Fibers

US Army – Army Research Office

This project's objective is to advance understanding of synthesis and functional performance of metal-organic framework and related materials integrated with fibrous and polymer platforms of interest to DoD. Primary focus is on active and passive protection from chemical warfare agent exposure.

Research Facilities

Parsons' lab occupies approximately 2400 ft² in the Department of Chemical and Biomolecular Engineering in three lab rooms in Engineering Building I (opened January 2005) on NC State's Centennial Campus. The labs have four 6-foot chemical hoods, two 6-foot walk-in hoods, and 7 ventilated gas bottle cabinets. Available equipment includes:

Analytical equipment:

- Quantachrome Autosorb-1C for Brunauer-Emmett-Teller (BET) surface area, pore size distribution, and gas nitrogen adsorption/desorption analysis
- Micromeritics 3 Flex surface characterization and smart vac prep
- Q2000 Differential scanning CA with liquid nitrogen cooling
- Leica GZ6T crystal probe
- Ramé-Hart Contact Angle Goniometer
- Digital Instruments D3000 AFM (equipped with conducting probe capability)
- Nicolet Evolution 300 UV-Vis Spectrophotometer
- Nicolet 6700 FT-IR Spectrophotometer (with near- and far-IR detectors)
- Nicolet iso59 FTIR
- SZH10 Olympus Stereoscope
- BX-51 Olympus Microscope (5x-100x objectives, transmitted/reflected/Nomarski)
- Olympus BX60
- J.A. Woollam Alpha-SE Spectroscopic Ellipsometer
- Veeco Dektak D-150 Step Profilometer (with 3D profiling accessory)
- On-line Mass Spectrometer x 2

Processing Equipment:

- Linberg/Blue Controlled Atmosphere Tube Furnace
- Laurell Series 400 Spin Processor
- Thermolyne Benchtop Muffle Furnaces (Si oxidation, calcination, atm anneal)
- AX8560 semiconductor grade ozone generator
- Twelve custom-made hot-wall ALD and MLD flow reactors:
 - Two 2.5" diameter Al₂O₃, ZnO, TiO₂ furnace tube systems
 - One 2.5" diameter exploratory tube reactor (various materials)
 - Two large diameter tube systems (TMA, DEZ, TiCl₄)
 - W ALD tube system (WF₆/Si₂H₆), in walk-in hood
 - MLD tube reactor (TMA, DEZ, EG, glycidol, APTES, etc)
 - TiO₂ furnace system (Ti i-propoxide, TDMAT, TiCl₄, etc)
 - Oxide/Organic ALD system, with in situ IR transmission capability
 - Two custom ALD reactors for metal and metal oxides.
- 3 custom modified Maxtek BSH-150 quartz crystal microbalance sensor heads
- Leybold dryvac 50B
- Emitech SC7620 sputter coater
- Thermolyne flow through annealing furnace
- RF generator PFG 300 RF
- Thermolyne tube furnaces 79300 and 79400

Chemical Synthesis Equipment

- Parr Instrument Autoclaves (MAWP 3000 PSI at 350C) x3
- Fisher Isotemp model 828A vacuum oven

- Nexus II integrated glove box with vacuum system
- Benchtop glove box

Electrical, Electrochemical and opto–electrical characterization:

- Janis probe station with controlled temperature (80–450 K) and ambient
- Keithley high impedance ammeter
- Agilent LCR meter (capacitance vs. voltage analysis)
- Newport 91160 solar simulator (150W and 300W)
- Princeton Applied Research Electrochemical Impedance Analyzer
- Several PAR and other cyclic voltammetry systems
- Gamry 36029 potentiostat/galvenostat/ZRA

Equipment in the NC State Analytical Instrument Facility: The Analytical Instrumentation Facility (AIF) enables state-of-the-art research through acquisition, development, maintenance, training, and access to major analytical and materials characterization instrumentation. Facilities currently include:

- FEI Titan G2 80-300 with 5th-order aberration corrector with point-to-point resolution less than 0.07 nm in STEM mode
- FEI Verios monochromatic FESEM/STEM
- FEI Quanta 3D FEG dual-column SEM/FIB
- State of the art TEM sample preparation laboratory
- JSM-7600F Cryo-SEM
- JEOL 2010F S/TEM, for high resolution TEM, ADF-STEM, EELS and EFTEM
- JEOL 2000FX for conventional bright-field/dark-field imaging, with in situ heating and voltage biasing, liquid flow cell stages (Protochips)
- Hysitron Ubi-1 Nanoindenter with in situ SPM imaging
- SPECS XPS/UPS
- ION TOF TOF-SIMS5 Time-of-Flight Secondary Ion Mass Spectrometer (TOF-SIMS)
- PANalytical Empyrean X-ray Diffractometer
- Rigaku SmartLab X-ray Diffractometer
- Bruker AXS General Area Detector Diffraction System (GADDS)
- Bruker Dimension 3000 and MultiMode scanning probe microscopes