

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY,
LIMITED

Petitioner

v.

GODO KAISHA IP BRIDGE 1

Patent Owner

Case IPR2016-01247/2016-01246
U.S. Patent No. 7,126,174

Palo Alto, California

June 30, 2017

CROSS-EXAMINATION

ALEXANDER D. GLEW, Ph.D., P.E.

1 Cross-Examination of ALEXANDER D. GLEW, Ph.D.,
2 P.E., a witness herein, called for examination
3 by counsel for Petitioner in the above-entitled
4 matter, pursuant to notice, the witness being
5 duly sworn by MARY HOGAN, CSR, a Certified
6 Shorthand Reporter in and for the State of
7 California, taken at the offices of Ropes &
8 Gray, 1900 University Avenue, 6th Floor, East
9 Palo Alto, California, commencing at 8:54 a.m.

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1 C O N T E N T S

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3 ALEXANDER D. GLEW, PH.D. EXAMINATION

4 By Mr. Jiron 5

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7 E X H I B I T S

8 **Exhibits previously marked

9 IP BRIDGE EXHIBIT NO. 2009 68

10 Declaration of

11 Alexander D. Glew, Ph.D., P.E.

12 TSMC EXHIBIT NO. 1001 94

13 696 Patent

14

15 **Exhibits marked

16 GLEW EXHIBIT 1 86

17 Layer Etching Pattern Sketch

18

19

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1 P R O C E E D I N G S

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3 Whereupon, ALEXANDER D. GLEW, PH.D.,
4 P.E., was called as a witness by counsel for
5 Petitioners, and having been duly sworn, was
6 examined and testified as follows:

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8 CROSS-EXAMINATION

9 BY MR. JIRON:

10 Q Good morning, Dr. Glew.

11 A Good morning.

12 Q Could you state your full name and
13 address for the record, please?

14 A Yes. Work or home address?

15 Q Work address.

16 A Okay. Alexander David Glew, 240
17 Pamela Drive, Mountain View, California 94040.

18 Q You understand you are under oath
19 today, correct?

20 A Yes.

21 Q That means you must testify
22 truthfully as if you were in front of a judge or

1 in a courtroom, okay?

2 **A Yes.**

3 Q Is there any reason that would
4 prevent you from understanding my questions
5 today that you know of?

6 **A No.**

7 Q Are you taking any medications that
8 would hinder your ability to understand
9 questions?

10 **A No.**

11 Q Earlier it sounded like you had been
12 involved in some deposition prep, so I assume
13 you have been involved in depositions before, is
14 that right?

15 **A Yes, I have.**

16 Q About how many times have you been
17 deposed?

18 **A Approximately 40.**

19 Q So given your experience, even in
20 view of your experience, I'll just go over a
21 couple of ground rules for today.

22 As we have a court reporter today who

1 will be recording responses and questions, do you
2 understand that she needs to hear verbal responses
3 rather than head nods and things like that?

4 **A Yes.**

5 Q Also I'll ask a number of questions
6 today and I'll ask you that if there is any
7 question that you don't understand, could you
8 let me know that you don't understand the
9 question?

10 **A Yes.**

11 Q If you don't let me know that you
12 don't understand the question, would it be fair
13 to assume then that you do understand?

14 **A That's reasonable.**

15 Q I will try to take a break about
16 once every hour but if you need a break any time
17 other than that, just let me know, okay?

18 **A Okay. I will do that.**

19 Q The only request that I have is that
20 if there is a question pending that you complete
21 your answer to the question before we take a
22 break. Understood?

1 **A** **I understand.**

2 **Q** You are currently employed at Glew
3 Engineering and Consulting, is that right?

4 **A** **That's correct.**

5 **Q** You have been there since 1997?

6 **A** **Yes.**

7 **Q** What type of consulting do you do in
8 that position?

9 **A** Well, we do a few things. I wear
10 two hats.

11 I'm a mechanical engineer and material
12 scientist. I have a BS and MS in Mechanical
13 Engineering and a license in Mechanical
14 Engineering. I am insured in errors and omissions
15 in mechanical engineering, so we do some work
16 which is largely equipment design.

17 I started my career in semiconductor
18 equipment, so we do a lot of equipment work, and
19 the material science part of me, the Master's in
20 Material Science does more of the material
21 processing, which dovetails nicely with the
22 equipment, as well as materials characterization.

1 So in terms of technical areas, those
2 are kind of the technical areas we largely work
3 in.

4 Along with the materials is a lot of
5 semiconductor and thin film technology, some
6 display technology now, and then I would divide
7 the business in terms of its practice areas into
8 largely engineering and litigation support, some
9 small amount of general consulting, companies that
10 want to evaluate technology or that sort of thing.

11 Q How many people are at Glew
12 Construction?

13 A Currently three. We should be
14 staffed at four. We're short one now.

15 Q You mentioned litigation support.
16 That falls under the umbrella of Glew
17 Consulting?

18 A Yes.

19 Q About how much of your time in
20 percentage numbers do you spend on litigation
21 support versus the other types of work you
22 mentioned?

1 A It depends year to year. My goal is
2 to keep it about 50/50.

3 Q When you mentioned that you do
4 equipment design, what type of equipment are you
5 designing?

6 A Well, everything from semiconductor
7 equipment, thin film processing, to some
8 industrial equipment, what you might call
9 general industry.

10 Q So you mentioned that you do about
11 50/50 litigation support and other work.

12 Is that about what you would say an
13 average year is in actual numbers or does it vary
14 from 50/50?

15 A It varies year to year. Engineering
16 work is more predictable. There is usually a
17 start and an end to a project.

18 Litigation work is very unpredictable.
19 Sometimes cases end the first week you're engaged,
20 other times they carry on for -- I think I'm
21 finishing a case that has been going on for 14
22 years, so it's just hard to predict how much

1 **litigation work comes out of the agreement.**

2 Q Maybe as an example, do you recall
3 in 2016 what the percentage might have been
4 roughly?

5 A **Probably 60 litigation, 40**
6 **engineering.**

7 Q I would like to talk for a minute
8 about your experience at Applied Materials.

9 A **Okay.**

10 Q You were at Applied Materials from
11 1987 through 1997, is that right?

12 A **Yes.**

13 Q During that time it sounded like
14 there were different divisions of Applied
15 Materials. What were those divisions?

16 A **Well, the divisions changed over**
17 **time. There was a CVD division, an etch**
18 **division. The CVD and etch division merged for**
19 **a while. I was in both.**

20 **There was an implant division.**
21 **Eventually there was a CMP division, chemical**
22 **mechanical polishing.**

1 There was a division for service.

2 There was a division for high temperature
3 processing. It was part of CVD, and then I think
4 it got spun out to its own group.

5 The divisions initially were more
6 oriented along the lines of CVD etch, which you
7 might think of as traditional technologies. Then
8 over time they reoriented themselves to be more
9 oriented toward the fabrication process, meaning
10 there would be a group that focused on
11 transistors, a group that focused on
12 interconnects.

13 Then there was also a corporate
14 function, corporate entity, that I served in also
15 that worked with all the divisions.

16 Q So during the time that you were at
17 Applied Materials you mentioned that you were a
18 member at one time of both the CVD and the etch
19 division?

20 A Yes.

21 Q How long did you spend in the CVD
22 division?

1 A If I was there ten years, probably I
2 would say at least six years were CVD.

3 Then for another period of time it was
4 a combination of CVD and etch, a few years of
5 that.

6 Q Then it was merged?

7 A Yes.

8 Q Approximately how long were you a
9 member of the merged etch CVD group?

10 A Probably something short of two
11 years.

12 Q Were you a member of any other
13 divisions?

14 A I was a member of -- I served in the
15 corporate group.

16 I was a core technologist, so I was
17 one of 15 corporate experts, so I served at the
18 corporate level and then worked with all of the
19 divisions.

20 Sometimes -- there was a period of
21 time where I had a few appointments within the
22 company. I was both -- I had a corporate position

1 as well as divisional responsibility.

2 It's been a while, but I may have also
3 been in a division that was toward the end an
4 operations division responsible for manufacturing,
5 but that's been a long time.

6 There was also a TFT division, thin
7 film transistors. Applied made tools to make flat
8 panel displays.

9 They eventually -- there was a joint
10 venture. They eventually spun off. They were
11 down the hall, in the same building, but I think
12 they were at some point officially a joint
13 venture.

14 There may have been other divisions,
15 too. By the time I left it was a \$6 billion
16 company.

17 Q You were a member of the TFT
18 division?

19 A I was a core technologist then, so I
20 worked with them, but I was not in the TFT
21 division.

22 Q You mentioned as a core

1 technologist. That was a corporate division?

2 A That's like -- yes, it's a corporate
3 function. There is a corporation, then there's
4 divisions under the corporation, if you think of
5 it like that.

6 So there was a small cadre of core
7 skills kept at the corporate level. I was one of
8 15 corporate experts, core technologists, for a
9 while, yes.

10 Q What would you characterize as the
11 responsibility of the division at the corporate
12 level that you were working in?

13 A The core technology group?

14 Q Yes.

15 A Well, there were about 15 of us. We
16 each had a responsibility for one area of
17 technology.

18 We met monthly with either the
19 president of the company or an executive vice
20 president, sometimes the CEO.

21 We tried to establish, make sure that
22 we had expertise in the technologies that the

1 corporation thought we needed to have expertise
2 in, and then propagate that expertise out to the
3 divisions, making sure that one division wasn't
4 lagging the other divisions.

5 If one division knew it or had the
6 skill set capability that all the divisions of the
7 corporation as a whole had access or that ability,
8 so one product wasn't lagging another group in an
9 area that we actually had expertise in.

10 Q What were the primary
11 responsibilities of the CVD division while you
12 were there?

13 A Well, when I started there -- I
14 think there had been a CVD tool years before,
15 but it was no longer in production, had been
16 defunct, so we made what I understood as the
17 first competitive CVD tool at Applied Materials.

18 We made the mainframe upon which
19 process chambers hung, and then we developed the
20 process chambers and the processes for the CVD
21 processes.

22 The tool that I worked on, Applied

1 Materials Precision 5000, was placed in the
2 Smithsonian Institute next to a Caterpillar
3 tractor.

4 Eventually, even though it was a
5 division, the mainframe we developed was used by
6 other divisions, so the etch division took our
7 mainframe and hung their process chambers on it.

8 So what we did is we made the first
9 single wafer processing. Up to that time all the
10 equivalent was batch, 25 wafers at a time, maybe
11 50.

12 So we made a chamber that processed
13 the single wafer, and there were perhaps up to
14 four chambers on the system.

15 Then after that we just started off
16 with a couple of processes. At one point I
17 counted over 25 different CVD processes that we
18 sold chambers for. Some of them were minor
19 variations on others, but we did that sort of
20 thing.

21 Then eventually that mainframe got
22 older and the corporation as a whole tried to

1 develop a new mainframe instead of a division, and
2 so we transitioned our processes and chambers to
3 the new mainframe.

4 We also developed different wafer
5 sizes. So when I started the industry wafers were
6 smaller. The biggest was 150 millimeter.

7 People still used 50 and 75, so we
8 developed the 200 millimeter processes, then
9 eventually, the 300 millimeter processes.

10 Q When you say mainframe, what
11 components are you referring to?

12 A Mainframe usually has a central load
13 lock chamber and a robot.

14 It has a port that accepts cassettes
15 of wafers from the factory. So the robot will
16 take the cassette and unload it into a load lock,
17 put it under vacuum and transfer the wafers out
18 to the process chambers, attach the load lock
19 or -- the mainframe is essentially a remote
20 mainframe with the dirty gear that doesn't need to
21 be in the clean room.

22 There is a big umbilical cord, so to

1 speak, and some vacuum pumps are right on the
2 chambers and the bigger are remote, the big power
3 supplies for generating RF plasmas or other types
4 of plasmas.

5 So the mainframe is pretty much
6 everything except for the process chamber that the
7 wafer goes into and the nasty chemicals go on.

8 The mainframe also includes the gas
9 delivery system, chemical vaporizers, things like
10 that, a gas panel.

11 Q So the wafers would transition from
12 the mainframe into the different process
13 chambers?

14 A Yes.

15 Q And what was your role, would you
16 say, in developing the mainframe?

17 A Well, initially quite a bit. I
18 actually ended up releasing the mainframe in a
19 manufacturing sense, so I was responsible for
20 creating all of the business and materials and
21 assembly drawings and configuring the system.

22 It's something I had a knack for,

1 system engineering, so if you ordered a system
2 nobody knew what to build, nobody, except for
3 maybe two or three people, so sales would sell
4 something, marketing would get an order, and you
5 have to figure out how to -- what actually went on
6 this.

7 If you want two CVD chambers that
8 deposit silicon oxide and one that deposited doped
9 silicon oxide, what showed up on the sales order,
10 what went to manufacturing, that's one element.

11 Then the other element is how do you
12 get that order into manufacturing because
13 basically it just looked like a big menu with
14 hundreds of choices of modules and subassemblies
15 could be done.

16 Over the first year I sorted all that
17 out and made sense out of that.

18 I also worked on detail design of many
19 aspects of the mainframe, everything from the
20 robot to the RF matches, the gas panels, the
21 vacuum pump systems, the remote frame.

22 I ended up redesigning the rear half

1 of the mainframe to accommodate a bigger breaker
2 box and bigger chemical delivery system, so
3 various aspects of it.

4 I re-did the hepa filters on it so
5 they would run in Japan also on 50 hertz. There
6 is numerous problems.

7 After that I took over as a customer
8 engineering specials manager. We ended up -- I
9 don't want to say modifying every system we built.
10 Every system was different, but there were a lot
11 of idiosyncrasies to each manufacturer and each
12 country and jurisdictions for safety, so ended up
13 modifying the equipment with my team repeatedly
14 over the first few years, so that type stuff.

15 Q You mentioned the etch division.
16 What were the primary responsibilities of the
17 etch division at Applied Materials?

18 A Well, when I started the etch
19 division had their own batch processor.

20 They didn't use the mainframe. They
21 had their own tool, and I wouldn't call it a
22 mainframe.

1 It was just a batch system with one
2 big chamber and really wasn't reconfigurable, so
3 the etch division initially transitioned their
4 processors from batch to single wafer and put them
5 on the mainframe, the 5,000, it was called.

6 Then after that they had
7 responsibility for modifying the mainframe in any
8 way that they needed for their particular
9 processes.

10 Of course, any division is responsible
11 for developing their processes and chambers. Of
12 course, they have to support the marketing and
13 sales teams with demonstrations, so whether it was
14 CVD or etch, you had to run wafers for customers
15 both for demonstrations and acceptance sometimes.
16 You know, in the end these were billion dollar
17 divisions.

18 They had a lot of responsibilities.
19 In the end they would, of course, have
20 responsibility for support in the field when the
21 service division needed high level support,
22 specialized factory support, things along those

1 lines, from an engineering and operational sense.

2 Q Sounds like the etch division and
3 CVD division were both involved in developing
4 this 5000 mainframe tool. Would that be
5 accurate to say?

6 A If you asked the CVD people, they
7 developed it and they pretty much did.

8 When this 5000 came out, there were no
9 etch chambers on it, only CVD.

10 Shortly after that -- it sold really
11 well, customers loved it. It was considered big
12 change to go to single wafer, so the company
13 decided that the etch group had to use that
14 mainframe.

15 So rather reluctantly, you know, there
16 was a lot of people with a lot of history, and you
17 know, corporate politics, they adopted the new
18 mainframe and transitioned their processes to
19 single wafer.

20 After that though, they had a big role
21 in the mainframe because at the time when I
22 started there were no CVD sales. It was a new

1 division. Etch was carrying the company.

2 So going forward, to put etch on the
3 5,000, it had to accommodate that -- the mainframe
4 had to accommodate the largest division in the
5 company, so they both over time had the large
6 amount of influence over the mainframe.

7 Eventually the mainframe went
8 corporate though. It was built by the corporate
9 group and then divisions had to work with the
10 corporate group to manage their mainframe
11 requests.

12 Q So it sounds then like the CVD group
13 initially developed and designed the 5,000
14 mainframe tool, and the etch group incorporated
15 their own etch specific chambers onto that tool?

16 A Yes, that's reasonable.

17 Q Did you ever have an opportunity to
18 interact with the etch group or work with the
19 etch group on the tools they were developing?

20 A Yes, because as some point shortly
21 after that the -- around that time, when all
22 this activity was going on, the etch and CVD

1 groups merged.

2 What better way to help the etch group
3 get their chambers onto the tool than have the
4 people who developed the tool work with them.

5 So yes, at some point I was in a joint
6 CVD etch division, and we were integrating the
7 etch processes into the new platform, new
8 mainframe.

9 Q So what tasks did you work on to
10 integrate the etch chambers to the mainframe
11 device?

12 A Well, very similar to what you would
13 do in CVD. Once the mainframe was established
14 you had less to do.

15 You had to make sure that, from a
16 systems point of view, that the interfaces
17 existed, so you sort of break it down to
18 electrical signals.

19 You have analog ins and analog outs,
20 digital ins and digital outs. This was before we
21 went to a serial bus.

22 Then you have pneumatics interfaces,

1 turn valves on and off, cooling water, a power
2 limit.

3 You have to understand how much power
4 the plasma sources are going to draw or magnets
5 for etch processes.

6 The pumps are sometimes enormous.
7 They have to physically fit. You have to design
8 the flow paths. Vacuum lines are kind of like
9 car exhausts, very particular.

10 So all of this, you had a lot of
11 detail into getting these things to fit. This was
12 back in the days where a lot of the design was
13 done with pen and pencil and two dimensional CAD,
14 so, you know, if you didn't have a lot of
15 experience with the system, you couldn't design
16 something without running into 14 other things, so
17 it was a lot of key people that could make things
18 work and fit.

19 Of course, you had to -- I'm talking
20 about the system level integration.

21 Then at the chamber level integration
22 you had more stuff along the lines of making sure

1 that, you know, there was adequate temperature
2 control, that the magnetic system didn't talk to
3 the rest of the system, that it was shielded, that
4 the RF was shielded so that it didn't short
5 everything out around it, that things were safe.

6 I remember talking to an etch engineer
7 once about the safety issues of the chamber, and
8 he said, no, it's fine, while he had this big burn
9 mark across his forehead.

10 Then, of course, the gases were
11 hazardous, deadly in a lot of cases.

12 That was one of my areas of expertise,
13 was hazardous chemicals that touch wafers, wedded
14 gases. Gases wedded a wafer, so you had to make
15 sure all of the safety was in place, and it was
16 integrated properly into the tool, so that people
17 didn't get hurt, and you couldn't assemble -- to
18 the extent that you couldn't build a system that
19 wasn't safe, there were kind of design features
20 that were keyed, so to speak, that you couldn't
21 put things that didn't go there, and then try to
22 get some things in place so that sales couldn't

1 **sell configurations that weren't safe.**

2 Q Did you ever have a chance to do any
3 etching while you were at Applied Materials?

4 A **Yes.**

5 Q Can you describe what etching you
6 did?

7 A I'll start with one example. While
8 I was at Applied I proposed a project to
9 Sematech which they accepted that I managed, in
10 which case we looked at the effects of micro
11 contamination on a CVD process and an etch
12 process.

13 So we ran numerous etch processes,
14 looked at the effect on the etch uniformity, the
15 etch profiles. We examined them under SEMs
16 ourselves.

17 Some work we sent to outside labs for
18 equipment we didn't have for measurements, but we
19 could determine when there was an effect, or not,
20 of a proposed contaminant upon the etch processing
21 results.

22 Q In that study do you recall what

1 percent were being etched?

2 A I think in the Sematech program it
3 was -- probably could have been a metal etch,
4 aluminum. That would be one example, yes.

5 Q Do you remember the chemistries that
6 were being used to etch the aluminum?

7 A My recollection, it's been a long
8 time, is it was a bromine chlorine combination,
9 hallogen gas species.

10 Q You think it was called Sematech?

11 A Sematech, yes. S E M A T E C H.

12 Q In addition to the Sematech project
13 were there other opportunities you had to
14 perform any etch processes?

15 A Yes. All of the processes we
16 developed, we had to run wafers for, so I was on
17 numerous teams with hardware process, software
18 engineers, where we developed process chambers,
19 and when we -- whether we were doing a CVD or an
20 etch project, invariably a CVD film gets etched
21 and you need to deposit a film to etch it, so
22 they pretty much went hand in hand in all the

1 projects.

2 One of the key measurements of a
3 material is how well you can etch it. If you
4 deposit a film, you have to create a pattern in
5 it.

6 Some films are difficult to pattern
7 because they erode too quickly or are not
8 selective, so we etched -- we deposited and etched
9 oxides and nitrides and tungsten films.

10 Basically any film that we sold, we
11 had to be able to deposit an etch, so numerous
12 silicon compounds and the various metals.

13 Q It sounds, too, like you would do
14 testing of the system or a demonstration of the
15 system for customers?

16 A Well, we did -- when we developed
17 the process tools we ran processes.

18 We had to characterize it and decide
19 what its performance was, and invariably it wasn't
20 what we wanted the first time, but testing went on
21 for months typically until you went through the
22 experimental parameters.

1 It might be the design of the
2 showerhead to distribute the gas to the wafer, so
3 the thickness of the film was uniform, and
4 invariably it wasn't uniform at first, and the end
5 would be thin or the middle too thin, or
6 something.

7 There was just lots of problems, so we
8 did lots of that.

9 And then we ran marathon tests to show
10 that the process and equipment together were
11 reliable, because, you know, depending on who you
12 talk to, the company would say we don't sell
13 equipment, we sell processes, so you had to make
14 sure the equipment performed the process, and you
15 didn't get paid for the equipment until it met the
16 process spec.

17 Customer demos, the design group
18 didn't have to do most of the demos. There was a
19 demo group that did that.

20 We would help the demo group in terms
21 of hardware and set up, because they had to have
22 sometimes a specific configuration for a specific

1 customer, but for the most part the -- largely
2 there was a demo group that ran the demos.

3 Q I think also at Applied Materials
4 you said you were systems engineer. Is that
5 right?

6 A Yes.

7 Q And was one of the areas that you
8 worked in as systems engineer developing
9 dielectrics of silicon dioxide?

10 A Yes. When I started at Applied
11 Materials I came in as a mechanical
12 engineer/systems engineer, and what we did was
13 develop the first CVD processes for the 5,000
14 which were silicon oxide dielectrics, and then
15 of course, silicon nitride, silicon oxinitride,
16 and then doped silicon oxide, boron phosphorus,
17 silicon glass, PBPSG, and then phosphorus
18 silicon glass, PSG, and then we also developed
19 many flavors of silicon dioxide after that, ones
20 that were deposited at higher pressures, ones
21 that were deposited thermally without plasma,
22 ones that were deposited with ozos instead of

1 oxygen, and so there are a lot of different
2 silicon oxides.

3 Q So when you say you developed layers
4 of those materials, is it kind of like you
5 developed recipes for specific versions of
6 silicon oxide, for example?

7 A We developed the equipment or the
8 modifications for the equipment, and then the
9 recipes, yes.

10 As an equipment company, you had to
11 deliver a piece of equipment that performed this
12 process, so you gave -- what you sold to the
13 customer was BKM, or best known method, so that
14 was the process recipe that you guarantee, and
15 when your equipment performed that process, it was
16 considered working.

17 Q What were your responsibilities in
18 developing the list of materials that you
19 described?

20 A It varied over time. You know,
21 everything from designing detailed parts.

22 I was the supervising manager of the

1 design group for a while, responsible for
2 thousands and thousands of blueprints and layouts
3 to making sure that it transitioned to the
4 manufacturing, building the prototypes, making
5 sure that the prototypes started up in the
6 laboratory for running the processes, helping to
7 run the processes and equipment, modifying the
8 equipment to support the experimental plan to get
9 the film to where the company needed it to be.

10 Some cases, I would go out to customer
11 sites. We would have joint development projects
12 where we would send a piece of equipment to a
13 customer site, but modify it so that it would meet
14 their specific needs, and I can go out and do
15 that.

16 Q Did you engage in any testing of the
17 materials that you developed -- let me start
18 over.

19 In developing the list of materials
20 that you provided, did you have an opportunity to
21 engage in any testing of those materials?

22 A Yes.

1 Q What type of testing?

2 A I used at Applied Materials scan
3 electron microscope, profilometers, stylist
4 profilometers, sort of like a record player, has
5 a needle that you can measure things that are
6 nanometers thick, used that to measure film
7 thickness, thickness measurement tools, such as
8 ellipsometers, and the like that would measure
9 either 13 or 49 points on the wafer optically to
10 know how thick a film was.

11 Did other testing that was, you know,
12 process chamber related testing.

13 I used RGAs, residual gas analyzers,
14 to look at the chemistry in the chamber or what
15 was coming out of the chamber, too.

16 I also had some particle measurement
17 equipment.

18 Q Did you have an opportunity to do
19 any etch testing of any of those materials you
20 listed?

21 A You know, a lot of the etched
22 examination would be, first of all, a profile

1 that was largely at the time SEM.

2 You would look at etch profiles to
3 make sure they had the profile you were interested
4 in and then thickness measurements.

5 Q When you say profile, what were you
6 looking at under the SEM specifically?

7 A Okay. In theory, when you see
8 things in patents and in papers, you see a
9 rectangular hole and they call that a groove.
10 In reality it's not. The bottom corners are
11 rounded.

12 There is no such thing as nature pours
13 a corner, so the corners aren't around. The top
14 corners are usually kind of beat up. The walls
15 may not be straight.

16 The lithography may have -- sometimes
17 you get standing waves in the resist, so when it's
18 exposed it's not straight either, so it causes odd
19 artifacts in the etching profile.

20 You're basically comparing the desired
21 profile to the output, the result.

22 A lot of times the edges are also not

1 vertical, they are tapered.

2 In some cases they are designed to be
3 tapered, in some cases they are not, but they are
4 tapered, so these are the kind of things you would
5 look for in terms of the profile of the etch
6 pattern.

7 Q And were the different materials
8 tested against different etching materials to
9 give a desired profile for each one?

10 A Well, a material, say, for example,
11 silicon oxide based on TEOS plasma, very routine
12 film we sold, probably our most common film.
13 You know, that would have a certain spec for the
14 width at the bottom of the via or the bottom of
15 the groove, or whatever you want to call it,
16 whatever you're working with, to the top.

17 Is it the same, how verticle is it, is
18 it five percent thinner at the bottom, you would
19 have specs like that, so you're just looking at
20 that film, you know, for what its goal was, what
21 you promised the customer it would do, or what the
22 spec is you're trying to hit to guarantee to your

1 client base.

2 Or you might look at sometimes
3 contamination. When you etch you can also etch
4 the chamber.

5 When you're etching aluminum, etching
6 an aluminum chamber isn't really a problem, not
7 contamination exactly, aluminum on aluminum, but
8 if you get material from a chamber into an
9 insulator, dielectric, it's a problem, so that
10 goes more along the lines of either it's ionic
11 contamination, metal species running around, and
12 there are certain tests for that, or you get
13 chunks of material, parts down into the groove.
14 Ninety percent plus of yield loss is particle
15 based.

16 It's not deformity of the pattern.
17 It's undesired chunks of material falling off the
18 chamber wall, either material that you had etched
19 that deposited on the wall and came off or part of
20 a chamber liner or something down into a groove,
21 so you look for things like that.

22 The same in CVD. You look for

1 particles because that's your main loss of yield,
2 particle.

3 Q Were the etch profile specs tied to
4 any particular etching conditions?

5 A The etching conditions -- well, a
6 certain etch recipe was guaranteed to yield a
7 certain result.

8 Q And did you investigate or provide
9 specifications for different etch recipes?

10 A We had BKM, a best known method that
11 was the starting point, and that's usually what
12 you show the customer first.

13 After that the customer could request
14 a change. They could say, okay, that's great, but
15 we need a hole that's deeper than all our
16 competition, we need a better film than you are
17 selling everyone else, so then you would go try to
18 develop something for that particular customer and
19 they might have a specific recipe that you
20 developed for them and then guaranteed that the
21 tool would perform that particular recipe and give
22 the desired result.

1 Q Do you recall any of the types of
2 etching recipes that were at issue at the time?

3 A Well, you know, any recipe
4 regardless of the process, CVD, etch or implant,
5 could be at issue.

6 You know, oxide etches, silicon oxide
7 was, at a certain point in time, you know, a big
8 seller.

9 We also sold a lot of metal etching,
10 aluminum etching. Thermite copper is chemically
11 etched, it's CMP.

12 There were always some difficult
13 etches. Tungsten etch back was difficult, CMP
14 eventually replaced it. Nitride etches were
15 difficult.

16 In the end, whenever a customer wanted
17 to go to a new technology node and make a smaller
18 feature on a chip, that usually pushed the
19 technology, and that's when you got requests for
20 improving your process.

21 So basically nothing was really state
22 of the art for more than 18 months, so it was sort

1 of a continual improvement upon the process to
2 meet the next generation of technology as stuff
3 shrank from one micron down to, you know, I guess
4 we're down to nanometers now.

5 Q Also as a systems engineer at
6 Applied Materials, I think you mentioned
7 developing organometallic CVD systems?

8 A Yes.

9 Q What aspects of the organometallic
10 systems did you develop?

11 A For a long time I was responsible
12 for all of the organometallic delivery, so we
13 used TEOS, tetra ethol orthosilicate, which was
14 the most common precursor in the industry for
15 silicon oxide because it was safe. It replaced
16 zilene that was very dangerous.

17 We used other organometallics for
18 phosphorus and boron doping.

19 I'll refer to them by their acronyms,
20 TMP and TMB, for brevity here.

21 So I would be responsible for
22 everything from working with the suppliers of the

1 chemicals to designing the ampules that we would
2 put them in, because we used customized ampules,
3 and then designing the vaporization or transition
4 from the liquid to the gas phase, the vapor phase,
5 the flow control and heaters that allowed one to
6 deliver these organometallics to the chamber
7 before they recondensed as a liquid, so did a lot
8 of organometallic design back then.

9 Of course, I worked with the jets that
10 introduced it into the chamber.

11 Q Just to be clear, when you refer to
12 organometallics, what are those?

13 A Organometallics are something that
14 has a organic component and a metal component.

15 People usually refer in that context
16 to silicon as metal. Technically it's a
17 semiconductor, but whether it's something you
18 might more traditionally understand as a metal or
19 silicon, they refer to them as organometallics, so
20 the ethel groups on TEOS are organic groups.
21 There are four of them.

22 Q Did you have any experience while at

1 Applied Materials designing or building complete
2 semiconductor devices?

3 A Well, what we made at Applied
4 Materials were largely what I would call the
5 building blocks of semiconductors.

6 So we made the films and eventually we
7 kind of stepped up and started making the
8 functional groups.

9 Let me explain what I mean by
10 functional group. In the early days, if one
11 wanted to deposit a metal layer, one had two
12 things to think about, the dielectric and the
13 metal.

14 However, eventually that became much
15 more complicated. One might have, instead of a
16 dielectric deposition, an etch and a metal
17 deposition and metal etch, four processes to run
18 and two different materials. It became five or
19 six materials and maybe a dozen different tools.

20 One might have a dielectric, then a
21 low K dielectric, then a barrier layer on the low
22 K, then a liner in the trench or via, so that the

1 copper didn't escape, and then a cap on that, so
2 it went from a couple of steps that the fabs can
3 manage to being multiple systems that needed to be
4 integrated, so what we eventually started doing
5 was basically packaging that as a selling point.

6 You know, we would sell you all the
7 capability you needed to have to make this entire
8 metal layer including the metal, the barrier
9 layers and the various low Ks.

10 Same things for transistors.
11 Transistors are very complicated, so we had
12 different groups that could sort of package
13 different parts of the system. A gate stack.

14 We had a group that did nothing but
15 the gate stack eventually because it became
16 multiple layers and multiple pieces of equipment.

17 The transistors were, of course,
18 numerous pieces of equipment, but even just metal,
19 two out of ten metal layers, that was a group of
20 things you needed.

21 We did have a capability to make
22 chips. We didn't sell chips, we sold equipment.

1 There were times when local fabs had
2 problems and they would come over with their
3 product wafers and we could run them for them and
4 that would be the exception.

5 That was a favor we did for the
6 companies, smaller companies. We couldn't handle
7 the volume of an Intel or something, but we had a
8 few pieces of equipment at a fab, and they were
9 having problems with our equipment, they would
10 have no problem asking us to help them.

11 There used to be more small fabs in
12 the Bay Area.

13 Q How about while in your role at Glew
14 Engineering? Do you have any experience
15 building semiconductor devices there?

16 A Well, basically we work with
17 semiconductor equipment and semiconductor
18 materials. So we're a small company. We don't
19 make a chip. That's a multibillion dollar fab
20 that does that.

21 Q How about any role in designing
22 chips?

1 **A** Well, largely we work with design of
2 the equipment for making the chips in the
3 processor.

4 **Q** I would like to talk now about your
5 doctoral dissertation.

6 **A** Yes.

7 **Q** 1996 to 2002 you were working on
8 your Ph.D. at Stanford?

9 **A** Yes.

10 **Q** I think you mentioned one of the
11 areas that you worked on was a project that
12 involved MIS capacitors, is that right?

13 **A** Yes.

14 **Q** What's an MIS capacitor?

15 **A** MIS is an acronym for metal
16 insulator semiconductor, but basically a
17 capacitor is simply two metal electrodes and an
18 insulator in between them.

19 So you can determine properties of the
20 insulator by building a capacitor with it, and
21 then that gives you you a lot of information about
22 the dielectric values.

1 Q You built some MIS capacitors?

2 A I built test structures for testing
3 the dielectric properties of the dielectrics I
4 was developing, yes.

5 Q What were some of those dielectrics
6 that you were looking at?

7 A Well, largely diamond like carbon
8 and fluorinated diamond like carbon, which we
9 called fluorinated amorphous carbon or FLAC.

10 Q How did you build the MIS
11 capacitors?

12 A There was, I would call it, a mini
13 fab at Stanford that we had access to.

14 Q What were the steps involved?

15 A Create the lithography patterns,
16 deposit the films, deposit the photoresist,
17 develop the photoresist, etch the patterns.
18 Then when you had the devices, take it over to
19 test equipment and test the properties.

20 Q You said develop the photoresist and
21 etch the patterns. Then did you etch the
22 materials below the patterns?

1 A Yes. You had to etch -- you know,
2 the purpose of a photoresist mask is to create a
3 material that you can etch around, so to speak,
4 you know, etch through holes in the photoresist,
5 the pattern, and that allows you to create
6 structures.

7 Q Then did you deposit other materials
8 in the holes that you created?

9 A Well, there are multiple systems.
10 First you have to deposit a metal.

11 You basically have to deposit a metal
12 and a dielectric and a second metal, because it's
13 a capacitor, so it's a sandwich of metal,
14 insulator, metal.

15 You can also do directly metal on an
16 insulator on the semiconductor. That's a
17 different structure.

18 So the metal insulator, metal
19 sandwiches, the MIMs, are essentially at that
20 point capacitors, and given the geometry, one can
21 determine the capacitance.

22 One measures the capacitance and from

1 the geometry one determines the dielectric
2 properties of the material.

3 As I was developing materials that
4 were dielectrics, I needed to know the dielectric
5 values.

6 I was also co-developing test
7 techniques where you could optically measure
8 dielectric properties, and I wanted to confirm the
9 optical measurements against a more standard
10 measurement, which would have been a test
11 structure, so I basically wanted to verify the
12 spectroscopic techniques I was using and that I
13 wrote software for against -- I don't want to say
14 an established -- yes, an established method.

15 Q So the dielectrics that you were
16 placing or depositing included diamond like
17 carbon and fluorinated diamond like carbon?

18 A Yes.

19 Q Did you deposit any other dielectric
20 materials or were those the two primary
21 materials that you were working with?

22 A Those were the focus of my thesis.

1 I did work with some other materials here and
2 there for fun or side projects and support other
3 laboratories, yes.

4 Q What is diamond like carbon?

5 A Diamond like carbon is a form of
6 carbon that has a certain SP3 content or diamond
7 structure.

8 There isn't just one material known as
9 diamond like carbon. I worked with hydrogenated
10 diamond like carbon.

11 Diamond in its purest sense is just
12 carbon, and it has a specific structure known as
13 diamond cubic. Now we're in the realm of material
14 scientists and geologists.

15 So there are certain structures that
16 crystals can have. Diamond actually has the same
17 crystal structure as silicon, so a silicon wafer
18 and diamond have diamond cubic structure.

19 If you think of a single carbon atom
20 in the middle of a tetrahedron, it has four bonds.
21 Think of it like a solid triangle, and it was
22 bonded only to other carbons.

1 That's another way to look at it from
2 the atomic view, as opposed to the crystal view.

3 However, in diamond like carbon not
4 all of those bonds are carbon. Some may be to
5 hydrogen. Furthermore, there may be some bonds
6 that aren't single bonds to other carbon but may
7 be double bonds to other carbon, and that's called
8 a graphitic bond, because graphite has a double
9 bond between the carbons.

10 In a crystal there is long range
11 order, so the atomic bonds are repeatable and the
12 same over long ranges.

13 In diamond like carbon you also have
14 very small granules, so there aren't crystals as
15 you think of them. They are on the nano scale.

16 So the bonds may repeat for a short
17 period but not for long periods. The result is
18 something that is fairly easy to make. Sometimes
19 it can even be deposited on plastic at low
20 temperatures, unlike diamond, which is difficult
21 to make and requires generally either high
22 temperature and pressure for industrial processes,

1 such as the GE process, or when deposited by thin
2 film methods is still a fairly hot process.

3 The properties of diamond like carbon
4 are good, but not as good as diamond. The
5 compromise is that it's much easier to deposit and
6 can be deposited on many things.

7 For example, there is a good chance
8 that all of us actually touched diamond like
9 carbon this morning. Many razors have diamond
10 like carbon on them.

11 Q Did you ever have a chance to etch
12 any of the diamond like carbon materials?

13 A Yes. I routinely etched them.

14 Q How did you do that?

15 A Well, there are different things. I
16 both etched and I obliterated or removed.

17 Sometimes if I had wafers I wanted to
18 re-use, and you know, wasn't that critical, I
19 could introduce oxygen into a process chamber,
20 strike a mass plasma, and basically ash or burn
21 off the carbon.

22 Q How does that compare to -- would

1 that be referred to as a dry etching process?

2 A It was a -- well, dry etching
3 includes plasma.

4 Generally, when one says dry etching
5 in the context of semiconductor processing, one
6 means plasma.

7 There are a few obscure efforts to
8 etch without plasma but in industry the vast
9 preponderance of dry etching is plasma etching but
10 that's different than ashing per se.

11 Etching usually implies that you are
12 creating a pattern. Ashing is just the removal of
13 a film, whether -- whether it's a photoresist or
14 carbon film, if you burn it off with oxygen, ash
15 it, you are just removing everything. There is no
16 pattern left in that case.

17 Q So you could -- if you wanted to
18 etch using a pattern, if you wanted to etch the
19 diamond like carbon, you could use an oxide
20 plasma?

21 A Well, no. At that point actually
22 you would -- DLC -- how should I put this. A

1 CVD chamber and etch chamber are not all that
2 different in some regards.

3 When you really mess up a deposition
4 process, and you might do this experimentally
5 sometimes, instead of depositing you etch. So
6 depending upon the energy in the plasma and how it
7 impacts the wafer, you can either deposit a
8 material or etch a material.

9 The plasma used in DLC or fluorinated
10 DLC included CF₄, carbon tetra flouride, as well
11 as methane.

12 The flourine provided the flourine in
13 the fluorinated carbon but it also etches.

14 The plasma produces a few ions. One
15 out of every 100,000 molecules or atoms in a
16 plasma in chamber is ionized.

17 A flourescent light bulb is similar,
18 25 degrees, not millions of degrees, because it's
19 not fully ionized like a super Nova or the sun.

20 So a process chamber creates lot of
21 reactive species that do much of the work both in
22 deposition and etching and a few ions, so the

1 balance between the number of ions and the energy
2 of the ions gives you the ability to either
3 deposit, deposit slowly with certain properties,
4 or more quickly with different properties, or in
5 some cases that same chemistry but with different
6 process conditions will allow you to actually
7 etch, because you are knocking more off than you
8 are actually accumulating on the surface.

9 Q So if you wanted to deposit diamond
10 like carbon you could use environments that
11 included oxygen and flourine? Is that what I
12 heard?

13 A No. Typically for depositing FLAC
14 what I used was methane, which is an organic
15 component, as carbon and hydrogen, and CF₄, and
16 then of course a filler gas or carrier gas,
17 argon.

18 Argon doesn't deposit but allows one
19 to tune the plasma and ballast it, keep the
20 pressure at a certain level without increasing the
21 other gases.

22 Q So conversely, if you wanted to

1 etch, what chemistries would you use to remove
2 diamond like carbon?

3 A Diamond like carbon, well, if you
4 just wanted etching as opposed to obliteration
5 or ashing, I could etch with CF₄ in the
6 chemistry. CF₄ is a very common etching in the
7 industry.

8 Flourine is a good material for
9 removing. It's very reactive, it's more reactive
10 than oxygen.

11 Q So could you also use as an
12 alternative oxides or oxygen containing
13 chemistries to etch diamond like carbon?

14 MR. DAVIS: Objection.

15 THE WITNESS: I didn't. I used oxygen
16 only for the removal of the -- when I wanted to
17 strip the wafer of everything I used oxygen.

18 Q (By Mr. Jiron) Would it have been
19 possible to use oxygen containing gases to remove
20 diamond like carbon from an etching process?

21 MR. DAVIS: Objection to form.

22 THE WITNESS: Oxygen wouldn't give

1 much selectivity itself. One might be able to use
2 dilute amounts of N2O or nitrogen oxygen compound
3 that is much less reactive than oxygen.

4 Q (By Mr. Jiron) When you say it wouldn't
5 provide much selectivity, what do you mean?

6 A Oxygen just basically largely
7 provides sort of an isotropic etch.

8 The difference between an isotropic is
9 you can etch a pattern, a verticle pattern,
10 plasmas that are very high pressure and don't have
11 a lot of ions because they run into other atoms or
12 molecules. I'll say plasmas that are low -- low
13 ion content but high reactive species content are
14 generally isotropic so oxygen generally
15 contributes to more of an isotropic type etch
16 which is essentially I what an ashing is.

17 Q What about combinations of oxygen
18 chemistry with flourine chemistry? Could that
19 be used to etch diamond like carbon?

20 A One could try flourine chemistry in
21 something like an N2O, something like a dilute
22 form of oxygen that's bonded.

1 As an engineer or scientist, my first
2 approach wouldn't be to use oxygen if I want to
3 try accelerating the etch rate or something.

4 I would probably -- I don't know if it
5 would work, but I would try N20.

6 The problem with -- the faster the
7 etch rate in general, the lower the selectivity.
8 There is a trade off between the speed of the etch
9 and the number of reactive species, radicals,
10 versus the number of ions, kind of is a trade off.

11 Q We have been going for about an hour
12 so you want to take a break?

13 A Sure.

14 Q Ten minutes?

15 A Sure.

16 (Recess)

17 Q So we were talking about MIS
18 capacitors before the break, so I would like to
19 go back and continue that discussion.

20 I think you had mentioned that
21 construction of the MIS involved pattern? Is that
22 right?

1 A Yes. A capacitor has two
2 electrodes, so one has to have an electrode on
3 each side of known dimension for calibration
4 purposes, in my case.

5 Q How were the patterns used?

6 A Well, the patterns were used to
7 create electrodes of different sizes, so I could
8 create electrodes with different capacitance.

9 I wanted to decouple any effects
10 associated with etches or other artifacts by
11 testing different multiple capacitors or different
12 sizes to make sure that I got a consistent reading
13 for the dielectric value of the material in
14 between the two electrodes.

15 Q What types of patterns did you use?

16 A Generally fairly straightforward, I
17 would call simple patterns, rectangles and
18 squares, you know.

19 Q What types of materials were used to
20 create the patterns?

21 A Well, the electrodes were aluminum
22 so I sputtered aluminum for the electrodes, and

1 the dielectric, of course, was flourinated
2 amorphous carbon or DLC.

3 Q Was there photoresist?

4 A Yes, photoresist is used to create
5 the pattern.

6 The material that we were patterning
7 was either the electrode or the insulator, the
8 dielectric in the capacitor, and we used
9 photoresist to provide the pattern that we etched
10 into the materials.

11 Q Can you describe the process by
12 which you have created the photoresist needed to
13 pattern the materials?

14 A Well, the photo -- it's been a long
15 time but the photoresist was a purchased
16 commodity, one buys photoresist.

17 There is a dispense unit that
18 dispenses a certain amount of photoresist in terms
19 of, you know, X volume onto a surface of a certain
20 size which you calculate to make a thickness of a
21 micron or so of photoresist, and then there is a
22 spinner.

1 You know, as the draw is dispensed
2 onto the spinning wafer, it disperses on top the
3 wafer, and then one has a photoresist that needs
4 to be baked at some point, needs to be exposed and
5 needs to be developed.

6 Q How do you develop it?

7 A Well, you start with exposure and
8 after exposure it's weakened and then a chemical
9 that attacks the exposed portion of the
10 photoresist simply washes it away.

11 Q What's that chemical?

12 A I don't recall which one I used back
13 then, whatever was in the laboratory at the
14 time.

15 It was a university laboratory so you
16 basically used what they had, didn't have the
17 choice to change it, didn't have the need to
18 either.

19 Q Are there various chemicals that
20 would work in removing the photoresist?

21 A Different photoresists are meant to
22 work with different chemicals.

1 Q Was it a wet process or a dry
2 process that removed the photoresist?

3 **A In the exposure that was a wet**
4 **process.**

5 Q Could photoresist be removed using a
6 dry process?

7 **A One can ash photoresist.**

8 Q Are there any other processes for
9 removing photoresist in the dry process?

10 MR. DAVIS: Objection to form.

11 THE WITNESS: In that laboratory the
12 process for removing the photoresist was a wet
13 process. That was the process I used.

14 Q (By Mr. Jiron) Were any other processes
15 known at the time for removing photoresist in the
16 dry method?

17 MR. DAVIS: Same objection.

18 THE WITNESS: I'm not sure at the time
19 if there were dry methods.

20 We used a wet method for exposure --
21 excuse me, for -- yeah.

22 Q (By Mr. Jiron) How would you ash a

1 photoresist?

2 A Photoresist ashing, also known as
3 photoresist strip, is an oxygen based plasma.

4 We sold PRS or photoresist strip tools
5 while at Applied Materials, so they were
6 essentially oxygen based plasmas that reacted with
7 the material and essentially created volatile
8 species that disappeared. They burned off
9 basically.

10 The reason they call it ashing is
11 because it's kind of like burning. You oxidize
12 it.

13 Q When we're talking about photoresist
14 is there a particular material that's used for
15 photoresist?

16 MR. DAVIS: Objection to form.

17 THE WITNESS: The materials used for
18 photoresist are fairly complex polymers,
19 combinations. The different manufacturers have
20 their offerings.

21 Q (By Mr. Jiron) And are those polymers
22 organic polymers?

1 **A** One generally considers them
2 **organic. They are organic in that sense.**

3 They are not organic in that you would
4 **ever find them in a living creature.**

5 Q They contain carbon?

6 **A** **Yes.**

7 Q So what did you do to prepare for
8 the deposition today?

9 MR. DAVIS: To the extent the question
10 asks for any communications with counsel, those
11 would be privileged, but the witness can answer
12 otherwise.

13 THE WITNESS: I reviewed documents
14 related to the IPR. You know, might have
15 consulted with a reference or two on my bookshelf,
16 and met with attorneys.

17 Q (By Mr. Jiron) Who did you meet with?

18 **A** **Mr. Davis and Mr. Yen.**

19 Q For how long did you meet with the
20 attorneys?

21 **A** **In total maybe 10 or 12 hours.**

22 Q When did those 10 or 12 hours of

1 meetings occur?

2 **A** **I met with them once last week and**
3 **once this week.**

4 **Q** Were those in person meetings?

5 **A** **Yes.**

6 **Q** You mentioned that you reviewed some
7 documents in preparation. Which documents did
8 you review?

9 **A** **Well, off the top of my head, I'll**
10 **try to remember that.**

11 MR. DAVIS: Any conversations, again,
12 to the extent that any question calls for any
13 communications with counsel, again, those are
14 going to be privileged.

15 You can answer as to what you
16 reviewed.

17 THE WITNESS: I reviewed the
18 institutions from the patent office, the patent
19 office exhibits, the expert reports by Dr. Smith,
20 the petitioner's exhibits, the patent owner's
21 exhibits, my declarations and related support
22 documents for those documents.

1 Q (By Mr. Jiron) You also mentioned that
2 you had made a reference or two from your shelf.
3 Do you recall what those references were?

4 **A Usually keep Tauber, T A U B E R,**
5 **and Wolfe or one of the Wolfe series.**

6 Q When were you first contacted, as
7 best you can recollect, about these IPR
8 proceedings?

9 MR. DAVIS: Again, you can answer as
10 to the timing if you remember, but I cannot -- any
11 particular communications would be privileged.

12 I understand your question is not
13 asking for any particular communications. Is that
14 right?

15 MR. JIRON: That's correct.

16 THE WITNESS: Earlier this year.

17 Q (By Mr. Jiron) In 2017?

18 **A Yes.**

19 Q Do you remember which month?

20 **A No.**

21 Q Do you recall when you were retained
22 as an expert in these IPR proceedings?

1 A I was retained in a related Federal
2 District matter about two years ago, so that
3 sort of segued into this.

4 I was retained separately on this
5 matter this year.

6 Q Also 2017?

7 A Yes.

8 Q About how many hours have you spent
9 so far in these IPR proceedings in developing
10 the opinions that you included in your
11 declarations?

12 A That's a complicated question
13 because I worked on the related federal matter,
14 so I had reviewed the 696 patent in that context
15 already quite a bit.

16 That's sort of off limits here.
17 Working specifically on the IPR addendum,
18 something in the hundreds of hours.

19 Q You said that's sort of off limits
20 here. What did you mean by that?

21 A Well, the Federal Court case is
22 under a protective order.

1 Q I would like to hand you an exhibit
2 that has been marked IP Bridge Exhibit 2009 for
3 IPR 2016-01376.

4 **A Thank you.**

5 Q I suppose I should say, too, is it
6 okay when I refer to these IPR proceedings that
7 that includes IPR 2016 matters 1376, 1377, 1378
8 and 1379?

9 **A I would understand when you say that**
10 **that you are referring to these, yes.**

11 Q Do you recognize the document that I
12 just handed to you?

13 **A Yes, I do.**

14 Q What is this document?

15 **A This is a declaration I wrote with**
16 **regards to IPR 2016-1376.**

17 Q Until I say otherwise, can we
18 understand that when I refer to your
19 declaration, I'm referring to the declaration
20 that's IP Bridge Exhibit 2009?

21 **A Yes.**

22 MR. DAVIS: Objection to form.

1 Q (By Mr. Jiron) Let me go back. Just to
2 be clear for the record, in the questions that
3 I'll be asking, when I refer to your declaration
4 will you understand that to be IP Bridge Exhibit
5 2009 submitted in IPR 2016-01376?

6 A **That gets complicated if you ask me**
7 **about other declarations. I'm not sure how that**
8 **would work.**

9 Q I'm just trying to clear up, when I
10 do ask about things you understand I'm only
11 asking about this particular document.

12 Just as a shorthand, if I say "in your
13 declaration," you will understand that I'm talking
14 about only this particular declaration as IP
15 Bridge Exhibit 2009?

16 MR. DAVIS: Same objection.

17 THE WITNESS: It might be cleaner if
18 we just came up with something a little more
19 specific but still a shorthand like 1376 or
20 something.

21 Q (By Mr. Jiron) Sure. I'll say "your
22 1376 declaration."

1 **A** **Okay.**

2 **Q** I'll try to remember. If I don't,
3 please let me know.

4 **A** **Okay.**

5 **Q** Okay. So can you describe for me
6 the process for preparing your 1376 declaration?

7 MR. DAVIS: So any communications with
8 counsel involving the preparation of the
9 declaration will be privileged.

10 That's my view on it. We can have a
11 discussion on it, if that's helpful.

12 MR. JIRON: What specifically are you
13 considering to be privileged?

14 MR. DAVIS: The process, to the extent
15 there was one, of any interaction he had with
16 counsel in preparing his declaration.

17 MR. JIRON: On what basis are we
18 asserting a privilege here?

19 MR. DAVIS: Pevarello vs. Lan.

20 MR. JIRON: What did it say?

21 MR. DAVIS: I'm not going to read you
22 an excerpt from that if it's helpful.

1 MR. JIRON: I would just like to
2 understand your position.

3 MR. DAVIS: "Between one, an inquiry
4 into details of how a direct testimony declaration
5 can be prepared, on the one hand, and two, both
6 the attorney work product doctrine and attorney
7 work product privilege on the other hand, an
8 attorney needs to be able to freely talk with a
9 client, witness or non-client witness to formulate
10 a litigation strategy, or even to see if there is
11 a case to present. After the fact cross
12 examination inquiries into declaration preparation
13 tend to chill an inquiry an attorney might
14 initially make into what the facts are and who
15 should testify concerning particular facts."

16 Another quote from that case, "All of
17 these reasons are consistent with limitation in
18 patent interference cases for not permitting
19 inquiry into how a direct testimony declaration
20 was prepared and with the underlying philosophy
21 governing contested cases, citing 37CFR-14 2d
22 41.1(b), 2006. In the future absent a compelling

1 reason against any attempt to inquire on cross
2 examination into how direct testimony declarations
3 came to be prepared."

4 MR. JIRON: What was the court?

5 MR. DAVIS: I think that's the
6 precursor for the PTAB, but I don't have the full
7 cite. I can get that for you, if needed.

8 MR. JIRON: So in that case it sounds
9 like what they are after is how the testimony came
10 to be prepared.

11 What I'm interested in here is just
12 what the witness did in terms of a mechanical
13 action.

14 MR. DAVIS: That would be fine as long
15 as we're in agreement as to a line being drawn
16 between those two things.

17 MR. JIRON: Understood. I'm not
18 trying to ask about the conversations or how the
19 opinions came to be developed in terms of
20 discussions between counsel and the witness.

21 MR. DAVIS: Understood.

22 Q (By Mr. Jiron) Okay. So going back to

1 the question I was asking, can you describe the
2 process for mechanically preparing your
3 declaration?

4 Did you, for example, type your
5 declaration? Did you write your declaration?

6 MR. DAVIS: And again, I have this
7 same -- and I have an objection to this line of
8 testimony.

9 You can inquire as to what the witness
10 did, but not the interactions with counsel.

11 Q (By Mr. Jiron) Did you understand?

12 A Yes. I understand the question. I
13 typed much of my report, not all of it.

14 Q About how much would you say?

15 MR. DAVIS: Same objection, same
16 understanding.

17 THE WITNESS: Well, quite a bit of
18 work I had done previously in the federal case on
19 the 696, so a lot of this comes from that. I
20 can't put an exact percentage on how much of it I
21 typed.

22 Q (By Mr. Jiron) Okay. How many hours

1 would you estimate that you spent on the specific
2 task of preparing your 1376 declaration?

3 MR. DAVIS: Same objection, and to the
4 extent that you are also inquiring into anything
5 relating to the underlying litigation, which I
6 understand you are not, Mr. Jiron.

7 Are you inquiring as to anything
8 relating to the underlying litigation?

9 MR. JIRON: No. I think the question
10 was clear. At least, I thought it was.

11 It was how many hours did you spend on
12 the specific task of preparing your 1376
13 declaration just in terms of mechanics.

14 MR. DAVIS: Same objections regarding
15 privilege, as well as the underlying litigation.

16 THE WITNESS: A lot of the work for
17 this analysis of the 696 was performed -- I
18 performed previously in the context of the
19 district court litigation.

20 I think of this as sort of an addendum
21 to that. This addendum was, you know, a few weeks
22 worth of work.

1 Q (By Mr. Jiron) Do you understand that
2 there has been something called a patent owner
3 response filed in the 1376 proceeding?

4 **A Yes.**

5 Q Have you reviewed the patent owner
6 response from the 1376 proceeding?

7 **A Yes, I have.**

8 Q When did you review it last?

9 **A I reviewed it briefly for this**
10 **deposition.**

11 **I reviewed it more thoroughly when I**
12 **was working actively on the case a few months ago.**

13 Q Which case do you mean?

14 **A This case.**

15 Q Did you review any drafts of the
16 patent owner response in preparing your 1376
17 declaration?

18 MR. DAVIS: That would be directly
19 covered by Pevarello vs. Lan and also be
20 privileged.

21 You're asking for communications with
22 counsel there.

1 MR. JIRON: I'm not asking for a
2 communication. I'm just asking whether he looked
3 at the document.

4 MR. DAVIS: I disagree. You're asking
5 for communication. That's privileged.

6 MR. JIRON: It sounds like you're
7 forbidding us to find out what materials the
8 witness reviewed in preparing his declaration. Is
9 that what you're saying?

10 MR. DAVIS: No, I'm not.

11 MR. JIRON: So one of the materials
12 that I'm interested in, just as if he reviewed
13 prior art or reviewed a document, I'm interested
14 in did he review the patent owner's response
15 document while preparing the declaration.

16 MR. DAVIS: And I understand that's
17 what your question is.

18 I do view that as being privileged and
19 relating to the preparation of a declaration.

20 I'll tell you what. To circumvent
21 this, I'll allow the witness to answer as long as
22 you are agreeing there is no waiver of privilege

1 here.

2 MR. JIRON: That's fine. I'm only
3 interested in the mechanics, not a privilege
4 issue.

5 MR. DAVIS: Okay.

6 THE WITNESS: Can you repeat the
7 question?

8 (Question read)

9 MR. DAVIS: Same agreement. There is
10 no waiver of privilege.

11 THE WITNESS: I don't recall if I
12 received drafts.

13 I would have received the document at
14 some point, as it was given to the PTAB.

15 I think more it's a case of their
16 reviewing my work than my reviewing their work.

17 Q (By Mr. Jiron) I would like to take a
18 look at Page 36 of your 1376 declaration.

19 Q Page 36?

20 A I'm sorry. Are you referring to
21 page 0036 or 36 of my -- because there's
22 different page numbers.

1 Q Understood. I'll go with your
2 convention.

3 Looking at the page number at the
4 bottom right corner, which is the page of the
5 exhibit, and I think that's Page 40, is what I was
6 looking for.

7 A Okay. I am looking at the page
8 **marked 36 of the report and page 0040.**

9 Q Great.

10 A **In the production.**

11 Q You see a figure at the top of the
12 page?

13 A **Yes.**

14 Q And the figure has a label "Etching
15 Source" and a multilevel structure there that
16 has the word "substrate" at the bottom?

17 A **Yes.**

18 Q Did you prepare that figure?

19 A **I described the figure to the**
20 **attorneys and they, either them or their**
21 **graphics person, prepared it.**

22 **I prepared some other figures in here**

1 **but not that one.**

2 Q Which other figures did you prepare?
3 Do you recall?

4 A Well, I prepared some 3-D figures,
5 things that would look like -- I'm not sure if
6 they made it into this report, but I prepared a
7 number of three dimensional figures that look
8 substantially like 20 -- like the ones on page
9 0037, so I prepared --

10 MR. DAVIS: Any inquiry into any
11 communications with counsel, I have a standing
12 objection.

13 THE WITNESS: I would have prepared
14 the CAD image and they would have labeled it.

15 Q (By Mr. Jiron) Take a look at page 0057
16 of the exhibit which is also Page 53 of the 1376
17 declaration.

18 A **Yes.**

19 Q You see the figure in the middle of
20 the page that's got a red box surrounding the
21 words "layer 355 etched"?

22 A **Yeah.**

1 Q Did you prepare this figure?

2 MR. DAVIS: Again, this line of
3 questioning I think falls directly under
4 Pevarello.

5 You're talking about the preparation
6 of his declaration.

7 Also potentially, I'm not actually
8 sure wonder way or the other, I wasn't involved in
9 the underlying litigation, but you may also be
10 asking about communication there as well.

11 MR. JIRON: I'm not asking anything
12 about any communications.

13 If you want to have a standing
14 objection to this line of questioning that we
15 understand that none of it is to waive privilege,
16 I'm happy to do that, but I really strongly
17 believe that asking him about the mechanics of
18 whether he prepared a figure or not is well
19 outside of the issue that you described in the
20 case which is directly related to the direct
21 testimony.

22 It's related to how the direct

1 testimony came into existence, not about the
2 mechanics of who drew a figure or not.

3 MR. DAVIS: I'm not sure I understand
4 how you are drawing the line between direct
5 testimony and the declaration.

6 My understanding is the declaration is
7 direct testimony.

8 MR. JIRON: I think we'll just have to
9 elevate this issue to the board, if we can't
10 agree, like we did in the past.

11 MR. DAVIS: What do you mean we did in
12 the past?

13 MR. JIRON: We can allow the question
14 if we would agree that there is no waiver of
15 privilege, you said.

16 I don't see this as an issue of any
17 privilege waiver, and if you want to have that
18 objection, then you are free to make the
19 objection, but I believe that this is no more of
20 an issue than the other question I asked that you
21 allowed.

22 MR. DAVIS: Well, I disagree. There

1 is a distinction between some of these things and
2 I'll take it on a case by case basis for purposes
3 of this particular question, again agreeing there
4 is no waiver.

5 You can go ahead, but I'm not agreeing
6 to waive -- I'm not agreeing to drop my objection
7 on all future questions.

8 MR. JIRON: I'm not asking you to drop
9 the objection.

10 Q (By Mr. Jiron) The question was, did
11 you prepare the figure on Page 57 of the exhibit,
12 Page 53 of the 1376 declaration?

13 A I discussed the underlying content
14 of this figure and the text of this figure with
15 the attorneys.

16 This was my understanding of what
17 would result from the text.

18 As for the actual fabrication of this
19 image, it was produced by the attorneys or their
20 contractor. I'm not sure if they have a graphics
21 person.

22 Q All right. Then can you turn to

1 Page 97 of the exhibit, which is page --
2 actually, turn to Page 96 and 97, which is Page
3 92 and 93 of your 1376 declaration.

4 **A Okay.**

5 Q You see the figures that appear on
6 the top half of the page as 92 and 93 which are
7 Page 96 and 97 of the exhibit?

8 **A Yes.**

9 Q Same question, did you prepare those
10 figures?

11 MR. DAVIS: Same objection.

12 THE WITNESS: I discussed my
13 understanding of some of the problems that could
14 occur here and then they created the actual
15 graphic itself, but I don't know, again, if it was
16 them or a graphics company.

17 Q (By Mr. Jiron) Okay. I would like to
18 turn to paragraph 137 of your 1376 declaration and
19 specifically a section located on page 82 of the
20 exhibit, page 78 of the declaration.

21 Do you see the sentence that is about
22 halfway down the page that says "Petitioners

1 propose modification of Grill to remove layer 7
2 would result in the creation of an insulating film
3 that would rendered Grill's final structure
4 inoperable because it would prevent electrical
5 contact between a lower and upper layer"? Do you
6 see that?

7 **A Yes.**

8 Q Is that your opinion?

9 **A Well, I could put a finer point on**
10 **that. Without a stop layer seven, one of three**
11 **things could happen.**

12 **Either one would underetch, meaning**
13 **one didn't etch all the way down, or one could**
14 **etch too far, overetch, so without a stop layer**
15 **it's difficult to know where to stop the etch.**

16 **So in some instances without a stop**
17 **layer there would certainly be underetching,**
18 **because the only option then would be to overetch**
19 **which wouldn't necessarily be desirable.**

20 Q Can you explain how removal of layer
21 seven would result in the creation of an
22 insulating film?

1 A If one was trying to etch through
2 layer or material eight, which is above material
3 seven, one has to know when to stop the etch.

4 When one has a material that functions
5 as a stop layer, one can etch to the stop layer
6 and keep etching a bit longer to make sure that
7 all of material eight is gone without damaging
8 anything.

9 If one doesn't have a stop layer
10 seven, then one has to use a timed etch, so one
11 etches down, and in some cases, parts of the wafer
12 or different wafer, the amount of etch time for
13 different contacts will be slightly different.

14 So there may be cases where the
15 material is thicker or the plasma isn't uniform in
16 that part of the chamber, so it doesn't etch as
17 quickly or doesn't etch all the way through eight
18 down to hit the underlying metal.

19 There will be other metal. There will
20 be other cases where it etches fine and other
21 cases where it overetches, but basically a timed
22 etch is not necessarily as precise as having an

1 etch stop.

2 That is generally the purpose of an
3 etch stop, to make a more robust process.

4 It's not my opinion that it always
5 results in an insulating film. It's that in some
6 instances it's not going to etch all the way
7 through and there will be insulator left, and in
8 other cases it will overetch and there would be
9 other types of damage, to clarify that opinion.

10 Q All right. I would also like to
11 mark a little sketch as Glew Exhibit 1.

12 (Glew Exhibit 1 marked)

13 MR. DAVIS: Do you have a copy?

14 MR. JIRON: No, I don't. Do you want
15 to go off the record and make a copy?

16 MR. DAVIS: Yes.

17 (Recess)

18 Q (By Mr. Jiron) So, Dr. Glew, you have
19 the paper that's been marked as Glew Exhibit 1
20 that shows a sketch. Is that correct?

21 A Yes, there is a sketch.

22 Q And on the sketch are three

1 structures. One is called a resist, one is
2 called a pattern film and one is called layer X
3 or a layer to be etched. Do you see that?

4 **A Yes.**

5 Q Do you have an understanding of what
6 this sketch is depicting?

7 MR. DAVIS: Objection to form.

8 THE WITNESS: I have a rough idea that
9 this is a pattern one wishes to etch into
10 something.

11 Q (By Mr. Jiron) Maybe a better question
12 would be, you are familiar with this type of
13 sketch? Would that be fair?

14 MR. DAVIS: Objection to form.

15 THE WITNESS: It seems understandable
16 at face value. I would -- I could try to divine a
17 meaning from it.

18 If you have some detail on this
19 hypothetical, that wouldn't be a bad thing either.

20 Q (By Mr. Jiron) Okay. So the resist
21 that's shown on top, it has a hole in the middle
22 which would correspond to a pattern on the resist.

1 Is that fair to say?

2 A Yes. This is a two dimensional -- a
3 cross section showing the cross section of the
4 pattern. We don't know how deep or long it is,
5 but yes.

6 Q Okay. You could use, say, a dry
7 etching process to transfer the pattern from the
8 resist into layer X, which is the layer to be
9 etched. Would that be fair to say?

10 A Presuming one had the appropriate
11 dry etch process for layer X material, it's
12 certainly possible.

13 You have to have a process that can
14 achieve that aspect ratio width to depth and
15 compatible with that material as well as the
16 photoresist, so given the correct etching process,
17 you know, in this kind of pictogram or schematic
18 form, I understand that that's what you have in
19 mind.

20 Q Okay. And if you were to transfer
21 the pattern from the resist into layer X, it
22 would be fair to call the resist a mask,

1 correct?

2 MR. DAVIS: Objection to form.

3 THE WITNESS: Let me put -- are we
4 talking about in the context of the 696 patent or
5 in general?

6 Q (By Mr. Jiron) Actually, this is just a
7 sketch in general.

8 A In general, okay. I mean, the
9 reason I said that is sometimes people call the
10 reticle or mask that focuses the optics a mask,
11 and they would just call the resist the resist.

12 If we want to call the resist the
13 etching mask, that's fine, too. Sometimes mask
14 has additional meanings.

15 Q So you would agree then that at
16 least it would be customary for people in the
17 semiconductor field to refer to the resist in an
18 etching process as a mask?

19 MR. DAVIS: Objection to form.

20 THE WITNESS: I would say that it's
21 fine to do that. A lot of times mask is an
22 abbreviation for the reticle, which is sort of an

1 awkward word, but yes, for the purposes here, one
2 can call the pattern the mask, the template.

3 Q (By Mr. Jiron) Template?

4 A There is a lot of synonyms for the
5 templet and mask.

6 The odd thing about this hypothetical
7 is there is a layer to be etched, but there is
8 nothing underneath it, so I'm not sure when you
9 say etching if you mean you're going to etch right
10 through it.

11 Q I think the sketch is meant to just
12 be an assumption that there are structures below
13 it.

14 We're just talking about the first
15 interaction of the etchant with such structure.

16 A Okay.

17 Q You mentioned earlier the
18 possibility of doing a timed etch so rather than
19 using an etch stop layer.

20 Could you use a timed etch here to
21 etch a portion of layer X using the resist?

22 MR. DAVIS: Objection to form.

1 THE WITNESS: If one had worked up a
2 timed etch that etched approximately say half of
3 it, one could do that.

4 The weakness or aspect of the timed
5 etch is the stop point is timed so you never
6 necessarily end up with exactly the same thing,
7 device to device, wafer to wafer.

8 It may be close. How close it is
9 depends on the parameters in the equipment and the
10 product started with.

11 Q (By Mr. Jiron) So as drawn here in the
12 cross section, let me give you another assumption
13 for the hypothetical.

14 The resist is a resist that is an
15 opening that would correspond to a contact hole
16 and the pattern film has an opening in it that
17 corresponds to a wiring groove. Are you familiar
18 with those two structures?

19 A **I'm familiar with those structures,**
20 **yes.**

21 Q So with that assumption, in going
22 back to the case where the etchant is

1 penetrating through the opening in a resist,
2 what interaction would the pattern film have
3 with the etchant?

4 **A Well, my understanding --**

5 MR. DAVIS: I'll object form. Go
6 ahead.

7 THE WITNESS: My understanding from
8 this TIG is that the resist is completely covering
9 the pattern film at least over the area of the
10 hole in the resist that it's covered.

11 So neither the ions -- initially
12 neither the ions nor the more abundant reactive
13 chemistry, the radicals, will contact the pattern
14 film and interact with it.

15 It's possible that subsequently the
16 sidewall of the resist erodes and the pattern film
17 contacts it or that the top of the resist erodes
18 and contacts it, but as drawn here, I don't see
19 that there is any contact between the chemistry
20 and the pattern film.

21 There doesn't need to be a line on
22 site, so to speak, or a verticle path. It just

1 needs to be a chemical pathway to it, and I don't
2 see a chemical pathway to the pattern film the way
3 it's drawn.

4 Q (By Mr. Jiron) So you would agree then,
5 the way it's drawn, pattern film would not be
6 functioning as a mask in an etch that transfers
7 the resist pattern into layer X. Would that be
8 fair to say?

9 A In this particular example or
10 sketch, in the area of the hole in the resist, I
11 don't see that the pattern film is interacting
12 with the chemicals in any way, the etchants, so
13 I don't see that it has a role in determining
14 much at all at this point. It may later.

15 Q So if it doesn't interact with it,
16 it doesn't have a role, it wouldn't be a mask,
17 right?

18 A If we're using mask in the context
19 or to mean that it determines or partially
20 determines the pattern that is transferred, no,
21 it is not.

22 Q I think I understand what you mean

1 but I just want to make sure that the record is
2 clear.

3 Assuming that we're using the mask in
4 the context to mean that a mask determines or
5 partially determines the pattern transferred, in
6 that context what's drawn on this sketch as the
7 pattern film, that wouldn't be behaving as a mask,
8 correct?

9 **A That's essentially what I said, yes.**

10 Q I'll hand you what's been marked as
11 TSMC Exhibit 1001. Do you recognize this
12 document, Dr. Glew?

13 **A Yes, I do.**

14 Q What document is this?

15 **A This is the patent in question in
16 the proceeding.**

17 Q The 696 patent?

18 **A Yes.**

19 Q Okay. Let's turn to column 23 and
20 then at about line 40 in column 23, where it
21 starts, "Then as shown in Figure 22B, a second
22 resist pattern 510, having openings performing

1 contact holes is performed on mask pattern 509,"

2 do you see that?

3 **A Yes.**

4 Q You see the sentence after that that

5 says, "Thereafter the second silicon dioxide

6 film 506 is dry etched using the second resist

7 pattern 510 and the mask pattern 509 as a mask"?

8 You see that?

9 **A Yes.**

10 Q It's your understanding that that

11 passage is referring to Figure 22-B?

12 MR. DAVIS: I'll object, completeness.

13 THE WITNESS: The passage starts with

14 "as shown in Figure 22-B" and ends with "as shown

15 in Figure 22-C," so it appears to be referring to

16 at least these two figures.

17 Q (By Mr. Jiron) Okay. So going from

18 Figure 22-B to 22-C, is it your understanding what

19 this is depicting is a resist -- okay. Let me

20 just take it in smaller parts.

21 In Figure 22-B do you understand layer

22 510 to be a resist that includes a contact hole

1 pattern?

2 **A Yes, I understand 510 is a resist**
3 **for forming a contact hole.**

4 Q Okay. And do you understand that
5 pattern 509 has openings -- is a layer that has
6 openings performing wiring grooves out of a
7 titanium nitride film? Is that your
8 understanding?

9 **A That's my understanding, yes. 507**
10 **is etched from a pattern for wiring groove and**
11 **thereafter called 509.**

12 Q Going from Figure 22-B to 22-C,
13 what's being depicted here is an etch of layer
14 506, is that correct?

15 **A Yes. 506 is shown as etched, a**
16 **silicon dioxide film.**

17 Q So in this particular case certainly
18 510 is functioning as a mask to transfer the
19 contact hole pattern to layer 506, right?

20 **A I understand that 510 is described**
21 **as that in the text.**

22 **Is there somewhere in my report you**

1 **wish to refer me to where I opined on this?**

2 Q Yes. Actually, for now we're just
3 talking about -- I think the passage of most
4 relevance would be in column 23 and then these
5 two figures. Do you need to review column 23?

6 A No. My point was that did you wish
7 to refer me to somewhere in my report where I
8 have opined on this figure?

9 Q No.

10 A I don't recall opining on this
11 figure.

12 Q Do you understand the figure?

13 A I believe I understand the figure.

14 Q Okay. Maybe then can you explain to
15 me in your words and in view of the passage in
16 the middle of column 23 what's going on between
17 Figure 22-B and 22-C, and maybe that will help
18 me structure my question.

19 MR. DAVIS: Objection to form.

20 THE WITNESS: I think generally it's
21 described at 23, lines 40 to 46, from which you
22 partially read, "Photoresist pattern is used to

1 provide a template to transfer a feature to an
2 underlying layer 506."

3 Q (By Mr. Jiron) So when you say a
4 template, that could also be referred to as a
5 mask?

6 A Yes.

7 Q What role does layer 509 have in
8 transferring that pattern from layer 510 into
9 layer 506?

10 MR. DAVIS: Objection to form.

11 THE WITNESS: In this particular
12 image, as I understand it -- again, I haven't
13 opined on this image.

14 If I recall, I don't see a pathway for
15 the reactive chemistry to touch 509.

16 My understanding is that in order for
17 the material, the layer, to impart or help impart
18 a feature, a pattern, function as a mask, if you
19 will, it has to have a chemical pathway. It has
20 to be able to touch the reactive chemistry.

21 As I see Figure 22-B and C, 509 is
22 completely covered and there is no chemical

1 contact between the etchant and 509, so it can't
2 determine the transfer to pattern.

3 Q (By Mr. Jiron) So in other words, it
4 doesn't have a role in transferring the pattern?

5 MR. DAVIS: Objection to form.

6 THE WITNESS: Well, due to its being
7 chemically isolated, it can't contact the reactive
8 chemistry of the etchant, it can't determine the
9 pattern that's transferred.

10 Q (By Mr. Jiron) So looking at that
11 Figure 1, wouldn't you understand layer 509 to be
12 a mask in transferring the pattern from layer 510
13 into layer 506? Right?

14 A It may be a mask for later purposes.
15 In this particular step, 509 is not functioning
16 as a mask to transfer a pattern or feature into
17 506 because the etchant cannot chemically
18 contact it.

19 There is no interaction between the
20 etchant species, the reactive species to do the
21 work and the material 509.

22 Q All right. Maybe we can go off the

1 record and take a quick break.

2 (Recess)

3 Q So I would like for you to turn to
4 paragraph 171 of your 1376 declaration.

5 A Paragraph?

6 Q Paragraph 171 of your 1376
7 declaration. Are you there?

8 A Yes.

9 Q So in paragraph 171, at the end it
10 sounds like you indicate that part of Aoyama's
11 misalignment solution is its use of edge stopper
12 film 45. Do you see where it says that?

13 A Essentially.

14 Q And then turning to paragraph 174,
15 in paragraph 174 there is a sentence that says,
16 "Instead a person of ordinary skill in the art
17 would have understood that it would not be
18 possible to modify Grill by combining it with
19 Aoyama's wider via hole pattern and certainly
20 would not have had a reasonable expectation of
21 success without also including Aoyama's carbon
22 etch stopper film 45. Do you see that?

1 MR. DAVIS: Objection.

2 THE WITNESS: I see that. That's a
3 partial sentence, yes.

4 Q (By Mr. Jiron) Is that your opinion?
5 Is that representative of your opinion?

6 MR. DAVIS: Objection, form.

7 THE WITNESS: My opinion is, you know,
8 in this report and further lengthy form, this is
9 half of a sentence out of my opinion, yes.

10 Q (By Mr. Jiron) So I can better
11 understand, is it your position that the wider
12 hole pattern of Aoyama would not work in the Grill
13 device without Aoyama's carbon etch stopper film?

14 MR. DAVIS: Objection, form.

15 THE WITNESS: What I've described in
16 my report here are a number of problems that would
17 result without use of etch stopper 45.

18 Q (By Mr. Jiron) So does your opinion
19 assume that there must be an analog to etch
20 stopper 45 in the Grill device in order for the
21 modification of the water hole in Grill to work?

22 MR. DAVIS: Objection to form.

1 THE WITNESS: What I've essentially
2 said is that limiting, controlling the width, does
3 depend upon having a stop film there, etch stopper
4 45.

5 Q (By Mr. Jiron) Which part of the etch
6 stopper 45 is most important for your opinion?

7 It sounds like there is an etch stop
8 characteristic that you rely upon and also the
9 carbon material portions you rely upon. Which one
10 of those, if any, is the critical piece that your
11 opinion relies upon?

12 MR. DAVIS: Objection, form.

13 THE WITNESS: Could you repeat the
14 question?

15 (Question read)

16 MR. DAVIS: Same objection.

17 THE WITNESS: The question I am taking
18 as kind of compound.

19 It's which part do I rely on and which
20 part is more important.

21 Q (By Mr. Jiron) Maybe I can try to
22 clarify. I'm not trying to confuse you, so I

1 apologize if I am.

2 When I read the opinion that's in
3 paragraph 171 through 174, it sounds like what you
4 are saying is that it wouldn't be possible to
5 modify Grill by combining it with Aoyama's wider
6 via hole pattern without including Aoyama's carbon
7 etch stopper film.

8 Which part is the reason why it
9 wouldn't be possible to modify Grill? Is it the
10 carbon aspect or the etch stopper aspect?

11 MR. DAVIS: Objection, form.

12 THE WITNESS: Aoyama discloses using a
13 carbon etch stop to stop the etch at the
14 appropriate depth.

15 I don't believe that Aoyama would
16 function as Aoyama describes without the carbon
17 etch stop.

18 Q (By Mr. Jiron) Why wouldn't one be able
19 to make the contact hole pattern in Grill wider as
20 taught by Aoyama?

21 MR. DAVIS: Objection, form.

22 THE WITNESS: What Aoyama teaches is

1 making it wider and etching it to a certain depth
2 and stopping it with a stopper. Without that
3 stopper one can't control the depth very well.

4 Q (By Mr. Jiron) Okay. So let's assume
5 that Grill had an analog to Aoyama's edge stopper.

6 There wouldn't be any impediment to
7 making Grill's contact hole pattern wider then,
8 would it?

9 MR. DAVIS: Objection to form.

10 THE WITNESS: I'm not aware that the
11 Petitioner proposed an analog to it.

12 I analyzed the embodiment or the
13 proposed embodiment that was put before me.

14 Q (By Mr. Jiron) In your opinion is it
15 necessary for Aoyama's etch stopper to be made of
16 carbon for it to function?

17 MR. DAVIS: Objection to form.

18 THE WITNESS: I think Aoyama generally
19 describes carbon etch stop as something that would
20 work with the materials and design that he has.
21 Any more discussion of Aoyama, I'm going to have
22 to ask for the reference.

1 Q (By Mr. Jiron) All right. I'm handing
2 you what's been marked as TSMC Exhibit 1018.
3 Okay.

4 Perhaps if you could review the
5 section that's labeled as example 7 in column 15
6 and let me know when you're through, the bottom of
7 column 16 through to the middle of column 16.

8 **A Okay.**

9 Q So the question would be, is it your
10 position that Aoyama's etch stopper layer 45
11 must be made from carbon?

12 **A Aoyama describes only carbon. There**
13 **are certain material requirements of selectivity**
14 **so in Aoyama's invention carbon based material**
15 **provides this etch selectivity that they need in**
16 **order to implement this via approach.**

17 I haven't evaluated another material
18 that the Petitioner's -- because the Petitioners
19 have not put one forward to evaluate off the top
20 of my head, I don't know of something other than a
21 carbon like material that's going to have the
22 selectivity in this environment.

1 Q But in column 15 at line 61, Aoyama
2 said that the second stopper film 45 can be made
3 of e.g. carbon, correct?

4 A **Yes, it does.**

5 Q E.g. means for example?

6 A **Yes.**

7 Q For example would mean to one
8 skilled in the art that it can be made of carbon
9 but can be made of other things as well, right?

10 MR. DAVIS: Objection to form.

11 THE WITNESS: I understand e.g. to
12 mean for example in this instance.

13 It doesn't mean it can be made of
14 anything, but it can be made of something that
15 would have the requirements of etch selectivity or
16 be able to endure through an etching cycle without
17 being ablated or removed.

18 There are other limitations. It isn't
19 just or any other material. The other limitations
20 include this etching requirement and to be
21 selective and in this instance.

22 Q (By Mr. Jiron) But e.g. at least would

1 mean that it's not limited to carbon?

2 A Well, I don't take the e.g. in this
3 context as being open ended, meaning it could be
4 anything.

5 It would have to be carbon or
6 something substantially similar to carbon, an
7 organic material that had the selectivity to the
8 etch that they are going to use subsequent that
9 they need to protect from.

10 Q So as long as it had the selectivity
11 to the etch such that it remained during the
12 etch and protected the films below it from etch,
13 they would perform the function of the etch
14 stopper, correct?

15 MR. DAVIS: Objection to form.

16 THE WITNESS: Well, I understand that
17 it needs to have -- it needs to serve this
18 function of stopping the etch.

19 It needs to be essentially a different
20 material because it has to be selective. It has
21 to be selective to the materials described in
22 Aoyama and that largely limits it to something

1 organic.

2 It has to be removable without
3 destroying the rest of the device after the fact,
4 too, potentially, or -- excuse me -- strike that
5 last point.

6 It needs to be consistent with all the
7 other requirements of the Aoyama invention.

8 Q (By Mr. Jiron) Are there other
9 materials that would have been known to be etch
10 stoppers, for example, in different chemistries,
11 etching chemistries, than carbon?

12 MR. DAVIS: Objection to form.

13 THE WITNESS: Well, there are, and
14 it's very interesting that, you know, they point
15 out one layer 43, which is silicon nitride, which
16 is an etch stop, but they specifically don't point
17 it out for 45.

18 I take it that silicon nitride, being
19 the other common etch stop, doesn't appear that it
20 would work here.

21 I think if something was carbon or
22 substantially carbon, there are related materials

1 that have this selectivity to these etch
2 chemicals.

3 You know, it's along the lines of
4 photoresist is resistant. It's essentially
5 organic, carbon based, carbon or DLC or sputtered
6 carbons. These are all related materials.
7 Fluorinated carbon. These are going to be
8 resistant to the chemistries that he used in the
9 subsequent etch.

10 Specifically, they don't suggest
11 nitride, even though they suggested it in a
12 different application two sentences before.

13 Q (By Mr. Jiron) What if an interlayer
14 dielectric was diamond like carbon? Would SiO2
15 work as an etch stopper?

16 A **Are you asking me could they use DLC**
17 **for 45?**

18 Q I think just in the more general
19 context, that if -- actually, with respect to
20 the example in Aoyama, if layer 44 was diamond
21 like carbon, could layer 45 be SiO2?

22 A **I'm not aware of any instance where**

1 diamond like carbon has been used as an
2 interlayer dielectric, much to my chagrin after
3 having completed a Ph.D. in related materials.
4 It's just not a material that's used for that
5 application.

6 I can make the general comments that
7 carbon based films can be oxidized or burned,
8 whereas silicon oxide is already oxidized. You
9 can't photooxidize it further.

10 So there is some selectivity in that
11 sense, but the hypothetical you have drawn is not
12 really something I can answer.

13 Q Would it be fair to say that the
14 function of Aoyama's edge stop layer 45 is to
15 protect the underlying interlayer in 44 from
16 being etched during the process from forming the
17 through hole?

18 MR. DAVIS: Objection to form.

19 THE WITNESS: The specification
20 specifically described at 16, column 16, line 13,
21 of 024 Aoyama, that at this time the second
22 interlayer insulating film 44 below the stopper

1 film 45 is not etched by virtue of the second
2 stopper film 45, so that's my understanding.

3 That's what the patent describes, is
4 that the stopper stops the underlying material
5 from being etched.

6 Q (By Mr. Jiron) So you would agree then
7 that if Grill had a layer that prevented etching
8 of the underlying material, this function
9 described in Aoyama would be met, right?

10 A Aoyama describes that the stopper is
11 a carbon based material.

12 It wouldn't be Aoyama if it wasn't
13 using the etch stopper 45.

14 If there is another hypothetical on
15 the table or another combination that wasn't put
16 forward for me to rebut, I haven't opined on it
17 yet.

18 Q I guess what I'm wondering is why
19 did you reach the conclusion that it's necessary
20 to import etch stopper layer 45 into Grill?

21 MR. DAVIS: Objection to form.

22 THE WITNESS: Well, Aoyama's invention

1 includes etch stopper 45, so to import Aoyama is
2 to import the etch stopper.

3 Q (By Mr. Jiron) Did you consider whether
4 Grill has any analogs to etch stopper layer 45?

5 MR. DAVIS: Objection to form.

6 THE WITNESS: I rebutted the arguments
7 put in front of me that I was asked to rebut.

8 I don't recall seeing -- there was no
9 argument put forward to substitute a material that
10 I recall for Aoyama's number 45 etch stopper.

11 Q (By Mr. Jiron) So in your opinion that
12 one would not widen the contact hole pattern of
13 Grill without also including the -- like in
14 Aoyama, without also including etch stopper 45,
15 which opinion were you rebutting with that
16 observation?

17 MR. DAVIS: Objection to form.

18 THE WITNESS: I was rebutting the
19 opinion that Aoyama would be combined with Grill,
20 that the steps that Aoyama describes for widening
21 the etch pattern would or would not work with
22 Grill.

1 Q (By Mr. Jiron) Did you consider whether
2 the contact hole pattern of Grill could be widened
3 just like as shown in Aoyama?

4 MR. DAVIS: Objection to form.

5 THE WITNESS: What I considered was
6 using the method or the techniques of Aoyama in
7 combination with Grill, and my determination was
8 that the etch stop layer taught by Grill would be
9 problematic -- excuse me.

10 The etch stop layer as taught by
11 Aoyama, etch stop layer 45, would be problematic
12 in the context of the Grill technology.

13 Q (By Mr. Jiron) Why do you need to
14 import the etch stop layer 45 with Aoyama into
15 Grill?

16 A **Aoyama expressly describes the need**
17 **for an etch stop layer and the use of carbon.**

18 Q Are you suggesting that in instances
19 where the contact hole pattern is wider than the
20 wiring groove pattern, that those must be
21 accompanied by a carbon etch stop layer?

22 MR. DAVIS: Objection to form.

1 THE WITNESS: Aoyama teaches that when
2 the contact hole pattern is wider than the groove,
3 that it should be accompanied by a carbon etch
4 stop layer.

5 Q (By Mr. Jiron) Would you be surprised
6 if there were other instances where contact holes
7 wider than the wiring groove included etch stop
8 layers, layers not made of carbon?

9 A I would have to look at the specific
10 scenario.

11 Q Are you aware of any scenarios where
12 non carbon etch stops were used in a situation
13 where the contact hole pattern was wider than a
14 wiring groove pattern?

15 MR. DAVIS: Objection to form.

16 THE WITNESS: I can speak in a general
17 sense. The top layer dielectric generally can't
18 be low K that's naked. It generally needs a
19 capping layer so that it's not exposed to moisture
20 when it moves from tool to tool.

21 So one generally sees an oxide on top
22 of an organic or low K dielectric, so one would

1 typically never see something equivalent to 44
2 nakedly exposed to the environment.

3 So that leads -- it's ubiquitous
4 essentially that the top is going to be a silicon
5 oxide of sorts or some sealing material, in which
6 case carbon is a very nice stop layer because
7 you're not going to hurt -- you know, things which
8 will etch oxide aren't going to hurt carbon or
9 organic molecule in the same way that it doesn't
10 harm -- that the resist holds up.

11 Q (By Mr. Jiron) So in proposing that the
12 combination of Aoyama and Grill would require etch
13 stop layer 45 from Aoyama to be incorporated into
14 Grill, did you consider whether Grill already had
15 an etch stop layer?

16 MR. DAVIS: Objection to form.

17 THE WITNESS: What I considered was
18 the importation of Grill as it was -- excuse me,
19 Aoyama, as it was into Grill.

20 Q (By Mr. Jiron) Meaning importation of
21 layer 45 into Grill?

22 A **Yes, as well as --**

1 MR. DAVIS: Objection to form. Go
2 ahead.

3 THE WITNESS: I considered the
4 importation of the wider feature and the etch
5 stopper 45 from Aoyama into Grill.

6 Q (By Mr. Jiron) Wouldn't it be true if
7 Grill already had an etch stop layer, it wouldn't
8 need to import layer 45?

9 MR. DAVIS: Objection to form.

10 THE WITNESS: Well, then that's a
11 detail that Applicants could have put forward for
12 me to rebut.

13 I'm not aware that there is an etch
14 stop on top, something referred to as an etch stop
15 on top of Grill.

16 Q (By Mr. Jiron) So you didn't find an
17 etch stop layer in Grill?

18 MR. DAVIS: Objection to form.

19 THE WITNESS: Grill doesn't refer to
20 an etch stop that I recall on the top, but none
21 the less, it's not -- it's no longer Aoyama if it
22 doesn't import Aoyama's teaching.

1 Q (By Mr. Jiron) So are you saying you
2 just didn't find something in Grill labeled as an
3 etch stop, specifically using that terminology?

4 MR. DAVIS: Objection to form.

5 THE WITNESS: There is nothing
6 described necessarily as an etch stop on top.

7 Q (By Mr. Jiron) You understand that
8 Grill includes two hard mask layers, correct?

9 **A Yes.**

10 Q Wouldn't the hard mask layer
11 function to stop an etch?

12 MR. DAVIS: Objection to form.

13 THE WITNESS: Not necessarily. A hard
14 mask layer is there for lithographic purposes, not
15 necessarily as a blanket layer.

16 Q (By Mr. Jiron) When you say
17 lithographic purposes, what do you mean?

18 **A Well, a mask and an etch stop are**
19 **similar, but they are not the same.**

20 Q How do they differ?

21 **A An etch stop is meant to stop an**
22 **etch at the end of an etch.**

1 A lithography feature, a mask, a
2 template, is meant to impart a feature, a shape,
3 into a part through an etch.

4 Q So both provide etch resistance,
5 correct?

6 MR. DAVIS: Objection to form.

7 THE WITNESS: All materials have some
8 etch resistance, but they are referred to
9 differently and have different functions.

10 Q (By Mr. Jiron) You said a mask and an
11 etch stop are similar. How are they similar?

12 A They are both involved in the
13 etching process but one is designed to impart a
14 pattern, a feature. The other is designed to --
15 at the start of an etch, the top, an etch stop
16 is a material that is at the bottom of an etch.

17 An etch stop also has potentially no
18 need for any optical properties, whereas masks are
19 part of the reflective path of exposure.

20 Q So in a situation where you have a
21 hard mask and you are forming a contact hole
22 using the pattern of the hard mask to form the

1 contact hole, do you understand that situation?

2 **A Generally.**

3 Q Would it be fair to say that the
4 function of the mask was to allow the pattern to
5 be transferred in areas where the mask didn't
6 exist?

7 MR. DAVIS: Objection to form.

8 THE WITNESS: I think the general
9 function of a mask or template is to allow
10 selective transfer of feature through selected
11 exposure of a chemical.

12 Q (By Mr. Jiron) So while allowing
13 transfer of the features through the areas where
14 the mask doesn't exist, it would prevent the
15 etching of material below the mask, right?

16 MR. DAVIS: Objection to form.

17 THE WITNESS: Well, the hard mask --
18 the hard mask has other jobs other than just that.

19 Q (By Mr. Jiron) But that is one job of
20 the hard mask?

21 **A It's one job but it doesn't -- the**
22 **dielectric constants are also very different**

1 between potential materials, whereas nitride is
2 a high K, dielectric constant of about eight,
3 depending how it's formed.

4 Silicon oxide has a constant of about
5 four, and DLC is on the order of three, so if the
6 material is going to be adjacent to low K
7 dielectrics, one can't put a high K material there
8 because it would ruin -- it offsets the low K of
9 the high K, so it slows down the circuitry.

10 Furthermore, the dielectric constant
11 is also related to the optical constant by the
12 square route, and this comes into play when one is
13 exposing, whether or not one reflects light,
14 doesn't reflect light, at what frequencies and the
15 thicknesses that are allowed in order to make this
16 work, so it's not a trivial matter just to
17 randomly change the material.

18 Q Sure, but what if you didn't change
19 the material? What if you relied upon the
20 material that was already in Grill?

21 Wouldn't it be fair to say that the
22 hard mask prevents etching of the underlying

1 dielectric during transfer of the contact hole
2 pattern to that dielectric?

3 MR. DAVIS: Objection to form.

4 THE WITNESS: It would depend on
5 whether it could do it or not, whether it was
6 selective enough, whether it was thick enough,
7 whether it had the right properties.

8 No one put forward a proposal that
9 this would work or analyzed it, so that was not
10 something that I rebutted.

11 Q (By Mr. Jiron) Okay. So assuming that
12 one did select -- assuming that Grill selected an
13 appropriate hard mask to perform the job that you
14 indicated, it would prevent etching of the
15 underlying dielectric during transfer of the
16 content hole pattern to dielectric, right?

17 MR. DAVIS: Objection to form.

18 THE WITNESS: You know, is it possible
19 that they select another material?

20 I would have -- I can't evaluate
21 whether it would work or not unless I had the
22 material and the situation in front of me.

1 I do know that Aoyama has described
2 the material that in his situation works and
3 functions as an etch stop.

4 Q (By Mr. Jiron) Actually, I think you
5 may not have caught what I was asking, so I'll try
6 to clarify.

7 I actually wasn't suggesting changing
8 the material that Grill had. My hypothetical was
9 take Grill for what it teaches. So Grill has a
10 hard mask. Do you agree with that?

11 MR. DAVIS: Objection to form.

12 THE WITNESS: Grill has what it
13 describes as hard masks, yes.

14 Q (By Mr. Jiron) And Grill has identified
15 materials that could be used as that hard mask,
16 right?

17 A **Could I see Grill, please?**

18 Q I'm handing you what's been marked
19 as TSMC Exhibit 1005.

20 A **Yes, Grill has identified materials**
21 **for hard masks.**

22 Q Okay. And what are those materials?

1 A In Figure 5 Grill identifies lower
2 hard mask 506 from silicon nitride and upper
3 hard mask 58 from silicon oxide.

4 Q Are there any other examples of
5 materials that Grill identifies for hard masks
6 56 and 58?

7 A They identify other materials such
8 as carbon based dielectrics, silicon carbide
9 dielectrics, polycrystalline silicon, amorphous
10 hydrogenated silicon and metals.

11 Q So doesn't the fact that Grill
12 describes hard masks that include carbon
13 undercut your opinion that one would somehow
14 have to import the carbon etch stop layer 45
15 into Grill?

16 MR. DAVIS: Objection to form.

17 THE WITNESS: The choice of one
18 material is affected by the choice of other
19 materials.

20 Grill cautions extensively against the
21 exposure of carbon based materials to oxygen
22 plasmas and ashing.

1 I don't take it in Grill that one can
2 necessarily put metal in there either without
3 shorting everything out.

4 So given that he's thrown out carbon,
5 inorganic and metal as possible alternatives, I
6 understand that one would be required to think
7 through the problem a bit and figure out, given
8 the other choices for materials that one makes,
9 one would work it out.

10 Q (By Mr. Jiron) So given the materials
11 list that Grill provides and taking into account
12 the problems you identified, when you say that one
13 would work it out, one skilled in the art would
14 understand those issues and know how to
15 essentially work it out, correct?

16 MR. DAVIS: Objection to form.

17 THE WITNESS: If there was a solution,
18 one of skill in the art could find it, but there
19 may not be a solution.

20 One can't willy-nilly substitute
21 materials.

22 For example, the metal example.

1 Nobody, I don't think, off the top of their head
2 would suggest that you put a layer of metal down
3 and leave it there. A layer of metal functioning
4 as a mask left in place would short out the entire
5 circuit.

6 So these are the kind of details that
7 have to be thought through before the combination
8 of different technologies takes place
9 successfully.

10 Q (By Mr. Jiron) All right. I think now
11 would be a good time to take a lunch break.

12 A Sure.

13 (Recess)

14 Q Could you look at Paragraph 72 of
15 the 1376 declaration? You see that paragraph?

16 A Yes.

17 Q So this paragraph, in this paragraph
18 you say Dr. Smith himself acknowledged that
19 these multiple layers are used to etch a
20 substrate clean film material using this
21 process.

22 Then it continues, "Thus Petitioner's

1 expert Smith himself has acknowledged that
2 multiple layers having plus edges (like the
3 multilayer resist in his own text) may be used as
4 a mask." Do you see that?

5 **A I see that, yes.**

6 Q What was the basis for your
7 conclusion that Dr. Smith acknowledged that
8 multiple layers having plus edges may be used as
9 a mask in that paragraph?

10 **A He acknowledges multilayer resist,**
11 **as I'm sure anybody in the industry would,**
12 **existed at the time. Multilayer resists are in**
13 **fact multilayer masks.**

14 Q Where did you find that Dr. Smith
15 acknowledged that the multilayer -- that
16 multilayers having flush edges may be used as a
17 mask? Was there any particular place?

18 **A Let's see. Do we have the exhibits?**
19 **I've got some cites in here.**

20 Q Sure. Which one are you looking
21 for?

22 **A Exhibit 2010. I believe there's**

1 two, and 2017 and 18.

2 Q I will hand you what's been marked
3 as IP Bridge Exhibit 2010.

4 I'll also hand you what's been marked
5 as IP bridge Exhibit 2017.

6 A Thank you.

7 Q And next I'll hand you what's been
8 marked as IP Bridge Exhibit 2018.

9 A Thank you. So I cited in my report
10 to Page 64 at 5 through 8, but also starting
11 really on 63 in this discussion.

12 6321 through 644 describes that the
13 line control is established with this multilayer
14 resist.

15 The question really starts at 633 and
16 goes forward. He describes in here, Page 64
17 through 5, the multilayers in the multilayer
18 resist, and then that is the multilayer resist, so
19 clearly there are multiple layers described as
20 "control the opening."

21 In Exhibit 2018 at page 0033, labeled
22 657 in the upper right corner page number, also is

1 a description of multilayer resist applications,
2 describes in the first paragraph that tri-level
3 resists have demonstrated enhanced resolution
4 compared with singular resists, does admit there
5 is additional processing which makes it more
6 difficult but it acknowledges the benefit of using
7 multiple layers in a resist.

8 He discusses also trying to do it in
9 single layer and essentially equates the method of
10 three layers and one layer as both being
11 performing the function of the resist, essentially
12 the patterning.

13 The other reference, 2017, is an
14 earlier edition of this which has substantially
15 the same information.

16 Page 0079, also labeled Page 592,
17 describes silicon containing resists for
18 multilayer surface imaging for resist
19 applications, talks about again the increased
20 performance in the ability to accommodate
21 difficult applications.

22 Q You referred to page 0033 in Exhibit

1 2018. Maybe you could turn back to that page?

2 **A Yes.**

3 Q Do you see in the first line after
4 the sentence "Multilayer resist techniques have
5 long been used to ease requirements for resist
6 performance"?

7 **A Yes.**

8 Q There is some citations to items 51
9 through 56?

10 **A Yes.**

11 Q Did you consider any of those
12 documents in arriving at your opinion?

13 **A I didn't pull these citations, 51
14 through 56.**

15 Q Going back to your 1376 declaration,
16 right above Paragraph 72 you have included a
17 figure that's labeled "Tri-layer system." Do
18 you see that?

19 **A Yes.**

20 Q That's Figure 12.3C from Exhibit IP
21 Bridge 2017, correct?

22 **A Yes.**

1 Q That's Dr. Smith's book entitled
2 Microlithography Science and Technology, Second
3 Edition?

4 A **2017 is, yes. You're asking is that**
5 **figure from that?**

6 Q Yes. Well, actually I was asking --
7 I think I had two questions.

8 One was Figure 12.3C, is that taken
9 from Exhibit 2017?

10 A **12.3C is a colorized version from --**
11 **sorry, it's shown in 2018. It's shown -- Figure**
12 **12.3C is from Exhibit 2018, I believe.**

13 Q Okay.

14 A **We have colorized it here.**

15 Q So the citation in your 1376
16 declaration, paragraph 71, directed to Figure
17 12.3C, that should refer to Exhibit 2018 instead
18 of 2017?

19 A **Yes.**

20 Q And you understand that Figure 12.3C
21 from Exhibit 2018 represents a tri-layer system,
22 right?

1 A Yes, it does.

2 Q What's your understanding of how a
3 tri-layer resist process works?

4 A Tri-layer resists essentially break
5 up the functioning.

6 First layer is largely for planarizing
7 when things are at different heights or
8 thicknesses above the surface, causes
9 complications, so one establishes a first layer
10 for planarization purposes.

11 There is another layer typically
12 that's a bit more robust and another essentially
13 optimized for optical properties.

14 Q Is it your belief that a buried
15 layer with flush edges acts as a mask in a
16 tri-layer process?

17 MR. DAVIS: Objection to form.

18 THE WITNESS: By buried layer with
19 flush edges, you would perhaps be referring to the
20 dark green layer in Figure 12-C on the bottom of
21 the two figures.

22 If that is the case, then my

1 understanding is all of the multilayer resist acts
2 as the mask.

3 Q (By Mr. Jiron) Is it your belief that
4 the process in Figure 12.3C described a single
5 etch process?

6 MR. DAVIS: Objection to form.

7 THE WITNESS: 12.3C is a tri-layer
8 mask. The mask can be used for whatever purpose
9 is desired.

10 Q (By Mr. Jiron) Is it your understanding
11 that one of its purposes would be a single etch
12 process?

13 A It's my understanding that this is a
14 general description of a three layer, a
15 multilayer photoresist mask.

16 A photoresist mask could be used for a
17 single etch process or, depending on materials in
18 the etch properties, multiple etches, if you had
19 two or three materials underneath it and you
20 wanted to etch through all of them.

21 Q Is it your understanding that what's
22 represented in Figure 12.3C is representative of

1 an actual process?

2 **A What's shown in Figure 12.3C --**

3 MR. DAVIS: Objection to form. Go
4 ahead.

5 THE WITNESS: -- is simply one
6 approach to a multilayer resist formation.

7 Q (By Mr. Jiron) I understand, but is
8 that multilayer resist one that in your
9 understanding would be used in a single etch
10 process?

11 MR. DAVIS: Objection to form.

12 THE WITNESS: My understanding, and I
13 thought I answered this question before, is that
14 this is the, or one, approach to a multilayer
15 resist structure that can be used for any desired
16 purpose.

17 Q (By Mr. Jiron) I'll ask a slightly
18 different question.

19 Is it your understanding that Figure
20 12.3C represents a structure that is formed by a
21 single etch process?

22 MR. DAVIS: Objection to form.

1 THE WITNESS: My understanding is that
2 one can transfer a pattern through the entire
3 stack.

4 This is an alternative to, in some
5 cases, just a singular resist.

6 Q (By Mr. Jiron) So looking at Figure
7 12.3C, could you walk through the steps of the --
8 could you take a look -- I'll start over.

9 Could you take a look at IP Bridge
10 Exhibit 2010 and take a look at Page 64 at lines 9
11 and 10? This passage is within the portion cited
12 where Dr. Smith is talking about Figure 12.3C. Is
13 that right?

14 A **Yes, 12.3C is cited.**

15 Q And so you see at lines 9 and 10 of
16 Page 64, Dr. Smith indicates that there are two
17 etch processes and a develop process involved in
18 what's depicted in Figure 12.3C, correct?

19 MR. DAVIS: Objection to form.

20 THE WITNESS: In the formation of this
21 multilayer resist, yes.

22 Q (By Mr. Jiron) Do you disagree with

1 what he says there?

2 **A That's how he's characterizing it.**

3 Q Could you take a look at page -- do
4 you have any reason to believe that Dr. Smith
5 has mischaracterized what Figure 12.3C
6 represents when he says that there are two etch
7 processes and a develop process involved?

8 MR. DAVIS: Objection to form.

9 THE WITNESS: This is in the context
10 of describing the formation of this multilayer
11 resist he's asked about. That's how he's
12 characterizing it. If that's how he understands
13 his illustration to be, then so be it.

14 Q (By Mr. Jiron) Do you understand his
15 illustration differently?

16 A **I think there is a difference**
17 **between the questions you're asking and what's**
18 **in his book and testimony here.**

19 So I am referring to a multilayer
20 resist. The deposition question in Exhibit 2010
21 is regarding a multilayer resist, so the
22 multilayer resist, et cetera, so this is about the

1 formation of a multilayer resist.

2 Your questions seem to imply that
3 they're actually forming the circuitry, but this
4 is just the resist that I'm talking about and that
5 I think Dr. Smith is talking about and the
6 deposition attorney was talking about.

7 Q I'm just curious about the statement
8 where after Dr. Smith is asked, "So the
9 multilayer resist that we're talking about here
10 contained the imaging layer the intermediate
11 etch stop layer and the plane layer," he says,
12 "There are two etch processes and a develop
13 process involved." What's he referring to
14 there?

15 MR. DAVIS: Objection to form. Go
16 ahead.

17 THE WITNESS: I understand he's
18 referring to the formation of the multilayer
19 resist.

20 He then says at Page 65, row 3, that
21 then would be etched using this process, and then
22 he goes on to say at 5, "So this doesn't address

1 what would be etched underneath. That hasn't been
2 etched yet."

3 This is just defining the multilayer,
4 the multilayer resist, so all this etching
5 information is talking about is the multilayer
6 resist.

7 It's certainly more complicated than
8 just spinning on a resist polymer. You know, it's
9 almost like processing itself but it allows one to
10 image over a fairly uneven surface.

11 Q (By Mr. Jiron) Is it your understanding
12 that all of the layers in the multilayer resist
13 shown in Figure 12.3C would remain during the
14 etching of the device layers down the line?

15 A Yes, they could. In his book he
16 describes that you can image through all of the
17 layers.

18 There are a lot of variations on this.
19 At Page 643 of the 218 he writes -- I'm in the
20 first full paragraph, second line -- "Three resist
21 layers may be used to allow specific feature
22 shaping through the depth of the resist stack,"

1 and then he goes on to describe the bottom layer
2 and the top coat and the middle layer.

3 Q In your answer were you talking
4 about imaging or etching?

5 A Well, the image can be exposed
6 throughout the three layers. The template, if
7 you will, the shape.

8 Q How about etching? Is that
9 something you understand to occur with respect
10 to all three layers?

11 A Generally the layers are sort of
12 divied up into three, one that helps with the
13 imaging, one that is chemically very resistant,
14 and lastly, on the bottom, one that allows
15 planarization.

16 So even if the top layer is removed in
17 the etching process, you still have the more
18 chemically resistant middle layer that would
19 survive through the etching process.

20 Q I think indeed Dr. Smith testified
21 that the top layer wouldn't remain in the actual
22 process, right?

1 MR. DAVIS: Objection to form.

2 THE WITNESS: He may have. I don't
3 recall off the top of my head. You may want to
4 point me to it.

5 Q (By Mr. Jiron) Take a look at Page
6 62 -- I'm sorry, 61, lines 14 through 63 --
7 actually let's look more specifically at Page 62,
8 lines 4 through 14.

9 A I don't completely agree with your
10 characterization.

11 Q Okay.

12 A It says that the top layer,
13 essentially the imaging layer, is used only for
14 imaging and that the etch stop, the middle layer
15 basically serves the function, as I described
16 previously, of being robust and resisting
17 ablation.

18 Q So looking at Page 62, lines 12
19 through 14, Dr. Smith says, "So it would be
20 obvious that what would happen as you do the
21 oxygen plasma RIE is the resist would be gone."
22 Do you see that?

1 **A Yes.**

2 Q Isn't the resist referring to one of
3 the layers shown in Figure 12.3C?

4 MR. DAVIS: Objection to form.

5 THE WITNESS: Okay. I see that.

6 Q (By Mr. Jiron) So you would agree then
7 that Dr. Smith is saying when you do the oxygen
8 plasma RIE the resist is in fact not there any
9 more?

10 **A In this instance --**

11 MR. DAVIS: Objection to form.

12 THE WITNESS: In this instance, yes, I
13 believe he's describing that the imaging layer is
14 removed in that step.

15 As I stated earlier, the middle layer
16 is the one that provides the robustness in the
17 etch process and that's the one that must survive
18 the etching.

19 Q (By Mr. Jiron) So if the resist is gone
20 and it's the middle layer that provides the
21 robustness, which layer is a buried layer with the
22 threshold edge functioning as the mask?

1 MR. DAVIS: Objection to form.

2 THE WITNESS: All three are resist
3 layers. There are different types of resist.
4 It's a multilayer resist. Top layer is there
5 principally, as I said earlier, for optical
6 purposes to enhance imaging.

7 The middle layer is there for chemical
8 robustness to resist etching, and the bottom layer
9 is there to planarize the rough surface.

10 So they are all resists. Together
11 they form a multilayer resist, and each layer has
12 a different function for optimization.

13 Q (By Mr. Jiron) So of those three layers
14 you identified, which one acts as the mask during
15 etching?

16 MR. DAVIS: Objection to form.

17 THE WITNESS: In this case where they
18 have removed the imaging layer, the remaining
19 portion -- the remaining multilayer resist which
20 would include the planarizing layer shown in dark
21 green in figure -- on page 0043 of my 1376
22 declaration, as well as the layer labeled plasma

1 RIE.

2 So he has labeled them as he described
3 in his deposition by how they were made, not
4 necessarily their properties.

5 So they are labeled in his book and in
6 our figure here as plasma RIE and oxygen plasma
7 RIE.

8 Q (By Mr. Jiron) And which one are you
9 saying is the mask?

10 MR. DAVIS: Objection to form.

11 THE WITNESS: The multilayer resist
12 has, as he's described here, at least two layers
13 remaining that function as a mask, the bottom
14 layer and the middle layer.

15 The bottom layer is there for
16 planarization. It evens out uneven surfaces. And
17 the top layer is there for strength or resistance
18 to the chemical etching process.

19 MR. JIRON: Let's take a quick break,
20 five minutes.

21 (Recess)

22 MR. JIRON: That's all from us. We

1 have no more questions.

2 (Whereupon, at 2:06 p.m., the taking
3 of the deposition ceased.)

4 * * *

5

6 ACKNOWLEDGMENT OF DEPONENT

7

8 I, _____, do hereby

9 acknowledge that I have read and examined the
10 foregoing testimony, and the same is a true, correct
11 and complete transcription of the testimony given by
12 me, and any corrections appear on the attached Errata
13 Sheet signed by me.

14

15

16

17 _____
(DATE)

(SIGNATURE)

18

19

20

21

22

1 CERTIFICATE OF REPORTER

2 UNITED STATES OF AMERICA)

3 DISTRICT OF COLUMBIA)

4

5 The within and foregoing deposition of
6 the witness, ALEXANDER D. GLEW, Ph.D., P.E., was
7 taken before MARY HOGAN, CSR, at Ropes & Gray,
8 1900 University Avenue, 6th Floor, East Palo Alto,
9 California, commencing at 8:54 a.m., on the 30th
10 day of June, 2017.

11 The said witness was first duly sworn
12 and was then examined upon oral interrogatories;
13 the questions and answers were taken down in
14 shorthand by the undersigned, acting as Certified
15 Shorthand Reporter; and the within and foregoing
16 is a true, accurate and complete record of all the
17 questions asked of and answers made by the
18 aforementioned witness at the time and place
19 herein referred to.

20 I further certify that present on
21 behalf of Taiwan Semiconductor Manufacturing
22 Company Limited, Petitioner, were Darren M. Jiron,
Esquire, and J. Preston Long, Ph.D., Esquire, of
Finnegan, Henderson, Farabow, Garrett & Dunner,
LLP, and on behalf of Patent Owner, Godo Kaisha IP
Bridge 1, was James L. Davis, Esquire, of Ropes &
Gray.

The signature of the witness was not
waived and the deposition was submitted to the
deponent as per copy of the attached letter.

The undersigned is not interested in
the within case, nor of kin or counsel to any of
the parties.

Witness my signature this July 3rd,
2017.

21



22

MARY HOGAN, CSR NO. 5386

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