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BRUCE SMITH

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY, LTD.,

Petitioner,

- vs -

GODO KAISHA IP BRIDGE 1,

Patent Owner.

Case IPR2016-01376

Patent 6,197,696

Examination before trial of BRUCE SMITH,

taken pursuant to 37 C.F.R. Section 42.53, at the

Hilton Garden Inn Rochester, 30 Celebration Drive,

Rochester, New York, on March 23, 2017, commencing

at 9:05 a.m., before JOAN M. METZGER-HUBBELL, CRR,

RMR, RPR, Notary Public.

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1 B R U C E S M I T H, 22 Mount Eagle Drive,
2 Penfield, New York, after being duly called and
3 sworn, testified as follows:

4
5 EXAMINATION BY MR. ROSSEN:

6
7 Q. Dr. Smith, have you been deposed
8 before?

9 A. Yes, I have.

10 Q. How many times have you been deposed?

11 A. Somewhere a little more than 20
12 probably.

13 Q. And have you been deposed in what I'm
14 going to call PTAB proceedings, like IPRs, those
15 types of proceedings?

16 A. No, I have not. This is the first time
17 in a PTAB proceeding.

18 Q. Did you prepare for this deposition?

19 A. Yes, I did.

20 Q. For approximately how long did you
21 prepare for this deposition?

22 A. For the deposition -- deposition

1 itself?

2 Q. Yes, the deposition today.

3 A. I'd say probably 30, 40 hours maybe,
4 close to 30.

5 Q. Okay. And in forming your opinions for
6 this -- for your declaration in this IPR, did you
7 review any documents from the litigation in the
8 Eastern District of Texas?

9 A. I don't believe so. I don't think I've
10 seen any of that.

11 Q. And in preparing and forming your
12 opinions, did you receive any documents from
13 Broadcom?

14 A. Not that I'm aware of, no.

15 Q. Okay. And in forming your opinions,
16 did you speak to counsel for Broadcom?

17 A. No, I did not.

18 Q. Are you familiar with the requirements
19 for finding a claim obvious?

20 A. Yes, I -- I think I am.

21 Q. Okay. And for obviousness, are you
22 aware of the requirement that you must identify the

1 differences between the prior art in the claims of
2 the patent at issue?

3 A. Sure, differences and similarities,
4 sure.

5 Q. Okay. And did you perform that
6 analysis for this case?

7 A. Yes, I did.

8 Q. Okay. And so talking about the -- the
9 main reference in this case, which we'll call it
10 Grill --

11 A. Okay.

12 Q. -- are you familiar with that?

13 A. Yes. I've read through Grill several
14 times.

15 Q. So what would you say are the
16 differences between Grill and the '696 patent?

17 MR. JIRON: Objection. Form.

18 THE WITNESS: Yeah, I guess that's a good
19 question. Both deal with multi-level
20 metallization, and they do so in a way they use
21 what we refer to as dual damascene. The Grill,
22 patented Grill reference, is based on work and

1 inventions filed by a team of IBM workers, and
2 during the time period in the 1990s, IBM had worked
3 extensively on what we refer to as dual damascene,
4 especially dual damascene or including dual
5 damascene that uses things like multiple thin
6 layer -- thin protection layers, often referred to
7 as hard masks, and then corresponding dielectric
8 layers for a wiring level in a contact or via
9 level. Both the '696 patent and the Grill patent
10 deal with that sort of technology.

11 BY MR. ROSSEN:

12 Q. Okay. And so it's your understanding
13 that what you just explained there is -- it's a
14 difference between the '696 patent and the Grill
15 reference?

16 MR. JIRON: Objection. Form.

17 THE WITNESS: I think the aspects covered in
18 the specification and claims of the '696 patent are
19 covered by the dual damascene process that is
20 described in the Grill reference, but that Grill
21 reference in combination, for instance, with
22 another reference that I referred to in my report

1 is the Aoyama reference that leads to support for
2 some possible weaknesses in the Grill patent,
3 especially related to the use of some of the layers
4 to etch some of the underlying films.

5 BY MR. ROSSEN:

6 Q. Okay. Okay. So let's talk about the
7 Aoyama reference for a second, the one you just
8 mentioned.

9 A. Right.

10 Q. And the one you cited in your
11 declaration. I believe in your declaration you
12 talked about what the problem that Aoyama was
13 attempting to solve?

14 A. I did. I discussed a problem that is
15 common with dual damascene processes for
16 multiple-level metallization, and that is because
17 multiple photoresist layers are used, the
18 misalignment of one layer to the other can lead to
19 problems.

20 So both Aoyama and Grill deal with solutions
21 or design alternatives to either solve for or
22 alleviate some of the problems associated with what

1 we call misalignment.

2 MR. ROSSEN: Okay. I'm going to go ahead
3 and give you a copy of your declaration.

4 THE WITNESS: Okay.

5 MR. ROSSEN: Which we can mark as Deposition
6 Exhibit 1.

7 The following was marked for Identification:

8 SMITH EXH. 1 Declaration of Dr. Bruce W.
9 Smith, Ph.D.

10 BY MR. ROSSEN:

11 Q. Okay. And this is the -- just to
12 clarify, this is your declaration from the
13 IPR2016-01376 IPR.

14 Do you recognize this document?

15 A. Yes, I do. This is one of four
16 declarations that I -- that I authored and worked
17 on.

18 Q. Okay. Can I point you to paragraph 155
19 of your declaration, and particularly the last
20 sentence of that.

21 A. I see that.

22 Q. Okay. So in this section you're

1 talking about the problems that Aoyama's attempting
2 to solve; is that correct?

3 A. Well, as I say, it explains a problem,
4 but, sure, it is a problem that Aoyama is working
5 to -- to -- working to solve.

6 Q. Okay. And one of these problems that
7 you mention here is integration density?

8 A. Well, not exactly. What this means --
9 so you're reading the last few words, problems for
10 increasing integration density. The integration
11 density isn't the problem, but, instead that's the
12 direction that semiconductor technology goes as we
13 move along to advance device performance, and a
14 fundamental direction of integrated circuit
15 technology is to make things smaller and packed
16 closer together to make things more dense.

17 So what this -- this sentence means is, as
18 device generations continue and geometry is made
19 smaller and features are packed closer together,
20 and in particular this is -- this deals with wiring
21 and contact level, as these features are made
22 smaller and closer together, there is -- there are

1 increasingly difficult -- more difficult problems
2 with things like contact resistance, degradation,
3 and liability.

4 So it is increasingly more important for
5 advanced generations that misalignment is minimized
6 or avoided.

7 Q. Okay. So just so that I'm clear on
8 this, the problem is not integration density. The
9 problem is how to increase integration density?

10 A. Right. The target is to increase
11 density. That's the goal. As density's increased,
12 problems associated with contact misalignment or
13 misalignment between two layers becomes
14 increasingly important.

15 Q. Okay. And integration density, I
16 believe you sort of talked about this, but that's
17 the -- the number of wires per area?

18 A. In a simple sense, that's right. It's
19 the density of the circuit pattern features in a
20 particular electronic device, and particular to
21 what Aoyama and Grill and the '696 deal with, this
22 is for wiring levels, inter -- multiple-level

1 wiring levels and the interconnection of those
2 wiring levels with contacts, or sometimes these are
3 referred also to -- also as vias.

4 Q. Okay. So are you familiar with the
5 term dimension control?

6 A. Sure. And I think probably what you're
7 referring to is critical dimension control. We
8 abbreviate that as CD, and critical dimension
9 control is the ability to maintain a given, let's
10 say, line width or space width to a -- to a
11 specified dimension.

12 Q. Okay. And does -- does critical
13 dimension control, as you're calling it, allow for
14 an increased integration density?

15 A. Without well-controlled -- without good
16 control over things like critical dimension,
17 integration -- increasing integration density
18 becomes difficult. Without tight control over
19 critical dimension sizes, let's say, it's difficult
20 to increase integration density.

21 Q. Okay. Can I direct you to paragraph 47
22 of your declaration now.

1 A. Sure. I see that.

2 Q. So can you read the last sentence here.

3 A. Sure. It says -- this is referring to
4 the Huang, Zhao, and Yu reference, and that
5 paragraph begins talking about dual damascene,
6 selective anisotropic dry etching, and it says:
7 This preserves the critical dimensions,
8 parentheses, i.e., the sizing, closed parentheses,
9 of the vias and trenches and ensures that the
10 correct layers are etched during each step of the
11 process.

12 Q. Okay. So this critical dimensions here
13 that you're referring to here is what we were just
14 talking about with the critical dimension control?

15 A. Yes. This is the sizing of -- the word
16 critical means -- generally means, and it's a term
17 that has been used in semiconductor processing for
18 generations, critical means a feature that is of
19 interest. It means a small or maybe the smallest
20 feature. It means not the biggest features in that
21 device. It's the ones that are going to be most
22 critical, the ones that you have to control.

1 So critical dimension, or what we often call
2 CD, is the size of that feature of interest or that
3 critical feature. So this paragraph says the use
4 of a particular type of dry etching, one that leads
5 to anisotropy, a directional etch, is necessary to
6 preserve the kind of critical dimension control,
7 the CD control, that's needed for vias and trenches
8 for corresponding layers.

9 Q. Okay. So here what we're talking about
10 is the critical dimension is the size of the vias
11 and the trenches?

12 A. In a general sense, that's -- that's
13 right, the size, the control of size of vias,
14 trenches. Again, via is often referred to as
15 contacts or contact holes.

16 Q. Okay. And why is the sizing of the via
17 important?

18 A. Well, the via often refers to the hole
19 which is filled with metal which then becomes the
20 connection, which becomes the contact. If that
21 hole or that via, sometimes also called a contact
22 hole, can't be sized correctly, if it isn't, for

1 instance, etched to the right critical dimension --
2 and these are dimensions that are -- need to be
3 tightly controlled. There are specifications in
4 how tight these dimensions have to be controlled
5 for any process. If they're not controlled with
6 some -- within some tight critical dimension, then
7 that influences things like contact resistance. It
8 influences the resistance or conductivity of that
9 feature, for instance, that via feature as it
10 connects to metal layers and things like that.
11 Basically, bottom line, the device that this would
12 be applied to won't work.

13 Q. Okay. Can I now have you turn to
14 paragraph 158 of your declarations.

15 A. Okay. I see that.

16 Q. Okay. And in particular the last
17 sentence of that paragraph, can you -- can you read
18 that sentence for me.

19 A. Sure. Let me review the paragraph
20 first.

21 Q. Sure.

22 A. So this paragraph addresses what's

1 referred to -- what's often referred to and can be
2 a common problem with semiconductor processing,
3 especially processing for multiple-level metal.

4 So lithographic rework generally means after
5 patterning of one photoresist level, that
6 photoresist material may have to be removed, and
7 that process has to be done again. That is why we
8 call it rework.

9 Rework in a dual damascene process like that
10 described in the Grill patent, or that like
11 described in the Grill patent in the discussion of
12 prior art, can be difficult if that lithographic
13 rework at stripping of the photoresist damages
14 underlying materials like, for instance, organic
15 dielectric materials that are made of similar --
16 similar composition.

17 So the Grill patent, the IBM dual damascene
18 process utilizes something that IBM calls dual hard
19 mask, and those two hard masks are underneath --
20 are coated on the top of a multilayer stack and
21 below the photoresist materials to be able to
22 transfer those photoresist patterns into the hard

1 mask layers and allow protection of some of the
2 underlying films like, for instance -- for
3 instance, organic dielectrics.

4 So you asked me to read -- oh, and then the
5 sentence after that, so I'm reading the
6 second-to-last sentence, I say: This ensures
7 alignment of both via and wiring levels is
8 completed and transferred into the thin films.

9 So this allows, if rework needs to be done
10 to ensure this such alignment, it can be done
11 without damaging underlying films. And then that
12 last sentence you asked me to read, did you want me
13 to read it out loud?

14 Q. Sure.

15 A. It says: Figure 2B and 2C of Grill
16 below show how stripping misaligned photoresist 28
17 can damage interlayer dielectric 12 and make it
18 difficult to control the via dimension.

19 Q. And here when we say via dimension, are
20 we talking about the via size as we were talking
21 about before? Are those synonyms?

22 A. Yeah. Via here is used as a noun, so

1 it's the size or the critical dimension of the via.
2 And the via is the eventual hole that's made
3 through the entire stack. So if -- if damage is
4 made, for instance, to layer 12 of figure 2C, it
5 becomes difficult to control the dimension of that
6 via as it's transferred through the remainder of
7 the stack.

8 Q. Okay. And why is controlling the --
9 the via dimension important in Grill?

10 A. Well, for the same reason I stated. If
11 that via dimension, once it's filled with metal and
12 becomes the connection between metal layers, if
13 that's not controlled correctly, it can lead to
14 problems like resistance or conductivity and
15 eventually lead to a failed device, a nonworking
16 device.

17 Q. Okay. And is there a problem if the
18 via dimension is too small?

19 A. There can be a problem if the via
20 dimension is too small or too large.

21 Q. Or too large? Okay. And so what
22 factors would constrain the target, the via

1 dimension?

2 A. I'm not sure I follow.

3 Q. So if you have to -- I believe you just
4 said that it's important to control the via
5 dimension and that there would be problems if it
6 was too big or too small, but I guess I'm asking:
7 What factors would lead to knowing the correct
8 size, the correct via dimension?

9 A. So that's a difficult question to
10 answer in a general sense, but I think generally
11 the best answer I can give you is as any
12 semiconductor device is designed from the -- from
13 the beginning, from the designing standpoint, that
14 design is based on -- that design for that
15 particular generation is based on all the learning
16 of all the generations that came ahead of it. So
17 generally any device generation is a modification
18 or an improvement over another.

19 So from the design standpoint and the
20 requirements of the electrical characteristics and
21 the design of that -- of each and every process
22 step, engineers would design into that -- these

1 processes or this process what would -- what the
2 required contact hole size needs to be and the
3 tolerance it would need to have in order to allow
4 for that -- a particular device and device
5 generation to work.

6 Not only does it come down to the electrical
7 characteristics which occur from the design
8 standpoint, but the process conditions, it would
9 allow, for instance, that contact hole to be
10 patterned all the way through an entire stack.

11 One problem with contact holes or vias
12 during patterning and etch is we need to realize
13 that it's not just one hole like figures 2B and 2C,
14 a Grill or some of the other figures in the
15 patents. It's not just a single hole, but it's an
16 array of many, many holes, thousands, millions, and
17 each of these has to perform identically over a
18 large area.

19 So all these things take into account to
20 insure that that contact hole has the right -- to
21 insure that contact hole in the ultimate connection
22 has the right electrical performance, but also has

1 the ability to be able to be processed through the
2 entire device process. Those kind of things
3 determine the tolerance on what that hole has to
4 be.

5 Once that's set, once that's known, once
6 that's determined and described very completely in
7 any process control what the dimensional control
8 has to be, if it deviates from what those
9 allowances are, the device won't work. We -- we
10 call that yield issues, and if the device doesn't
11 work, then the entire -- the entire wave would be
12 scrapped or need to be scrapped.

13 Q. Okay. And is there any -- is there any
14 particular relationship between the via dimension
15 and the dimension of the wire above the via?

16 A. Sure, there would be, but it's nothing
17 that -- it's not an answer I could give you in a
18 general sense, but there certainly would be a tied
19 tolerance on what that via dimension would need to
20 be for a particular generation as it makes contact
21 with the metal layer above and the metal layer
22 below. It's -- that would be -- that would be very

1 well established for any particular device.

2 Q. Okay. But you're saying you wouldn't
3 know necessarily whether the via dimension would be
4 larger than the dimension of the wire above it or
5 the wire below it?

6 A. You mean sitting here I wouldn't know?
7 I think I would know if I looked at a -- if you put
8 a particular process in front of me, I could tell
9 you, but there is not a general rule that has to be
10 any -- any degree smaller or the same size.

11 Q. Okay. Okay. So talking about the
12 processes here, like the process in Grill, there --
13 would there be advantages to any particular
14 relationship between the via dimension and the --
15 the wire dimension?

16 A. What Grill does -- what the Grill
17 process and process flow does is it leads to a -- a
18 patterning and a pattern transfer approach that
19 would allow for the control of that via or that
20 contact hole to meet the required specifications.

21 I can't answer any questions related to, you
22 know, how much variation there would be and how

1 much matters and that kind of thing unless we
2 looked at a real process. I think if we looked at
3 a real process, if we looked at a real IBM dual
4 damascene process, we could answer those questions.
5 The key of what Grill does, though, is it allows
6 those tolerances to be met to size that contact
7 hole as it needs to be.

8 Q. Okay. And is there any benefit to
9 having the -- in these processes to having the via
10 hole be smaller than the wire dimension?

11 A. Again, it depends on the process. It
12 depends on -- there -- there are generalities. If
13 that hole is made too small, it will close up and
14 may not fill. If that hole is -- again, in a
15 general sense, if features are made too large,
16 without -- without necessarily regard to via, if a
17 feature is made too large, you run into issues as
18 your density increases of decreasing the width of
19 the dielectric insulating layer between those
20 features.

21 So it's not just what happens when that via
22 or that contact hole is made smaller. It's what

1 happens to the neighboring features and what
2 happens to the dielectric in between them.

3 So it's -- there are reasons why that
4 hole -- that via or any feature shouldn't be any
5 bigger than specified or any smaller than
6 specified, and in a general sense one wouldn't say
7 that it's advantageous to make something smaller or
8 bigger. The best thing to do is -- the way to make
9 a manufacturable process is to make that hole or
10 that feature or that via its correct size within
11 a -- within a tolerable -- specified tolerable
12 limit.

13 We often call that specified tolerable limit
14 a spec, S-P-E-C, and the spec on that contact hole
15 or via or whatever feature we're talking about
16 is -- is normally well defined.

17 Q. Okay. I guess what I'm -- what I'm
18 trying to ask is not so much in a vacuum, the via
19 size in a vacuum, but more the via size relative to
20 the metal wire below it. Are there instances in
21 which you'd want the via hole to be bigger than the
22 wire below it?

1 A. I think I'd have to give you the same
2 answer. You would want that via to be the size
3 that it should be based on the particular device
4 design. If that device is designed for that
5 contact hole to be the same dimension as the via,
6 that would be the target dimension.

7 If that contact hole was designed to be
8 smaller than -- I'm sorry, I'm not sure if I said
9 that right. If that contact hole was designed to
10 be the same size as the underlaying -- underlying
11 wiring feature, then the target -- it would be --
12 that would be the size that would be targeted. If,
13 instead, that contact hole was sized to be smaller
14 than the underlying wire, that would be its target.

15 One can't say that if you're targeting that
16 contact hole or via to be smaller than the
17 underlying wiring it's a good idea to make it
18 bigger or there are advantages to make it bigger.
19 That's -- the goal is to make it the size that it
20 should be based on that -- based on the device
21 design.

22 Q. Okay. And how would this concern --

1 how would these issues about the sizing of the via
2 dimension affect the integration density that we
3 talked about before?

4 A. Okay. So the integration density is --
5 is the goal, to increase the integration density,
6 and to increase integration density, everything is
7 made smaller. Things are packed closer together.

8 So for a particular device of a given
9 density, the wiring, the wiring level for that
10 device as well as the via structures for that
11 device are designed to a particular dimension. As
12 I said -- as I said before, that particular
13 dimension is what is -- what is targeted during
14 processing and the goal to meet that specified
15 critical dimension.

16 Q. Okay. Let me -- let me go ahead and
17 give you a copy of Grill.

18 A. Before we move on to Grill, you gave me
19 one of my declarations, the declaration ending in
20 01376. I'm not sure if we're going to look at
21 other ones, but I have a correction to make in this
22 declaration which carries over to all the rest of

1 them, if I could.

2 I've noticed one or two typos along the way,
3 which I don't think that impacts the substance of
4 the declaration, but there are two that I'd like to
5 make that do impact the substance.

6 Q. Okay.

7 A. Actually, I've got three. Appendix A
8 is my CV, but this is a bit dated now, and I've
9 provided to the lawyers for TSMC an updated CV
10 which includes at least one other case that I
11 worked on and some updates to my references. So I
12 think that can be provided.

13 Another correction is also in an appendix,
14 Appendix B-9 -- or, I'm sorry, Appendix B at page
15 B-9 and 10. And Appendix B addresses the Grill
16 patent and the '628 application, which is the
17 disclosure of the provisional application, and on
18 B-9, the second full paragraph, I say: Although
19 the nonprovisional application for the '696 patent.
20 That should read the Grill patent. That's what
21 this appendix is about, and that correction should
22 carry through. So I'm going to cross that out on

1 my copy, if that's okay. I'm just going to write
2 Grill here.

3 It only makes sense if that's Grill. This
4 isn't the '696 patent.

5 Q. Okay.

6 A. And the other correction in B-10, I
7 talk about in the second full paragraph the
8 photoresist layer 62 and the layer 12, and at the
9 end of -- at the bottom of the first paragraph in
10 that column, I say: A person of ordinary skill in
11 the art would have understood that etching layer 12
12 under such circumstances concurrently etches layer
13 58 because the two layers have similar etch
14 properties, but layer 12 and 58 don't have similar
15 etch properties. The layer that I'm talking to --
16 talking about here is not 58. It's 62. So that
17 correction should be, instead of layer 58, it
18 should be layer 62.

19 Q. Okay. I believe that this has actually
20 been an issue in this IPR before, about trying to
21 correct this -- this particular --

22 MR. ROSSEN: We've been going for about 45

1 minutes. Do you want to take a quick -- a quick
2 break?

3 THE WITNESS: It's your call. I'm okay.

4 MR. ROSSEN: Okay. Let's take like a
5 five-minute break.

6 MR. JIRON: Okay.

7 (A recess was then taken.)

8 MR. ROSSEN: So I'm going to start by noting
9 our objection to the correction, both because it
10 wasn't an answer to any question and because
11 petitioner has already attempted to file a
12 corrected declaration on that issue and the board
13 has disallowed it, so I just want to note my
14 objection.

15 MR. JIRON: In response I'll note that I
16 don't think that the board disallowed it. I think
17 it was a premature issue. As Dr. Smith indicated,
18 the issues in the declaration are merely
19 typographical, and there are corrections made and
20 certainly he's entitled to clarify or correct any
21 points that he believes are inaccurate or need to
22 be corrected, and that's exactly what he's done

1 here to make the record clear.

2 MR. ROSSEN: Okay. I'm just noting my
3 objection. I think we have a disagreement on that
4 issue so -- okay. Let's -- I'm going to give you a
5 copy of the -- what we're calling the '696 patent.

6 The following was marked for Identification:
7 SMITH EXH. 2 United States Patent No.

8 6,197,696 B1

9 BY MR. ROSSEN:

10 Q. Are you familiar with this document?

11 A. Yes, I am.

12 Q. Okay. Take a look at figures 15(a)
13 through 15(c) as well as 16(a) through 16(d) and
14 17(a) through 17(c).

15 A. Okay.

16 Q. Are you familiar with these figures?

17 A. So you asked me about figures 15(a)
18 through 17(c), I believe, and those are figures
19 that relate to, as the specification in this patent
20 describes, the modified example of embodiment 3
21 which are described at least in column 18 starting
22 around line 60 and then going on until about column

1 20 when the fourth embodiment starts somewhere
2 around line 50.

3 You just asked me about figures 15, 16, and
4 17; is that right?

5 Q. That's correct.

6 A. Okay.

7 Q. So just -- just to make sure that I'm
8 clear, you're saying that figure -- the figures 15
9 through 17 deal with the modified -- the modified
10 third embodiment?

11 A. That's correct, and the third
12 embodiment is -- refers to figures 12 and 13(a), b,
13 and c of each, which the modified third embodiment
14 is a modification to.

15 Q. Okay. Turning now to figure 15(a) --

16 A. Okay.

17 Q. -- and in particular layer 352.

18 A. I see that.

19 Q. Okay. Layer 352 is made of silicon
20 nitride; is that correct?

21 A. It says in the specification at line --
22 at column 18, line around 66, it says: First, as

1 shown in 15(a), the silicon nitride film 352 is
2 formed over first metal interconnect 351.

3 Q. Okay. So you agree that it's made of
4 silicon nitride?

5 A. It's described that way in the
6 specification, right.

7 Q. Okay. And layer 353 now, do you see
8 that layer?

9 A. I see that layer.

10 Q. Do you agree that that layer is made of
11 silicon dioxide?

12 A. In this description that's an example
13 of the film that can be used. It says, for
14 instance, in column 19, we're talking about film
15 353, is that what you asked me about?

16 Q. Yes.

17 A. It says in column 19 around line 4: A
18 first silicon dioxide film 353, first insulating
19 film, is formed to be one micron thick, for
20 example. So that's an example of the type of film
21 353.

22 Q. Okay. And where are you reading from?

1 A. I'm column 19 starting around line 4.
2 Thereafter, a first silicon dioxide film 353,
3 parentheses, first insulating film, is formed to be
4 one micron thick, for example, on the silicon
5 nitride film.

6 Q. Okay. So the spec calls it a silicon
7 dioxide film 353?

8 A. In this example, yes.

9 Q. Okay. Okay. And now turning to layer
10 354.

11 A. Okay.

12 Q. I believe that the '696 calls that an
13 organic film; is that correct?

14 A. It says in same column 19, line 6:
15 Next, an organic film 354, parentheses, second
16 insulating film, closed parentheses, is deposited
17 to be 400 nanometers thick, for example, on the
18 first silicon dioxide film 353.

19 Q. Okay. And layer 355, is that a silicon
20 dioxide film?

21 A. Same -- same sort of language in column
22 19. It describes the top of column 19 starting on

1 line 8. Then a second silicon dioxide film 355,
2 parentheses, third insulating film, is formed to be
3 50 nanometers thick, for example, on the organic
4 film 354.

5 Q. Okay. And just to clarify, silicon
6 dioxide and silicon nitride have different
7 compositions; is that correct?

8 A. Right. The composition of silicon
9 dioxide, as the name implies, is one silicon with
10 two oxygens. Silicon nitride, as described, for
11 instance -- as used, for example, for film 352,
12 that name silicon nitride doesn't necessarily imply
13 the chemical formula, the balance of how much
14 silicon and nitrogen, but it would be a chemical
15 compound that would contain silicon and nitrogen.

16 Q. Okay.

17 A. Different from silicon dioxide.

18 Q. Okay. And is it your understanding
19 that the organic film would have a different
20 composition than either silicon dioxide or silicon
21 nitride?

22 A. Well, a silicon nitride or a silicon

1 dioxide could have also organic components to them.
2 An organic film is generally, or an organic
3 material is generally a material that contains
4 carbon and often other things, generally oxygen,
5 hydrogen, and nitrogen, so that organic film 354
6 would contain carbon and possibly other
7 constituents that would make it in that way
8 different from a silicon nitride film or a silicon
9 dioxide film as long as those silicon nitride and
10 silicon dioxide films don't contain, for example,
11 carbon.

12 Q. Okay. Turning now to figure 15(b), is
13 it your understanding that -- that 357 is a first
14 resist pattern formed on layer 356?

15 A. So you're asking me about 357 and
16 figure 15(b)?

17 Q. That's correct.

18 A. It describes -- this patent describes
19 in column 19 starting at line 23, it says: Next,
20 as shown in figure 15(b), which is the figure
21 you're referring to, it goes on to say: A first
22 resist pattern 357, having openings performing

1 wiring grids -- I'm sorry, performing wiring
2 grooves, is formed by lithography on titanium
3 nitride film 356.

4 So, yes, 357 is what's referred to here as a
5 first resist pattern.

6 Q. Okay. Moving on to figure 15(c) now.

7 A. Okay.

8 Q. Is it your understanding here that
9 layer 358 -- sorry.

10 Is it your understanding that going from
11 figures 15(b) to 15(c), the 356 -- layer 356 has
12 been etched; is that correct?

13 A. Right. That layer 356 is described in
14 this example as a titanium nitride film. We see
15 that in figure 15(a). We also see that in figure
16 15(b), film 356, that titanium nitride film.

17 And then in figure 15(c), the patent says at
18 column 19, starting at line 26: Thereafter, the
19 titanium nitride film 356 is dry etched using the
20 first resist pattern 357 as a mask, thereby forming
21 a mask pattern 358 out of the titanium nitride film
22 356 as shown in figure 15(c).

1 So I think -- I'm agreeing with what you
2 said, right.

3 Q. Okay. And I believe what you just said
4 is the 356 was etched using 357 as a mask; is that
5 correct?

6 A. Right, to leave 358 patterned.

7 Q. Okay. Now, turning to 16(a).

8 A. Okay.

9 Q. Okay. For figure 16(a), is it your
10 understanding that -- that 359 is a second resist
11 pattern formed on silicon dioxide film 355?

12 A. I'm sorry, could you say that again?

13 Q. Is -- sorry. Is it your understanding
14 that 359 --

15 A. 359.

16 Q. -- is a pattern formed on silicon
17 dioxide film 355?

18 A. So you see in column 19 around line 30
19 the patent describes the first resist pattern is
20 removed, so 357 in 15(c) is gone. And then a
21 second resist pattern 359, which we see in 16(a),
22 the patent describes in column 19, line 32, it

1 says: Resist pattern 359 having openings
2 performing contact holes is formed on the second
3 silicon dioxide film 355.

4 So we see that that photoresist 359 is
5 formed on 355, and it's also been patterned, as we
6 see in 16(a), having the contact hole openings.

7 Q. Okay. And then in figure 16(b), layers
8 355 and 354 are sequentially dry etched; is that
9 correct?

10 A. The patent says, same column 19 around
11 line 33, it describes that then, the silicon
12 dioxide film, which is 355, and the organic film,
13 which is 354, are sequentially dry etched using the
14 second resist pattern 359 as a mask, thereby
15 forming a patterned second silicon dioxide film
16 350A and a pattern organic film -- I'm sorry, 355A
17 and a patterned organic film 354A having openings
18 360 for forming contact holes as shown in the
19 figure 16(b).

20 So, yes, those layers are sequentially
21 etched using the second resist pattern 359 as a
22 mask.

1 Q. Okay. Moving on to figures 16(c) and
2 16(d) now, is it correct that going from figure
3 16(c) to 16(d), layer 354A is being etched?

4 A. Well, the patent says to me, again, in
5 the same column, what happens after we do the
6 patterning of 355 and 354 with that second
7 photoresist pattern, it says at line 38, same step
8 as I talked about before, in this case the second
9 resist pattern 359 is removed during the step of
10 etching the organic film 354.

11 So we see in step 16(c) -- actually, we see
12 in step 16(b) the result, the second photoresist
13 now is gone. I think you asked me about figure
14 16(c). It says, line 41: Next, as shown in figure
15 16(c), the first silicon dioxide film 353 is dry
16 etched using the patterned silicon dioxide film
17 355A, using the second patterned silicon dioxide
18 film 355A and the patterned organic film 354A as a
19 mask, thereby forming a pattern for silicon dioxide
20 film 353A having contact holes 361. I think that's
21 what you asked me.

22 Q. Okay. And based on your understanding

1 of that, what layer or layers are being used as a
2 mask when etching 354A?

3 A. You're asking about now the figure
4 16(b), etching 354A or 353A?

5 Q. No. Well, I'm speaking about what we
6 were just talking about, going from 16(c) to 16(d),
7 where 354A is etched.

8 A. Okay. So I'll go back then. It's in
9 column 19, line 33, it says: The second silicon
10 dioxide film 355 and organic film 354 are
11 sequentially etched -- dry etched using the second
12 resist pattern 359 as a mask. That's 16(b). So
13 that's etching 354.

14 Q. Okay. But I'm actually referring to
15 later on in the figures where 354A is etched.

16 A. I think that's what I answered. So it
17 says, line 35: Thereby forming patterned second
18 silicon dioxide film 355A and patterned organic
19 film 354A having openings 360 for forming contact
20 holes. That is the step etching 354A -- or 354 and
21 then leaving -- and then patterning those contact
22 holes leaving it as 354A. A, referring to the

1 letter A, generally designates that it's patterned
2 for contact holes.

3 Q. Okay. Maybe we'll take a step back.
4 So going between figure 16(c) and 16(d) --

5 A. Okay. So that's a step forward.

6 Q. -- what is being etched in that step?

7 A. Are you talking about 16(d) or 16(c)?

8 Q. I'm talking about the step from 16(c)
9 to 16(d).

10 A. Oh, so we skipped step 16(c), which I
11 think is important, right? So 354A is patterned in
12 step 16(b), but 16(c) patterns 353 turning into
13 353A. So we should talk about that one first.

14 Q. Okay.

15 A. So the patent says: As shown -- I'm
16 reading from line 41. Next, as shown in figure
17 16(c), the first silicon dioxide film 353 is dry
18 etched using the patterned silicon dioxide film
19 355A, and we can see that in figure 16(b), what
20 355A is, and the patterned organic film 354A has a
21 mask, and again we can see 354A in figure 16(b).

22 So both the patterned silicon dioxide film

1 355A and the patterned organic film 354A are used
2 as a mask to form the patterned first silicon
3 dioxide film 353A having contact holes which are
4 labeled as 361.

5 It says: The mask pattern 358 is
6 transferred to the patterned second silicon dioxide
7 film 355A accordingly. Accordingly, openings for
8 forming wiring grooves are formed in the patterned
9 second silicon dioxide film 355A.

10 And then you wanted to go to 16(d)?

11 Q. Yes, please.

12 A. So it says: The patterned organic film
13 354A -- I'm reading from line 50, same column -- is
14 dry etched using the mask pattern 358, and the
15 patterned second silicon dioxide film 355A having
16 openings for forming wiring grooves -- I'm sorry,
17 let me start over. Thereby, as shown in figure
18 16(b), the patterned organic film 354A is dry
19 etched using the mask pattern 358, and the
20 patterned second silicon dioxide film 355A having
21 openings for forming wiring grooves as a mask,
22 thereby forming wiring grooves 362.

1 Q. Okay. So just to clarify, in this step
2 358 and 355A are used as a mask to etch 354A?

3 A. Well, that's what it says, but as we
4 see in figure 16(d) and 17(a), that both 358 and
5 355 remain through steps 16(c), 16(d), and 17(a).
6 So as 354 is dry etched using that mask pattern
7 358, it's the mask pattern 358 that provides the
8 mask to -- to create the openings to allow for the
9 etching of 354. So 358 is the mask that is defined
10 areas for etching.

11 Q. Okay. So are you saying that 355A is
12 not being used as a mask to etch 354A?

13 A. As this -- these diagrams show and as
14 the description of the process flow indicates in
15 the context of all that's in column 19, the one --
16 one of ordinary skill or one that would read this
17 patent would know that the mask pattern 358 is what
18 is providing the etch resistance, it's what is
19 providing the definition for patterning layers --
20 layer 354 below it.

21 Q. Okay. So the -- the quote that you
22 read from column 19, line 50, you don't understand

1 that to mean that second silicon dioxide film 355A
2 is being used as a mask?

3 A. Well, there are a lot of things that
4 are described in the process flow for this third
5 embodiment, or this is the modified third
6 embodiment we're looking at, and things that in
7 particular that -- that support that the mask
8 pattern 358 is the mask for dry etching of 354 or
9 354A includes things like the description of how
10 it's etched, it's etched using a dry etch, the
11 anisotropy that is -- that occurs during this dry
12 etch. Further description is not only of 16(d),
13 but as we go to 17(a) and figures after that, 17(b)
14 as well, that 355A does not contribute to masking
15 of the dry etching of 354A below it.

16 Q. Okay. So what do you think that this
17 quote that you read means?

18 A. I think it means that mask pattern 358
19 is the mask that provides the openings, the etching
20 for layer 354A.

21 Q. Okay. And the part where it says "and
22 the patterned second silicon dioxide film 355A,"

1 what is your understanding as to what that means?

2 A. I -- I believe that 355A does not mask
3 the etching of 354A.

4 Q. So you read this sentence to say that
5 355A is not being used as a mask?

6 A. It's not consistent with what is
7 described in the rest of the process flow nor is it
8 consistent with the diagrams.

9 Q. Okay. So you're saying that the
10 specification here is not consistent with the
11 diagrams?

12 A. I think that reference to -- that
13 second silicon dioxide 355A is not consistent with
14 the entire process flow or the way that that
15 process is depicted in the diagrams or the way that
16 one operating a process as explained in this third
17 embodiment description would know that it would
18 work based on that description.

19 Q. Okay. Let's turn to figure 17(a). In
20 17(a) is it your understanding that layer 352 has
21 been etched to form layer 352A?

22 A. So layer 352 we talked about before is

1 made up of, for example, silicon nitride film, and
2 that is also referred to as a protection layer.
3 That protection layer in this example still exists
4 in figure 16(d). It protects the underlying
5 interconnects 351, that wiring layer below it, but
6 is removed in step 17(a) as described -- just give
7 me a minute as I read through the rest of the lines
8 we need to get to to get to 17(a).

9 Okay. So up to line -- up to column 20,
10 around line 9, it says: Subsequently, the silicon
11 nitride film 352, which is that underlying
12 protection layer, is dry etched using the patterned
13 first silicon dioxide film 353A as a mask, thereby
14 forming the patterned silicon nitride film 352A and
15 exposing the first metal interconnect 351 with the
16 contact holes as shown in 17(a).

17 Q. Okay. And -- and then in figure 17(b),
18 is it your understanding that the wiring groups and
19 contact holes have been filled to form a metal
20 interconnect?

21 A. 17(b) shows two things. It shows
22 what's referred to as an adhesion layer, 350 --

1 363, which may be titanium nitride, and also metal
2 film 354 which is deposited over the entire surface
3 to completely fill in the contact holes 361 and
4 wiring grooves 362. And this is explained in
5 column 20 starting around line 15.

6 MR. ROSSEN: Okay. All right. I'm going to
7 introduce another document. Can I get you to --
8 the court reporter to label this as Smith Exhibit
9 3.

10 The following was marked for Identification:
11 SMITH EXH. 3 Chapter 12 of textbook titled
12 Microlithography: Science
13 and Technology

14 BY MR. ROSSEN:

15 Q. Are you familiar with this document?

16 A. I am. This looks like one chapter out
17 of a textbook that I've edited and authored called
18 Microlithography: Science and Technology.

19 Q. Okay. So this is chapter 12 from the
20 book that you edited, correct?

21 A. It looks to be some front matter for
22 the book which includes a page describing

1 various -- various other publications by the
2 publisher, a preface to the book itself, a
3 description of the editors, including my coeditor,
4 Dr. Suzuki, a list of contributors to the chapters,
5 a table of contents, and then, yes, it looks like
6 chapter 12 is included.

7 Q. Okay. And you edited this chapter 12?

8 A. I co-wrote this chapter and edited it,
9 yes.

10 Q. Okay. Can I get you to turn to page
11 657.

12 A. Okay.

13 Q. Can I get you to read the second
14 sentence of section 12.7.

15 A. The sentence starts with "this goal"?

16 Q. Yes, please.

17 A. It says: This goal is achieved by
18 using physically distinct layers to separate the
19 imaging function from etch resistance,
20 planarization, and reflection suppression function.

21 Q. Okay. And based on this sentence, is
22 it your understanding that a multilayer resist can

1 include an etch-resistant layer?

2 MR. JIRON: Objection. Form.

3 THE WITNESS: This is a general lead-in to
4 many multilayer resists and also describes some of
5 the processing and process requirements in sections
6 prior to 12.7. For instance, section 12.1. And
7 section 12.1 describes all the demands that are
8 placed on a photoresist material, and I've listed
9 these starting on page 638 as resist sensitivity,
10 depth of focus, aspect ratio, reflection effects,
11 standing wave effects, plasma-etch resistance, and
12 planarization.

13 This sentence that you had me read says that
14 when asking so many things out of a photoresist, it
15 may be possible or it may be desirable to separate
16 some of those functionalities out of a singer-layer
17 resist and use multiple layers.

18 These have been referred to and referred to
19 in this book, and you see the name implies this, as
20 multilayer resists. That name doesn't mean that
21 you have multiple resist layers, but instead the
22 things you're asking out of a conventional

1 single-layer resist you would use multiple layers
2 for, or you may use multiple layers for.

3 I'd also say that a lot of things that are
4 in this chapter, the publication date is 2007, but
5 a lot of the technology and descriptions of these
6 technologies are older than that, and some have
7 been proven since not necessarily to be
8 manufacturable, but they, indeed, were technologies
9 that were explored and researched and developed for
10 possible application to manufacturing.

11 BY MR. ROSSEN:

12 Q. Okay. So just to make sure that I'm
13 clear, are you saying that -- that you're not
14 talking about multilayer resists here? You're
15 talking about a single layer that does multiple
16 things?

17 A. No, no. I'm not saying that. I say in
18 the very first paragraph of this chapter on page
19 12 -- on page 638, I describe that in I believe the
20 third sentence. As long as single-layer resist
21 materials can meet requirements for, and then I go
22 on to list the things that I just mentioned in the

1 subsequent sections: High-aspect ratio resolution,
2 photosensitivity, and so forth. And I've got a
3 list of a handful of things here.

4 These -- or I say they, meaning these
5 photoresists, these single-layer resists may be
6 preferred over most multiple-layer or
7 pseudo-multilayer techniques. This becomes
8 increasingly difficult, and at some point the
9 lithographer needs to consider the advantage of
10 dividing the functions of a single-layer resist
11 into separate layers.

12 So it's taking all the things that we have
13 traditionally asked and continue to ask of a
14 single-layer resist and dividing that into separate
15 layers. That's the multilayer. It's not -- it's
16 not multiple photoresist layers, but it is the
17 function of a photoresist divided into multiple
18 layers.

19 Primarily, if we think about what a
20 photoresist is, there are two aspects to the name
21 itself. It's a contraction of photoreactive and
22 etch resistant. Hence, the name photoresist. It's

1 nice to be able to achieve that in one layer, but
2 if it can't be, you may need to do that in multiple
3 layers.

4 Q. Okay. And we're talking about
5 physically distinct layers?

6 A. Well, I also mention -- mention
7 pseudo-multi-layers which may be a single layer
8 that has different properties, for instance, at the
9 top than it does at the bottom.

10 Q. Okay. But in 12.7, what we were
11 talking about before, I mean, we're talking about
12 using physically distinct layers to separate out
13 the functions; is that correct?

14 A. Yes. This sentence that I read from
15 before in 12.7 leads into the further discussion in
16 that section as it's named in 12.7,
17 silicon-containing -- silicon-containing resists
18 for multilayer and surface imaging resist
19 applications. So that paragraph says, as I read
20 before: The goal is achieved by using physically
21 distinct layers.

22 But it goes on to say in that paragraph,

1 however, additional processing of these multiple
2 layers sometimes adds difficulty. So this section
3 in the chapter talks about ways to incorporate
4 silicon into the resist to reduce the number of
5 layers. So that's a lead-in discussion to what's
6 called silicon-containing resist.

7 And then you see in the sections that follow
8 there are a whole lot of process descriptions from
9 various references and publications talking about
10 silicon-containing resist and dry-developing resist
11 and what's called silylation, that's
12 S-I-L-Y-L-A-T-I-O-N, and other things similar to
13 that.

14 Q. Okay. So at other points you talk
15 about combining them all into a single layer,
16 but -- but here in this portion that I refer you
17 to, you're talking about three physically distinct
18 layers?

19 A. Well, like I said, this section is a
20 lead-in to the sections that follow. This is 12.7,
21 and every subsection after that I think is 12.7.1
22 and 12.7.2, and I guess we get into 12.8 as we talk

1 about other surface-imaging approaches.

2 But this sentence that you've had me read
3 describes many of the other multilayer approaches
4 that are included in the chapter starting, for
5 instance, in section 12.2. That's called wet
6 development approaches. 12.3 is wet
7 development/dry pattern transfer. 12.4 is resist
8 reflectivity and antireflective coatings. And I
9 think -- oh, and then 12.6 is what we call contrast
10 enhancement materials.

11 So those are the physically distinct layers
12 that are referred to in this sentence, in 12.7 you
13 asked me to read. So this section 12.7 essentially
14 says everything that was talked about before in
15 these possible multilayer techniques. They may be
16 usable, they may be good, they may also offer
17 additional process difficulties, so an alternative
18 is to use silicon-containing resists, and that's
19 what's talked about from 12.7 on.

20 Q. Okay. So which of the layers that
21 you -- you just listed and stated that those are
22 the layers you're talking about here, the

1 physically distinct layers. Which of those
2 performs the function of etch resistance?

3 A. Well, that depends. Let's look at --
4 and it depends and it's very particular to these
5 examples. It's been -- you know, honestly, it's
6 been a long time since I've read through this
7 chapter.

8 Can you ask that question again, please?

9 Q. Okay. I'm just trying to understand.
10 So I believe what you said was that in this
11 sentence, in 12.7 that you've read, where it says
12 "the goal is achieved by using physically distinct
13 layers to separate these three functions," I
14 believe what you said was that the layers that
15 you're talking about here are the layers in the
16 sections 12.2, 12.3, 12.4, and 12.6. Is that -- am
17 I understanding correctly?

18 A. Right. Those --

19 MR. JIRON: Objection. Form. Relevance.

20 THE WITNESS: Those are the examples of the
21 physically distinct layers that are described in
22 that sentence in 12.7, as examples.

1 MR. ROSSEN: Okay.

2 THE WITNESS: And I've got -- by the way, in
3 addition to those examples, there are several
4 references that are cited that I think would
5 introduce probably other possibilities. Again,
6 it's been a while since I've looked at that.

7 BY MR. ROSSEN:

8 Q. Okay. Well, let's turn to page 642.

9 A. Okay.

10 Q. And, in particular, figure 12.3(c).

11 A. Okay.

12 Q. Is figure 12.3(c) illustrating a
13 trilayer photoresist system?

14 A. The top of 12 -- the top of 12.3(c)
15 shows those 12 -- shows those three layers, that's
16 right.

17 Q. Okay. The top meaning the upper part
18 of -- sorry, can you explain what you mean by the
19 top?

20 A. The trilayer system, the layers we see
21 over the substrate include a planarizing layer, an
22 intermediate etch-stop layer, and imaging layer.

1 So there are the three layers.

2 Q. Okay. And in the bottom portion of
3 12.3(c), is it your understanding that those three
4 layers are depicted on the right-hand side?

5 A. Those are the same -- that describes
6 how that pattern is transferred, and the words that
7 describe that are in -- on page 643. It says -- or
8 I say, starting section 12.3, I think this is the
9 third sentence: The three-layer scheme, depicted
10 in figure 12.3, makes use of a polymeric
11 planarizing layer, such as novolac resin or
12 polyimide, and a thin intermediary etch-stop. This
13 etch-stop layer can be a spin-on organosilicon
14 compound, parentheses, spin-on glass, closed
15 parentheses, a low-temperature oxide, a silicon
16 oxynitride, or a metallic layer, which provide
17 oxygen etch resistance. A thin resist imaging
18 layer is coated over this etch-stop, exposed, and
19 wet developed, which is the traditional way to
20 pattern a photoresist. Pattern transfer into the
21 intermediary etch-stop layer can be achieved with
22 wet-etch or dry-plasma techniques with suitable

1 chemistry. Anisotropic pattern transfer through
2 the thick polymeric planarizing layer can be
3 achieved via an oxygen RIE process.

4 Then I say: Variations on this technique
5 have been used for both optical and electron beam
6 applications. That describes what is happening in
7 that trilayer system.

8 Q. Okay. And so in the figure 12.3(c),
9 the bottom box --

10 A. Okay.

11 Q. -- are those three layers that you've
12 just read about and talked about, are those three
13 layers depicted on the right-hand side?

14 A. Well, I can tell you what's depicted on
15 the right-hand side.

16 Q. Okay.

17 A. So what this 12(c) on the bottom is,
18 shows the accurate delineation of a pattern in a
19 top film, and I've described this in what I just
20 read, it's a thin photoresist layer. That opening
21 is transferred into the thin etch-stop -- I'm
22 sorry, let me back up. That photoresist layer is

1 patterned using exposure, then develop. That's the
2 standard way that you would pattern a photoresist,
3 and that opening and the integrity and the sizing
4 of that opening is transferred into the etch-stop
5 layer, and I say plasma RIE. That's how that is
6 done.

7 And then that same opening, and we talked
8 about this earlier this morning, with the control
9 over that opening size, and that's critical in any
10 semiconductor processing, is transferred with the
11 desired integrity into that what I've called the
12 polymeric planarizing layer using an oxygen plasma
13 RIE.

14 This bottom figure is not intended to show
15 what the structure would look like after the
16 processing. Instead, this is intended to show, and
17 it's consistent with the words that I just read,
18 how the integrity of that pattern is transferred
19 through those three layers.

20 I've said in the excerpt that I've just read
21 that the etch-stop layer provides oxygen etch
22 resistance. I've also said the thick planarizing

1 layer can be patterned using an oxygen RIE process.

2 That etch-stop layer provides resistance to
3 etch the planarizing layer. The functionality is
4 then not part of the photoresist. The photoresist,
5 as I've said, is a thin resist imaging layer, so
6 it's used for imaging only, and it's only used to
7 transfer the pattern into the etch-stop.

8 What happened since I've said the
9 planarizing layer is polymeric, and I had in
10 parentheses "such as novolac resin or polyimide,"
11 novolac resin is the same resin that we used in a
12 photoresist. So it would be obvious that what
13 would happen as you do the oxygen plasma RIE is the
14 resist would be gone.

15 The reason I've drawn the picture the way I
16 did, as I've said before, to show that pattern
17 transfer from top to bottom can retain that same
18 sidewall angle if it's done in a way that I've
19 described. It's not meant to depict what the final
20 result would be, and you can tell that based on the
21 words I've used. I've not labeled these in terms
22 of what they are but the process that's used to

1 transfer those layers, exposed developed plasma RIE
2 and then oxygen plasma RIE.

3 Q. Okay. And the diagonally shaded
4 region, what does that depict?

5 A. This -- this block here -- and, again,
6 this is a very crude diagram. It's not meant to be
7 used to depict any real device. You can see it's
8 just blocks and angles. That block right there I
9 included to show in all these schemes, whether
10 bilayer or trilayer, that that thick layer, what
11 I've called planarizing layer, is coated thick
12 enough so that, indeed, smooths out the topography
13 that would exist because of that block that's
14 there. So it's a thick-enough planarizing layer.

15 So that could be -- that would be an
16 underlying film, whether it's a dielectric
17 insulator film or it's a metal. Whatever it is,
18 it's the patterning for the underlying layer, and
19 that planarizing layer is coated thick enough to
20 smooth that out.

21 And it shows -- then the figure 12.3(c) on
22 the bottom shows that you can have that opening

1 control, that line with control, that opening,
2 consistent, whether you're patterning over
3 topography or you're patterning over areas that
4 don't have topography.

5 Q. So the multilayer resist that we're
6 talking about here containing the imaging layer,
7 the intermediate etch-stop layer, and the
8 planarizing layer, what -- what does it etch?

9 A. So there are two etch processes and a
10 develop process involved. The imaging layer is
11 exposed and developed. The etch-stop is etched in
12 a plasma RIE. If it's a -- I have used examples,
13 for instance, let's say a spin-on glass, that
14 plasma RIE would be a fluorine-containing plasma,
15 for example, SF6 maybe, fluorine-containing plasma.
16 Then the plasma etch conditions, and in particular
17 the reactive-ion etch conditions, would be changed
18 to etch the planarizing layer. So it would be an
19 oxygen plasma.

20 After all is said and done, after the
21 exposed developed and the two plasma reactive-ion
22 etch steps, then that layer is defined to etch

1 something underneath that. So in the diagram, that
2 very bottom horizontal line would be whatever that
3 substrate thin film material is. That then would
4 be etched using this process.

5 So this doesn't address what would be etched
6 underneath that hasn't been etched yet. This is
7 just defining that multiple layer -- multiple layer
8 resist.

9 Q. Okay. Let's go back to your
10 declaration now, which I believe we marked as Smith
11 Exhibit -- Depo Exhibit 1. Okay. And I am going
12 to point you to page 46. So starting with
13 paragraph 122 and going through paragraph 140.

14 A. Okay. I see that.

15 Q. In this -- in these paragraphs, you are
16 providing your opinions on the priority of the '696
17 patent application; is that correct?

18 A. Well, I'm offering my opinion. I
19 haven't specifically addressed the entire legal and
20 priority issue of -- or the legalities involved in
21 the entire priority issue of the Japanese patent
22 application.

1 What I've addressed in my declaration is
2 that in this particular disclosure where I'm
3 looking at claims 13 and 15, this Japanese
4 application doesn't disclose the elements that I'm
5 describing of claims 13 and 17, and then that goes
6 towards the priority issue, which is -- which is,
7 of course, legal implications beyond what I'm
8 qualified to answer questions about. So I'm
9 addressing the technology involved.

10 Q. Okay. And turning in particular to
11 paragraph 124.

12 A. Okay.

13 Q. Here -- is it your opinion that claims
14 13 and 15 relate only to the fifth, modified fifth,
15 sixth, and modified sixth embodiments of the '696
16 patent?

17 MR. JIRON: Objection. Form.

18 THE WITNESS: So as I've said in that
19 sentence, figures 21(a) through 37(b) and claims 13
20 and 15 relate to those embodiments you just
21 described. And in this sentence I have said that
22 the '371 application doesn't include these figures

1 or claims.

2 MR. ROSSEN: Okay.

3 THE WITNESS: Did I answer your question?

4 I'm not sure if I did.

5 MR. ROSSEN: I think so.

6 THE WITNESS: Because, you know, I go on
7 further to say that the claims don't cover the
8 first, second, third, the variant of the third and
9 the fourth embodiments, which are those that are
10 included in the '371 application, and I'm referring
11 again to claims 13 and 15.

12 BY MR. ROSSEN:

13 Q. Okay. So in paragraph 125 -- actually,
14 no, let's -- sorry. Let's turn to paragraphs 126
15 and 127.

16 A. Okay.

17 Q. Here you are providing your opinion
18 that step G of claim 13 is not supported by the
19 first, second, and fourth embodiments of the '371
20 application; is that correct?

21 A. Well, I think it goes beyond my
22 opinion. Yes, that's my opinion, but the

1 application itself says this. It says, and I'm
2 reading from paragraph 127, I say, referring to the
3 '371 application, it explicitly states that the
4 second resist pattern 109 is formed without
5 removing the first resist pattern 107.

6 So step G couldn't be practiced, because
7 step G requires removing the first resist pattern
8 and then forming a second resist pattern on the
9 third insulating film.

10 Q. Okay. And we're talking about the
11 first, second, and fourth embodiments?

12 A. This is true for the first, second, and
13 fourth embodiment, yes.

14 Q. Okay. And in this declaration, you
15 provided your opinions on steps G, H, and I as to
16 whether they're supported by the Japanese
17 application; is that correct?

18 A. Yes. I've described in the section
19 referring to steps G, H, and I of the 13th claim --
20 of claim 13.

21 Q. Okay. And in your declaration, did you
22 provide an opinion on any of the other steps of

1 claim 13 as to whether they're supported by the
2 Japanese application?

3 A. Well, I've said in paragraph 140,
4 because of these deficiencies at least, it's my
5 opinion that a person of ordinary skill would not
6 have found the '371 application to adequately
7 describe the challenged claims.

8 What I haven't done is gone into whether or
9 not the steps that follow G, H, and I, that is, J
10 and K, could be practiced by those -- by those
11 embodiments if G, H, and I weren't practiced. So I
12 would have to say that it's very likely that J and
13 K -- I would have to look further at J and K, but I
14 hadn't offered an opinion on J and K.

15 Q. Okay. Okay. And we're talking about
16 the declaration for the 2016-01376 petition, right?

17 A. In this -- these are the questions
18 you've asked me regarding claim 13, and I also
19 would like to point out that what I'm looking at as
20 I'm referring to claim 13 and the steps involved,
21 I'm actually looking at the 6 -- I'm looking at the
22 '696 patent itself to compare those to.

1 So my -- my other declarations that address
2 claim 10, for instance, I have compared that to
3 claim 10 of the '696 patent.

4 Q. Okay. So for the -- for the 2016-01378
5 petition, are you familiar with that petition?

6 A. Well, inasmuch as I know that's one I
7 have petitions, I would have to look at it to
8 recollect which claims and -- which claims and
9 which structure formation I addressed in that
10 report, but I am familiar with it.

11 Q. Okay. I can tell you that it's the
12 one -- it's the other one that deals with claim 13
13 as the independent claim.

14 Do you know if you addressed the same
15 elements from claim 13 in your other petition?

16 A. I'd have --

17 MR. JIRON: Objection. Form.

18 THE WITNESS: I wouldn't know that. If I
19 looked at it -- I would have to look at it to be
20 certain.

21 MR. ROSSEN: Okay. All right.

22 MR. JIRON: We've been going for about an

1 hour and 10. When you come to a stopping point,
2 maybe we can take a break.

3 MR. ROSSEN: Sure, yeah. We'll do this
4 quickly. Okay. I'm going to ask the court
5 reporter to mark this as Depo Exhibit 4.

6 The following was marked for Identification:

7 SMITH EXH. 4 Declaration of Dr. Bruce W.
8 Smith, Ph.D.

9 BY MR. ROSSEN:

10 Q. Are you familiar with this document?

11 A. Yes, I am. This is my declaration
12 for -- regarding the '696 patent that is referred
13 to -- or I refer to as 01378.

14 Q. Can I point you to paragraphs 122 to
15 140.

16 A. Okay. Okay. I see that.

17 Q. Okay. Similar to the last declaration
18 we were talking about, did you opine on any of the
19 steps or the limitations of claim 13 other than G,
20 H, and I in this section?

21 A. No. This section is essentially the
22 same as the section we looked at in the 01376

1 report or declaration.

2 Q. Okay. So they're substantively the
3 same?

4 A. Yes.

5 MR. ROSSEN: Okay. Quickly, let's -- I'm
6 going to provide you with this, which we will have
7 marked as Smith Deposition Exhibit 5.

8 The following was marked for Identification:
9 SMITH EXH. 5 Declaration of Dr. Bruce W.
10 Smith, Ph.D.

11 BY MR. ROSSEN:

12 Q. Are you familiar with this document?

13 A. Yes. This is my declaration regarding
14 the '696 patent, and it is, as you said, referred
15 to as 01377. It addresses claims 10, 11, 12, and
16 particular structures of the Grill and Aoyama
17 patents as they relate to those three claims, 10,
18 11, and 12.

19 Q. Okay. Can I point you to paragraphs
20 140 through 166 of this declaration.

21 A. I see that.

22 Q. In this section, is it your

1 understanding that you are providing your opinions
2 as to what is disclosed in the Japanese patent
3 application, priority patent application, the '371
4 application is what I believe you called it in this
5 declaration?

6 A. Right. And in particular the
7 disclosures of the '371 application which are the
8 first, second, third, modified third, and fourth
9 embodiments of what is -- what we're referring to
10 as the '696 patent.

11 Q. Okay. And directing your attention to
12 paragraph 142, is it your opinion -- or in this
13 declaration, were you opining that claims 10
14 through 12 relate only to the fifth, modified
15 fifth, sixth, and modified sixth embodiments of the
16 '696 patent?

17 A. Well, my opinion, and I'll say it a
18 little bit differently, is that claims 11 and 12 do
19 not pertain to the first, second, third, modified
20 third, and fourth embodiment. The figures 21(a)
21 through 37(b) are not included in the '371
22 application, nor are claims 11 through 12, nor are

1 descriptions of what the processes entail for
2 figures 21(a) through 37(b). And the same would go
3 true for the other two disclosures we talked about.
4 But in this time it's related to claims 11 and 12,
5 not 13 and the claims that depend on 13.

6 Q. And just to be clear, are you including
7 10 as well or just 11 and 12?

8 A. I'm sorry, if I said 11 and 12, what I
9 say in paragraph 142 is 10 through 12, 10, 11, and
10 12. If that's not what I said, that's what I meant
11 to say.

12 Q. Okay. So what you just said applies to
13 10, 11, and 12?

14 A. In that 11 and 12 depend from 10, if it
15 pertains -- my statement does pertain to claim 10
16 and those that depend on them, which would include
17 11.

18 Q. Okay. Turning to paragraphs 143 and
19 144, here you're talking about step H of claim 10;
20 is that correct?

21 A. Paragraph 144 is step H, that's right.
22 Recites removing the first resist pattern and then

1 forming a second resist pattern on the fourth
2 insulating film and the mask pattern.

3 Q. Okay. And in particular here you're
4 providing your opinion as to whether a person of
5 ordinary skill in the art would have understood the
6 first, second, and fourth embodiments of the
7 application to disclose step H of claim 10; is that
8 correct?

9 A. I'm not too sure about your question,
10 but I say this in paragraph 145, that those
11 embodiments, first, second, and fourth of the '371
12 application, do not disclose removing the first
13 resist pattern and then forming the second resist
14 pattern. This is stated explicitly in the
15 application, I believe paragraph 43, where it says
16 the second resist pattern 109 is formed without
17 removing the first resist pattern 107.

18 Q. Okay. And turning to paragraph 146
19 now -- actually, looking at -- more broadly,
20 looking at this section that we've been talking
21 about, paragraphs 140 through 166 in your
22 declaration, is it correct to say that you have

1 provided your opinion as to whether steps H, I, J,
2 and L of claim 10 are supported by the Japanese
3 patent application?

4 A. Steps H, which is removing the first
5 resist pattern, I, which is dry etching the fourth
6 insulating film, J, which is dry etching the third
7 insulating film, and L which is dry etching the
8 patterned third insulating film are not, in my
9 opinion, disclosed in those embodiments of the '371
10 application.

11 Q. Okay. And did you provide your opinion
12 on any of the other -- on whether any of the other
13 limitations in claim 10 were supported by the prior
14 application?

15 A. Well, I say in paragraph 167 of this
16 declaration: Because of these deficiencies at
17 least, it's my opinion that a person of ordinary
18 skill in the art would not have found the '371
19 application to adequately describe the challenged
20 claims. I haven't addressed any other specific
21 deficiencies. The one that would come to mind as
22 to whether or not the steps that follow L, like,

1 for instance, M, could be carried out without
2 carrying out I, J -- H, I, J, and L.

3 Q. But you haven't opined on that in your
4 declaration; is that correct?

5 A. That's right.

6 MR. ROSSEN: One more. I'm going to ask you
7 to mark this as Deposition Exhibit 6.

8 The following was marked for Identification:

9 SMITH EXH. 6 Declaration of Dr. Bruce W.

10 Smith, Ph.D.

11 BY MR. ROSSEN:

12 Q. Can I direct your attention to
13 paragraphs 134 through 160.

14 A. So this is a declaration regarding the
15 '696 patent that I've referred to as 01379 in the
16 declaration for that matter. It addresses claim 10
17 and claim 12 of the '696 patent, and the
18 combinations of Grill, Aoyama, and Wetzel. So
19 paragraph 134 addresses the '371 application that
20 we've been talking about related to claims 10 and
21 12 of the '696 patent.

22 Q. Can you take a look at paragraphs 134

1 through 160 and tell me whether they're
2 substantively the same as the paragraphs that you
3 were just discussing in the 1377 declaration?

4 MR. JIRON: Objection. Form.

5 THE WITNESS: I address the deficiencies of
6 the '371 patent as they pertain to claims 10
7 through 12 and described as deficiencies related to
8 the steps -- the same steps of claim 10 of the '696
9 patent, and I believe I've made the same arguments
10 or offer the same opinion as I have for the
11 disclosure we just talked about, 01377.

12 MR. ROSSEN: Thank you. We can break now.

13 (A recess was then taken.)

14 BY MR. ROSSEN:

15 Q. Can I get you to turn back to the first
16 declaration that we talked about, the 1376
17 declaration.

18 A. Okay. I've got it.

19 Q. And in particular let's turn to
20 paragraph 148. Do you see what's labeled as number
21 20 in figure 1J, which follows paragraph 148?

22 A. Yes, I see that.

1 Q. And to be clear, this is figure -- this
2 is a version of figure 1J from the Grill reference
3 that we've been talking about; is that correct?

4 A. That's right.

5 Q. Do you know why it's -- 20 is labeling
6 there?

7 A. Well, I can tell you if you can give me
8 the Grill patent. I don't think I've got it.

9 MR. ROSSEN: Okay. I can do that. So can I
10 get the court reporter to label this as Smith
11 Deposition Exhibit 7.

12 The following was marked for Identification:
13 SMITH EXH. 7 United States Patent No.

14 6,140,226

15 THE WITNESS: So in the Grill patent if we
16 look at column 4, it describes what the structure
17 of figure 1J is starting around line 60. It goes
18 on to say at line 63: The structure of figure 1J
19 containing dual relief cavity 20. So it's the
20 cavity, the dual relief cavity, that contains an
21 opening in the wiring level dielectric 12 for the
22 wiring level, the opening in the via level

1 dielectric 8, and then the corresponding etch-stop
2 in other layers.

3 BY MR. ROSSEN:

4 Q. Okay. So what is -- what is a dual
5 relief cavity?

6 A. Well, as Grill describes in this IBM
7 dual damascene process, it is an opening that will
8 be later filled with metal, as we see in figure 1K
9 and the descriptions of figure 1K and then polished
10 back in figure 1L, that contains regions that are
11 both the wiring level or wiring or the
12 interconnects and then the via, which are the
13 contact holes of the underlying -- underlying metal
14 films.

15 Q. Okay. So looking at figure 1J, is it
16 considered a dual relief cavity because of the step
17 between the two portions of the cavity?

18 A. No, it's not necessarily the step. It
19 is that that opening -- this only shows
20 one-dimensional or two-dimensional, one directional
21 view of what the structure would look like. In
22 that opening is contained both the opening for

1 wiring level, which would be filled, and the
2 opening for the via level, which would be filled.
3 So the dual structures are both for wiring and
4 for -- for the via, or the fill via.

5 Q. Okay. So can you point me in Grill to
6 where it shows -- it shows a three-dimensional
7 view?

8 A. Well, the description of how these
9 processes flow, for instance, figure 5A through H,
10 which I describe in detail in my disclosure, the
11 opening for the contact level would be placed in
12 the wiring levels below and above it but only in
13 areas where the contact is made in between it.

14 So there is no figure, there's no depiction
15 of that other direction, but that is what's
16 understood in the description of the processes or
17 one would understand from the description of the
18 processes.

19 Q. Okay. But all of the -- all of the
20 figures in Grill are showing the same
21 two-dimensional cross-section; is that correct?

22 MR. JIRON: Objection. Form.

1 THE WITNESS: So even as we read the
2 background of the invention, one reading this
3 patent would know that the multilevel structures or
4 the metal wiring layers are connected with
5 interconnects which those vias provide the holes
6 through. So understanding what a multilevel
7 interconnect is, what the metal wiring layers do
8 and what those vias -- how those vias provide
9 interconnect, one would know what the particular
10 structures would look like into the page in the
11 other direction.

12 BY MR. ROSSEN:

13 Q. Okay. Looking at the same paragraph of
14 your declaration, 148, you have two additional
15 figures: Figures 5G and 5H; is that correct?

16 A. That's right, from the Grill patent.

17 Q. Okay. Looking at 5H, does 5H show a
18 dual relief cavity?

19 A. Well, yes, it shows a dual relief
20 cavity, but additional processing is carried out
21 before that cavity is filled, before you move on to
22 the steps that are described in -- or shown in

1 figure 1K, for instance, the cavity filling. In
2 order to provide a -- a completed cavity that would
3 be filled, it would have to make connection to
4 what's labeled in those figures as the conductive
5 via at the bottom underlying metal labeled as 4.

6 Q. Okay. But it does show -- sorry, I'm
7 just trying to make sure I understand it. It does
8 show a dual relief cavity or no?

9 A. In 5H?

10 Q. In 5H.

11 A. Yes, the dual relief cavity is shown in
12 5H. I'm just going to go back to the description
13 of 5H. And it says in column 8, I'm looking at
14 around line 5: The cavity structure may then be
15 completed as shown in figure 1J. So it's a cavity
16 structure already. Figure 5H leads into 1J or
17 structures similar to 1J as required based on what
18 films -- what layers actually remain in 5H in order
19 to follow ahead with 1K, which is the filling
20 process. But 5H is called in the application, is
21 already called the cavity structure.

22 Q. And it's a dual cavity structure; is

1 that correct?

2 A. Dual meaning that it's got -- it's got
3 patterns defined for the via level and the wiring
4 level. Those are the -- those are the -- that is
5 what the dual refers to.

6 Q. Okay. Looking at your declaration in
7 paragraph 144 --

8 A. Same declaration?

9 Q. Yes, same declaration.

10 A. Okay.

11 Q. That paragraph contains a quote from
12 Grill, correct?

13 A. That's right. And I've said Grill at
14 abstract, and if I'm not mistaken, it's also -- it
15 is -- that quote was taken out of the abstract,
16 that's correct.

17 Q. Okay. And this -- the dual relief
18 cavity mentioned in this quote is the -- is the
19 dual relief cavity the same concept as dual relief
20 cavity that we've been talking about?

21 A. Well, this quote talks about the dual
22 damascene but, yes, that dual damascene means a

1 relief pattern that defines the two structures, and
2 these are what Grill refers to as the via level and
3 the wiring level. They're referred to by slightly
4 different names in the '696, but those are the
5 same -- the same levels, the via or also called the
6 contact hole in the wiring.

7 Q. Okay. So let's take a look in your
8 declaration, I believe we were already looking
9 there, but paragraphs 144 to 145.

10 A. Okay.

11 Q. And I believe what you're doing here is
12 walking through the embodiment shown in figure 5 of
13 Grill; is that correct?

14 A. Yeah. As -- yes, as supported in the
15 citations that I show. For instance, 145, I
16 describe figure 5A as detailed in column 7, I
17 believe lines 30 through 44. So that's what's
18 occurring as that structure of 5A is formed, formed
19 and patterned, as shown in figure 5B.

20 Q. Okay. And figures 5A through 5E are
21 embodiments of the -- of what's being described in
22 Grill; is that correct?

1 A. Yes, that's correct.

2 Q. Okay. So looking at figure 5A of
3 Grill --

4 A. Okay.

5 Q. -- is 5A -- would you agree with me
6 that 5A shows the same structure as figure 1B of
7 Grill but with the addition of a lower hard mask
8 layer 56 and upper hard mask 58?

9 A. 5A with 1C or D?

10 Q. 1B.

11 A. Oh, 1B.

12 Q. Yes, B.

13 A. So you're asking me, I'm sorry, again,
14 5A and compare that to 1B, right?

15 Q. Yes.

16 A. Okay. So what is not in 1B are the
17 dual hard masks of figure 5A which are labeled as
18 56, the lower hard mask layer, and 58, the upper
19 hard mask layer.

20 Q. Okay.

21 A. Did I answer your question?

22 Q. Yes. And these figures, for example,

1 figure A, but these figures in figures 5 -- 5A
2 through 5E, are the layers drawn to scale?

3 A. Well, if we look through some of the
4 descriptions, as far as I recall, there are some
5 thicknesses of some layers. For instance, if we
6 look at the description of -- if I look at column
7 8, line 31, and the description figure 6-A, this
8 happens to tell me that 68 may be formed from a
9 50-nanometer thickness of silicon dioxide, and the
10 upper hard mask layer may be formed from a
11 40-nanometer thickness of silicon nitride. That's
12 68 and 70.

13 But to interpret the scale of the figures
14 themselves, there's not a lot of meaning that you
15 would be able to take away from that regarding
16 particular layer of thicknesses. There might be
17 other references to some thicknesses throughout the
18 description, but not all of them.

19 Q. Okay. So just to clarify, the
20 thicknesses you were reading about were in figure
21 6A; is that correct?

22 A. That's correct, where the hard

1 layers -- the hard mask layers 56 and 58 are
2 referred to as 68 and 70. So they are different
3 layers, but they are hard mask layers.

4 Q. Okay. But you don't take any meaning
5 from the relative sizes of the layers in figures 5A
6 or 5E?

7 A. Simply the way -- as they're drawn?

8 Q. Well, as they're drawn in the context
9 of the Grill patent.

10 A. Sure, I don't take any meaning to the
11 dimensions that are drawn in those figures to
12 imply -- necessarily imply thicknesses.

13 Q. So take figure C, for example. You
14 don't -- you don't think that there's any meaning
15 to the fact that layer 7 is drawn as thinner than
16 layer 12?

17 A. Well, some of these layers, and I think
18 you point out layer 7 as a good example, one with
19 skill would know that that is an optional, as it's
20 described in the top of column 4, an optional
21 dielectric passivation layer. That would be a
22 layer that would not need to be thick. It would be

1 a thin layer. Although, its comparative thickness
2 related to other layers, even seeing that it is
3 drawn thinner than some others, it still doesn't --
4 is not an indication of what the thickness might
5 be.

6 Q. Okay. So from -- from the relative
7 sizes of thicknesses of the layers in the drawing,
8 you can't make any -- you don't draw any
9 conclusions from that?

10 MR. JIRON: Objection. Form.

11 THE WITNESS: Well, that's a bit of a
12 different question, because I asked you before just
13 with regard to the figures alone, and you asked me
14 in terms of the context -- I think you asked me in
15 terms of the context of the Grill patent, and in
16 terms of the context of the Grill patent one would
17 know what several of these layers would need to be
18 in terms of their thickness range to carry out
19 their function.

20 But based just on those figures and those
21 figures alone, those don't tell me what those
22 thicknesses are.

1 BY MR. ROSSEN:

2 Q. Okay. So looking now at figure 5B,
3 what -- what is 5B depicting, going from 5A to 5B?
4 What -- what process is this depicting?

5 A. So 5A shows all the materials that
6 we've talked about. I think I've mentioned them
7 all already, from the semiconductor phase up to --
8 which is labeled as 2, up to the upper hard mask
9 layer 58.

10 And, again, looking at a figure, one using
11 the figure alone wouldn't necessarily know what
12 those thicknesses are but would know based on what
13 those materials are, for instance, the wiring level
14 dielectric and the via level dielectric and so
15 forth.

16 Moving from 5A to 5B, that is the step
17 that's described in the patent. In column 7 where
18 starting on line 40, the first resist layer 60, a
19 first resist layer 60 patterned with a first wiring
20 level pattern is formed on layer 58 to form the
21 structure of figure 5B.

22 Q. Okay. So moving to figure 5C, does --

1 do you agree that 5C shows the structure figure 5B
2 after etching of the upper hard mask layer 58?

3 A. And it describes -- yes, and it
4 describes -- the patent describes this around line
5 44 or 45. It says: The pattern of resist layer 60
6 is then transferred into upper hard mask layer 58
7 by an etching process to form the structure figure
8 5C.

9 Q. Okay. And so moving on to figure 5D,
10 figure 5D shows the structure of figure 5C after
11 patterned layer 62 is deposited; is that correct?

12 A. Yes. And layer 62, as the patent
13 describes in column 7, line 51, is patterned with a
14 second via level pattern, and that is -- follows
15 the resist layer 60 which has been removed, and we
16 see the result in figure 5D.

17 Q. Okay. So for figure 5E, figure 5E is
18 the structure of figure 5D after etching the lower
19 hard mask layer 56; is that correct?

20 A. That's correct.

21 Q. Okay. And then figure 5E, is that --
22 does that show a dual relief cavity?

1 A. Well, figure 5E has the portion of the
2 hard mask layer 56 patterned for the contact hole
3 using resist layer 62 to define the area that is
4 opened with etching.

5 There are two -- two structural areas
6 defined in figure 5E where the wiring grid
7 structures are defined in layer 58 that we saw in
8 the patterning steps 5B and C, and the vias, or the
9 contact holes, those are defined in the second
10 photoresist 62 and then the openings in 56, but
11 there is not a dual relief structure yet in that --
12 in that figure because the only opening is -- the
13 only opening that is truly opened is that between
14 photoresist layer -- second photoresist layer 62
15 and 56.

16 Q. Okay. So does figure 5E illustrate a
17 dual patterned hard mask?

18 A. Does -- can you say that again?

19 Q. Does figure 5E illustrate a dual
20 patterned hard mask?

21 A. I'm not too sure where -- how you're
22 defining a dual patterned hard mask. Can you refer

1 me to where there is reference to that?

2 Q. Sure. Let's look at column 7, line 58,
3 of the Grill reference.

4 A. Okay. So it says figure 5E shows the
5 completed dual patterned hard mask comprising the
6 patterned hard mask layers 56 and 58. So the dual
7 patterned -- completed dual patterned hard mask is
8 the pattern in 56 and 58. That's the dual pattern
9 in a hard mask.

10 Q. Okay. And what -- what does that mean?

11 A. Well, as the patent describes, 56 and
12 58 is a dual hard mask, and figures 5A is a lower
13 hard mask 56 and an upper hard mask 58. That
14 comprises the dual hard mask.

15 Once they are patterned as completed in 5E,
16 those dual hard masks are patterned and become dual
17 patterned hard -- becomes a completed dual
18 patterned hard mask. And it says comprising the
19 patterned hard mask 56 and 58, so I think it's
20 clear from that sentence what that means.

21 Q. Okay. So in the embodiments shown here
22 in figure 5A through E, does Grill teach etching

1 the lower hard mask 56 with the upper hard mask 58?

2 A. It says -- the patent says at line 57:
3 The pattern of resist layer 62 is then transferred
4 into lower hard mask 56. The mask -- the resist
5 layer is the mask that defines what is etched into
6 layer 56, so what's used to -- what's used as a
7 mask to -- after the pattern 56 is resist layer 62.

8 Q. And not layer 58; is that correct?

9 A. As shown in figure 5E and described in
10 the description column 7, it is -- photoresist
11 layer 62 is used to pattern or mask the etching of
12 layer 56.

13 Q. Okay. And hard mask layer 58 is etched
14 using what layer?

15 A. It was etched in figure 5B, first
16 photoresist layer 60.

17 Q. Just to clarify, it was etched by
18 photoresist layer 60?

19 A. You asked me what layer 56 was -- or,
20 I'm sorry, what layer -- how layer 58 was
21 patterned, how layer 58 was etched? It was etched
22 in step 5B using photoresist layer 60.

1 Q. Okay. Okay. Looking at figure 5F now,
2 do you agree that figure 5F shows the structure of
3 figure 5E after etching lower layer 12?

4 A. It's -- the patent says, line 62, that
5 the via level pattern is then transferred into
6 dielectric 12 by an etching process such as
7 reactive-ion etching to produce the structure --
8 such as reactive-ion etching to produce the
9 structure of figure 5F.

10 In this case photoresist layer 62 would be
11 used to pattern the dielectric layer 12, and the
12 patent goes on to describe that the patterned
13 second resist layer 62 is absent from 5F because it
14 is typically removed by the etching process used to
15 pattern dielectric 12.

16 So what this means is after dielectric
17 pattern -- dielectric layer 12 is patterned, the
18 process is set up such that layer 62, that second
19 photoresist, is removed. If it's not removed as
20 the end point is reached for pattern dielectric 12,
21 the process would continue on until all the
22 photoresist would be gone.

1 Q. Okay. And does figure 5F illustrate a
2 dual relief cavity?

3 A. There are -- there is a dual patterned
4 hard mask, as we've talked about before, 56 and 58,
5 but if you're asking me -- I think you asked me if
6 5F shows a dual -- a dual relief cavity like in
7 figure 1J, figure 1J shows that layers that
8 correspond -- layers corresponding to what will be
9 wiring level, for instance, 12, are not yet wiring
10 level, and areas that would correspond to contact,
11 the contact level, for example, which would include
12 structures defined underneath the wiring level,
13 aren't patterned either.

14 So at this point 5F is not yet the dual
15 relief cavity.

16 Q. Okay. And so figure 5G, do you agree
17 that figure 5G shows the structure of figure 5F
18 after etching layers 56 and layer 10?

19 A. That's correct. 56 has been etched,
20 and layer 10 has been etched, and the process is
21 described at the top of column 8 of the patent.

22 MR. ROSSEN: This might be a good time to

1 take a break for lunch. It's a little after 12:30.

2 MR. JIRON: Okay.

3 (A luncheon recess was taken at 12:34 p.m.)

4 BY MR. ROSSEN:

5 Q. Dr. Smith, in paragraph 151 of the 1376
6 declaration, your declaration, towards the end you
7 say that a person of ordinary skill in the art
8 would have understood that etching etch-stop layer
9 10 with the conductive via exposed could damage the
10 underlying conductive via.

11 So just to make sure that I'm clear, etching
12 with the via exposed could damage the via; is that
13 correct?

14 A. Sure. If you give me just a minute to
15 read paragraph 151 to kind of find just where we
16 are in the process.

17 So as I say in the beginning of paragraph
18 151, in the embodiment that I've described in the
19 previous paragraphs, if layer 7 is, as it's stated,
20 an optional layer and not used, there's no reason
21 to open up the -- the via hole any further than the
22 via level dielectric 8 because 7 isn't present.

1 There's also no need to remove layer 10 for
2 reasons I've stated. If -- if it's thin, it
3 doesn't impart any harm to the interlevel
4 dielectric layer 8 and, furthermore, in the
5 sentence you're pointing to, one would know not to
6 carry on any etch process that isn't necessary when
7 a metal film like that in what's labeled as 4, the
8 conductive via, is exposed to that etching
9 environment, because it can be damaged with an etch
10 process.

11 So what I say there, a person of ordinary
12 skill would know it was preferable not to form the
13 etch of figure 1J, which means not to remove that
14 area of layer 10, just to remove layer 10 if 7
15 isn't there, if it's not used as an optional layer.

16 Q. Okay. And just -- just so that I make
17 sure I understand, one of the reasons for that is
18 that etching with the exposed via could damage
19 the -- damage it, right?

20 A. It might damage it, and it would be a
21 reason not to do it, is to prevent any possible
22 damage to that exposed surface of that underlying

1 via.

2 Q. Okay.

3 (Discussion off the record.)

4 BY MR. ROSSEN:

5 Q. Okay. So do you agree that Grill, the
6 process disclosing Grill, describes using two hard
7 masks?

8 MR. JIRON: Objection. Form.

9 THE WITNESS: There are processes in Grill,
10 like we've talked about those described in figure
11 5, that use hard mask layers 56 and 58 which are
12 two hard masks.

13 MR. ROSSEN: Okay. I'm going to go ahead and
14 give you Aoyama and ask the court reporter to mark
15 this Deposition Exhibit 8.

16 The following was marked for Identification:

17 SMITH EXH. 8 United States Patent No.

18 5,592,024

19 BY MR. ROSSEN:

20 Q. Do you recognize this document?

21 A. I do, yes.

22 Q. If we look at figure 18A through 18C.

1 A. Okay.

2 Q. Is Aoyama teaching the use of a dual
3 hard mask?

4 A. Well, there are a lot of things that
5 Aoyama teaches, and Aoyama teaches methods of a
6 dual damascene process, primarily ways to avoid a
7 common problem addressed not only in Aoyama but
8 in -- in Grill, also, and that is to avoid
9 misalignment errors or to account for or correct
10 for misalignment errors. The way that Aoyama --
11 Aoyama does it is through shaping of a -- of a
12 contact hole. I can spend a little time
13 identifying a number of hard mask layers that are
14 used in Aoyama, but let me know if you'd like me to
15 do that.

16 Q. Just -- I'm not sure that I quite
17 understand. Are you saying that you're not sure
18 how many hard masks Aoyama teaches to use and you'd
19 need to study Aoyama to find out, or what -- what
20 are you saying?

21 A. No. I'm -- I guess I would like you to
22 clarify the question when you asked if it teaches

1 using I think dual hard masks. Aoyama teaches the
2 use of hard masks, and it teaches the use of more
3 than one instance of a hard mask.

4 Q. Okay.

5 A. Do you want me to limit my analysis
6 just to figures 18 through -- just starting at
7 figure 18?

8 Q. Well, let's start with figure 18.

9 A. Okay. Okay. So what's the question?

10 Q. Does the embodiment of Aoyama in figure
11 18 involve a dual hard mask?

12 A. Figure 18 is the -- at example 7,
13 figure 7 -- I'm sorry, figure 18A, B, and C include
14 in this example 7 what's referred to as etch
15 stopper films, and column 15 of Aoyama, you see
16 starting around line 55 a first etch stopper film
17 43 and a second stopper film 45. Those could be
18 considered hard mask layers.

19 With regards to you asked me about a dual
20 hard mask, they are different than the hard mask
21 layers used in the Grill patent.

22 Q. Okay. If you were going to use the

1 dual hard mask that we talked about with regard to
2 the embodiment of the figure 5 of Grill but in
3 Aoyama's example 7, which is the one I believe you
4 said was -- had to do with figures 18A through 18C,
5 would that involve more process steps to implement
6 than the current Aoyama system?

7 MR. JIRON: Objection. Form.

8 THE WITNESS: Well, it's a different thing.
9 The Aoyama approach that I've referenced in my
10 declaration is a -- an approach to address issues
11 of misalignment, as is Grill. One doesn't conflict
12 with the other. As a matter of fact, they can be
13 used together quite nicely, but if you were to take
14 figure 18 of Aoyama, the example 7, and add to
15 that, as I think you might have asked me in your
16 question, two more layers, 58 -- like 58 and 56 of
17 Grill, that would involve the additional process
18 steps of adding those layers.

19 And let me explain that further, that 45
20 is -- the etch stopper film 45 underneath the
21 photoresist layer 47 could be one of those hard
22 mask layers to begin with.

1 BY MR. ROSSEN:

2 Q. So 45 would be one of the dual hard
3 mask layers in this -- if we were to use a dual
4 hard mask layer such as described in Grill and
5 Aoyama's embodiment here?

6 A. Well, it acts as a hard mask. It's a
7 single hard mask layer in that there's not another
8 one above it or below it. If we've used 45 as part
9 of a dual hard mask, then there would be the
10 requirement of putting a layer either above it or
11 below it.

12 Q. And that would lead to additional
13 process steps?

14 A. If you add the additional layers, it
15 would be additional process steps, that's correct.

16 Q. Okay. Let's turn to figures 5A through
17 5D, if you don't mind.

18 A. Okay. I think I'm already -- in Grill
19 or Aoyama?

20 Q. In Aoyama.

21 A. Okay.

22 Q. Do you agree that the pattern of layer

1 224 in figure 5B corresponds to the through-hole in
2 figure 5D?

3 A. Well, figure 5D is labeled as -- the
4 contact hole is 225 and the wiring line is 223.
5 That doesn't answer your question?

6 Q. I guess I just want to -- want to get
7 your opinion on the -- the pattern of layer 224 and
8 5B.

9 A. Okay. So what is 224?

10 Q. Yes.

11 A. So if we look at column 3 around lines
12 17 or 18, it tells us that in figure 5B there is a
13 resist pattern 224 for forming the through-hole.
14 It is a through-hole in the resist -- in the resist
15 layer.

16 Q. And that's the same through-hole
17 depicted in figure 5D?

18 A. No, because that's the photoresist in
19 figure 5B. There's no photoresist as you get to
20 5C. So it says on line 22-ish: With a resist
21 pattern 224 used as a mask, the first insulating
22 film 221 is etched to form a through-hole 225.

1 So 225, as we see in 2C, is a resulting hole
2 in layer 221, the first interlayer insulating film
3 as a result of the -- as a result of the
4 photoresist opening -- or the opening in the
5 photoresist for the contact hole 224.

6 In 5C, there's no photoresist remaining. It
7 is 222, the second interlayer insulating film, and
8 221, the first interlayer insulating film. And
9 that is depicted in 5D. So there is no 224 in 5C
10 or D.

11 Q. Okay. So in 5B, if you were to widen
12 the pattern of layer 224, how would that affect the
13 result of figure 5D?

14 A. That would -- with the photoresist
15 still gone in 5B and -- I'm sorry, 5C and D,
16 widening the opening in 224 in that photoresist
17 layer would allow layer 221 to be patterned with a
18 contact hole that extends from at least -- well, it
19 extends as far as you have widened the 224
20 photoresist pattern.

21 Q. So you'd end up with a wider contact
22 hole; is that correct?

1 A. You would wind up -- in the example
2 being -- this figure addresses the problem as the
3 solution is described in later embodiments, like
4 figure 18, yes, you would wind up with a wider
5 contact by doing this.

6 Q. Okay. So turning back to figure 18 of
7 Aoyama.

8 A. Okay.

9 Q. I believe we already -- we already
10 mentioned it a little bit, but can you tell me what
11 your understanding of layer 45 is?

12 A. Sure. 45 is described in column 15 of
13 the patent. It's called at line 60, second
14 interlayer film -- I'm sorry, it says a second
15 interlayer film 44 and a second stopper film 45
16 made of carbon and functioning as an etch stopper
17 at the time of etching a wiring material.

18 So it is an etch stopper made of carbon that
19 functions as an etch stopper when doing the wiring
20 etch.

21 Q. Okay. So looking at figure 18B, does
22 this figure show layers 47 after exposure and

1 development?

2 A. This is the second -- 47 is the second
3 resist layer. This is described in column 17
4 around line 3 where it says: In the next step as
5 shown in 18B, the resist pattern 46 is removed, so
6 it's no longer there, and the resist pattern 47
7 forming a through-hole widening the wiring is
8 provided. That is the through-hole that's been
9 exposed and developed with a width that is wider,
10 as it states, than the wiring.

11 Q. And figure 18B is showing layer 47
12 after it's been exposure and developed?

13 A. That's correct.

14 Q. So if we were to have a drawing of 47
15 before exposure and development, what would it look
16 like?

17 A. 45, layer 45, that second stopper film,
18 has already been patterned in figure 18A. Layer
19 44, which is the second interlayer insulating film,
20 has also been patterned. Coating photoresist 47
21 over that would conform to the topography, and that
22 would be created by layers 44 and 45 as they -- as

1 they are -- as they exist over the layer 43, which
2 is the first stopper film.

3 So it would be a somewhat conformal film
4 over that stack underneath.

5 Q. Okay. But specifically talking about
6 layer 47, what -- before exposure and development,
7 what would it look like?

8 A. Yeah, that's what I'm saying. It would
9 be conformal to the topography of layers 44 and 45.

10 Q. Can you explain what you mean by that?

11 A. Well, if it was coated to a thickness
12 as depicted in that figure, although I can't really
13 say what that thickness necessarily is, it would be
14 a similar thickness outside of that hole as inside
15 of that hole with some degree of planarization
16 towards the top. It would fill in that hole to
17 some extent but also be somewhat conformal.

18 So I would say 47 coated thick enough would
19 lead to some planarizing of that hole to some
20 degree of conformity.

21 Q. Okay. And to be clear, that would mean
22 that layer 47 would -- would be thicker over the --

1 the hole than it would be elsewhere; is that
2 correct?

3 A. It could very well be, yes.

4 MR. ROSSEN: Okay. Okay. I'm going to
5 introduce another exhibit, and I'll ask the court
6 reporter to name this Smith Deposition Exhibit 9.

7 The following was marked for Identification:

8 SMITH EXH. 9 Chapter 11 from textbook titled
9 Microlithography: Science
10 and Technology

11 BY MR. ROSSEN:

12 Q. Do you recognize this document?

13 A. Yes. This is another chapter out of
14 the textbook we talked about this morning. This is
15 Chapter 11, a chapter that I authored on resist
16 processing.

17 Q. Okay. Let's turn to page 605.

18 A. Okay.

19 Q. Okay. Can you read the last sentence
20 on page 605. It actually goes over to page 606.

21 A. It starts with "for instance"?

22 Q. Actually -- actually, why don't you

1 start with the sentence -- hold on. Yes, sorry,
2 it's the last two sentences.

3 A. Okay. It says: Together with
4 tolerance limits on CD, resulting usable depth of
5 focus, UDOF, can be determined. For instance, for
6 a plus or minus 10 percent exposure latitude
7 requirement and a plus or minus 10 percent
8 specification on CD, the optimum exposure from
9 figure 11.11 is 240 millijoules per square
10 centimeter, and the UDOF is near 1.8 microns.

11 Q. Okay. And let's take a look at page
12 607.

13 A. Okay.

14 Q. Can you also read the first sentence on
15 page 607.

16 A. Sure. If the resulting k2 does not
17 correspond to UDOF values large enough for device
18 topography, techniques of planarization may be
19 required.

20 Next sentence, also?

21 Q. No, that's -- that's fine.

22 A. Okay.

1 Q. So based on these two quotes, what
2 you've written here, is it your understanding that
3 a large change of photoresist step height is
4 undesirable?

5 A. No, that's not really what this is all
6 about. This is about optimizing exposure dose and
7 requirement on things like exposure latitude to
8 reach a given specification on CD, or critical
9 dimension, given a -- given certain process
10 conditions which would lead to what's referred to
11 as a usable depth of focus. That usable depth of
12 focus, that UDOF, should be sufficient to account
13 for the device topography that I've referred to on
14 the top of page 607.

15 Q. So are you saying it is desirable to
16 have a large change in photoresist step height?

17 A. No, I didn't say that. I said given
18 what your photoresist requirements are, you
19 optimize your exposure dose and your exposure
20 latitude to reach a required usable depth of focus.
21 This has really nothing to do with what you're
22 having me look at in figure 18B. Figure 18B is a

1 single opening that would be filled with
2 photoresist. The edges of that photoresist feature
3 are defined as we see in figure 18B.

4 The -- the width of that photoresist
5 feature, since it is larger than the topography
6 that it is coated over, would be -- would be
7 very -- influenced very little by in this case that
8 topography underneath, that photoresist feature
9 being wider than the opening below it.

10 It's not the kind of topography that is
11 being addressed in this sentence, in these excerpts
12 you had me take a look at. This is topography
13 which is, as I said later on in that excerpt,
14 topography across an entire field which might be
15 multiple layers of material that would then go
16 through something like a chemical-mechanical
17 polishing, a CMP, to reduce -- reduce topography.

18 MR. ROSSEN: Would it be okay if we take
19 another break now?

20 MR. JIRON: Okay.

21 (A recess was then taken.)

22 MR. ROSSEN: I have no further questions.

1 THE WITNESS: Okay.

2 (Discussion off the record.)

3 MR. ROSSEN: I would like a rough as soon as
4 available, three-day expedited, and realtime, which
5 we already used.

6 MR. JIRON: And we will take the same thing.

7 (Deposition concluded at 3:14 p.m.)

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1 I, JOAN M. METZGER-HUBBELL Certified
2 Reporter and Notary Public within the State of New
3 York do hereby certify:

4 That BRUCE SMITH, the witness whose
5 deposition is hereinbefore set forth, was duly
6 sworn by me before the commencement of such
7 deposition and that such deposition was taken
8 before me and is a true record of the testimony
9 given by such witness.

10 I further certify that the adverse party was
11 represented by counsel at the deposition.

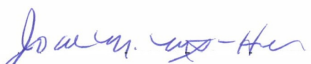
12 I further certify that the deposition of
13 BRUCE SMITH occurred at the Hilton Garden Inn
14 Rochester, 30 Celebration Drive, Rochester, New
15 York, on Thursday, March 23, 2017, commencing at
16 9:05 a.m. to 3:14 p.m.

17 I further certify that I am not related to
18 any of the parties to this action by blood or
19 marriage, I am not employed by or an attorney to
20 any of the parties to this action, and that I am in
21 no way interested, financially or otherwise, in the
22 outcome of this matter.

1 IN WITNESS WHEREOF, I have hereunto set my hand
2 this _____ day of _____, 2017.

3 My commission expires:

4 _____

5 
6 NOTARY PUBLIC IN AND FOR THE
7 STATE OF NEW YORK

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