

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2 BEFORE THE PATENT TRIAL AND APPEAL BOARD

3 Case IPR2015-00466 Patent 6,030,893

4 Case IPR2015-00467 Patent 6,030,893

5 -----X

6 SAMSUNG ELECTRONICS CO. LTD.,

7 SAMSUNG ELECTRONICS AMERICA, INC., Volume 2 of 2

8 SAMSUNG SEMICONDUCTOR INC., and

9 SAMSUNG AUSTIN SEMICONDUCTOR LLC

10 Petitioner,

11 vs

12 HOME SEMICONDUCTOR CORPORATION

13 Patent Owner.

14 -----X

15
16 VIDEOTAPED DEPOSITION OF GARY W. RUBLOFF, PH.D.

17
18 Washington, DC 20005

19 Thursday, December 17, 2015

20
21
22 By: Denise D. Vickery, RMR, CRR Job No. J0254991

Thursday, December 17, 2015

9:04 a.m.

VIDEOTAPED DEPOSITION OF GARY W. RUBLOFF, PH.D.,
held at the offices of:

FISH & RICHARDSON PC
1425 K Street NW, 11th Floor
Washington, DC 20005

Pursuant to notice, before Denise D. Vickery,
Registered Merit Reporter, Certified Realtime
Reporter, and Notary Public in and for the District
of Columbia.

A P P E A R A N C E S

For the Petitioner and the Witness:

FISH & RICHARDSON PC

1425 K Street NW, 11th Floor

Washington, DC 20005

202.783.5070

BY: JOSEPH V. COLAIANNI, ESQ.

colaianni@fr.com

BY: ANDY I. HSIEH, PH.D., ESQ.

ahsieh@fr.com

For the Patent Owner:

TECHKNOWLEDGE LAW GROUP LLP

100 Marine Parkway, Suite 200

Redwood Shores, CA 94065

650.517.5200

BY: JERRY CHEN, ESQ.

jchen@tklg-llp.com

Also Present: James McGrath, Videographer

I N D E X

EXAMINATION OF GARY W. RUBLOFF, PH.D.	PAGE
By Mr. Chen on IPR2015-00466	225
By Mr. Chen on IPR2015-00467	285

E X H I B I T S

RUBLOFF

EXHIBIT	DESCRIPTION	PAGE
No. 9	Declaration of Dr. Gary W. IPR2015-00466 U.S. Patent No. 6,030,893 Samsung 1019	228
No. 10	U.S. Patent No. 5,843,840 Miyazaki et al., Samsung 1005	231
No. 11	Modeling and Optimization of the Step Coverage of Tungsten LPCVD in Trenches and Contact Holes IPR2015-00466, Samsung 1022	288
No. 12	Declaration of Dr. Gary W. Rubloff IPR2015-00467 U.S. Patent No. 6,030,893 Samsung 1019	290

EXHIBIT	DESCRIPTION	PAGE
No. 13	U.S. Patent No. 5,043,299	301

Chang et al.

IPR2015-00467, Samsung 1023

No. 14	U.S. Patent No. 5,407,698
--------	---------------------------

Emesh, Samsung 1009

7

8

- EXHIBITS REFERENCED -

(Previously marked)

EXHIBIT	REFERENCED
---------	------------

No. 1	Deposition Testimony of Gary W.
-------	---------------------------------

Rubloff, Ph.D., August 18, 2015

No. 2	Deposition Testimony of Gary W.
-------	---------------------------------

Rubloff, Ph.D., August 19, 2015

16

17

18

19

20

(Exhibits attached to transcript.)

22

P R O C E E D I N G S

- - -

THE VIDEOGRAPHER: Here begins
Volume 1 disk 1 in the video deposition of Gary
Rubloff taken in the matter of Samsung Electronics
CO., LTD., Samsung Electronics America, Inc.,
Samsung Semiconductor Inc., and Samsung Austin
Semiconductor LLC versus Home Semiconductor
Corporation, in the United States Patent and
Trademark Office before the Patent Trial and Appeal
Board, Case No. IPR 2015-00466.

Today's date is December 17, 2015.
The time on the video monitor is 9:04. The
deposition is being held at Fish & Richardson, Suite
1100, 1425 K Street, Northwest, Washington, DC
20005.

The court reporter is Denise
Vickery on behalf of Esquire Deposition Solutions.
The video camera operator is James McGrath on behalf
of Esquire.

Will counsel please introduce
themselves and who they represent.

1 MR. CHEN: Jerry Chen from
2 TechKnowledge Law Group representing Home
3 Semiconductor Corporation.

4 MR. COLAIANNI: Joseph Colaianni
5 of Fish & Richardson representing the Samsung
6 Petitioners.

7 MR. HSIEH: Andy Hsieh of Fish &
8 Richardson representing Samsung Petitioners.

9 THE VIDEOGRAPHER: Will the court
10 reporter please swear in the witness.

11 - - -

12 GARY W. RUBLOFF, PH.D.
13 called for examination, and, after having been duly
14 sworn, was examined and testified as follows:

15 THE VIDEOGRAPHER: Counsel may
16 proceed.

17 CROSS-EXAMINATION

18 BY MR. CHEN:

19 Q. Good morning, Dr. Rubloff.

20 A. Good morning.

21 Q. Today I will be cross-examining you
22 regarding your reply declaration submitted in

1 connection with the IPR filed by Samsung, IPR No.
2 2015-00466. I'll ask you questions related to the
3 subject matter discussed in your reply declaration.

4 You understand?

5 A. Yes.

6 Q. You will need to answer my questions
7 truthfully and completely. The court reporter will
8 record my questions and your answers in writing. As
9 explained, if your attorney objects, you must still
10 answer all my questions, unless he instructs you not
11 to answer.

12 Do you understand?

13 A. Yes.

14 Q. If you do not hear or understand my
15 questions, please ask -- please ask me to repeat or
16 clarify. If you answer my questions, my assumption
17 will be that you understood the questions.

18 You understand?

19 A. I understand.

20 Q. And, of course, if you need a break,
21 please let me know and we will take one.

22 Can you think of any reason that might

1 affect your ability to provide truthful and complete
2 answers to my questions today?

3 A. Only if I don't know the answer.

4 Q. Okay. Do you have any questions before
5 we begin?

6 A. No.

7 Q. Okay. Now, Dr. Rubloff, you recall
8 that you were previously deposed in this matter back
9 in, I believe, August of this year; correct?

10 A. Yes.

11 Q. And in that prior deposition, I also
12 asked you to let me know if you did not understand
13 any of my questions; correct?

14 A. Yes.

15 Q. And I told you that if you did not
16 understand my questions, you could ask me to repeat
17 or clarify; correct?

18 A. Yes.

19 Q. And I told you that if you answered my
20 questions, my assumption would be that you
21 understood my questions; correct?

22 A. I think you said the same things you're

1 saying now.

2 Q. Yes. And barring any circumstances
3 where you asked me to repeat or clarify a question,
4 you understood my questions; correct?

5 A. Yes, I think so.

6 Q. And you were truthful in that prior
7 deposition?

8 A. Yes.

9 Q. And you gave complete answers to my
10 questions?

11 A. As best I could.

12 Q. And you stand by the answers you
13 provide in that prior deposition; correct?

14 A. Yes.

15 MR. CHEN: Which exhibit?

16 THE REPORTER: 9.

17 (Document marked, for
18 identification purposes, as Rubloff Exhibit No. 9.)

19 BY MR. CHEN:

20 Q. Dr. Rubloff, I've asked the court
21 reporter to mark as Exhibit No. 9 your reply
22 declaration submitted in the -- in connection with

1 Samsung's IPR No. 466.

2 You have that now in front of you;
3 correct?

4 A. Yes.

5 Q. Did you draft this declaration?

6 A. Yes.

7 Q. Are you aware of any errors in this
8 declaration?

9 A. You know, in reviewing materials, in
10 one of the two we'll discuss today, I found a
11 typo --

12 Q. Okay.

13 A. -- about it's supposed to be
14 "deposition" and it said "disposition."

15 Q. Okay.

16 A. But I don't remember which one it was.

17 Q. Okay. All right. If we come across
18 it --

19 A. That's the only one.

20 Q. -- you can point it out.

21 A. Yeah.

22 Q. And we'll make note of that.

1 Other than that typo, are you aware of
2 any other errors in this declaration?

3 A. No, not now certainly.

4 Q. Okay. And are there any other
5 corrections that you would like to make to this
6 declaration?

7 A. No.

8 Q. How did you arrive at the opinions in
9 this declaration?

10 A. So I -- I studied the deposition of
11 Mr. Maltiel and I reviewed my previous declaration,
12 and I reviewed the primary sources, which would be
13 the '893 patent at hand and in this case the
14 Miyazaki patent, and probably some of the other
15 sources that I used to form my opinions in my
16 original declaration. I don't recall which ones.

17 Q. Did you arrive at the conclusions in
18 this declaration based on your own analysis?

19 A. Yes.

20 Q. This was not attorney analysis;
21 correct?

22 A. No. No. This is my declaration.

1 MR. CHEN: Okay. 10.

2 (Document marked, for
3 identification purposes, as Rubloff Exhibit No. 10.)

4 BY MR. CHEN:

5 Q. Dr. Rubloff, I've asked the court
6 reporter to mark as Exhibit No. 10 U.S. Patent No.
7 5,843,840.

8 This is the Miyazaki reference that you
9 had just mentioned in your prior answer; correct?

10 A. Yes.

11 Q. All right. And you reviewed this
12 reference --

13 A. Certainly.

14 Q. -- in --

15 A. I'm sorry.

16 Q. -- preparing your declarations?

17 A. Yes.

18 Q. Could you please turn to column 7 line
19 25 of the Miyazaki reference.

20 Are you there?

21 A. Yes.

22 Q. Okay. And you see that there Miyazaki

1 is about to describe the third embodiment?

2 A. Uh-huh.

3 Q. Correct?

4 A. Yes.

5 Q. And going down to column 7 line 51,

6 Miyazaki is describing the deposition -- CVD

7 deposition of the first tungsten film that will fill

8 the contact hole; correct?

9 A. (Reviewing document). Yes.

10 Q. Okay. And it says there that that

11 first CVD deposition will use tungsten hexafluoride

12 and hydrogen as raw material "under a condition

13 realizing an excellent step coverage"; correct?

14 A. Yes.

15 Q. All right. If you could look -- now

16 move to Miyazaki column 8 line 15.

17 A. Yes.

18 Q. There Miyazaki is about to describe its

19 fourth embodiment; correct?

20 A. That's correct.

21 Q. And at column 8 line 28, Miyazaki again

22 says that the -- well, at column 8 line 28, Miyazaki

1 is describing the CVD deposition of the first
2 tungsten layer to fill the contact hole again;
3 correct?

4 A. Yes.

5 Q. And there it says, much like the third
6 embodiment, that "tungsten film is formed by a
7 chemical vapor deposition using tungsten
8 hexafluoride and hydrogen as a raw material, under a
9 condition realizing an excellent step coverage";
10 correct?

11 A. Yes.

12 Q. And if you go to column 8 line 47,
13 Miyazaki is about to describe the fifth embodiment;
14 correct?

15 A. Yes.

16 Q. And at line -- column 8 line 56,
17 Miyazaki is describing for the fifth embodiment the
18 deposition of the first tungsten layer in the
19 contact hole; correct?

20 A. Correct.

21 Q. And, again, it uses the same language.
22 It says that "the tungsten film is formed by a

1 chemical vapor deposition using tungsten
2 hexafluoride and hydrogen as a raw material, under a
3 condition realizing an excellent step coverage";
4 correct?

5 A. I'm sorry. Which line are you at?

6 Q. I am at column 8 line 56 --

7 A. Oh. Oh.

8 Q. -- through 59.

9 A. Yes.

10 Q. Right.

11 A. Yes, I see it.

12 Q. All right. And then if you go to
13 column 9 line 8, Miyazaki is about to describe the
14 sixth embodiment; correct?

15 A. Yes.

16 Q. And at line 25 of column 9, Miyazaki
17 states that for the sixth embodiment you also want
18 to have a lower level tungsten film that has
19 excellent step coverage; correct?

20 A. Yes.

21 Q. Although it doesn't -- here it doesn't
22 give you the specific parameters for forming that

1 first tungsten layer; correct?

2 A. Correct.

3 Q. All right. So for all of Miyazaki's
4 embodiments 3 through 6, they all use the term
5 "excellent step coverage" to describe the first
6 tungsten layer that is used to fill the hole;
7 correct?

8 A. Yes.

9 Q. Okay. Please turn to column 1 of
10 Miyazaki.
11 Column -- if you look at column 1 line
12 25.

13 A. Okay.

14 Q. This is the portion of Miyazaki where
15 it's describing the Background of the Invention;
16 right? Description of prior art to Miyazaki;
17 correct?

18 A. Yes.

19 Q. Okay. And beginning at column 1 line
20 25, Miyazaki is describing another method of --
21 sorry.

22 Beginning at column 1 line 25, Miyazaki

1 is describing one method of describing a tungsten
2 film; correct?

3 A. Yes, he's referring to prior art.

4 Q. A prior art method?

5 A. Right.

6 Q. And he refers to the prior art method
7 in connection with FIGS. 1A through D; correct?

8 A. Yes.

9 Q. And in discussing this prior art
10 method, Miyazaki is stating that it's possible to
11 form a plug with no void; correct?

12 A. I'm sorry. Which line is this?

13 Q. Well, I think at line -- column 2 line
14 27 to 37, it says:

15 "In the prior art, however, the
16 tungsten film used to form a tungsten plug can fill
17 the fine contact hole with no void."

18 But then it goes on to talk about the
19 high internal stress; correct?

20 A. (Reviewing document). Yes, I see those
21 words. And your question was?

22 Q. Okay.

1 A. Or your point was? I'm sorry.

2 Q. Okay. Let me -- let me just retrace
3 this last step.

4 So the -- what we were just talking
5 about beginning at column 1 line 25 --

6 A. Uh-huh.

7 Q. -- there Miyazaki was describing a
8 prior art method of depositing a tungsten film;
9 correct?

10 A. Yes.

11 Q. And it was describing that prior art
12 method in connection with FIGS. 1A through D;
13 correct?

14 A. Yes.

15 Q. And that prior -- prior art method was
16 the first example of prior art that Miyazaki was
17 describing; correct?

18 A. Yes.

19 Q. Okay. And then if you go to column 2
20 line 21, it says there.

21 In the first example of the prior art
22 as mentioned above, the tungsten film formed by the

1 blanket tungsten CVD is required to fill a fine
2 contact hole having a diameter of not greater than
3 .5 micron without occurrence of the void."

4 Do you see that?

5 A. Yes.

6 Q. Okay. And so there it's saying that
7 that first prior art method was filling a contact
8 hole without a void; correct?

9 A. Yes.

10 Q. And then it goes on to say -- continue
11 to describe that prior art method at column 2 line
12 27.

13 "In the prior art, however, the
14 tungsten film used for forming a tungsten plug can
15 fill the fine contact hole with no void, but has the
16 internal stress of 1×10 to the 10th dyne per
17 centimeter squared or more, so that the wafer has a
18 large bowing."

19 Do you see that?

20 A. Yes.

21 Q. So it's saying that that first prior
22 art method could fill a contact hole without a void,

1 but you would create high internal stress which
2 would create the undesirable effect of wafer bowing;
3 correct?

4 A. Yes.

5 Q. All right. This description of that
6 methodology is in the Background of the Invention of
7 Miyazaki; correct?

8 A. Yes.

9 Q. It was describing prior art to
10 Miyazaki; correct?

11 A. Yes.

12 Q. It was not describing the Miyazaki
13 inventions; correct?

14 A. Yes.

15 Q. All right. The prior art that is
16 void-free is shown in FIGS. 1A through D; correct?
17 Or at least the process for making the void-free
18 layer is shown in FIGS. 1A through D; correct?

19 A. Yes.

20 Q. And that shows a single layer of
21 tungsten; correct?

22 A. That's correct.

1 Q. And not a two layer tungsten film;
2 correct?

3 A. Yep.

4 Q. All right. If you could look at FIGS.
5 2A through 2D.

6 There in FIGS. 2A through 2D, Miyazaki
7 is showing another prior art method of forming a
8 tungsten film; correct?

9 A. Yes.

10 Q. In FIGS. 2A through 2D, Miyazaki shows
11 a tungsten film, but it shows a void in the film
12 that's formed in the contact; correct?

13 A. Yes.

14 Q. And that void is represented by that
15 gap or line down the center of the contact; correct?

16 A. Yes, right in the center of the plug.

17 Q. Right. And the plug is actually closed
18 at the top?

19 A. It's drawn that way.

20 Q. Yeah.

21 A. It appears to be closed.

22 Q. Right. Okay.

1 If you go to Miyazaki, could you please
2 turn to Miyazaki column --

3 A. I'm sorry. Before we jump off that, I
4 just want to glance at the description of the FIG.
5 2.

6 Q. Right.

7 A. Because it's aluminum. I recall that.
8 (Reviewing document). Yes.

9 Q. Okay.

10 A. Okay. Thank you.

11 Q. What were -- did you think that it was
12 an aluminum or is that --

13 A. Well, 2D says "aluminum."

14 Q. Oh. The aluminum is the layer on top?

15 A. Yeah. It's the second layer; right.

16 Q. But the layer in the contact is
17 tungsten; right?

18 A. Yeah, right. I just hadn't
19 remembered --

20 Q. Right.

21 A. -- what this was.

22 Q. Okay. Well, let's look at the

1 description.

2 The description in Miyazaki of FIGS. 2A
3 through 2D begins at column 1 line 65 and extends
4 through column 2 line 20; correct?

5 A. Column 2 line -- okay.

6 Q. All right. FIGS. 2A through 2D show
7 the second example of prior art that Miyazaki
8 describes; correct?

9 A. Yeah, it seems to be.

10 Q. All right. Beginning at column 2 line
11 6, Miyazaki is describing the process used to form
12 the first layer of tungsten that is used to fill the
13 contact hole; correct?

14 A. Yes.

15 Q. That is tungsten film 15 shown in FIG.
16 2B; correct?

17 A. Yes.

18 Q. And Miyazaki states at -- beginning at
19 column 2 line 6 that:

20 "Thereafter, as shown in FIG. 2B, a
21 tungsten film 15 is formed by a chemical vapor
22 deposition using tungsten hexafluoride and hydrogen

1 as a raw material, under a condition realizing an
2 excellent step coverage, namely, a reaction rate
3 controlling condition such as a tungsten
4 hexafluoride flow rate of 50 sccm to 100 sccm and a
5 deposition temperature of 400 to 460 degrees
6 Celsius."

7 Do you see that?

8 A. Yes.

9 Q. Okay. So when Miyazaki is describing
10 the formation of that tungsten film that fills the
11 contact hole, which is shown in FIG. 2B, Miyazaki
12 says that that film is formed "under a condition
13 realizing an excellent step coverage"; correct?

14 A. That's what it says.

15 Q. And so when Miyazaki was using the term
16 having "excellent step coverage," it was describing
17 a contact that still had a void; correct?

18 A. Something is inconsistent here, either
19 the figure or the choice of words. Most likely the
20 figure.

21 There are conditions, I believe, that
22 where one could realize that tungsten flow rate

1 that's given here and the temperature range in which
2 you could have a void because there are a number of
3 parameters that trade off against each other in
4 determining whether there's a void or not.

5 But the most -- the rest of the
6 teaching of Miyazaki and many references that I
7 think I included, some of them at least in my
8 original declaration, make it very clear that under
9 proper reaction rate controlling conditions, there
10 would not be a void.

11 And it's hard for me to imagine that --
12 that the inventor here drew the void in there
13 inconsistent with the description elsewhere in the
14 patent.

15 Q. So --

16 A. But I can't explain the discrepancy.

17 Q. So are you saying that the FIGS. 2A
18 through 2D are erroneous?

19 A. I'm saying that the existence of a void
20 in 2B, C, and D is inconsistent with the teaching of
21 "realizing excellent step coverage" and inconsistent
22 with at least the proper application of a reaction

1 rate controlling condition.

2 Q. But at least as used in Miyazaki, when
3 Miyazaki says here at column 2 beginning at line 6
4 that the tungsten film 15 is deposited "under a
5 condition realizing an excellent step coverage" and
6 showing the deposition in FIG. 2B, Miyazaki is using
7 the term "an excellent step coverage" to refer to a
8 film formed in a contact hole where there is still a
9 void in the contact hole; correct?

10 A. There are two different parts to
11 this -- this discussion and comparison.

12 One is, what would be an excellent step
13 coverage? And people would normally think an
14 excellent step coverage is excellent step coverage
15 would be 90 to 99 percent or something like that.

16 If I look at that figure and if I were
17 to blow it up and measure it, I'd probably conclude
18 the step coverage is excellent, but there's a void
19 there.

20 On the other hand, we know in the
21 patents we're talking about today that removing the
22 void, guaranteeing that there's not a void there is

1 what the goal is, and so this shows a void. So it's
2 really two separate issues.

3 Q. Excellent step coverage --

4 A. I would not have drawn it that way
5 consistent with the teaching of the patent.

6 Q. Excellent step coverage doesn't mean
7 100 percent step coverage; correct?

8 A. Well, it means as close as you can get,
9 but if you do 90 or 95 percent or something like
10 that, in some cases much closer to 100 percent,
11 you'd call that "excellent step coverage."

12 Q. Okay.

13 A. But -- but the reason for step coverage
14 -- a important reason -- I can think of others. The
15 reason for wanting high step coverage is in
16 applications like this to prevent the persistence of
17 voids.

18 Q. Could you turn to Miyazaki column 3
19 line -- well, can you turn to column 3 line 11.

20 There at column 11 to line 15 it says:

21 "Another object of the present
22 invention is to provide a semiconductor device and a

1 method for manufacturing the same, which have a
2 tungsten plug and a tungsten wiring conductor, and
3 which have a minimized wafer bowing and an excellent
4 step coverage."

5 You see that?

6 A. Uh-huh.

7 Q. Is the -- in that paragraph, does
8 Miyazaki say that the objective is to form a
9 void-free contact?

10 A. Well, the words aren't -- of "void-free
11 contact" are not there, but the implication one of
12 ordinary skill in the art would take is when you're
13 talking about excellent step coverage and the
14 application for that is in -- in putting material
15 inside a trench, a hole, a via, that it means no
16 void.

17 People -- people use -- sometimes step
18 coverage can be important for electrical
19 conductivity in a film which goes over a step, and
20 there are ways in which that can matter in -- in
21 creating these three-dimensional profiles.

22 But in the case when you're doing

1 filling like this, you just don't want a void and so
2 these terms are used interchangeably. They imply
3 each other.

4 If I say, I want it void-free, well,
5 you better have good step coverage. Excellent step
6 coverage. If I say, I'm trying to fill this hole,
7 this via, and I've got a process that has excellent
8 step coverage, I've measured it over a regular step.
9 Oh, well, it should fill it fine. You should be
10 able to get it void-free.

11 Q. Is the objective for excellent step
12 coverage to get void-free or simply to minimize the
13 void?

14 A. When I first moved from basic science
15 to silicon technology in my career at IBM, I
16 remember the first time I saw a picture like this,
17 it was an SEM cross-section and there was a void
18 there.

19 And I didn't think too much of it
20 because who was I? I'm just a physicist who never
21 looked at this before, and it was then explained to
22 me how important that is because chemicals get

1 trapped in these voids. It changes mechanical
2 properties. It can cause corrosion, all kinds of
3 things, and so the message was no voids period.

4 So in -- in closing structures as this
5 does, the object has to be to make it void-free as
6 much as possible.

7 Q. As much as possible?

8 A. Yeah.

9 Gee, it only takes a few lines to get
10 the "no void" words in line 30 in column 3.

11 MR. CHEN: 11.

12 (Document marked, for
13 identification purposes, as Rubloff Exhibit No. 11.)

14 MR. COLAIANNI: Thank you.

15 THE WITNESS: Thank you.

16 (Laugh).

17 BY MR. CHEN:

18 Q. Dr. Rubloff, I've asked the court
19 reporter to mark as Exhibit No. 11 a paper titled
20 "Modeling and Optimization of the Step Coverage of
21 Tungsten LPCVD in Trenches and Contact Holes."
22 Authors are A. Hasper, J. Holleman, and J.

1 Middelhoek as well as C.R. Kleijn and C.J.
2 Hoogendoom.

3 A. Yeah. The C is Chris whose thesis is
4 on my bookshelf.

5 Q. Okay.

6 A. (Laugh).

7 Q. We'll just refer to this as the Hasper
8 reference.

9 A. Okay.

10 Q. Okay?

11 This is the reference that you cited in
12 your reply declaration; correct?

13 If you need a moment --

14 A. Yeah.

15 Q. -- to take a look at it.

16 A. I think so. (Reviewing document).

17 Oh, yes. Sorry. It was at the front.
18 Yes.

19 Q. Okay. You rely on Hasper for its
20 definition of "step coverage"; correct?

21 A. Yes.

22 Q. And Hasper is a reliable reference

1 regarding the meaning of "step coverage" as it
2 relates to the filling of contact holes; correct?

3 A. Yes, certainly.

4 Q. Hasper describes what you call a
5 "common definition" of the term "step coverage";
6 correct?

7 A. Yes.

8 Q. And on page 2 of Hasper, on page 2
9 of -- yeah, page 2 of Hasper. Page 2 shown on the
10 bottom and page 1729 shown at the upper right-hand
11 corner.

12 A. Yeah.

13 Q. Depending on how you want to refer to
14 it.

15 A. (Laugh).

16 Q. Anyways --

17 A. It's -- it's FIG. 3 of Hasper.

18 Q. Right. On page 2 of Hasper, under the
19 heading "Theory," Hasper provides the definition of
20 "step coverage"; correct?

21 A. Yes.

22 Q. There Hasper says:

1 "In our study, we defined the step
2 coverage as the ratio in percents of the tungsten
3 thickness "A" taken halfway the feature depth and
4 the substrate surface thickness "B" at the moment
5 the feature closes."

6 You see that?

7 A. Yes.

8 Q. And that is the definition of "step
9 coverage" that you've used; correct?

10 A. Yes.

11 Q. That definition says that step coverage
12 is the ratio of A and B at the moment the feature
13 closes; correct?

14 A. Uh-huh.

15 Q. And that's because when the feature
16 closes, no more reactants can get into the contact
17 hole to continue the deposition; correct?

18 A. Well, I'm not sure that's why he chose
19 to define it that way. My -- my guess would be,
20 well, that's when the most thickness is available
21 inside the hole, so it's easiest to measure it
22 accurately.

1 Q. When the feature hole closes, the
2 growth on the sides of the contact hole would
3 effectively stop; correct?

4 A. It should.

5 Q. The definition that Hasper provides is
6 shown in FIG. 3 of Hasper; correct?

7 A. Yes.

8 Q. And you also cite FIG. 3 in your
9 declaration; correct?

10 A. Yes.

11 Q. And there in FIG. 3 it shows step
12 coverage as a measure of A over B; correct?

13 A. I'm -- yes.

14 Q. It might be in the -- the --

15 A. It's --

16 Q. -- heading below FIG. 3.

17 A. Yes.

18 Q. All right. It says:

19 "Our definition of step coverage. SC
20 equals A over B times 100 percent."

21 A. Yep.

22 Q. Okay. In looking at FIG. 3, the

1 thickness of the deposit -- sorry.

2 Looking at FIG. 3, A is the thickness
3 of the layer, the deposited tungsten layer halfway
4 up the contact hole; correct?

5 A. Yes.

6 Q. And B is the thickness of the layer,
7 the deposited tungsten layer on the substrate
8 surface outside of the hole the moment the hole
9 closes; correct?

10 A. Yeah.

11 Q. In looking at FIG. 3, the thickness of
12 the deposited layer near the top of the hole is
13 thicker above the midpoint where A is measured;
14 correct?

15 A. Yes.

16 Q. And the thickness of the deposited
17 layer near the bottom of the hole is thinner below
18 the midpoint where A is measured; correct?

19 A. Yes.

20 Q. And the differential between the layer
21 thicknesses at the top of the contact hole and the
22 layer thickness at the bottom of the contact hole is

1 the reason why voids are created; correct?

2 A. Yes, it's certainly a significant
3 feature of the mechanism for leaving voids.

4 Q. Okay. And the differential between the
5 layer thickness at the top of the contact hole and
6 the layer thickness at the bottom of the contact
7 hole is less pronounced if you have higher step
8 coverage; correct?

9 A. Yes, that's right.

10 Q. And it would be more pronounced if you
11 have lower step coverage; correct?

12 A. Yes.

13 Q. When you have 100 percent step
14 coverage, there is no differential and you would
15 have no void; correct?

16 A. That's right.

17 Q. And that's what Hasper says; correct?

18 A. Yeah. Yeah.

19 Q. Hasper says -- after giving its
20 definition, Hasper says:

21 "This definition is shown --"

22 A. I'm sorry. Where are you reading?

1 Q. I'm reading right after I read the
2 first paragraph under "Theory."

3 A. Okay. Yeah.

4 Q. The first line I've already read, which
5 is the definition that they provided of step
6 coverage.

7 A. Yes.

8 Q. Then it follows with the sentence "This
9 definition is shown in FIG. 3." Then it follows and
10 it says -- Hasper says "Thus, we obtain 100 percent
11 step coverage if no void formation occurs."

12 A. Yes.

13 Q. And you agree with Hasper's definition;
14 correct?

15 A. Yes.

16 Q. That --

17 A. It's a fine definition.

18 Q. Right.

19 No void or void-free equals 100 percent
20 step coverage?

21 A. No, it doesn't say that.

22 Q. It says "Thus, we obtain 100 percent

1 step coverage if no void formation occurs."

2 A. Right, but what I don't remember if
3 that's called the converse. In logic "if then"
4 doesn't mean "then if." So I can't conclude from
5 that sentence that the absence of a void means I had
6 100 percent step coverage.

7 Q. All right. But the sentence says "we
8 obtain 100 percent step coverage if no void
9 formation occurs."

10 So what --

11 A. Yes. He's teaching what the idea of
12 step coverage is and talking to some of the
13 examples.

14 Q. All right.

15 A. That's all this is doing.

16 Q. He's associating 100 percent
17 coverage -- step coverage with no void formation?

18 A. No, or at least I think that statement
19 can be misleading if we say he's associating them.

20 He's saying, as an example, if we have
21 a 100 percent step coverage, there should be no void
22 because basically there's no tapering of the layer

1 as you go down the hole. That's really all he's
2 saying.

3 Q. You would have tapering if you didn't
4 have 100 percent step coverage to some degree?

5 A. By definition, if it's less than 100
6 percent step coverage, there is some tapering
7 someplace, but it doesn't tell you how.

8 It's important to realize that these
9 materials are being deposited and grown at elevated
10 temperatures. And whenever you grow materials,
11 there's grain formation there, you know, you form
12 polycrystalline grains or maybe some amorphous
13 structure. The structure can relax. There's
14 surface diffusion.

15 There's a lot of chemistry and physics
16 happening there, and that's why it's important to --
17 to understand that you can form a void-free filling
18 without exactly 100 percent step coverage because
19 you'll never get exactly 100 percent step coverage.

20 Q. In general, the higher the aspect ratio
21 of the hole, the more difficult it is to fill the
22 hole with no void; correct?

1 A. Yes.

2 Q. And this is because the higher the
3 aspect ratio, the harder it is to get reactants into
4 the hole; correct?

5 A. It's not -- that's not quite right.

6 What happens is the reactants enter the
7 hole, and they may react because they hit a wall
8 before they've gotten very far. Sometimes they'll
9 bounce off the wall and they'll just bounce all the
10 way down. Somewhere they will finally react, and
11 this is kind of the classic process.

12 So given that there's a finite
13 probability that they will react on the first hit or
14 the second hit or something, there's less
15 impingement that actually gets down to the bottom --

16 Q. Yeah.

17 A. -- and that's why higher aspect ratios
18 are harder to -- to fill.

19 Q. I see. So it's because -- because of
20 the higher aspect ratio, there's a higher likelihood
21 for impingement before reactants can get all the way
22 to the bottom of the hole?

1 A. Yes, that's right.

2 Q. Okay. If you have, for example, a .5
3 micron hole and before you deposit the tungsten, you
4 first deposit an adhesion layer into the hole and
5 let's say your deposition of the adhesion layer is,
6 you know, uniform thickness through the hole.

7 A. So conformal with that.

8 Q. Conformal, right.

9 A. Okay.

10 Q. That deposition of the adhesion layer
11 would increase the aspect ratio of the hole;
12 correct?

13 A. If you put a conformal layer down, you
14 will increase the aspect ratio somewhat, depending
15 on the thickness of that layer compared to the
16 dimensions of the hole.

17 Q. And the thicker the adhesion layer, the
18 more you would increase the aspect ratio; correct?

19 A. Yes.

20 Q. And this is because the width of the
21 hole becomes narrower by twice the thickness of the
22 deposited layer.

1 A. Uh-huh.

2 Q. Whereas, the height of the hole if
3 you're measuring it from the bottom to the top of
4 the layer doesn't change; correct?

5 A. Right.

6 Q. All right. And so as you deposit
7 layers within the hole, it becomes harder and harder
8 to fill that hole without a void because the aspect
9 ratio is increasing; correct?

10 A. It would seem that way. I mean,
11 geometrically you would say that, and -- and it's
12 known that at the end of the filling process, that's
13 when you really test the ability for getting good
14 step coverage and conformality.

15 It's probably helpful to make the point
16 that these kinds of grain growth and materials
17 reaction and surface diffusion that I alluded to
18 earlier are probably what makes CVD as successful as
19 it is in filling high aspect ratio structures.

20 Q. When -- typically in semiconductor
21 fabrication, when you are talking about depositing a
22 layer of film and you say you want to deposit a

1 layer of film that is, say, 1,000 angstroms, a
2 conformal layer of 1,000 angstroms, is that
3 thickness of the layer measured at the -- the flat
4 surface or is it measured within the hole?

5 A. Well, I think most everyone would
6 measure it at the flat surface.

7 Q. Okay.

8 A. It's very often -- I mean, you think
9 about how you do something like that. You're trying
10 to develop and qualify a process to do 1,000
11 angstroms of whatever. You're not going to make
12 fine structures to develop that process. You take a
13 flat surface --

14 Q. Right.

15 A. -- like a clean silicon wafer.

16 Q. So what I'm saying -- when I say or --
17 sorry.

18 In semiconductor processing, when you
19 say deposit a tungsten layer of .2 microns to fill
20 the contact hole, the .2 micron thickness refers to
21 the thickness of the tungsten layer at the flat
22 surface; correct?

1 A. That's what I would take and I think
2 most would take as the default, unless there were
3 some other words to say try and deposit so much in
4 the hole or on the sidewall of this step.

5 Q. Right. Okay.

6 The thickness of the deposited layer
7 would be at most equal to the thickness on the flat
8 surface, but would not be greater than the thickness
9 on the flat surface; correct?

10 MR. COLAIANNI: Objection. Vague.
11 Incomplete hypothetical.

12 THE WITNESS: Yeah, the thickness
13 on -- what was the first part? (Laugh).

14 BY MR. CHEN:

15 Q. Sorry. Let me -- that was a poorly
16 worded question. Let me re-ask it.

17 So when you're depositing, for example,
18 a tungsten layer of .2 microns.

19 A. Right.

20 Q. And let's say you have a hole of .5
21 microns. When you're depositing that tungsten layer
22 and you finish the deposition, the thickness of the

1 tungsten layer on the flat surface is .2 microns;
2 correct?

3 A. Uh-huh.

4 Q. Right. The thickness of that tungsten
5 layer within the hole would be no greater than .2
6 microns, correct, on the sidewalls of the hole?

7 MR. COLAIANNI: Objection.
8 Incomplete hypothetical.

9 THE WITNESS: Well, in the cases
10 that we're talking about now like described in -- in
11 this figure we just spoke to, that's true. It won't
12 be larger. I'm not sure there aren't some
13 exceptional conditions, like if you were very high
14 temperature and you deposited the film and it melts
15 and falls on the bottom or --

16 BY MR. CHEN:

17 Q. Right.

18 A. -- something like that, but these seem
19 pretty outlandish cases. I don't think of a
20 relevant counter-example.

21 Q. Okay. Typically when you're depositing
22 films within holes, the thickness of the film within

1 the hole is less than the thickness of the film on
2 the flat surface; correct?

3 A. Well, if I take random CVD processes or
4 BCVD or evaporation, generally speaking, that would
5 be the case. Where that's not quite the case is
6 when you have a highly conformal deposition as is
7 attempted to dominate the first layer here.

8 Q. Sure.

9 A. And then you won't have more than 100
10 percent of the flat surface --

11 Q. Right.

12 A. -- but you may have very close to that.

13 Q. Right. The max is equal to the
14 thickness on the flat surface?

15 A. Yeah, I can't think of a -- offhand of
16 a mechanism that would be a counter-example to that.

17 Q. Okay. Whether or not you fill a hole
18 without a void is dependent on the step coverage,
19 correct, not really the thickness of the layer?

20 A. Well, if the hole is big and you put a
21 thin layer, you won't fill it. So it does depend on
22 thickness.

1 Q. Okay.

2 A. And these filling procedures,
3 particularly with regard to whether there's a void
4 at the end, aren't only a question of step coverage
5 and conformality. Because the material changes that
6 happen during these processes alter that picture and
7 actually allow us to make CVD considerably more
8 effective than one would have expected from purely
9 geometrical considerations of step coverage.

10 Q. Okay. If you are filling a hole with
11 conditions of, let's say, less than poor step
12 coverage -- let's use an example poor step
13 coverage -- it's possible that the hole would close
14 at the top and then you would no longer be
15 continuing your deposition within the hole, but that
16 you would just continue to deposit material on the
17 flat surface above the hole; correct?

18 MR. COLAIANNI: Objection.
19 Incomplete hypothetical.

20 BY MR. CHEN:

21 Q. And, therefore, you would end up with a
22 layer that's very thick, but the hole still has a

1 void; correct?

2 MR. COLAIANNI: Objection. Vague.
3 Hypothetical.

4 THE WITNESS: Yeah, if the -- if
5 the step coverage is poor, then typically what
6 happens is you build up the deposition near the top
7 and eventually that will close. And if you didn't
8 turn off the tool, you'll keep growing and nothing
9 else can change inside the trench until -- until
10 some condition changes.

11 BY MR. CHEN:

12 Q. Okay. If you turn back to Miyazaki,
13 which is Exhibit 10.

14 Miyazaki describes a number of
15 different embodiments for forming the tungsten
16 layer; correct?

17 A. Well, he describes more than that.
18 There are two layers involved and various
19 embodiments involving different temperatures and
20 stresses and flow rates and so on.

21 Q. Right. For embodiment 3, which begins
22 at column 7 line 25, Miyazaki discloses the specific

1 process parameters that are used for forming the two
2 layers of tungsten; correct?

3 This is column 7 line 25.

4 A. Column 7.

5 Q. Beginning at column 7 line 25.

6 A. Third embodiment.

7 Q. Right.

8 A. And that's FIG. 8.

9 Q. Yes.

10 A. Yes. It's starting column 7 and
11 reading down, I think, yeah, down near line 50.

12 Q. Yeah. Near line 50.

13 A. Gives a whole bunch of --

14 Q. Right.

15 A. -- specifications.

16 Q. Right. Those are the specific process
17 parameters that Miyazaki teaches to form the
18 tungsten layers; correct?

19 A. Yes.

20 Q. And Miyazaki is teaching these
21 conditions for -- for at least the first layer of
22 tungsten it's for filling a contact hole of a

1 diameter of roughly .5 microns; correct?

2 A. Yes.

3 Q. And so at these sub-micron dimensions,
4 having specific parameters is very important;
5 correct?

6 A. Well, it's useful to have some guidance
7 in where to set the knobs and to -- that's what he
8 provides here as an example.

9 Q. The process is very sensitive to
10 changes at these sub-micron dimensions; correct?

11 A. I'm not quite sure I know how to
12 calibrate the word "very."

13 Q. Would you agree that the process is
14 sensitive to changes at these sub-micron dimensions?

15 A. I think the process is sensitive to
16 changes at any dimension. Because if I'm -- if I'm
17 using tungsten CVD to deposit a film, the nature of
18 the material that's grain structure, resistivity and
19 so on, and the growth rate will depend on these
20 various parameters.

21 Q. Does the sensitivity increase as the
22 dimensions get smaller?

1 A. Well, the material itself won't change
2 very much, except in structures. If you're talking
3 about the dimensions of the structures, then there
4 are consequences on structure, yes.

5 Q. Is the process less tolerant to changes
6 as your dimensions get smaller?

7 A. That's a good question.

8 Q. You don't know the answer to that?

9 A. No, I'm thinking.

10 Q. Okay.

11 A. I'm thinking about it.

12 Q. Sorry.

13 A. So if we take the example of a
14 reasonable high aspect ratio trench, which is not
15 that high, but say a trench with an aspect ratio of
16 2, your question is, is the process more sensitive?

17 If we go from an aspect ratio to trench
18 that's let's say a micron down to a 10th micron, can
19 you rephrase your question for that example so I
20 know how to think about it?

21 Q. No, I just recall you previously saying
22 how at sub-micron dimensions or small dimensions --

1 A. Uh-huh.

2 Q. -- the process is very sensitive to
3 changes. So I was just trying to confirm that.

4 A. I'm not sure I remember that.

5 MR. COLAIANNI: Objection to form.
6 Mischaracterizes testimony.

7 BY MR. CHEN:

8 Q. When you're doing semiconductor
9 manufacturing, is it important to follow the recipes
10 that are provided?

11 MR. COLAIANNI: Objection to form.

12 THE WITNESS: Well, if you're the
13 process engineer and there's a recipe provided,
14 that's what you should follow. And if you -- if you
15 were to play with the parameters, in the old days
16 when there were knobs, turn the knobs, that would be
17 verging on irresponsible.

18 When you're going to do something
19 like that, you have to say -- you have to think
20 through. I'd like to be able to make such and such
21 improvements. Perhaps if I move the process
22 variables in this way, I'll get that, and I may do a

1 design of experiments so that I can determine
2 whether that's right. We'll have to stop -- we'll
3 have to stop processing product so I can do a set of
4 experiments as a development exercise to see if I
5 can do that.

6 BY MR. CHEN:

7 Q. Right.

8 A. That's how it would happen.

9 Q. When you modify the process, you would
10 need to conduct some experiments to ensure that
11 you're still achieving the results that you want to
12 achieve; correct?

13 A. Or -- or improving the results but, I
14 mean, generally speaking -- well, I mean, people go
15 through these exercises when they're trying to tune
16 up a process or to tune up a process integration
17 sequence which involves multiple processes.

18 So you have to do it then as a
19 legitimate purpose, and then when tools go off-line
20 because they need preventive maintenance or
21 something, you have to come back and do a couple of
22 wafers experiment to prove that you're back online

1 correctly.

2 Q. So when -- in semiconductor
3 fabrication, when you specify parameters for a
4 process, those parameters are designed to achieve a
5 specific result; correct?

6 A. Oh, yes.

7 Q. And you wouldn't want to change those
8 parameters without some experimentation to ensure
9 that you have -- you're still able to achieve your
10 desired results or you've been able to achieve any
11 improvement that you are seeking to achieve;
12 correct?

13 MR. COLAIANNI: Objection.
14 Incomplete hypothetical.

15 THE WITNESS: Yeah. Well, you
16 don't just go changing things without good reason
17 and some diligence in thinking, well, what do we
18 have to do to make -- test that kind of change?

19 Now, there's one potential
20 exception I should mention, which is that, take a
21 tungsten CVD tool. It's running I don't know how
22 many wafers a day, but a lot of them. And as a

1 function of how many depositions have been done or
2 how much material has been deposited since the last
3 chamber clean, you may see that the performance --
4 what do you call it? -- the performance shifts in
5 time a little bit. The deposition rate goes down or
6 it goes up or something like that, and so you're
7 running a lot of wafers through the fab.

8 You have data on that, and so it
9 may be that there are cases where people know that
10 they have to turn the knob a little bit every 50
11 wafers to get optimum quality out.

12 BY MR. CHEN:

13 Q. I see.

14 A. I'm not sure if anybody practices that,
15 but all the people who have been interested in
16 advanced process control for 20 years certainly have
17 thought of that.

18 Q. Right. Okay. Looking at Miyazaki
19 embodiment 3, which begins at column 7 line 25 or
20 26.

21 A. Yes.

22 Q. And if you go down to roughly line 50

1 or 51, Miyazaki talks about depositing the first
2 layer of tungsten film; correct?

3 A. Yes.

4 Q. Then going down to line 64, Miyazaki is
5 talking about depositing the second layer of
6 tungsten film on top of the first layer; correct?

7 A. Yes.

8 Q. And Miyazaki there says:

9 "Furthermore, as shown in FIG. 9, in
10 the same deposition chamber, a tungsten film 16 is
11 continuously formed by the chemical vapor deposition
12 using tungsten hexafluoride and hydrogen as a raw
13 material."

14 You see that?

15 A. Yes.

16 Q. So for embodiment 3, Miyazaki is
17 specifically emphasizing that the second layer of
18 tungsten is deposited in the same deposition chamber
19 as the first layer and that it is continuously
20 formed; correct?

21 A. Yes.

22 Q. Miyazaki doesn't say that it's not

1 important to do a same chamber deposition; correct?

2 A. Not here.

3 Q. Right.

4 A. He says it elsewhere.

5 Q. Okay.

6 A. Says something related to it elsewhere.

7 Q. Moving on to the fourth embodiment,
8 which begins at column 8 line 15.

9 A. Yes.

10 Q. Miyazaki starts to describe the
11 formation of the first tungsten film for the fourth
12 embodiment at column 8 line 27; right?

13 A. Yes.

14 Q. And then it forms the second layer of
15 tungsten for the fourth embodiment beginning at
16 column 8 line 37; correct?

17 A. Yes.

18 Q. And there it says.

19 "Furthermore, as shown in FIG. 11, in
20 the same deposition chamber, a tungsten film 16 is
21 continuously formed by the chemical vapor deposition
22 using tungsten hexafluoride and hydrogen as a raw

1 material."

2 Correct?

3 A. Yes.

4 Q. So, again, for embodiment 4, Miyazaki
5 is emphasizing that the second layer of tungsten is
6 deposited in the same deposition chamber as the
7 first and is continuously formed; correct?

8 A. Yes.

9 Q. And again here Miyazaki does not say
10 that using a single chamber or the same deposition
11 chamber is not important; correct?

12 A. Doesn't say that using a single chamber
13 is not? No. Why would he -- but why would he say
14 it's not important? If he says, I'm doing this, why
15 would he --

16 Q. Right.

17 A. -- say it's not important that I do it?
18 (Laugh).

19 Q. Right.

20 A. I wouldn't expect him to comment here.

21 Q. He's specifically saying to do it in
22 the same chamber; correct?

1 A. No, he's specifically saying that's
2 what he does.

3 Q. Right.

4 A. That's his teaching here.

5 Q. Okay. Then moving on to the fifth
6 embodiment, which begins at column 8 line 47.

7 A. Yes.

8 Q. The first tungsten film is deposited --
9 the description of the deposition of the first
10 tungsten film begins at around line 56 of column 8.

11 You see that?

12 A. Yes.

13 Q. And then the deposition of the second
14 layer of tungsten film begins at column 8 line 66.

15 A. Yes.

16 Q. And there Miyazaki says with reference
17 to the fifth embodiment:

18 "Furthermore, as shown in FIGS. 9 and
19 11, in the same deposition chamber, a tungsten film
20 16 is continuously formed by the chemical vapor
21 deposition using tungsten hexafluoride and hydrogen
22 as a raw material."

1 You see that?

2 A. Yes.

3 Q. So, again, for the fifth embodiment,
4 Miyazaki is emphasizing that the same deposition
5 chamber is being used for the deposition of the
6 second tungsten film; correct?

7 A. Yes, in this part, in these three
8 embodiments of the spec --

9 Q. Right.

10 A. -- that's what he use -- uses.

11 Q. And he doesn't say that it's not
12 important to do it in the same -- same chamber;
13 right?

14 A. Well, he said -- no, he just says he
15 does it.

16 Q. Right.

17 A. That's what he's teaching.

18 Q. That's what he's teaching.

19 For embodiment 6 which begins at column
20 9 line 8.

21 A. Yes.

22 Q. Miyazaki doesn't disclose specific

1 process parameters for the formation of the tungsten
2 layers; correct?

3 A. No, not -- not for the sixth
4 embodiment. He's just given three different
5 examples --

6 Q. Right.

7 A. -- in previous embodiments. So I think
8 the reader already knows some specific process
9 parameters that could be used for these two films.

10 Q. Embodiment 6 is focusing on adjusting
11 the ratios of the thicknesses of the two different
12 layers; correct?

13 A. In part, yes.

14 Q. Now, in your declaration, you had
15 stated that there was an error in FIG. 12 of the
16 Miyazaki reference?

17 A. Yes.

18 Q. Could you explain what that error was?

19 A. Yes. So FIG. 12 plots the stress from
20 a combination of two films as a function of their
21 composition, and the teaching of Miyazaki is that
22 you want to have at the lower level it's called,

1 that's the first deposition, a film that,
2 unfortunately, has a high stress. You're not
3 looking for high stress, but that's just what you
4 get if you do void-free filling. And above that,
5 the upper level layer to have a low stress to
6 compensate for the high stress of the first film.

7 So when we look at this chart, let's
8 look at the right-hand side of the chart. You see
9 the curve goes through a high stress of about 10 to
10 the 10th dynes per square centimeter at the
11 right-hand side, but the compositions that are given
12 for the two films on the X axis indicate that the
13 high stress film is not there, has zero composition,
14 and the low stress film is always there because it
15 has 100 percent of the composition.

16 So my conclusion was this is obviously
17 an axis that is mislabeled, the X axis, and so all
18 that one needs to do is to switch the labels for --
19 for the two X axes that are provided there.

20 So, in other words, the numbers that go
21 from 1 on the left to 0 on the right, that's the low
22 stress film and from 0 to 1 on the right, that's the

1 high stress film. So one can either change the
2 labels or take the X axis that's below and put it
3 above.

4 Q. Okay.

5 A. Okay?

6 Q. Because -- okay. So effectively what
7 you're saying is simply that the high stress film
8 label and the low stress film label should be
9 reversed?

10 A. Yes. Yes.

11 Q. Okay. All right. Why don't we take a
12 break.

13 A. Okay. I'm taking off my microphone.

14 THE VIDEOGRAPHER: We are going
15 off the record at 10:16.

16 (Recess - 10:16 a.m. - 10:31 a.m.)

17 THE VIDEOGRAPHER: We are now back
18 on the record at 10:31.

19 BY MR. CHEN:

20 Q. Dr. Rubloff, I believe that in your
21 declarations you had proposed some modifications to
22 the disclosures of Miyazaki; correct?

1 A. Could you be more specific?

2 Q. In your reply declaration, I think you
3 refer to at least one instance where you talk about
4 adjusting some of the Miyazaki parameters for a
5 contact hole of .35 microns as opposed to the .5
6 micron hole that is discussed in Miyazaki.

7 A. Which? Which paragraph?

8 Q. Let me look for it.

9 I think in paragraph 8A, you talk
10 about -- or 8B. Sorry. 8B.

11 A. 8B?

12 Q. Yeah. You said -- the last sentence
13 you're talking about combining Miyazaki with Felix
14 and I think Wolf and you talk about:

15 "Thus, in view of Miyazaki's general
16 teaching that its process is applicable to contact
17 holes arising from advanced microminiaturization, a
18 POSITA would have found it obvious to apply
19 Miyazaki's process to smaller contact holes, such as
20 0.35 micron hole disclosed in Felix, and that when
21 applied to these smaller holes, the corresponding
22 deposition time would fall within the range recited

1 in claims 10 and 23."

2 You see that?

3 A. (Reviewing document). Yes.

4 Q. Did you conduct any experiments to
5 determine the effect of applying the Miyazaki
6 teachings for a .5 micron hole to a hole the size of
7 .35 microns?

8 A. Did I do experiments; was that your
9 question?

10 Q. Yes.

11 A. I didn't do any experiments, no.

12 MR. CHEN: Okay. All right. I
13 don't have any questions -- further questions for
14 him at this time.

15 Would you like to do your
16 redirect?

17 MR. COLAIANNI: We don't have any
18 questions.

19 MR. CHEN: Okay. Thanks.

20 THE VIDEOGRAPHER: We are going
21 off the record at 10:34.

22 (Recess - 10:34 a.m. - 10:43 a.m.)

1 THE VIDEOGRAPHER: Here begins
2 Volume 2 disk 2 in the video deposition of Gary
3 Rubloff taken in the matter of Samsung Electronics
4 CO. LTD., Samsung Electronics America, Inc., Samsung
5 Semiconductor Inc., and Samsung Austin Semiconductor
6 LLC versus Home Semiconductor Corporation, in the
7 United States Patent and Trademark Office, Before
8 the Patent Trial and Appeal Board, Case No. IPR
9 2015-00467.

10 Today's date is December 17, 2015.
11 The time on the video monitor is 10:43.

12 Counsel may now proceed.

13 CROSS-EXAMINATION

14 BY MR. CHEN:

15 Q. Dr. Rubloff, I will now be
16 cross-examining you regarding the reply declaration
17 that you submitted in connection with Samsung's IPR
18 2015-00467.

19 I will ask you questions related to the
20 subject matter disguise -- discussed in your reply
21 declaration. You will need to answer my questions
22 truthfully and completely.

1 The court reporter will record your
2 question -- my question and your answers. If your
3 attorney objects, you still must answer all my
4 questions, unless he instructs you not to answer.

5 If you do not hear or understand my
6 questions, please ask me to repeat or clarify. If
7 you ask -- answer my questions, my assumption will
8 be that you understood the questions. If you need a
9 break, please let me he know and we'll take one.

10 Do you understand?

11 A. Yes.

12 Q. Can you think of any reason that might
13 affect your ability to provide truthful and complete
14 answers to my questions today?

15 A. To the extent that I know the answers,
16 no problem.

17 Q. Okay. Do you have any questions before
18 we start?

19 A. No.

20 Q. All right. And, again, I think as we
21 discussed before, you were previously deposed in
22 connection with this Samsung IPR; correct?

1 A. Right.

2 Q. And in that prior deposition, I asked
3 you to let me know if you didn't understand my
4 questions; correct?

5 A. Yes.

6 Q. And if -- I told you that if you didn't
7 understand my questions, you could ask me to repeat
8 or clarify; correct?

9 A. Yes.

10 Q. And I told you that if you answer my
11 questions, my assumption would be that you
12 understood my questions; correct?

13 A. Yes.

14 Q. And outside of any circumstances where
15 you asked me to repeat or clarify a question, you
16 understood my questions; correct?

17 A. Yes.

18 Q. And you were truthful in that prior
19 deposition; correct?

20 A. Certainly.

21 Q. And you gave complete answers to my
22 questions?

1 A. Yes.

2 Q. And you stand by the answers provided
3 in that prior deposition?

4 A. Yes.

5 MR. CHEN: Okay. This is, I
6 believe, 11.

7 THE REPORTER: 12.

8 MR. CHEN: No, 12. Sorry.

9 (Document marked, for
10 identification purposes, as Rubloff Exhibit No. 12.)

11 BY MR. CHEN:

12 Q. Dr. Rubloff, I've asked the court
13 reporter to mark as Exhibit No. 12 your reply
14 declaration submitted in connection with Samsung's
15 IPR 467.

16 Do you have this declaration now in
17 front of you?

18 A. Yes.

19 Q. Okay. And did you draft this
20 declaration?

21 A. Yes.

22 Q. And are you aware of any errors in this

1 declaration?

2 A. Except for the misspelling that I
3 mentioned earlier and which may be in this one or in
4 the previous. Oh, here it is.

5 Q. Okay.

6 A. Oh, no, no, no. I'm sorry.

7 Well, I mentioned it in the previous
8 discussion.

9 Q. Right.

10 A. Other than that, no.

11 Q. Other than a typo that you had
12 mentioned before --

13 A. Right.

14 Q. -- there's no other errors in this
15 declaration; right?

16 A. Right.

17 Q. And there are no corrections that you
18 would like to make to this declaration; right?

19 A. I don't think so.

20 Q. And how did you arrive at the opinions
21 that are in this declaration?

22 A. So I reviewed the declaration and

1 deposition of Ron Maltiel and my previous
2 declaration and the patents at issued -- at issue,
3 Emesh and Mak and the '893. I probably went over
4 some of the other materials that I thought about in
5 drafting my original declaration, and I had
6 discussions with the attorneys, who asked questions
7 here and there to clarify things.

8 Q. Okay.

9 A. I think that covers it pretty well.

10 Q. All right. And you arrived at the
11 conclusions in this declaration based on your own
12 analysis; correct?

13 A. Absolutely.

14 Q. Okay.

15 (Document marked, for
16 identification purposes, as Rubloff Exhibit No. 13.)

17 BY MR. CHEN:

18 Q. Dr. Rubloff, I asked the court reporter
19 to mark as Exhibit 13 U.S. Patent No. 5,043,299.
20 This is the Chang patent.

21 This is the patent that you referenced
22 in your declaration; correct?

1 A. Yes.

2 Q. All right. In your declaration, you
3 referenced the Chang patent as showing that a person
4 of ordinary skill in the art would know about the
5 AMAT 5000 machine in the time frame of the '893
6 patent; correct?

7 A. Well, I would say it differently from
8 the way you said it.

9 It's an example of the AMAT machine.

10 Q. Right.

11 A. But I wouldn't say that Chang in this
12 patent was demonstrating how many hundreds or
13 thousands of people knew about the machine.

14 Q. Okay. At least it's an example of
15 somebody using the AMAT 5000 tool; correct?

16 A. Yes.

17 Q. All right. And the Chang patent
18 discusses the use of the AMAT 5000 for CVD
19 deposition; correct?

20 A. Now, let me just take a quick look at
21 it.

22 Q. Sure.

1 A. (Reviewing document). Yes. So your
2 question was, it describes CVD?

3 Q. My question was confirming that the
4 Chang patent discusses the use of the AMAT 5000 for
5 CVD tungsten deposition; correct?

6 A. Yes.

7 Q. Yeah. And the Chang patent discloses
8 the AMAT 5000 tool with two chambers; correct?

9 A. Yes.

10 Q. And the Chang patent uses one chamber
11 as a dedicated cleaning chamber; correct?

12 A. Yes.

13 Q. And the Chang patent discusses the use
14 of the other chamber as a tungsten CVD chamber;
15 correct?

16 A. Yes.

17 Q. The Chang patent discloses the use of
18 only a single tungsten CVD chamber; correct?

19 A. Let's see. It seems that way, yes.

20 Q. The Chang patent does not discuss the
21 deposition of two layers of tungsten using two
22 different CVD chambers; correct?

1 A. (Reviewing document). Yes.

2 Q. Okay. Now, if you turn to your
3 declaration, Exhibit -- which is Exhibit 12.

4 In your reply declaration at paragraph
5 2B, you state that cluster tools like the AMAT 5000
6 were well known at the time of the '893 invention;
7 correct?

8 A. Yes.

9 Q. You said that the whole world knew
10 about them; correct?

11 A. Yes. Well, I mentioned that should be
12 in the context of practitioners of the art.

13 Q. Sure.

14 A. (Laugh).

15 Q. I mean, I think that's fair.

16 We're talking about those involved in
17 semiconductor processing?

18 A. Yes.

19 Q. And that any person of ordinary skill
20 in the art would have known about that tool;
21 correct?

22 A. Yes.

1 Q. All right. Now, in performing your
2 analysis of the '893 patent, you searched for prior
3 art; correct?

4 A. Yes.

5 Q. And some of that art is what was
6 referenced in your declarations; correct?

7 A. Sure.

8 Q. Right. And you selected the best
9 references for your declarations; correct?

10 A. The best references of the ones I
11 found --

12 Q. Right.

13 A. -- or considered.

14 Q. Right. And you looked at many
15 references that describe depositing two layers of
16 CVD tungsten to fill a contact hole; correct?

17 A. Well, certainly at quite a number. I
18 don't -- I don't know about "many."

19 Q. Okay.

20 A. I don't remember how many there were.

21 Q. Right. But you searched for references
22 that talked about the depositing of two layers of

1 CVD tungsten to fill a contact hole; correct?

2 A. Yeah.

3 Q. All right. You searched for patents;
4 right?

5 A. Yes.

6 Q. And you also searched nonpatent
7 literature; correct?

8 A. Yes.

9 Q. Textbooks?

10 A. Yes. Yes.

11 Q. And journal articles?

12 A. Yeah, sure.

13 Q. Yeah. You also looked at references
14 that describe the use of the AMAT 5000 cluster tool;
15 correct?

16 A. Yes.

17 Q. All right. In all of your searching,
18 you did not find any references that taught a
19 specific process for depositing two layers of
20 tungsten CVD in two separate CVD deposition
21 chambers; correct?

22 A. No.

1 Q. No, you did not find any references;
2 correct?

3 A. No, I disagree.

4 For example, there's a -- there's a
5 part of the sixth embodiment of the previous, the
6 Miyazaki reference, which I think alludes to this
7 possibility in a very clear way that anyone would
8 understand. And this was an era since about 1987 I
9 think was the introduction of the P-5000 cluster
10 tool, and there were other companies putting out
11 cluster tools in the years that followed.

12 And this was -- this was so well known
13 by the time of Miyazaki or Emesh that anyone who
14 saw, well, I want to do two layers and I want the
15 process conditions to be different and in particular
16 for there to be different temperatures, there's a
17 benefit to using a cluster tool to do that.

18 Q. Miyazaki --

19 A. You know, you know, Applied Materials
20 made its name, as I think it's just about the
21 biggest company making semiconductor manufacturing
22 equipment in the world or one of the biggest, out of

1 that tool and introducing the concept of cluster
2 tools. And the benefits in contamination control
3 and throughput and so on were so profound, that
4 everyone went to that. When you go into a fab
5 today, you'll have a hard time to find anything that
6 is not a cluster tool.

7 Q. Miyazaki does not disclose or discuss
8 the use of AMAT 5000 cluster tool; correct?

9 A. Doesn't mention it. Probably didn't
10 need to.

11 Q. Okay.

12 A. And there would have been other
13 companies than AMAT that had cluster tools. For
14 example, Novellus, Lam, and so on.

15 Q. Miyazaki doesn't discuss the use of
16 cluster tools; correct?

17 A. Does not mention cluster tools, but
18 says it doesn't have to be all in the same chamber.

19 Q. Okay. And Miyazaki embodiment 6 does
20 not disclose specific process parameters for the
21 deposition of tungsten CVD layers; correct?

22 A. No, I disagree with that.

1 I think he's -- anyone who -- who reads
2 Miyazaki will see very clear definition of what the
3 process chemistry is, examples of what settings to
4 use from embodiments 3, 4, 5. It would be very well
5 known.

6 Furthermore, Miyazaki does something
7 that the '893 just doesn't do, which is to tell --
8 tell you what reactive gases you need.

9 I was -- I was frankly shocked when I
10 read the '893 to find out that someone could
11 actually get a patent on a tungsten CVD process
12 without saying you need a reducing species in
13 addition to the tungsten hexafluoride, and -- and
14 all that information is prescribed in both Miyazaki
15 and Emesh in terms of how the process chemistry
16 works.

17 Q. In the portion of Miyazaki discussing
18 embodiment 6, no specific process parameters are
19 disclosed; correct?

20 A. They're not stated in embodiment 6, but
21 they're taught in the specification very clearly.

22 Q. Right.

1 A. And -- and so maybe there are people
2 who would go to a patent like that and read. I
3 don't like these numbers, but let me just read one
4 embodiment, I'll pick 6, and never look at the rest
5 of it. I just don't think it's realistic.

6 Q. Okay. Embodiments 3 through 5 do
7 disclose specific parameters for depositing two
8 layers of tungsten; correct?

9 A. Yes.

10 Q. Right. And embodiments 3 through 5
11 both teach specifically to use a single chamber for
12 both depositions -- for the deposition of both
13 layers of tungsten; correct?

14 A. Embodiments 3 through 5 say that, yes.

15 Q. Okay. Outside of Miyazaki, in all your
16 searching, you did not find any references that
17 taught a specific process for depositing two layers
18 of tungsten CVD using two different CVD deposition
19 chambers; correct?

20 A. Outside of Miyazaki, I don't know of
21 one that makes that explicit.

22 Q. Right. And Emesh doesn't teach it;

1 correct?

2 A. No, Emesh doesn't.

3 Q. Mak doesn't teach it; correct?

4 A. Mak makes it pretty obvious.

5 Q. Mak doesn't teach it; correct?

6 A. Mak does not -- does not teach the two
7 layer tungsten deposition.

8 Q. Okay. You didn't cite any other
9 references that teach that; correct?

10 A. No, I didn't, but this is something
11 that people reading both of those references would
12 immediately come to the conclusion this is how to do
13 it in reality in a tool.

14 Q. Okay. In fact, the only reference that
15 we've seen that explicitly teaches depositing two
16 layers of CVD tungsten in two separate deposition
17 chambers to fill a contact hole is the '893 patent
18 itself; correct?

19 A. I don't agree with that.

20 I think Miyazaki does that or, in
21 combination, Emesh and Mak.

22 (Document marked, for

1 identification purposes, as Rubloff Exhibit No. 14.)

2 BY MR. CHEN:

3 Q. Dr. Rubloff, we've -- I've asked the
4 court reporter to mark as Exhibit No. 14 U.S.
5 Patent No. 5,407,698, which is the Emesh patent.

6 And you relied on the Emesh patent to
7 help formulate the analysis for your declarations;
8 correct?

9 A. Yes.

10 Q. All right. And you rely -- Emesh
11 discloses a number of different embodiments for the
12 deposition of tungsten, and you specifically relied
13 on embodiment 2 of Emesh; correct?

14 A. That's correct.

15 Q. All right. And the gas flow rate for
16 tungsten hexafluoride that Emesh discloses for
17 embodiment 2 is 10 to 40 sccm; correct?

18 A. Can you point me to the place you're
19 seeing that?

20 Q. Sure. Just make sure I'm looking at.
21 (Reviewing document).

22 Okay. Embodiment begins --

1 embodiment 2, the description of embodiment 2 begins
2 at column 8.

3 A. Yeah, 55.

4 Q. Yeah, line 55; right.

5 And there if you continue on --
6 (reviewing document).

7 All right. Well, we might have to come
8 back to this because --

9 Well, if you look to column 5 --

10 A. Yeah.

11 Q. -- and beginning at line 36, it's not
12 speaking specifically about embodiment 2 I think
13 it's speaking more generally about the embodiments
14 that are disclosed --

15 A. Uh-huh.

16 Q. -- in Emesh.

17 A. Okay.

18 Q. And there it says that the gas flow
19 rates for tungsten hexafluoride, for example, is 10
20 to 40 sccm.

21 A. Yeah, I see that, 10 to 40. In
22 hydrogen, 240 to 800.

1 Q. Right.

2 A. And silane, 0 to 15.

3 Q. So those are the gas flow rates that
4 Emesh discloses for the embodiments described in the
5 patent; correct?

6 A. Yes.

7 Q. And then specifically for embodiment 2,
8 the gas flow rate of tungsten hexafluoride is 40
9 sccm and this is shown in column 11 --

10 A. Yes.

11 Q. -- towards the bottom in that table;
12 correct?

13 A. Yep.

14 Q. All right. And Emesh teaches a very
15 specific recipe for the deposition of the tungsten
16 layers in embodiment 2; correct?

17 A. Well, he teaches in two places. One is
18 in giving guidance about the hydrogen-to-tungsten
19 hexafluoride ratio and the total pressure and so on.
20 So some of it is in the specification text.

21 Q. Right.

22 A. And then there's an example given,

1 which is probably not to be considered inclusive but
2 exemplary of a way you would use this process.

3 Q. What is shown in the table is
4 reflective of what is described in the text;
5 correct?

6 A. Well, I would say it's probably not
7 inconsistent with it, but there's more information
8 in the table. Because this is the process looking
9 at, as you see, preheat, predeposition, the plug
10 filling, the interconnect deposition, the pumpdown,
11 and so on and it gives more information.

12 So, for example, the hydrogen, which is
13 the reductant that's required, and silane, which can
14 be an additional reductant, those flow rates are
15 specified through each step or sub-step of the
16 recipe that's in example 2, as well as the tungsten
17 hexafluoride parameters and the argon and nitrogen
18 parameters as well.

19 So that's much more than the text of
20 the specification for embodiment 2.

21 Q. Okay. So the table provides more
22 detail than the text?

1 A. The table looks like what you'd see on
2 the screen of the tool.

3 Q. Okay. And that's a very specific set
4 of process parameters?

5 A. Yeah. Yeah. It's one that works.

6 Q. Okay. And if you were manufacturing
7 the device according to process, you'd want to
8 follow these parameters; correct?

9 A. Well, or something along these lines,
10 but I think more important is that if you wanted to
11 modify the parameters in a way to gain some
12 advantage, you would look at these parameters. But
13 you'd also look at the teaching in the text, which
14 points to the controlling significance of the
15 hydrogen and tungsten flow rate and the existence of
16 a reductant, namely, hydrogen.

17 You'd want to know what it tells you
18 about that to get the very different properties that
19 the two layers are requiring. One is it's okay to
20 be high stressed as long as it's void-free and the
21 second is low stress.

22 Q. And you would then run experiments to

1 determine how your modification to the process
2 parameters might affect your results; correct?

3 A. Sure. So, for example, if I wanted to,
4 I'd go to higher flow rate. Then what I might do is
5 to turn up the tungsten hexafluoride by -- I don't
6 know -- 20 percent, 50 percent, and I would at the
7 same time proportionally increase the hydrogen and
8 the silane so that I kept the same distribution of
9 reactive gases and stayed in the same domain of
10 either reaction rate limited deposition or supply
11 limited deposition.

12 Q. Did you run any experiments on your
13 proposed modification to the disclosed gas flow
14 rates of Emesh in embodiment 2?

15 A. No. No. (Laugh).

16 Q. All right.

17 A. No. I have a different job. (Laugh).

18 Q. Right. Inert gases, like argon and
19 nitrogen, will affect the characteristics of the
20 tungsten deposition; correct?

21 A. Typically not. Inert gases generally
22 are regarded and behave as inert; namely, they don't

1 do anything except change the total flow of the --
2 of the through -- of gases through the tool and
3 sweep reaction products out with them.

4 So their effect is -- their chemical
5 effect is -- is essentially zero if they're truly
6 inert gases, like argon is. Their effect on let me
7 call it the mechanics or the physics -- it's
8 actually the chemical engineering -- of the reactor
9 can be an effect, but only indirectly by changing
10 residence times of the reactive gases and products
11 in the -- in the chamber.

12 Now, nitrogen is a somewhat different
13 story here. Nitrogen is normally regarded as an
14 inert gas, and it's very often used as inert gas
15 because it's inert and it's cheaper than argon or
16 helium.

17 But here it evidently plays some role
18 in improving the specular reflectivity of the top
19 layer tungsten surface by some kind of mediating
20 role as a chemisorption agent.

21 That's -- that's what's speculated here
22 in Emesh. So it's not quite inert because it

1 affects the grain structure and, therefore, the
2 reflectivity of the surface that's important to
3 lithography.

4 Q. Doesn't Emesh teach that the inert
5 gases, like argon or nitrogen, would affect the
6 characteristics of the layer of tungsten that is
7 being deposited?

8 A. So where does it say that for argon?

9 I mean, argon will not chemically
10 interact with these materials.

11 Q. Okay. Let me find it.

12 A. I don't think that that's what's said.

13 Q. So if you look at column -- if you look
14 at column 6 line 67, Emesh is discussing the effect
15 of varying deposition parameters and it refers to
16 FIGS. 3 and 8.

17 A. (Reviewing document).

18 Q. Actually, 3 through 8. FIGS. 3 through
19 8 show the effect of varying certain deposition
20 parameters on the characteristics -- characteristics
21 of the resulting tungsten film.

22 Do you see that?

1 A. Yes.

2 Q. And they show different results for
3 experiments conducted with nitrogen as opposed to
4 experiments conducted with argon; correct?

5 A. Right.

6 Q. So depending on whether you use
7 nitrogen or argon, the characteristics of the
8 tungsten film will change; correct?

9 A. Right. I think that's consistent with
10 what I said.

11 Usually nitrogen and argon are inert in
12 most processes like these, but in this case I think
13 they've shown that the nitrogen does have some
14 effect on the surface morphology and, therefore, the
15 specular versus diffuse reflectants.

16 Nitrogen is slightly reactive. If you
17 take a fresh tungsten or titanium surface at
18 sufficient temperature, expose it to nitrogen,
19 you'll form a tungsten or titanium nitride. So it
20 is not strictly an inert species.

21 Q. Okay. So then it's fair to say that
22 the question of whether you use a gas -- a carrier

1 gas like argon or whether you use a carrier gas like
2 nitrogen will affect the characteristic of the
3 tungsten film that is deposited; correct?

4 A. Yes, that's what -- that's shown here,
5 I think.

6 Q. Okay.

7 A. I don't know how common it is but --
8 actually, I don't think it's very common. I was --
9 I was kind of surprised to see that there's an
10 effect.

11 Q. Changing the amount or the gas flow of
12 these carrier gases will also affect the
13 characteristics of the tungsten film that's
14 deposited; correct?

15 A. That's a complicated question.

16 So for argon, I would expect any
17 changes to be minimal because it's truly inert.

18 For nitrogen, since it clearly has some
19 effect on surface morphology, there could be some
20 effect. There probably would be some effect, but I
21 think it's important to distinguish the use of the
22 term "gas flow."

1 So the deposition rate depends on how
2 many molecules per second hit the surface and then
3 what the conditions are, like the temperature of the
4 surface, to determine what fraction of those
5 actually deposit.

6 The thing that's -- that's not so
7 obvious here either in the '893, or in some of these
8 references, is that what you really want to know is
9 the partial pressure of the reacting species and the
10 partial pressure is because that's what determines
11 the impingement rate and ultimately the deposition
12 rate with other parameters like temperature.

13 And in a reactor like this, you have a
14 source of the gas flowing in at some flow rate, you
15 have your reactor and your wafer that's being
16 deposited, and then you have a pump which is pumping
17 the gases away.

18 So when I specify a flow rate coming
19 in, I'm actually not defining what the impingement
20 rate is on the surface because I can change the
21 speed of the pump. Typically there's a valve there
22 that allows you to make it pump faster or slower.

1 And if I pump faster, I reduce the impingement rate
2 on the surface by lowering the partial pressure.

3 So I have a hard time answering your
4 question completely when it's given in terms of flow
5 rate. Because if somebody is playing with the
6 pumping speed or the throttle valve that controls
7 the pumping speed --

8 Q. Right.

9 A. -- behind my back, I don't know what's
10 going on in impingement.

11 Q. When the patent discloses a particular
12 gas flow rate, the patent is trying to teach one of
13 ordinary skill in the art how much gas should be
14 introduced into the reaction chamber; correct?

15 A. Yes.

16 Q. Okay. So a higher gas flow rate would
17 indicate that more gas should be introduced;
18 correct?

19 A. It certainly will be more gas. I agree
20 to that.

21 Q. Right.

22 A. The thing that's missing is, we really

1 don't know when you -- the problem is one of
2 transference of the knowledge.

3 If it's taught here in a certain tool
4 and now I try to reproduce it in another tool that
5 has a different pumping speed or something, then
6 those numbers will probably not give me the same
7 result.

8 Q. Right.

9 A. So I have to be careful and judicious
10 about taking those numbers literally --

11 Q. Right.

12 A. -- for flow rates and translating them
13 into teaching it to me environment and my tool.

14 Q. Okay. Similarly, if the patent
15 indicates a lower flow rate, the patent is trying to
16 teach that less gas should be introduced; correct?

17 A. Yes, that's true. Sure.

18 Q. Okay.

19 A. Assuming nothing else changes.

20 Q. Right.

21 A. No pump changes, no valve changes and
22 so on.

1 Q. What is the function of a carrier gas?

2 A. A carrier gas can have several
3 different functions. Sometimes one wants a carrier
4 gas present to be able to increase the total
5 pressure in the chamber to prevent backstreaming of
6 species from the pump or from some downstream part
7 of the reactor back toward where the -- where the
8 wafer is, let's say.

9 Sometimes it could be that I like to
10 run at a higher pressure where I have a decent
11 pressure gauge that works.

12 Sometimes I know that for the control I
13 need in deposition rate, maybe I need a very thin
14 layer. So I don't want high gas flows because I
15 won't be able to time accurately how thick the layer
16 is going to be.

17 So what could I do? Well I can keep
18 the active species gas flows low, but I don't want
19 them to stay -- the reaction products to stay around
20 the sample, the wafer, very long. So if I add more
21 inert gas and I turn up the pumping speed, I can get
22 those species out away from the wafer more quickly.

1 So there are plenty of reasons that
2 people do it.

3 Q. Okay. So a carrier gas is not there to
4 carry reactants to the reaction site; right?

5 A. Well, it does that to some extent,
6 sure.

7 Q. Okay.

8 A. And that depends on pressure. If
9 you're working at sufficiently high pressures where
10 you have what's called viscous flow, then there are
11 convective forces that the flow patterns, the
12 streamlines of the carrier gas, may determine what
13 the supply of active species goes to the wafer.
14 That's when you're -- and that's important when your
15 supply rate limited.

16 If you work at much lower pressures,
17 then the presence of the carrier gas doesn't do much
18 because the active species hit walls or wafers
19 before they ever find a gas molecule. That's called
20 molecular flow.

21 Q. Okay. So changing the gas flow rate of
22 a carrier gas can affect the characteristics of the

1 tungsten CVD deposition; correct?

2 A. Which? If we're talking about Emesh,
3 do you mean argon or nitrogen?

4 Q. Even for argon.

5 A. For modest changes, I don't think that
6 would be. Modest changes in the flow rate, like
7 factors of 2 or something, 4, 5, I don't think there
8 will be much change.

9 Q. But larger changes in the gas flow rate
10 would affect the characteristics of the tungsten
11 deposition; correct?

12 A. Well, if I start at 1 Torr with my
13 reactive gases and I decide, well, let's run at a
14 100 Torr, well, that will change the flow patterns
15 to some extent. And, generally speaking, I would
16 expect that if I'm running under reaction-limited
17 conditions trying to fill that hole with a --
18 without a void, I won't see much change in that.

19 But if I'm running supply-limited
20 conditions, as the second layer prescribes, then I
21 might see a change in the deposition rate. I might
22 see nonuniformity across the wafer if the gases are

1 coming along the surface as opposed to a shower head
2 design.

3 Q. Changing the gas flow rate of a carrier
4 gas will change the pressure of the reaction
5 chamber; correct?

6 A. Assuming that the flow rate and partial
7 pressures of the carrier gas are already comparable
8 to or are significantly larger than the reactive
9 species, yes.

10 Q. And the pressure of the reaction
11 chamber is a factor that can affect the
12 characteristics of the tungsten film that is being
13 deposited; correct?

14 A. The characteristics of the film or the
15 deposition rate?

16 Q. Let's start with the deposition rate.

17 A. Certainly can change it. If -- if the
18 -- if the partial pressures of the reactive species
19 change, then the deposition rate will be affected.

20 If the partial pressure of the inert
21 gas changes within factors of -- I don't know -- 10
22 or something like that, I don't think the deposition

1 rate will change nor do I think the material will
2 change very much, if it's truly inert gas.

3 Q. So if you went from a gas flow rate of,
4 say, 1 sccm to a gas flow rate of, say, 50 sccm of
5 the inert gas -- let's use argon -- that would
6 affect both the characteristics of the deposition
7 film, that is the tungsten film that is being
8 deposited, as well as the deposition rate; correct?

9 A. I don't think so. It's inert gas.

10 Q. It's 50 times difference.

11 A. Yeah, but it doesn't matter. Unless
12 you're in supply rate-limited conditions, then you
13 have convective streamlines for where the gas flow
14 is that dramatically changed what the impingement
15 rate on the surface is.

16 So -- so, for example, if I have here
17 the wafer and if I have arranged the gas flow so
18 that at 1 Torr that inert gas flow is going -- I
19 don't know -- like this and it's hitting the surface
20 and coming with it will be the reactive species, and
21 then when I turn it up to 50, somehow very little of
22 the active species ever get to the surface and, I

1 mean, a transport- or supply-limited regime of the
2 reaction, then it could change the deposition rate.
3 Probably only the deposition rate.

4 Q. So you're saying that -- well, how
5 about this?

6 What if you went from a gas flow rate
7 of 0, no argon carrier gas, to 50 sccm's of argon
8 carrier gas?

9 In that situation, would you see any
10 effect on the characteristic of the tungsten film
11 that's being deposited?

12 A. I have to look at what -- what pump
13 speed I have and the vacuum design of the system
14 because, I mean, if it were 0, I might be working at
15 a total pressure of the reactive species at the
16 range of 100 milliTorr or some Torr or something
17 like a few Torr, something like that.

18 If all of a sudden it goes -- that
19 adding of the inert gas flow pushes it up to 100
20 Torr, well, then, I better make sure the pump can
21 handle it.

22 Q. So are you saying that it would or

1 would not affect the characteristic of the tungsten
2 film that's being deposited?

3 A. Of the tungsten film?

4 Q. Yeah.

5 A. I think minimally.

6 Q. All right.

7 A. Except under the unusual circumstances
8 that I described with my hand waving that's now on
9 the videotape --

10 Q. Right.

11 A. -- under supply rate-limited
12 conditions.

13 Q. Okay. So it's your opinion that really
14 the use of a true inert gas, like argon, has minimal
15 effect on the characteristic of the tungsten film
16 that's being deposited?

17 A. Yes, it doesn't have a significant
18 effect on the tungsten film. It has effect
19 secondarily in determining how long the residence
20 time is in the reactor and so -- and what the total
21 pressure is.

22 Q. Okay. The gas flow rate of the inert

1 gas, using argon as the example, would affect,
2 however, or would potentially affect, however, the
3 rate at which the film is deposited; correct?

4 A. No. I think I just -- didn't I just
5 address that question?

6 The rate at which the film was
7 deposited depends on the process parameters like
8 wafer temperature and the active gas partial
9 pressures and impingement rates --

10 Q. Right.

11 A. -- but not the impingement rate of
12 argon.

13 Q. So all things being equal, if you had
14 an increased flow of carrier gas, like argon, you
15 would not increase the tungsten film deposition
16 rate; correct?

17 A. Typically not very much, except for
18 secondary effects that have to do with the design of
19 the -- of the vacuum system.

20 Q. Even though an increased flow of
21 carrier gas means increased care -- more of the
22 reactant is carried to the reaction site?

1 A. No. No, it isn't.

2 When you think about these reactors,
3 you have to imagine that each of the species has its
4 own partial pressure which relates to the number of
5 molecules per cubic centimeter, and except under the
6 specific circumstances where convective flow is
7 sending things a little bit haywire, they don't
8 interact substantially.

9 It's only when you change -- only when
10 you can change the total convective flow pattern of
11 the active species by changing the flow rates of a
12 truly inert gas will you see an effect.

13 Q. Didn't you say that the carrier -- one
14 of the functions of the carrier gas is to carry
15 reactants to the reaction site?

16 A. It can be if you're working at
17 relatively high pressures.

18 Q. Okay. So let's look at Emesh, which is
19 Exhibit 14, and we were talking about embodiment 2,
20 which is the embodiment that you relied on for your
21 declarations.

22 Emesh discloses that the time for the

1 tungsten CVD deposition of the first layer is 200
2 seconds; correct?

3 A. (Reviewing document). Let's see.

4 Where is that? The second embodiment --

5 Q. Second embodiment.

6 A. -- starts on column 8 near the bottom.

7 Q. Right. It's shown in the table in
8 column 11 near the bottom.

9 A. Yes.

10 Q. And I think step 3 is the step where --

11 A. Right.

12 Q. -- the first layer of tungsten is
13 deposited.

14 A. Right.

15 Q. And it says time --

16 A. Yes.

17 Q. -- 200 seconds.

18 And what Emesh is teaching is that you
19 are depositing the first layer of tungsten for 200
20 seconds to fill the contact hole; correct?

21 A. Uh-huh.

22 Q. And following the deposition of the

1 first layer of tungsten, Emesh teaches that you
2 conduct an etchback of the first layer of tungsten;
3 correct?

4 A. Yes.

5 Q. And that etchback is to remove the
6 tungsten that was deposited on the substrate surface
7 outside of the hole; right?

8 A. Yes.

9 Q. All right. And that etchback would
10 then remove that excess tungsten, leaving only
11 tungsten within the hole; correct?

12 A. Yes.

13 Q. All right. And typically when you
14 design processes for semiconductor manufacturing,
15 you would not design them to waste materials;
16 correct?

17 MR. COLAIANNI: Objection
18 hypothetical.

19 THE WITNESS: Well, of course
20 nobody likes to waste things, but the reality is
21 that semiconductor manufacturing wastes a lot of
22 material because it uses subtractive processes.

1 BY MR. CHEN:

2 Q. It wouldn't be perfect, of course. You
3 could never achieve that level of perfection with no
4 waste, but you wouldn't specifically design it to
5 waste materials; correct?

6 A. Yeah, this is usually pretty low on the
7 priority list --

8 Q. Okay.

9 A. -- one way or the other.

10 Q. In other words, if you needed a layer
11 to be 5000 -- 500 angstroms thick, you would not
12 then deposit a layer of 1,000 angstroms and then
13 etchback to get your 500 angstroms; correct?

14 MR. COLAIANNI: Objection.
15 Incomplete hypothetical.

16 THE WITNESS: Well, there may be
17 other considerations in the total process flow.

18 Remember that the game is never
19 about optimizing only one step or sub-step of a
20 sequence. It's about the consequences of the total
21 sequence. So it sounds crazy to do that --

22 BY MR. CHEN:

1 Q. Right.

2 A. -- in isolation --

3 Q. Sure.

4 A. -- but there may be benefits to it or
5 only disadvantages. It depends on the context.

6 Q. Okay. The purpose of depositing the
7 first layer of tungsten in Emesh embodiment 2 is to
8 fill the contact hole; correct?

9 A. Yes.

10 Q. All right. They are not looking for
11 film to remain outside of the contact hole because
12 they conduct an etchback; correct?

13 A. Well, it's their choice of what
14 sequence of things they want to do to accomplish the
15 result. There may be a benefit to depositing extra
16 and then doing some kind of etchback planarization.

17 Q. Okay. So you're saying that there
18 could be a potential benefit to Emesh's -- to the
19 fact that there's tungsten deposit outside of the
20 hole, which is layered, which is then subsequently
21 etched, removed through etchback process?

22 A. There may be.

1 Q. But you don't know what that benefit
2 is?

3 A. I don't recall that the larger context
4 is described here. The two embodiments give two
5 ways of achieving a result.

6 Q. Okay.

7 A. But it's just for this part of a much
8 larger process flow.

9 Q. Okay. But, nevertheless, Emesh --
10 Emesh teaches that you would conduct the first CVD
11 tungsten deposition for 200 seconds in order to fill
12 the contact hole; correct?

13 A. I think that's too strong a statement.
14 Emesh gives as an example a set of
15 process parameters and example 2, the table, gives
16 you a list of them that would accomplish the filling
17 in 200 seconds, but I don't think that need -- that
18 should be interpreted as the only condition and the
19 only time that could be realized using the teachings
20 of Emesh, in particular about gas flow ratios and
21 things like that, that are important to the very
22 characteristics that he's trying to get out of these

1 two layers.

2 Q. Okay. But the -- what the parameters
3 that Emesh discloses for embodiment 2 to fill the
4 contact hole are tungsten CVD deposition of 200
5 seconds; correct?

6 A. That's what's in example 2, yes.

7 Q. Okay. It's your opinion that the
8 200-second deposition time taught by Emesh is too
9 long and unnecessary to fill the contact hole;
10 correct?

11 A. Are you looking at my declaration?

12 Q. Yes.

13 A. Let's look at how I said that.

14 Q. I think the discussion is fairly long.
15 It's in section 5 of your deposition, but I think
16 where your conclusion -- and please feel free to,
17 you know, review it as necessary -- but your
18 conclusion, I believe, is in paragraph 5F where you
19 say that:

20 "Thus, a POSITA would have understood
21 that reducing a deposition time to be 80 seconds, 80
22 seconds, which is the time it takes to deposit a 2

1 micron layer using a 25 angstrom per second
2 deposition rate disclosed in Emesh, would be proper
3 because the hole remains completely filled after the
4 etchback process."

5 A. Yes. So -- so the statement that 200
6 seconds is more than needed is based on at least two
7 -- two examples.

8 One of them is the recognition that in
9 Emesh, there are adhesion layers of reasonable
10 thickness already inserted in the half micron hole,
11 thereby changing the diameter.

12 And the second because as I -- as I
13 explained in regard to example 2, that table, that
14 these are examples of parameters, but there are a
15 variety of correlated parameters which would give
16 faster or slower deposition rates, and that's part
17 of the reason that I explain that the flow rates
18 alone do not tell you what happens to the deposition
19 rate.

20 So by changing the pumping speed, for
21 example, I can increase or decrease the deposition
22 rate without changing the flow rates at all, and

1 we're not given here information about what the
2 pumping speed is or what the relevant partial
3 pressures are that are really the critical
4 parameters for that surface deposition rate to be
5 determined.

6 But I think in 5 here, I'm really
7 talking about the adhesion layer part of the story.

8 Q. Nevertheless, your conclusion is that
9 you only need to deposit the CVD tungsten for 80
10 seconds as opposed to the 200 seconds disclosed in
11 Emesh; correct?

12 A. Yes. This is -- this is for filling
13 Emesh's hole.

14 Q. Right. Right. For filling the hole of
15 the diameter disclosed in Emesh --

16 A. Yes.

17 Q. -- which is .5 microns?

18 A. For filling the hole that's described
19 in Emesh, which has these adhesion layers in it.

20 Q. Right. It starts at .5 microns, but
21 then it has some adhesions on it?

22 A. Gets smaller, yes.

1 Q. Okay. Now, Emesh discloses that to
2 fill the hole, the first layer of tungsten that they
3 deposit should be about 5000 angstroms; correct?

4 A. (Reviewing document).

5 Q. I believe the thickness of that layer
6 is described at column 9 line 7.

7 A. Would you please repeat the question?

8 Q. Emesh discloses that to fill that
9 contact hole, you should deposit the tungsten layer
10 of roughly 5000 angstroms using the process
11 parameters described in the table on column -- in
12 column 11; correct?

13 A. No, I don't think that's what he says
14 here.

15 He says about 5000 angstroms tungsten
16 was deposited. He didn't say that's what's needed
17 to fill the hole. He said, we just deposited that.

18 Q. All right. At column 9 line -- line 7,
19 Emesh states:

20 "About 5000 angstroms tungsten was
21 deposited using a low hydrogen-to-tungsten
22 hexafluoride ratio of about 6 to 8, and 0 to 15 sccm

1 of silane, in a carrier gas of argon, at a total
2 pressure of 9 Torr, to a sufficient thickness to
3 fill the contact vias with a film of tungsten with
4 high step coverage."

5 A. Yes. So that's enough to at least fill
6 the hole.

7 Q. Right. So what Emesh is saying is that
8 that thickness was a sufficient thickness to fill
9 the contact vias with a film of tungsten with high
10 step coverage; right?

11 A. To at least fill it. Remember, he does
12 etchback after this. So -- so that means he didn't
13 need the full 5000 to fill the hole. Otherwise,
14 there would be nothing to etchback; right?

15 Q. That's not true; correct?

16 Because no matter what, when you
17 deposit the tungsten, you would have tungsten
18 material on the surface area outside of the hole,
19 and if you wanted to get rid of that, you would need
20 to conduct the etchback; correct?

21 A. Well, let me read this again.

22 (Reviewing document).

1 Yes, you're right there. Of course
2 it's deposited on the top surface as well.

3 Q. Right.

4 A. Right.

5 So -- so where -- where is the
6 disclosure of what the width and depth of the hole
7 is in embodiment 2?

8 Q. (Pause). Well, it says that in column
9 9, it discusses the aspect ratio. Column 9 line 15.

10 A. Uh-huh.

11 Q. And then at column 9 beginning at line
12 47, it's talking about the second embodiment.

13 A. Uh-huh.

14 Q. And it's talking about the -- how the
15 method is advantageous for filling the small via
16 holes of roughly .5 microns.

17 A. Okay. So -- so if you took the
18 simplest model and you had no adhesion layers.

19 Q. Okay.

20 A. And it's a half micron wide by a micron
21 deep and you put 5000 angstroms on, you will
22 certainly overfill the hole; right?

1 Q. Well --

2 A. And if you look at FIG. 2C, which
3 relates to this embodiment, component 40 is what
4 fills the hole, and you notice that the little dip
5 in the middle over the trench over the hole doesn't
6 extend down to the top surface of the substrate.

7 And it's important to note that if it
8 did, if you had only provided -- if you hadn't
9 overfilled the hole, then that little dip would be
10 at the surface of the insulator number -- well,
11 what's the number? I don't see a number here -- of
12 the insulator that has the hole in it.

13 So that when you did any etchback, you
14 would propagate that little crevice down into the
15 hole and create a void. So you have to overfill it.

16 Q. So --

17 A. I agree that, you know, there's enough
18 to have some etchback on the blanket areas.
19 That's -- that's correct, but you have to overfill
20 it --

21 Q. Okay.

22 A. -- if you're going to do etchback.

1 Q. Okay.

2 A. So the 5000 angstroms is an
3 overfilling, according to the dimensions of the hole
4 that you suggest that you found, and it has to be
5 greater than what's needed.

6 Q. Okay. So whatever the case is, for the
7 Emesh process that's being described, it's important
8 that they use or they deposit 5000 angstroms of the
9 first layer of tungsten?

10 A. Well, I don't know if that's the number
11 it has to be. It's important that you overfill.

12 Q. Okay. It's important that you
13 overfill.

14 Now, looking at FIG. 2C, which you just
15 referred to, you said that if there was no
16 overfilling, then that divot in the layer of
17 tungsten at the center of the hole would extend down
18 effectively to the -- the surface of the -- the
19 outer surface of the hole; correct?

20 A. Yes.

21 Q. All right. And so as shown in FIG. 2C,
22 what does -- how much overfilling would you estimate

1 is there?

2 A. How much overfilling is here?

3 Q. Yeah.

4 A. Well, you mean where is the bottom of
5 the little crevice?

6 Q. Uh-huh. As compared to the height of
7 the hole.

8 A. Well, you know, this is -- this is
9 difficult to answer because the drawing is clearly
10 not to scale.

11 Q. Okay.

12 A. Because it's supposed to have an aspect
13 ratio of 2.

14 Q. Okay.

15 A. And this is an aspect ratio of 1, to
16 start with.

17 Q. Okay. But all you really need is to
18 overfill it such that when you do the etchback, the
19 crevice is above the hole? So that --

20 A. Yes.

21 Q. -- when you remove the excess tungsten,
22 you don't propagate the crevice within the hole;

1 correct?

2 A. Right. Right.

3 Q. Okay. So you would need to do some
4 amount of overfilling but --

5 A. Yes.

6 Q. -- you wouldn't overfill it by twice
7 the amount; correct?

8 A. I don't know. It probably doesn't cost
9 you much to do more -- more than less. I mean, when
10 you're running the tool that's going to do the
11 etchback, if you have to run it an extra 10 percent
12 of time, it probably doesn't matter because you
13 already have the overhead of moving the wafer into
14 the tool, taking it out and so on.

15 Q. Okay.

16 A. I don't know how to estimate that.

17 Q. Okay. But then you would -- then what
18 you're saying is that you would want to do a certain
19 amount of overfill to ensure that you don't have
20 that crevice propagated within the hole?

21 A. Right.

22 Q. Right. And what Emesh teaches is that

1 you should deposit a layer of tungsten that is 5000
2 angstroms in thickness; correct?

3 A. It's what he teaches in the example,
4 yes.

5 Q. Right. And that example is for the .5
6 micron diameter hole; correct?

7 A. Yes, I think so.

8 Q. Right. And that thickness is based on
9 the parameters for the deposition that Emesh
10 specifically discloses in the table at column 11;
11 right?

12 A. I don't think I could go that far. I
13 mean, he's giving an example in the table that's
14 shown. He says 5000 angstroms. That will clearly
15 overfill the hole. That's what's needed, and later
16 in the method he says down in line 47:

17 In the method of the second embodiment,
18 the first layer is provided under reaction
19 conditions for high step coverage and that it's
20 advantageous in filling small via holes,
21 approximately -- the little tilde -- .5 microns.

22 So I don't think that he's -- he's not

1 saying that there's something magic about a half
2 micron here. He's saying small vias holes are going
3 to be in the range of half micron. They used to be.
4 I think the implication is, we used to be working at
5 a micron, now we're at a half micron, and tomorrow
6 we'll be at a quarter micron.

7 Q. So what Emesh teaches for embodiment 2
8 is a deposition time for the first tungsten CVD
9 deposition of 200 seconds; correct?

10 A. Example 2.

11 Q. Right. And Emesh teaches that for that
12 first layer of CVD tungsten deposited for 200
13 seconds, you achieve a 5000-angstrom thickness;
14 correct?

15 A. (Reviewing document). Well, I suppose
16 the 5000 angstroms in the spec corresponds to the
17 example 2 would be the natural assumption.

18 It doesn't say the thickness in example
19 2, which normally one would expect to find there.

20 Q. Right. But if you look at the spec --

21 A. Yeah. Yeah.

22 Q. -- at column 9, when it's discussing

1 the deposition of the 5000-angstrom layer --

2 A. Yes.

3 Q. -- of tungsten, it refers you to the
4 parameters disclosed in example 2 in the table;
5 correct?

6 A. Yes.

7 Q. Okay. Now, you gave the opinion that
8 to achieve the same objectives of Emesh, a person of
9 ordinary skill in the art would know that only 80
10 seconds are necessary to fill the contact hole;
11 correct?

12 A. To fill the hole of Emesh.

13 Q. Yes.

14 A. Is that what you said?

15 Q. And I think your conclusion is at
16 paragraph 5F of your declaration.

17 A. (Reviewing document). Yes.

18 Q. All right. So Emesh teaches 200
19 seconds for a 5000-angstrom thick layer, whereas,
20 you teach or you propose 80 seconds for a
21 2000-angstrom thick layer; correct?

22 A. I don't -- (reviewing document).

1 Is there someplace I'm allowed to
2 write? (Laugh). I want to get the numbers right.

3 Q. If you want to write on the reference,
4 you can do that. I mean, on the exhibit. Sorry.
5 It will be -- I mean, it will be recorded.

6 A. Well, let me just think it through
7 then. (Pause).

8 So the calculation that I included in
9 my reply declaration, Emesh discloses that the first
10 conductive layer 40 has a step coverage of greater
11 than 90 percent. So a deposition of .2 microns,
12 2000 angstroms, on a planar surface would yield at
13 least .18 microns on the sidewall, and that's more
14 than is needed to completely fill the remaining void
15 -- vacancy volume in what started out as a half
16 micron hole before the adhesion layers were put
17 down.

18 So what's needed is .142 microns, and I
19 think that's what corresponds to the 80 seconds.

20 No. The 80 seconds is 2000 divided by
21 25; right?

22 Yes. 80 seconds is 2000 divided by 25,

1 and that will fill the hole because you only need
2 .14.

3 Q. Okay. So what Emesh specifically
4 teaches is a layer that's 5000 angstroms thick and
5 requires 200 seconds to deposit that layer; correct?
6 That's what Emesh teaches?

7 A. No. Emesh teaches that he deposited
8 5000 angstroms to fill the hole and more. That's
9 what -- that's what it says.

10 Q. And you said it's important to do
11 overfilling; correct?

12 A. Yeah. So he overfills the hole.

13 Q. Right. You -- in your example, you're
14 not overfilling the hole?

15 A. No, because I'm looking here at what it
16 takes to fill the hole and just to fill the hole
17 without a void, anticipating that we'll just add the
18 second layer on top of that.

19 Q. So in your example, the crevice would
20 be propagated throughout the -- the --

21 A. No. No. It would look like -- well,
22 this FIG. 1 is not a good example, but basically

1 where there's a crevice after -- since there's --
2 I'm not talking about using any etchback. The
3 second layer deposition, which is the low stress
4 layer, will fill that crevice and that's just fine.

5 Q. Why wouldn't there be etchback?

6 Doesn't Emesh teach the use of etchback?

7 A. Yes, but it's not needed.

8 Q. So your modification to the Emesh
9 process includes eliminating the etchback step?

10 A. Well, you could probably do it either
11 way.

12 Q. Okay. So in order to use your
13 modification to the Emesh process, you would need to
14 eliminate the etchback step; correct?

15 A. No, I didn't say that.

16 I think you can do it either way.

17 Q. So if you do have the etchback step in
18 your modification to the Emesh process, you would
19 then propagate the crevice throughout the contact
20 holes; correct?

21 A. Not necessarily.

22 Q. You said it was important for Emesh to

1 do overfilling so that you do not propagate the
2 crevice throughout the contact holes because in
3 Emesh you do an etchback, and if you did the
4 etchback and you had the crevice, it would be
5 propagated throughout the contact holes.

6 That was your testimony; correct?

7 A. Right, but I could -- if I wanted to do
8 the etchback, I could do more than 80 seconds and
9 still be in the range as disclosed in the '893
10 patent and have enough to deal with any alteration
11 that might happen in the crevice, if I do etchback.

12 Q. So I'm trying to understand what you're
13 proposing as the modification to Emesh, which you
14 rely on for your declaration and your opinion that
15 Emesh discloses certain limitations of the '893
16 patent.

17 In your proposed modification, is there
18 etchback or not?

19 A. Let me see how I stated that.

20 (Reviewing document).

21 Okay. Sorry. I had to reread.

22 So, no, I'm proposing the same thing

1 that Emesh has with the etchback. The 2000
2 angstroms deposition, which is done in 80 seconds,
3 will more than fill the hole and, therefore, be fine
4 without the crevice encroaching on the area in the
5 hole.

6 Q. Okay. So let me -- let me make sure I
7 understand your modification to the Emesh process.

8 Everything is effectively the same as
9 the Emesh process. The only difference is, is that
10 you're changing the time of the first tungsten CVD
11 deposition from 200 to -- 200 seconds to 80 seconds,
12 which will result in a CVD tungsten film of 2000
13 angstroms instead of 5000 angstroms; correct?

14 A. Yes.

15 Q. And it's your opinion that doing that
16 will still achieve all of the objectives that Emesh
17 is trying to achieve, which is filling the contact
18 hole without a void and being able to etchback and
19 depositing the second layer of tungsten without
20 propagating a crevice in the contact hole; correct?

21 A. That's correct.

22 Q. Okay.

1 A. And I'd like to add that these numbers,
2 which we do as a kind of sanity check to see what
3 works and what doesn't compared to the specific
4 examples given, are only one part of the picture.

5 I explained several times the kinds of
6 things that happen in the real world. So one of
7 them is the issue that deposition rates and,
8 therefore, the times it would take are not really
9 specified here to the precision that would be
10 necessary for one of ordinary skill.

11 Because one of ordinary skill knows
12 that it's the impingement rate and the associated
13 partial pressures that are important, and they're
14 not only determined by flow rates.

15 Secondly, in a general sense, these
16 kinds of examples are subject to -- the parameters
17 given in such examples are subject to the
18 recognition that experimentation never put -- never
19 recognizes fixed boundaries on parameters, that
20 these are kind of gray boundaries at the edges.

21 And so I think it's -- it's an
22 exaggeration of importance to take some of these

1 numbers literally. Though we always in your
2 business check these things for legal consistency
3 and their legal consequences. I know that.

4 Q. So it's your opinion that an 80-second
5 deposition of CVD tungsten, keeping all the other
6 parameters the same as what's discussed in Emesh,
7 would allow a person of ordinary skill in the art to
8 achieve the same objectives as disclosed in Emesh
9 for the deposition of the first layer of tungsten;
10 correct?

11 A. I didn't get the first part of that
12 question.

13 Q. Let me re-ask it.

14 It's your opinion that changing the
15 deposition time of the first layer of CVD tungsten
16 in Emesh embodiment 2 from 200 seconds to 80 seconds
17 would still achieve all the objectives that Emesh is
18 trying to achieve with that deposition of the first
19 layer of tungsten; correct?

20 A. Yes.

21 Q. Okay. So what you're saying then is
22 Emesh does 120 seconds -- Emesh discloses the -- an

1 additional 120 seconds of CVD tungsten deposition
2 for no benefit; correct?

3 A. Well, I don't know that there's no
4 benefit to that.

5 There's for one thing -- so you're
6 talking about 80 seconds compared to 200 seconds.
7 It may be that there's better smoothing if you
8 provide a little more. So you start with these
9 crevices and then you put a layer on top that will
10 be conformal, relatively conformal because it's
11 fairly flat, and so it will have a crevice on top.
12 In fact, it may even be depicted here.

13 No, it's not shown here, but there will
14 be some crevice there. And it may be that by adding
15 more and then sputtering down, backetching down
16 through more material, you can make that top surface
17 of the second layer smoother, which may have
18 benefits in terms of lithography, for example.

19 Remember, we had an extensive
20 discussion about another patent at issue where
21 planarity was important.

22 So I don't know if that's why he didn't

1 mind wasting 120 seconds of time, but there are
2 plenty of reasons that could happen and some of them
3 are even more practical than that. Like, you know,
4 getting to a steady state in the tool when you first
5 turn it on or something like that. There are many
6 considerations.

7 This industry does not worry a lot
8 about the extra material.

9 Q. So you're saying that there is some
10 benefit to Emesh's deposition of 200 seconds of CVD
11 tungsten. You just don't know what that is;
12 correct?

13 A. No. No. I said I don't know if
14 there's a benefit to it or what that might be.

15 Q. Okay.

16 A. There could be. There may not be.
17 And, remember, this is only one concrete example
18 he's trying to show of what he's disclosing in the
19 patent.

20 Q. Right. Emesh teaches 200 seconds, but
21 you don't think that's necessary. You think only 80
22 seconds is necessary; correct?

1 A. Yes.

2 Q. And Emesh teaches a 5000-angstrom thick
3 layer, and you don't think that's necessary. You
4 think only 2000 angstroms is necessary; correct?

5 A. Yes.

6 Q. And you can't explain why Emesh would
7 specifically teach the deposition of an additional
8 3000 angstroms of CVD tungsten for that first layer;
9 correct?

10 A. I could speculate on reasons, as I
11 have, but that's about it.

12 Q. Did you run any experiments based on
13 your modifications of the Emesh parameters to
14 determine whether those modifications would still
15 fill a contact hole of .5 micron void-free?

16 A. No.

17 MR. CHEN: Why don't we take a
18 break.

19 THE VIDEOGRAPHER: We are going
20 off the record at 12:18.

21 (Whereupon, at 12:18 p.m., a
22 luncheon recess was taken.)

AFTERNOON SESSION

(12:55 p.m.)

GARY W. RUBLOFF, PH.D.

called for continued examination and, having been
previously duly sworn, was examined and testified
further as follows:

CROSS-EXAMINATION (CONTINUED)

THE VIDEOGRAPHER: We are now on
the back on the record at 12:55.

BY MR. CHEN:

Q. All right. Dr. Rubloff, I believe for
your reply declaration in connection with the 467
IPR, you also rely on the Hasper reference that we
discussed earlier today; correct?

A. Yes.

Q. The Hasper reference is Exhibit 11.

A. Yeah. (Indicating).

Q. Right. And you rely on the Hasper
reference for its definition of "step coverage";
correct?

A. Yes.

Q. And the Hasper definition of "step

1 coverage" is the definition that you used for your
2 analysis of your dec -- for your analysis included
3 in your declaration for the 467 IPR; correct?

4 A. Yes.

5 Q. And as we discussed earlier today, the
6 Hasper definition of "step coverage" is the ratio of
7 the tungsten thickness taken halfway up the feature
8 that is over the substrate surface thickness at the
9 moment the feature closes; correct?

10 A. Yes.

11 Q. And as we discussed earlier today that
12 for any step coverage less than 100 percent, the
13 layer deposited on the sidewall of the contact hole,
14 the surface at that layer would have some tilt;
15 correct?

16 A. Yes.

17 Q. And so the layer would be -- so if the
18 thickness midway up the feature is A, the thickness
19 of the layer near the top of the contact hole would
20 be thicker than A; correct?

21 A. Yes.

22 Q. And the thickness of the layer near the

1 bottom of the contact hole would be thinner than A;
2 correct?

3 A. Yes.

4 Q. Okay. And so for a step coverage of 90
5 percent, which I believe is what you used to perform
6 your calculations of what thickness tungsten is
7 needed to fill the contact hole in Emesh.

8 For a step coverage of 90 percent, the
9 actual thickness of the layer closer to the bottom
10 of the hole would be less than -- would be less than
11 the .142 microns or 1420 angstroms of the first
12 tungsten layer that you say would be needed to fill
13 the via hole; correct?

14 A. Yeah, a little bit. Yes.

15 Q. Right. So in order to fill that via
16 hole so that there's no void, you would actually
17 need to deposit more than what you've described here
18 in your declaration at paragraph 6C; correct?

19 A. Yeah, at the bottom maybe a little bit,
20 but these were just estimates to give a feeling for
21 what's really happening. I mean, I didn't attempt
22 to model the vertical profile.

1 There always is, as -- as the Hasper
2 reference shows, there always is a vertical profile
3 to this and it's subject to, of course, the dominant
4 features of what reaction regime you're in, but also
5 to the details of how that vertical profile look and
6 how it's modified by the material reactions that I
7 mentioned earlier with crystallization, surface
8 diffusion and the like.

9 Q. So in order to fill the hole,
10 completely fill the hole with no void, the thickness
11 values that you've disclosed here in 6C would need
12 to be increased by some amount; correct?

13 A. A few percent probably.

14 Q. Okay.

15 A. Well, let me clarify that, actually.

16 When you have a 60 percent or a 90
17 percent step coverage, there will be a tilt to the
18 surface, but it's really hard to predict how much
19 surface smoothing is going on during the deposition
20 process. So it's -- it's difficult to estimate what
21 that correction is. There's a correction, but I
22 don't.

1 Q. All right. There's a correction but as
2 an internal --

3 A. I know about it.

4 Q. -- increasing the thickness of the
5 layer, but you are unable to determine how much that
6 would require; correct?

7 A. Yeah, I think it's small.

8 Q. Okay. But you don't know?

9 A. My intuition is that it would be small.

10 Q. Okay. Now, previously in your
11 declaration, you had determined the thickness of the
12 nucleation layer and adhesion layers on the
13 sidewalls of the contact hole; correct?

14 A. Yes.

15 Q. And you made that determination based
16 on a calculation using the step coverage of those
17 layers; correct?

18 A. Yes.

19 Q. Okay. Given what we just discussed
20 about how the thickness of the layers would vary
21 between the top of the contact and the bottom of the
22 contact, it's also true then that the calculations

1 that you made for the thickness of these, the
2 adhesion layers and the nucleation layers, would
3 actually be thinner towards the bottom of the
4 contact; correct?

5 A. Yeah. Yeah, a bit.

6 Q. Right. And especially there where
7 we're talking about a step coverage of 60 percent,
8 the variation in thickness would be more significant
9 than what we had discussed for the 90 percent step
10 coverage; correct?

11 A. Yes. Yes.

12 Q. Okay. And so the -- because the
13 nucleation layer and the adhesion layer are actually
14 thinner at the bottom of the hole, thinner than the
15 480-angstrom and 600-angstrom thicknesses that you
16 describe in paragraph 5E of your declaration, the
17 resulting hole would be greater than -- than the, I
18 guess, 2.284 micron hole size that you calculated in
19 your declaration; correct?

20 A. 2. -- I'm sorry. Where is 2.284?

21 Q. I think --

22 A. I'm sorry, I don't --

1 Q. -- you calculated the size of the hole
2 that would need to be filled by the first tungsten
3 layer based on the thickness of the adhesion layer
4 and the thickness of the nucleation layer --

5 A. Uh-huh.

6 Q. -- subtracted from the size of the
7 original hole --

8 A. Yes.

9 Q. -- which was .5 microns; correct?

10 A. Yes.

11 Q. And now that we've confirmed that at
12 least towards the bottom of the hole, the calculated
13 adhesion layer and nucleation -- the thicknesses of
14 the adhesion layer and the nucleation layers would
15 actually be thinner.

16 Then that means the size of the hole
17 after the deposition of the adhesion layer and the
18 nucleation layers would actually be larger than what
19 you had estimated in your declaration; correct?

20 A. Yes, so on.

21 Q. Yeah.

22 A. Subject to the -- the tilt in the

1 angle, the slant angle --

2 Q. Right.

3 A. -- on the sidewall, which is -- which
4 is dependent on the chemical nature of the
5 deposition process because the species on the
6 surface have some mobility, as I -- as I meant
7 before. So in some cases, it may be more or less
8 close to vertical than in others.

9 Q. Okay. And so because the hole at the
10 bottom of the contact is now larger than what you
11 had estimated, that means that the thickness of the
12 tungsten layer that is deposited or required to fill
13 the hole --

14 A. Uh-huh.

15 Q. -- would again need to be increased by
16 a certain amount; correct?

17 A. Right. But we were talking about a
18 difference between -- we were talking about 2000
19 angstroms deposition compared to 1420, which is in
20 FIG. 2B on page 10 of my declaration.

21 I mean, I don't think these effects
22 you're talking about are anything like the

1 difference between those two.

2 Q. Suffice it to say that --

3 A. A long ways to go to get there this
4 way.

5 Q. Sure. But suffice it to say that what
6 you calculated for the thickness of the tungsten
7 layer, right, that you believe would be required to
8 fill the contact hole with no void is actually too
9 low; correct?

10 A. It may be a little low, but I wouldn't
11 put much stock in that answer without doing a much
12 more serious evaluation of the vertical profile that
13 results from the adhesion layer and nucleation layer
14 chemistries themselves.

15 The work that we cited, Chris Kleijn's
16 work, Hasper is it? Is that the Hasper work?
17 These -- these are the kinds of -- of studies that
18 one would have to look at if you want to make a
19 better estimate of how big an effect it is that
20 you're getting at.

21 Q. Okay.

22 A. And I wouldn't speculate short of

1 taking something serious on like that modeling
2 effort.

3 Q. Right. So without that modeling effort
4 or at least that further study, you're not able to
5 say specifically by how much your proposed thickness
6 of the tungsten layer would need to be increased in
7 order to fill the contact hole; correct?

8 A. No, I don't think I can be quantitative
9 about it, short of a significant modeling exercise
10 like that.

11 But from having looked at -- I don't
12 know -- hundreds of cross-sectional SEMs for CVD
13 process, you know, I've been doing research in CVD,
14 including tungsten CVD, for -- for many years and
15 I've seen lots of SEM cross-sections. And I don't
16 recall substantial angle variation in many of those
17 cross-sections. Modest but not substantial.

18 Q. But you do agree that the thicknesses
19 would need to be increased by some amount; correct?

20 A. In principle, it could -- it could be.
21 I mean, if we assume that the step coverage is
22 measured right at the middle and that there is an

1 angle that goes from full coverage to less than full
2 further down, there will be some correction, but I
3 think it will be small.

4 Q. Okay. Now, the definition of "step
5 coverage" that's given in Hasper is based on the
6 ratio of A, which is the thickness of the layer
7 halfway up the feature, and B, which is the
8 thickness of the layer on the flat surface, flat
9 subsurface right outside of the feature or the
10 contact hole; correct?

11 A. Yes.

12 Q. Okay. And the definition of "step
13 coverage" given in Hasper performs that measurement
14 at the moment that the feature closes; correct?

15 A. Uh-huh.

16 Q. Right?

17 A. Yes.

18 Q. And we've discussed earlier today that
19 when the feature closes, then you are now preventing
20 additional reactant from entering into the contact
21 hole and, theoretically, the reactions or the --
22 within the contact hole would -- would stop;

1 correct?

2 A. Should, yes.

3 Q. Right. And, therefore, the thickness
4 of the layer on the walls would no longer increase;
5 correct?

6 A. That's correct.

7 Q. Right. Okay. So when you did your
8 calculations you started with the, I believe,
9 nucleation layer which is -- no. I'm sorry. Let me
10 restate that. I don't recall whether it was the --
11 I'm going to assume it's the adhesion layer. That
12 makes more sense.

13 So the first layer that's deposited in
14 the contact hole is the adhesion layer; correct?

15 A. I think that's right.

16 Q. Okay. And you calculated the
17 thicknesses of that layer based on the step coverage
18 of 60 percent; correct?

19 A. Yes. Now, I don't recall whether
20 that's -- that's disclosed in Emesh or not. I think
21 some of them were.

22 Q. Right. I believe you're right. Some

1 of the step coverages for those layers were
2 disclosed. Whether it's embodiment 1 that was
3 carried over to embodiment 2, I don't recall but --

4 A. The adhesion layer is Ti nitride.

5 Q. I think that's a fair assumption. I
6 don't --

7 A. Yeah, it is.

8 Q. -- recall.

9 A. It says it --

10 Q. Okay.

11 A. -- bottom of column 8.

12 Q. Okay. Okay. So the first layer that's
13 deposited in the hole is an adhesion layer of
14 titanium nitride?

15 A. Yes.

16 Q. And you calculated how -- what the
17 thickness would be within the hole of that titanium
18 nitride based on the deposited thickness on the
19 surface and a step coverage of at least 60 percent;
20 correct?

21 A. Yes.

22 Q. All right.

1 A. It's an assumption.

2 Q. Right. You're assuming that the step
3 coverage was 60 percent?

4 A. Yeah.

5 Q. Okay. In order for the -- your
6 calculations to be correct, you're using the Hasper
7 definition of "step coverage"; correct?

8 A. Yes.

9 Q. All right. And so assuming a step
10 coverage of 60 percent, you calculated that the
11 thickness of adhesion layer within the hole would be
12 480 angstroms; correct?

13 A. Yes.

14 Q. All right. However, as Hasper says,
15 their step coverage is measured at the moment that
16 the feature closes; correct?

17 A. Yes.

18 Q. Okay. So if you've deposited the
19 adhesion layer and you used your step coverage of 60
20 percent to determine the 480-angstrom thickness, at
21 that point the feature or the top of the contact
22 hole has now closed; correct?

1 A. So let's be careful, though. The
2 adhesion layer is Ti nitride sputter-deposited. The
3 Hasper reference refers only to CVD.

4 Q. Okay.

5 A. So the typical way people do step
6 coverage estimates is you've got a vertical step
7 like a little chair. You do the deposition. You
8 measure in a cross-sectional SEM what's on the top
9 and you measure halfway down the step. So there's
10 nothing about closing in that case.

11 Q. Okay. But the Hasper definition --

12 A. As I recall --

13 Q. I'm sorry.

14 A. -- I picked the 60 percent number to be
15 kind of conservative and to, you know, just get in
16 the ballpark.

17 Q. Okay. But the Hasper definition of
18 "step coverage" says that step coverage is the ratio
19 in percents of the tungsten thickness A taken
20 halfway up the feature depth and the substrate
21 surface thickness B at the moment the feature
22 closes.

1 That's the definition that Hasper uses
2 for "step coverage"; correct?

3 A. Yes, but --

4 Q. And --

5 A. -- that's the same definition I just
6 gave for what people normally do.

7 Q. Right. And that's the definition that
8 you used as well; right?

9 A. Yeah. Yeah. Yeah.

10 Q. And so when you've hit that point, the
11 feature is closed; correct?

12 A. You mean to make the measurement?

13 Q. Sure.

14 A. Yeah. If it's in a hole, yes.

15 Q. Right. Okay. So if the feature is
16 closed, how do you deposit more reactants to deposit
17 your next layer and your follow-on layer?

18 A. Oh, no, that has nothing to do with it.
19 Let me see if I can clear up this confusion.

20 When Hasper gives this definition, if
21 you were doing an experiment to try to measure the
22 step coverage in CVD, you could do this experiment

1 and try to time the deposition so that it's just
2 closed. It's probably not quite closed because if
3 it's already -- if it's after it's closed, it's
4 going to be too thick on top. You get the wrong
5 answer.

6 Q. Right.

7 A. So you look for a set of
8 cross-sectional SEMs that let you see one that's
9 essentially closed, and the reason you choose to do
10 that is you'd like to be able to see what is the
11 thickness with as much measurement accuracy as you
12 can. So you want it thick.

13 This, I think, would provide a kind of
14 minimum value to the conformality --

15 Q. Right.

16 A. -- or step coverage because in practice
17 you never go to the point where it's closed unless
18 you're filling. So you in that case have very high
19 conformality.

20 Q. Okay.

21 A. Does that help?

22 Q. Yes.

1 So the step coverage of a -- the step
2 coverage is a characteristic of the deposition;
3 correct?

4 A. Yes.

5 Q. All right. It is -- would you say it
6 is a constant at any point during the deposition?

7 A. No, probably not.

8 Q. Oh.

9 A. If you do very thin layer -- I think
10 the reality is, as you get toward closure --

11 Q. Right.

12 A. -- you may have some nonlinearities
13 because it changes the fraction that are getting
14 into the hole. It's changed the -- the aspect ratio
15 of the hole in a funny way. That's why you really
16 need more sophisticated calculations to know what to
17 expect.

18 Q. Okay.

19 A. But in most of these cases, we're
20 talking -- when you're trying to make conformal
21 structures, you're usually working in the regime
22 where you have reasonably high step coverage and

1 thin layers. So the adhesion layer, the nucleation
2 layer. These would be thin layers.

3 MR. CHEN: Uh-huh. Okay. I have
4 no further questions for Dr. Rubloff at this time.

5 MR. COLAIANNI: Can we take a
6 short break?

7 MR. CHEN: Sure.

8 MR. COLAIANNI: Okay.

9 THE VIDEOGRAPHER: We are going
10 off the record at 13:18.

11 (Recess - 1:18 p.m. - 1:30 p.m.)

12 THE VIDEOGRAPHER: We are on the
13 record at 13:30.

14 MR. COLAIANNI: I don't have any
15 questions.

16 Thank you, Dr. Rubloff, for your
17 time.

18 THE WITNESS: Oh. Oh, my
19 pleasure.

20 MR. CHEN: All right. Thank you
21 as well.

22 THE WITNESS: Thank you.

1 THE VIDEOGRAPHER: Okay. We are
2 going off the record at 13:30.

3 (Signature having not been waived,
4 the taking of the deposition concluded at 1:30 p.m.)

5

6 * * *

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

CERTIFICATE OF COURT REPORTER

UNITED STATES OF AMERICA)

DISTRICT OF COLUMBIA)

I, DENISE D. VICKERY, the reporter before
whom the foregoing deposition was taken, do
hereby certify that the witness whose testimony
appears in the foregoing deposition was sworn by me;
that the testimony of said witness was taken by me
in machine shorthand and thereafter transcribed by
computer-aided transcription; that said deposition
is a true record of the testimony given by said
witness; that I am neither counsel for, related to,
nor employed by any of the parties to the action in
which this deposition was taken; and, further, that
I am not a relative or employee of any attorney or
counsel employed by the parties hereto, or
financially or otherwise interested in the outcome
of this action.

Denise D. Vickery

Notary Public in and for the
District of Columbia

My Commission expires February 14, 2018

DEPOSITION ERRATA SHEET

Our Assignment No. J0254991

Case Caption: SAMSUNG ELECTRONICS CO. LTD. vs. HOME
SEMICONDUCTOR CORPORATION

DECLARATION UNDER PENALTY OF PERJURY

I declare under penalty of perjury
that I have read the entire transcript of
my Deposition taken in the captioned matter
or the same has been read to me, and
the same is true and accurate, save and
except for changes and/or corrections, if
any, as indicated by me on the DEPOSITION
ERRATA SHEET hereof, with the understanding
that I offer these changes as if still under
oath.

Signed on the _____ day of
_____, 2015.

GARY W. RUBLOFF, PH.D.

DEPOSITION ERRATA SHEET

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

SIGNATURE: _____ DATE: _____

GARY W. RUBLOFF, PH.D.

DEPOSITION ERRATA SHEET

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

Page No. _____ Line No. _____ Change to: _____

Reason for change: _____

SIGNATURE: _____ DATE: _____

GARY W. RUBLOFF, PH.D.