

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2
3 BEFORE THE PATENT TRIAL AND APPEAL BOARD

4
5
6 SAMSUNG ELECTRONICS CO., LTD.,

7 Petitioner,

8 v.

9 ACORN SEMI, LLC,

10 Patent Owner.

11
12 Case Nos. IPR 2020-01183

IPR 2020-1204

13 IPR 2020-1205

14 IPR 2020-1206

IPR 2020-1207

15 IPR 2020-1279

16 IPR 2020-1282

17 VIDEO-RECORDED ZOOM DEPOSITION

18 UPON ORAL EXAMINATION OF

19 KELIN J. KUHN, Ph.D.

20 VOLUME II

21 9:04 A.M. PDT

22 WEDNESDAY; JULY 7, 2021

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I N D E X

WITNESS: KELIN J. KUHN, Ph.D.

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Mr. Maier 227

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WEDNESDAY; JULY 7, 2021

9:04 A.M.

--oOo--

THE VIDEOGRAPHER: We are on the record. The time is 9:04 a.m. on July 7th, 2021. This deposition is being conducted using virtual technology, and all participants are attending remotely. Audio and video recording will continue to take place unless all parties agree to go off the record.

This is Media Unit 1 in the video-recorded deposition of Dr. Kelin Kuhn taken by counsel for petitioner in the matter of Samsung Electronics Company Limited versus Acorn Semi LLC, filed before The Patent Trial and Appeal Board, Case No. IPR 20200-1183.

My name is Lori Talbott with the firm Veritext. I'm the videographer. The court reporter is Judy Bonicelli from the firm Veritext. I am not related to any party in this action, nor am I financially interested in this outcome.

If there are any objections to proceeding, please state them at the time of your appearance, and we'll begin with the noticing attorney, please.

MR. MAIER: Cosmin Maier of Desmarais LLP on behalf of petitioner.

1 MR. PHILLIPS: Matthew Phillips from
2 Laurence & Phillips IP Law on behalf of the patent
3 owner Acorn.

4 THE VIDEOGRAPHER: Thank you. Would the
5 court reporter please swear in the witness?

6 KELIN J. KUHN, Ph.D.,
7 sworn as a witness by the Certified Court Reporter,
8 testified as follows:

9 DIRECT EXAMINATION

10 BY MR. MAIER:

11 Q. Good morning, Dr. Kuhn.

12 A. Good morning.

13 Q. Just a couple preliminary things first. Am I
14 correct that you did not discuss the substance of your
15 testimony between the end of last night's --
16 yesterday's deposition and today?

17 A. I've had no discussion with Matt Phillips on
18 any topic between yesterday and today.

19 Q. And have you discussed the substance of your
20 testimony with anyone in between the end of yesterday's
21 deposition and today's?

22 A. No.

23 Q. And have you performed any additional research
24 to help with your testimony in these depositions since
25 the deposition yesterday ended?

1 A. I reread my declaration.

2 Q. Anything else?

3 A. No. I just reread my declaration.

4 Q. Now, I want to pick up on something you said
5 yesterday. Yesterday you described the alleged
6 invention of the challenged patents using an analogy to
7 Lego blocks. Do you recall that?

8 A. Yes.

9 Q. Can you explain what you meant by that
10 analogy?

11 A. Yes, I can. I'm viewing this patent as a
12 patent that introduced an idea which is the idea of
13 putting this passivating and mid-separation layer
14 between a metal and a semiconductor for the purpose of
15 reducing contact resistance. And that idea used things
16 already in the industry.

17 As we've had some discussions, the idea of the
18 metal-semiconductor junction is certainly not new,
19 people had built metal insulator semiconductor
20 structures and semiconductor junction in the
21 source-drain region is well discussed in research at
22 the time of the patent. And the way I have always
23 perceived this patent, and it's almost in context with
24 Figure 8, is the inventors put the idea described by
25 Figure 8 on the table with all of the building blocks

1 to make Figure 8 existent in the industry already.

2 Q. And you used the term "patent" in the
3 singular, but were you referring to all of the
4 challenge patents that are at issue here?

5 A. Yes, that's correct. On the Acorn patents, I
6 often say patent singular because I tend to gloss over
7 the fact that there is a multiplicity of these patents.
8 So when I say Acorn patent, I do mean the set of Acorn
9 patents.

10 Q. So I want to break down a little bit about
11 which Lego blocks were known and what was actually
12 novel.

13 Metal interface layer semiconductor structures
14 were known before the alleged invention of the
15 challenge patents, correct?

16 A. Let me pause for a moment and ask a procedural
17 question. As with yesterday, I would like to take
18 short notes, and you can certainly have copies of them
19 whenever you want, to make sure that when I answer
20 these questions I'm answering the stack that you asked.
21 Are you okay with that?

22 Q. Yeah, that's fine. And we can mark them all
23 at the end.

24 A. Okay. So could you please reask the question?

25 Q. Yes, so metal interface layer semiconductor

1 structures were known before the alleged invention of
2 the challenge patents, correct?

3 A. Yes, metal interface layer semiconductor
4 structures were known before the invention of the
5 challenge patents.

6 Q. Metal insulating layer semiconductor
7 structures were known before the alleged invention of
8 the challenge patents, correct?

9 A. Metal insulating layer semiconductor
10 structures were known before the invention of the
11 challenge patents; that's correct.

12 Q. Structures comprising a metal layer, metal
13 oxide layer, semiconductor oxide layer, and
14 semiconductor substrate were known before the alleged
15 invention of the challenge patents, correct?

16 MR. PHILLIPS: Objection to scope.

17 THE WITNESS: Yes. Structures formed of
18 metal, metal oxide, semiconductor oxide, and
19 semiconductor were known. An example of this is a HiK,
20 gate dielectric.

21 (Reporter clarification.)

22 THE WITNESS: H-i-K, often with the K
23 capitalized.

24 BY MR. MAIER:

25 Q. It was known before the alleged invention of

1 the challenge patents that an interface layer between a
2 metal layer and a semiconductor could passivate the
3 semiconductor by satisfying dangling bonds, correct?

4 A. It was known prior to the patents that an
5 interface layer between a metal and semiconductor could
6 passivate dangling bonds on the semiconductor; that's
7 correct.

8 Q. It was known before the alleged invention of
9 the challenge patents that moving a metal layer farther
10 from a semiconductor would reduce the effects of MIGS
11 or metal-induced gap states, correct?

12 A. So the work of Tersoff showed that moving a
13 metal layer away from a semiconductor could reduce the
14 metal-induced gap states; that's correct.

15 Q. The novel aspect of the challenged patents was
16 to provide an interface layer between a metal and a
17 semiconductor that resulted in a reduction of specific
18 contact resistivity, correct?

19 MR. PHILLIPS: Objection. Form.
20 Objection. Scope.

21 THE WITNESS: One of the novel aspects
22 of the patent was to introduce an interface layer or a
23 combination of an interface layer and a separation
24 layer between the metal and the semiconductor to reduce
25 the contact resistance of a metal-semiconductor

1 junction.

2 BY MR. MAIER:

3 Q. So I think we've got our terminology a little
4 bit mixed up because you mentioned combination of
5 interface layer and separation layer. I believe that
6 the interface layer includes a separation layer and a
7 passivation layer. Is that your understanding?

8 A. Yeah, I accept that correction. To be clear,
9 there is a passivation layer and a separation layer,
10 and I believe the patent does call those two together,
11 an interface layer. In the literature, it is not
12 uncommon for the passivation layer alone to be called
13 the interface layer. So I will try to use the
14 terminology of the patent in a clear way and say
15 passivation layer and separation layer to keep that
16 clear.

17 Q. Okay, thank you. I appreciate that.

18 You mentioned that one of the novel aspects of
19 the patent was to provide an interface layer between a
20 metal and semiconductor that results in a reduction of
21 specific contact resistivity, correct?

22 A. Yes, I used the words "one of," that's
23 correct.

24 Q. What are the other novel aspects of the
25 challenge patents?

1 MR. PHILLIPS: Objection. Form. Scope.

2 THE WITNESS: I'd like to turn -- okay.

3 In addition to the Figure 8 discussion we've had, the
4 patent also discussed other applications of the
5 structure, and I point out, in particular, the patent
6 has a section -- and let me find this. Okay, so I'm in
7 the '423 patent, and I'm at the bottom of 15, and I'm
8 going through one of several embodiments.

9 And the first embodiment is the interface
10 layer incorporated into a device operable to pass
11 current through the semiconductor surface and the
12 interface layer during operation, and what I'm looking
13 for -- ah, is in paragraph -- column 16 where the
14 patent emphasizes barrier height can be adjusted. And
15 then later on, the patent describes making the barrier
16 height larger in order to create a Schottky barrier as
17 opposed to an Ohmic barrier.

18 And so my point here is, and I'm not trying to
19 limit this, but the patent describes more embodiments
20 than just the one that we've been talking about to a
21 large extent in this deposition.

22 BY MR. MAIER:

23 Q. But all of those embodiments that the patent
24 describes rely on the concept of using an interface
25 layer between a metal and semiconductor to reduce the

1 specific contact resistivity, correct?

2 MR. PHILLIPS: Objection. Form. Scope.

3 THE WITNESS: And I disagree with that,
4 because of the discussion of making this do a Schottky
5 diode, a diode that is conducting in one direction and
6 not conducting in another direction. So I believe the
7 core of the patent is the passivation and the use of
8 the MIGS separation layer, the passivation, and the
9 MIGS separation layer. The piece of the invention that
10 I consider the most novel is the piece reflected by
11 Figure 8 for a minimum in the curve of the specific
12 contact resistivity.

13 But the patent discusses other embodiments,
14 and I've not spent a lot of time studying those other
15 embodiments, so I'm reluctant to limit the patent to
16 embodiments I've not studied in any great length.

17 (Exhibit 2070 marked for identification.)

18 BY MR. MAIER:

19 Q. So let's try to limit this to what you've
20 actually testified about via your declaration. Okay.
21 Turn to paragraph 52 of your declaration, and the one
22 I'm referencing is Exhibit 2070 in the 1204 proceeding.

23 A. I'm at paragraph 52.

24 Q. In paragraph 52, you say, "The core concept
25 underlying the Acorn patents is deeply

1 counterintuitive. The idea that one would place an
2 insulator which has higher resistivity than either a
3 metal or a semiconductor at the metal-semiconductor
4 interface to improve the contact resistance of the
5 junction is not something that would occur to even very
6 skilled practitioners," and so forth.

7 Do you see that?

8 A. Yes.

9 Q. So in your declaration, the novel aspect of
10 the Acorn patents that you identified was the idea of
11 placing an insulator at the interface between a
12 metal-semiconductor structure to improve the contact
13 resistivity of the structure, correct?

14 MR. PHILLIPS: Objection. Form.

15 THE WITNESS: So as I stated in this
16 paragraph, I consider the core concept to be the idea
17 of the insulator which has the high resistivity to be
18 placed at the metal-semiconductor interface to improve
19 the resistance. That, in my mind, is a
20 counterintuitive concept and it's core to the patent.
21 It's not the only concept in the patent and it's not,
22 you know, the only embodiment in the patent, but it's
23 the one that struck me as being central and
24 counterintuitive at the same time.

25

1 BY MR. MAIER:

2 Q. And is that core concept a novel concept
3 attributable to the Acorn patents?

4 MR. PHILLIPS: Objection. Form.
5 Objection. Scope.

6 THE WITNESS: So I've not studied at any
7 length the novelty of this concept. I've not gone back
8 and done a significant review of the literature. When
9 we've had questions of this type before, I've been
10 relying either on the patent or on my own memory, but
11 if I would be asked, I would not be able to answer that
12 question effectively without having done a detailed
13 study of the past literature. In my belief, this is
14 novel to this patent, but I've not done the extensive
15 background study to justify that comment other than my
16 own personal belief.

17 BY MR. MAIER:

18 Q. So let me try to get this right, then. You
19 cannot say one way or another, sitting here today at
20 your deposition, that the core concept of the Acorn
21 patents which involves placing an insulating interface
22 layer at the metal-semiconductor junction -- strike
23 that. Let me try to say this a different way. I'll
24 start over.

25 You cannot say one way or another in this

1 deposition that the core concept of the Acorn patents
2 which involves placing an interface layer between a
3 metal and semiconductor to reduce the specific contact
4 resistivity of the structure was novel to Acorn,
5 correct?

6 MR. PHILLIPS: Objection. Scope.

7 THE WITNESS: I have not studied the
8 question of novelty of the metal-insulator-
9 semiconductor structure as described in the Acorn
10 patents. So any information I give today in response
11 to questions is not the result of an extensive study.
12 I cannot say one way or the other, because I've not
13 studied that in-depth.

14 BY MR. MAIER:

15 Q. So when you say the core concept of the Acorn
16 patents is deeply counterintuitive, you're not certain
17 whether someone else had come up with that
18 counterintuitive concept before Acorn, correct?

19 A. When I say the core concept underlying the
20 Acorn patents is deeply counterintuitive, I'm
21 describing my response to seeing the concept for the
22 first time, which was in roughly 2009, and I have not
23 done a study of whether the concept is unique or novel
24 to the Acorn patents. I've not done that study. I've
25 not, you know, made any opining on that study in this

1 declaration, and I do not recall opining on that in any
2 other material for this case.

3 If I have, it would be great for you to point
4 it out and we can talk about it and I can refresh my
5 memory, but I do not believe I have opined on that
6 question.

7 Q. Specific contact resistivity is a quantity
8 expressed in ohms micron squared, correct?

9 A. Specific contact resistivity is a quantity
10 expressed in ohm per unit squared. It could be ohm per
11 micron squared, ohm per centimeter squared, ohm per
12 meter squared. Different references use different
13 numbers.

14 Q. The interface layer the challenge claims must
15 be a thin film that permits tunneling, correct?

16 MR. PHILLIPS: Objection. Form.

17 THE WITNESS: Can we go through the
18 claims? This is one of these questions is a particular
19 claim may not say that, and so it would be helpful to
20 review the claims.

21 BY MR. MAIER:

22 Q. Yeah, I mean you have all of the patents. I'm
23 happy for you to look at every single claim in the
24 patents if you want, but my understanding was for this
25 structure to work, you have to tunnel through the

1 interface layer; is that right?

2 A. That version of the question I like better.
3 This structure requires tunneling through the interface
4 layer; that's correct.

5 Q. I believe it's also your opinion that the
6 interface layer of the challenge patents would be
7 considered a dielectric or electrical insulator,
8 correct?

9 A. Here, I need to refine that statement because
10 of the comment you made earlier about the interface
11 layer. The passivation layer is more broad than that.
12 The patent itself describes arsenic as a possible
13 passivation material. My comment was with regards to
14 the separation layer, and my statement was the patent
15 is clear, and we can reference the points in my
16 declaration, that the separation layer needs to be a
17 dielectric or insulator.

18 BY MR. MAIER:

19 Q. The interface layer can include an oxide,
20 correct?

21 A. I'm going to answer that again breaking it up.
22 I'm worried about the interface layer terminology now,
23 simply because of the patents' use of it is -- or
24 perhaps more specific than the broader culture. The
25 passivation layer may be an oxide, does not have to be

1 an oxide. The separation layer is expressly described
2 as an oxide.

3 Q. And I was actually quoting from a patent so
4 let me just give you the patent.

5 A. Okay. And also I want to check my notes
6 because I want to make sure I have the citation for
7 that. Yes, okay.

8 (Exhibit 1001 marked for identification.)

9 BY MR. MAIER:

10 Q. So what I've uploaded is Exhibit 1001 from the
11 1183 proceeding which is U.S. patent 9,209,261. Let me
12 know when you have it.

13 A. I'm opening '261 from a local copy. Where
14 would you like me to go?

15 Q. Column 9, line 48.

16 A. Okay. I'm here.

17 Q. So let me just ask you a couple questions.

18 MR. PHILLIPS: Can you give me a second
19 to catch up? Sorry.

20 MR. MAIER: Yes, no problem.

21 MR. PHILLIPS: Okay, '261 patent.

22 MR. MAIER: In column 9, line 48 for
23 that whole paragraph.

24 MR. PHILLIPS: Okay. I'm there, thank
25 you.

1 BY MR. MAIER:

2 Q. So the reason I was using the word interface
3 layer, Dr. Kuhn, was because the patent here is talking
4 about an interface layer. So let me ask the questions
5 again.

6 The interface layer of the Acorn patents may
7 be an oxide, correct?

8 MR. PHILLIPS: Objection. Form.

9 THE WITNESS: The interface layer --
10 okay, so the interface layer, and we're talking here
11 about the interface layer 520, may be an oxide. That's
12 correct.

13 BY MR. MAIER:

14 Q. The interface layer of the Acorn patents may
15 be an inorganic oxide, correct?

16 MR. PHILLIPS: Objection. Form.

17 THE WITNESS: The patent does not
18 restrict the oxide to any particular oxide. It simply
19 says an oxide. So I would consider an inorganic oxide
20 to be a subset of oxide and does include it.

21 BY MR. MAIER:

22 Q. The interface layer may be a nitride, correct?

23 MR. PHILLIPS: Objection. Form.

24 THE WITNESS: The interface layer
25 expressly is described -- sorry, the exact words are

1 the interface layer 520 may include a nitride; that's
2 correct.

3 BY MR. MAIER:

4 Q. For the next questions, you may want to look
5 at the paragraph beginning at line 60 of column 9.

6 A. Okay.

7 Q. The typical thickness of the claimed interface
8 layers is less than about 50 angstroms, correct?

9 MR. PHILLIPS: Objection. Form.

10 THE WITNESS: Well, the patent reads,
11 "For example, depending on the particular
12 implementation, the thickness may be less than about
13 1 nanometer," which would be 10 angstroms, "less than
14 about 0.5 nanometers," which would be 5 angstroms, and
15 "less than about 0.2 nanometers," which would be 2
16 angstroms.

17 Am I missing the place that you wish to
18 discuss?

19 BY MR. MAIER:

20 Q. The very previous sentence. "Often, the
21 520-interface layer includes or is made up of a
22 passivation layer with a thickness of between
23 approximately .1 nanometers and about 5 nanometers."

24 Do you see that?

25 A. Yes.

1 Q. So that the claimed interface layers can be
2 less than 50 angstroms, for example, correct?

3 MR. PHILLIPS: Objection. Form.

4 THE WITNESS: Yes, the patent says with
5 a thickness between approximately 0.1 nanometer, which
6 would be 1 angstrom, and about 5 nanometers, which
7 would be 50 angstroms.

8 BY MR. MAIER:

9 Q. The claimed interface layers can passivate the
10 semiconductor by satisfying dangling bonds, correct?

11 A. Passivation is the process of satisfying
12 dangling bonds of reducing surface states by completing
13 dangling bonds; that is correct.

14 Q. And that is one of the functions provided by
15 the claimed interface layers, correct?

16 MR. PHILLIPS: Objection. Form.

17 THE WITNESS: That's actually the
18 function of the passivation part of the interface layer
19 if it's a bilayer, and it's a function of the entire
20 layer if it's a single layer.

21 BY MR. MAIER:

22 Q. And the challenge patents explain that the
23 interface layer can be a single layer, or they can be
24 two layers, correct?

25 MR. PHILLIPS: Objection. Form.

1 THE WITNESS: Yes, the patent describes
2 the possibility of a bilayer where the first layer is a
3 passivation layer, and the second layer is a separation
4 layer; that's correct.

5 BY MR. MAIER:

6 Q. And the patent also describes the interface
7 layer as a single layer, correct?

8 A. Yes, the patent, in places, describes the
9 interface layer as a single layer that has all the
10 functions in one layer; that's correct.

11 Q. And the claimed interface layers can reduce
12 the effects of MIGS, correct?

13 MR. PHILLIPS: Objection. Form.

14 THE WITNESS: If the interface layer is
15 in the form of a single layer, then it has the two
16 functions, the passivation function, and the MIGS
17 separation function. If the interface layer is in the
18 form of the two-layer version, the separation layer
19 does the MIGS separation function.

20 BY MR. MAIER:

21 Q. Well, the passivation layer would actually
22 perform some reduction in MIGS as well by virtue of it
23 separating the metal from the semiconductor, right?

24 A. The patent allows the possibility of a
25 monolayer passivation layer. And I would need to

1 locate that -- ah, it's at the bottom of the page in
2 column 9, and it does say, "may be the thickness
3 corresponding to a single layer or monolayer of
4 passivation material that is bonded to the
5 semiconductor surface."

6 So while I agree the passivation layer could
7 serve a MIGS separation function, the fact the patent
8 expressly describes a monolayer says it does not have
9 to serve that function.

10 Q. So let me make sure I understand this. The
11 passivation layer of the challenge patents -- and I'm
12 going to try to use challenge patents because we keep
13 saying "patent" in the singular.

14 A. Uh-huh.

15 Q. I'll try to refer to the plural, the challenge
16 patents allow for the passivation layer to reduce the
17 effects of MIGS, correct?

18 A. I don't believe the challenge patents either
19 limit -- let me say this another way. I don't believe
20 the challenge patents discuss the MIGS separation
21 function of the passivation material. The fact the
22 passivation material can be a monolayer and the
23 separation material is expressly described as
24 performing the MIGS function, would suggest to me that
25 while the passivation material may have a MIGS

1 separation function, it is not required to have a MIGS
2 separation function, nor is it prohibited from having a
3 MIGS separation function.

4 Q. And you also said that the challenge patents
5 allow for the passivation layer to be a monolayer. Do
6 you recall that?

7 A. Yes. A few minutes ago I cited the bottom of
8 column 9, line 67 and the top of column 10 where it
9 says, "may be the thickness corresponding to a single
10 layer or monolayer of passivation material that is
11 bonded to the semiconductor surface or may even be the
12 number of atoms of passivation material required to
13 passivate substantially all the dangling bonds
14 associated with the semiconductor surface."

15 So the patent describes a situation of even
16 perhaps a partial monolayer of passivation material.
17 It simply tagging all the bonds and it's done.

18 Q. Wait. So now you introduced another term
19 there. I want to understand what you mean there. What
20 do you mean that the challenge patents describe the
21 passivation layer as perhaps even a partial monolayer?

22 A. So in column 10, line 3 -- column 10, lines 2
23 through 5, "or may even be the number of atoms of
24 passivation material required to passivate
25 substantially all the dangling bonds associated with

1 the semiconductor surface." That phrase follows a
2 stack of thickness phrases. From the previous column,
3 "the thickness may be less than about 1 nanometer, less
4 than about .5 nanometers, less than about .2
5 nanometers." Then it goes into, "may be the thickness
6 corresponding to a single layer or monolayer of
7 passivation material that is bonded with semiconductor
8 surface or may even be the number of atoms of
9 passivation material required to passivate
10 substantially all the dangling bonds associated with
11 the semiconductor surface."

12 The structure of that paragraph appears to be
13 just walking down a layer of thickness options. It can
14 be less than 1, less than .5, less than .2, a layer, a
15 monolayer, or even the number of atoms of passivation
16 material required to passivate substantially all the
17 dangling bonds associated with the semiconductor
18 surface.

19 A POSITA would read that last phrase as being
20 "a layer of atoms that may not be complete, but that is
21 passivating all the dangling bonds."

22 Q. Okay, so maybe I need just a little bit of
23 technical definition here. What is a monolayer?

24 A. In the context that I've run into the term, a
25 monolayer is a single, complete layer of a material

1 that covers whatever your substrate is. If you're
2 doing epitaxy-like MBE growth, it is extremely
3 well-defined. Because a monolayer means you've bonded
4 at least one atom to every location on the surface.

5 If you're doing an amorphous deposition, it's
6 a little fuzzier, but the idea is that the surface is
7 covered to the extent of one atom or one cluster
8 everywhere that is appropriate for coverage.

9 Q. And when you say "cluster," are you talk about
10 how, you know, like, SiO₂ isn't one atom, it's three
11 atoms? So is that what you're talking about as a
12 cluster?

13 A. Yes, and SiO₂ is even messier than that
14 because it forms little tetrahedrons, so it has kind of
15 a quasi-crystal structure. So the definition of a
16 monolayer when you are talking about SiO₂ is
17 intrinsically a little fuzzier. If I have a crystal
18 and I grow -- and let's say I have a silicon crystal
19 and I'm growing layers of silicon on it very slowly,
20 well, a monolayer is very well defined. I have added
21 one atom everywhere that the crystal permits an atom,
22 and that's a monolayer.

23 If I'm putting SiO₂ down and I'm depositing
24 it, for the other extreme, it's a little harder to
25 describe exactly what a monolayer is because they'll

1 tend to come down and bind tetrahedrally and may or may
2 not give as complete and smooth a layer as a
3 monolayer --

4 (Reporter clarification.)

5 -- as complete a surface coverage.

6 Q. So let me try to break that down since we had
7 kind of a mix-up in the transcript. So let me ask just
8 more definitional terms.

9 What is a partial monolayer?

10 A. Again, I'm going to jump back to the simplest
11 definition which is when you're putting a crystal on
12 top of a crystal, a partial monolayer is when all of
13 the available atomic sites, one layer up are not
14 filled. So if I have a perfectly flat semiconductor
15 surface with all the bonds sticking up and I'm growing
16 a new semiconductor layer on that perfectly flat
17 surface, and I don't have the semiconductor on all the
18 possible locations, I have islands that are 1 atom
19 thick. People usually call that a partial monolayer.
20 They sometimes call it island growth.

21 Q. Thank you. I think I'm visualizing what
22 you're talking about now. The challenge claims allow
23 for the passivation layer to be a monolayer thickness,
24 correct?

25 MR. PHILLIPS: Objection. Form.

1 THE WITNESS: The patent certainly
2 describes the possibility of the thickness being of the
3 passivation layer corresponding to a single layer or
4 monolayer of passivation material. That's what the
5 specification says. And if the claim is referring to a
6 passivation layer, I would assume that that monolayer
7 would apply as well.

8 BY MR. MAIER:

9 Q. And similarly, the challenge patents allow for
10 the passivation layer to be a partial monolayer,
11 correct?

12 A. I don't want to use "that" words because I use
13 those somewhat casually and I would prefer to use the
14 words that the patent itself says because the patent
15 was much more precise about saying it than I was, and I
16 think the correct words are "may even be the number of
17 atoms of passivation material required to passivate
18 substantially all the dangling bonds associated with
19 the semiconductor surface."

20 Q. So do you interpret that phrase to refer to a
21 partial monolayer?

22 A. That would depend on the semiconductor.

23 Q. The semiconductor --

24 A. Would also did not on the surface
25 reconstruction and some other things that are going on.

1 Keep in mind that the surface of the semiconductor does
2 some oddball things that the bulk does not do, and so
3 the number of atoms required to passivate all the
4 dangling bonds on the surface may or may not be equal
5 to the number of atoms required to make a monolayer,
6 which is undoubtedly why the patent is written this way
7 is they describe first a monolayer, then they describe
8 the circumstance where the number of dangling bonds is
9 less than the number of atoms required to make a
10 monolayer, and then they basically say, "or even the
11 number of atoms of passivation material required to
12 passivate substantially all the dangling bonds."

13 Q. So I guess another way of asking it is do the
14 challenge patents exclude a passivation -- let me ask
15 it the other way. Strike that.

16 Do the challenge patents permit the
17 passivation layer to be a partial monolayer?

18 MR. PHILLIPS: Objection. Form.
19 Objection. Scope.

20 THE WITNESS: Following my definition of
21 a monolayer and allowing that we do need to passivate
22 substantially all the dangling bonds as discussed in
23 column 10, yes, the patent specifications -- the
24 patents specifications, in the plural, permit that
25 configuration.

1 BY MR. MAIER:

2 Q. I'm going to add another exhibit here and this
3 may actually go pretty quick because I think you said
4 that you haven't reviewed certain materials, but I just
5 want to be sure. So give me one minute and I'll upload
6 another document.

7 (Exhibit 1016 marked for identification.)

8 BY MR. MAIER:

9 Q. So I've uploaded 1016 from IPR 2020-1183 which
10 is U.S. patent No. 6,724,088 to Jammy et al. Let me
11 know when you have that.

12 A. Okay. Okay. I have this patent open, U.S.
13 Patent 6,724,088.

14 Q. Will you understand if I refer to this exhibit
15 as Jammy, the name of the first-named inventor?

16 A. That's fine.

17 Q. You did not consider Jammy in forming your
18 opinions stated in your declaration, correct?

19 A. I did not consider Jammy, and as a more global
20 comment, I don't recognize this patent. I've not
21 reviewed it or studied it.

22 Q. Okay, all right. Well, I think we can take a
23 quick break because you haven't looked at this, so I
24 think we can move onto the next section. So why don't
25 we take ten minutes and then I'll move onto the next

1 section and then I think I only have about another two
2 sessions left for this morning.

3 THE WITNESS: Okay. So let's take a
4 ten-minute break. We'll be back at 10 o'clock.

5 THE VIDEOGRAPHER: We are going off the
6 record at 9:48.

7 (Recess taken 9:48 a.m. to 10:05 a.m.)

8 THE VIDEOGRAPHER: We are back on the
9 record the time is 10:05. Please proceed.

10 (Exhibit 1132 marked for identification.)

11 (Exhibit 1133 marked for identification.)

12 BY MR. MAIER:

13 Q. Dr. Kuhn, very brief questions on two other
14 exhibits that I've uploaded to the Exhibit Share. They
15 are both from IPR 2020-1282. They are Exhibit 1132,
16 which is a Japanese patent, and Exhibit 1133, which is
17 a translation of that patent. Can you just take a
18 glance at those and let me know when you're ready?

19 A. Okay, working on it. Okay. I have
20 Exhibit 1133, which is the translated version, open.

21 Q. And do you see that the inventor's last name
22 is Iwaguro?

23 A. Curiously, no. Where should I look?

24 Q. First page --

25 A. Oh, there I see, Iwaguro, yes, I see that.

1 Q. I'm going to refer to this Japanese patent and
2 the translation as Iwaguro; is that okay?

3 A. Yes.

4 Q. You did not consider the Iwaguro reference in
5 forming your opinions stated in your declaration,
6 correct?

7 A. I have not seen this patent or studied this
8 patent, and I have not discussed it in my declaration,
9 that's correct.

10 Q. So we can put those away, then.

11 A. Okay.

12 Q. All right. A couple more questions on the
13 interface layer. I believe you agree that the claimed
14 interface layers can passivate the semiconductor by
15 satisfying dangling bonds, correct?

16 A. Yes. Passivation by satisfying dangling
17 bonds -- sorry, satisfying dangling bonds is the
18 definition of passivation; that's correct.

19 Q. And I believe you also agree that the claimed
20 interface layers can reduce the effects of MIGS,
21 correct?

22 MR. PHILLIPS: Objection. Form.

23 THE WITNESS: So again, keeping in mind
24 that the interface layer may consist of a passivation
25 layer and a separation layer, the purpose of the

1 combined structure is to both passivate and reduce the
2 impact of MIGS; that's right.

3 BY MR. MAIER:

4 Q. Can the claimed interface layers have any
5 additional beneficial properties?

6 MR. PHILLIPS: Objection. Form.

7 THE WITNESS: I'm unaware of the patent
8 either excluding or pointing out additional beneficial
9 properties. If you have a place I should look at, we
10 can talk about it.

11 BY MR. MAIER:

12 Q. I think we're on the same page, so let me just
13 confirm. Can the claimed interface layer serve as a
14 diffusion barrier so that dopant atoms in the
15 semiconductor substrate do not diffuse into the metal
16 contact?

17 MR. PHILLIPS: Objection. Scope.

18 THE WITNESS: I've not reviewed
19 diffusion barriers in my declaration, and I'm unaware
20 of the patent either discussing or -- what's the right
21 word? Refuting, discussing, or not permitting
22 diffusion barriers. So we've got a couple of layers
23 "I've not thought about it, I've not talked about it,"
24 and I'm unaware of the patent either require or not
25 requiring such layers. And again, if there is a place

1 in the patent you can show me that we can talk about,
2 we can continue the discussion.

3 BY MR. MAIER:

4 Q. So to me, I think it's silent on those. I
5 just want to be sure you're not taking a position that
6 the interface layer excludes certain properties.

7 MR. PHILLIPS: Objection. Form.

8 BY MR. MAIER:

9 Q. So let me ask a question.

10 A. Why don't you ask the question again, because
11 I may be answering a slightly different question.

12 Q. And the word I'm going to begin with is "can."
13 So can the claimed interface layers serve as a barrier
14 so that metal atoms in the metal contact do not spike
15 through into the semiconductor substrate?

16 MR. PHILLIPS: Objection. Scope, form.

17 THE WITNESS: So I've not taken a
18 position on that question, so I have no opinion on that
19 question either way.

20 BY MR. MAIER:

21 Q. Let's do the other one again just so I can get
22 the clear answer. Can the claimed interface layers
23 serve as a diffusion barrier so that dopant atoms in
24 the semiconductor substrate do not diffuse into the
25 metal contacts?

1 MR. PHILLIPS: Same objections.

2 THE WITNESS: And somewhat the same
3 answer. I've not taken a position on diffusion
4 barriers. I've not studied them. I have no opinion
5 either way on that.

6 BY MR. MAIER:

7 Q. Let's turn back to your declaration, and
8 specifically at paragraph 112. Let me know when you're
9 there.

10 A. Yes, I'm at paragraph 112.

11 Q. Here you're summarizing, among other things, a
12 set of criteria that would allegedly lead a person of
13 ordinary skill in the art to a set of materials for the
14 claimed separation layer, correct?

15 A. In general, yes.

16 Q. So what I want to do now is test these
17 criteria, and you may want your notepad for this.

18 A. Okay.

19 Q. Okay. So I want you to consider a prior art
20 structure that has the following configuration: Metal,
21 silicide separation layer, silicon dioxide layer, and
22 silicon substrate. Do you have that in mind?

23 A. So, let me repeat the layer back at you. It's
24 a metal, it's a silicide, it's SiO₂, and it's a silicon
25 substrate?

1 Q. Right.

2 MR. PHILLIPS: And I want to state a
3 form objection.

4 BY MR. MAIER:

5 Q. In this structure, the silicon dioxide layer
6 can passivate the silicon semiconductor, correct?

7 MR. PHILLIPS: I'm going to have a
8 running form objection to all the questions pertaining
9 to this structure.

10 BY MR. MAIER:

11 Q. Okay.

12 A. So I've not opined on a structure with
13 silicide, and so I'm going to answer some of these
14 questions based on broad knowledge but sometimes I'm
15 going to say I've not studied it and I've not thought
16 about it.

17 So in the form of the question, the metal, the
18 silicide, the SiO₂, and the silicon, the SiO₂ could
19 passivate the silicon layer, but is not -- you need to
20 know more details of the structure to know if it does.

21 Q. And in our hypothetical prior art structure,
22 the silicide layer is sandwiched between the metal and
23 the silicon dioxide layer. Are you with me so far?

24 A. I understand the structure to be a metal, an
25 arbitrary metal, an arbitrary silicide at this point,

1 so it's an arbitrary metal, an arbitrary silicide, an
2 SiO2 layer, and a silicon layer. That's how I
3 understand the structure.

4 Q. And let's say that the silicide is a silicide
5 of the metal in the metal layer, okay?

6 MR. PHILLIPS: Objection, scope.

7 THE WITNESS: Okay.

8 MR. PHILLIPS: I want to make a running
9 scope objection as well to all questions pertaining to
10 this structure.

11 BY MR. MAIER:

12 Q. And so if you can, Dr. Kuhn, keep
13 paragraph 112 of your declaration open because I want
14 to test these criteria, but I'm also going to give you
15 some other documents. So if you can have 112 of your
16 declaration open, what I'm going to do next is I'm
17 going to upload Exhibit 1001 from the 1204 proceeding
18 which is U.S. patent 8,766,336. I'll let you know once
19 I've uploaded that.

20 (Exhibit 1001 marked for identification.)

21 BY MR. MAIER:

22 Q. So it should be accessible let me know when
23 have it?

24 A. I'm doing the usual syncing of the share,
25 which is very slow.

1 Q. Yes.

2 A. Can you remind me of the exhibit number? I'm
3 not sure I have it yet.

4 Q. It's Exhibit 1001, and it's U.S. Patent
5 8,766,336.

6 A. Sorry, there are two, 101s [sic].

7 Q. Yeah, usually the patent in each IPR
8 proceeding is 1001, so there are multiple versions.
9 This is from the 1204 IPR.

10 A. Ah, I'm with you here. Okay. So I have
11 patent 8,766,336 up, and I'm content with us calling it
12 the '336 patent.

13 Q. Can you turn with me to column 14 at lines 56
14 to 60? Let me know when you're there.

15 A. 56 to 60, it's a paragraph starting "Another
16 advantage."

17 Q. And I'm going to start with the second
18 sentence of that paragraph where the '336 patent
19 states, "Typically, metals chosen for application in
20 classic Schottky diodes are those that conform a
21 silicide with a silicon semiconductor. The formation
22 of the silicide helps to reduce surface states
23 (resulting from dangling bonds), but not the effect of
24 MIGS. Thus, the Fermi level at the semiconductor
25 surface is still pinned."

1 Did I read that correctly?

2 A. Yes, you did.

3 Q. Now, I want to go back to our hypothetical
4 metal, metal silicide, silicon dioxide, silicon
5 structure. Do you have that there?

6 A. Yes, I do.

7 Q. In the context of the '336 patent, the
8 silicide layer cannot itself be a passivation layer,
9 correct?

10 A. I don't know. I have not thought about the
11 application of silicides to the question of the
12 passivation layer.

13 Q. Well, the reason I'm asking that question is
14 that in paragraph 112 of your declaration you say that
15 the separation layer is not itself a passivation layer.
16 Do you see that?

17 A. That's correct.

18 Q. Yet the challenge patents have this statement
19 that "silicide helps to reduce surface states resulting
20 from dangling bonds." Do you see that?

21 A. That's -- the formation of silicide helps to
22 reduce surface states, that's quoted from the patent,
23 that's correct.

24 Q. So I'm trying to reconcile those two
25 statements. Can the silicide layer in our hypothetical

1 structure itself be a passivation layer in the context
2 of the challenge patent?

3 MR. PHILLIPS: Objection. Form. And
4 scope.

5 THE WITNESS: So, first, I have not
6 studied that question in detail, but I do want to add
7 an additional observation which complicates the
8 question. Many silicides are metals, so a structure
9 that has a metal and a silicide may, in fact, have two
10 metals one on top of the other. And so in your
11 hypothetical of a metal, a silicide, SiO₂, and Si,
12 depending on what silicide it is, what you may actually
13 have is simply a metal, SiO₂, silicon structure, which
14 is certainly within the claims of the patent.

15 BY MR. MAIER:

16 Q. Okay. So I see the confusion. So let's get a
17 little more specific. Do you remember what the patent
18 example is?

19 A. You mean its column --

20 MR. PHILLIPS: Object to the form.

21 BY MR. MAIER:

22 Q. That's a bad question, so let me ask this.
23 The patent talks about using titanium as the metal
24 layer.

25 A. For silicides? I'm sorry, you're going to

1 have to tell me where to go in the patent. I just got
2 enormously lost. I am at column 14 the discussion on
3 metal silicides at the bottom of column 14.

4 Q. So remember when we talked about the '423
5 patent and we went through about over a dozen different
6 metals that could be the metal layer during yesterday's
7 deposition?

8 A. Yes, I recall that.

9 Q. And one of those options for the metal layer
10 was titanium, do you recall that?

11 A. Yes, I recall that.

12 Q. Okay. So I want to put this structure
13 together and ask about this passage in the '336 patent.
14 So let's revise our structure to titanium, titanium
15 silicide, silicon dioxide, silicon. Do you have that
16 in mind?

17 A. Yes.

18 MR. PHILLIPS: Objection. Scope.

19 BY MR. MAIER:

20 Q. The '336 patent at column 14, lines 56
21 through 61, includes the statement, "The formation of
22 the silicide helps to reduce surface states (resulting
23 from dangling bonds), but not the effects of MIGS.
24 Thus, the Fermi level at the semiconductor surface is
25 still pinned."

1 Do you see that?

2 A. I see that.

3 Q. In the context of the challenge patents, a
4 titanium silicide layer could have the proper thickness
5 and band structure to reduce the effects of MIGS to
6 prevent Fermi level pinning, correct?

7 A. I disagree with that. In my knowledge,
8 titanium silicide is a metal. So if I have, for
9 example, a metal contact of tungsten, a metal layer of
10 Ti silicide, an SiO₂ layer, and a silicone layer, I
11 have a metal insulator metal structure. And so the
12 question of passivation in a metal layer is something
13 that I've not discussed, and I don't actually
14 understand.

15 If we're talking about a metal structure, a
16 metal is a metal, it has pre-carrier density, it acts
17 like a metal. So in my mind, the example of tungsten,
18 Ti silicide, SiO₂, and silicon is simply another
19 example of a metal SiO₂ semiconductor structure.

20 Q. Okay, give me one second. Let me ask you
21 this, though, wouldn't you expect there to be some
22 small amounts of oxygen in any titanium silicide layer
23 that is formed?

24 MR. PHILLIPS: Objection. Scope, form.

25 THE WITNESS: That's actually an

1 interesting question because Ti silicide is formed by
2 an exothermic reaction, and I think you'd have to know
3 exactly how it was formed to know if it was
4 contaminated by oxygen.

5 BY MR. MAIER:

6 Q. Well, let's assume that it was contaminated by
7 some amount of oxygen, let's say 10 percent. Would
8 such a titanium silicide layer satisfy the separation
9 layer of the challenge claims?

10 MR. PHILLIPS: Objection. Form.
11 Objection. Scope.

12 THE WITNESS: Okay. So I think the more
13 interesting question here is if I have a layer,
14 whatever percentage of titanium and silicon and
15 oxygen -- or what exactly was your -- it was Ti
16 silicide and oxygen? Do I have that correct?

17 BY MR. MAIER:

18 Q. Some oxygen got in there.

19 A. Yes, so if you have a Ti silicide and oxygen
20 layer, that layer could easily be a metal oxide. Ti
21 silicide is a metal and there is oxygen, so it's a
22 metal oxide layer. And so, you know, depending on the
23 circumstances and the formation of the layer and a
24 whole bunch of other details of your hypothetical I
25 don't have, it could certainly fulfill the definition

1 of a metal oxide.

2 Q. How high would the concentration of oxygen
3 have to be in order for that titanium silicide layer to
4 be a metal oxide in your mind?

5 MR. PHILLIPS: Objection. Scope.
6 Objection. Form.

7 THE WITNESS: There is no way I can
8 answer that here. We have a hypothetical that is
9 becoming a very complex hypothetical. We have a
10 hypothetical Ti silicide layer with a hypothetical
11 oxygen content, and I am going back to the very
12 fundamental point I make in paragraph 112 that -- and
13 let me find the sentence which is important. "And has
14 the function of providing the proper thickness and band
15 structure."

16 In questions of this type, the band structure
17 of your material becomes important because the band
18 structure determines whether you have a metal, whether
19 you have an insulator, and it determines other
20 properties that are discussed in the patent around that
21 particular layer. So you know, your hypothetical is
22 rapidly moving into an "I would need to know the
23 structure, its chemical properties, its dimensions, and
24 so on and so forth" to give you an adequate answer to
25 that question.

1 BY MR. MAIER:

2 Q. So what would the band structure have to be in
3 our hypothetical Ti silicide oxygen layer for it to be
4 considered a metal?

5 MR. PHILLIPS: Objection. Scope.

6 THE WITNESS: The definition of a metal
7 from the band structure is well established in basic
8 semiconductor physics. It's often Chapter 1 or 2 of
9 the semiconductor physics textbook. And the definition
10 of a metal is either the bands are overlapping or --
11 hold one second. Sorry. My thunderstorm just showed
12 up -- either the bands are overlapping, or the Fermi
13 level is lined through the band, and the patent itself
14 describes this in very similar language. So you can
15 determine whether a material is a metal based upon the
16 band structure.

17 BY MR. MAIER:

18 Q. I want to talk a little bit about a different
19 patent that I'm going to upload. And this will be the
20 '395 patent, and I apologize but it is yet another
21 Exhibit 1001, and it's in the 1282 proceeding.

22 (Exhibit 1101 marked for identification.)

23 BY MR. MAIER:

24 Q. I've just uploaded it. Let me know when you
25 have access -- and I'm sorry, it's actually

1 Exhibit 1101 in this case.

2 A. So I used my local copy. Just to confirm this
3 is U.S. Patent 10,090,395; is that correct?

4 Q. That's right.

5 A. Okay. Where would you like me to go?

6 Q. Okay, if you could go to column 8, lines 24 to
7 37, let me know when you're there.

8 A. So it's a paragraph starting, "A common
9 processing operation"?

10 Q. That's right. The '395 patent states, "A
11 common processing operation performed during
12 semiconductor device fabrication is silicon surface
13 passivation. Surface passivation, whether by an oxide
14 or another material, chemically neutralizes and
15 physically protects the underlying silicon.

16 For example, exposing a silicon surface to
17 oxygen under the appropriate conditions to grow a
18 protective film of silicon dioxide will allow the
19 oxygen to react with the dangling bonds of the silicon
20 surface to form covalent bonds that satisfactory the
21 surface silicon atom's valency and render the surface
22 fully coordinated. These covalent bonds provide
23 chemical stability to the silicon surface. The
24 covalent bonds also tie up unbound charges that exist
25 on the silicone surface as a result of the

1 discontinuation of the semiconductor crystal at the
2 surface."

3 Did I read that correctly?

4 A. Yes, you did.

5 Q. What is your understanding of that paragraph
6 and what it's describing?

7 A. So the paragraph is somewhat of an
8 introductory or tutorial paragraph, in my mind. It's
9 describing a common passivation process, and the
10 particular example is probably the most common and
11 well-understood passivation process, which is exposing
12 a clean silicon surface to oxygen, the oxygen reacts
13 with the dangling bonds, it satisfies the silicon
14 surface atom's valency, or in a more relaxed parlance,
15 it completes the surface dangling bonds, and it ties up
16 unbound charges that exist on the silicon surface. So
17 it's somewhat a textbook or standard description of
18 passivation with a silicon dioxide example.

19 Q. Yesterday we used the term "native silicon
20 dioxide." Do you recall that?

21 A. Yes.

22 Q. What is a "native silicon dioxide"?

23 A. The term native oxide in the general form is a
24 common term applied to an oxide that grows on a
25 material in the presence of oxygen. It's usually

1 referred to as, for example, silicon dioxide is the
2 native oxide of silicon. Iron oxide is the native
3 oxide of iron, and so on. There is usually a level of
4 detail involving which particular crystal structure or
5 coordination of the oxide, but in sort of broad terms,
6 a native oxide is the oxide that grows on a material
7 surface in the presence of oxygen or water or steam or
8 something of this nature.

9 Q. When you say, "in the presence of oxygen," are
10 you referring to oxygen in the air?

11 A. There are -- let me describe this in a broad
12 sense. First, the term "native oxide" is a generic
13 term to describe the growth of an oxide in the presence
14 of oxygen. There is also a use in the field of the
15 word native oxide to describe surface contamination.
16 This is -- I would call it a more casual use.

17 For example, when I was in the MBE world, we
18 would talk about native oxides as a shorthand for
19 surface contamination that we needed to be removed.
20 And if one wants to be precise, one would say native
21 oxide contamination is kind of a phrase to distinguish
22 the contamination that forms on a wafer in an
23 uncontrolled environment with the other definition of
24 native oxide, which is simply the oxide that forms in
25 the presence of the material in oxygen.

1 Q. Okay, thank you.

2 Let's keep reading in column 8 of the '395
3 patent, and specifically at lines 38 to 52.

4 A. I'm there.

5 Q. This passage states, "However, passivation
6 with silicon dioxide has several significant
7 disadvantages. For example, silicon dioxide is a
8 dielectric insulator that poses a significant barrier
9 to the flow of current. Accordingly, a layer of
10 silicon dioxide deposited or grown on a silicon surface
11 may significantly reduce the ability for electrical
12 current to flow through that surface. As a result, the
13 use of silicon dioxide has been limited in practicality
14 to surfaces external to the active region of
15 semiconductor devices through which current passes
16 during device operation (e.g. as a gate oxide layer).
17 This disadvantage is compounded by the fact that the
18 silicon dioxide grows very rapidly and readily on the
19 silicon surface so that it is difficult to limit the
20 growth to a thin layer. Silicon dioxide is also a poor
21 diffusion barrier to semiconductor dopants such as
22 boron."

23 Did I read that correctly?

24 A. Yes, you did.

25 Q. And can you explain what you understand that

1 paragraph to be describing?

2 A. The paragraph prior to this is, as I mentioned
3 earlier, is a somewhat textbook or tutorial paragraph
4 that describes silicon and silicon dioxide, where
5 silicon dioxide is a passivation layer on silicon.
6 Silicon dioxide is universally understood to be an
7 excellent passivation layer for silicon. The culture
8 is extraordinarily familiar with the material since the
9 first MOS device was ever made in whatever year it was,
10 the use of silicon dioxide on silicon has been known
11 for the quality and excellence of its passivation.

12 So a POSITA understands that paragraph 1 is
13 sort of saying at a very high level "we all understand
14 silicon dioxide, and it's really, really good as a
15 passivation layer," and then paragraph 2 is "but it's
16 not perfect." And then paragraph 2 goes on to say that
17 passivation with silicon dioxide has some issues. And
18 then the paragraph lists the issues.

19 It's a dielectric insulator that poses a
20 barrier to current flow, which is true of all
21 dielectric insulators. And then it also talks about, I
22 think, some more significant, more manufacturing
23 concerns, which is silicon dioxide grows rapidly, and
24 so it is not as easy to, perhaps, make a thin layer of
25 the material as of certain other materials, and is a

1 poor diffusion barrier to boron.

2 So I see these two paragraphs taken together
3 to be kind of tutorial. The first paragraph in the
4 general form saying, "We all know silicon dioxide.
5 It's a wonderful passivation layer. We're all very
6 familiar with it."

7 And then the second paragraph saying, "but it
8 has some issues that we need to talk about, and
9 maybe" -- and I presume the third paragraph after this
10 is going to be, "and maybe we can use something else."

11 Q. Okay. So let's go to that next paragraph, and
12 this will be the last one, but I want to get your take
13 on it as well. At column 8, lines 53 to 63 of the '395
14 patent, it states, "Instead of making use of silicon
15 dioxide then, in one embodiment, the present inventors
16 utilize a nitride semiconductor surface to provide
17 chemical passivation; that is, a nitride layer is
18 introduced to passivate the semiconductor surface by
19 eliminating or at least reducing the effects of surface
20 states and possibly inhomogeneities. The nitride layer
21 also displaces the metal from the semiconductor and
22 eliminates or at least reduces the effects of MIGS.
23 The result of introducing the nitride layer as an
24 interface between the semiconductor and the metal is a
25 depinning of the Fermi level of the semiconductor."

1 Did I read that correctly?

2 A. Yes, you did.

3 Q. I guess my question here is -- let me take it
4 in two parts because you mentioned there are two
5 understandings of native oxides. One understanding of
6 a native silicon oxide is a native silicon dioxide that
7 forms from contamination, right?

8 A. So, as I mentioned, there are two common uses
9 of the word "native oxide." The first is native oxide
10 simply being the oxide that forms on a material in the
11 presence of oxygen. And then the second form that you
12 see is people using it as a shorthand for native oxide
13 contamination; and by that, what is meant is the myriad
14 of things that form on the surface in ambient air,
15 which could include oxygen. It could also include oil.
16 It could include other background chemicals that adsorb
17 to the surface. The culture does generically use the
18 term "native oxide," and sometimes forgets to use the
19 term "contamination" when they're referring to the
20 contaminated layer that forms on a wafer in an
21 uncontrolled environment.

22 BY MR. MAIER:

23 Q. So I'll try to be specific when I'm referring
24 to those two different options. It was -- actually,
25 let me ask it this way: Does -- can a native silicon

1 dioxide from contamination satisfy the passivation
2 layer of the challenge claims?

3 MR. PHILLIPS: Objection. Scope. Form.

4 THE WITNESS: Keep in mind that a native
5 oxide from contamination is contaminated. And in the
6 usual way that word is used, it is contaminated in an
7 uncontrolled way in an uncontrolled environment. So
8 back in my university days, we used the term when we
9 wafer were sitting on the table and it could have been
10 contaminated by somebody's lunch. So in order to
11 answer that question, you would need to know the
12 contamination.

13 Certainly, if the native oxide happened to not
14 be contaminated but was a pure and well-behaved silicon
15 dioxide layer that simply formed, then it would be as
16 good as any other silicon dioxide layer. But if it was
17 contaminated in some way, then, of course, your
18 properties would be influenced by the contamination.

19 BY MR. MAIER:

20 Q. Okay. So I think I'm confused by the word
21 "contamination." When you say contamination in the
22 context of a silicon dioxide, are you saying that the
23 layer is not solely silicon dioxide but has some other
24 things in it?

25 MR. PHILLIPS: Object to form.

1 THE WITNESS: When people use the word
2 "native oxide contamination" or more commonly -- and
3 I'll give an example -- the graduate student walks in
4 with the wafer, gloved, true, in his gloved hands with
5 the box open and says, "I have native oxide on this
6 wafer," what the graduate student means is that the
7 wafer has been left out in the open and has formed a
8 native oxide that is contaminated by the ambient
9 environment. And the term is used very commonly that
10 way.

11 And back when I was doing MBE, the first thing
12 we did is we shove those wafers in the load lock and
13 blew off the native oxide contamination, which included
14 oxygen oxides, and since this was 35, it was arsenic
15 and germanium oxides and things of that nature.

16 And so whenever someone uses the word "native
17 oxide," you need to drill down as to whether someone
18 simply means an oxide that was formed under controlled
19 conditions, but possibly not in a high-temperature
20 chamber. So for example, you could take a wafer and
21 put it in a room temperature chamber that was purged
22 with oxygen, and you'd get a native oxide growth that
23 is quite thin, and that's a perfectly respectable
24 oxide.

25 You could also leave it out in your laboratory

1 overnight and put it in your tool, and then that native
2 oxide will be contaminated. And one of the issues that
3 exists in the culture is people use the two terms
4 interchangeably, so when -- you have to look at the
5 layer itself and how it was formed. There is nothing
6 wrong with taking a clean wafer, sticking it at room
7 temperature in a purged box and purging the box with
8 oxygen. It will then form a perfectly respectable film
9 that is a native oxide film; however, if you take that
10 same wafer and leave it out in the laboratory all
11 night, it will become contaminated with native oxide
12 and that native oxide will be contaminated with all the
13 other things that are going on in the laboratory.

14 BY MR. MAIER:

15 Q. I think what threw me off is you mentioned it
16 could be contaminated by someone's lunch and I was
17 picturing someone spilling ketchup on the wafer, but
18 maybe that's a different level of contamination than
19 you were talking about.

20 A. Well, if you're talking about graduate
21 students, that's actually realistic. Keep in mind that
22 the most common appearance of native oxide issues tends
23 to be in an academic setting because there are not load
24 locks. There are not vacuum chambers to store things
25 in between operations. So wafers are carried around

1 the university to various tools at the university, and
2 they pick up native oxide contamination because they're
3 not being stored in a high vacuum between steps.

4 And so issues of native oxide contamination in
5 an academic environment can indeed include the
6 student's lunch. I'm being a little facetious there.
7 More often, there is every attempt by the students to
8 keep things clean, but you're still taking a wafer out
9 of a tool, putting it in a box, running across campus
10 with it, putting it back into another tool, and that is
11 going to create issues. There is going to be adsorb
12 CO2. There is going to be other materials.

13 In an industrial environment or a
14 highly-constrained academic environment, the wafer
15 never leaves the vacuum system, and so you can do
16 something like take the wafer, put it in a side
17 chamber, close off the side chamber, purge the wafer
18 with oxygen, get a controlled native oxide growth that
19 is not contaminated and pop it back in the tool if you
20 want.

21 BY MR. MAIER:

22 Q. I think I have one more question on this
23 topic. Would a silicon dioxide layer, 1 monolayer
24 thick, still satisfactory the passivation layer of the
25 challenge claims?

1 A. Well, one would need to know a few more
2 characteristics of the layer but given what we have
3 discussed earlier about the passivation layer needing
4 only to terminate the dangling bonds, I see no reason
5 why a single monolayer of SiO₂ that terminated dangling
6 bonds correctly would not serve as a perfectly fine
7 passivation.

8 Q. Can you turn to page 22 of your declaration,
9 it's not paragraph, but page 22 of your declaration?

10 A. Sure. I'm on page 22.

11 Q. On the previous page, you mention that the
12 figure shown on page 22 is taken from a book, a
13 textbook, right?

14 A. Ah, yes and no. The figure is a textbook
15 figure but the picture itself was taken from my IEDM
16 2008 short course.

17 Q. So my question was going to be what textbook
18 was that figure taken from, and your answer would be?

19 A. My answer would be I was using "textbook" in a
20 different sense. I was using textbook in the sense of
21 a tutorial image. I was not using textbook in the
22 sense of a literal textbook. The image at the top of
23 page 22 is an image from my IEDM short course. It's an
24 image I drew personally for the short course, and so it
25 is not in itself from any particular textbook. It is

1 simply intended to be of a tutorial nature in the sense
2 of textbook with quotes around it.

3 Q. I have a number of questions that relate to
4 your past work. You have previously been adverse to
5 Samsung, correct?

6 A. Yes.

7 Q. How many times have you been an expert witness
8 adverse to Samsung?

9 A. Two different patents. The first one was what
10 I'm going to call the Kaist patent which was an
11 extensive litigation. The plaintiff changed names once
12 during the litigation, and it's referenced in my CV,
13 and why don't I go to my CV, if I may, and give you
14 some more details on that.

15 Q. Yeah, and you've provided a case list that was
16 separate from your CV, so if it would be helpful I will
17 upload that in the Exhibit Share as well.

18 A. That would be good. I'm going to actually
19 open that too.

20 (Exhibit 2072 marked for identification.)

21 BY MR. MAIER:

22 Q. So it's Exhibit 2072 from the 1204 IPR
23 proceeding. And let me know when you're ready.

24 A. Yeah, I have that open. The two bottom cases,
25 Kaist IP versus Samsung and KIPB versus Samsung, are

1 the same patent in the same group. The broad history
2 here is the -- and it's a single FinFET patent, and we
3 can look up the number if we want, but let me give you
4 the broad history and then I can go back and dig up the
5 number. The litigation began with Kaist versus
6 Samsung, and that was the Glaser Weil project. It
7 moved through IPRs which we've talked about. It then
8 litigated and ended in trial here in 2018. The verdict
9 was in favor of Kaist, and then this particular first
10 proceeding only litigated up to 14 nanometers.

11 And so Kaist, which by then had changed names
12 and turned to KIPB, started its second litigation
13 against Samsung on the same patent for 14 nanometers
14 and beyond. And that litigation got up to the point of
15 a report in a deposition in 2020, and then Kaist, which
16 by then was KIPB, and Samsung sat down and settled.
17 And so this was a case that, you know, basically went
18 over about four years when you count day 1 to day end
19 that involved four different law firms during this
20 time, but was a single patent moving through the
21 system. So that was my first option to Samsung.

22 And my second opposition for Samsung is the
23 case we're talking about now, the Acorn case.

24 Q. Other than the Acorn case, can you describe
25 your role in your cases adverse to Samsung in terms of

1 infringement and validity, et cetera?

2 A. So in the two Kaist cases, I did both
3 infringement and validity. In the first Kaist case, as
4 I mentioned, I gave the direct infringement report and
5 did that at trial, and then a day or so later did the
6 validity, and as I mentioned I did the IPRs on that
7 case.

8 On the second case, I'd have to look because
9 it terminated with settlement. I certainly recall
10 doing the direct report. I don't recall if I did the
11 validity or not because it -- I believe I did, and then
12 it terminated before trial. And there was no IPR on
13 the second. There was an EPR on the second one but no
14 IPR.

15 Q. When you say "EPR," you're referring to an
16 ex parte re-exam?

17 A. Yes.

18 Q. And did you submit declaration testimony
19 during that ex parte re-exam?

20 A. Yes.

21 Q. The next question may require an
22 approximation, but approximately how much money have
23 you made in your work adverse to Samsung over the
24 years?

25 MR. PHILLIPS: Objection. Scope.

1 Objection. Relevance.

2 THE WITNESS: I don't know. If it's
3 incredibly important, I can sit down and go through all
4 the invoices, but I can't do that off the top of my
5 head.

6 BY MR. MAIER:

7 Q. Do you know whether it was above or below a
8 million dollars?

9 MR. PHILLIPS: Same objections.

10 THE WITNESS: I don't think I've made a
11 million dollars consulting if I include all my
12 consulting wages for the past five years. I don't know
13 exactly but I don't think I'm anywhere close to that.

14 BY MR. MAIER:

15 Q. What's your best ballpark for how much money
16 you made from your consulting work adverse to Samsung?

17 MR. PHILLIPS: Same objections.

18 THE WITNESS: I'm -- I can't do this,
19 you know, if this is important, we can go offline and I
20 can put the invoices together and I can answer that
21 question accurately, but it's not something I even
22 thought of in preparing for this deposition.

23 MR. MAIER: All right. Why don't we
24 take another break, and then we'll do the last section.

25 THE WITNESS: Okay, sounds good. Ten

1 minutes, maybe 11:05?

2 MR. MAIER: Let's go off the record.

3 THE VIDEOGRAPHER: Thank you. We are
4 going off the record at 10:54.

5 (Recess taken 10:54 a.m. to 11:15 a.m.)

6 THE VIDEOGRAPHER: We are back on the
7 record the time is 11:15. Please proceed.

8 MR. MAIER: Dr. Kuhn, I have no further
9 questions unless there is any redirect, so thank you
10 for your time.

11 THE WITNESS: Well, thank you.

12 MR. PHILLIPS: Sorry to interrupt. I do
13 not have any redirect. So I believe we are done.

14 THE VIDEOGRAPHER: This concludes
15 today's testimony given by Dr. Kelin Kuhn. The total
16 number of media units used is two. All media will be
17 retained by Veritext on a local secured drive and
18 redundantly stored in the Veritext-managed Amazon Cloud
19 S-3 services for preservation purposes.

20 We're going off the record at 11:15.

21 (Signature was reserved.)

22 (Deposition concluded at 11:15 a.m.)

23

24

25

REPORTER'S CERTIFICATE

I, JUDY BONICELLI, the undersigned Certified Court Reporter, pursuant to RCW 5.28.010 authorized to administer oaths and affirmations in and for the State of Washington, do hereby certify:

That the sworn testimony and/or proceedings, a transcript of which is attached, was given before me at the time and place stated therein; that any and/or all witness(es) were duly sworn to testify to the truth; that the sworn testimony and/or proceedings were by me stenographically recorded and transcribed under my supervision, to the best of my ability; that the foregoing transcript contains a full, true, and accurate record of all the sworn testimony and/or proceedings given and occurring at the time and place stated in the transcript; that I am in no way related to any party to the matter, nor to any counsel, nor do I have any financial interest in the event of the cause; that a review was requested.

WITNESS MY HAND and DIGITAL SIGNATURE this 13th day of July 2021.



JUDY BONICELLI, RPR, CCR

Washington Certified Court Reporter, CCR 2322

California Certified Court Reporter, CSR 9091

1 Matthew Phillips, Esq.,
2 MPHILLIPS@LPIPLAW.COM

3 July 13, 2021

4 RE: Samsung Electronics Co. v. Acorn Semi, LLC
5 7/7/2021, Dr. Kelin Kuhn (#4683523)

6 The above-referenced transcript is available for
7 review.

8 Within the applicable timeframe, the witness should
9 read the testimony to verify its accuracy. If there are
10 any changes, the witness should note those with the
11 reason, on the attached Errata Sheet.

12 The witness should sign the Acknowledgment of
13 Deponent and Errata and return to the deposing attorney.
14 Copies should be sent to all counsel, and to Veritext at
15 cs-ny@veritext.com

16
17 Return completed errata within 30 days from
18 receipt of testimony.

19 If the witness fails to do so within the time
20 allotted, the transcript may be used as if signed.

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22 Yours,
23 Veritext Legal Solutions
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SEE ATTACHED

1 Samsung Electronics Co. v. Acorn Semi, LLC

2 Dr. Kelin Kuhn (#4683523)

3 E R R A T A S H E E T

4 PAGE _____ LINE _____ CHANGE _____

5 _____

6 REASON _____

7 PAGE _____ LINE _____ CHANGE _____

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9 REASON _____

10 PAGE _____ LINE _____ CHANGE _____

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12 REASON _____

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18 REASON _____

19 PAGE _____ LINE _____ CHANGE _____

20 _____

21 REASON _____

22 _____

23 Kelin Z. Kuhn _____ 7/22/21 _____

24 Dr. Kelin Kuhn _____ Date

25 _____

1 Samsung Electronics Co. v. Acorn Semi, LLC

2 Dr. Kelin Kuhn (#4683523)

3 ACKNOWLEDGEMENT OF DEPONENT

4 I, Dr. Kelin Kuhn, do hereby declare that I
5 have read the foregoing transcript, I have made any
6 corrections, additions, or changes I deemed necessary as
7 noted above to be appended hereto, and that the same is
8 a true, correct and complete transcript of the testimony
9 given by me.

10

11 Kelin Z. Kuhn 7/22/21
12 Dr. Kelin Kuhn Date

13 *If notary is required

14 SUBSCRIBED AND SWORN TO BEFORE ME THIS
15 _____ DAY OF _____, 20____.

16

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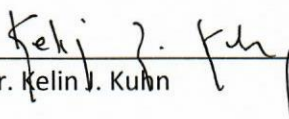
25

ERRATA FOR DEPOSITION OF DR. KUHN – JULY 6-7, 2021

<u>Page:Line</u>	<u>Correction</u>
15:16	“patents” → “petitions”
30:1	“for” → “from”
45:9	“exclaiming” → “explaining”
54:15	“interphase” → “interface”
94:15	“oxide silicon” → “oxide, silicon”
95:616-17	“widely spread” → “widely read”
95:23	“must” → “much”
102:20	“EV” → “eV”
141:13	“reprise” → “rephrase”
146:4	“R-fab” → “our fab”
151:3	“mass” → “mask”
153:6	“one more” → “one or more”
172:10	“silk” → “SiLK”
186:25	“this” → “this is a”
193:13	“intentioned” → “in tension”
204:4	“doesn’t” → “does”
228:12	“an idea which” → “an idea, which”
228:13	“mid-separation” → “MIG-separation”
228:20	“structures and” → “structures. And”
228:25	“table with” → “table, with”
229:15	“challenge” → “challenged”
230:2	“challenge” → “challenged”
230:5	“challenge” → “challenged”
230:8	“challenge” → “challenged”
230:11	“challenge” → “challenged”
230:15	“challenge” → “challenged”
231:1	“challenge” → “challenged”
231:9	“challenge” → “challenged”

§2 7/22/21

232:25 "challenge" → "challenged"
243:22 "challenge" → "challenged"
245:11 "challenge" → "challenged"
245:12 "challenge" → "challenged"
245:15 "challenge" → "challenged"
245:18 "challenge" → "challenged"
245:20 "challenge" → "challenged"
246:4 "challenge" → "challenged"
249:22 "challenge" → "challenged"
250:24 "did not" → "determined"
251:6-7 "this way is" → "this way, in"
251:16 "challenge" → "challenged"
255:24 "require" → "requiring:"
264:3 "challenge" → "challenged"
264:10 "silicone" → "silicon"
264:16 "pre-carrier" → "free-carrier"
276:14 "35" → "III-V"
278:11 "adsorb" → "adsorbed"
281:21 "option" → "opposition"


Dr. Kelin J. Kuhn

Date: 7/22/21

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