

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2
3 BEFORE THE PATENT TRIAL AND APPEAL BOARD

4
5 HANWHA SOLUTIONS CORPORATION,

6 Petitioner,

7 v.

8 MAXEON SOLAR PTE. LTD.,

9 Patent Owner.

10
11 Case IPR2024-01198

12 U.S. Patent No. 11,251,315

13
14 Deposition of

15 E. FRED SCHUBERT, Ph.D.

16 Albany, New York

17 Tuesday, July 15, 2025

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22 Reported By: Kadi A. Harmon

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2 held at the offices of:

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11 Pursuant to notice, before Kadi A. Harmon,
12 Court Reporter and Notary Public in and for the
13 State of New York.

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

2 THE COURT REPORTER: Would you raise your
3 right hand, please?

4 Do you swear or affirm that the testimony
5 you provide today will be the truth, the whole
6 truth and nothing but the truth?

7 THE WITNESS: I do.

8 THE COURT REPORTER: Thank you.

9 E X A M I N A T I O N

10 BY ATTORNEY SELWYN:

11 Q Good morning, sir.

12 A Good morning.

13 Q Could you please state your full name for
14 the record?

15 A Eric Fred Schubert.

16 Q And Dr. Schubert, have you ever been known
17 by any other names?

18 A Yes.

19 Q What else?

20 A Well, I was Erdmann, E-r-d-m-a-n-n,
21 Friedrich, F-r-i-e-d-r-i-c-h, and same last name.
22 That's my birth name.

1 Q And may I ask when you changed your name?

2 A When I became a natural US citizen in the
3 1990s.

4 Q By whom are you employed?

5 A Rensselaer Polytechnic Institute, RPI, in
6 Troy, New York.

7 Q What is your current business address,
8 sir?

9 A 110 8th Street, Troy, New York.

10 Q Do you understand that you have been
11 placed under oath?

12 A Yes.

13 Q And do you understand that you must give
14 complete, honest, and responsive answers to my
15 questions today, just as if you were in a
16 courtroom?

17 A I do.

18 Q Is there any reason you can't provide your
19 best testimony here today?

20 A No.

21 Q Have you ever been deposed before?

22 A Yes.

1 Q Approximately how many times?

2 A Between 30 and 40 times.

3 Q Have you ever testified at trial before?

4 A Yes.

5 Q How many times?

6 A 5 to 10 times.

7 Q Could you tell us what you did to prepare
8 for today's deposition, please?

9 A I reviewed the relevant documents, I met
10 with counsel during a teleconference, and I
11 considered the technical questions at hand.

12 Q For how long did you meet with counsel?

13 A Three hours.

14 Q When was that?

15 A Last week.

16 Q Did you review any documents to prepare
17 for today's deposition, other than the ones that
18 are cited in your declaration?

19 A I may have reviewed documents that I've
20 cited in the petition. Yeah. I'm not 100 percent
21 sure about that, but I may have reviewed some
22 documents that are not cited in my declaration.

1 Q How did you come to be engaged for this
2 matter?

3 A I received an email from, like, an expert
4 company, and that started it.

5 Q What was the expert company?

6 A I think it's called the Litigation Expert
7 Group.

8 Q When was that?

9 A Earlier this year.

10 THE AV TECHNICIAN: I apologize for the
11 interruption. Can we go off the record briefly?

12 ATTORNEY SELWYN: Sure.

13 (Recess from 8:34 a.m. until 8:35 a.m.)

14 BY ATTORNEY SELWYN:

15 Q You have been retained to work on behalf
16 of Maxeon for this matter; is that right?

17 A Yes.

18 Q When were you retained?

19 A Earlier this year.

20 Q Do you recall what month?

21 A Maybe the February to April time frame.

22 Q Before you were retained, were you told

1 that counsel was interested in you providing an
2 opinion that supported the validity of the '315
3 patent?

4 A I don't recall.

5 Q What were you told about this matter
6 before you were retained?

7 A By whom?

8 Q By counsel for Maxeon.

9 A I don't recall specifics.

10 Q Before being retained for this matter, had
11 you ever worked for or on behalf of Maxeon?

12 A No.

13 Q Before you were retained for this matter,
14 had you ever heard of Maxeon?

15 A I may have, but I'm not sure.

16 Q Have you ever seen any Maxeon product?

17 A I don't recall.

18 Q Before you were hired for this matter,
19 were you aware of any Maxeon patents?

20 A No.

21 Q Before you were hired for this matter, had
22 you done any research about Maxeon?

1 A I don't think so.

2 Q Before you were retained for this matter,
3 had you ever worked for or on behalf of SunPower?

4 A Can I hear the question again?

5 Q Sure.

6 Before you were hired for this matter,
7 have you ever worked for or on behalf of SunPower?

8 A I don't think so.

9 Q Before you were retained for this matter,
10 had you ever heard of Hanwha?

11 A I may have. I'm not sure.

12 Q Have you ever seen any Hanwha product?

13 A I've seen a lot of solar cell products,
14 but not always have I associated the manufacturer
15 with these products.

16 Q Do you have a memory of ever having seen a
17 Hanwha product in particular?

18 A I don't recall.

19 Q Have you ever disassembled any Hanwha
20 product?

21 A No.

22 Q Are you familiar with Hanwha's reputation

1 in the solar cell industry?

2 A No.

3 Q Have you ever read any Hanwha patents?

4 A That I don't recall.

5 Q Have you ever investigated any Hanwha
6 patents?

7 A You mean patents that are owned by the
8 company Hanwha?

9 Q Correct.

10 A I don't know. I do not know.

11 Q How many hours have you worked on this
12 matter to date?

13 A 50 to 100 hours.

14 Q How many of those hours were spent
15 preparing your declaration in support of the
16 patent owner's response?

17 A I don't recall.

18 Q Would you be able to give any estimate
19 without guessing?

20 A Between 30 and 80 hours.

21 Q How much have you billed so far in
22 connection with this matter?

1 A I don't know.

2 Q Would you be able to give any estimate
3 without guessing?

4 A Between 30 and 60,000.

5 (Schubert Deposition Exhibit 1 marked for
6 identification and attached to the transcript.)

7 Q Let me hand you what I've marked as
8 Exhibit 1, which is also Maxeon Exhibit 2028.

9 Do you recognize this as a copy of the
10 declaration you submitted in this matter?

11 A Yes.

12 Q Are you aware of any corrections or
13 changes that need to be made to your declaration?

14 A No.

15 Q Do you stand by all the opinions provided
16 in your declaration?

17 A Yes.

18 Q Is your declaration a complete description
19 of all the opinions that you plan to give in this
20 matter?

21 A It was a complete description at the time
22 that I signed it. In the meantime, there was the

1 deposition of Dr. Holman, and I probably developed
2 some new opinions based on his testimony.

3 Q Can you describe the general methodology
4 that you followed in arriving in the opinions that
5 are set forth in your declaration, Exhibit 1?

6 A I reviewed the patent, the '315 patent. I
7 reviewed its file history. I reviewed the
8 asserted prior art, and I had a collaborative
9 effort with counsel to compose the declaration.

10 Q What do you mean by a collaborative effort
11 with counsel?

12 A We had maybe a couple of conferences,
13 during which we discussed the matter.

14 Q Who wrote the first draft of your
15 declaration?

16 A The first draft was written with input
17 from myself and with input from counsel.

18 Q And were you the drafter of the first
19 draft or was counsel the drafter?

20 A You mean who made the first integrated
21 version?

22 Q Yes.

1 A I think that was counsel.

2 Q Are there any portions of Exhibit 1, your
3 declaration, that you personally drafted?

4 A Yes. I think so.

5 Q Can you tell us which ones?

6 A I had contributions to Section 2, summary
7 of opinions; I had contributions to Section 3, my
8 qualifications; I had contributions to Section 7,
9 the '315 patent; Section 8, claim construction;
10 section 9, Ground 1, Ground 2, Ground 3; and
11 contributions to conclusions, Section 10.

12 Q Thank you.

13 Could you turn, please, to Paragraph 83,
14 which is on Page 37 of 58, and carries over to
15 Page 38?

16 Do you see that in Paragraph 83 on Page 38
17 there's an annotated figure of 7.1 Granek?

18 (Reporter clarification.)

19 A Yes.

20 Q Did you create the annotated figures --
21 strike that.

22 Did you create the annotations shown in

1 Paragraph 83?

2 A I created an annotated version of this
3 figure. We had several annotated versions of the
4 figure, and the figures that we see here, Page 37
5 and Page 38, are a result of the figure that I
6 originally annotated.

7 Q Does your declaration include all the
8 support that you intend to present for your
9 opinions in this matter?

10 A I'm not sure if I understand the question.

11 Where do I present -- where do you think I
12 will present something?

13 Q Let me ask you this: Can you turn,
14 please, to Paragraph 19 on Page 9 of your
15 declaration?

16 Do you see that Paragraph 19 says that it
17 is a list of the documents you considered in
18 forming the opinions set forth in your
19 declaration?

20 A Yes.

21 Q Is that a complete list of the documents
22 that you considered in forming the opinions set

1 forth in your declaration?

2 A I also did consider the deposition
3 testimony or the deposition transcript of
4 Dr. Holman.

5 Q Does Paragraph 19 contain a complete list
6 of the documents that you considered in reaching
7 the opinions set forth in your declaration?

8 A I think so.

9 Q And did you review each and every exhibit
10 listed in the documents considered table in
11 Paragraph 19 of your declaration?

12 A Yes.

13 Q Do you see in the second page of the
14 table, on Page 10 of your declaration,
15 Exhibit 2003 is an article by Lamers?

16 Pardon me.

17 Exhibit 2002 is an article by Lamers?

18 A Yes.

19 Q Who found Exhibit 2002, the Lamers
20 Reference?

21 A I don't know.

22 Q Who found Exhibit 2003, the Desa

1 Reference?

2 A I don't know.

3 Q And who found Exhibit 2005, the Procel
4 Reference?

5 A I do not know.

6 Q You were not the one to find
7 Exhibits 2002, Exhibit 2003 or 2005, correct?

8 A I think that's correct.

9 (Schubert Deposition Exhibit 2 marked for
10 identification and attached to the transcript.)

11 Q Dr. Schubert, you've been handed a copy of
12 US Patent Number 11,251,315, which I've marked as
13 Exhibit 2, and is also marked as Hanwha 1001.

14 Do you have that before you?

15 A Yes.

16 Q Is it okay as a shorthand that we refer to
17 this patent today as the '315 patent?

18 A Sure.

19 Q When did you first become aware of the
20 existence of the '315 patent?

21 A Earlier this year.

22 Q Did you first become aware of the '315

1 patent before or after you were contacted by
2 Maxeon's counsel regarding the possibility of
3 working for Maxeon on this matter?

4 A I don't recall.

5 Q Did you first become aware of the '315
6 patent -- strike that.

7 Were you aware of the '315 patent before
8 you were contacted by the search firm about the
9 possibility of working on this matter?

10 A I do not recall. Maybe not.

11 Q You have no recollection of -- strike
12 that.

13 You have no recollection of being aware of
14 the '315 patent before you were contacted by the
15 expert search firm about the possibility of
16 working on this matter; is that fair?

17 A I do not recall if I have seen that patent
18 before that time.

19 Q So the first time you can say with
20 certainty you became aware of the '315 patent is
21 after you were contacted about the possibility of
22 working on this matter; is that right?

1 A I may have come across the patent before,
2 but I certainly became aware of it during my
3 engagement.

4 Q Do you have any recollection of having
5 come across the patent before you were engaged for
6 this matter?

7 A The expert company may have provided a
8 copy of the patent to me.

9 Q Do you have any recollection of having
10 come across the patent before the expert company
11 may have provided a copy to you?

12 A No specific recollection.

13 Q When did you first read the '315 patent?

14 A I may have read parts of it earlier this
15 year.

16 Q Did you read the '315 patent before you
17 were contacted by the expert search firm about the
18 possibility of working on this matter?

19 A I can't exclude that possibility, but I
20 don't have a specific recollection.

21 Q Before you were hired for this matter, had
22 you ever heard of any of the named inventors of

1 the '315 patent?

2 A I have no recollection on this point.

3 Q Are you aware of any books, papers or
4 articles that mention or discuss the '315 patent?

5 A Not at the moment.

6 Q Are you aware of any industry praise for
7 the '315 patent?

8 A The type of technology that is disclosed
9 in the '315 patent is pioneering technology, and
10 specifically the employment of tunneling oxide
11 passivation context, and that technology in
12 general is being talked about a lot, and I'm sure
13 has received praise from various sources.

14 Q We'll get to your opinions about the
15 patent, but my question is a little bit different.

16 Are you aware of any praise in the
17 industry specifically for the '315 patent?

18 A The type of technology that is disclosed
19 in the '315 patent has received praise from
20 various sources, and I'm aware of that praise.

21 Q Who in the industry has ever mentioned the
22 '315 patent?

1 A I guess Hanwha is one of the companies
2 that have -- that has mentioned the patent.

3 Q Anyone else?

4 A I guess Maxeon has mentioned the patent.

5 Q Anyone else?

6 A I guess CSI may have mentioned the patent.

7 Q When did Hanwha mention the '315 patent?

8 A In its petition.

9 Q You're not aware of Hanwha ever mentioning
10 the '315 patent outside the context of the IPR
11 petition or its litigation with Maxeon, correct?

12 A I don't know.

13 Q Have you ever read the '315 patent in its
14 entirety?

15 A Yes.

16 Q Is there anything in the '315 patent that
17 you don't understand?

18 A No.

19 Q In your view, what, if any, problem with
20 the state of the art for solar cells as it existed
21 in 2004 [sic] does the '315 patent address?

22 A Can I hear the question again?

1 Q Of course.

2 In your view, what problem with the state
3 of the art for solar cells as it existed in 2014
4 does the '315 patent address?

5 A There is a continuous search for technical
6 solutions that bring about an improved efficiency
7 of solar cells, and the '315 patent makes progress
8 in this regard.

9 Q Can you be any more specific about what
10 problem with the state of the art as it existed in
11 2014 the '315 patent purports to address?

12 A It is desirable to improve the conversion
13 efficiency of solar cells, and that has been an
14 issue with the prior art, and the '315 patent has
15 improved the efficiency of solar cells.

16 Q What was the specific problem with the
17 efficiency of solar cells that the '315 patent
18 purports to address?

19 A The efficiency had a lower value, and
20 having a lower value efficiency is, among
21 technical, people considered a problem.

22 Q Was there a problem with the design of

1 solar cells as they existed in 2014 that the '315
2 patent purports to address?

3 A The '315 patent has new structural
4 features that ultimately result in an improved
5 efficiency.

6 Q I'm going to give you an opportunity to
7 talk about the -- what you see as the
8 improvements, but my question right now is: Was
9 there a specific problem with the design of solar
10 cells as they existed in 2014 that the '315 patent
11 purports to address?

12 A The '315 patent has succeeded in improving
13 the efficiency, and if you have two efficiencies,
14 one is lower; one is higher, the higher efficiency
15 is progress, and the lower efficiency is a problem
16 that has been addressed.

17 Q Let me ask it this way. With respect to
18 the design of solar cells as they existed in 2014,
19 does the '315 patent identify a problem that it
20 purports to address?

21 A Yes.

22 Q What is that problem?

1 A The lower efficiency of the prior art.

2 Q And what about the design of the -- of
3 solar cells as they existed in 2014 does the '315
4 patent claim as the problem?

5 A I'm not sure if I understand the question.
6 Maybe I can hear it again?

7 Q Sure.

8 What aspect of the design of solar cells
9 as they existed in 2014 does the '315 patent
10 identify as a problem?

11 A Some of the problems are described in the
12 background section of the patent.

13 Q Okay. Can you tell us, as specifically as
14 you can, what aspect or aspects of the design of
15 solar cells as they existed in 2014 the '315
16 patent identifies as a problem?

17 A My first point is the efficiency.

18 My second point is improvement of the
19 fabrication process.

20 A third point is reduction of cost of
21 manufacturing, all of which is described as
22 desirable.

1 Q Could you please describe in your own
2 words the invention that is described and claimed
3 in the '315 patent?

4 A Any specific claim?

5 Q I'm really talking about how you would
6 describe the invention claimed in the '315 patent
7 in your own words?

8 A The invention relates to a tunneling oxide
9 passivation contact solar cell that addresses
10 metal contaminates and reduces the deleterious
11 aspects of such metal contaminates, and also
12 includes specific guidance with respect to a front
13 surface field layer.

14 Q Are you aware of any products that have
15 used the solar cell design described and claimed
16 in the '315 patent?

17 A I've not looked into this question.

18 Q Your list of documents considered,
19 Paragraph 19 of your declaration, identifies all
20 of the file histories you have reviewed in this
21 matter, correct?

22 A I think that's correct.

1 Q You have not reviewed any prosecution
2 histories for patents in the same family as the
3 '315 patent, correct?

4 A I don't recall right now.

5 Q Could you turn, please, to Claim 10 of the
6 '315 patent?

7 Do you see that Claim 10 recites a solar
8 cell: The solar cell having a front side which
9 faces the sun during normal operation, and a back
10 side opposite the front side, and it continues?

11 A Yes.

12 Q Have you ever designed a solar cell?

13 A I've designed aspects of solar cells, yes.

14 Q Have you ever designed an entire solar
15 cell?

16 A You mean just myself, individually?

17 Q Yes, sir.

18 A Well, it's usually done in a team.

19 Q You have not designed an entire solar
20 cell, correct?

21 A I've designed various aspects of solar
22 cells, including anti-reflection coatings,

1 location of P-N junction, front surface field,
2 context, passivating context, tunnelling context.

3 I've designed a wide range of aspects of solar
4 cells.

5 Q And have you ever designed an entire solar
6 cell?

7 A It's usually done in a team.

8 Q I'll get to that. But have you personally
9 ever designed an entire solar cell?

10 A Just by myself?

11 Q Yes, sir.

12 A It's usually done in a team.

13 Q So you, yourself, have not designed an
14 entire solar cell, correct?

15 A It's done in a team.

16 Q I will ask the question about the team,
17 but first I'm asking about you personally.

18 Have you ever, yourself, designed an
19 entire solar cell?

20 A For manufacturing?

21 Q For any purpose.

22 A I've not worked for a solar cell

1 manufacturing company, if that's your question.

2 Q It's not. My question is broader.

3 Have you, sir, ever designed an entire
4 solar cell yourself for any purpose?

5 A Well, I teach in the field. And you know,
6 during my teachings I explain how the solar cell
7 works and how it's designed, but I have not worked
8 for a solar cell manufacturing company.

9 Q Have you ever built or manufactured a
10 solar cell yourself?

11 A I'm not a manufacturer.

12 Q So the answer is no?

13 A We have built solar cells in my
14 laboratory. We have equipped those solar cells
15 with specific anti-reflection coatings, we have
16 measured properties of solar cells, and I've
17 worked extensively on solar cells.

18 Q Have you ever written any books, papers or
19 articles about solar cell design?

20 A I didn't hear the question.

21 Q Have you ever written any books, papers or
22 articles about solar cell design?

1 A Yes.

2 (Schubert Deposition Exhibit 3 marked for
3 identification and attached to the transcript.)

4 Q Let me hand you a copy of your CV, which
5 we've marked as Exhibit 3.

6 Does that CV include -- strike that.

7 Does your CV identify your books, papers
8 or articles that you've written about solar cells?

9 A Yes.

10 Q Could you identify any that you've written
11 since 2014?

12 A CV Page 32, Patent Number 39 relates to
13 ultra-low reflectance broadband omni-directional
14 anti-reflection coating, which relates to solar
15 cells.

16 Q Okay. Anything else?

17 A CV Page 32, Patent Number 38, relates to
18 tuneable nanoporous film on polymer substrates and
19 method for their manufacture, and this relates to
20 solar cells.

21 Q Anything else?

22 A I've written teaching documents that

1 relate to solar cells.

2 Q Are any of those identified on your CV?

3 A My teachings are generally identified in
4 my CV.

5 Q Looking at the list of papers that begins
6 on Page 33 of your CV, are you there?

7 A Yes.

8 Q If you go forward a few pages, you'll see
9 the year 2014. Are any of the papers, articles or
10 books that you've written since 2014 related to
11 solar cell design?

12 A Article 325 is related to solar cells.

13 Q Any others?

14 A Article 328 has solar cells in the title,
15 and accordingly is related to solar cells.

16 Q Have you ever designed a silicon solar
17 cell?

18 A I have designed aspects of silicon solar
19 cells, yes.

20 Q Have you ever designed an entire silicon
21 solar cell?

22 A As I said earlier, in my teachings, I

1 teach on the subject of solar cells, including
2 silicon solar cells.

3 Q My question is different. Have you,
4 yourself, ever designed an entire silicon solar
5 cell, yes or no?

6 A I have not worked for a solar cell
7 manufacturing company, but I have designed aspects
8 regarding -- you know, everything, designing
9 everything just by myself, as I communicated to
10 you earlier, it's done in a team.

11 Q Have you published any books, papers or
12 articles about silicon solar cells?

13 A Yes.

14 Q Looking again at your CV of the
15 publications since 2014, which are specifically
16 about silicon solar cells?

17 A Patent Number 39 was published in 2021.

18 That relates to broadband anti-reflection
19 coatings, and is typically used with silicon solar
20 cells.

21 Q Anything else?

22 A The technology that is disclosed in Patent

1 Number 38 can be used for silicon solar cells.

2 Q Is the patent listed at Number 38 about
3 silicon solar cells?

4 A It's about thin films that can be used in
5 silicon solar cells.

6 Q Okay. Do you have any publications
7 specifically about silicon solar cells?

8 A Patent Number 39 relates to
9 anti-reflection coatings that are used
10 specifically for silicon solar cells.

11 Q Focusing on your list of publications, do
12 you have any publications specifically about
13 silicon solar cells?

14 A Based on my understanding, a patent is a
15 publication.

16 Q Okay. Let me direct your attention,
17 please, sir, to the list of publications that
18 appear on your CV, beginning on Page 33.

19 Do you see that?

20 A Yes.

21 Q Do any of those publications, beginning on
22 Page 33, relate specifically to silicon solar

1 cells?

2 A So just for clarification, you want me to
3 exclude patent publication; is that right?

4 Q For this question, yes, sir.

5 A Just so that I understand your question
6 correctly, you're insisting that the solar cell
7 has a silicon substrate?

8 Q Yes, sir.

9 A And you would want me to exclude anything
10 that comes before 2014?

11 Q Let's just start -- the question's a
12 straightforward one.

13 Looking at your list of publications since
14 2014, are any of them specifically about silicon
15 solar cells, yes or no?

16 A And when you say publications, you exclude
17 patents?

18 Q Yes, sir.

19 A And you also exclude teaching materials
20 that I made available on the internet?

21 Q Sir, I'm focusing on your CV. Okay?

22 You list publications beginning on

1 Page 32, do you not?

2 A Journal publications.

3 Q Okay. And they're listed by year, right?

4 A Yes.

5 Q So if you look to the years 2014 to the
6 present, are there any journal publications
7 specifically about silicon solar cells, yes or no?

8 A One example is Publication Number 338.

9 Q Do you know what a front surface field is?

10 A Yes.

11 Q What is it?

12 A It's an electric field at the surface of a
13 solar cell that faces the sun.

14 Q You've designed front surface fields; is
15 that right?

16 A I've designed aspects of solar cells,
17 including anti-reflection coatings, including
18 features to reduce the surface recombination,
19 aspects that relate to the doping of solar cells.
20 And based on these aspects, you obtain a certain
21 electric field that have an effect on the movement
22 of carriers, and so I would say I have worked in

1 that field, and I have designed aspects that
2 relate to the front surface field.

3 Q Well, do you feel comfortable saying under
4 oath that you have designed front surface fields?

5 A I have designed surface layers of solar
6 cells, and this includes the doping of these
7 layers, as well as coatings, oxide coatings,
8 anti-reflection coatings, passivation coatings,
9 and they all relate to the front surface field.

10 Q Do you know what a passivation layer is?

11 A In the context of solar cells?

12 Q Yes.

13 A Yes.

14 Q What is it?

15 A A passivation layer can relate to the
16 chemical passivation of a surface. It can also
17 relate to the electrical passivation of a
18 semiconductor surface.

19 Q What is surface passivation?

20 A Surface passivation can passivate the
21 chemical nature of a semiconductor surface.
22 Surface passivation can also passivate or reduce

1 the electrical activity of surface states.

2 Q Have you researched surface passivation in
3 solar cells?

4 A I have conducted work in the field, yes.

5 Q Okay. Have you ever optimized the doping
6 concentration of a front surface field in a solar
7 cell?

8 A Can I hear the question again?

9 Q Have you ever optimized the doping
10 concentration of a front surface field of a solar
11 cell?

12 A You mean like an experimental
13 optimization, or an optimization that is based on
14 theoretical considerations?

15 Q Either one. Take them separately.

16 A Sure. Yeah.

17 I mean, when it comes to theoretical
18 considerations, I have performed these
19 considerations, taught about these considerations
20 in the past.

21 Q If you needed to optimize the doping
22 concentration of a front surface field of a solar

1 cell, how would you go about doing that task?

2 A Well, you would look at the specific
3 structure at hand and what type of semiconductor
4 do you have, what is the state of the surface.

5 Is this a semiconductor surface that is
6 coated by another layer?

7 Does it have an anti-reflection coating?

8 Where is the photo-generated carrier
9 region?

10 And so those are all aspects that relate
11 to the functioning and the working of a front
12 surface field layer, and I am considering and
13 conducting work in that field, and teaching in
14 that field, and have done so for a number of
15 years.

16 Q Have you done experimental optimizations
17 of the doping concentration of a front solar -- of
18 a front surface field in a solar cell?

19 A I have not conducted a series of
20 experiments where I bury the doping concentration
21 and looked at the efficiency of the solar cell.

22 If that's what you're looking for, I have not

1 done that.

2 Q Have you done that in a theoretical way?

3 A Yes. I would say so.

4 I mean, there are limits for the doping
5 concentration. There are various ways on how to
6 dope a solar cell. I've looked at the cost of the
7 doping, and including implantation, processes, and
8 defusion processes, and so I recall having worked
9 in that field of doping a solar cell, the methods
10 of doping, the doping optimization, and the
11 various aspects for which the doping is used.

12 Q If you had to optimize the doping
13 concentration of a front surface field of a solar
14 cell, would you begin by simulating different
15 doping concentrations and identifying how changing
16 the doping concentration affects the performance
17 of the solar cell?

18 A It's a possibility, but not a necessity.

19 Q Are theoretical considerations and models
20 useful, in your experience, when attempting to
21 optimize doping?

22 A They can be useful, but I recall a

1 statement by Dr. Holman in which he indicated that
2 simulations can be garbage, and so I think they
3 can be useful. Dr. Holman believes that some
4 simulations are garbage.

5 Q I'm asking your opinions now.

6 Under what circumstances do you believe
7 that theoretical considerations and models can be
8 useful when attempting to optimize doping?

9 A Well, your question is very broad, but do
10 we know all the parameters of the simulation?
11 Before we start our simulation, what are the
12 uncertainties? What are the parameters that we
13 need to know?

14 Is this a one-dimensional model? Is it a
15 two-dimensional model? Is it a three-dimensional
16 model?

17 Generally, I think simulations can be
18 useful, but there can be situations where
19 simulations have uncertainty associated with them,
20 and that needs to be taken into account as well.

21 Q If you needed to optimize the doping
22 concentration of a front surface field to the

1 solar cell, is one of the things that you would do
2 to look at literature to identify what others in
3 the field have learned about how the doping
4 concentration affects solar cell performance?

5 A Can I hear the question again?

6 Q Sure. If you needed to optimize the
7 doping concentration of a front surface field to a
8 solar cell, would you look at literature to
9 identify what others in the field have learned
10 about how the doping concentration affects solar
11 cell performance?

12 A It's a possibility. It's not a necessity,
13 but it's a good habit to look at the technical
14 literature and see what others have done.

15 Q What is a dielectric region of a solar
16 cell?

17 A I'm not exactly sure what you're referring
18 to, but it can be an insulating region,
19 electrically insulating region.

20 Q Well, you know that the claims of the '315
21 patent refer to dielectric regions, right?

22 A Which claim are you referring to?

1 Q Claim 10, for example.

2 A Yes. I see that Claim 10 refers to a
3 dielectric region.

4 Q What is a dielectric region?

5 A A dielectric region is a region that is
6 made of an insulating material.

7 Q What is an emitter region?

8 (Reporter clarification.)

9 A And you're referring to Claim 10, or in
10 general?

11 Q In general, but if there's a difference in
12 how it's used in Claim 10, let me know.

13 A In general, emitter can mean many things.

14 Q What is an emitter region?

15 A It can mean multiple things. For example,
16 in a bipolar transistor, we have an emitter, and
17 we have an emitter region. But a bipolar
18 transistor is not related to solar cells.

19 Q What is an emitter region, as the term is
20 used in Claim 10?

21 A The emitter region is a semiconductor
22 region that is located over the dielectric region.

1 Q Why is an emitter region for bipolar
2 transistors not relevant to solar cells?

3 A I was just indicating that those are two
4 different devices. A transistor has only
5 electrical functionality, and is not related to
6 optics. A solar cell has optical aspects, as well
7 as electrical aspects.

8 Q Are you familiar with different qualities
9 of silicon wafers?

10 A Quality in which regard?

11 Q In terms of purity.

12 A Generally, yes.

13 Q How generally do high quality silicon
14 wafers differ from low quality silicon wafers?

15 A Generally, high purity silicon is higher
16 quality than low purity silicon.

17 Q Are you familiar with solar grade silicon
18 substrates?

19 A The term means something to me. I'm not
20 exactly sure what you mean by being familiar with.

21 Q Okay. What is a solar grade silicon
22 substrate?

1 A A substrate that is suitable for being
2 used in a solar cell.

3 Q Are the type of silicon wafers used to
4 make solar cells different from those used to make
5 silicon chips?

6 A They can be different, yes.

7 Q How so?

8 A The minority carrier lifetime -- the
9 minority carrier lifetime is a quantity relevant
10 to solar cells, but less so for silicon integrated
11 circuits.

12 Q Are there any other differences?

13 A I'm sorry. Difference between what?

14 Q Between the type of silicon wafers used to
15 make solar cells, as compared with the type of
16 silicon wafers used to make silicon chips.

17 A Yes. There are other differences.

18 Q Like what?

19 A Silicon substrates used in silicon chips
20 is typically shielded from light; whereas silicon
21 substrates used for solar cells is not shielded
22 from light.

1 Q Are you familiar with the properties of
2 solar grade silicon substrates in 2014?

3 A I'm not sure what you specifically refer
4 to.

5 Q What's confusing about my question to you?

6 A I'm not sure if you have a certain grade
7 qualification or categorization in mind.

8 Q Is it fair to say that in 2014, low
9 quality silicon substrates were used for solar
10 cells to reduce manufacturing costs?

11 A I wouldn't say this as a general
12 statement. I would say that there is always a
13 tradeoff between different factors, and it is
14 generally the case that lower quality materials
15 are less expensive, but their technical
16 characteristics are not as good.

17 Q Would you agree that in 2014, as a general
18 matter, low quality silicon substrates were used
19 for solar cells in order to reduce manufacturing
20 costs?

21 A It's an option, but not a necessity.

22 Q The inventors of the '315 patent were

1 concerned with metal impurities in silicon
2 substrate, right?

3 A With metal contaminating impurities, yes.

4 Q And are you familiar with gettering in
5 solar cells?

6 A Yes.

7 Q What is gettering?

8 A Gettering is the segregation or the
9 separation or the direction of unwanted
10 contaminating impurities at locations where they
11 are less harmful.

12 Q Are you familiar with gettering in
13 non-solar cell semiconductors?

14 A Yes.

15 Q How does gettering in solar cells compare
16 with gettering in non-solar cell semiconductors?

17 A Your question is too broad for me to
18 answer. Gettering is really a broad term. It
19 includes the cleaning of vacuum systems by getter
20 pumps. So the term gettering is really broad.

21 If you want me to compare two specific
22 things, I would need to understand what you are

1 trying to compare.

2 Q You described a moment ago what gettering
3 is, correct?

4 A I tried to.

5 Q Okay. Are there similarities between
6 gettering, as you've described it, in solar cells,
7 and gettering in non-solar cell semiconductors?

8 A I really don't know what you're talking
9 about. Your question is very broad, and I can
10 only guess that there are similarities and there
11 are differences.

12 Q Can you identify for us any similarities
13 between gettering in solar cells and gettering in
14 non-solar cell semiconductors?

15 A I don't know what you mean by non-solar
16 cell semiconductors. So it appears to me that
17 you're talking about a semiconductor, and so if
18 you're talking about silicon, you know, silicon is
19 used in solar cells, as well as non-solar cells.
20 So I'm -- I'm not sure if I can answer the
21 question as it is posed.

22 Q Are there similarities between gettering

1 in solar cells and gettering in integrated
2 circuits?

3 A I'm not sure what type of gettering you
4 refer to in integrated circuits.

5 Q Are there similarities in gettering using
6 heating materials in solar cells, as compared with
7 integrated circuits?

8 A I'm not sure right now, based on your
9 question, what type of gettering you talk about,
10 when you say gettering in integrated circuits.
11 And if I don't understand what you're talking
12 about, it's difficult for me to answer a question
13 that I don't know what it relates to.

14 Q What is N-type doping?

15 A N-type doping typically is negative type
16 doping.

17 Q What are common dopants for N-type doping?

18 (Reporter clarification.)

19 A For silicon?

20 Q Yes.

21 A Phosphorus is a common N-type dopant.

22 Q Any others?

1 A Arsenic.

2 Q Any others?

3 A Antimony may work as an N-type dopant.

4 Q What is P-type doping?

5 A P-type stands for positive type.

6 Q What are common dopants for P-type doping?

7 A In silicon?

8 Q Yes.

9 A Boron is a common P-type dopant.

10 Q Have you ever modified a substrate or
11 front surface field from N-type doping to P-type
12 doping?

13 A I don't recall.

14 ATTORNEY SELWYN: Why don't we take our
15 first break?

16 (Recess from 10:01 a.m. until 10:13 a.m.)

17 BY ATTORNEY SELWYN:

18 Q Dr. Schubert, to what extent is knowledge
19 in the semiconductor field applicable to solar
20 cells?

21 A To what extent is knowledge applicable?

22 Yes. Knowledge is applicable. Knowledge

1 is applicable.

2 Q Okay. Why is knowledge in the
3 semiconductor field applicable to solar cells?

4 A Because solar cells are made of
5 semiconductors.

6 Q Are technical terms generally understood
7 to have the same meanings in the solar and
8 semiconductor fields?

9 A Frequently, yes. Sometimes no.

10 Q Is impurity understood to have the same
11 meaning in the solar and semiconductor fields?

12 A They are different types of impurities,
13 for example, contaminating impurities and doping
14 impurities, and I'm not sure to which type of
15 impurity your question relates to.

16 Q I'm just focused on the word impurity, and
17 my question to you is: Is impurity understood to
18 have the same meaning in the solar and
19 semiconductor fields?

20 A The meaning of the word impurity varies a
21 bit across the people who are using the term and
22 across the fields that are using the term.

1 As I indicated earlier, it is useful to
2 differentiate between a contaminating impurity.
3 Contaminating impurity has negative -- has
4 generally negative effects.

5 And doping impurity -- and doping impurity
6 has a purpose; and therefore, if we just say
7 impurity -- if you just say impurity -- it's not
8 clear to me if you're referring to a contaminating
9 impurity or a doping impurity.

10 And as I indicated, it is useful to
11 differentiate between those two types of
12 impurities, or two types of usages of the word
13 impurity, because they are very different.

14 Q So you can't say one way or the other
15 whether the word impurity is understood to have
16 the same meaning or a different meaning in the
17 solar or semiconductor fields, correct?

18 A No. I wouldn't put it this way. I mean,
19 people generally understand what an impurity is.
20 I'm just saying there are different of types of
21 impurities. Contaminating impurity is an impurity
22 that has a negative effect. Doping impurity has a

1 positive effect.

2 Q Sir, that's not my question. My question
3 is about the word impurity, just the word
4 impurity.

5 And my question is: Is impurity, that
6 word, understood to have the same meaning in the
7 solar and semiconductor fields, yes or no?

8 A So you mention two fields. Solar field
9 and semiconductor field. And solar field is a
10 sub-field of the semiconductor field. So I don't
11 see these as, you know, two separate fields. One
12 is the sub-field of the other. So a semiconductor
13 field is everything that includes semiconductors.

14 Now, what do we do with these
15 semiconductors? We make LEDs, solar cells,
16 integrated circuits, photodetectors,
17 photoreceptors with it. And so all of these
18 fields are sub-fields of semiconductor.

19 So you're asking me what's the difference
20 between those two fields, but what I'm pointing
21 out to you is that these are not really two
22 separate fields, but one is a sub-field of another

1 field. That's how I see it.

2 Q Can a dopant have a negative effect?

3 A I'm not sure if I understand your
4 question. So you dope a semiconductor and you're
5 asking is there a negative effect that is
6 associated with the process of doping; is that the
7 question?

8 Q My question is: Are there circumstances
9 under which a dopant can have a negative effect?

10 A Your thinking is not immediately clear to
11 me. Doping is a process that we, the engineers,
12 are initiating. If there would be a negative
13 consequence of that process, why would we initiate
14 it? That's not clear to me.

15 But we do doping in order to provide a
16 certain conductivity to a semiconductor. If we
17 wouldn't want that conductivity, we wouldn't dope.
18 So I don't fully understand the question.

19 Q Can a dopant never have a negative effect?

20 A Maybe if we choose a doping concentration
21 that is too high or too low, then in that case,
22 it's too high or too low, and that's not what we

1 want. And so I would say a doping concentration
2 can be too high, or a doping concentration can be
3 too low. That's how I would say it.

4 If that's what you're looking for, I agree
5 that a doping concentration can be too high or too
6 low.

7 Q Can you turn now, please, to your
8 declaration, Paragraph 21.

9 Do you see in Paragraph 21 of your
10 declaration, you state, quote: I have been asked
11 to assume that a person having ordinary skill in
12 the art, POSITA, is as described in the petition?

13 A Yes. I see this.

14 Q You agree with the definition set forth in
15 Hanwha's IPR petition of a POSITA as of the
16 claimed priority date of the '315 patent, correct?

17 A You're asking me if I agree with that
18 definition?

19 Q Yes.

20 A You know, I think it's a reasonable
21 definition.

22 Q Your declaration doesn't dispute that

1 Dr. Holman is a POSITA with respect to the '315
2 patent, correct?

3 A I think that's correct.

4 Q Your declaration doesn't dispute that
5 Dr. Holman was a POSITA as of the claimed priority
6 date of the '315 patent, correct?

7 A I think that's correct.

8 Q Do you, sir, have, quote: At least one
9 year of experience designing, developing or
10 researching the design and/or manufacture of solar
11 cells or related technologies?

12 A Sure.

13 Q By what date do you believe you had,
14 quote: At least one year of experience designing,
15 developing or researching the design and/or
16 manufacture of solar cells or related
17 technologies?

18 A I would say 2000.

19 Q What experience did you have by the year
20 2000 in designing, developing or researching the
21 design and/or manufacture of solar cells or
22 related technologies?

1 A I had worked on the doping of
2 semiconductors. I had worked on the fundamental
3 limits of the efficiency of solar cells. I have,
4 at that time, had extensive experience with thin
5 film coatings, including coatings for solar cells.

6 I was familiar with considerations for the design
7 of solar cells, and I have also taught in the
8 field of solar cells.

9 Q You agree that semiconductors are a
10 technology related to solar cells, correct?

11 A Say that again, please?

12 Q You agree semiconductors are a technology
13 related to solar cells, correct?

14 A Yes.

15 Q And you agree that knowledge in the
16 semiconductor field is applicable to solar cells,
17 correct?

18 A Yeah. As I mentioned before, the way I
19 see it is solar cells is part of the semiconductor
20 field. You can look at it as a sub-field, and
21 knowledge is applicable.

22 Q Could you turn, please, to Paragraph 13 of

1 your declaration?

2 In Paragraph 13 you state, quote: My
3 general expertise is in the field of electrical
4 engineering and applied physics, including
5 semiconductor materials, semiconductor physics,
6 processing and devices.

7 Do you see that?

8 A I do.

9 Q Is your general expertise in each of those
10 areas applicable to solar cell technology?

11 A To some degree, yes.

12 Q In what ways do you believe your general
13 expertise in semiconductor materials,
14 semiconductor physics, processing and devices
15 applies to solar cell technology?

16 A My expertise in these fields that are
17 listed here are useful for the design,
18 manufacturing, and operation of solar cells.

19 Q In what ways?

20 A Can I hear the question again?

21 Q In what ways?

22 A What in what ways? Can you give me a

1 complete, like, a complete question?

2 Q Okay. In what ways is your expertise in
3 these fields useful for the design, manufacturing
4 and operation of solar cells?

5 A It is useful because I can base my
6 opinions on my expertise.

7 Q Does your experience in semiconductor
8 materials, semiconductor physics, processing and
9 devices count towards your at least one year of
10 experience designing, developing or researching
11 the design and/or manufacture of solar cells?

12 A I'm not sure if I understand the question.
13 You're relating experience to one year?

14 Q I'll break it down. You understand that a
15 POSITA would have at least one year of experience
16 designing, developing, or researching the design
17 and/or manufacture of solar cells, correct?

18 A Yes.

19 Q My question to you is: Is your experience
20 in semiconductor materials, semiconductor physics,
21 processing and devices, expertise that should
22 count towards the at least one year of experience

1 designing, developing or researching the design
2 and/or manufacture of solar cells?

3 A It's up to you. If you want to count it,
4 it's fine we me. But, you know, we have given
5 here the definition of a person of ordinary skill,
6 and I believe that I meet that definition.

7 Q Do you believe that your experience in
8 semiconductor materials, semiconductor physics,
9 processing and devices, should count towards at
10 least one year of experience designing, developing
11 or researching the design and/or manufacture of
12 solar cells?

13 A I've never asked myself this question. I
14 don't know.

15 Q I'm asking you that.

16 A I've never asked myself the question. I
17 don't know.

18 Q Do you know who Dr. David Carroll is?

19 A I've heard the name.

20 Q Where did you hear the name?

21 A I think he was an expert at the POPR
22 stage.

1 Q Are you aware that Dr. Carroll is Maxeon's
2 expert for the IPR filed by Canadian Solar related
3 to the '315 patent?

4 A No.

5 Q Are you aware that Dr. Carroll submitted a
6 declaration in support of Maxeon's patent owner
7 response in the IPR filed by Canadian Solar
8 against Claims 10 through 16 and 19 of the '315
9 patent?

10 A I'm not.

11 (Schubert Deposition Exhibit 4 marked for
12 identification and attached to the transcript.)

13 Q Let me hand you what I've marked as
14 Exhibit 4, which is entitled: Declaration of
15 David Carroll, Ph.D., in Support of Patent Owner
16 Preliminary Response.

17 And it's in the Canadian Solar against
18 Maxeon Solar IPR. Do you have that before you?

19 A Yes.

20 Q And you have not seen this before; is that
21 right?

22 A I don't think so.

1 Q You can put that aside for a moment.

2 (Schubert Deposition Exhibit 5 marked for
3 identification and attached to the transcript.)

4 Q Okay. Let me hand you what I've marked as
5 Exhibit 5.

6 Do you recognize Exhibit 5, which is also
7 Hanwha Exhibit 1010, as a Ph.D. dissertation
8 published in 2009 by Filip Granek?

9 A Yes.

10 Q And Filip Granek was a Ph.D. student as of
11 2009; is that right?

12 A Yes.

13 Q You've reviewed Exhibit 5 in its entirety,
14 correct?

15 A Yes.

16 Q Now, Filip Granek's dissertation indicates
17 that he was able to find the appropriate doping
18 concentration for his particular solar cell,
19 correct?

20 A I'm not sure which doping concentration
21 you're referring to. There are multiple doping
22 concentrations in a solar cell.

1 Q Well, would you agree that his
2 dissertation indicates that he was able to find an
3 appropriate doping concentration for his
4 particular solar cell?

5 A You're talking about front surface field
6 doping concentration, or are you talking about
7 emitter doping concentrations?

8 Q Both.

9 A With respect to the front surface field
10 doping concentration, I do recall that he has some
11 statements relating to the optimum or good doping
12 concentration.

13 Q Would you agree that Granek met the
14 qualifications for a POSITA with respect to the
15 '315 patent when he wrote his dissertation?

16 A The question is if he was a POSITA in
17 2009? Is that the question?

18 Q Yes.

19 A Yeah. I think so.

20 Q You're familiar with the concept of doping
21 as it relates to solar cells, correct?

22 A Yes.

1 Q Would you agree that doping is the
2 introduction of a charged impurity into the
3 substrate?

4 A I would say that doping is the
5 introduction of a charged doping impurity into a
6 substrate.

7 Q Would you disagree with the statement that
8 doping is the introduction of a charged impurity
9 into the substrate?

10 A No. I don't -- I wouldn't disagree, but I
11 would say it would be helpful to identify impurity
12 further. Is the impurity that you're talking
13 about a doping impurity, or is it a contaminating
14 impurity? And so one is a positive thing and one
15 is negative thing, and so I think it would be
16 helpful if that sentence would include a further
17 clarification of what type of impurity we are
18 referring to. I think that could be helpful in
19 some circumstances, and so that's what I'm
20 pointing out.

21 (Schubert Deposition Exhibit 6 marked for
22 identification and attached to the transcript.)

1 Q Let me hand you what I've marked as
2 Exhibit 6.

3 A Sure.

4 Q Do you recognize Exhibit 6 as the preface
5 from your book, Doping in III-V Semiconductors?

6 A Sure.

7 Q On page Roman Numeral XVI of your
8 preface -- it appears that we're missing the page
9 that I wanted in that exhibit, so we'll have to
10 get it again.

11 (Schubert Deposition Exhibit 7 marked for
12 identification and attached to the transcript.)

13 Q Let me hand you what I've now marked as
14 Exhibit 7.

15 Now, do you recognize Exhibit 7 as
16 containing the preface from your book, Doping in
17 III-V Semiconductors?

18 A Yes.

19 Q On Page XVI of your preface, you provide a
20 meaning for the term impurities, correct?

21 A You're referring to the first paragraph
22 here, or what are you referring to?

1 Q Sure. If you look on the first full
2 paragraph of the Page XVI, you wrote, quote: Thus
3 the term impurities is used for unintentional, as
4 well as intentional foreign atoms in the
5 semiconductor, while the term dopants is used
6 exclusively for deliberately added impurities.

7 Did I read that correctly?

8 A Yes.

9 Q You wrote here that the term impurities is
10 used to describe both unintentional, as well as
11 intentional foreign atoms in the semiconductor,
12 correct?

13 A Yes.

14 Q Would you agree that the term impurities
15 was understood the same way in the semiconductor
16 field as of 2014?

17 A I would say that the usage of the term
18 varies, and that impurities can be used for
19 unintentional, as well as intentional foreign
20 atoms in a semiconductor. I think that's a fair
21 statement. I think if we add doping impurity or
22 contaminating impurities, the term impurity

1 becomes more clear.

2 So if we just say impurity, if we look at
3 the word impurity in a vacuum and we know nothing
4 about the context, then impurity can be a negative
5 thing. It can have a negative connotation, if
6 used as contaminating impurity.

7 On the other hand, it can be a positive
8 thing, a positive connotation, if we understand it
9 as a doping impurity.

10 So I'm just saying, if we just hear the
11 word impurity without any context, we do not know
12 what is being referred to. Are we referring to a
13 contaminating impurity, or are we referring to a
14 doping impurity?

15 Q Would you agree that a fair definition of
16 the term impurities as of 2014, is unintentional,
17 as well as intentional, foreign atoms in the
18 semiconductor?

19 A It depends about on the context. In some
20 context, I would agree with you. But sometimes
21 people reserve the word impurity for unwanted
22 impurities, and I think that is perfectly

1 reasonable.

2 And a doping impurity is not an unwanted
3 impurity. A doping impurity is being inserted
4 into the semiconductor by an intentional process;
5 whereas a contaminating impurity usually is not
6 deliberately added. A contaminating impurity
7 would not be deliberately added to a
8 semiconductor.

9 Q In your book, you gave a definition of the
10 term impurities, correct?

11 A I'm saying how the term impurities is
12 used. I'm not sure if I would look at this as a
13 formal definition, but it's a helpful explanation.

14 And what I'm saying is the term impurities is
15 used for unintentional, as well as intentional,
16 foreign atoms.

17 Q Would you agree that the way that you have
18 described impurities in the preface of your book
19 also applies to the solar cell field?

20 A Some people will use it that way. Some
21 people will use it as an unintentional as well as
22 an intentional impurity. However, some people or

1 publications or patents will reserve the term
2 impurities for contaminating impurities.

3 Q Would you agree that the way you have
4 described impurities in your book would apply to
5 the solar cell field as it existed in 2014?

6 A As I expressed in my expert report, there
7 are two definitions or usages, or common usages,
8 of the term impurities, and I discuss this in my
9 expert report starting on Page 18, and I'm happy
10 to be more detailed in this regard, if you wish.

11 Q Sure. So let's go to Paragraph 43 of your
12 declaration, Exhibit 1.

13 In Paragraph 43, you state that:
14 Generally in the solar cell field, impurities can
15 refer either to an undesired material (undesired
16 trace substances) within another material; or two,
17 any material (any trace substances) within another
18 material.

19 Do you see that?

20 A Yes.

21 Q Would you agree that the definition for
22 the term impurities that you provide in your book,

1 in the preface, Exhibit 7, corresponds to the
2 second definition for impurities that you propose
3 in Paragraph 43 of your declaration?

4 A Generally, yes. But I would not exclude
5 the usage of the term impurities as defined by my
6 first definition. So I would say my 1993 book
7 does not contradict what I'm writing here in
8 Paragraph 43 of my expert report.

9 Q Could you put back in front of you what we
10 previously marked as Exhibit 6?

11 Exhibit 6 is the first two pages from the
12 introduction of your book, Delta-Doping of
13 Semiconductors, correct?

14 A Correct.

15 Q If you would turn please, sir, to Page 3,
16 do you see it says in the second full paragraph
17 towards the middle, quote: All impurities shown
18 as dark circles in the inset of Figure 1.1 occupy
19 substitutional lattice sites in the host
20 semiconductor?

21 A Yes. I see that.

22 Q Then if you would turn, please, to Page 4,

1 at the top, that shows Figure 1.1 from the
2 sentence that I just read to you, correct?

3 A Yes.

4 Q Impurities are shown as dark circles in
5 the inset to Figure 1.1, correct?

6 A Dopants, lists as dopants, yes. Dopants
7 impurities, yes. Doping impurities.

8 Q You see the key in the lower left-hand
9 corner of Figure 1.1?

10 A Yes.

11 Q The key refers to the dark circles as
12 dopants, right?

13 A Correct. It's a doping impurity.

14 Q Your book, Delta-Doping in Semiconductors
15 uses the term impurities to include dopants,
16 correct?

17 A It can be used in that way, yes. Doping
18 impurity or contaminating impurity, and then once
19 you have introduced the impurity as a doping
20 impurity, if the context is established, you may
21 leave out the doping.

22 Similarly, if you establish the context of

1 a contaminating impurity, you may leave out the
2 contaminating.

3 Q Now, turn back to Paragraph 43, please, of
4 your declaration, Exhibit 1.

5 Again, in Paragraph 43, you say that:
6 Impurities can refer either to one, an undesired
7 material (undesired trace substances) within
8 another material, and then it goes on, right?

9 A Correct.

10 Q Your declaration does not cite any source
11 that defines impurities to mean, quote: An
12 undesired material within another material,
13 correct?

14 A Well, my declaration cites the '315
15 patent, and I think understanding the '315 patent
16 would lead a person of skill in the art that the
17 term impurity is used synonymously with
18 contaminate. And for that reason, the impurities,
19 that I refer to in the '315 patent are not doping
20 impurities.

21 Q Sir, I'm looking at Paragraph 43. You
22 don't cite any source defining impurities to mean

1 an undesired material within another material,
2 correct?

3 A In my expert report, or in the first
4 sentence?

5 Q In your declaration, Paragraph 43.

6 A Well, I do not refer to the '315 patent in
7 Paragraph 43, but I do in Paragraph 44.

8 Q Nowhere in your declaration do you cite
9 anything other than the '315 to suggest that
10 impurities means an undesired material within
11 another material, correct?

12 A In Paragraph 12, I refer to my book
13 titled: Doping in III-V Semiconductors, and I'm
14 happy to look at that book, and I believe you had
15 one of the exhibits relates, or is an excerpt of
16 the book.

17 And I would say that the technical
18 literature, including the book that I'm disclosing
19 here, is consistent with the definitions, with the
20 two definitions that I offer.

21 Q Is that your best answer to my question?

22 A Well, this section is related to claim

1 construction, and the claim construction of a
2 technical term is done in the context of a patent.

3 Here, the claim construction of metal
4 impurities, is done in the context of the '315
5 patent. And so looking at the '315 patent for
6 guidance for the meaning of the term impurities,
7 is, in my view, a reasonable thing to do.

8 And I think that my definitions, the two
9 definitions that I offer, are consistent with my
10 previous writings in the field, but more
11 importantly are consistently with the
12 understanding of a POSITA of the term impurity.

13 (Schubert Deposition Exhibit 8 marked for
14 identification and attached to the transcript.)

15 Q Let me hand you what I've marked as
16 Exhibit 8.

17 Do you recognize Exhibit 8 as an excerpt
18 from the Sixth Edition of McGraw-Hill Dictionary
19 of Scientific and Technical Terms, correct?

20 A Yes.

21 Q This is a dictionary that you're familiar
22 with?

1 A Yes.

2 Q This is a dictionary that you've relied
3 upon in your work, correct?

4 A Say that again?

5 Q This is a dictionary that you've relied on
6 in the course of your work, correct?

7 A Yes.

8 Q And this is a dictionary that's generally
9 relied upon in the scientific and technical
10 fields, correct?

11 A Yes.

12 Q Could you please turn to the last page of
13 the exhibit?

14 Do you see that there's a definition of
15 impurity?

16 A Yes.

17 Q Have you seen that definition before
18 today?

19 A You're referring to an undesirable foreign
20 material in a pure substance?

21 Q And it goes on, yes.

22 A And the question is if I have seen this

1 before?

2 Q Yes.

3 A I think so, yes.

4 Q Did you consider the definition in
5 Exhibit 8 of impurity in the course of preparing
6 your declaration, Exhibit 1?

7 A Yes. I cite to it in my expert report.

8 It's Exhibit 2030, and I have considered all the
9 exhibits that I have cited in my declaration.

10 Q And you specifically considered the
11 definition of impurity in Exhibit 8 in preparing
12 your declaration; is that your testimony?

13 A Yes.

14 Q You see that the entry for impurity
15 includes two definitions, right?

16 A Yes.

17 Q The first definition of impurity is
18 denoted sci tech, correct?

19 A Yes.

20 Q And that's a reference to science and
21 technology, correct?

22 A I would assume so.

1 Q The second definition of impurity is
2 denoted solid state, correct?

3 A Yes.

4 Q And that's a reference to solid state
5 physics, correct?

6 A Yeah. Solid state -- I mean, if you want
7 to call it solid state physics, fine. Solid state
8 technology is fine too.

9 Q Solid state includes semiconductors,
10 correct?

11 A Yeah. Science and technology also
12 includes semiconductors.

13 Q The McGraw-Hill Dictionary of Scientific
14 and Technical Terms' definition of impurity that
15 is specific to the semiconductor field is, quote:
16 A substance that, when diffused into the
17 semiconductor material in small amounts, either
18 provides free electrons to the metal, or accepts
19 electrons from it.

20 Do you see that?

21 A I see that, and I believe that the
22 definition, the two definitions that are provided

1 here, are reasonable. The first definition
2 relates to an undesirable contaminating impurity,
3 and the second definition relates to a desirable
4 doping impurity.

5 So I have no problem with that definition
6 at all. I think it's very reasonable, and I'm not
7 sure what you're looking for, but I think this
8 definition is a perfectly fine definition.

9 Q The solid state definition encompasses
10 dopants, correct?

11 A Correct.

12 Q And the solid state definition of impurity
13 encompasses intentionally introduced dopants,
14 correct?

15 A Correct. Just as I said in Paragraph 43
16 of my expert report, or my expert declaration.

17 Q Let me now hand you what we'll mark as
18 Exhibit 9.

19 (Schubert Deposition Exhibit 9 marked for
20 identification and attached to the transcript.)

21 BY ATTORNEY SELWYN:

22 Q Do you recognize Exhibit 9 as an excerpt

1 from the 11th Edition of the Merriam-Webster's
2 Collegiate Dictionary?

3 A I do.

4 Q And this is a dictionary that you cited in
5 your own declaration, correct, on Paragraph 52?

6 A Yes.

7 Q And you cited the Merriam-Webster's
8 Collegiate Dictionary's definition of contaminate,
9 correct?

10 A Yes.

11 Q You didn't cite the Merriam-Webster's
12 Collegiate Dictionary's definition of impurity in
13 your declaration, correct?

14 A Well, a contaminate can be an impurity --

15 Q Sir, I'm just asking you whether you cited
16 the definition of impurity in your declaration
17 from the Merriam-Webster's Collegiate Dictionary.

18 ATTORNEY SNODGRASS: And Dr. Schubert, if
19 you don't finish your answer, please tell Counsel
20 that you wish to finish your answer.

21 And Dr. Schubert, if you recall your
22 answer to the prior question before you were

1 interrupted, please provide a complete answer.

2 BY ATTORNEY SELWYN:

3 Q And let me know if you want to the
4 question again.

5 A Sure.

6 Q You didn't cite the Merriam-Webster's
7 definition of impurity in your declaration,
8 correct?

9 A Well, as I said, in Paragraph 52, I cite
10 the Merriam-Webster's Dictionary for the word
11 contaminate. Contaminate.

12 And as I expressed before, an impurity can
13 be a contaminate. An impurity just has these two
14 natures. One we refer to as contaminating
15 impurity, and the other we refer to as a doping
16 impurity. Now, if we just say impurity, we don't
17 know what you're referring to. We need to have
18 context.

19 Q Do you know whether the Merriam-Webster's
20 Collegiate Dictionary includes a definition of
21 impurity?

22 A I would assume so.

1 Q The Merriam-Webster's Collegiate
2 Dictionary is not a technical or scientific
3 dictionary, correct?

4 A It doesn't say so on its title page, but
5 it probably includes, or it certainly includes
6 some terms that are technical terms.

7 Q Do you consider the Merriam-Webster's
8 Collegiate Dictionary to be a scientific or
9 technical dictionary?

10 A I would be happy to consider anything that
11 is written in that dictionary.

12 Q Right. But my question is different.

13 Do you consider the Merriam-Webster's
14 Collegiate Dictionary to be a scientific and
15 technical dictionary?

16 A I'm not sure.

17 Q Could you turn back to Paragraph 43 of
18 your declaration?

19 In Paragraph 43 of your declaration, in
20 the first sentence, you provide two meanings of
21 the term impurities, correct?

22 A Yes.

1 Q And in the last sentence of Paragraph 43,
2 you write: In my opinion, both meanings of
3 impurities are plain and ordinary.

4 Do you see that?

5 A Yes.

6 Q And then in Paragraph 44, you state,
7 quote: A POSITA would have understood that the
8 inventors of the '315 patent use impurities to
9 have the first plain and ordinary meaning.

10 Do you see that?

11 A Yes.

12 Q Your belief is that the term impurities,
13 as used in the '315 patent, should be construed
14 according to its plain and ordinary meaning,
15 correct?

16 A I believe that the term should be
17 construed by its plain and ordinary meaning in the
18 context of the '315 patent.

19 Q And you'd agree that in the case of the
20 '315 patent, the patentee did not set forth a
21 definition of impurities, other than its plain and
22 ordinary meaning, correct?

1 A I think the inventors were specific enough
2 so that a person of skill would understand that
3 the metal impurities are contaminating impurities,
4 and not doping impurities.

5 Q But you'd agree that in the '315 patent,
6 the patentee didn't define impurities, other than
7 its plain and ordinary meaning, correct?

8 A It is my opinion that the inventors were
9 sufficiently clear what they mean by impurities or
10 contaminants. It would be understood by a person
11 of skill in the art. A person of skill in the art
12 would not confuse contaminating impurities with
13 doping impurities.

14 Q But you'd agree that there is not a
15 definition in the '315 patent of the term
16 impurities, correct?

17 A I wouldn't express it in this manner. I
18 would say that when the inventors use the term
19 impurities, and when the inventors essentially say
20 that impurities and contaminates are sharing the
21 same meaning, they refer to contaminating
22 impurities.

1 A contaminating impurity is different from
2 a doping impurity, and I believe that this
3 difference is made sufficiently clear. It would
4 be clear to a POSITA that the contaminating
5 impurities that the '315 patent talks about should
6 not be confused with doping impurities.

7 Q So let's turn to Claim 10, please, of the
8 '315 patent.

9 Are you there?

10 A Yes.

11 Q Under your proposed interpretation of the
12 term impurities, Claim 10 would encompass a solar
13 cell where no undesired foreign metals were
14 removed from the substrate, provided that there
15 are also undesired foreign metals in the emitter,
16 correct?

17 A Sorry. I don't follow your question.

18 Q Let me try it again.

19 Under your proposed interpretation of
20 impurities, Claim 10 would cover a solar cell
21 where no undesired foreign metals were removed
22 from the substrate, provided that there are also

1 undesired foreign metals in the emitter, right?

2 A Are you referring to a specific limitation
3 of Claim 10, or Claim 10 in its entirety?

4 Q Claim 10 in its entirety.

5 A So the last claim limitation of Claim 10
6 refers to metal impurities, and I think your
7 question is related to these metal impurities.

8 I don't understand the question, if you...

9 Q Let me try a different question.

10 Does Claim 10 say anywhere that there are
11 no undesired foreign metals in the substrate?

12 A The claim in the context of the
13 specification would convey to a POSITA that there
14 is a gettering process, and the gettering process
15 results in an emitter region that includes or
16 contains unwanted metal impurities.

17 Q Where in Claim 10, what words, where does
18 it say that there are no undesired foreign metals
19 in the substrate?

20 A The term substrate is not mentioned in
21 Claim 10. I'm just saying that a person of skill
22 would understand that the '315 patent discloses a

1 gettering process. But I agree with you.

2 Substrate is not mentioned in Claim 10.

3 Q Where does it say in Claim 10 that the
4 metal impurities in the emitter are gettered from
5 the silicon substrate?

6 A I believe that the context of the '315
7 patent would lead a POSITA to this realization.

8 Q What words are used in Claim 10 that
9 suggest that metal impurities in the emitter are
10 gettered from the silicon substrate?

11 A Claim 10 just requires that there are
12 metal impurities, or contaminating metal
13 impurities, in the first emitter region. I'm
14 saying if we just isolate -- if we just look at
15 Claim 10 in isolation, this is what Claim 10 says.

16 There needs to be metal impurities for
17 contaminating metal impurities in the first
18 emitter region.

19 Q Do the words of Claim 10 say that metal
20 impurities in the emitter originated in the
21 substrate?

22 A The context of the '315 patent would

1 convey this to a POSITA.

2 Q Do the words of Claim 10 say that there
3 are no undesired foreign metals in the substrate?

4 A I think it is a fair statement to say that
5 there is a gettering process, and this gettering
6 process results in a first emitter region having
7 metal impurities.

8 Q Under your proposed meaning of impurities,
9 Claim 10 would cover a solar cell in which metal
10 impurities were intentionally introduced into the
11 emitter from a source other than the substrate,
12 correct?

13 A So by metal impurities, are you referring
14 to dopants? I'm not clear about the question.

15 Are you referring to doping impurities or
16 are you referring to contaminating impurities?

17 Q I want you to have in mind the
18 construction of impurities that you propose in
19 your declaration at Paragraph 43. Do you have
20 that in mind?

21 A So in this case, you are referring to
22 contaminating impurities, if I understand you

1 correctly.

2 Q I'm not trying to characterize your
3 interpretation. I'm saying applying your proposed
4 construction of impurities as set forth in your
5 declaration, Claim 10 would encompass a solar cell
6 in which metal impurities were intentionally
7 introduced into the emitter from a source other
8 than the substrate, correct?

9 A Sorry. The question is not clear to me.

10 If I have contaminating metal
11 impurities -- if I have contaminating impurities,
12 it is unclear to me how someone would contemplate
13 to intentionally introduce unwanted impurities.
14 That logic, that appears to be the premise of your
15 question, is not clear to me.

16 Because in my view, nobody would
17 intentionally introduce metal impurities, unwanted
18 metal impurities, to degrade a semiconductor
19 device. I mean, the steps of gettering make sense
20 to me. You have a substrate. You have unwanted
21 impurities in that substrate. You apply a
22 gettering process in the annealing step, a

1 procedure that getters the impurities, the
2 unwanted impurities in the emitter region.

3 But you're presenting some kind of other
4 scenario, and that scenario at the moment does not
5 make sense to me. I apologize.

6 Q Let me ask you --

7 A I don't understand it.

8 Q Okay. Let me ask you to focus on the
9 words of Claim 10. Do you have those in mind?

10 A Sure.

11 Q Claim 10 does not require the metal
12 impurities to come from the silicon substrate,
13 correct?

14 A As I said previously, Claim Number 10 does
15 not mention the word substrate. However, if we
16 look at the '315 patent in its entirety, a POSITA
17 would understand that we have a purification
18 process, a gettering process, a segregation
19 process. And the purpose of this process is to
20 further purify the substrate, and move unwanted
21 metal impurities to a location where they do not
22 cause harm.

1 Q Does Claim 10 recite gettering?

2 A Claim 10 does not use the word substrate,
3 and it does not use the word gettering. But if we
4 look at the patent in its entirety, we would get
5 an understanding of the transport procedure or
6 gettering procedure that is contemplated by the
7 inventors.

8 Q Can you put back in front of you your
9 declaration, and let me direct your attention,
10 please, to Paragraph 57?

11 Do you see that this section, beginning on
12 Paragraph 57 of your declaration, has the title:
13 Choi Does Not Disclose Metal Impurities?

14 A Correct.

15 Q And this section in Paragraphs 57 and 58
16 addresses whether Choi alone discloses, quote: A
17 first emitter region having metal impurities,
18 correct?

19 A Yes.

20 Q Paragraphs 57 and 58 consider whether Choi
21 alone discloses a first emitter region having
22 metal impurities without reliance on Istratov,

1 correct?

2 A Paragraphs 57 and 58 do not mention
3 Istratov.

4 Q And you also considered whether the
5 combination of Choi and Granek alone disclose all
6 limitations of the challenged claims without
7 reliance on Istratov, correct?

8 A Sorry. Can I hear the question again?

9 Q You considered whether the combination of
10 Choi and Granek disclose all limitations of the
11 challenged claims without reliance on Istratov,
12 correct?

13 A Sorry. That question is not clear to me.

14 I mean, Petitioner relies on Istratov, and
15 I analyzed the arguments of Petitioner. So I
16 don't rely on Istratov. It's Petitioner who
17 relies on Istratov.

18 So maybe I don't understand the question.
19 But, you know, I am not relying on Istratov. It's
20 Petitioner who relies on Istratov.

21 Q The first sentence of Paragraph 57 says,
22 quote: Under the proper construction of metal

1 impurities, i.e., undesired foreign metals, Choi
2 fails to disclose the feature a first emitter
3 region having metal impurities.

4 Do you see that?

5 A I do.

6 Q And when you say in Paragraph 57: The
7 proper construction of metal impurities, you're
8 referring to the construction of metal impurities
9 that you propose in your declaration, correct?

10 A Correct. Undesired foreign metals.

11 Q Your declaration doesn't address whether
12 Choi discloses metal impurities under any
13 construction, other than the one that you,
14 yourself, have proposed, correct?

15 A I would say that my understanding of metal
16 impurities is that they are undesired foreign
17 metals. If one would understand metal impurities
18 to mean metal dopants, that would be a
19 misunderstanding of the teachings of the '315
20 patent, and one would come to incorrect
21 conclusions. That is my opinion.

22 Q Okay. But you'd agree that your

1 declaration doesn't address whether Choi discloses
2 metal impurities under any construction of that
3 term, other than Maxeon's, correct?

4 A I agree with you that doping impurities
5 and contaminating metal impurities are different,
6 if I understand you correctly, and I have
7 interpreted the claims based on the constructions
8 that I have proposed here.

9 Q Can you put back in front of you
10 Exhibit 7?

11 And you'll recall earlier, we discussed
12 the statement in your book that, quote: The term
13 impurities is used for unintentional, as well as
14 intentional, foreign atoms in the semiconductor.

15 Do you recall that?

16 A Yes.

17 Q You agree that Choi discloses intentional
18 foreign metallic atoms in its first and second
19 conductive-type areas, correct?

20 A I'm not sure if I understand your
21 question, but Choi does not disclose metal
22 impurities that are claimed.

1 Q Well, does Choi disclose intentional
2 foreign metallic atoms in its first and second
3 conductive type areas?

4 A Choi discloses doping impurities, but not
5 contaminating impurities. It's a big difference.
6 You know, you're basically talking about very
7 different things: Doping impurities and
8 contaminating impurities. Very different.

9 And Choi discloses doping impurities, but
10 Choi does not disclose the contaminating metal
11 impurities that are claimed in the '315 patent.

12 Q Does Choi disclose intentional foreign
13 metallic atoms in its first and second conductive
14 type areas?

15 A Choi discloses dopants. Dopants -- and
16 these dopants can be metallic dopants. Aluminum
17 is a metallic dopant, but that is not the metal
18 impurity that the '315 patent is talking about in
19 Claim 10.

20 Q Okay. I didn't use the word impurity in
21 my question. Let me try it one more time.

22 Would you agree that Choi discloses

1 intentional foreign metallic atoms in its first
2 and second conductive type areas?

3 A Well, let's take an example. Aluminum is
4 a metal atom. Aluminium is added intentionally in
5 Choi. And Choi has an emitter region. So, you
6 know, we have all elements that appear to be
7 relating to your question. But as I said before,
8 we should not confuse doping impurities and
9 contaminating impurities.

10 (Schubert Deposition Exhibit 10 marked for
11 identification and attached to the transcript.)

12 Q Let me hand you what I've marked as
13 Exhibit 10.

14 Do you recognize Exhibit 10, which is also
15 Hanwha Exhibit 1006, as the Choi reference?

16 A Yes.

17 Q And can I direct your attention, please,
18 to Paragraph 36 and 37 of Choi?

19 A Sure.

20 Q You would agree that in Paragraphs 36 and
21 37, Choi discloses intentional foreign metallic
22 atoms in the first and second conductive type

1 areas, correct?

2 A I would say it discloses doping atoms.
3 I'm not sure if I would call it -- you know, you
4 can call it foreign atoms, if you wish. But I
5 think in order to use a terminology that is
6 constructive, that is helpful, it would be better
7 if you would say that Choi discloses doping
8 impurities, and some of these doping impurities
9 are metals, specifically aluminum and gallium and
10 indium. I think that is a fair characterization.

11 Q Are you saying that aluminum is not a
12 foreign atom?

13 A Well, what I'm saying is that aluminum is
14 a doping atom.

15 Q Is aluminum a foreign atom?

16 A It's foreign to silicon. It's different
17 from silicon. But it's a very common element in
18 silicon. You know, it's just like boron or
19 phosphorus. Those are elements that are always
20 used, or very frequently used, in semiconductors.

21 So if you want to call it foreign, that's
22 fine. I may also call it foreign. But I'm just

1 saying that those are typical dopants, and a
2 person of skill would understand that these are
3 dopants, that it's natural to introduce them into
4 the semiconductor material.

5 It's common to introduce them into the
6 semiconductor material. And this is what we can
7 say about dopants. But when it comes to
8 contaminating impurities, contaminating impurities
9 would not intentionally be introduced into a
10 semiconductor.

11 Q You'd agree that a POSITA would consider
12 aluminum to be a foreign atom, correct?

13 A It's different than silicon. It's
14 different from silicon, and if you want to call it
15 a foreign atom in silicon, fine with me. I'm
16 happy to follow your guidance in this regard. If
17 you want to classify aluminum as a foreign type of
18 atom, fine with me.

19 Q Okay. And you'd agree that a POSITA would
20 consider aluminum to be a foreign atom, correct?

21 A I would say a POSITA would consider
22 aluminum as a doping atom, as a metal doping atom.

1 Q You disagree that a POSITA would consider
2 aluminum to be a foreign atom?

3 A Well, why use a vague terminology if you
4 can be specific? You know?

5 Q I'm asking --

6 A Like, if we say impurity, nobody knows if
7 you just say impurity, if you just say the word
8 impurity, then what does it mean, impurity?

9 Well, people would not be able to answer
10 or to let you know if I'm saying unwanted,
11 undesired contaminating impurity, or if I'm saying
12 desirable doping impurity. You know, so we have
13 this big difference between doping impurity and
14 contaminating impurity.

15 So if I say the word, you know, I wouldn't
16 want to be ambiguous. I'm a technical person. I
17 would want to be understood by those people who
18 listen to me.

19 So, you know, I wouldn't intentionally go
20 in front of my class and say: Impurity, because
21 it could be misunderstood. I would go out there
22 and say contaminating impurity, doping impurity.

1 Big difference. So you know, if we can use clear
2 terminology, we should use it.

3 And I think the '315 patent has clearly
4 said, you know, we don't want these metal
5 impurities, these contaminating metal impurities,
6 these contaminates in the substrate, because they
7 shorten the lifetime. We don't want them.

8 So let's get them out. Let's segregate
9 them to the emitter region. Let's getter them
10 into the emitter region. That's what the '315
11 patent teaches.

12 And it would be clear to a POSITA. It
13 would be absolutely clear to a POSITA what's going
14 on. So I'm not sure why we get hung up on trying
15 to confuse doping impurities with contaminating
16 metal impurities. They are totally different.

17 Q Okay. Let me focus your attention on
18 Choi. Do you have that in mind?

19 A Sure.

20 Q Okay. Is the aluminum present in the
21 conductive region of Choi a metal impurity under
22 your definition?

1 A The aluminum is not a contaminating metal
2 impurity as used in the '315 patent.

3 Q Would you agree that under -- strike that.
4 Why not?

5 A A person of skill in the art would
6 understand aluminum not to be the type of
7 contaminants, the type of metal contaminating
8 impurities, that the '315 patent -- the '315
9 patent is talking about. It would be absolutely
10 clear to a POSITA.

11 Q Could aluminum ever be a contaminant?

12 A In a solar cell, or in general?

13 Q Both.

14 A I'm not sure what you're talking about.

15 Q In a solar cell, could aluminum ever be a
16 contaminant?

17 A Your question is very broad. And if we
18 have for example, a copper contact, if we have too
19 much aluminum, in the copper contact, somebody may
20 refer to the aluminum as a contaminant.

21 But I'm not talking about such a broad
22 scenario. I'm only talking about contaminating

1 impurity, doping impurity. The two, from a
2 technical point of view, are different.

3 You know, it's fair characterization.

4 They are different. And if they are different,
5 they shouldn't -- they -- we should realize, we
6 should accept their difference. We should -- we
7 should just accept their difference.

8 Q Could aluminum in the emitter region of a
9 solar cell ever be a contaminant?

10 A If we use aluminum as a doping impurity,
11 and intentionally introduce the aluminum as doping
12 impurity, it would be somewhat difficult for me to
13 envision that what we introduce intentionally is a
14 contaminating impurity.

15 Q You'd agree that under the meaning of
16 impurities given in your book, Doping in III-V
17 Semiconductors, Choi discloses a second emitter
18 region having metal impurities, correct?

19 A No. I believe that Choi does not disclose
20 that. I believe that Choi has doping impurities,
21 and the aluminum would not be understood by a
22 POSITA as a contaminating metal impurities.

1 Q Would aluminum be a metal impurity in the
2 emitter region of a solar cell if the emitter was
3 overly doped?

4 A Can I hear the question again?

5 Q Would aluminum be a metal impurity in the
6 emitter region of a solar cell if the emitter were
7 overly doped?

8 A No. I don't think so.

9 Q Why not?

10 A It's a dopant. We have doping impurities.
11 I mean, we're coming back to the same thing, and
12 I've said this many times, but I'm happy to repeat
13 it again. And I will be happy to repeat it 10
14 more times if you wish. I'm happy to repeat it
15 100 more times if you wish.

16 Q Well, let me ask you this: At what point
17 would aluminum go from being a dopant to an
18 impurity from a concentration standpoint?

19 A I'm happy to repeat it a 100 times.

20 Q Can you answer my question?

21 A Sure.

22 Q Please.

1 A There is a difference between a
2 contaminating impurity. A contaminating impurity,
3 has a negative connotation, and Dr. Holman agrees,
4 I believe, that contamination has a negative
5 connotation. He said that in his deposition
6 transcript. So I fully agree with Dr. Holman that
7 contaminates have a negative connotation.

8 Doping impurity does not have that
9 negative connotation. So you're talking about
10 those two very different things. And I think what
11 I'm hearing is that you wish to call a doping
12 impurity a contaminating metal impurity, and I'm
13 just saying no, no. Please not.

14 It's not what a technical person would do.
15 It's not what a POSITA would do. A POSITA would
16 reject this notion. A POSITA would know those are
17 two different things.

18 Q Okay. You believe that aluminum can be
19 considered a dopant, correct?

20 A In silicon, correct.

21 Q And you also believe that there are some
22 circumstances where aluminum can be considered an

1 impurity, correct?

2 A Well, if we leave the field of
3 semiconductors and we go into metallurgy, and we
4 have a block of copper and we add aluminum to it,
5 then aluminum will be a contaminant, contaminant
6 in the copper.

7 Q Okay. So my question to you is: From the
8 perspective of concentration, at what point does
9 aluminum go from being a dopant to being an
10 impurity?

11 Where is the threshold?

12 ATTORNEY SNODGRASS: Objection to form.

13 You can answer.

14 A I'm not sure what you talk about when you
15 say impurity. Sorry. I mean, there are these two
16 types of impurities, and I'm happy to repeat it
17 again. There is, like, a contaminating impurity
18 or a doping impurity.

19 Now, when you just say impurity without
20 context, I don't know -- I really don't know what
21 you're talking about. So to me it would be
22 helpful if you would say: Is aluminum a

1 contaminating impurity in silicon? And I would
2 say no, not in the context of the '315 patent,
3 because the '315 patent is very clear.

4 Q Well, the '315 patent never uses the term
5 contaminating impurity, correct?

6 A The '315 patent states: Contaminates
7 and/or impurities can be used interchangeably.

8 Q Sir, that's not my question. Listen to my
9 question. Okay?

10 The word -- the term contaminating
11 impurities, which you keep saying over and over
12 and over again in this deposition, that term never
13 appears in the '315 patent, correct?

14 A The '315 patent uses the term
15 contaminates, and says that contaminates and/or
16 impurities can be used interchangeably.

17 ATTORNEY SELWYN: Not my question. I move
18 to strike.

19 BY ATTORNEY SELWYN:

20 Q Sir, does the term contaminating
21 impurities appear in the '315 patent, yes or no?

22 A And you're just looking for, like the

1 literal disclosure of this specific term?

2 Q Sir, is my question unclear to you?

3 A Well, I mean, the '315 patent discloses
4 contaminates, right?

5 Q Yes. You've used the term contaminating
6 impurities, right?

7 A Correct.

8 Q Okay. Does that term appear in the '315
9 patent, yes or no?

10 ATTORNEY SNODGRASS: Dr. Schubert, I'll
11 remind you that if Counsel interrupts your answer,
12 please inform him that you are not finished with
13 your answer. He's been interrupting you multiple
14 times over this last span. Please do not let him
15 interrupt your answer.

16 BY ATTORNEY SELWYN:

17 Q Do you need the question again?

18 A No.

19 The '315 patent discloses contaminates.
20 First point. The '315 patents discloses
21 impurities, and the '315 patent says that the two
22 terms, contaminants and impurities, can be used

1 interchangeably.

2 So I, as the expert, take the freedom -- I
3 take the liberty to say contaminating impurities,
4 in order to reduce ambiguity. I mean, everybody
5 should be grateful if somebody tries to reduce
6 ambiguity. I mean if we talk about impurity, if
7 you tell me impurity, I don't know -- you know, I
8 don't know what you're talking about. I'm not
9 sure if you're talking about doping impurity, or
10 contaminating impurity.

11 I'm saying there is a huge difference.
12 There is difference between those two terms. It
13 is fair to say that there is a difference. One is
14 desirable, one is undesirable. And so you know,
15 that's all I'm saying. I take the liberty as an
16 expert, because I think it's useful, to use that
17 term contaminating impurity and doping impurity,
18 two different things.

19 ATTORNEY SELWYN: Why don't we take a --
20 my suggestion would be five minutes to stretch our
21 legs?

22 (Recess from 11:54 a.m. until 12:01 p.m.)

1 BY ATTORNEY SELWYN:

2 Q Dr. Schubert, what is a back contact solar
3 cell?

4 (Reporter clarification.)

5 A A solar cell has a front side and a back
6 side. And a back side solar cell has back side
7 contacts, has contacts on the back side.

8 Q Can you put in front of you, please, what
9 we previously marked as Exhibit 10. It's also
10 Hanwha 1006.

11 And if you'd turn, please, to Figure 1 in
12 Choi, would you agree with me that Choi solar cell
13 in Figure 1 shows a back contact solar cell?

14 A Yes.

15 Q In Choi's Figure 1 solar cell, the P-N
16 junction is on the back side of the solar cell,
17 correct?

18 ATTORNEY SNODGRASS: Objection to form.

19 A Which P-N junction are you talking about?

20 Q The P-N junction in Figure 1.

21 ATTORNEY SNODGRASS: Same objection.

22 A Sorry. I don't know which P-N junction

1 you're talking about.

2 Q Okay. Let's go through it then.

3 In Choi's solar cell, the substrate and
4 the second conductive type area have opposite type
5 doping, correct?

6 A I recall that I discussed this issue in my
7 expert report. So in Paragraph 58 of my expert
8 report, I discuss Choi, and Choi has a base area
9 110 that is N-type -- that is an N-type impurity,
10 and it's referred to as a first conductive type
11 dopant.

12 And then Choi also has regions 34, which
13 is of the second conductive type, and area 32,
14 which is of the first conductive type. I'm not
15 sure if that answers your question, but here I
16 identify the substrate, and areas 34 and 32.

17 Q Okay. And in Choi's solar cell, the
18 second conductive type area forms a P-N junction
19 with the substrate, right?

20 A 110 substrate is N-type; 34, P-type; and
21 there is a layer 20 in between, and a layer 20 is
22 the tunneling layer; and if you want to call this

1 a P-N junction, I am happy to follow your lead.

2 I -- you know, it's a bit unusual, but
3 because there is an oxide, there is a tunneling
4 layer in between. But I agree that the substrate
5 is N-type, and layer 34 is P-type, for example,
6 P-type. And so we have a transition from an
7 N-type semiconductor to a P-type semiconductor
8 through a tunneling oxide layer 20.

9 Q Okay. And in Choi's solar cell shown in
10 Figure 1, the P-N junction is on the back side of
11 the solar cell, right?

12 A If you want to express it this way, I'm
13 happy to follow you.

14 Q Choi's solar cell has a front surface
15 field layer, correct?

16 A Yes.

17 Q And Choi's front surface field layer is
18 doped at a higher concentration than its
19 semiconductor substrate, correct?

20 A Can you refer me to a statement in Choi
21 saying this?

22 Q Paragraph 29.

1 A Yes. I agree.

2 Q The third sentence in Paragraph 29 of Choi
3 says: That is the front surface field layer 120
4 prevents electrons and holes separated by incident
5 light from being recombined and then decay on the
6 front surface of this semiconductor substrate 10.

7 Did I read that right?

8 A Yes.

9 Q Choi teaches the function of its front
10 surface field layer is to reduce recombination,
11 correct?

12 A Correct.

13 Q And you have not offered the opinion in
14 your declaration that Choi's front surface field
15 layer includes lateral transport, correct?

16 A What I have said is that in some solar
17 cell configurations such as the one shown by Choi,
18 lateral transport is required. Because, you know,
19 we have laterally displaced N-type contact and
20 P-type contacts.

21 Q But you don't say in your declaration
22 anywhere that Choi's front surface field layer

1 improves lateral transport, correct?

2 A I may not have made that point.

3 Q Choi doesn't indicate who supplied the
4 silicon that was used in Choi's solar cell,
5 correct?

6 A If that's what you're representing to me,
7 I'm happy to follow your representation.

8 Q You don't recall Choi indicating who
9 supplied the silicon that was used in the Choi
10 solar cell, correct?

11 A I have no recollection on that point.

12 Q Choi doesn't state that its front surface
13 field layer improves lateral transport, correct?

14 A I don't recall any statement to that
15 regard.

16 (Schubert Deposition Exhibit 11 marked for
17 identification and attached to the transcript.)

18 Q Let me hand you what I've marked as
19 Exhibit 11, which is a copy of the Cousins
20 reference to US Patent Number 8,207,444, also
21 marked as Exhibit Hanwha 1007.

22 Do you have that before you?

1 A I do.

2 Q And you've studied the Cousins reference,
3 correct?

4 A Correct.

5 Q And Cousins nowhere indicates who supplied
6 the silicon that was used in Cousins' solar cell,
7 correct?

8 A If you have a specific paragraph that you
9 want to point me to, I'm happy to look at that.

10 Q Well, my question is about the absence of
11 something. Cousins nowhere indicates who supplied
12 the silicon that was used in Cousins' solar cell,
13 correct?

14 A I don't see any indication at the moment.

15 Q Would you agree that a POSITA with respect
16 to the '315 patent, as of 2014, would have
17 understood that an emitter region of a solar cell
18 would necessarily contain at least trace amounts
19 of unwanted contaminants?

20 ATTORNEY SNODGRASS: Objection to form.

21 A It depends on the reference. If the
22 reference says there are contaminants in there,

1 then I would say yes. But if the reference is
2 silent or says there's no significant
3 contamination in there, then there is no
4 contamination.

5 Q Let me focus you in particular on Claim 10
6 of the '315 patent.

7 Do you see the limitation in Claim 10 that
8 recites, quote: A first emitter region having
9 metal impurities?

10 A Yes.

11 Q Can that limitation be met by the first
12 emitter having trace amounts of unwanted metal
13 contaminates?

14 ATTORNEY SNODGRASS: Objection to form.

15 A The limitation is met if the first emitter
16 region has metal impurities where metal impurities
17 are to be understood, as I discussed earlier in
18 this deposition.

19 Q So can that limitation be met by the first
20 emitter having trace amounts of unwanted metal
21 contaminants?

22 ATTORNEY SNODGRASS: Objection to form.

1 A Yeah. It would be helpful if I would
2 understand your terminology "trace amounts"
3 better. What are you referring to?

4 Q Have you ever heard of that term before,
5 trace amounts?

6 A Sure.

7 Q What do you understand it to mean?

8 A Yeah. It could be trace amount, depending
9 on the context could include measurable amounts,
10 or immeasurably low trace amounts.

11 The question is, is it significant. So if
12 we have the material, do we have significant
13 amount, amounts of a contamination in there? And
14 if there are significant amounts, then we care
15 about it. If the quantity of contamination is
16 insignificant, irrelevant, not meaningful, then we
17 don't care about it.

18 Q And what's the criteria that you would use
19 to evaluate significance?

20 A It depends on the context.

21 Q In the context of the '315 patent?

22 A The goal of the gettering process is to

1 improve carrier lifetime, and ultimately
2 efficiency. So if we have a procedure that
3 results in an efficiency improvement, then we have
4 achieved our goal.

5 And if we look at, for example, Figure 11
6 of the '315 patent, we can see a table where we
7 have different processing conditions and different
8 design conditions, and ultimately the result is a
9 0.5 percent absolute improvement.

10 Q Can a limitation in a first emitter region
11 having metal impurities be met by the first
12 emitter having a quantity of contamination that's
13 insignificant or not meaningful?

14 A I'm not sure. You know, I have not
15 conducted an infringement analysis. And if I
16 understand you correctly, you're talking about a
17 specific product or a specific solar cell, and
18 this solar cell has a certain concentration of
19 contaminating metal impurities, and you're asking
20 me is that product that you envision, is that
21 practicing the claim.

22 That's a difficult question. I have not

1 conducted this type of analysis in my work for
2 this project. I'm not making any statements of
3 certain products practicing certain claim
4 limitations.

5 Q Can Claim 10 be met by a first emitter
6 having non-zero amounts of metal impurities?

7 A It depends on the specifics. I can see
8 some scenarios where I would answer your question
9 with a yes. And I can envision some scenarios
10 where I would answer your question with a no.

11 Q Okay. Can you turn to claim -- Column 5
12 of the patent, please?

13 Do you see on Lines 3 and 4 of Column 5,
14 it states: Metal impurities can be -- I'm
15 skipping a little.

16 Metal impurities can be sources of
17 recombination resulting in poor lifetime, surface
18 passivation and/or lower cell efficiency?

19 A Yes. I see this.

20 Q What is recombination?

21 A Recombination refers to the transitioning
22 of an electron from the conduction band through a

1 metal impurity state to a hole in the valance
2 band.

3 (Reporter clarification.)

4 Q Do you agree that a POSITA, as of
5 December 2014, would have understood that metal
6 impurities are sources of recombination?

7 A Yes. Contaminating metal impurities, such
8 as iron, nickel --

9 Q You agree that --

10 A -- or chromium can serve as recombination
11 centers.

12 Q You agree, a POSITA, as of December 2014,
13 would have understood that metal impurities can
14 lead to poor lifetime and lower solar cell
15 efficiency, right?

16 A Yes. I agree.

17 Q You agree that a POSITA, as of December
18 2014, would have understood metal impurities in
19 silicon wafers are detrimental to solar cell
20 performance, correct?

21 A Can I hear the question again?

22 Q You agree that a POSITA, as of December

1 2014, would have understood metal impurities in
2 silicon wafers to be detrimental to solar cell
3 performance, correct?

4 A I would say that they can be detrimental,
5 if we just envision a situation where these metal
6 impurities have a very, very, low concentration,
7 then the effect may be negligible. But if the
8 concentration is high enough, there can be
9 detrimental effects.

10 Q Would it be fair to say that as of
11 December 2014, the metal impurities' concentration
12 in silicon wafers was a concern in the solar
13 industry?

14 A It depends on the circumstances.

15 Sometimes there could be a concern. Under other
16 circumstances, they may not be a concern.

17 Q Gettering was one known way to reduce the
18 metal impurities concentration in silicon wafers
19 as of December 2014, correct?

20 A Yes.

21 Q The '315 patent discloses gettering at a
22 temperature above 900 degrees Celsius, right?

1 A Yes.

2 Q In fact, the '315 patent discloses heating
3 the solar cell at temperatures even above 900
4 degrees Celsius, for example, to 975 degrees
5 Celsius or higher, correct?

6 A Yes.

7 Q And would you agree that the '315 patent
8 doesn't say that heating the solar cell above 900
9 degrees Celsius causes a dielectric region to
10 dissolve?

11 A The '315 patent doesn't address that
12 possibility.

13 Q Would you agree that the '315 patent
14 doesn't say that heating the solar cell above 900
15 degrees Celsius causes dopants from the conductive
16 type regions to disperse throughout the silicon
17 substrate?

18 A The '315 patent is not detailed on this
19 dopant diffusion that you appear to be referring
20 to.

21 Q A POSITA, as of December 2014, would have
22 understood that the purpose of gettering --

1 gettering impurities was to increase solar cell
2 efficiency, correct?

3 A Yes.

4 Q You agree a POSITA, as of December of
5 2014, would have understood that gettering was
6 known, both to reduce recombination and improve
7 lifetime, correct?

8 A It can do so.

9 Q In your declaration, you don't dispute
10 that as of December of 2014, gettering was
11 commonly used in solar cell fabrication, correct?

12 A I'm unable to confirm the fact that you
13 appear to be presenting, that this was a common
14 process in solar cell manufacturing.

15 Q Well, my question is a little bit
16 different. In your declaration, you don't
17 dispute, you don't challenge, that as of December
18 of 2014, gettering was commonly used in solar cell
19 fabrication, correct?

20 A You appear to be saying that gettering is
21 commonly used in solar cell fabrication. That's
22 what I hear. And I'm not sure what this is based

1 on.

2 Q No. That's not what I'm saying.

3 In your declaration, you don't say --
4 strike that.

5 In your declaration, you don't disagree
6 that gettering was commonly used in solar cell
7 fabrication, correct?

8 A Well, you appear to say that gettering was
9 commonly used. Did I understand you correct?

10 Q No. You didn't.

11 A Then I don't understand the question.

12 Q Okay. In your declaration, you offer
13 various opinions; correct?

14 A Yes.

15 Q You don't offer the opinion in your
16 declaration that gettering was not commonly used
17 in solar cell fabrication as of December of 2014,
18 correct?

19 A I have not made statements on the
20 gettering process being a common process, or being
21 a non-common process.

22 Q Are you familiar with commercial solar

1 cell manufacturing as of December of 2014?

2 A To some degree, yes. But it's a big
3 field. There are many manufacturers.

4 Q Are you knowledgeable regarding the
5 typical level of metal impurities in silicon
6 wafers that were used in commercial solar cell
7 manufacturing as of December of 2014?

8 A It's a difficult question. What level of
9 impurities? What impurities are you talking
10 about?

11 Q I'm just asking whether you're
12 knowledgeable about that subject. Are you?

13 A Well, impurities you're referring to as
14 contaminating impurities, if I understand you
15 correctly. Or are you saying impurities are also
16 doping impurities?

17 Q I'm using impurities in the sense that you
18 used it in your book, that we've marked as an
19 exhibit, Exhibit 7.

20 A So if I understand you correctly, when you
21 say impurities, you include doping impurities?

22 Q Let me just use the word impurities, as

1 you've used in your book, Exhibit 7.

2 A Right. I included doping impurities and
3 contaminating impurities in that particular
4 sentence that you refer to.

5 Q Okay. So let's start with contaminating
6 impurities. Do you have that in mind?

7 A Okay.

8 Q Okay. What were the typical levels of
9 contaminating impurities in silicon wafers used in
10 the commercial solar cell manufacturing arena as
11 of December of 2014?

12 A I can't give you a number. I don't know.

13 ATTORNEY SELWYN: Why don't we take our
14 lunch break?

15 (Recess from 12:34 p.m. until 1:03 p.m.)

16 BY ATTORNEY SELWYN:

17 Q Good afternoon, Dr. Schubert.

18 A Good afternoon.

19 Q Was iron a common metal impurity in
20 commercial silicon wafers as of December of 2014?

21 A I can't say. It depends too much on the
22 circumstances.

1 Q What circumstances?

2 A What type of wafers I'll be using. What
3 is the level of iron.

4 Q So I'm talking about commercial silicon
5 wafers for commercial solar cells. Do you have
6 that in mind?

7 A Yes.

8 Q Was iron a common metal impurity in
9 silicon wafers for commercial use as of December
10 of 2014?

11 A It may. It may not.

12 Q You don't know?

13 A It would depend on the specifics. I'm not
14 sure if there is a general answer to all. It
15 could be.

16 Q In your declaration, you don't dispute
17 that as of December of 2014, solar cell device
18 fabrication could introduce metal impurities into
19 silicon wafers, correct?

20 A Solar cell fabrication would introduce
21 metal impurities; is that what you're suggesting?

22 Q I'm saying you don't dispute in your

1 declaration that as of 2014, solar cell device
2 fabrication could be something that introduces
3 metal impurities into silicon wafers, correct?

4 A Well, it could. It could. But who would
5 want to have a manufacturing process that
6 introduces metal impurities? I mean, if we have a
7 process that introduces metal impurities, one
8 would modify the process so that no metal
9 impurities are introduced.

10 Q I'm just asking what you say in your
11 declaration. There's no place in your
12 declaration, is there, where you dispute that as
13 of December of 2014, solar cell device fabrication
14 was a source for metal impurities in silicon
15 wafers, correct?

16 A If I understand your question correctly,
17 you start out with a premise that solar cell
18 manufacturing causes metal contamination. And I'm
19 just saying that I'm not sure if that premise is
20 correct.

21 Q You don't address that premise anywhere in
22 your declaration, correct?

1 A I don't think I address in my declaration
2 the introduction of metal impurities during a
3 manufacturing process. I don't discuss this
4 topic.

5 Q In your declaration, you don't dispute
6 that there would have been a reasonable
7 expectation of success in adding Istratov's -- let
8 me try that one more time. New question.

9 In your declaration, you don't dispute
10 that there would have been a reasonable
11 expectation of success in adding Istratov's
12 gettering process to Choi's solar cell, correct?

13 A No. I wouldn't agree with that. My view
14 is different. I'm happy to give more details.

15 Q I'm just interested in what you say in
16 your declaration. Where, sir, in your declaration
17 did you dispute that there would have been a
18 reasonable expectation of success in adding
19 Istratov's gettering process to Choi's solar cell?

20 A I would not -- I do not agree with your
21 statement, but I'm happy to be more detailed if
22 you wish.

1 Q No. I'm just interested in what you say
2 or don't say in your declaration. Is there any
3 place in your declaration where you have disputed
4 that there would have been a reasonable
5 expectation of success in adding Istratov's
6 gettering process to Choi's solar cell?

7 A Well, if you're interested in my opinion,
8 my opinion is that there is not a reasonable
9 expectation of success.

10 Q I'm --

11 A If you're not interested in my opinion,
12 you can look at my report.

13 Q Right. I'm interested in what you say in
14 your declaration. Okay?

15 A Look at my declaration if you want to know
16 my declaration.

17 Q That's what I'm asking you, sir. You know
18 your declaration, right?

19 So my question to you is: In your
20 declaration, that the judges will have to
21 consider, you don't dispute that there would have
22 been a reasonable expectation of success in adding

1 Istratov's gettering process to Choi's solar cell,
2 correct?

3 A Okay. Again, I believe there is no
4 reasonable expectation of success in Istratov.

5 ATTORNEY SELWYN: I move to strike.

6 A And the reason is --

7 ATTORNEY SELWYN: I move to strike.

8 That's not my question.

9 A I'm happy to have you strike my answer.

10 Q Sir, you --

11 A But --

12 Q No, no, no. Let me stop you.

13 Don't interrupt me. You have to answer my
14 question. My question is about what's in the four
15 corners of your declaration.

16 Do you have that in mind?

17 A If you don't want to hear my answer, I'm
18 happy to be silent.

19 Q I want you to answer with respect to --

20 A If you don't want to answer my question,
21 go ahead.

22 Q Sir, let me ask the question.

1 A I will ask my question -- I will answer
2 your question in the way I wish to.

3 Q No. That's not the way the rules work.

4 A Well, that's what I'm doing.

5 Q Right. That's what you're doing, but
6 that's not the way the rules work.

7 ATTORNEY SNODGRASS: Dr. Schubert,
8 continue what you're doing. He can move to
9 strike. He cannot strike. That's for the Board
10 to decide whether --

11 THE WITNESS: Sure.

12 ATTORNEY SNODGRASS: -- your answers
13 should be stricken or not. So you continue to
14 answer his questions to the best of your ability.
15 BY ATTORNEY SELWYN:

16 Q Let me ask the question again.

17 Okay. I want you to have in mind what you
18 wrote in your declaration.

19 Do you have that in mind?

20 A I'll give you the same answer. If you
21 don't want to hear it, I'm going to be quiet.

22 Q Do you have in mind what you wrote in your

1 declaration, yes or no?

2 A If you want me -- if you want me to keep
3 in mind what I have written in my declaration, I'm
4 happy to do so.

5 Q Okay. So I am interested in whether or
6 not you gave a certain opinion in your
7 declaration. Okay?

8 And my question to you is: In your
9 declaration, within the four corners of your
10 declaration, did you ever dispute that there would
11 have been a reasonable expectation of success in
12 adding Istratov's gettering process to Choi's
13 solar cell, yes or no?

14 A Okay. You want to hear my answer?

15 Q I want an answer to my question.

16 A You want to hear it?

17 Q If you're answering my question, I do.

18 A If you want to hear my answer, I'm happy
19 to give you my answer. If you don't want to hear
20 my answer, I'm not going give you my answer.

21 Q Sir, you're required to answer my
22 questions.

1 A I am.

2 Q Answer my question.

3 A Okay. Are you going to let me answer the
4 question?

5 Q Go ahead and say whatever you want, sir.

6 A Without interrupting me?

7 Q I'm not interrupting you, sir. I'd like
8 an answer to my question.

9 A Okay. I need an atmosphere where I'm not
10 interrupted.

11 Q Go ahead and answer.

12 A Okay. As I said, I believe that there is
13 no expectation of success by combining Choi with
14 Istratov because Istratov teaches the opposite.

15 It teaches removing metal impurities and
16 putting them into the substrate. Removing metal
17 impurities from the device layer, and putting them
18 in the substrate. So Istratov teaches the
19 opposite, and for that reason, it is my opinion
20 there is no chance for success.

21 Q Do you say that, sir, in your declaration?

22 A Yes.

1 Q Where do you say it?

2 A IX. Roman Numeral IX, A2.

3 Q What paragraph?

4 A Paragraphs 59 to 71.

5 Q Okay. In which of those paragraphs do you
6 refer to a reasonable expectation of success?

7 A Paragraph 60, 61, 62, 63, 64, 65, 67, 68,
8 69, 70, and 71.

9 Q Are you as confident in the accuracy of
10 that answer as all the other answers that you've
11 given today?

12 A If you wish, I can talk about each
13 paragraph individually.

14 Q That wasn't my question.

15 (Schubert Deposition Exhibit 12 marked for
16 identification and attached to the transcript.)

17 BY ATTORNEY SELWYN:

18 Q Let me hand you, sir, what I've marked as
19 Exhibit 12.

20 Do you recognize Exhibit 12 as the
21 Istratov reference?

22 A I do.

1 Q Now, Istratov evaluated gettering
2 techniques for iron and copper, right?

3 A Yes.

4 Q And if you turn, please, to your
5 declaration, Paragraph 64, you reference the
6 sentence on Page 568 of Istratov that reads,
7 quote: The box layer -- and I'll skip some
8 words -- the box layer introduces a barrier for
9 defusion of metal impurities from the device layer
10 to the gettering sites in the substrate, right?

11 A Correct.

12 Q And that sentence I just read comes from
13 the introduction section of Istratov?

14 A Yes.

15 Q And if you turn now to Page 569 of
16 Istratov, do you see that Istratov discusses in
17 the third to last paragraph on Page 569, a
18 reference where the author is Graff, G-r-a-f-f?

19 A Page 569?

20 Q Yes.

21 A Last...

22 Q Third to last paragraph.

1 A Third to last paragraph.

2 Right-hand column?

3 Q Yes.

4 A In the middle?

5 Q Yeah. In contrast, Graff.

6 ATTORNEY SNODGRASS: I believe it's one
7 paragraph down, Dr. Schubert. Towards the middle
8 of the paragraph.

9 A Yes. I see the sentence.

10 Q And you see that Istratov says about
11 Graff, quote: Several consecutive oxidations
12 improve the lifetime through the process of
13 gettering of iron by silicon dioxide?

14 A I see that sentence.

15 Q Is it fair to say that Istratov is
16 teaching that the process of gettering improves
17 lifetime?

18 A Lifetime in the substrate, no. Because
19 the purpose of Istratov is to clean up the device
20 layer, which is the top layer, and move the
21 unwanted impurities into the substrate. So the
22 lifetime in the substrate is negatively affected,

1 not positively affected. Not positively affected.

2 Q You see the reference to the lifetime in
3 the third to last paragraph on the right-hand
4 column?

5 Let me ask you a question.

6 Do you see where it says: In contrast,
7 Graff, in Section 6.2.3 of his book, 12, stated
8 just the opposite, that several consecutive
9 oxidations improved the lifetime through the
10 process of gettering of iron by silicon dioxide?

11 A I see the sentence.

12 Q What do you understand lifetime is
13 referring to there?

14 A I don't know, because it does not say
15 lifetime in the substrate, or lifetime in the
16 device layer. I would need to either read the
17 whole paragraph, or look at the reference. But
18 right now, I don't know.

19 Q You've studied this reference before,
20 right?

21 A I do. I did, yes.

22 Q You would agree that Istratov is directed

1 to using gettering techniques to improve device
2 efficiency, right?

3 A Which device are you talking about?

4 Q Solar cell device.

5 A Istratov is not talking about solar cells
6 at all. He has nothing to do with solar cells.
7 He or she.

8 Q What device is Istratov directed to?

9 A SOI devices. Silicon on insulator
10 devices. Those are not solar cell devices.

11 Q You'd agree that Istratov is directed to
12 using gettering techniques to improve efficiency
13 in those devices, correct?

14 A So you're not talking about solar cell
15 efficiency right now, if I understand you
16 correctly?

17 Q You've just explained what the device of
18 Istratov is, correct?

19 A I said Istratov is completely unrelated to
20 solar cells. Istratov does not mention solar
21 cells. So if you say efficiency in the context of
22 Istratov, I am saying the efficiency that you

1 mentioned cannot have possibly anything to do with
2 the efficiency of solar cells, because Istratov is
3 not directed to solar cells at all.

4 Q Okay. Let's take it in steps.

5 What is the device that Istratov is
6 directed to?

7 A Microprocessor devices.

8 Q Would you agree that Istratov is directed
9 to using gettering techniques to improve
10 efficiency in those devices?

11 A Microprocessor devices, yes.

12 Q Now, would you look, please, to the last
13 sentence on Page 569?

14 Do you see it states: To perform
15 predictive modeling of gettering, we've performed
16 several experiments to determine or verify the
17 materials, parameters essential for a correct,
18 quantitative description of the processes involved
19 in gettering of metals in SOI wafers.

20 Do you see that?

21 A I do.

22 Q And then Istratov's discussion of

1 experiments that it performs starts after this
2 last sentence on Page 569, correct?

3 A Yes.

4 Q Then in the first paragraph of Page 570,
5 in the first sentence, Istratov describes a test
6 structure, correct?

7 A Yes.

8 Q Do you understand what Istratov's test
9 structure consisted of?

10 A It was an SOI wafer.

11 Q Istratov's test structure had a silicon
12 substrate with an oxide layer on top of that
13 silicon substrate, and then a poly-silicon layer
14 on top of the oxide layer, right?

15 A It was an SOI wafer, silicon on insulator,
16 as used for silicon integrated circuits, such as
17 microprocessors, yes. There is a silicon
18 substrate, oxide, and then again a silicon layer
19 on top of it.

20 Q Then do you see in the second paragraph on
21 Page 570, Istratov states, quote: Iron
22 contamination was performed by scratching the back

1 side of the sample (i.e., the side opposite to the
2 side in which the poly-silicon, silicon dioxide
3 was deposited) with a 99.999 percent purifier.

4 Did I read that right?

5 A Yes.

6 Q So iron contamination was introduced into
7 Istratov's test structure on the side opposite to
8 the poly-silicon layer; is that right?

9 A Correct. But again, it's unrelated to
10 solar cells. The oxide is much thicker, and we
11 have an electronic device, not an auto electronic
12 device here.

13 Q Istratov's test structure included a
14 silicon substrate, correct?

15 A It included a silicon substrate, yes.

16 Q And iron contamination was introduced into
17 Istratov's test structure in the silicon
18 substrate, correct?

19 A Yes.

20 Q And then if I could direct your attention,
21 please, sir, to the paragraph that spans the left
22 and right columns on Page 570.

1 Do you see it says: Figure 2 presents a
2 depth profile obtained on a poly-silicon, silicon
3 dioxide sample, after intentional contamination
4 with iron and annealing for eight hours at 1020
5 degrees Celsius?

6 A Yes.

7 Q And then in Figure 2 of Istratov, it shows
8 that the concentration of iron is higher in the
9 poly-silicon region than in the silicon substrate
10 in the silicon dioxide layer, right?

11 A Yes.

12 Q Figure 2 of Istratov shows that iron moved
13 from the silicon substrate through the silicon
14 dioxide, and then into the poly-silicon region,
15 right?

16 A Yes.

17 Q Then sir, please turn to Page 571 of
18 Istratov.

19 Do you see in the second sentence of the
20 first paragraph, it reads: Copper contamination
21 was performed by scratching the back side of the
22 wafer with a copper wire?

1 A I see the sentence.

2 Q So copper contamination was introduced
3 into Istratov's test structure on the back side of
4 the silicon substrate, correct?

5 A Correct.

6 Q Then the second paragraph on Page 571
7 states, quote: Figure 4 presents a SIMS -- all
8 caps, S-I-M-S -- depth profile obtained after
9 copper diffusion at 690 degrees Celsius.

10 Do you see that?

11 A Yes.

12 Q And Figure 4 of Istratov shows that the
13 concentration of copper is generally higher in the
14 poly-silicon region than in the silicon substrate
15 and the silicon dioxide layer, right?

16 A That's not a full characterization of the
17 profile. I would say in addition to the features
18 that you mentioned, there is also an accumulation
19 layer of copper that's the interface between the
20 silicon dioxide and the silicon substrate. And
21 this accumulation layer would be undesirable.

22 Q Figure 4 shows that copper moved from the

1 silicon substrate through the silicon dioxide and
2 then into the poly-silicon region, right?

3 A Generally, yes. But there is also an
4 accumulation layer in the interface between the
5 silicon dioxide and the silicon substrate, and we
6 find high concentrations of copper in the
7 substrate here, which is undesirable.

8 Q Do you see in the third paragraph on
9 Page 571 of Istratov, it states, quote: SIMS
10 profile obtained after copper diffusion at 1,100
11 degrees Celsius as plotted in Figure 5?

12 A Yes.

13 Q And then, if I could direct your attention
14 to Figure 5 of Istratov, that shows that the
15 concentration of copper is higher in the
16 poly-silicon region than in the silicon substrate,
17 and the silicon dioxide layer, right?

18 A Yes.

19 Q And Figure 5 of Istratov shows that copper
20 moved from the silicon substrate through the
21 silicon dioxide and into the poly-silicon region,
22 right?

1 A Correct.

2 Q Turning back to Page 570, do you see in
3 the first full paragraph on Page 570, it states
4 that the oxide layer in Istratov's test structure
5 was 197 nanometers thick?

6 A Yes.

7 Q And then the next -- the second sentence
8 of that paragraph states: The oxide layer in our
9 test structures was intentionally chosen thicker
10 than that in typical production wafers in order to
11 separate metal diffusion profiles and equilibrium
12 metal concentration within the oxides for metals
13 accumulated in silicon and silicon dioxide
14 interfaces.

15 Did I read that right?

16 A Yes.

17 Q What was the thickness of an oxide layer
18 in a typical production wafer as of 2014?

19 A Are you talking about SOI wafers, or are
20 you talking about tunneling oxide passivation
21 contacts in solar cells?

22 Q The type of wafers that Istratov was

1 using.

2 A Well, the thickness of the oxide is
3 certainly so thick that no current is flowing
4 through it, because the oxide layer in the SOI
5 wafers have the purpose of insulating. This would
6 not work in a solar cell with a tunneling oxide
7 passivation contact because in that case,
8 electrons flow through the oxide by tunneling.

9 Q Okay. My question was different.

10 Do you know what the thickness of an oxide
11 layer in a typical production wafer was as of
12 2014?

13 A In SOI?

14 Q Yes.

15 A Wafer?

16 Q Yes.

17 A It would be so thick that the oxide is
18 insulating. If the oxide is insulating, it
19 wouldn't work for a solar cell.

20 Q So Istratov says that he was using an
21 oxide layer that was 197 nanometers thick.

22 Do you see that?

1 A I do.

2 Q And he says that that was thicker than a
3 typical production wafer, right?

4 A I agree.

5 Q So do you know how much thicker it was
6 than a typical production layer -- production
7 wafer as of 2014?

8 A If you're looking for a numerical value, I
9 can't give you a numerical value. But if you're
10 looking for an explanation, and for the nature of
11 the oxide, I'm happy to give that explanation.

12 Q Istratov was using an oxide layer that was
13 thicker than a typical production wafer, but
14 you're not sure how much thicker; is that fair?

15 A It was part of the story, and the other
16 part is that even if that oxide is thinner, it's
17 still insulating, and therefore unsuitable for
18 solar cells.

19 Q Istratov was using an oxide layer that was
20 thicker than a typical production wafer, correct?

21 A Generally, yes.

22 Q Istratov says that, quote: Metals

1 accumulated at the silicon, silicon dioxide
2 interfaces, because the metals were introduced in
3 the silicon substrate, correct?

4 A Not based on my understanding. But if you
5 point me to where Istratov says this, I'm happy to
6 look at it.

7 Q Okay. Look at the abstract.

8 Would you agree that Istratov's abstract
9 in the case of the oxide layer formed a diffusion
10 barrier for transition metals in silicon?

11 A Yes. The oxide is somewhat of a diffusion
12 barrier.

13 Q And iron and copper were the examples of
14 transition metals, right?

15 A Correct.

16 Q What is a diffusion barrier?

17 A It is a layer that reduces diffusion.

18 Q How does it do that?

19 A By slowing down the motion of atoms.

20 Q The diffusion barrier would be lower if
21 the thickness of the oxide layer were decreased,
22 right?

1 A If the oxide layer thickness is decreased,
2 then the thickness of the diffusion barrier is
3 lower.

4 Q Can you look, please, at Figure 2 of
5 Istratov?

6 Istratov's Figure 2 shows that iron was
7 gettered through an oxide layer that is thicker
8 than Choi's tunneling layer, correct?

9 A I would say that the oxide layer thickness
10 in Figure 2 is thicker than the oxide layer in
11 Choi, and the thickness difference is significant.

12 Q And is it fair to say that Istratov's
13 Figures 4 and 5 show that copper was gettered
14 through an oxide layer that is significantly
15 thicker than Choi's tunneling layer?

16 A With respect to Figure 4, I see an
17 accumulation effect at the interface, so I
18 wouldn't agree with your statement.

19 But with respect to Figure 5, I would say
20 that copper has moved through the silicon dioxide
21 to be gettered by the layer above it.

22 Q Istratov is generally directed to using

1 gettering techniques to improve integrated circuit
2 device efficiency, correct?

3 A Correct. But importantly, Istratov has
4 the purpose of freeing the device layer and moving
5 the transition metal impurities into the
6 substrate. This would have detrimental effects in
7 the field of solar cells.

8 Q Could you put back in front of you Choi,
9 which is Exhibit 10, and also Hanwha 1006, and let
10 me direct your attention, please, to Paragraph 34.

11 In the second sentence of Paragraph 34 of
12 Choi, it states, quote: When the thickness of the
13 tunneling layer 20 exceeds 5 nanometers, tunneling
14 is not efficiently performed in solar cell --
15 solar cell 100 may not operate, then it continues.

16 Do you see that?

17 A Yes.

18 Q And then the third sentence in the same
19 paragraph states: In order to further improve the
20 tunneling effect, the thickness of the tunneling
21 layer 20 may be 1 nanometer to 4 nanometers, and
22 then it continues.

1 Do you see that?

2 A Yes.

3 Q So Choi here is teaching that if thicker
4 than 5 nanometers, the tunnel layer may not
5 perform, may not permit -- strike that.

6 Choi teaches here that if thicker than 5
7 nanometers, the tunneling layer may not permit
8 tunneling, correct?

9 A Correct.

10 Q And increasing the thickness of the
11 tunneling layer in Choi would increase the
12 diffusion barrier, correct?

13 A Choi has no diffusion barrier that I'm
14 aware of that Choi is talking about.

15 Q Choi teaches that if thickness of the
16 tunneling layer is lowered to between 1 nanometer
17 and 4 nanometers, the tunneling effect would be
18 improved, right?

19 A Correct.

20 Q Would you agree that decreasing the
21 thickness of the tunneling layer in Choi would
22 decrease a diffusion barrier?

1 A There is no suggestion to that extent in
2 Choi, because Choi does not discuss at all the
3 diffusion of impurities through the TOP layer,
4 tunneling oxide passivation layer.

5 Q Can you put Istratov back in front of you,
6 and specifically Figure 4?

7 In Istratov's Figure 4, some copper has
8 moved through the silicon dioxide layer into the
9 poly-silicon layer, right?

10 A Yes.

11 Q All right. Now, please put your
12 declaration back in front of you, and let me ask
13 you, please, to turn to Page 58, Paragraph 111.

14 A Page?

15 Q 53, Paragraph 111.

16 In the last sentence of that paragraph,
17 you write: Petitioner also failed to show that
18 any gettering step could be employed without
19 adversely impacting the solar cell of Cousins.

20 Do you see that?

21 A Yes.

22 Q Could you elaborate for us on what you

1 meant when you said gettering could adversely
2 impact the solar cell of Cousins?

3 A Istratov discloses a gettering step that
4 has the purpose of removing impurities, unwanted
5 contaminating impurities, from the device layer
6 and putting them into the substrate. That's the
7 purpose of Istratov. If we follow that purpose,
8 the solar cell would be negatively impacted.

9 Furthermore, Istratov has a set of
10 annealing processes that employ certain
11 temperatures and certain durations. If you look
12 at the temperatures and the duration, we find that
13 the temperatures are high, exceeding 1,000 degrees
14 Celsius, and the durations are long. Durations
15 that I recall are, for example, eight hours.

16 Such annealing processes could negatively
17 affect -- would likely negatively affect -- the
18 TOP layer, tunneling oxide passivation layer, that
19 Choi discloses.

20 Q You don't suggest in your declaration that
21 Istratov discourages gettering at temperatures
22 lower than that disclosed, correct?

1 A Istratov gives guidance on temperature and
2 duration of the annealing process, and the range
3 of temperature and duration would likely be
4 unsuitable for solar cells.

5 Q Istratov never suggests that gettering at
6 temperatures lower than those that he has
7 disclosed shouldn't be done, correct?

8 A Istratov does not talk about solar cells
9 at all. There is no disclosure of solar cell
10 technology in Istratov.

11 Q And Istratov also discloses processing
12 times, right?

13 A Yes. Eight hours is one of the times that
14 I recall.

15 Q He never discourages using shorter
16 processing times that he has disclosed, correct?

17 A I would say that Istratov gives guidance
18 with respect to temperature and duration, and one
19 could refer to such anneals as high temperature
20 anneals, high temperature long duration anneals,
21 and I see no indication that these processes could
22 be suitable for a solar cell manufacturing

1 process.

2 Q Would you know how to calculate the
3 temperature and the time that would result in
4 gettering metal impurities from the substrate to
5 the emitter in Choi's solar cell?

6 ATTORNEY SNODGRASS: Objection to form.

7 A Can I hear the question again?

8 Q Would you know how to calculate the
9 temperature and the time that would result in
10 gettering metal impurities from the substrate to
11 the emitter in Choi's solar cell?

12 ATTORNEY SNODGRASS: Objection to form.

13 A In Choi?

14 Q Choi.

15 A I don't see metal impurities disclosed in
16 Choi, so let me just understand the premise of
17 your question. You believe that there are
18 contaminating metal impurities in Choi?

19 Q Do you disagree with that?

20 A Well, Choi doesn't disclose that, right?
21 Show me where he discloses that.

22 Q Would a person of ordinary skill in the

1 art understand that there are metal impurities in
2 Choi's solar cell?

3 A When you say metal impurities, are you
4 talking about doping impurities, or are you
5 talking about contaminating impurities?

6 Q Let's say either.

7 A Okay. So Choi does not disclose
8 contaminating metal impurities in the substrate.

9 There is nothing that indication that this is a
10 problem in Choi as far as I can see. Based on my
11 recollection of having reviewed Choi, I don't see
12 that being disclosed.

13 Q Does Choi disclose a tunneling layer?

14 A Yes.

15 Q What's the lowest temperature time
16 combination that would cause Choi's tunneling
17 layer to dissolve?

18 A I would not be able to give you a certain
19 temperature and duration combination, but the
20 thicknesses that Choi proposes are 1 nanometer to
21 4 nanometer.

22 So 1 nanometer is 10 angstroms. 10

1 angstroms is twice constant, so what I'm saying is
2 those layers are extremely thin, and they could
3 just dissolve. They could disappear after the
4 annealing process that is practiced by Istratov.

5 Q What's the lowest temperature time
6 combination that could potentially cause dopants
7 from the conductive type regions in Choi's solar
8 cell to disperse throughout the silicon substrate?

9 A Experimental or theoretical?

10 Q Both.

11 A Okay. Let's do theoretical at first.

12 That's something nobody can calculate.

13 That's beyond the capability of calculating,
14 because nobody knows exactly how strongly unwanted
15 metal impurities are, are bonded, are trapped, are
16 gettered in poly-silicon.

17 Experimentally, one would need to do
18 experiments, and nobody knows the outcome of those
19 experiments until they have been done.

20 Q Did you calculate in your declaration a
21 temperature time combination that would result in
22 gettering metal impurities from the substrate to

1 the emitter in Cousins' solar cell?

2 A Cousins has no indication of metal
3 impurities.

4 Q Let's say -- pardon me.

5 A And I'm just saying that attempting such a
6 calculation has a lot of uncertainty associated
7 with it. A lot of uncertainty.

8 (Schubert Deposition Exhibit 13 marked for
9 identification and attached to the transcript.)

10 Q Okay. I'm going to hand you what I've
11 marked as Exhibit 13, which is also Hanwha
12 Exhibit 1008.

13 Do you recognize this as the Marvin
14 reference?

15 A Yes.

16 Q Marvin evaluated a back contact solar cell
17 design, right?

18 A Right.

19 Q Marvin's front surface field was doped
20 with P-type dopants, right?

21 A Yes.

22 Q In Marvin's figure for the IBC solar cell,

1 which is on Page 4, the N and P regions at the
2 back side of the solar cell are carrier collection
3 regions, right?

4 A Can I hear the question again?

5 Q Sure.

6 In Marvin's figure for the IBC solar cell,
7 the N and P regions at the back side of the solar
8 cell are carrier collection regions, correct?

9 A Figure 1?

10 Q Figure 1.

11 A If you want to call it this way, if you
12 want to call these regions in this manner, that's
13 fine with me.

14 Q The N regions are the minority carrier
15 collection regions, correct?

16 A Yes.

17 Q The P regions are the majority carrier
18 collection regions, correct?

19 A Yes.

20 Q The majority and minority of carrier
21 collection regions are on the opposite side of the
22 solar cell than the front surface fields, correct?

1 A Yes.

2 Q Marvin has a silicon dioxide layer that's
3 located between the majority and minority carrier
4 collection regions and the metal contacts,
5 correct?

6 A I would -- I would phrase it in the
7 following way. Marvin has, in Figure 1, a feature
8 labeled as SIO 2, and they cover the surface of
9 the wafer at locations between the aluminum metal
10 contacts.

11 Q And in his study, Marvin varied certain
12 design parameters and then evaluated the solar
13 cell performance, right?

14 A Yes.

15 Q And he says that he used the baseline cell
16 designed as a starting point, and then he varied
17 the parameters, correct?

18 A I don't recall that off the top of my
19 head, but you may be right about this. If you
20 show me what you're referring to, I'm happy to
21 look at it.

22 Q If it will help, let me direct your

1 attention to Page 16, the first sentence.

2 A Yes.

3 Q So Marvin here explains that he is using
4 the baseline cell design as a starting point and
5 varying the parameters, right?

6 A Yes.

7 Q Marvin's Table 2 provides that baseline
8 cell design, correct?

9 A Yes.

10 Q And Marvin's Table 2 provides that in the
11 baseline cell design, the front surface field
12 doping level was, quote: $5E\ 18$ P-type, correct?

13 A I don't see the front surface field doping
14 in Table 2. Sorry, Table 2 you're saying?

15 Q I am. Second line in the bottom.

16 A Yes.

17 Q And $5E\ 18$, that's a scientific notation,
18 right?

19 A Say that again, please?

20 Q $5E\ 18$ is a scientific notation?

21 A Yeah. That's right.

22 Q Marvin's Table 2 provides that in the

1 baseline cell design, the front surface field
2 thickness is half a nanometer, correct?

3 A No.

4 Q What's the front surface field thickness?

5 A 0.5 micrometers.

6 Q Thank you for that correction.

7 Marvin's Table 2 provides that in the
8 baseline cell design, the P thickness was 1
9 micrometers, correct?

10 A P thickness, I read 50 micrometers.

11 Q Okay. And what is the N thickness?

12 A I don't see an N thickness.

13 Q Do you see where it says: P positive
14 thickness?

15 A P plus thickness?

16 Q Yeah.

17 A I do.

18 Q What is that thickness?

19 A One micrometer.

20 Q And what does it say below that for N
21 thickness?

22 A N plus thickness, 0.3 micrometer.

1 Q Marvin's study varied the parameters of
2 the baseline cell design in order to evaluate the
3 effect on solar cell performance, correct?

4 A Yes.

5 Q And one of the design parameters that
6 Marvin changed was carrier collection region
7 thickness, correct?

8 A Where do you get that information from?

9 Q For example, Page 11. Do you see that in
10 the second full paragraph, the first sentence
11 says: Subsequent sections present the effect on
12 cell performance of variations about this baseline
13 design?

14 A I see the sentence.

15 Q So would you agree that his study varied
16 the parameters of baseline cell design to
17 evaluate, among other things, the effect on solar
18 cell performance?

19 A Can I hear the question again?

20 Q Would you agree that Marvin's study varied
21 the parameters of the baseline cell design to
22 evaluate the effect on solar cell performance?

1 A Yes.

2 Q One of the design parameters that Marvin
3 varied was the carrier collection region
4 thickness, correct?

5 A Where do you get that information from?

6 Q Page 12. Do you see on the last sentence,
7 he says that the cell thickness was selected,
8 quote: To study the effects of carrier collection
9 region thickness?

10 You can also refer to the table in the
11 next page.

12 A Yeah. I see that to the cell thickness is
13 changed. For example, in Table 3, we see a cell
14 thickness of 25, 50 and 200 micrometer.

15 Q So one of the design parameters that
16 Marvin varied was carrier collection region
17 thickness, right?

18 A Why are you using carrier collection
19 region? I mean, Marvin talks about cell
20 thickness, solar cell thickness. Substrate
21 thickness would be maybe the more appropriate
22 term.

1 Q Well, I'm using the words that appear on
2 the bottom of Page 12.

3 A The thickness 50 micrometers refers to the
4 cell thickness. You know, it says the 50
5 micrometer thick cell. So the 50 micrometer is
6 the cell thickness.

7 Q Right. And he's varying that -- strike
8 that.

9 Marvin varied both the thickness of the
10 majority carrier collection regions and the
11 minority carrier collection regions, right?

12 A Are you saying this with reference to a
13 specific paragraph of --

14 Q Well, look if you would at the last
15 columns of Tables 4 and 5.

16 Do you see in the last column of Tables 4
17 and 5, Marvin varies the thickness of the P plus
18 and N plus regions?

19 A Yes.

20 Q Marvin also varied the front service field
21 doping level, correct?

22 A And you're referring this from where?

1 Q For example, if you turn to Page 9, the
2 first sentence in the second full paragraph, do
3 you see it says: A subset of all the possible
4 design parameters was selected for study in order
5 to have a management task. These include cell
6 thickness, contact with spacing and thickness,
7 front surface field doping and thickness, and
8 light intensity?

9 A Right. It refers to a simulation.

10 Q And my question to you is: Marvin varied
11 the front surface field doping level, correct?

12 A Yes.

13 Q And he also varied the front surface field
14 thickness, correct?

15 A Yes.

16 Q And Marvin evaluated the solar cell
17 performance at both the beginning of life and the
18 end of life?

19 A Can I hear the question again?

20 Q Marvin evaluated solar cell performance at
21 both the beginning of life and the end of life,
22 correct?

1 A Some of it. I mean, what we are seeing
2 here on Page 9 is a reference to simulations. The
3 beginning of life and end of life efficiency
4 cannot be simulated. So those are experiments.

5 I'm just pointing out a difference.

6 Q But you'd agree that he did evaluate solar
7 cell performance at both the beginning of life and
8 end of life, correct?

9 A I think I saw some data of that, yes.

10 Q What does beginning of life conditions
11 mean?

12 A In the context of space applications, it's
13 before the cell is subjected to cosmic rays,
14 cosmic radiation.

15 Q Is that only true for space applications?

16 A The degradation is more significant in
17 space applications.

18 Q Beginning of life is the state of the
19 solar cells when first made, right?

20 A Yes. That's a fair statement.

21 Q When does end of -- strike that.

22 What does end of life conditions mean?

1 A Marvin's scope relates to space
2 applications. So if we have a satellite that
3 includes a solar cell, that satellite has a
4 certain lifetime, and the solar cells must work
5 during that time. And when the satellite is
6 decommissioned or when the satellite does no
7 longer need to work, then we have reached the end
8 of the intended life of the solar cells.

9 Q Is beginning of life of a solar cell more
10 applicable when evaluating a solar cell for
11 consumer solar panel use?

12 A Solar cells for terrestrial applications
13 do not degrade that strongly, do not degrade as
14 strongly as solar cells used in high cosmic
15 radiation environments, or generally space
16 applications, outer space applications.

17 Q Would you agree then that end of life
18 performance of a solar cell is more applicable
19 when evaluating a solar cell for use in space?

20 A Yes.

21 Q Marvin evaluated the solar cell
22 performance at illumination intensities of 1 sun

1 and 100 suns, right?

2 A Yes.

3 Q Can you explain what 1 sun means?

4 A Just regular sunlight without having a
5 concentrator length.

6 Q What does 100 sun mean?

7 A It means that there is some optical
8 concentration, some higher concentration is found
9 in so-called concentrator solar cells.

10 Q Illumination at 100 suns means receiving
11 light that's 100 times more intense than regular
12 sunlight, right?

13 A Yes.

14 Q And in Marvin, a concentrator solar cell
15 is illuminated in 100 suns, correct?

16 A Some of them, yes.

17 Q Illumination at 1 sun conditions would be
18 more representative of terrestrial use than space
19 use, correct?

20 A No. I wouldn't see it this way. The
21 difference between terrestrial applications and
22 space application is the high cosmic radiation

1 that we have in space, but we don't have on earth.

2 Q But you would agree, wouldn't you, that
3 illumination at 100 sun conditions would be more
4 applicable to space conditions than terrestrial
5 use?

6 A No. The difference between terrestrial
7 use and space applications is the cosmic
8 radiation. And the cosmic radiation is high in
9 space, in outer space, but low or nonexistent for
10 terrestrial applications. Solar cells can be
11 concentrator or non-concentrator solar cells, and
12 both can be either be in space or on the surface
13 of the earth.

14 Q Would you agree that 100 suns is more
15 representative of high cosmic radiation than 1
16 sun?

17 A No. The two are unrelated. I mean, you
18 can have low cosmic radiation on the surface of
19 the earth, and no concentrator or concentrator
20 solar cells. Likewise, you can have high cosmic
21 radiation environments using concentrator or
22 non-concentrator solar cells. So we have these

1 four options.

2 I mean, on earth the most common type of
3 solar cell is an non-concentrator solar cell, and
4 of course low radiation.

5 Q Could you turn, please, to Page 15 of
6 Marvin?

7 Do you see in the first sentence of the
8 second paragraph, it states: The effects of FSF
9 thickness and doping level were studied for the
10 baseline geometry at beginning of life?

11 A Yes.

12 Q So here, Marvin is evaluating the effects
13 of front surface field thickness and front surface
14 field doping level for a beginning of life solar
15 cell, correct?

16 A Yes.

17 Q And in the second paragraph of Marvin on
18 Page 15 states, on the second sentence: For
19 thicknesses of .25, .5 and 1 micrometer, at 1
20 times 10 to the 18th cubic centimeters doping, no
21 significant effect was observed at 1 sun.

22 Do you see that?

1 A I do.

2 Q Here Marvin is evaluating the effect of
3 varying the front surface field thickness,
4 correct?

5 A Yes.

6 Q And he's evaluating the solar cell under 1
7 sun conditions?

8 A Yes.

9 Q He's not evaluating a concentrator solar
10 cell here, correct?

11 A Correct.

12 Q Marvin discloses a front surface filed
13 doping level of 1 times 10 to 18th cubic
14 centimeters for a beginning of life solar cell
15 here, correct?

16 A Can I hear the question again?

17 Q Sure.

18 Marvin, in the second paragraph on
19 Page 15, discloses a front surface field doping
20 level of 1 times 10 to the 18th cubic centimeters
21 for a beginning of life solar cell?

22 A Yes. However, importantly we need to

1 understand the conditions that are disclosed here.

2 I agree with you that this is a non-concentrator
3 solar cell, 1 sun. But the question is, is this
4 high cosmic radiation environment, or low cosmic
5 radiation environment?

6 And the section that you're reading from
7 is Section E. And if we go back to Section A, we
8 find the scope of the study, and the scope of the
9 study is disclosed in Section A, Page 9, is as
10 follows: The purpose of this study is to evaluate
11 the usefulness of IBC solar cells in space
12 applications.

13 So what Marvin talks about are space
14 applications, and space applications are high,
15 generally high cosmic radiation applications. So
16 the statement that relates to the doping
17 concentrations on Page 15, 10 to the power of 17th
18 and 10 to the power of 18th, that range of doping
19 relates to high cosmic radiation environments.

20 This interpretation is confirmed by the
21 conclusions of Marvin.

22 Q Okay. Directing your attention to the

1 third sentence of the second paragraph of Page 15,
2 do you see that it reads, quote: The FSF
3 effectiveness is relatively constant over a rather
4 broad range, around 1×10^{17} to 1×10^{18}
5 cubic centimeters, decreasing
6 below this level, due to the weakness of the
7 electric field, and decreasing above this level
8 due to increased Auger recombination.

9 Do you see that?

10 A I do.

11 Q Marvin discloses that front surface field
12 effectiveness is relatively constant when the
13 front surface field doping level is around 1×10^{17}
14 to 1×10^{18} cubic
15 centimeters, correct?

16 A Yes. And this applies to high cosmic
17 radiation environments.

18 Q And he --

19 A -- not to terrestrial environments.

20 Q And he teaches that decreasing the front
21 surface field doping level below 1×10^{17}
22 cubic centimeters reduces front surface

1 field effectiveness due to weakness of the
2 electric field, right?

3 A Yes. For high cosmic radiation
4 environments.

5 Q And Marvin teaches that increasing the
6 front surface field doping level above 1 times 10
7 to the 18th cubic centimeters reduces front
8 surface field effectiveness due to increased Auger
9 recombination, right?

10 (Reporter clarification.)

11 A Yes. For space applications, that is for
12 high cosmic radiation environments.

13 Q What is Auger recombination?

14 A That is a recombination process that does
15 not produce electricity.

16 Q One effect of Auger recombination is it
17 reduces solar cell efficiency, correct?

18 A Correct.

19 Q Marvin teaches that increasing the front
20 surface field doping level above 1 times 10 to the
21 18th cubic centimeters induces Auger
22 recombination, correct?

1 A I think that is not the complete story. I
2 would say that Marvin makes this statement in the
3 context of space applications. If we look at
4 terrestrial applications, Marvin discloses that
5 the optimum doping concentration is 5×10^{18} , as
6 found in the conclusion section.

7 Q Do you see on Page 15 of Marvin, he
8 writes: The effects of FSF thickness and doping
9 level were studied for the baseline cell geometry
10 at beginning of life?

11 A Yes.

12 Q Marvin discloses a front surface field
13 doping level range of 1×10^{17} to 1×10^{18} cubic centimeters for a
14 beginning of life solar cell, right?

15 A For space applications, yes. Not for
16 terrestrial applications.

17 Q And he discloses a front service field
18 doping level range of 1×10^{17} to 1×10^{18} cubic centimeters under 1 sun
19 conditions, right?

20 A Correct. For high cosmic radiation
21
22

1 environments, I agree.

2 Q Can you turn, please, to Page 16 of
3 Marvin?

4 Actually, before we get there, would you
5 agree that regardless of space or terrestrial
6 application, increasing front surface field will
7 increase Auger recombination?

8 (Reporter clarification.)

9 Q Let me re-ask the question. I'll try to
10 make it clearer.

11 Would you agree that regardless of space
12 or terrestrial application, increasing the front
13 surface field doping concentration will increase
14 Auger recombination?

15 A If you look at the effect of Auger
16 recombination, A-u-g-e-r, it may be insignificant
17 in the range that is considered by Marvin. If we
18 look at the conclusion section, the optimum doping
19 concentration is found to be 5×10^{18} .

20 Now, if that's the optimum, it is not
21 compromised by a significant Auger effect at that
22 concentration. So if we look at Marvin in its

1 entirety, we see that Marvin comes to the
2 conclusion repeatedly, that $5E 18$ is the optimum
3 doping concentration. And based on that, I'd say
4 if that's the conclusion of Marvin, then Auger
5 recombination may be an academic issue, but it's
6 not limiting the solar cell efficiency if Marvin
7 teaches that $5E 18$ is the optimum concentration.

8 Q Putting Marvin aside, would you agree that
9 regardless of space or terrestrial application,
10 increasing front surface field doping
11 concentration will increase Auger recombination?

12 A If we look at the technical literature, we
13 find that Auger recombination is found to be more
14 of a problem in concentrator solar cells than in
15 non-concentrator solar cells. So I would say yes
16 for concentrator solar cells, but I don't see this
17 for non-concentrator solar cells in terrestrial
18 environment.

19 Yeah. I've not seen technical literature
20 that would show this. If such literature is
21 produced, I'm happy to look at it. But at this
22 point, I have not seen technical literature citing

1 that Auger recombination is a significant problem,
2 or a problem for non-concentrator terrestrial
3 solar cells.

4 Q So would it be fair to say that you don't
5 know one way or the other whether, regardless of
6 space or terrestrial application, increasing front
7 surface field doping concentration will increase
8 Auger recombination?

9 A Well, I'm happy to show you publications
10 that clearly state Auger recombination is not a
11 problem for non-concentrator terrestrial solar
12 cells. I have found such technical literature,
13 and I believe I have cited that literature in my
14 declaration.

15 Q So. In my question, I'm not asking
16 whether it's significant or a problem. I'm just
17 asking whether it increases. So let me just try
18 one more time.

19 Do you know, one way or another, whether,
20 regardless of space or terrestrial application,
21 increasing front surface field doping
22 concentration will increase Auger recombination?

1 A In my view, it's an academic that may bear
2 no practical relevance. But if we restrict
3 ourselves to the academic ivory tower, then yes.
4 Auger recombination increases through the doping
5 concentration. But as I said, I view this as an
6 academic question that has no practical relevance
7 based on the publications that I have cited in my
8 declaration.

9 Q Where does Marvin say, in your view, that
10 he simulated high cosmic radiation environments?

11 A Where is Marvin saying this?

12 Q Yes. What would -- if you can point me to
13 the words where he says this?

14 A Page 9, Section A, scope of the study.

15 And Marvin says: The purpose of this study is to
16 evaluate the usefulness of IBC solar cells in
17 space applications. That sets the theme.

18 So Marvin is a defense contractor, or the
19 research program is part of a space systems
20 division air force systems command, as disclosed
21 on the title page. So Marvin has the orientation.
22 We're interested in space applications. We're

1 interested in space systems, and that's the mind
2 set. That's the scope. That's what Marvin says
3 at the outset.

4 And then we come to Section A, B, C, D, E.
5 And in E, it doesn't mention high radiation
6 environment, but the scope is clear. The scope is
7 fully disclosed here at the very beginning. We
8 are concerned with space applications, and space
9 applications means high cosmic radiation
10 environments unless shielded.

11 Q Can you turn, please, to Page 16?

12 We'll go a few more minutes and then take
13 a break.

14 Do you see in the second paragraph, it
15 states, quote: For space use for radiation as
16 present in the flight performance must be
17 considered?

18 A Yes.

19 Q So he's teaching there that end of life
20 performance must be considered for space use,
21 correct?

22 A Absolutely.

1 Q And then he says, quote: The baseline
2 cell parameters are near optimum for end of life
3 efficiency?

4 A Yes.

5 Q And the baseline cell parameters, again,
6 were provided in Marvin's Table 2, correct?

7 A I'm sorry. I didn't understand.

8 Q The baseline cell parameters Marvin has
9 provided in Table 2, right?

10 A Yes.

11 Q So the baseline cell parameter for front
12 surface field doping level was $5E\ 18$ P-type,
13 correct?

14 A Correct.

15 Q So Marvin teaches that the front surface
16 field doping level of $5E\ 18$ P-type was near
17 optimum for end of life efficiency, correct?

18 A I think without qualification, I wouldn't
19 make that qualification. I would just plainly say
20 Marvin teaches that a doping concentration of the
21 front surface field of $5E\ 18$ is best, is optimum,
22 for terrestrial applications, and this is found in

1 the conclusion section.

2 And the first paragraph makes the
3 statement that the FSF should be an approximately
4 0.5 micrometer step with a doping concentration of
5 $5E 18$ per cubic centimeter.

6 Q And he's describing that as near optimum
7 with respect to end of life efficiency, correct?

8 A I don't see this end of life qualification
9 in the conclusion section. I think it's a
10 recommendation that goes without qualification
11 just for terrestrial applications.

12 Q So are you saying that Marvin teaches that
13 the best front surface field doping concentration
14 is the same for both beginning of life and end of
15 life?

16 A I'm not sure if I understand the question.
17 But if you look at the conclusion section, so the
18 conclusion section in the second line mentions
19 near optimum design. In the fourth line, it
20 discloses low radiation environment. And then in
21 the seventh line, it discloses an unqualified
22 doping concentration of $5E 18$ per cubic

1 centimeters.

2 And then in the second paragraph in the
3 conclusion section, it talks about higher
4 radiation environment. And in the higher
5 radiation environment, the beginning of life and
6 end of life issue is more relevant because solar
7 cells degrade when they receive cosmic radiation,
8 higher radiation. Cosmic ray radiation.

9 And so I would say the first paragraph is
10 an unqualified optimum or near optimum low
11 radiation environment, terrestrial environment
12 recommendation of 5×10^{18} .

13 The second paragraph then relates to the
14 high radiation environment, and that's where the
15 beginning of life and end of life comes in,
16 because solar cells degrade in space under high
17 cosmic radiation exposure.

18 Q Okay. I think you and I are referring to
19 different portions of Marvin. Let me direct your
20 attention to Page 16, the second full paragraph.

21 Do you see there, it reads: For space use
22 where radiation is present, end of life

1 performance must be considered. The baseline cell
2 parameters are near optimum for end of life
3 efficiency.

4 Did I read that right?

5 A Yes.

6 Q And when he refers to baseline cell
7 parameters, he's talking about the figures that
8 are provided in Table 2, correct?

9 A I'm not certain.

10 ATTORNEY SELWYN: Why don't we take a
11 break?

12 (Recess from 2:49 p.m. until 2:58 p.m.)

13 BY ATTORNEY SELWYN:

14 Q Dr. Schubert, can you turn to Page 25 of
15 Marvin, Exhibit 13?

16 Do you see the first paragraph under
17 conclusion states: The design of IBC solar cells
18 for space use has been investigated using
19 two-dimensional computer simulations. Near
20 optimal designs have been presented for missions
21 using either planar or 100 sun concentration for
22 arrays under high or negligible radiation

1 influences.

2 A Yes.

3 Q That paragraph discusses the design of IBC
4 solar cells for space use, correct?

5 A Well, the first two sentences, yes. But
6 the third sentence goes on to say: Low radiation
7 environment.

8 Q Okay. Then that third sentence says: In
9 the low radiation environments, the minority and
10 majority carrier collection regions should be of
11 comparable width, with thicknesses of .9
12 micrometers and 3 micrometers respectively,
13 correct?

14 A Correct.

15 Q So there, Marvin is discussing the
16 thicknesses of the minority and majority carrier
17 collection regions in the low radiation
18 environments, correct?

19 A Yes.

20 Q And then he says: The FSF should be
21 approximately .5 micrometers step with doping
22 concentration of 5×10^{18} cubic centimeters. These

1 parameters are much more critical for 100 sun
2 operation, correct?

3 A Correct.

4 Q So there he's teaching that a doping
5 concentration of 5×10^{18} cubic centimeters is,
6 quote: Critical for 100 sun operation, right?

7 A No. The 5×10^{18} applies to 1 sun
8 efficiency.

9 Q Dr. Schubert, in your research on solar
10 cells, have you ever used simulations?

11 A I've used simulations, yes.

12 Q And is it fair to say that simulations are
13 widely used in the field of solar cells?

14 A Simulations are used, yes.

15 Q And simulations can show general trends
16 for a given set of parameters, correct?

17 A They can.

18 Q Are you familiar with the concept of
19 parametric sweeps?

20 A I'm not sure what you mean by this.

21 Q Is a parametric sweep a concept where a
22 skilled artisan may systematically vary one

1 parameter over a specified range to analyze how
2 changing the parameter may change a particular
3 design?

4 A It can mean that, yes.

5 Q Before fabricating a solar cell, a skilled
6 artisan may choose the doping concentration of the
7 solar cell based on simulation results, correct?

8 A A person of skill may perform simulations,
9 but would also be aware of the limitations of
10 simulations.

11 Q A skilled artisan may simulate multiple
12 doping concentration values to determine how
13 changing the doping concentration would affect
14 solar cell design, right?

15 A It's a possibility, yes.

16 Q Are you familiar with a simulator called
17 PC 1D?

18 A I've not used it.

19 Q Are you aware of its existence?

20 A Sounds like a one-dimensional simulation
21 to me, 1D. I'm not sure.

22 Q PC 1D is simulation software, correct?

1 A It's simulation software?

2 Q Yes.

3 A Yes. Is there a question? I'm not sure
4 if I understood the question.

5 Q Sure.

6 Do you know what PC 1D is?

7 A I've -- no. I've not heard of this
8 simulation software, but it sounds like a 1D
9 simulation to me. One-dimensional.

10 Q Let's go back, if we can, to Exhibit 5,
11 Granek, which is Hanwha Exhibit 1010.

12 You would agree that one of the solar
13 cells studied by Granek has a doping concentration
14 of 1 times 10 to the 18th, correct?

15 A Front surface field doping concentration;
16 is that what you're referring to?

17 Q Yes.

18 A I think it's fair to say that Granek
19 performed simulations, and varied the doping
20 concentration in the simulations.

21 Q And one of the solar cells that he studied
22 has a doping concentration of 1 times 10 to

1 the 18th. That's in Figure 7-1, correct?

2 A Yeah. It's a simulation. It's not really
3 a solar cell. It's a simulation.

4 But yes, I agree. A peak concentration
5 for the front surface field is $1E\ 18$.

6 Q Now, can you put in front of you, please,
7 Exhibit 10, which is the Choi reference, which is
8 also Hanwha 1006.

9 Got it?

10 A Yes.

11 Q Can I ask you some questions, please,
12 about the design of the solar cell in Choi?

13 A Sure.

14 Q The solar cell of Choi has a passivated
15 front surface, right?

16 A I see a front surface field, and I see an
17 anti-reflection coating, and assuming that there
18 is a passivation is a reasonable assumption.

19 Q Can you put in front of you Exhibit 11,
20 which is the Cousins reference, Hanwha 1007?

21 The solar cell of Cousins has a passivated
22 front surface, correct?

1 A Yes.

2 Q Would you agree that the passivation of
3 the front surfaces in Choi and in Cousins lowers
4 their front surface recombination velocities
5 relative to non-passivated front surfaces?

6 A Yes.

7 Q Did you -- strike that.

8 Put back in front of you, if you could,
9 Exhibit 5, Granek, which is Hanwha Exhibit 1010,
10 and let me ask you, please, sir, to turn to
11 Figure 7.1, which is on Page 121.

12 A Yes.

13 Q You've reviewed Figure 7.1 of Granek?

14 A Correct.

15 Q And Figure 7.1 shows the efficiency of
16 five different solar cells, right?

17 A Right.

18 Q It shows the efficiencies of a solar cell
19 with a front surface field doping concentration of
20 1 times 10 to the 18th, correct?

21 A Right.

22 Q Out of the five solar cell designs in

1 Figure 7.1, the solar cell with the front surface
2 field doping concentration of 1×10^{18} has highest efficiency for front surface
3 recombination velocities below 500 centimeters per
4 second, correct?

6 A I wouldn't say it in this manner. What I
7 would say is that in the low front surface
8 recombination velocity region, there are two
9 curves that are very close, and the two curves are
10 the 1×10^{18} curve, and the 1×10^{19} curve.

11 Now, each curve has an error bar
12 associated with it. And an error bar is the
13 result of parameters that are known to a certain
14 degree, but not totally accurately. So we have
15 simulation parameters, and they are not perfect.
16 And for that reason, I would say that the two
17 curves are within the error bar.

18 A person of skill in the art would see
19 that these two curves are overlapping within the
20 error bar that is associated with that
21 calculation. As a result, the person of skill
22 would not conclude that 1×10^{18} or 1×10^{19} is better

1 than 1E 19.

2 ATTORNEY SELWYN: Okay. I'm going to move
3 to strike, because I don't think that's responsive
4 to my question. Let me pose it again.

5 BY ATTORNEY SELWYN:

6 Q Do you see that there are five solar cell
7 designs depicted in Figure 7.1?

8 A Yes.

9 Q Out of the five solar cell designs,
10 Figure 7-1 shows that the solar cell with a front
11 surface field doping concentration of 1 times 10
12 to the 18th has the highest efficiency for front
13 surface recombination velocities below 500
14 centimeters per second, correct?

15 A No. And I'm happy to explain my answer,
16 if you wish.

17 Q The horizontal axis of Figure 7.1
18 corresponds to the front surface recombination
19 velocity of the solar cell, correct?

20 A Correct.

21 Q And one factor that affects front surface
22 recombination velocity is the front surface doping

1 concentration, correct?

2 A It can be affected by the doping
3 concentration.

4 Q The front surface recombination velocity
5 increases as the doping concentration increases,
6 right?

7 A Not always, but this can happen.

8 Q All else being equal, a POSITA would
9 expect the front surface recombination velocity of
10 a solar cell with a front surface field doping
11 concentration of 1×10^{18} , to be
12 lower than the front surface recombination
13 velocity of a solar cell with a front surface
14 field doping concentration of 1×10^{19} , correct?

16 A Can I hear the question again?

17 Q All else being equal, a POSITA would
18 expect the front surface recombination velocity of
19 a solar cell having a front surface field doping
20 concentration of 1×10^{18} , to be
21 lower than the front surface recombination
22 velocity of a solar cell having a front surface

1 field doping concentration of 1 times 10 to the
2 19th, correct?

3 A No. You cannot make that general
4 statement because if you have a higher doping, the
5 repulsion of minority carriers from the surface is
6 better. So they are competing effects, and I
7 would not be able to make such a general
8 statement, as you just made it.

9 Q Let me ask you, please, to turn to Page 42
10 of Granek, and focus on your attention on
11 Figure 3.6.

12 Do you see there are two graphs on Page 42
13 of Granek?

14 A Yes.

15 Q And if I could focus you on the left-most
16 graph of Figure 3.6; do you see that?

17 A Yes.

18 Q The left graph corresponds to a front
19 surface doped with phosphorus, right?

20 A Yes.

21 Q And the graph shows a formula inside of
22 it, right?

1 A Yes.

2 Q According to this graph and the formula
3 shown inside the graph, the front surface
4 recombination velocity for a doping concentration
5 of 1×10^{18} is 100, correct?

6 A Yes.

7 Q And according to this graph, and the
8 formula shown inside the graph, the front surface
9 recombination velocity for a doping concentration
10 of 1×10^{19} is 1,000, correct?

11 A Correct.

12 Q So now let me ask you to flip back to
13 Figure 7.1 of Granek.

14 Do you see that the curve that corresponds
15 to a front surface field doping concentration of 1×10^{18}
16 times 10^{18} ?

17 A I see, yes.

18 Q Do you see the efficiency value of that
19 curve for a front surface recombination velocity
20 of a 100?

21 A Yes.

22 Q And what is that efficiency value?

1 A Well, it's 22.5 percent.

2 Q Do you see the curve that corresponds to a
3 front surface field doping concentration of 1
4 times 10 to the 19th?

5 A Yes.

6 Q And do you see the efficiency value of
7 that curve for a front surface -- strike that.

8 Do you see the efficiency value of that
9 curve for a front surface recombination velocity
10 of a 1,000?

11 A Yes.

12 Q Again, focusing just on Figure 7.1, would
13 you agree that the efficiency of a solar cell with
14 a front surface field doping concentration of 1
15 times 10 to the 18th, and a front surface
16 recombination velocity of 100 is higher than the
17 efficiency of a solar cell with a front surface
18 field doping concentration of 1 times to the 19th,
19 and a front surface recombination velocity of a
20 1,000?

21 A I think you're changing two parameters at
22 the same time, and you're changing the doping

1 concentration, and you're changing the front
2 surface recombination velocity.

3 In my view, I do not see what Petitioner
4 is postulating. What I see is that there are two
5 curves that are very close. They are too close to
6 call for a clear winner. They are too close to
7 call for a clear winner, because every curve has
8 an error bar associated with it, and a person of
9 skill would understand.

10 A person who performs these simulations, a
11 person of the field, an expert, would see that the
12 spacing between the curves is too small, exceeding
13 the width of the error bars so that a clear winner
14 cannot be determined. A clear efficiency winner
15 cannot be determined because the curves are too
16 close.

17 If we go to high surface recombination
18 velocities, there is a difference that is more
19 pronounced. But in the low surface recombination
20 velocity region, the two curves are too close to
21 say one way or the other, that one curve is
22 clearly above the other curve.

1 ATTORNEY SELWYN: I'm going to move to
2 strike because I don't think that answers my
3 question.

4 BY ATTORNEY SELWYN:

5 Q Can you answer this question yes or no.

6 My question is as follows: The efficiency
7 of a solar cell with a front surface field doping
8 concentration of 1 times 10 to the 18, and a front
9 surface recombination of velocity of 100 is higher
10 than the efficiency of a solar cell with a front
11 surface field doping concentration of 1 times 10
12 to the 19th, and a front surface recombination
13 velocity of 1,000, correct?

14 A No. And I explained my reasons in my
15 previous answer.

16 Q Figure 7.1 of Granek also shows a curve for
17 a solar cell with quote: No FSF, correct?

18 A Correct.

19 Q And that indicates that this practitioner
20 solar cell did not have a front surface field,
21 correct?

22 A Correct.

1 Q The doping concentration of the front
2 surface of this solar cell with no FCF -- FSF --
3 strike that. Let me try again.

4 The doping concentration of the front
5 surface of this solar cell with no FSF is equal to
6 the doping concentration of the body of the solar
7 cell, correct?

8 A Correct.

9 Q The front surface doping concentration of
10 the solar cell with no FSF is lower than 1 times
11 10 to the 18th, correct?

12 A It has no FSF doping concentration.
13 That's how I would put it.

14 Q According to Figure 3.6 of Granek, this
15 solar cell would have a surface recombination
16 velocity of 70, correct?

17 A Yes.

18 Q And do you see in Figure 3.6, the curve
19 that corresponds to no FSF?

20 A Figure 3.6 does not include information
21 about no FSF configuration.

22 Q In your declaration, you have cited a

1 couple of papers showing a surface recombination
2 velocity of 1,000, right?

3 A Correct.

4 Q You cite a paper for by Korte, correct?

5 A Correct.

6 Q And Korte uses surface recombination
7 velocity of 1,00 for its simulations, correct?

8 A That is consistent with my recollection.

9 Q Korte simulates a P-doped substrate and
10 not an N-doped substrate, correct?

11 A I would need to see the reference in order
12 to answer that question.

13 Q Sure.

14 (Schubert Deposition Exhibit 14 marked for
15 identification and attached to the transcript.)

16 Q Let me hand you what I've marked as
17 Exhibit 14, which is Maxeon Exhibit 2035, the
18 Korte reference, correct?

19 A Yes.

20 Q Korte simulates a P-doped substrate and
21 not an N-doped substrate, correct?

22 A Yes.

1 Q Does a P-doped substrate have the same
2 surface recombination velocity as an N-doped
3 substrate, all things being equal?

4 A I'm not sure if I can give a general
5 answer because there are too many parameters
6 involved.

7 Q You cite Marvin in your declaration for
8 surface recombination velocities, correct?

9 A Correct. Korte. I cite Korte for a
10 typical surface recombination velocity of 1,000
11 centimeters per second.

12 Q Well, if you look at Paragraph 88 of your
13 declaration, you cite Marvin in Paragraph 88 of
14 your declaration for surface recombination
15 velocities, correct?

16 A Yes. Among other references.

17 Q Marvin solar cell has a P-type substrate
18 and a P-type FSF, correct?

19 A Yes.

20 Q Marvin teaches that poorly passivated
21 interfaces have a surface recombination velocity
22 of 10,000 centimeters per second, correct?

1 A It also depends on the passivation, but
2 what I cite here or what I reference here is that
3 Marvin assumes a surface recombination velocity of
4 1,000 centimeters per second.

5 Q Could you put Marvin back in front of you?
6 It's Exhibit 13, and turn, please, to Page 17.

7 Do you see in the first full sentence on
8 Page 17, it reads: Even if the interface between
9 these doping regions and the oxide surface is
10 poorly passivated (S equals 1 times 10 to the 4th
11 centimeters per second) this performance can be
12 achieved?

13 A I see the sentence.

14 Q And that's an indication by Marvin that
15 poorly passivated interfaces have a surface
16 recombination velocity of 10,000 centimeters per
17 second, correct?

18 A Yes. At the high end, the passivation is
19 lower quality.

20 Q Marvin reports lower on that page that for
21 well passivated interfaces, a surface
22 recombination velocity of lower than 1,000

1 centimeters per second, correct?

2 Sorry. I misdirected you. Strike that.

3 Can you turn to Page 16?

4 Do you see in the last sentence of the
5 third full paragraph on Page 16, it says: The
6 results presented below indicate that if the
7 latter interface can be well-passivated (S is less
8 than 1 times 10 to the 3rd centimeters per second)
9 high end of life efficiency can be obtained in a
10 thicker cell?

11 A I see that, yes.

12 Q So for well-passivated interfaces, Marvin
13 reports a surface recombination velocity lower
14 than 1,000 centimeters per second, right?

15 A I would say that Marvin teaches a range of
16 surface recombination velocities, and this is
17 consistent with the fact that there is some
18 variance with respect to the surface recombination
19 velocity, and if we look at a number of
20 references, a surface recombination velocity of
21 1,000 is a reasonable velocity.

22 Q Are you familiar with a saturation current

1 of a solar cell?

2 A Yes.

3 Q And would you agree that generally a lower
4 saturation current leads to higher solar cell
5 efficiency?

6 A Sometimes yes, but not always.

7 Q Okay. But would you agree that in
8 general, a lower saturation current leads to
9 higher solar cell efficiency?

10 A It depends on the specifics. A general
11 statement, in my view, cannot be made because the
12 saturation current can be reduced by reducing the
13 area of the solar cell, but reducing the area
14 would capture less light, and therefore will have
15 a lower efficiency. So I can give you some
16 counter examples of configurations where this
17 correspondence, as you suggested, is not
18 satisfied.

19 Q Would you agree that all other things
20 being equal, a lower saturation current leads to
21 higher solar cell efficiency?

22 A No. In that particular situation that I

1 just mentioned, it does not. We can reduce the
2 solar cell area, reduce the saturation current,
3 but hurt the efficiency.

4 Q Can you put Granek back in front of you,
5 Exhibit 5, and let me ask you to turn to Page 122,
6 Figure 7.3?

7 Do you see Figure 7.3 includes two graphs?

8 A I do.

9 Q The top graph corresponds to a surface
10 recombination velocity of 10 to the 6th cubic
11 centimeters -- I'm sorry -- centimeters per
12 second?

13 A Yes.

14 Q The bottom graph corresponds to a surface
15 recombination velocity described in a paper by
16 Cuevas, C-u-e-v-a-s?

17 A Yes.

18 Q And you'd agree that a surface
19 recombination velocity of a million is several
20 orders of magnitude higher than surface
21 recombination velocity values that a skilled
22 artisan would typically expect in 2014, correct?

1 A It depends on the surface. I'm not sure
2 if I understood the question correctly. I'm happy
3 to listen to it a second time.

4 Q Well, in Paragraph 88 of your declaration,
5 you say: A typical surface recombination velocity
6 is 10 to the 3rd centimeters per second, correct?

7 A Correct, for a passivated silicon surface.

8 Q And what time frame were you referring to
9 there?

10 A 2010. 2015.

11 Q So fair to say that a surface
12 recombination velocity of a million is several
13 orders of magnitude higher than the typical
14 surface recombination velocity values a skilled
15 artisan would expect between 2010 and 2015?

16 A It depends on the surface preparation and
17 surface layers. That cannot be said in general.

18 Q Well, what did you mean by a typical
19 surface recombination velocity?

20 A Well, I'm talking about an oxidized
21 silicon surface. And for oxidized silicon
22 surface, so standard passivation. 1,000

1 centimeters per second is a reasonable value for
2 the surface recombination velocity.

3 Q A surface recombination velocity of a
4 million would correspond to non-passivated front
5 surfaces, right?

6 A It could, yes. Or to metallized surfaces.

7 Q The bottom graph of Figure 7.3 of Granek
8 is for solar cells with passivated front surfaces,
9 right?

10 A Yes.

11 Q So fair to say that a skilled artisan
12 designing a solar cell with passivated front
13 surfaces in 2014 would look to the bottom graph of
14 Figure 7.3 of Granek, rather than the top graph?

15 A No. I think both curves are relevant.

16 Q Let's look at the bottom graph. That
17 bottom graph plots the saturation currents as a
18 function of surface phosphorous concentration and
19 junction depth, right?

20 A Correct.

21 Q And this graph indicates that the lowest
22 saturation value is obtained when the front

1 surface field doping concentration is about 6 or 7
2 times 10 to the 17th, right?

3 A Yes.

4 Q So according to this graph, the front
5 surface doping concentration of the solar cell
6 with the lowest saturation current is lower than 2
7 times 10 to the 18th, correct?

8 A If you just isolate this graph and keep it
9 from all other contexts, I would say yes.

10 However, two points.

11 The first point is we have here saturation
12 current. Saturation current is of secondary
13 importance. Efficiency is of primary importance.

14 The second point is why would a POSITA
15 infer information from a graph such as Figure 7.3,
16 if the reference, Granek explicitly states what is
17 best, what is the optimum.

18 And I would say if there's a statement in
19 Granek that clearly spells out 5 times 10 to the
20 18th power is our best configuration, this is what
21 we should have, then why would we not take
22 Granek's word for it, and rather go to some

1 figures and infer from that figure information
2 that relates, not to efficiency, but saturation
3 current.

4 ATTORNEY SELWYN: I move to strike
5 everything after the first sentence of that
6 answer.

7 BY ATTORNEY SELWYN:

8 Q Granek also conducted experiments with
9 different front surface field doping
10 concentrations, right?

11 A Yes.

12 Q He fabricated five solar cells, correct?

13 A At least five.

14 Q Table 7.1 indicates that the solar cells
15 that Granek fabricated had front surface field
16 doping concentrations ranging from 3.8 times 10 to
17 the 18th to 6 times 10 to the 20th, correct?

18 A Yes.

19 Q Granek didn't conduct experiments for
20 solar cells with front surface field doping
21 concentrations that were lower than 3.8 times 10
22 to the 18th, correct?

1 A So you're excluding simulations?

2 Q Yes, for purposes of this question.

3 A Well, there is a no FSF line item in
4 Table 7-2, and that is a lower doping
5 concentration.

6 Q Is it your testimony that Granek conducted
7 experiments for solar cells with front surface
8 field doping concentrations lower than 3.8 times
9 10 to the 18th?

10 A If there is no FSF configuration, then the
11 doping concentration of the surface region is less
12 than 10 to the 18 -- 10 to the 18th per cubic
13 centimeter.

14 Q Did Granek conduct experiments for solar
15 cells that had an FCF -- FSF -- strike that.

16 Did Granek conduct experiments for solar
17 cells that had an FSF, but the concentration was
18 less than 10 times 3 -- I'm sorry -- 3 times 10 to
19 the 18th.

20 Let me try that one more time. Strike the
21 last question.

22 Did Granek conduct experiments for solar

1 cells that had an FSF, but the concentration was
2 less than 3.8×10^{18} ?

3 A I wouldn't want to exclude that
4 possibility, but they're not found in Table 7-1.

5 Q Do you recall any disclosure in Granek of
6 that?

7 A See, the FSF 5 profile shown in Table 7-1
8 is the sheet resistance of 148 ohms per square.

9 Now, if we look at Page 123, Marvin --
10 sorry -- Granek talks about a sheet resistance of
11 200 to 800 ohms per square. So a higher sheet
12 resistance means lower doping, so I wouldn't want
13 to exclude the possibility that Granek has
14 experimented with samples having a lower doping
15 concentration than 3.8×10^{18} per cubic centimeter.
16

17 Q Can you turn, please, to Table 7-5 of
18 Granek?

19 A Yes.

20 Q Table 7-5 shows the efficiency of the
21 various solar cells that Granek fabricated, right?

22 A Yes.

1 Q And Table 7-5 shows that the solar cell
2 FSF 2, which has a front surface field doping
3 concentration of 4 times 10^{20} has an
4 efficiency of 18.0 percent, correct?

5 A Yes.

6 Q The solar cell FSF 5, which has a front
7 surface field doping concentration of 3.8 times 10^{20}
8 to the 18^{th} has an efficiency of 20.8 percent,
9 correct?

10 A Correct.

11 Q Decreasing the front surface field doping
12 concentration further increased the efficiency of
13 the solar cell, correct?

14 A It may be a correct statement, but I would
15 like to caution, because FSF 2 has an error
16 function doping profile, and sample FSF 5 has a
17 Gaussian doping profile.

18 Q In Figure 7-1 of Granek, for solar cells
19 with passivated -- with well-passivated front
20 surfaces, the efficiency of the solar cell
21 increases as the front surface field doping
22 concentration is reduced from 1 times 10^{20} to the

1 21st to 1 times 10 to the 18th, correct?

2 A Can I hear the question again?

3 Q Focusing on Figure 7.1 of Granek, for
4 solar cells with well-passivated front surfaces,
5 the efficiency of the solar cell increases as the
6 front surface field doping concentration is
7 reduced from 1 times 10 to the 21st to 1 times 10
8 to the 18th, right?

9 A No. I wouldn't see it that way, and I'm
10 happy to explain.

11 Q For solar cells with well-passivated front
12 surfaces, the efficiency of the solar cell with a
13 front surface field doping concentration of 1
14 times 10 to the 18th, is higher than 1 times 10 to
15 the 19th, correct?

16 A No. The two curves are very close. They
17 are most likely within the error bar, so no clear
18 winner can be called.

19 Q Can you look, please, at Figure 7 -- well,
20 strike that.

21 Where do you see error bars in Figure 7.1?

22 A Well, every result has an error bar. I am

1 not aware of any result that does not carry an
2 error bar.

3 Q Okay. But where in Figure 7-1 do you see
4 error bars?

5 A There is an error bar associated with the
6 result of a calculation, if the calculation has so
7 many parameters as what we have here.

8 Q Does Figure 7-1 depict an error bar?

9 A It's not drawn in the graph, but it is
10 unavoidable when doing a calculation or a
11 simulation or a theoretical analysis that has
12 certain input parameters that are not known with
13 arbitrary precision.

14 Q An error bar is something that is visual,
15 correct?

16 A It has a justifiable background. You can
17 see it if you draw it into the figure.

18 Q There's no error bar drawn in Figure 7-1,
19 correct?

20 A A simulation has associated error bars,
21 and if two simulated curves are very close, at
22 some point, a POSITA would understand that the

1 difference is so small that it's within the error
2 bar.

3 ATTORNEY SELWYN: I move to strike as
4 non-responsive.

5 (Schubert Deposition Exhibit 15 marked for
6 identification and attached to the transcript.)

7 BY ATTORNEY SELWYN:

8 Q Let me hand you what I've marked as
9 Exhibit 15, which is a copy of the Lamers
10 reference, which is also Maxeon Exhibit 2002.

11 You've studied that reference, correct?

12 A Yes.

13 Q Would you turn to Page 2 under the
14 heading 3.1, front service field optimization.

15 Do you see that it states, quote: The
16 function of the front surface is to reduce the
17 recombination at the front side, and improve
18 lateral transport. Recombination in the FSF
19 should be minimal, and the optimal doping level
20 was found to be 3.10×10^{18} atoms per
21 centimeters squared, right?

22 A Yes.

1 Q Lamers teaches that for this FSF design
2 with optimal doping level of 3 times 10 to the
3 18th centimeters squared, the FSF has two
4 functions; first, to reduce the recombination of
5 the front side; and second, to improve lateral
6 transport, correct?

7 A Yes.

8 Q What is lateral transport?

9 A A solar cell has electrical contacts,
10 in/out and CAT/out contacts, that are laterally
11 displaced, and carriers need to flow laterally to
12 reach their respective contact.

13 Q Lamers then states, quote: Improved
14 lateral transport by the FSF becomes increasingly
15 important for larger pitches and higher base
16 resistivity.

17 Do you see that?

18 A I do.

19 Q Can you explain why improved lateral
20 transport by the FSF is increasingly important for
21 larger pitches and higher base resistivity?

22 A Sure.

1 Larger pitches means that the contacts are
2 separated by a greater distance. If the contacts
3 are separated by a greater distance, the distances
4 traveled by the charge carriers are greater. For
5 this reason, lateral transport becomes more
6 important when the contact pitches increase. A
7 similar argument can be made for the substrate
8 resistivity.

9 Q Then Lamers states, quote: For this, the
10 optimal resistance was found to be 150 ohms per
11 square for the FSF. These specification indicate
12 that the FSF profile should be deep, close to 1
13 micrometer, in order to fabricate this by
14 diffusion and industrial process, and long process
15 time is required, which is undesired.

16 Did I read that right?

17 A Yes.

18 Q Lamers teaches that for this FSF design
19 with optimal doping level of 3 times 10^{18} to the
20 10^{18} th, the FSF profile should be deep, close to 1
21 micrometer, correct?

22 A The statement relates to the lateral

1 transport. So Lamers states that if we want
2 larger pitches, then the FSF profile should be
3 deeper.

4 Q Lamers states that fabricating this deep
5 FSF profile is -- strike that.

6 Lamers states that fabricating this deep
7 FSF profile, quote: In an industrial process
8 requires a long process time, which is undesired,
9 correct?

10 A Yes.

11 Q Lamers teaches that an FSF without the
12 lateral transport function can have, quote:
13 Moderate to low bulk resistances and small
14 pitches, correct?

15 A If less transport, less lateral transport
16 is required, then the depth can be shallower.

17 Q Lamers teaches that an FSF without the
18 lateral transport function should have a lightly
19 doped shallow FSF, with a high resistance in
20 combination with good surface passivation to
21 achieve the highest cell output, correct?

22 A Yes.

1 Q Lamers cites to the Granek reference for
2 disclosing a lightly doped and shallow FSF with a
3 high resistance in combination with good surface
4 passivation will give the highest cell output,
5 correct?

6 A Yes. With lightly doped, referring to 3
7 times 10 to the 18th per cubic centimeter.

8 (Schubert Deposition Exhibit 16 marked for
9 identification and attached to the transcript.)

10 Q Let me hand you what I've marked as
11 Exhibit 16, which is also Maxeon Exhibit 2003.

12 This is the Desa reference, correct?

13 A Correct.

14 Q And Desa evaluated P-type screen printed
15 interdigitated back contact silicon solar cells,
16 correct?

17 A Yes.

18 Q Desa used two-dimensional modeling
19 simulations to study solar cell performance,
20 correct?

21 A Yes.

22 Q The Desa reference doesn't contain any

1 experimental results, correct?

2 A The first sentence of the abstract refers
3 to the fabrication of solar cells.

4 Q I'm sorry. What's the answer to my
5 question?

6 A Based on my understanding, you asked if
7 Desa relates to simulations, and my answer was
8 yes.

9 But if you look at the first sentence of
10 the abstract, that sentence relates to
11 fabrication. It is not non-simulation, but
12 fabrication of solar cells.

13 ATTORNEY SELWYN: Okay. I move to strike.
14 That was not my question.

15 BY ATTORNEY SELWYN:

16 Q The Desa reference does not contain any
17 experimental results, correct?

18 A The first sentence reports an experimental
19 result of greater than 20 percent efficiency for
20 an IBC solar cell.

21 Q He's not describing they're his
22 experimental results, correct?

1 A Well, I'm not sure if I agree. Look, what
2 Desa writes about is a fabricated solar cell with
3 an efficiency exceeding 20 percent.

4 Now, this is the abstract of this
5 publication. And Desa, D-e-s-a, does not
6 reference a source for the 20 percent.

7 Accordingly, it would be reasonable to assume
8 that the 20 percent are Desa's results.

9 Q Do you believe that, sir?

10 A Yes.

11 Q You believe that 20 percent, Desa is
12 describing his own results; that's your testimony?

13 A That's what the abstract says.

14 Q Okay.

15 A The abstract says: IBC solar cells has
16 been routinely fabricated with efficiencies
17 exceeding 20 percent.

18 Q Did Desa fabricate any solar cells
19 himself?

20 A That's what the abstract says.

21 Q The abstract says that Desa fabricated
22 solar cells himself; that's your testimony?

1 A If it was produced by another literature
2 source, it would be normal custom to refer to that
3 literature source. If I write a publication and I
4 say that 20 percent efficiencies have been
5 achieved, I would speak for myself. And if it's
6 somebody else's 20 percent, I would reference that
7 other literature source. But here, I do not see
8 another literature source.

9 Q Where in the body of Desa does he say that
10 he fabricated solar cells?

11 A See, if you go to the first page, last --
12 very last paragraph, the objective of this paper
13 is to investigate the potential of screen printed
14 IBC solar cells, so they're talking about screen
15 printed IBC.

16 Now, screen printing is a fabrication
17 method. Why would they talk about a fabrication
18 method if there is no fabrication?

19 Q Okay. Let's go to the last page, Table 1.

20 Table 1 shows the solar cell parameters
21 used for Desa simulations for screen printed IBC
22 solar cells, correct?

1 A Yes.

2 Q And the first row shows Desa used a P-type
3 wafer, correct?

4 A Correct.

5 Q The second row says that Desa used a front
6 surface field floating junction, correct?

7 A Correct.

8 Q What is a floating junction?

9 A A floating junction is a junction where
10 one of the two regions electrically floats, that
11 is, it is not at a fixed potential.

12 Q For a floating junction, a P-N junction is
13 formed at the front side of the solar cell,
14 correct?

15 ATTORNEY SNODGRASS: Objection to form.

16 A A floating junction can be in the back
17 side or the front side. I'm not sure if I
18 understand the question you're asking me. But
19 floating junction is not directly related to a
20 front surface field.

21 Q Well, I'm asking about the location of the
22 P-N junction. Okay?

1 You'd agree that a floating junction forms
2 a P-N junction, correct?

3 ATTORNEY SNODGRASS: Objection to form.

4 A Not always. Junctions can be N-N
5 junctions, or P-N junctions.

6 Q You dispute that a floating junction forms
7 a P-N junction?

8 A I'm saying that the word junction can
9 refer to a P-N junction, but it also can refer to
10 an N-N junction. I'm happy to have a closer look
11 at what is being discussed here.

12 Q You'd agree that a floating junction
13 includes a P-N junction, correct?

14 A It can. It's a possibility, absolutely.

15 Q And a P-N junction is formed at the front
16 side of the solar cell for a front -- for a
17 floating junction, correct?

18 A I'm not following you. I -- as I said
19 earlier, a junction can be a P-N junction, but
20 it's not limited to a P-N junction. There are N-N
21 junctions as well.

22 Q Are you saying that a front surface field

1 could have a doping type that differs from the
2 substrate?

3 A We need to look at the specific
4 configuration.

5 Q So you're saying that's possible?

6 A I'm not exactly sure if I understand the
7 configuration that you have in mind, and so I need
8 to understand the configuration that you have in
9 mind in order to answer your question.

10 Q I'm asking about what you have in mind,
11 sir. Are you saying that there is a configuration
12 whereby a front surface field could have a doping
13 type that differs from the substrate?

14 A If we look at Table 1, we see that the
15 wafer is a P-type wafer, but the dopant is not
16 disclosed. But we can envision that the P-type
17 wafer is boron-doped.

18 Table 1 also discloses a front surface
19 field, and the dopant is identified as
20 phosphorous. Accordingly, the dopant of the
21 substrate would be different from the dopant of
22 the front surface field.

1 Q Are you saying that a floating junction is
2 a type of front surface field?

3 A A floating junction is a junction in which
4 one of the two sides is not connected to -- an
5 electrical potential is not connected to a
6 terminal. And accordingly, that side of the
7 junction is free to move up and down in electrical
8 potential, and that is being referred to as a
9 floating junction.

10 Q So is that floating junction a type of
11 front surface field?

12 A I would say a front surface field can
13 include a floating junction.

14 Q And in a front surface field, a high/low
15 junction is formed at the front side of the solar
16 cell, correct?

17 A A front surface field is formed at the
18 light incident, light incidence side of the wafer.
19 And you can refer to this as the front side, if
20 you wish.

21 Q My question is different.

22 In a front surface field, a high/low

1 junction is formed at the front side of the solar
2 cell, correct?

3 A Yes.

4 Q In a front surface field, the front
5 surface of the substrate and the rest of the
6 substrate have the same type of doping polarity,
7 correct?

8 A Yes. That's a possibility.

9 Q Phosphorus is an N-type dopant, correct?

10 A Yes.

11 Q Desa's front surface field floating
12 junction has the opposite doping polarity as
13 Desa's wafer, correct?

14 A Yes. Phosphorous.

15 (Schubert Deposition Exhibit 17 marked for
16 identification and attached to the transcript.)

17 Q Let me hand you what I've marked as
18 Exhibit 17, which is also Hanwha Exhibit 1040.

19 Do you recognize this as the Procel --
20 P-r-o-c-e-l -- reference?

21 A Yes.

22 Q And if you look, please, at the abstract,

1 do you see that the abstract indicates that Procel
2 used two-dimensional simulations rather than
3 three-dimensional simulations?

4 A Yes.

5 Q Procel doesn't contain any experimental
6 results, correct?

7 A Yes.

8 ATTORNEY SELWYN: Why don't we take a
9 short break? I'm going to wrap things up.

10 (Recess from 4:19 p.m. until 4:27 p.m.)

11 BY ATTORNEY SELWYN:

12 Q Can you turn, sir, please, back to the
13 '315 patent, Exhibit 2?

14 If you turn, please, to Column 4, Line 63?

15 Do you see that it says: In an
16 embodiment, the dopant region 216 can have
17 positive or negative type dopants?

18 A Yes.

19 Q And that's an indication that the dopant
20 region can be doped with N or P-type dopants,
21 correct?

22 A Yes.

1 Q Then at Column 5, Line 64, the '315 patent
2 states that, quote: In an embodiment, the heating
3 can drive the dopants from the dopant region 216
4 to a portion 206 of the silicon substrate 202.

5 Do you see that?

6 A Yes.

7 Q That indicates that the portion of the
8 substrate can be doped with N or P-type dopants,
9 correct?

10 A Are you referring to the Column 4
11 statement, or are you referring to the Column 5
12 statement?

13 Q The Column 5, Line 64 statement that I
14 just read to you.

15 A The column 5 statement does not have --

16 Q The -- finish.

17 A -- does not disclose any polarity of the
18 dopants.

19 Q The Column 5 statement that I just read to
20 you, in combination with the Column 4 statement,
21 indicates that the portion of substrate can be
22 doped with N or P-type dopants, correct?

1 A Yeah. That's what it appears like.

2 Q Then continuing on in Column 5, Line 67,
3 the patent says, quote: In an example, the dopant
4 concentration of the portion 206 of the silicon
5 substrate can be approximately less than or equal
6 to 2 times 10 to the 18th per cubic centimeter.

7 Do you see that?

8 A Yes.

9 Q The '315 patent discloses a single dopant
10 concentration to the portion 206 of the silicon
11 substrate 202, correct?

12 A What you refer me to discloses a specific
13 doping concentration 2E 18.

14 Q The '315 patent doesn't disclose different
15 appropriate doping levels for N and P-type
16 dopants, correct?

17 A Well, we have a range here, less than or
18 equal to 2E 18.

19 Q What are you referring to?

20 A Of Column 6, lines -- Line 2.

21 Q The '315 patent doesn't disclose any
22 adjustment of the doping concentration to achieve

1 similar results for N and P-type dopants, correct?

2 A I would say that there is room for
3 adjustments, because what is written here is
4 Column 6, Lines 1 and 2, approximately less than
5 or equal to 2×10^{18} .

6 Q But the '315 patent doesn't describe or
7 disclose any adjustment of the doping
8 concentration to achieve similar results for N and
9 P-type dopants, correct?

10 A I think that the '315 patent refers to
11 details in the implementation of the patented
12 technology. And if we look at Column 3, Line 12,
13 the patent states: It will be apparent to one
14 skilled in the art that embodiments of the present
15 disclosure may be practiced without the specific
16 details.

17 So you know, the description, the way I
18 understand this sentence, is that the description
19 is not exhaustive, but that one skilled in the art
20 would be able to practice the invention as it is
21 described in the present disclosure.

22 Q Is that your full answer?

1 A That is my answer, yes.

2 ATTORNEY SELWYN: I think I'm at time.

3 Thank you, sir.

4 ATTORNEY SNODGRASS: I have no questions.

5 (The deposition of E. FRED SCHUBERT, Ph.D.
6 was adjourned at 4:37 p.m.)

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1 CERTIFICATE OF SHORTHAND REPORTER - NOTARY PUBLIC

2 I, Kadi A. Harmon, Certified Reporter and
3 Notary Public within and for the State of New York
4 do hereby certify:

5 That E. Fred Schubert, Ph.D., the witness whose
6 deposition is hereinbefore set forth, was duly
7 sworn by me before the commencement of such
8 deposition and that such deposition was taken
9 before me and is a true record of the testimony
10 given by such witness.

11 I further certify that the adverse party,
12 Maxeon Solar PTE. Ltd., was represented by counsel
13 at the deposition.

14 I further certify that the deposition of
15 E. Fred Schubert, Ph.D., occurred at the offices
16 of Regus on Tuesday, the 15th day of July, 2025
17 commencing at 8:30 a.m. to 4:37 p.m.

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

1 the outcome of this matter.

2 IN WITNESS WHEREOF, I have hereunto set my hand
3 this 25th day of July, 2025.

4

5 My commission expires:

6 December 18, 2026

7

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11 STATE OF NEW YORK

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