UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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HANWHA SOLUTIONS CORPORATION,

Petitioner,

v.

MAXEON SOLAR PTE, LTD.,

Patent Owner

Case Nos.:

IPR 2024-01199,

IPR 2024-01203

U.S. Patent Nos.:

8,878,053,

8,222,516

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Deposition of DOUGLAS S. RUBY, Ph.D.
Conducted In person
Thursday, July 31, 2025
9:29 a.m. EDT
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Reported by: Christine J. Roybal, RPR, CCR, CSR

HANWHA v. MAXEON
IPR2024-01203
HANWHA 1075

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I N D E X

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(On the record at 9:29 a.m.)

July 31, 2025

Dr. Douglas Ruby, Ph.D.

DOUGLAS S. RUBY, PH.D.,

was called as a witness and, having been first duly sworn, was examined and testified as follows:

MR. SELWYN: Yes, for the petitioner, my name is Mark Selwyn of WilmerHale. With me today is Gilbert Smolenski, David Cavanaugh, and on the phone Bobby Hampton.

MS. ZHAO: Jang Zhao for PV Law for Maxeon.

EXAMINATION

BY MR. SELWYN :

Q. Good morning, sir.

A. Good morning.

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

A. Douglas Scott Ruby.

Q. Dr. Ruby, have you ever been known by any other names?

A. No.

Q. By whom are you employed?

A. Self-employed.
Q. What is the name of your firm?
A. Douglas Ruby, Ph.D.
Q. What is your current business address?
A. Say again.
Q. What is your current business address.
A. Address, 9040 Wind Caves Way, Albuquerque.
Q. Do you understand you're under oath today?
A. I do understand.
Q. Do you understand that you must give complete honest and responsive answers to my questions just as if you were in a courtroom?
A. Yes, I do.
Q. Is there any reason you can't provide your best testimony here today?
A. No reason.
Q. Have you ever been deposed before?
A. Yes.
Q. How many times, sir?
A. At least twice.
Q. What matters were those?
A. One was a few months ago, same patent, defending

against, I guess, litigation from Canadian Solar. And then last week different clients involving Trina Solar.

Q. Who are the parties to the matter that you were deposed in last week?

A. I was working for a firm hired by Trina Solar, and they were in litigation with a firm -- I can't remember right now who it was.

Q. Was that also an IPR?

A. It was an ITC case, International Trade Commission.

Q. Thank you.

Have you ever testified at trial before?

A. Yes.

Q. How many times?

A. Once.

Q. What was that matter?

A. Sorry?

Q. What was that matter?

A. That matter was a patent infringement case where I was hired by a firm defending Jinko Solar against Hanwha Solar.

Q. Was that an ITC matter?

A. No. That was a patent infringement case in Australia.

Q. And when did you testify?

A. September 2022.

Q. You are providing testimony for this matter supporting Maxeon, the patent owner, and to inter partes review proceedings; is that right?

A. Two, yes.

Q. You submitted two declarations supporting Maxeon's patent owner responses, correct?

A. Two declarations. Oh, you mean one for each patent? Yes, that's right.

Q. One of your declarations concerns U.S. Patent No. 8,222,516.

A. '516. Yes.

Q. Can we refer to that today as the '516 Patent?

A. Yes.

Q. And your other declaration concerns U.S. Patent No. 8,878,053?

A. '053, correct.

Q. And can we refer to that as the '053 Patent today?

A. Yes, you may.

Q. Tell us what you did to prepare for today's deposition.

A. I met with the law firm's representative here yesterday.

Q. For how long?

A. Maybe four hours.

Q. Did you do anything else to prepare for today's deposition?

A. Yes. I reread my declarations.

Q. In preparing for today's deposition, did you review any documents that are not cited in your declarations?

A. No.

Q. When did you first learn about the existence of the IPR proceedings against the '516 and '053 Patents filed by Hanwha Solutions?

A. Sometime early this year, maybe. I don't remember. February, March.

Q. How did you learn?

A. Oh, I was contacted by an intermediary who connects law firms with expert witnesses and I was interviewed and accepted.

Q. Are you aware that Maxeon has sued Hanwha Solutions and Hanwha Energy in district court?

A. Yes, I am.

Q. And when did you learn about the existence of the district court case?

A. It would have been some time after February or March of this year.

Q. How did you learn?

A. The law firm informed me.

Q. Other than the conversation that you have had with Maxeon's lawyers, have you talked to anyone about the lawsuit or about the IPR proceedings?

A. No.

Q. How did you come to be engaged in this matter?

A. Well, as I said, a intermediary firm whose job it is to connect experts with law firms sought me out and conducted a telephone interview and then forwarded my resume to the law firm.

Q. Before you were retained were you told that counsel was interested in you providing an opinion that supported the validity of the '516 and the '053 patents?

A. Before I was retained?

Q. Yes.
A. Before I was retained I was told nothing.
Q. When you were retained were you told that counsel was interested in you providing an opinion that supported the validity of the '516 and '053 patents?
A. Yes.
Q. How many hours have you worked on this matter to date?
A. To date?
Q. To date, yes.
A. I don't have that information available to me, but maybe 20 hours.
Q. All right. I'm handing you U.S. Patent No. 8,222,516 as Exhibit 1001 from IPR 2024-1203. Do you have that before you?
(Exhibit 1001 marked.)
A. Yes, I do.
Q. (BY MR. SELWYN) Were you aware of the '516 Patent before you were retained for this matter?
A. No, I wasn't.
Q. Were you aware of the '053 Patent before you were retained for this matter?

A. No, I wasn't.

Q. Were you aware of any patents in the same family as the '516 or '053 patents before you were retained for this matter?

A. What do you mean by "the same family"?

Q. Same patent family related to the '516 or '053 such as continuations.

A. No, I wasn't aware of any other patents related to this.

Q. Do you see that the named vetter on the '516 Patent is Peter John Cousins?

A. Yes, I see that.

Q. Had you heard of Peter John Cousins before you were retained for this matter?

A. I have heard his name mentioned.

Q. In what context?

A. As he was a researcher at SunPower Corporation.

Q. Had you heard anything else about Peter John Cousins before you were retained for this matter?

A. No.

Q. Had you heard anything about the reputation of Peter John Cousins before you were retained for this matter?

A. Well, I believe I had heard that he had a good reputation.

Q. When did you first read the '516 Patent?

A. When the law firm gave it to me.

Q. And that was in the February/March 2025 time frame; is that right?

A. Approximately.

Q. Did you read it in its entirety?

A. Yes, I did.

Q. And have you read it since you first read it?

A. I have read portions of it over again.

Q. How many times have you read it in its entirety?

A. In its entirety, probably once.

Q. Is there anything in the '516 Patent that you do not understand?

A. No.

Q. How long did you spend reading the '516 Patent?

A. An hour.

Q. And to date, how much time have you spent reading the '516 Patent, or is that an hour?

A. An hour-and-a-half.

Q. Thank you.

I'm now handing you U.S. Patent 8,878,053 as Exhibit 1001 from IPR 2024-01199.

(Exhibit 1001 marked.)

Q. (BY MR. SELWYN) Do you have that before you?

A. Yes, I do.

Q. When did you first read the '053 Patent?

A. It would have been same time frame, probably in the spring of this year.

Q. And how many times have you read the '053 Patent?

A. In its entirety, probably just once.

Q. And how much time have you spent to date reviewing the '053 Patent?

A. Probably an hour-and-a-half.

Q. Is there anything in the '053 Patent that you do not understand?

A. No.

Q. I'm going to hand you a copy of your declaration with the '516 matter, which is Exhibit 2027. Do you have that before you?

(Exhibit 2027 marked.)

A. Yes, I do.

Q. (BY MR. SELWYN) And this is the declaration you

submitted regarding the '516 Patent, correct?

A. Yes, it is.

Q. If you'd turn to, please sir, to Paragraph 1.

A. Okay.

Q. At the end of Paragraph 1 you say, "This declaration sets forth the opinions that I have reached to date regarding these matters." Do you see that?

A. Yes.

Q. Does this declaration provide your complete opinion regarding the '516 Patent?

A. Yes, it does.

Q. Would you describe for us, please, the process by which the declaration was prepared.

A. Well, I was asked to provide a background section on the relevant technology in this matter, which I did. And then the law firm drafted some sections on various matters in dispute regarding the patent. And I reviewed those drafts and edited them to make sure that all the statements were true and correct. And the edits went back and forth a few times with the law firm and then when we were all in agreement I signed it.

Q. How many hours did you spend preparing this

declaration?

A. Ten, approximately.

Q. And approximately how much time did you spend preparing your declaration regarding the '053 Patent?

A. Maybe another ten.

Q. When you say that you prepared the background sections, looking at the table of contents, can you identify the ones you're referring to?

A. Well, Section 6 entitled Background of the patent and related technology, Sections A through G.

Q. Thank you. Let me now hand you, please, Exhibit 2027 from IPR 2024-01199.

(Exhibit 2027 marked.)

Q. (BY MR. SELWYN) Which is your declaration regarding the '053 Patent. Do you have that before you?

A. Yes, I do.

Q. Did you file the same process in preparing your declaration for the '053 Patent as you described a moment ago for the '516 Patent?

A. Yes, I did.

Q. Have you conducted any experiments in connection with your work on these IPRs?

A. No.

Q. Let me now hand you Exhibit 2028 from IPR 2024-1203.

(Exhibit 2028 marked.)

Q. (BY MR. SELWYN) Is this a copy of your CV, sir?

A. Yes.

Q. Is it accurate?

A. Yes, it is.

Q. Do you see on the first page in front of the heading disclosure, it indicates that you were retained as an expert for Jinko Solar opposite Hanwha?

A. Where do you see that?

Q. About two-thirds down the first page.

A. Disclosure. Dr. Ruby was retained as an expert for Jinko Solar opposed to Hanwha. Yes.

Q. Can you describe what your work in that matter involved.

A. Well, Jinko Solar had been sued by Hanwha for patent infringement, and my work involved studying the device structure that Jinko Solar fabricated for use in its solar cells, and comparing that with the patent that was owned by Hanwha, and discussing the differences which I saw

in the Jinko product and the Hanwha Patent.

Q. Did you study any Hanwha products as part of your work in that matter?

A. No.

Q. Have you ever studied any Hanwha products?

A. No.

Q. Are you aware of any Hanwha products?

A. Not really.

Q. Do you know anything about the design of any Hanwha products?

A. No.

Q. On Page 4 of your CV you have a client list; is that right?

A. Page 4, list of clients. Yes.

Q. And your clients include SunPower Corporation.

A. Right.

Q. Is that the same SunPower that's listed as the applicant to the '053 and '516 patents?

A. Yes, it is.

Q. When did you work for SunPower?

A. Well, over the course of several years, probably between 2010 and 2015.

Q. And what was the nature of the work that you did for them?

A. Well, I authored a short course, a three-day course on the science and technology of photovoltaic cells, and I presented that course at the SunPower factory location in the Philippines.

Q. When was that?

A. As I said, sometime between 2010 and 2015.

Q. Did you do any other work for SunPower over that period of time?

A. No.

Q. Approximately how many hours of time did you bill SunPower for?

A. Well, it was a three-day course, I provided it four times, so 12 days.

Q. And have you listed on your CV all the times you've testified before a court?

A. I believe so. I believe there was only that one time in Australia.

Q. Thank you.

Approximately how much did you charge SunPower for the work that you performed for them?

A. I don't recall.

Q. Can you give us any estimate?

A. I don't recall.

Q. All right. Let me -- I will mark as our next Exhibit 1071, which is a document bearing the title video conference deposition of Douglas Ruby, Ph.D. for Case No. IPR 2024-1039 and case No. IPR 2024-1040. Do you have that before you?

(Exhibit 1071 marked.)

A. Yeah, I do.

Q. (BY MR. SELWYN) You gave a deposition on June 24th in two IPRs that were filed by Canadian Solar, correct?

A. Yes, that's right.

Q. Those IPRs also challenged the '516 and '053 patents, correct?

A. Yes, they did.

Q. And this is the transcript from your deposition of those IPRs?

A. That's what you allege it to be, yes.

Q. And you testified truthfully in that deposition, correct?

A. Yes.

Q. You had a chance to review your deposition transcript and make corrections after the deposition, correct?

A. No, I didn't. This is the first time I'm seeing it.

Q. Okay. Do you stand by all the answers you gave in response to the questions you were asked in that deposition?

A. Yes, I do.

Q. I ask you to put back in front of you your CV, please.

A. Okay.

Q. And can you turn, please, to Page 7.

A. Yes.

Q. Do you see on Page 7 you have listed various references?

A. Yes.

Q. One of the references is somebody named Dick Swanson; is that right?

A. Yes, that's right.

Q. Is Dr. Swanson an experienced solar cell scientist?

A. Yes, he is.

Q. Is he well known in the field?

A. Yes, he is.

Q. Do you consider Dr. Swanson's writing and scholarship in the solar field to be well researched and reliable?

A. Yes, I do.

Q. How long have you known Dr. Swanson?

A. Probably since about 1986.

Q. How did you come to know him?

A. Well, at the time, I was a member of the technical staff at Sandia National Laboratories here in Albuquerque in the Photovoltaic Cell Research Division. And at that time, we provided funding and expertise to several contract winners who received contracts through Sandia from the Department of Energy. And one of them was to Dick Swanson when he was a professor at Stanford University, performing research in his lab on new solar cell designs. And we did a lot of the measurement and testing of his solar cell products.

Q. Is Dr. Swanson well known in the solar field?

A. Dr. Swanson is the father of the photovoltaic

industry.

Q. He's actually considered one of the pioneers; is that fair?

A. Yes.

Q. Have you ever spoken with Dr. Swanson about these IPRs or about the '516 or '053 Patent?

A. No, I have not.

Q. I~-- I apologize if I'm mispronouncing -- Ajeet Rohatgi.

A. Ajeet Rohatgi.

Q. Rohatgi. He's also a reference; is that right?

A. Yes.

Q. And who is he?

A. Well, when I worked with him he was professor of electrical engineering at Georgia Tech.

Q. Is Dr. Rohatgi an experienced solar cell scientist?

A. Yes.

Q. Is he well known in the field?

A. Yes, he is.

Q. And he founded a solar cell company?

A. Apparently so, yes. Suniva, Incorporated.

Q. Do you consider Dr. Rohatgi's writing and scholarship in the solar field to be well researched and reliable?

A. Yes, I do.

Q. For how long have you known him?

A. Probably also since the 1980s.

Q. Do you know Peter Borden?

A. Not really, no. I don't think so.

Q. Let me ask you a few other names, see if you know them. Li Xudong, X-U-D-O-N-G?

A. No.

Q. How about Li Hai-ling, H-A-I-L-I-N-G?

A. No.

Q. Ju Ying, Y-I-N-G?

A. No.

Q. Song Shuang, S-H-U-A-N-G?

A. No.

Q. Hen Yang, Y-A-N-G.

A. No.

Q. Do you know Armin Froitzheim, F-R-O-I-T-Z-H-E-I-M?

A. No.

Q. Do you know Adolf Munzer, M-U-N-Z-E-R?

A. No.
Q. Do you know Jon Yewgan, J-O-N Y-E-W-G-A-N?
A. No.
Q. If you'll put back in front of you, please sir, your declaration.
A. Which one?
Q. For the '516.
And if you turn, please sir, to Paragraph 3.
A. Yes.
Q. You list your qualifications, right?
A. Yes.
Q. And this includes a summary of your qualifications and professional experience?
A. Yes.
Q. And in Paragraph 6 you discuss your university degrees.
A. Yes.
Q. And I see you received a Bachelor of Science in physics, a Master's Degree in semiconductor physics and your Ph.D. is in semiconductor physics; is that right?
A. Yes, it is.
Q. Were your studies in semiconductor physics

relevant to solar cells?

A. Not directly, no.

Q. Were they, indirectly?

A. Well, they involved semiconductors, and solar cells are made out of semiconductors.

Q. Does semiconductor physics include solar cells?

A. Yes.

Q. Are solar cells a type of semiconductor device?

A. Yes.

Q. And in your studies described in Paragraph 6 did you take any classes on solar cells specifically?

A. Not specifically, no.

Q. Do principles applicable generally to semiconductors often apply to solar cells?

A. Yes.

Q. Can you explain why?

A. As I said, solar cells are made using semiconductors, so the principles of semiconductor physics which apply to all semiconductor devices also apply to solar cells.

Q. Is a transistor a semiconductor device?

A. Yes.

Q. Did you study transistors during your education and schooling?

A. To some extent, yes.

Q. Can you describe how?

A. Well, they were discussed in courses that I took on semiconductor device physics in general. And they were one example of a semiconductor device.

Q. You worked at Sandia National Labs from 1985 to 2008; is that right?

A. Yes.

Q. How did you come to be hired by Sandia?

A. Well, I knew that they were one of the few domestic research laboratories involved in photovoltaics research, which is the area that I wanted to pursue my career in. So I called them and sent in an application, was interviewed and was hired.

Q. And would you describe for us what Sandia National Laboratories is?

A. It is a federally funded research laboratory that receives funds from U.S. Department of Energy to pursue research in many areas. And up until recently, one of them was photovoltaics.

Q. Has it ended?

A. My understanding is the budget for next year is zero.

Q. Did Sandia do any work related to solar cells while you were a member of its technical staff from 1985 to 2008?

A. Yes.

Q. At a high-level, what work did it do?

A. We pursued research to design and develop new architectures for solar cells and new processes to achieve those architectures in the hope of increasing the efficiency and reducing the cost or photovoltaic technology.

Q. So Sandia was doing research and design for solar cells between 1985 and 2008?

A. Well, certainly between 1985 and 2004. My laboratory was closed by the DOE in 2000, and I managed to continue doing research on my own until about 2004. And after that, I believe solar cell research at Sandia was suspended.

Q. Okay. But for a period of 19, 20 years or so, Sandia was doing research and design of solar cells; is that right?

A. Yes.

Q. And what was your contribution at a high-level to that work?

A. Well, I developed processes to introduce new materials and structures and solar cell architecture at the atomic level in order to improve the performance and reduce the cost.

Q. Did you do any manufacturing of solar cells as part of your work?

A. No.

Q. Did you sell any solar cells as part of your work?

A. No.

Q. Okay. Are you proud of the research and design work that you did on solar cells during that two-decade period?

A. Yes.

Q. Was Sandia respected in the solar cell industry during the time that you worked there?

A. I believe they were, yes.

Q. And did Sandia publish papers, articles, and the like related to solar cell design between 1985 and 2008?

A. Yes, many.

Q. Do you consider the publications and articles by Sandia during that period of time to be reliable?

A. Yes, I do.

Q. And you contributed to many of those articles, right?

A. Yes, I did.

Q. How big was the team that you worked on at Sandia working on solar cells?

A. There were several teams involved in different aspects of photovoltaic technology. In the team devoted to silicon solar cell device, design, and fabrication, at one time there may have been ten or 2012 people involved. And at other times, maybe seven people until the lab was finally closed down.

Q. And how big was the budget for the work that you and your team did?

A. I would say close to a million dollars per year.

Q. Can I ask you some questions about the work that you did there?

A. Yeah, sure.

Q. During your time at Sandia did you ever face design trade-offs when developing solar cells?

A. Yes.

Q. What types of design trade-offs did you face?

A. Well, for example, when I was designing a new passivation layer for silicon solar cells I had to trade off surface passivation against transmissivity of the layer.

Q. Did you ever face a trade-off between solar cell efficiency on the one hand that reduced cost on the other?

A. I would say we always geared our designs for both increased efficiency and reduced cost.

Q. Why?

A. Because they are both important.

Q. What was the passivation layer made of, of the cell that you just described a moment ago?

A. Various compositions of silicon nitride.

Q. May I ask what compositions.

A. They had varying ratios of silicon and nitrogen.

Q. Did you ever face a design trade-off where a feature added benefits to certain aspect of a cell but was disadvantageous for other reasons?

A. Say that again.

Q. Sure. Did you ever face a trade-off where a feature added benefits to some aspects of a cell, but was

disadvantageous for some other reason?

A. Well, it depends whose opinion you're referring to. When I was involved in silicon nitride work there were people who told me it could never be commercially acceptable because it was a vacuumed process, and therefore, in their mind, too costly. On the other hand, now, it is universally accepted and everybody uses silicon nitride surface passivation.

Q. So you turned out to be right?

A. I did.

Q. Was processing temperature ever a design trade-off you faced?

A. There was a variable in our experiments.

Q. How so?

A. Well, deposition at different temperatures resulted in different degrees of passivation and different refractive indices.

Q. So did you ever change processing temperature because it improved one aspect of a cell even if it had a negative effect on another?

A. I don't believe it ever had a negative effect.

Q. During your time at Sandia did you work on solar

cells with a rear PN-junction?

A. No.

Q. During your time at Sandia did you work on solar cells with tunnel oxide?

A. No.

Q. During your time at Sandia did you work on solar cells with front-surface texturing?

A. Yes.

Q. What work did you do regarding solar cells with a front-surface texturing?

A. Well, I was part of a group that worked on a process to develop front-surface texturing in one of several ways.

Q. Tell me about that, what you did.

A. Well, I personally worked on a technique known as reactive ion etching, typically known by the acronym RIE, to use a plasma process to texture the front surface of a solar cell.

Q. Were there any other aspects of texturing that you were working on?

A. There were others in my group who worked on wet chemical etches for silicon texturing.

Q. Plasma removes material from the surface of the cell, correct?

A. Yes, it does. Well, plasma etching does. Plasma deposition adds material.

Q. Plasma etching removes material from the surface of the cell, correct?

A. Yes.

Q. Did you or others at Sandia design and build a solar cell having front-surface texturing?

A. Yes.

Q. And did you publish any papers describing a solar cell with front-surface texturing?

A. Yes, I did.

Q. What papers did you publish?

A. Well, it should be listed in my CV under RIE texture silicon solar cells or plasma textured.

Q. What was your motivation at the time for studying front-surface texturing?

A. Well, at the time, solar cells made of silicon were made using either monocrystalline silicon wafers or multicrystalline silicon wafers, and for the case on multicrystalline silicon, there was no cost-effective wet

chemical etch that could provide texturing. So I investigated this plasma texturing process to develop a texturing method for multicrystalline silicon solar cells.

Q. Were any of the front-surface texturing techniques that you developed ever commercialized?

A. Well, I can't be certain.

Q. During your time at Sandia did you work on solar cells with the anti-reflection coating?

A. Yes.

Q. What work did you do regarding solar cells with the anti-reflection coating?

A. Well, silicon nitride, as I mentioned before serves a dual purpose providing not only surface passivation, but also acting as an anti-reflection coating.

Q. What partic- -- what particular aspects of anti-reflection coating were you working on?

A. I was working on providing a silicon nitride layer with the optimum refractive index to produce minimum reflection.

Q. Did you work on methods of making anti-reflection coating?

A. I worked on exploring the parameter space for

silicon nitride deposition in the plasma chamber, for the purpose of providing both surface passivation and anti-reflection coatings.

Q. Did you study the features that an ideal anti-reflection coating should have?

A. Did you say "ideal"?

Q. Yes.

A. I knew about those features.

Q. How did you know about them?

A. I studied them in several of my classes, and they were very well known.

Q. Your classes where?

A. University of Illinois.

Q. And while at Sandia did you ever design a solar cell having the anti-reflection coating?

A. Yes.

Q. Would you describe that solar cell?

A. It was a solar cell having a front-end junction with an RIE textured front surface and a silicon nitride layer on top of that surface, providing both passivation and anti-reflection.

Q. Did you or others at Sandia publish any papers or

articles describe that solar cell?

A. Yes.

Q. What articles? Are they listed in your CV?

A. Yeah, they are listed in my list of technical publications.

Q. Do you remember any of the titles?

A. Want me to look it up?

Q. If it helps, sure.

A. Well, should I list all of them.

Q. Sure.

A. Okay.

Q. Are there a lot?

A. There are many.

Q. Why don't you give us some examples, then.

A. Well, there's one here, authors D.S. Ruby, Wilbanks and Fleddermann, A Statistical Analysis of the Effect of (PECVD) Deposition Parameters on Surface and Bulk Retermination in Silicon Solar Cells, at the First World Conference on Photovoltaic Energy Conversion, in Waikoloa, Hawaii.

Q. How about another example?

A. Okay. Here is one by Ruby, Wilbanks, Fleddermann

and Rosenblum, Roncin and Narayanon, Optimization of Plasma Deposition and Etching Processes for Commercial Multicrystalline Silicon Solar Cells, Conference Record of the 25th Photovoltaic Specialist Conference, Washington D.C., May, 1996.

Q. Thank you. What did you believe at the time anti-reflection coating could provide?

A. Well, it is well known that anti-reflection coatings increase the amount of light that is transmitted into the solar cell.

Q. How is that beneficial?

A. The increased amount of light that's absorbed then generates a higher concentration of mobile carriers in the silicon.

Q. Was anti-reflection coating a feature of many solar cells at the time that you were working at Sandia?

A. Yes.

Q. Did you -- during your time at Sandia, did you work on solar cells with metal contacts?

A. Yes.

Q. What work did you do regarding solar cells and metal contacts while you were at Sandia?

A. All of the solar cells I made at Sandia used metal contacts.

Q. Why?

A. Because that's the only way to extract the electric current out of the solar cell.

Q. Were there particular aspects of metal contacts that you studied while at Sandia?

A. Not really.

Q. Did you ever work on screen printing while at Sandia?

A. No.

Q. Are you familiar with the phrase "firing through"?

A. Yes, I am.

Q. What does that mean?

A. That means depositing a metal paste on the surface of a solar cell which may have an anti-reflection coating on it, and then heating that solar cell to a relatively high temperature so the metal paste is able to react with and essentially remove the underlying film until it reaches the surface of the silicon where it makes contact, electrical contact with the silicon substrate.

Q. Were you aware of screen printing during your time

at Sandia?

A. Yes.

Q. And were you aware of firing through for screen printing while at Sandia?

A. Yes.

Q. How did you become aware of screen printing?

A. Well, I worked with many solar cell manufacturers. At that time, there were quite a few in the United States, and that was the commercial method used by manufacturers because it is very high throughput.

Q. How did you become aware of firing through for screen printing?

A. By having discussions with those individuals at the solar cell companies who were using it as a technique for mass producing solar cells.

Q. And that was during your time at Sandia; is that right?

A. Yes.

Q. Were you aware of solar cells with tunnel oxide while you were at Sandia?

A. No.

Q. During your time at Sandia did you work on solar

cells with an N-type substrate?

A. Did I personally?

Q. Let's start there.

A. Well, as I mentioned, we measured some cells from SunPower at Stanford previously, fabricated by Dick Swanson and his company which used N-type substrates.

Q. So during your time at Sandia you were aware of solar cells with an N-type substrate?

A. Yes.

Q. How did you become aware?

A. By working with SunPower.

Q. When was that?

A. Starting around 1986.

Q. Did you do any -- strike that.

Did you or your colleagues at Sandia do any work on solar cells with an N-type substrate?

A. In my laboratory we did not fabricate any solar cells on N-type substrates.

Q. How about other laboratories at Sandia?

A. I don't believe there were any.

Q. What work did you do with SunPower while at Sandia involving solar cells with an N-type substrate?

A. Measurement, and to some extent modeling, computer modeling of the performance of his N-type solar cells.

Q. Did that work involve commercialized solar cells?

A. I think at that stage it was primarily a research project.

Q. Were there any publications that came out of that work?

A. I'm sure there were.

Q. Did -- during your time at Sandia did you work on solar cells with a P-type emitter?

A. P-type emitter, no.

Q. Do you know what a P-type emitter is?

A. Yes.

Q. What is it?

A. It is a region of the device which has high concentration of acceptor ions, and therefore contributes many free holes to conduction and the holes are positively charged, which is why we call it P-type.

Q. When did you first become aware of solar cells with a P-type emitter?

A. Can't tell you exactly when.

Q. During your time at Sandia?

A. Yes.

Q. How did you become aware?

A. Reading the publications of solar cell researchers globally.

Q. Were solar cells with a P-type emitter well known during your time at Sandia?

A. I would say they became more and more well known over the course of time.

Q. Over the course of your time at Sandia?

A. Yes.

Q. During your time at Sandia, did you work on solar cells with a Polysilicon Emitter?

A. Did I, personally?

Q. Let's start there.

A. No.

Q. Did any anyone else at Sandia?

A. Not that I know of.

Q. While you were at Sandia, were you aware of solar cells with a Polysilicon Emitter?

A. I had heard that Professor Swanson and his research group were doing research on Polysilicon Emitters.

Q. What is a Polysilicon Emitter?

A. It is an emitter region of a solar cell characterized by its crystalline structure being many microscopic crystals of silicon.

Q. During your time at Sandia were there published articles regarding research on solar cells with a Polysilicon Emitter?

A. From whom?

Q. From anyone.

A. There may have been articles by Dick Swanson and his group.

Q. During your time at Sandia did you work on solar cells with a trench cutting?

A. Not personally, but there were colleagues of mine who I believe used laser trench cutting to isolate various regions of a solar cell from one another.

Q. And did they publish any articles about that?

A. They would have, yeah.

Q. What benefits did that type of trench cutting provide?

A. Well, if you were using a fabrication process that involved dopants that wrapped around from the backside of a cell to the front side, then you needed to provide some way

of preventing those regions from being electrically contacted to one another.

Q. When did you first become aware of solar cells with trench cutting?

A. Sometime when I was at Sandia.

Q. What is a dopant?

A. A dopant is a chemical additive introduced to silicon at a high temperature such that it replaces some silicon atoms buried.

Q. What is the purpose of adding in dopants?

A. The purpose is to provide in a certain region either an excess of electrons or holes which are the absence of free electrons.

Q. Were trench cuttings common features of many solar cells at the time you were working at Sandia?

A. I believe they were common in some commercial manufacturing lines.

Q. During the time -- strike that.

During your time at Sandia did you ever work on dopant diffusion processes?

A. Yes.

Q. What is dopant diffusion?

A. Dopant diffusion is introducing these dopant atoms, usually -- well, as -- by providing a dopant source, and then sending that wafer through a high-temperature furnace where those dopants were then able to diffuse into the silicon and create a doped region.

Q. When did you first become aware of dopant diffusion processes?

A. Way back during my studies at University of Illinois.

Q. Why were you and others at Sandia studying dopant diffusion?

A. Why?

Q. Yes.

A. Because the dopant diffusion profile is an important parameter affecting the solar cell efficiency and performance.

Q. Did you first learn that at the University of Illinois?

A. Do you mean regarding solar cells?

Q. Regarding semiconductors.

A. Well, a dopant diffusion profile is important for many semiconductor devices.

Q. Is that something you learned at the University of Illinois?

A. Yes.

Q. Did you or your colleagues at Sandia, while you were there, ever study the affect of time and temperature on dopant diffusion?

A. Yes.

Q. Can you describe that, please?

A. Well, a physical law of diffusion involves several parameters, two of which are time spent at an elevated temperature.

Q. What did Sandia study about the affects of time and temperature on dopant diffusion?

A. Sandia studied the dopant concentration profile, in particular, a maximum concentration at the surface and the depth of the diffused region into the silicon substrate.

Q. And that's work that occurred while you were at Sandia?

A. Yes.

Q. Did you participate in it?

A. I was peripherally involved.

Q. Were Sandia scientists, during the time that you

were there, regularly adjusting the time and temperature parameters of dopant diffusion processes in order to optimize a given process for making a solar cell?

A. We developed a process that optimized those doping profile parameters for optimum solar cell performance.

Q. What was that process?

A. That process was a diffusion process followed by an in-situ oxidation.

Q. Did Sandia publish articles about that work?

A. Yes.

Q. During your time at Sandia did you ever work on solar cells made with an in-situ diffusion process?

A. That's the one I just mentioned.

Q. What is an in-situ diffusion process?

A. It would be a process where you do, you can conduct multiple operations without removing the wafers from the furnace.

Q. When did you first become aware of the in-situ diffusion processes?

A. Well, I don't know if I first became aware of it then, but certainly during the proc- -- the experimentation, it should be recorded here in my CV. Like, for example

here, 1994 Schubert, et al., A Simple Single Photo Mass Process for Fabrication of High Efficiency Multicrystalline Silicon Solar Cells, also presented at Waikoloa, Hawaii.

Q. What benefits did you and your colleagues at Sandia believe an in-situ diffusion process would provide?

A. Well, in this case, it allowed us to adjust a doping profile to provide the optimum surface concentration and diffusion depth.

Q. Did in-situ diffusion also have the benefit of decreasing fabrication costs?

A. It probably would.

Q. Why?

A. Because it was a process that combined the benefits of two processes previously performed separately.

Q. What were those two processes?

A. One was a drive-in diffusions and the other was an oxidation.

Q. During your time at Sandia did you work on solar cells made with an atmospheric pressure chemical vapor deposition?

A. Yes.

Q. Or APCVD process?

A. Yes.

Q. What work did you do?

A. I use APCVD for deposition of silicon oxide layers.

Q. Okay. And what is APCVD?

A. It is a process, that atmospheric pressure whereby certain sources are heated and evaporate, and therefore deposit those materials on a substrate that's placed in front of those sources.

Q. When did you first learn of APCVD?

A. Let's see. I think I wrote a paper on it. I wrote a paper in 1992 Douglas Ruby and Jules Levine, Low Temperature Emitter Passivation for Silicon Solar Cells, presented at the European Photovoltaic Solar Conference in Montreux, Switzerland in 1992.

Q. How does APCVD differ from other deposition processes?

A. Well, it is atmospheric pressure, for one thing.

Q. Any other differences?

A. It results in a different molecular structure of the deposited layer.

Q. Okay. When you were at Sandia, was Sandia using

APCVD for cells with metal contacts on front and rear sides?

A. Yes.

Q. Why?

A. It was a simple way to deposit a masking oxide.

Q. And did you or your colleagues publish about that?

A. Well, that paper I mentioned definitely mentions using APCVD with -- what did you say, metal contacts?

Q. Yeah. On the front and rear sides.

A. Yes.

Q. During your time at Sandia did you do any work involving transistors?

A. No.

Q. Were you aware, during your time at Sandia, of the relevance of transistors to solar cells?

A. There were some -- there was some relevance, and was aware of it.

Q. How did you become aware?

A. Reading scientific papers in scientific periodicals and attending conferences such as those I mentioned.

Q. While at Sandia or before, did you ever study tunnel oxides for transistors?

A. Tunnel oxides for transistors, no.

Q. During your time at Sandia did you work on solar cells with a front surface field?

A. Yes, front surface field.

Q. What is a front surface field?

A. Front surface field is an electric field at the front surface of a solar cell, usually provided by the deposition of a dielectric layer of some kind that has fixed positive charges so that it creates an electric field that would repel other positively charged and mobile carriers such as holes in semiconductors.

Q. When did you first become aware of solar cells with a front surface field?

A. Probably when I first started at Sandia.

Q. What work did you or your colleagues do while you were at Sandia regarding solar cells with a front surface field?

A. What work did we do?

Q. Yes.

A. Well, for example, the silicon nitride layers, I optimized. One of their purposes was to provide a front surface field.

Q. Did you design and build solar cells while at Sandia having a front surface field?

A. Yes.

Q. And did you publish papers while at Sandia describing a solar cell with a front surface field?

A. Yes.

Q. What benefits did you believe while at Sandia a front surface field would provide to a solar cell?

A. Improved performance and efficiency.

Q. And did you publish any papers about that?

A. Yes, I did.

Q. Are they on your CV?

A. Yes, they are.

Q. Would you give us an example, if you could. Are there many?

A. There were many.

Q. Just give us one example.

A. Okay. Here is one by Chen, Rohatgi, and myself, 1994, Silicon Surface and Bulk Defect Passivation by Low Temperature PECVD Oxides and Nitrides, at the same world conference on photovoltaic energy conversion in Waikoloa, Hawaii.

Q. During your time at Sandia did you ever study Jo.
A. Yes.
Q. What is Jo?
A. It is a symbol representing saturation current density.
Q. When did you first become aware of Jo?
A. When I first started at Sandia?
Q. How did you become aware?
A. It is a parameter in the equation that defines current flow in a PN-junction.
Q. Why were you studying Jo while you were at Sandia?
A. Because it is an important parameter that determines, among other things, solar cell efficiency.
Q. How does it do that?
A. It is a measure of the recombination that takes place in a solar cell which is undesirable, because any recombination detracts from the current voltage that can be extracted from a solar cell.
Q. In your work at Sandia did you try to minimize Jo?
A. Yes.
Q. Why?
A. Because by minimizing Jo you can maximize the

voltage produced by a solar cell.

Q. Did you publish anything about that while you were at Sandia?

A. Yes, I did. Yes.

Q. And that would be on your CV?

A. Yes, it would.

Q. How did you measure Jo during your work at Sandia?

A. We used a transient photoconductive decay method.

Q. Was that well known method to measure Jo at the time?

A. Yes.

Q. During your work at Sandia did you ever study Pc?

A. By Pc I assume you mean specific contact resistivity?

Q. Yes.

A. Yes.

Q. When did you become aware of Pc?

A. During my time at Sandia.

Q. What work did you do at Sandia to study Pc?

A. Can you repeat the question?

Q. What work did you do at Sandia regarding Pc?

A. Well, at one point we were making concentrator

solar cells, and in that case, the contact resistivity usually limits the performance of a cell, so we had to measure and be aware of the resistance in order to optimize the performance of the concentrator cells.

Q. In your work while at Sandia were you trying to minimize Pc?

A. Yes.

Q. Why?

A. To optimize the performance at high concentration.

Q. Did you publish anything regarding the work that you did while at Sandia regarding Pc?

A. I believe I did.

Q. That would be reflected on one or more of the articles in your CV?

A. Yeah.

Q. How did you measure Pc while at Sandia?

A. From the electrical performance of the solar cell at different solar intensity levels.

Q. Was that a well-known method at the time for measuring Pc?

A. Yes.

Q. Okay. So you started working at Sandia in 1985,

you left in 2008, right?

A. Yes.

Q. And over that period of time, that 23 or so years, did the solar cell industry improve its fabrication process and capabilities?

A. Yes.

Q. Just at a high-level, can you tell us how it improved?

A. Well, for one thing they adopted silicon nitride as an anti-reflection coating, resulting in improved surface passivation at the front of the solar cell, boosting performance significantly. There were many other improvements.

Q. Like what?

A. The development of ALD or atomic layer deposition of aluminum oxide, which, for the first time allowed the passivation of P-type surfaces on solar cells.

Q. Did diffusion techniques improve between 1985 and 2008?

A. Yes.

Q. What was the nature of the improvements?

A. Well, to some extent because of our work showing

what the optimum diffusion profile needed to look like, it became universally adopted by industry.

Q. Did techniques to form emitters improve between 1985 and 2008?

A. To improve emitters? In what way?

Q. In any way.

A. I'm sure they did.

Q. Can you give us some examples?

A. They probably improved the dopant profile.

Q. Any others?

A. Maybe they found ways to do it more cheaply.

Q. Were there improvements to the solar cell industry between 1985 and 2008 related to forming external oxide layers?

A. There were many methods developed to form external oxide layers.

Q. Could you --

A. Some of which were improvements, I suppose.

Q. Could you describe for us how techniques for forming external oxides improved from 1985 to 2008?

A. One example would be the plasma deposition of silicon oxides.

Q. In what way did that improve?

A. Well, it avoids the use of a high-temperature thermal oxidation.

Q. Were there improvements to forming tunnel oxide layers from 1985 to 2008?

A. I'm not really aware of that particular improvements.

Q. How much would you say Sandia was able to improve solar cell efficiency between 1985 and 2008?

A. Well, we fabricated, I personally fabricated the world's first 20 percent efficient solar cell on low-grade silicon.

Q. Can you describe the structure of that solar cell?

A. It is described completely in one of these papers. Let's see here. Basore, et al., Simplified High-efficiency Silicon Cell Processing, published in Solar Energy Materials and Solar Cells in 1994. And by D.S. Ruby, et al., Simplified Processing for 23 percent Efficient Silicon Concentrated Solar Cells, presented at the 23rd IEEE Photovoltaic Specialists Conference in 1993.

Q. Was quality control something that was important to you in your work while at Sandia in designing solar

cells?

A. Yes, of course.

Q. Why?

A. For reproducibility.

Q. How does it relate to reproducibility?

A. Well, you need to start with the same conditions in order to achieve the same results.

Q. Did quality control for solar fabrication improve from 1985 to 2008?

A. Quality control, where?

Q. In the solar industry.

A. I can't speak for the entire solar industry.

Q. Let me ask you about Sandia, then; were you better able to ensure consistent fabrication processes by the end of your time at Sandia as compared with when you started?

A. When we started we designed the lab for exemplary quality control from the very beginning.

Q. Did it improve over time?

A. We maintained it over time.

Q. All right. Can you put back in front of you your declaration, please?

THE WITNESS: I'm going to need to take a break

pretty soon.

MR. SELWYN: Now is a good time.

(Off the record, 10:48 a.m. to 10:55 a.m.)

Q. (BY MR. SELWYN) Would you mind putting back in front of you, your declarations for the '516 Patent, Exhibit 2027.

A. Yes.

Q. Paragraph 7 explains your work as a consultant, correct?

A. Yes, it does.

Q. Can you explain at a high-level how your work as a consultant differs from what you were doing at Sandia?

A. Well, at Sandia, we were designing and developing new solar cells in the hope that they would improve the technology available; whereas as a consultant, I work with manufacturers and other groups to improve the quality of their products.

Q. In Paragraph 7 you say that you work with PV cell manufacturers to improve their performance of their cell designs and fabrication processes.

A. Yes.

Q. And at Sandia you were also working to improve

performance for solar cell design and fabrication processes, right?

A. Yes.

Q. Was that a regular part of your work there?

A. Was it, at Sandia?

Q. Yes.

A. Yes.

Q. What do you mean by "performance"?

A. Efficiency.

Q. What criteria, in your experience, do PV cell manufacturers use to measure and improve performance?

A. Efficiency, short circuit current, open circuit voltage, and field factor.

Q. How, if at all, does performance of a solar cell design differ from solar cell efficiency?

A. Efficiency is an overall measure of solar cell performance.

Q. How did Sandia measure or improve performance of solar cells during the time that you were there?

A. By measuring cell performance efficiency.

Q. And would you agree it is desirable to improve solar cell efficiency?

A. Yes.

Q. Do PV cell manufacturers regularly ask you for your advice on how to improve performance?

A. As a consultant they did, yes.

Q. Fair to say that improving performance is important to the solar cell industry?

A. Yes, it is.

Q. Why is that?

A. Because you can get more electricity out of a solar cell if it has a higher efficiency.

Q. And when you are working at Sandia you were also trying to improve performance, correct?

A. Yes.

Q. You knew it was important, right?

A. Right.

Q. At a high-level, what steps do you typically take to try to help a PV cell manufacturer improve its performance?

A. Depends on the problems they are having.

Q. How so?

A. Well, they may be having a problem with recombination; they may be having a problem with

anti-reflection coatings. As a consultant I would tailor my advice to my clients based on the goals they wanted to achieve.

Q. Do you typically propose alternative cell designs or alternative fabrication processes to PV cell manufacturers to help them improve performance?

A. Well, that would depend on how, how much they were able to change their designs and procedures.

Q. Is one of the things that you have done as a consultant is propose alternative cell designs and fabrication processes to PV cell manufacturers to help them improve performance?

A. In some cases, yes.

Q. How do you identify alternative cell designs in fabrication processes?

A. Well, I would measure cell performance in certain ways and compare those with experimental -- well, with performance models, and use the differences to pinpoint areas where the cell could use some improvement.

Q. And when you do what you've just described, how do you determine whether an alternative would actually improve performance?

A. I would use the computer modeling to determine whether an improvement in a certain parameter, or change in a certain parameter would result in an improvement to performance.

Q. Why do you use computer modeling?

A. Because they use the semiconductor physics equations to determine the performance of solar cells.

Q. I think you gave a moment ago as an example of a potential problem recombination; is that right?

A. Recombination is a problem in solar cells.

Q. And in instances where that has been presented to you as a problem, what are the types of things that you have done to try to address it?

A. Well, depends where that recombination is taking place. And an analysis of cell performance using the computer models will help determine that. If you find a recombination is taking place in the bulk of the material, there are various methods you can use to try to reduce that recombination in that region. If the recombination is taking place at the surfaces or in the emitters, there are other processes you can use to try to reduce that recombination in those areas.

Q. When you were at Sandia were you aware of ways to address problems of recombination?

A. Yes.

Q. What ways were you aware of at that time?

A. Well, we introduced atomic hydrogen to reduce bulk recombination, and we used field effect layers to address surface recombination.

Q. If recombination is at the PN-junction, what do you do?

A. What you mean by "at the PN-junction"?

Q. According at the location of the PN-junction.

A. It may be because you have too high of a dope intensity. So in that case you might reduce the dope intensity.

Q. While you were at Sandia did you ever encounter the problem of recombination at the PN-junction?

A. No. Because we optimize our diffusion profiles to avoid that.

Q. In helping PV cell manufacturers to improve performance, do you ever consider technologies from semiconductor devices that are not solar cell?

A. Well, I personally didn't.

Q. How about in your work as a consultant?
A. I'm not aware if any of the procedures we used are common in the transistor industry.
Q. While you were at Sandia did you ever look to transistor technologies in seeking to improve cell design or fabrication processes?
A. No.
Q. And how about as a consultant?
A. No.
Q. At a high-level, how do you determine whether the improved PV cell performance is meaningful enough to recommend a change to a manufacturer?
A. Well, I would say that if the, if there were any increased costs involved with changing the process, how does that compare to the increased cost of producing the cell?
Q. How do you weigh those two things?
A. Well, you knew what the cost -- you know what the cost of electricity is, so an increase in efficiency has a monetary value.
Q. Are there any performance metrics that you consider?
A. What do you mean by that?

Q. Well, in determining whether improved cell performance is meaningful enough to recommend a change, are there any performance metrics that you would consider?

A. The question is very vague. I don't really understand what you mean.

Q. Let me try another one: Is there a goal for improved solar efficiency that you try to reach?

A. Generally speaking, an improvement of even one-tenth of a percent in efficiency is worthwhile.

Q. Now, that sounds small. Why is one-tenth of one percent a meaningful improvement?

A. Because when you're producing millions of solar cells a year it adds up to a lot more electricity.

Q. Back to Paragraph 7 of your declaration, you discuss, "working with PV cell manufacturers to reduce the cost of their cell designs and fabrication processes," right?

A. Right.

Q. Why have PV cell manufacturers asked you to help reduce the cost of their cell designs and fabrication processes?

A. Why?

Q. Yes.
A. Have they asked me?
Q. Yes.
A. You would have to ask them.
Q. Okay. What is their motivation in trying to reduce the cost of their cell designs and fabrication processes?
A. Because they are competing with other manufacturers who are also making solar cells, and generally, the lower the cost of electricity you can produce the more people will buy it.
Q. How common is it for your clients to ask you for advice on how to reduce costs?
A. I would say it is not as common as asking me how to improve performance.
Q. Would you still regard it as something that happens relatively frequently, that is, cell manufacturer will ask for advice on reducing costs?
A. No. I'm not a cost expert, I'm a physicist.
Q. Have you ever proposed alternative cost-effective cell designs and processes to your clients?
A. Alternative cost-effective processes and designs,

yes.

Q. In what instances?

A. Well, for example, working for one of my clients, I proposed use of a passivating layer and different dopant concentrations that would result in improved performance that potentially lower costs.

Q. How do you determine whether a reduction in cost is meaningful enough to recommend a change?

A. Again, as I said previously, any change that I recommend would be based on whether the change results in a ratio of improved performance, to change in cost that is greater than 1.

Q. And would you agree that for your PV cell manufacturer clients reducing costs is often an important call?

A. Well, it is an important call for them to maintain competitiveness with their competing manufacturers.

Q. And one way to do that would be by reducing costs?

A. That would be one way to do it, assuming you could maintain performance at the same time.

Q. In Paragraph 7 of your declaration you explain that your work involves, "using numerical modeling to

pinpoint sources of loss mechanisms and to determine technical requirements necessary for cost-effective PV cell and module performance"; do you see that?

A. Yes.

Q. Can you explain what numerical modeling is?

A. For example, I would use a computer program that's designed to predict the performance of solar cells based on the values of various parameters. And using that, I could determine which mechanisms were the main contributors to loss in performance. Then I could suggest methods based on my experience of procedures that might reduce those lost mechanisms.

Q. And the computer program that you're referring to, was that something that you've designed or is that an off-the-shelf product?

A. It is actually free software.

Q. What is it called?

A. PC1D, written by one of my collaborators, Paul Basore.

Q. So is that software that people like you can just download for free?

A. Yes.

Q. How long has that existed?

A. Certainly since 1985. And now I believe there are two- even three-dimensional models of that software.

Q. What I just read for you from Paragraph 7, you refer to "sources of loss mechanisms." What are sources of lost mechanisms?

A. Well, it would be essentially where the recombination is taking place.

Q. So one source of loss would include recombination; is that right?

A. Yes. Other sources could be ineffective anti-reflection, ineffective back-surface reflection. There are many, many reasons why you might be incurring losses.

Q. Is recombination one of the major sources of loss?

A. It is a major component.

Q. How, if at all, is modeling different from an experiment testing a physical solar cell?

A. Well, modeling predicts what the behavior would be given the values of the parameters you've chosen. Testing or measurement would be actually determining what those, what those various semiconductor properties are.

Q. Is modeling worthwhile to do even if you're not

testing a physical solar cell?

A. Yes. Modeling is always worthwhile to do.

Q. Have you ever conducted modeling on just a part of a solar cell?

A. Well, generally you do modeling of an entire solar cell but that includes studying the various parts that comprise it.

Q. Have you ever modeled just an emitter?

A. You can look at a solar cell with varying emitter parameters and see how that affects your overall performance.

Q. Is that something you've done?

A. I can't recall.

Q. What data do you typically consider in your models?

A. Well, as I said, we conduct measurements beforehand to determine certain properties of the semiconductor, such as conductance, reflectance, resistivity, dopants, diffusion profile, rear surface reflectance, and many others.

Q. Have you ever modeled Jo or Pc?

A. I would say I have modeled emitter -- let's see,

yeah, Jo from, from the emitter.

Q. How did you go about doing that?

A. How did I model emitter saturation current density?

Q. Exactly. How did you model emitter saturation current density Jo?

A. That would be one of the parameters that you could choose in the computer modeling program, and by varying it, you can see what affect that had on the overall performance.

Q. Did the computer program that you use allow you to do that as far back as 1985?

A. Yes.

Q. And have you ever modeled contact resistance Pc?

A. Not personally, no.

Q. Does the software that you've described allow you to model Pc?

A. It would.

Q. And has it allowed you to do that since 1985.

A. Yes.

Q. At Sandia did you use numerical modeling to pinpoint sources of lost mechanisms and to determine technical requirements necessary for cost-effective PV cell

and module performance?

A. Yes.

Q. How, if at all, did your modeling work at Sandia differ from what you do today?

A. Well, today, I don't do much modeling because all the American manufacturers are out of business. So I primarily work for law firms that are suing people over device designs and patents.

Q. Got it. Okay, going back to Paragraph 7 of your declaration, you state that your consulting work includes, "providing PV module array and system performance measurements in comparison with energy production model predictions"; do you see that?

A. Yeah.

Q. So just a line on what some of the terms that you're using mean. First, can you tell us, what is a PV module?

A. PV module is a glass encapsulated package, usually be with an aluminum frame in which many solar cells are connected electrically in a series so that it provides a definite amount of electrical output.

Q. What is an array?

A. An array would be a grouping of such PV modules all connected in a series and in parallel to provide a larger amount of electricity to the external world.

Q. And what is "a system" as you've used that word in Paragraph 7?

A. A PV system would include a PV array connected to, perhaps, an inverter which converts the direct current output of the PV modules into alternating current that's typically used in the electrical grid.

Q. Paragraph 7 you refer to "experiments," right?

A. Where?

Q. Maybe you're right.

In your work do you conduct experiments?

A. Which work?

Q. As a consultant.

A. Well, when I was hired by a company trying to improve their cell performance I asked them to try a few different variations of their process to see whether the results could be improved based on my numerical modeling.

Q. What data to you typically consider in experiments?

A. What data do I consider?

Q. Uh-huh.

A. Well, there's measured cell efficiency, there's measured reflectance, there are current voltage characteristics of the solar cell in the dark. That's data.

Q. When you were at Sandia, how did Jo factor into the analysis that you did in your experiments?

A. Well, Jo was a measure of recombination which I intended to minimize by varying, for example, the deposition parameters of depositing silicon nitride.

Q. When you were at Sandia, how did Pc factor into the analysis that you did in your experiments?

A. In those experiments not, not at all.

Q. While you were at Sandia did you ever measure Jo using just an emitter.

A. Yes.

Q. What was the goal of that work?

A. The goal of that work was to, we simply identified what the optimum parameters of the silicon nitride deposition would be to produce a low Jo emitter, and then subsequently, we could incorporate that into a complete solar cell.

Q. The device that you tested did not have a

PN-junction, correct?

A. It did have a PN-junction.

Q. Did you publish anything regarding the work that you just described?

A. Yes.

Q. Is the --

A. Many of the previous papers which I mentioned incorporate that method.

Q. While you were at Sandia did you provide PV module array and system performance measurements in comparison with energy production model predictions?

A. Yes.

Q. Okay. In Paragraph 8 of your declaration you state that you initiated and directed a graduate student's research program that resulted in several graduate student theses projects in solar cell fabrication processing to improve solar cell performance, right?

A. Yes.

Q. Would you describe the work that you did in that regard.

A. Well, that was a program that I did jointly with Professor Fleddermann at UNM, using his graduate students

and I think some PECVD equipment that he had there to explore the parameter space and the deposition parameter space so that we could achieve low G zeros in emitters.

Q. While at Sandia did you review thesis projects?

A. Review?

Q. Review.

A. Well, I directed his thesis project.

Q. And did that include reviewing thesis papers?

A. Well, we wrote a joint paper.

Q. Who is the "we"?

A. Well, I read it to you earlier, it was me, Fleddermann, and Wilbanks.

Q. Got it, okay.

Did you review graduate student thesis papers?

A. The only papers that I reviewed were the ones that I wrote with those graduate students as co-authors.

Q. Okay. So you were a co-author on theses papers of graduate students?

A. Right.

Q. How many?

A. I think there were two.

Q. Can you find which ones those were?

A. Let's take a look. Well, there was certainly, there's several with Ruby, Wilbanks, and Fleddermann and possibly other authors. And there was an earlier one here, Ruby, Fleddermann, and Roblevsky [phonetic].

Q. And were those papers also tendered by the graduate student in the fulfillment of their thesis requirement?

A. I assume they were listed among his achievements.

Q. So as the director for the graduate student research program is it fair to say that you had a view as to what would make a good thesis paper.

A. I was not the director of the program. Professor Fleddermann was the director of the program.

Q. You helped initiate the program?

A. Yes.

Q. Can you tell us just at a high-level, what are the qualities that make a good thesis paper in your view?

A. Doing something of value that's never been done before.

Q. Should a thesis follow the scientific method?

A. Yes.

Q. Should a thesis identify and describe an issue?

A. Yes.

Q. Should a thesis propose a hypothesis?

A. Yes.

Q. Should a thesis consider relevant prior work on an issue?

A. Right.

Q. Should a thesis test the hypothesis with theoretical principles?

A. Well, it should test the hypothesis with experimental results.

Q. Would a good thesis identify any issues or problems with the study and propose other areas for study?

A. Yes.

Q. In Paragraph 8 of your declaration you explain that you served as a subarea Chairman of 2000 IEEE PV Specialist Conference on Silicon Cell Processing?

A. Yes.

Q. Tell us a little bit about what that role entailed, if you would.

A. Well, it involved reviewing and organizing the review of several proposed papers that were invited -- not invited, but were submitted for presentation at this

specialists conference, and then organize the, essentially the voting on which papers should be accepted and which are rejected.

Q. Are you a member of the IEEE?

A. No.

Q. Would you agree that the IEEE is a well-known and distinguished professional organization?

A. Yes.

Q. It is the world's largest professional organization of engineers; is that right?

A. I don't know.

Q. Does the IEEE publish papers?

A. Yes.

Q. Have you published for the IEEE?

A. Yes.

Q. How many times have you published through the IEEE?

A. Many.

Q. How does one get a paper published by the IEEE?

A. Well, it could be presented at a conference, in which case it has to be approved by this session chairman and his session reviewers; or it can be submitted as a

scientific research paper, in which case, it has to be approved by peer reviewers.

Q. Are the IEEE papers that you've done all peer-reviewed?

A. The ones that were submitted to conference were, I guess you would say peer-reviewed by my colleagues at Sandia.

Q. The papers that IEEE publishes are generally peer-reviewed, correct?

A. Yes, 100 percent.

Q. They are all peer-reviewed, correct?

A. Yes.

Q. And just so we're clear on our terms here; what is peer review?

A. Peer review would be a review by other experts in the field who have knowledge of the subject matter and who are seen as distinguished members whose opinions can be valued and believed in.

Q. Have you ever done a peer review of a paper published by IEEE?

A. Yes.

Q. Have you relied upon IEEE papers as part of your

own research work?

A. Yes.

Q. Is the IEEE typically considered to be a reputable source?

A. Yes.

Q. Are IEEE publications regularly relied on in the PV industry?

A. Yes, they are.

Q. All right. Could you turn, please, to the background of the '516 Patent and related technology section in your declaration that starts on Page 14.

While you're getting there, if we could go off the record for one second.

(Off the record, 11:29 a.m. to 11:34 a.m.)

Q. (BY MR. SELWYN) All right, Dr. Ruby, would you put in front of you the section of your declaration entitled, "Background of '516 Patent and Related Technology," which begins on Page 14.

A. Yes.

Q. And starting at Paragraph 23, you have a section entitled "Theory of converting solar energy into electricity," correct?

A. Yes.

Q. I think you told us earlier that you did the first draft of that entire section; is that right?

A. Yes.

Q. And Paragraphs 23 through 27, describe general background information about the function of solar cells, right?

A. Yes.

Q. And would you agree that what you describe in Paragraphs 23 through 27 is prior art to the '516 and '053 patents?

A. Yes.

Q. When was the theory that you described in Paragraphs 23 through 27 developed?

A. I can't say exactly, but quite early. Maybe, maybe in the 1950s.

Q. You'd agree that the theory of converting solar energy into electricity that you describe from Paragraphs 23 through 27 isn't the claimed invention of the '516 or '053 patents, correct?

A. Right.

Q. And you'd agree that a person of ordinary skill in

the art in the '516 and '053 patents would have known the principles that you describe from Paragraphs 23 through 27 by February 2008, correct?

A. Yes.

Q. Now, Paragraph 25 you have a graphic, right?

A. Twenty-five.

Q. Page 16.

A. Oh, yes.

Q. Is that a graphic that you prepared?

A. Yes.

Q. Sir, if you'd please turn to Paragraph 28.

A. Yes.

Q. Paragraph 28 is below the section heading, "Doping," is that right?

A. Yes.

Q. And the doping principle that you describe in Paragraph 28 are prior art to the '516 and '053 patents, correct?

A. Yes.

Q. When were the doping principles that you describe in Paragraph 28 developed?

A. 1950s.

Q. The doping principles you describe in Paragraph 28 are not the invention claimed by the '516 or '053 patents, correct?

A. That's right.

Q. A person of ordinary skill in the art would have -- strike that.

A person of ordinary skill in the art of the '516 and '053 patents would have known how to dope silicon by 2008, correct?

A. Yes.

Q. Sir, if you'd turn, please, to Paragraph 29, which is in a section entitled "Annealing"?

A. Yes.

Q. The annealing process that you describe in Paragraph 29 is the also prior art to the '053 and '516 Patents, correct?

A. Yes.

Q. The annealing process you describe in Paragraph 29 is not the invention claimed in the '053 or '516 patents, correct?

A. That's right.

Q. And you'd agree that a person of ordinary skill in

the art in the '053 and '516 patents would have known how to anneal by 2008, correct?

A. Yes.

Q. And if you turn, please, to Paragraph 30, which is the start of the section entitled, "Solar cell structure." Do you see in Paragraph 30 you provide a diagram of a generic solar cell?

A. Yes.

Q. And the generic solar cell that you depict in Paragraph 30 was prior art to the '053 and '516 patents, correct?

A. Yes.

Q. The generic solar cell that you show in Paragraph 30 existed by 2008, correct?

A. Yes.

Q. A generic prior art solar cell as of 2008 had an emitter region, correct?

A. Yes.

Q. A generic solar -- strike that.

A generic prior art solar cell as of 2008 had a silicon substrate basic cell, correct?

A. Yes.

Q. And a generic prior art solar cell as of 2008 had an N++ NP++ region, correct?

A. Certain types of solar cells did.

Q. N++ and P++ regions are highly doped regions on the front and rear of the cell, correct?

A. In that diagram, yes.

Q. Is the N++ region a front surface field?

A. It is a selectively doped emitter region.

Q. And as shown in Paragraph 30, the figure in Paragraph 30 is the N++ region a front surface field?

A. It provides some small electric field. It is what is known as a high-low junction, and it does provide some degree of field effect passivation.

Q. Is the P++ region a back surface field?

A. Yes.

Q. A generic prior art solar cell as of 2008 had a front and rear metal -- strike that.

A generic prior art solar sell as of 2008 had front and rear metal contacts, correct?

A. Yes. Well, bifacially contacted cells did. There were some cells at that point that had all of their metal contacts on the rear sides. They were known as back contact

solar cells.

Q. A generic prior art cell as of 2008 had a PN-junction, correct?

A. Yes.

Q. The junction shown in the figure in Paragraph 30 is where the P-type layer and the N-type layer meet, correct?

A. Yes.

Q. The features shown on the generic prior art solar cell in Paragraph 30 would have been known by 2008, correct?

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

Q. Sure. The features that are shown on the generic prior art solar cell in Figure 30 of your declaration were known by 2008, correct?

A. Yes.

Q. And, sir, if you'd turn, please, to Paragraph 31, which is the start of a subsection entitled "Junctions." Do you see that?

A. Yes.

Q. And in Paragraphs 31 through 45 you describe technological principles for junctions, right?

A. Yes.

Q. And what you described in Paragraphs 31 through 45 is prior art to the '516 and '053 patents, correct?

A. Yes.

Q. What you described in Paragraphs 31 through 45 is not the invention claimed by the '516 or '053 patents, correct?

A. That's right.

Q. And you'd agree that by 2008, a person of ordinary skill in the art of '516 and '053 patents would have known of homojunctions, correct?

A. Homojunctions, yes.

Q. And by 2008, a person of ordinary skill in the art in the '516 and '053 patents would have known of heterojunctions, correct?

A. Yes, that's right.

Q. In your declarations for the '516 and '053 patents you didn't offer any construction of the word "junction," right?

A. Not that I recall.

Q. In your declarations for the '516 and '053 patents you didn't suggest any of the prior art that the petitioner relies on that fails to disclose a junction, correct?

A. Petitioner relies on, fails to disclose a junction. Prior art that petitioner relies on, such as what?

Q. Such as Weisheim [phonetic], Borden, or Li.

A. Oh, no. They do not fail to disclose a junction.

Q. They do disclose a junction?

A. They do disclose a junction.

Q. If polysilicon forms a back surface field with a substrate, that's also considered to be a backside junction, correct?

A. Say it again.

Q. Sure. If polysilicon forms a back surface field with the substrate, that's also considered a backside junction, correct?

A. Yes.

Q. Now, in Paragraph 46, you describe an emitter, right?

A. Yes.

Q. And you state that both in a semiconductor device the emitter is usually defined as the region which is doped to have the opposite majority carrier polarity compared to the substrate, right?

A. Yes.

Q. What do you mean there by "semiconductor device"?

A. Solar cells and transistors.

Q. A person of ordinary care skill in the art of the '516 and '053 patents as of 2008 would have understood a solar cell to be a type of semiconductor device, correct?

A. Yes.

Q. And what do you mean in that sentence by "usually defined"?

A. Well, most of the experts in the field would think of an emitter as the region of the device doped to have the opposite polarity compared to a substrate.

Q. And the POSITA in the '516/'053 patents would understand the word "emitter" that way; is that right?

A. Well, those particular patents use the word "emitter" in a more general sense.

Q. You state that the emitter is, "The region which is doped to have the opposite majority carrier polarity compared to the substrate." Correct?

A. I say that it is usually defined that way.

Q. Would you agree that the emitter is the region that forms the PN-junction with the substrate?

A. Not always.

Q. If the substrate is N-type, emitter would usually be defined as the P-type region, correct?

A. Usually.

Q. And if the substrate is P-type, the emitter would usually be defined as the N-type region, correct?

A. Usually, but not always.

Q. Now, in the last sentence of Paragraph 46 you state, "However, as in Claim 9 of the '516 patents the emitter can be a polysilicon layer on the backside of the substrate," correct?

A. Yes.

Q. And in that paragraph you just cite the patent claim as support for that statement, correct?

A. Yes.

Q. What is polysilicon?

A. Polysilicon is a material composed of silicon atoms which consists of many small single crystalline silicon grains all smashed together.

Q. In your declarations regarding the '516 and '053 IPRs you don't suggest that the Board should construe emitter, correct?

A. That the Board should construe emitter. What do you mean by that?

Q. Sure. You don't suggest that the Board should interpret the word "emitter," correct?

A. Interpret in what way?

Q. Well, are you familiar with the concept of claim construction?

A. Vaguely.

Q. What is your understanding of the claim construction process?

A. If a term is used in -- it defines what a term means in that particular legal situation.

Q. And in your declarations for the '516 and '053 patents you don't suggest that the Board should go through the claim construction process to construe "emitter," correct?

A. Well, unless I have laid it out somewhere else in my declaration, no.

Q. In your declarations regarding the '516 and '053 IPRs, you don't suggest that Froitzheim, Borden Li, or Gan fail to disclose an emitter, correct.

A. They do not fail to disclose an emitter.

Q. They do disclose an emitter, correct?
A. That's right.
Q. Now, turning back, if you would --
A. I don't know if they use that terminology for it.
Q. But they do disclose it, right?
A. I believe so.
Q. Turning back to the generic prior art solar cell graphic in Paragraph 30. Let me ask a little bit of something else.
Okay, let's skip ahead to Paragraph 51. Do you see the section entitled "Solar cell efficiency"?
A. Yes.
Q. And that section, Paragraphs 51 through 59 is all about solar cell efficiency, correct?
A. Yes.
Q. And what you describe in Paragraphs 51 through 59 is prior art to the '516 and '053 patents, correct?
A. Right.
Q. And in that section you describe both the overarching goal of the solar cell industry and how it is achieved, correct?
A. Yes.

Q. What you describe in Paragraph 51 as the overarching goal of the solar cell industry was the same as of 2008, correct?

A. Yes.

Q. And you'd agree that a person of ordinary skill in the art in the '516 and '053 patents as of 2008 would have known that the overarching -- overarching goal of the solar cell industry was to increase the efficiency of the solar cell, which is the ratio of electrical power output at the max power point to the photo power incident and the incoming summary, correct?

A. Yes.

Q. You also write in Paragraph 51 that the solar cell industries' overarching goal of increasing solar cell efficiency, "is achieved by maximizing light absorption, reducing photo carrier recombination to increase current voltage, and maintaining low electrical resistance within the cell." Correct?

A. Yes.

Q. And a person of ordinary skill in the art of the '516/'053 patents as of 2008 would have known that, correct?

A. Yes.

Q. Paragraphs 52 through 58 of your declaration describe recombination and passivation principles that a person of ordinary skill in the art of the '516 and '053 patents would have known as of 2008, correct?

A. Yes.

Q. And in Paragraph 53, you describe a measurement known as saturation current density or Jo, correct?

A. Yes.

Q. And that's the same Jo that's discussed in the Gan reference, right?

A. Yes.

Q. By 2008, a person of ordinary skill in the art in the '516 and '053 patents would have known about Jo, correct?

A. Yes.

Q. And by 2013, a person of ordinary skill in the art in the '516 and '053 patents would have known that, "the goal of effective solar cell design is to minimize recombination by maximizing carrier lifetimes and diffusion lengths, thereby keeping Jo low," correct?

A. That's right.

Q. And in Paragraph 54, Dr. Ruby, you discuss

recombination due to surface defects and impurities, right?

A. Yes.

Q. And you would agree that by 2008 a person of ordinary skill in the art in the '053 and '516 patents would have known recombination occurred due to surface defects, right?

A. Yes.

Q. And by 2008, a person of ordinary skill in the art would have known that, "effective solar cell design implements the invention and inclusion of critical features to reduce the amount of recombination occurring at surfaces, which is known as surface passivation"?

A. That's right.

Q. In Paragraphs 54 through 57 you discuss surfaces, right?

A. Yes.

Q. And does that discussion of surfaces include a solar cell's internal surfaces?

A. What do you mean by "internal surfaces"?

Q. Well, are you familiar with the internal surfaces of a solar cell versus the external surfaces?

A. Well, there's the surface of the substrate, there

is a surface of any deposited layers you put on the substrate.

Q. Would internal surfaces be the interfaces between layers?

A. Yes.

Q. Okay. So with that understanding, does your discussion of surfaces in Paragraphs 54 through 57 include a solar cell's internal surfaces?

A. Yes, I believe so.

Q. And by 2008 a person of ordinary skill in the art would have known that effective solar cell design implements the invention and inclusion of critical features to reduce the amount of recombination occurring at internal surfaces of the solar cell --

A. Yes.

Q. -- as well as external surfaces, correct?

A. Primarily at the interface between the silicon surface and any deposited layers.

Q. Turning to the subsection entitled, "Resistance," Paragraph 60.

A. Yes.

Q. Is that subsection you discuss serious resistance

in solar cells, right?

A. Yes.

Q. And by 2008 a person of ordinary skill in the art of the '516 and '053 patents would have known if the principles that are described in Paragraphs 60 through 67, correct?

A. Yes.

Q. And the principles that are described between Paragraph 60 and 67 are not the invention claimed by the '053 and '516 patents, correct?

A. Right.

Q. Would you look, sir, to Paragraph 62.

A. Okay.

Q. Do you see in Paragraph 62 you discuss an example trade-off commonly occurring in solar cell design?

A. Yes.

Q. Could you explain for us that trade-off, please?

A. Well, in the case of a solar cell that has front metal contacts, those metal contacts usually are not transparent, and therefore they reduce the amount of light that manages to -- that can be absorbed by the silicon; therefore, you would like to reduce that amount of metal

shading, but you can only reduce it so far, because if you reduce it too much, then you incur excessive series resistance, which is another loss mechanism.

Q. Would a person of ordinary skill in the art of the '516 and '053 patents have been familiar with the trade-off that you just described as of 2008?

A. Yes, right.

Q. In Paragraph 63 and 64 you discuss Pc, correct?

A. Yes.

Q. In Paragraph 63 you explain how Pc is commonly measured, correct?

A. Right.

Q. And you'd agree that by 2008 a person of ordinary skill in the art of the '516 and '053 patents would have known how to measure Pc as you described in Paragraph 63?

A. Yes.

Q. Do the measurements you mention in Paragraph 63 need to be completed on a full solar cell?

A. No.

Q. Why not?

A. Because they are the measurements to see what the electrical resistance is between metal contacts, and those

metal contacts don't need to be on a completed solar cell, they can be on a test structure.

Q. Would you agree that as of 2008, a person of ordinary skill in the art would have known that you could study Pc for solar cells by testing only a part of a fully built-out cell?

A. Yes.

Q. And that person of ordinary skill in the art would know that the results would still be useful to consider how the contact would perform in a full solar cell?

A. Yes.

Q. By 2008, was measuring Pc by testing only a part of a fully built-out solar cell a common practice?

A. Yes.

Q. And is the Pc that you discuss in Paragraph 63 the same Pc that's discussed in the Gan reference?

A. Yes.

Q. Which of the methods, if any, that you describe in Paragraph 63 did the Gan reference use?

A. I believe they used this transmission-line method.

Q. And then turning from Paragraph 64. By 2008, would a person of ordinary skill in the art of the '516 and

'053 patents have known that a high Pc results in excessive loss of power and lower efficiency?

A. Yes.

Q. In the last sentence of Paragraph 64 you describe, "several trade-offs and careful optimization." Do you see that?

A. Yes.

Q. Can you explain what trade-offs and optimization you're referring to there?

A. Well, I believe this follows from the previous sentence, which says that contact resistance is only one component of total series resistance, and that all those components need to be optimized simultaneously, along with allowing maximum light collection. And those various components needed to be optimized simultaneously to achieve the best result.

Q. By 2008, would a person of ordinary skill in the art of the '516 and '053 patents have known that minimizing Pc involved the types of trade-offs and careful optimization that you describe in Paragraph 64?

A. Yes.

Q. Can you turn, please, to the section entitled

tunnel oxides which starts at Paragraph 77.

A. Paragraph 77.

Q. Yes.

A. Okay.

Q. What you describe in the section entitled "tunnel oxides" from Paragraph 77 through 84 is prior art to the '516 and '053 patents, correct?

A. Yes.

Q. And by 2008, a person of ordinary skill in the art of the '516 and '053 patents would have known of what you describe in Paragraph 77 through 84, correct?

A. Yes.

Q. By 2008 a person of ordinary skill in the art of the '516 and '053 patents would have known that, "tunnel oxides are high quality silicon dioxide layers that are extremely thin about, 1.5 nanometers just about 3 atomic monolayers that cover the entire backside surface of the substrate," correct?

A. Yes.

Q. Do you see the discussion starting at Paragraph 80 that describes U.S. Patents Publication No. 2022/0142500 to Foglietti?

A. Yes, I do.

Q. And you explain in Paragraph 80 that although Foglietti relates to bipolar transistors, the tunneling mechanism it describes, also applies to solar cells. Do you see that?

A. Yeah, I do.

Q. Can you explain why that's so?

A. Because the tunneling mechanism is a property of semiconductor devices. And bipolar transistors and solar cells are semiconductor devices. So those properties would apply to both types of devices.

Q. By 2008, a person of ordinary skill in the art of the '516 and '053 patents would have known how to add a tunnel oxide to a transistor, correct?

A. Yes.

Q. And by 2008, a person of ordinary skill in the art of the '516 and '053 patents would have known how to add a tunnel oxide to a solar cell, correct?

A. I presume so, yes.

Q. Your declaration doesn't cite or identify any articles from before 2008 that suggest that tunnel oxides are incompatible with solar cells, correct?

A. They are not incompatible, no.
Q. They are compatible, correct?
A. They are compatible.
Q. And that was known by 2008, correct?
A. Yes.
Q. In Paragraph 85 of your declaration you describe a solar cell having, "a layer of polysilicon, heavily doped with N-type dopants is formed on the tunnel oxide." Correct?
A. Yes.
Q. That was a structure that was known by 2008, correct?
A. I would say it was not widely known.
Q. But it was known, correct?
A. Yes.
Q. By 2008, it was known that, "the combination of a tunnel oxide and doped polycrystalline silicon layer provides excellent passivation and carrier re- -- carrier selectivity on the N-type substrate." Correct?
A. Where do you see that?
Q. Paragraph 85.
A. Repeat the question, please.

Q. Of course. By 2008, it was known that the combination of a tunnel oxide and doped polycrystalline silicon layer provides excellent passivation and carrier selectivity on the N-type substrate, correct?

A. It was not widely known.

Q. But it was known, correct?

A. It was known by some.

Q. In fact, Gan teaches that, right?

A. That's what he was working to prove.

Q. I have marked as Exhibit 1072.

(Exhibit 1072 marked.)

Q. (BY MR. SELWYN) A document entitled "Sandia Report Fundamental Understanding and Developments of Low Cost High-efficiency Silicon Solar Cells." Do you have that before you?

A. Yes.

Q. Do you recognize that?

A. I recognize the authors.

Q. Do you recognize the document?

A. I don't remember the document, but I can see that's what it is.

Q. Who are the authors?

A. Rohatgi, Narasimha, Moschner, Ebong, Kamra, Krygowski, Doshi, Ristow, and Yelundur.

Q. A. Rohatgi is the individual listed on your CV's references?

A. Yes.

Q. And I think you told me before that you hold him in high regard?

A. Yes.

Q. These are all individuals with whom you worked with at Sandia?

A. They were individuals at Georgia Tech, with whom we had a research contract.

Q. Can you turn to the very last page which says "distribution"?

A. Yes.

Q. And look at the bottom right-hand corner.

A. Yes.

Q. Do you see there is a reference "0752 Doug Ruby 6219."

A. Yes.

Q. That's you, right?

A. Right.

Q. You said this was a paper that was distributed to you?

A. Yes.

Q. What was your role on the project?

A. Well, I was probably a technical monitor for some of it.

Q. If you could look please, sir, to Page 4-9.

A. Yes.

Q. Do you see that this indicates that you were the source of the data provided for this -- strike that.

Do you see that this page indicates that you were a source for the data included in this graph?

A. Yes, I was a source for the data.

Q. So it appears that this report relies, at least to some extent, on your data, right?

A. On measurements.

Q. How was this report prepared?

A. Well, the authors would have written it and I probably provided some review, maybe some minor editing. But it was essentially -- it was the result of the authors.

Q. Could you turn, please, to the abstract, which is on Page 5 of the exhibit.

A. My abstract. Roman numeral 5, or...

Q. That's a good question.

A. I see a table of contents.

Q. It is not in a commonplace vernacular, in my experience, but it seems to be on Page 5 of the document under the list of authors.

A. Okay.

Q. Do you see the abstract describes, "the overall objectives of the program"?

A. Yeah.

Q. And do you see the overall objectives include developing processes and designs that increase performance and lower costs?

A. Well, it says, "can improve yield, throughput, and performance and design on promising low cost materials." That's what I see.

Q. Turn with me to Page 1-2. If you look about halfway down the page there is a sentence that reads, "the stack also lowers the emitter saturation current density Jo) of 40 and 90" --

A. Ohms per square.

Q. -- "ohms per square," thank you, "emitters by a

factor of 3 in 10 respectively, compared to no passivation."

A. I see that.

Q. Do you understand that sentence?

A. Well, I need to look at the context in which it is used.

Q. Please.

A. So the stack lowers the emitter saturation current density compared to no passivation. Yes, I see that and I understand.

Q. How, if at all, does the Jo -- strike that.

The Jo that's described in that sentence that I just read for you is the same Jo discussed in your declaration and the same Jo in Gan, right?

A. This Jo is Jo E, which means that component of the saturation current density, which is due exclusively to the emitter region of the solar cell. It is referred to here at Jo E.

Q. Can you turn the page, please, to the section entitled "introduction."

A. Yes.

Q. Do you see that the paragraph on Page 1-3 discusses the importance of reducing costs for both the

solar cell module and individual solar cells?

A. Yes.

Q. Do you agree that at the time of this paper it was important to create processes that can significantly reduce the cell processing time and number of processing steps?

A. Yes.

Q. And can you look, please, at the second paragraph on Page 1-4.

A. Okay.

Q. Do you see that the first sentence in the paragraph says, "most manufacturers, in an attempt to reduce manufacturing costs use a minimal number of low cost processing steps"?

A. Yes.

Q. And you'd agree that that was true as of 2008, correct?

A. Yes.

Q. And it is still true, right?

A. Right. But your definition of a low-cost processing step may differ from someone else's.

Q. Okay. Let's skip ahead. Can you turn to Page 1-19.

A. Okay.

Q. Below that heading, 1.6, the first sentence states, "Silicon solar cell fabrication involves processing of emitter back surface fields that electric passivation and anti-reflection coatings, and front and back contact formation." Do you see that?

A. Yeah, I do.

Q. And you'd agree that all those features were well known by 2008, correct?

A. Yes, they were.

Q. Now skip ahead to Section -- strike that.

Turn next to Chapter 2, Page 2-1.

A. Okay.

Q. And do you see the title of Chapter 2 is, "Fabrication and characterization of gridded back cells, GBC"?

A. Yes.

Q. What is a gridded back cell?

A. Well, I would assume it is a back contact cell with a grid on the back, or a cell with a metal contact on the back comprised of grids.

Q. Can you look at the first paragraph on Page 2-2.

A. Yes.

Q. The first paragraph uses the phrase, "Screen-printed solar cells," do you see that?

A. Where?

Q. First sentence.

A. Yes.

Q. What is a screen-printed solar cell?

A. It is a solar cell where the metal contact regions are produced on the cell surface using screen printing techniques.

Q. And screen printing was a method of forming a metal contact using a paste?

A. Yes.

Q. Screen printing was known by 2008, correct?

A. Yes.

Q. And by 2008, screen printing was a common way to form metal contacts, correct?

A. In industry, yes.

Q. And, high-level, can you describe the steps of a typical screen printing process?

A. Well, a screen is placed over the solar cell and a metal paste is pushed through the screen to only lie on top

of areas of the cell defined by the pattern in the screen. Then that paste is dried in an oven at what I would call low temperature to remove the components that make it viscous to solidify, dry it out. And then it goes through a higher temperature step where the grid lines are, go through a chemical reaction such that they ultimately come into contact with the silicon surface and make an electrical contact with it.

Q. What does "firing through" mean in the context of screen printing?

A. Firing through means if there is a dielectric layer on the surface of the silicon cell, the process of heating the paste up to the elevated temperature promotes a chemical reaction with the dielectric layer, such that the dielectric layer is dissolved in those regions where they are in contact with the paste, and this allows the metal paste to transfer or to go through whatever layer is on the surface and make contact with the underlying silicon substrate.

Q. So the purpose of firing through is so the metal reaches the substrate or the emitter?

A. Yes.

Q. And that allows the metal to extract energy?
A. It allows the metal to conduct current from the silicon.
Q. What would a cross-sectional view of the solar cell look like after the firing-through process?
A. Well, in the region under the grid line the metal would be in direct contact with the silicon. In regions adjacent to that with no metal present, the previous dielectric layer would remain intact.
Q. After firing through does the metal completely etch through the anti-reflection or passivation coating?
A. Yes.
Q. The first paragraph on Page 2-2 of the Sandia report, Exhibit 1072, explains that, "In order for these devices to be highly efficient two important requirements must be met." Do you see that?
A. Yes.
Q. And it says the first is that the contact resistance Pc at the rear SP electrode must be low, right?
A. Yes.
Q. Can you explain how, if at all, the contact resistance, that is Pc, differ from the Pc discussed in your

declarations and Gan, or is it the same?

A. I believe it is the same.

Q. Now, could you turn, please, to the second paragraph on Page 2-4 which starts Section 2.1.1 "quantitative assessment of Pc for rear conductor paste."

A. Yes.

Q. The conductor paste that is discussed here is the paste used in screen printing to form the metal contacts, right?

A. Yes.

Q. And do you see that the second paragraph on 2-4 discusses, "A pure, a one paste" --

A. Aluminum paste.

Q. Okay. Let me start again, thank you.

The second paragraph on 2-4 discusses a pure aluminum paste and the second was --

A. Silver paste.

Q. Mixed with a small fraction of aluminum additive?

A. Yes.

Q. That means for the resulting first paste, the resulting metal contact would be aluminum, right?

A. Yes.

Q. And for the second paste the resulting contact with be silver with a small fraction of aluminum?

A. Yes.

Q. And silver pastes were known by 2008, correct?

A. Yes.

Q. Silver contacts made from screen printing were known by 2008, correct?

A. Yes.

Q. Why was silver used?

A. It has a lower resistivity.

Q. Could you turn, please, now to Page 6-2, which starts at Chapter 6, entitled "Development of front surface field aluminum back junction, n+-n-p+ screen printed cell on dendritic web silicon." D-E-N-D-R-I-T-I-C.

A. Which paragraph?

Q. Page 6-2, first paragraph.

A. Okay.

Q. Do you see that the first sentence on Page 26 says that The chapter discusses, "A new silicon solar cell structure that is fabricated in which the PN-junction is formed by alloying aluminum with N-type silicon and where the PN-junction is located at the back (non-illuminated)

surface of the cell"?

A. Yes, I see that.

Q. Can you describe that solar cell structure?

A. Give me a moment, please.

So this describes a structure in which the, the silicon is N-type and a P-type emitter in this case is formed on the backside of the cell simply by alloying the silicon with aluminum.

Q. Was this silver cell structure commercially sold as of the time of this report?

A. I don't know.

Q. Then it says in the third sentence on Page 6-2, "The most striking feature of the cell" --

A. Wait a minute. Third sentence.

Q. I'm sorry. Three lines from the bottom.

A. Three lines from the bottom of the page?

Q. Yes.

A. Okay.

Q. Three lines from the bottom of Page 6-2, which is the third sentence under 6.1.

A. Right.

Q. Do you see it says, "The most striking feature of

this cell is the aluminum alloy PN-junction on the back, non-illuminated side"?

A. Yes.

Q. So this is describing that the PN-junction was on the side away from the sun, correct?

A. Right.

Q. And the emitter was on the rear side, correct?

A. Yes.

Q. It says the cell also had, "A phosphorus doped layer."

A. Where? Last sentence?

Q. Last sentence carrying over to Page 6-3.

A. Go ahead.

Q. It says that the cell also had a phosphorus --

A. It doesn't say that. It just starts, "A phosphorus doped layer..."

Q. Fair enough. Let me just read the sentence, then. Do you see the sentence reading, "A phosphorus-doped layer which gives rise to a strong electric yield for effectively passivating a front surface leading to an N+ NP+ structure."

A. Yes.

Q. The substrate of the solar cell was N-type,

correct?

A. I believe so, yes.

Q. And the emitter of the solar cell was P-type?

A. Yes.

Q. And according to the first full sentence on 6-3, the cell had a silicon nitride anti-reflective coating?

A. Yes.

Q. And silicon nitride is also referred to as SiN.

A. Right.

Q. And "AR" means anti-reflection?

A. Yes.

Q. And according to that first full sentence on 6-3 the cell also had a solderable silver contacts as a grid on the front?

A. Yes.

Q. And that refers to the front side contacts?

A. Yes.

Q. And also, according to the first full sentence on 6-3, the cell also had, "Two stripes over the aluminum silicon eutectic metal on the back."

A. Yes.

Q. And that refers to the backside contacts?

A. Well, the stripes are the solderable of the backside contacts.

Q. Can you look at the second paragraph on Page 6-3, please.

A. Yes.

Q. You see that it discusses, "A comparison of a conventional silicon cell with a dendritic" --

A. Dendritic web.

Q. Thank you. "dendritic web silicon PhosTop cell."

A. Yes.

Q. And the comparison is discussed in the second paragraph on 6-3 and in Table 6-1, right?

A. Apparently so.

Q. And according to Table 6-1, the conventional cell had a P-type boron-doped substrate?

A. Yes.

Q. And the junction (dopants) of the conventional cell were phosphorus and boron?

A. Yes.

Q. And that would indicate that the emitter of the conventional cell was N-type phosphorus-doped, correct?

A. Yes.

Q. According to Table 6-1 the junction location for its conventional cell is on the front, correct?
A. Right.
Q. And that means that the conventional cell's emitter would have been on the front of the cell, correct?
A. Yes.
Q. Can you look again at the second paragraph on Page 6-3?
A. Okay.
Q. Do you see where it explains, "There are several potential advantages of the PhosTop cell over the conventional cell"?
A. I see where it says that.
Q. And it says one advantage described is that, "Moving the PN-junction" --
A. Wait a minute. Where is, where are you reading?
Q. Do you see the sentence, two sentences up in the first full paragraph on 6-3 that begins, "moving the PN-junction"?
A. Now I see it.
Q. Great. So it says, "Moving the PN-junction from the front of the cell to the back opens the possibility of

making the front diffuse layer thinner without fear of shunting." Correct?

A. Yes.

Q. And there, it is describing one of the advantages of the PhosTop cell over the conventional cell?

A. Right.

Q. What is shunting?

A. Apparently, that's what they believe.

Q. What is it? What is shunting?

A. Shunting would be unintentional conductive path from the front contact to the back contact.

Q. Do you see the last sentence on that paragraph says, "The prospect of enhancing a blue response of the cell in this way was recognized previously as fabricating cells with a P* PN* structure using the 100-micrometer thick wafers sawn from a 3-grain ingot."

A. I see where it says that.

Q. What is "blue response of the cell"?

A. The blue response is the portion of the spectral response of a cell in the blue region of the spectrum, essentially the short wavelength response.

Q. And why would enhancing the blue response of the

cell be an advantage?

A. You can increase the short circuit current that way.

Q. Do you see that the last paragraph on Page 6-3 begins, "A second advantage of the PhosTop cell is the existence of a strong front surface field"?

A. Yes.

Q. Why would a strong front surface field be considered an advantage?

A. Well, it would reduce front surface recombination.

Q. And the last paragraph on Page 6-3 explains this decreased recombination, correct?

A. Yes.

Q. Would you please turn to Page 6-5.

A. Yes.

Q. Do you see the sentence that begins on the bottom of Page 6-5 reading, "The dendritic web silicon PhosTop cell holds a third potential advantage over the conventional cell in its high lifetime for minority characters [sic] in the base."

A. I see where it says that.

Q. What does "high lifetime for minority characters

in the base" mean?

A. It means less space recombination.

Q. Why is that a potential advantage?

A. Because reducing recombination in all regions results in higher voltages and currents.

Q. If you turn, please, to Page 6-6.

A. Yes.

Q. Do you see the second -- strike that.

Do you see that the first full sentence on Page 6-6 reads: "The choice of N-type is also important because minority carrier holds carry a positive charge."

A. Yeah.

Q. And that's referring to the importance of the substrate being N-type, correct?

A. Right.

Q. Why are minority carrier holds that carry a positive charge important?

A. Well, minority carrier holds -- minority carriers, regardless of their charge are important because the minority carriers which are generated in a solar cell are the carriers which have to be transferred across the PN-junction to result in the delivery of current to an

external circuit.

MS. ZHAO: Counsel, before you continue, we've been going for about an hour.

MR. SELWYN: Yeah, I probably have five more minutes on this document.

THE WITNESS: Five minutes is fine.

MR. SELWYN: That okay?

MS. ZHAO: Yeah.

MR. SELWYN: That would be a natural breaking point.

THE WITNESS: Good.

Q. (BY MR. SELWYN) All right, the second paragraph on Page 6-6 begins, "A final advantage of the PhosTop cell is that there is no light-induced degradation since it is an N-type base." Do you see that?

A. Yes, I do.

Q. What does "no light-induced degradation" mean?

A. Well, the P-type substrates that were normally produced using boron as a dopant have a fundamental flaw, which is that when light is absorbed in the substrate, after a while it creates boron-oxygen complexes which are recombination sites, and therefore, result in degradation of

device performance.

Q. Why is that an advantage?

A. Well, it is an advantage to avoid that because any recombination that can be avoided benefits the performance of the solar cell.

Q. Do you see in the middle of the Page 6-6 there is a reference to V sub OC?

A. V_OC, yes.

Q. What is that?

A. Open circuit voltage.

Q. What is open circuit voltage?

A. That's the voltage a solar cell would produce at zero delivered current.

Q. Would you agree that a person of ordinary skill in the art in '516 and '053 patents would have known about open circuit voltage as of 2008?

A. Yes.

Q. And a person of -- strike that.

Would a person of ordinary skill in the art of the '516 and '053 patents have known the equation for open circuit voltage as of 2008?

A. Which equation?

Q. I will come back to that.

Can you look at the section starting on Page 6-6 entitled "6.2 experimental results."

A. Yes.

Q. And according to the first sentence of that section, Sandia fabricated PhosTop the cell that we've been discussing, right?

A. No, Sandia did not fabricate it.

Q. Where did the PhosTop cell come from?

A. I don't know.

Q. Okay.

MR. SELWYN: I said five minutes, we'll keep to it.

(Off the record, 12:38 p.m to 1:18 p.m.)

Q. (BY MR. SELWYN) Can you put back in front of you, sir, the Sandia report marked as Exhibit 1072 that we were talking about before.

A. Uh-huh. Yeah, what page?

Q. Turn, please, to Page 6-6.

A. Okay, I'm there.

Q. And if you will recall I asked you before about the subscript OC open circuit voltage?

A. Yes.

Q. For context would you explain again what open circuit voltage is.

A. This is voltage generated by a solar cell when it is open and circuited.

Q. And open circuit voltage was known by the date of the Sandia report, correct?

A. Yes.

Q. And open circuit voltage was known to a person of ordinary skill in the art of '516 and '053 patents by 2008, correct?

A. Yes.

Q. The equation for open circuit voltage was also known by 1999, correct?

A. Which equation.

Q. An equation for determining open circuit voltage.

A. An equation?

Q. Yes.

A. There probably are more than one, but I know of at least one.

Q. That was known by 1999, correct?

A. Yes.

Q. And a person of ordinary skill in the art of the '516 and '053 patents would know of an equation for open circuit voltage by 2008, correct?

A. Yes.

Q. Let me hand you as our next exhibit U.S. Patent 5,792,280 which is Exhibit 1073.

(Exhibit 1073 marked.)

Q. (BY MR. SELWYN) Dr. Ruby, do you recognize U.S. Patent No. 5,792,280. It is one of your patents.

A. Yes.

Q. And does this patent relate to work that you did at Sandia?

A. Yes, it does.

Q. Can you explain how?

A. Well, this was a method for fabricating solar cells that we invented at Sandia.

Q. Will you please turn to the paragraph starting at Column 2, Line 50.

A. Okay.

Q. Do you see that the paragraph discusses current concentrator cells?

A. Yes.

Q. And then in the second sentence it states, "Silicon is chosen as a compromise between cost and conversion efficiency."

A. Yes.

Q. Can you explain what you meant by that?

A. Well, I think what was meant by that is that silicon is chosen as a material from which to make solar cells, for one reason, because it is widely available, which keeps the cost low. But it has certain material parameters known, one of which is known as a Band Gap, which is not ideal for converting terrestrial sunlight to the maximum amount of electricity; for example, gallium arsenide has a Band Gap that more closely matches the optimum for solar cell efficiencies using the terrestrial solar spectrum.

Q. And in what way, as of 1998 was silicon a compromise between cost and conversion efficiency?

A. As I mentioned, silicon is cheaper than gallium arsenide, but doesn't perform as well as gallium arsenide. So that was the trade-off that was made.

Q. In solar cell design, in your experience, is there frequently a compromise between cost and conversion efficiency?

A. It depends on the potential use of the product; for example for space satellites where cost is less of a constraint, gallium arsenide is the material of choice for solar cells. On earth where there are other forms of electricity to compete with, cost becomes an important factor.

Q. The next sentence in that same paragraph, Column 2, Line 53 reads, "A number of expedience known to those skilled in the art are utilized to obtain this level of conversion efficiency, including the use of anti-reflection coatings, texturization of the surface to reduce the reflectance of above Band Gap photons." Do you see that.

A. Yes.

Q. Was that sentence still accurate as of February 2008?

A. Yes.

Q. Would you turn, please, sir, to the first paragraph in Column 3. Do you see that this paragraph explains that, "There is room for improvement in the processing of high-efficiency concentrator cells"?

A. Yes.

Q. And then one issue identified with, "The current process streams," is that the designs, "included multiple dopant diffusions, many photolithography steps, and up to six high-temperature furnace steps."

A. Yes.

Q. What is a photolithography step?

A. Photolithography is a process whereby a light-sensitive substance is applied to the surface of a semiconductor and then light is shined on this semiconductor with the substance through a photo mask which illuminates certain portions, but keeps others in the dark. Then this photosensitive substance in the presence of light becomes more or less resistive to various chemical treatments, and so you're able to use it to, for example, selectively etch off underlying silicon regions in areas where the photoresist, which is normally what is used to spin onto the surface of the wafer has been illuminated and patterned by the photo mask.

Q. And then in the next sentence your patent explains, "Such complexity leads naturally to an expensive process with low product yield." Do you see that?

A. Yes, I do.

Q. Would you agree that a person of ordinary skill in the art of the '053 and '516 patents as of 2008 would have known that process complexity leads to an expensive process with a low product yield?

A. It leads to a more expensive product with a lower product yield.

Q. And the patent explains that the process needs to be simplified to reduce costs, right?

A. Right.

Q. Can you turn now to the section entitled "summary" which starts at Column 3, Line 30.

A. Yes.

Q. And that's a summary of your patent's invention; is that right?

A. Yes.

Q. The last sentence in the summary says this is process is applied here to a, capital P-E-S-C-type design, but can be applied to other solar cell designs producing significant reduction in the cost of the finished device?

A. Right.

Q. What is a PS -- PESC-type design?

A. PESC. It is an acronym standing for passivated

emitter solar cell, a diagram of which is included in my declaration.

Q. And before 2008 were there PESC-type designs that did not include features that concentrate sunlight such as --

A. Say that again.

Q. Sure. Before 2008, were there PESC-type designs that did not include features that concentrate sunlight?

A. Yes.

Q. What did you mean by the process, "can be applied to most solar cell designs"?

A. Well, I guess this was a process simplification, and so any solar cell design that used the aforementioned process could be simplified in the way described in this patent.

Q. Did you mean that a person of ordinary skill in the art would have understood that the invention could have been implemented in most solar cell designs?

A. Yeah. In other solar cell designs that used the processes described here that were amenable to process simplification.

Q. And your patent, the '280 Patent, doesn't include

figures or descriptions showing the invention applied to, "most solar cell designs," right?

A. No, I imagine it includes figures that pertain to a particular design when considered here.

Q. So when you were referring to most solar cell designs you were referring to things that were not shown in your patent, correct?

A. Right. Other designs not shown here in the patent.

Q. Now, can you turn to the description beginning here on Column 3, Line 60.

A. Sixty. Yes.

Q. The first sentence, which starts at Column 6, Line -- sorry, Column 3 -- start that over.

The first sentence under "description" beginning at Line 63.

A. Yes.

Q. Discloses user either a P and N-type substrate, correct?

A. Either a P-type or N-type silicon wafer.

Q. So if the substrate were N-type, the emitter would be P-type, correct?

A. If the substrate were N-type, the emitter would be P-type.

Q. And by 2008, a person of ordinary skill in the art of the '516 and '053 patents knew about N-type substrates and P-type emitters, right?

MS. ZHAO: Objection; form.

A. They knew about solar cells with -- say the question again.

Q. (BY MR. SELWYN) Sure. Let me ask a new question. By 2008, a person of ordinary skill in the art of the '516 and '053 patents knew about N-type substrates, right?

A. Yes.

Q. And by 2008, a person of ordinary skill in the art of the '516 and '053 patents knew about P-type emitters, right?

A. P-type emitters, yes.

Q. Now, sir, if you turn to the next column, Column 4, beginning at Line 8.

A. Yes.

Q. Do you see that the paragraph explains Figures 2A, B, and C illustrate the steps which take place to form a junction and an oxide passivation layer on a silicon wafer?

A. Yes.

Q. Would you agree that by 2008 a person of ordinary skill in the art of the '516 and '053 patents would have known how to form a junction in an oxide passivation layer on a silicon wafer as described in that paragraph?

A. Yes.

Q. The junction referred to in Column 4, Line 9 is formed when the silicon wafer is doped with dopant atoms of the opposite conductivity type to those originally in the dope silicon wafer, correct?

A. Say that again.

Q. Sure. The junction that's referenced in Column 4 Line 9, is formed when the silicon wafer is doped with dopant atoms of the opposite conductivity type to those originally in the doped silicon wafer, correct?

A. Yes.

Q. And this paragraph says that a dopant source material, "Comprises dopant atoms of the opposite conductivity type" --

A. Can you show me which sentence that is?

Q. Sure.

A. I think I found it. You're reading starting from

the middle of the sentence. Well, in Figure 2A the initial process atmosphere has been replaced by a gaseous dopant source material which comprises dopant atoms of opposite conductivity type, compared to those originally existing in the doped silicon wafer.

Q. Let me start over. I want to refer you to Column 4, Paragraph Lines 8 through 24.

A. Okay, that entire paragraph.

Q. And that paragraph talks about a dopant source material that is, "Comprised of dopant atoms of the opposite conductivity type to those originally existing in the doped silicon wafer."

A. Yes.

Q. That's about forming the emitter, correct?

A. Yes.

Q. The emitter is formed when the silicon wafer is doped with the doping atoms of the opposite conductivity type than those originally in the doped silicon wafer, right?

MS. ZHAO: Objection; form.

A. That is how the term "emitter" is used in this paragraph.

Q. (BY MR. SELWYN) Do you see the second to last sentence in parentheses, which says, note that it is also possible to -- strike that.

Do you see the second to last sentence in Column 4? Strike that.

Let me refer you to Column 4, Lines 19 through 24.

A. Okay.

Q. Do you see it reads, "Note, that it is also possible to directly deposit prior to placing the wafer, 11, into the high-temperature furnace, 10, the layer 16, using suitable physical deposition means"?

A. Yes.

Q. And then the following sentence after that explains that suitable deposition means include spin-on techniques, CVD deposition of a doped silicon glass, and ion implementation techniques, right?

A. Yes.

Q. Would you agree that a POSITA in the '516 and '053 Patents would have understood by 2008 that suitable means to form an emitter include, "Spin-on techniques, CVD deposition of doped silicon glass, and ion implementation techniques"?

A. Yes.

Q. What is a spin-on technique?

A. Well, you would take chemical compound, which is a viscous liquid and apply it to the surface of a spinning wafer so that once it deposits on it, it fans out over the entire area. And depending on the spin speed and the viscosity of the liquid you get a layer of a given thickness, predetermined thickness.

Q. What is CVD deposition of a doped silicon glass?

A. For example, you could use atmospheric pressure or plasma-enhanced chemical vapor deposition of a doped silicon dioxide glass.

Q. If a dopant is boron, this refers to borosilicate glass?

A. Yes.

Q. And that's also called BSG?

A. Yes, it is.

Q. That's boron-doped silicon dioxide?

A. Yes, boron containing silicon dioxide.

Q. And by 2008, a person of ordinary skill in the art of the '516 and '053 patents would have known how to dope using borosilicate glass, right?

A. Yes.

Q. If the dopant is phosphorus, this would refer to phosphosilicate glass?

A. Yes.

Q. And that's also called PSG, right?

A. Yes.

Q. Phosphorus-doped silicon dioxide?

A. Phosphorus containing silicon dioxide.

Q. By 2008, a person of ordinary skill in the art of the '516 and '053 patents would have known how to dope using phos --

A. Phosphosilicate glass, yes.

Q. Thank you. Now, sir, could you please look at the paragraph beginning Line 25 of Column 4. Do you see it begins, "A large number of possible gaseous dopant source materials exist"?

A. Yes.

Q. And the paragraph explains that, "The dopant chosen to form the PN-junction is phosphorus for the applicant's experimental work"?

A. Yes.

Q. And the gaseous dopant source material, thus was chosen to comprise a mixture of POCL3 and O2?

A. Yes.

Q. So this discloses POCl diffusion?

A. Yes.

Q. And by 2008 a person of ordinary skill in the art of the '516 and '053 patents would have known how to perform POCl diffusion?

A. Yes.

Q. Now, if you would, sir, please turn to Column 5, paragraph beginning Line 36.

A. Okay.

Q. Do you see that this discusses several reasons why the process described in your patents, "is so important in developing an overall process for manufacturing cost-effective, high-efficiency solar cells"?

A. Yes.

Q. And your patent explains, "The most obvious is that the fewer discrete operations required, the lower will be the cost of final product."

A. Yes.

Q. And this explains it was obvious that if you decrease the number of discrete operations, the cost of the solar cell would be lower, right?

A. Right.

Q. Then the patent also explained, "This is particularly true for multiple furnace operations which require care and handling wafers being processed time for thermal cycling." Do you see that?

A. Yes, I do.

Q. Could you explain why it was particularly true for multiple furnace operations?

A. Well, when you introduce a silicon wafer to a high-temperature operation there's always a chance that you might inadvertently contaminate the wafer carriers holding the wafers, and at high temperatures, those contaminants can be driven into the silicon, thereby creating recombination centers and reducing cell efficiency.

Q. And the next sentence says that the patents achieved this because --

A. Which line, which column?

Q. Sure, sure. We're still in Column 5, Line 42.

A. Okay.

Q. So Column 5, Line 42, your patent explains that, "All three steps of the current process take place in a single furnace, set at a single temperature."

A. Yes.

Q. The furnace steps will be, "The steps performed in one loading of the wafer into the furnace," right?

A. Yes.

Q. The steps will be performed using a single loading of the substrate in a furnace, right?

A. Yes.

Q. And the patent explains that this is a simplification that greatly reduces both processing time and the set-up cost for the processing line?

A. Yes.

Q. Sir, could you turn to Column 6, the paragraph beginning at Line 34. Do you see that this paragraph discusses how Figures 4A, B, C, D illustrate the process flow for fabrication of a PESC-type textured surface solar cell?

A. Yes.

Q. The patent says, beginning on Line 57, "The choice of this specific design, the particular processes"" --

A. Wait, Line 57?

Q. Sorry, my eyesight. Let me direct your attention, sir, to Column 6, Line 37.

A. Thirty-seven. Okay.

Q. Do you see it reads, "The choice of the specific designs, the particular process steps indicated, and the order of said steps is not intended to limit the scope of the present invention, as many variations will be clear to a person having ordinary skill in the art." What did you mean by that?

A. Yes. Well, this gives a single example of a way in which this patent can be used. And there may be other variations that can be used based on, I suppose, the claims of this patent.

Q. If you would turn to the next paragraph beginning at Line 46 of Column 6.

A. Yes.

Q. Do you see the second sentence says, "Begin with a P-type (N-type) single crystalline Silicon Wafer 40 having a front surface and a back surface"?

A. Yes.

Q. So that discloses beginning with either a P- or N-type substrate, correct?

A. Yes.

Q. If the substrate were N-type, again, the emitter

would be P-type, right?

A. Right.

Q. And turning to the next paragraph, beginning at Line 49 of Column 6, this describes the step of deposit silicon oxide layer 41 on the front surface of wafer 40 using a low temperature process, correct?

A. Right.

Q. What is the purpose of that step?

A. Well, without having read the whole thing, I presume that's a masking oxide.

Q. Do you see a few lines lower where it begins, "The inventors' demonstration used a CVD process"?

A. Which line? There it is.

Q. Line 51. Do you see beginning Column 6, Line 51 it reads, "The inventors' demonstration used a CVD process operating at 400 Celsius but other low temperature processes are possible (EG vacuum evaporation)."

A. Yes.

Q. So here you're explaining that a CVD process operating at 400 Celsius is a demonstration, but a person of ordinary skill in the art would have known alternative deposition techniques could have worked such as vacuum

evaporation?

A. Yes.

Q. And is that because a low temperature deposition process was known by the date of your patent?

A. I assume other low temp- -- low temperature deposition processes were known.

Q. What low temperature deposition processes were known by August 1998?

A. Deposition of what? Depositing a silicon oxide layer?

Q. Yes.

A. Maybe there was a spin-on process. I mean, it could be probably -- several low-temperature silicon oxide layer deposition processes have used low temperature.

Q. I then direct your attention to the paragraph beginning at Line 55 at Column 6.

A. Uh-huh.

Q. Do you see it begins, "Form a layer 42 comprising aluminum on the bottom surface of wafer 40."

A. Yes.

Q. And again, this paragraph explains the demonstrations technique, but it also says other techniques,

materials, thicknesses may be used?

A. Yes.

Q. And the paragraph doesn't explain what these other techniques, materials, and thicknesses may be used would be, right?

A. It doesn't explain.

Q. That's because you knew that a person of ordinary skill in the art would have understood that there would be other ways to form a layer comprising of aluminum, right?

A. Yes.

Q. And if you'd look to the next paragraph, Column 6, Line 59.

A. Uh-huh.

Q. That describes anneal wafer 40 at 800 Celsius and oxygen atmosphere, right?

A. Yes.

Q. And it says this step, "Has the combined effect of alloying the layer 42 of the silicon on the back surface of wafer 40 and of densifying the silicon oxide layer 41," right?

A. Yes.

Q. And you also discuss annealing in the technology

background section of your declaration in the IPR proceedings, right?

A. Yes.

Q. In the annealing discussed -- strike that.

Is the annealing that you describe in your declarations the same process as described in your patent, the 280 Patent?

A. Annealing is a term that's used by different authors for different reasons, or -- so it is somewhat author-dependent. In this case, I'm using the term "annealing" in the sense of not driving in a diffusion, but simply heating up sufficiently so that atoms can rearrange.

Q. And you agree that by 2008 a person of ordinary skill in the art of the '516 and '053 patents would have known now to anneal a wafer, right?

A. Yes. But again, different authors consider annealing to mean different things sometimes.

Q. Could you turn to Claim 1 of the '280 Patent. There is a column, it is Line 44.

A. Okay.

Q. And do you see that Column 8, Lines 44 through 48 describe, "A method for fabricating a junction between a

Silicon Wafer doped with a first-dopant species having a first electrical conductivity type and a silicon layer doped with a second dopant species having a second electrical conductivity type"?

A. Yes.

Q. And would you agree that by 2008, a person of ordinary skill in the art of '516 and '053 Patents would have known how to fabricate a junction between a Silicon Wafer doped with a first-dopant species, having a first electrical conductivity type and a second layer -- second dopant species having a second electrical conductivity type as you explain in your patent?

A. Yes.

Q. Claim 1 doesn't use the word "concentrator," right?

A. No, not in that paragraph.

Q. Just to be clear, Claim 1 does not use the word "concentrator," correct?

A. Well, I have to read the rest of Claim 1, then.

Q. Sure.

A. No, it doesn't use the word "concentrator."

Q. Claim 2 claims a silicon concentrate solar cell,

right?

A. Yes.

Q. Going back to Claim 1, Claim Element 1A recites, "Heating said Silicon Wafer at high temperature in a furnace." Do you see that?

A. Yes.

Q. Would you agree that by 2008, a person of ordinary skill in the art would have known how to heat a Silicon Wafer at high temperature in a furnace?

A. Oh, yes.

Q. And Claim Element 1B of your '208 Patent recites, "Forming a dopant silicon oxide layer on a top surface of said Silicon Wafer," right?

A. Yes.

Q. By 2008, a person of ordinary skill in the art of the '516 and '053 patents would have known how to form a dopant silicon oxide layer on a top surface of a Silicon Wafer, correct?

A. Yes.

Q. And Claim Element 1D recites, "Diffusing said second dopant species into the top surface of said Silicon Wafer to form said silicon layer doped with said second

dopant species," right?

A. That's what it says.

Q. And would you agree that by 2008, a person of ordinary skill in the art of the '516 and '053 Patents would have known how to diffuse a dopant species into the top surface of a Silicon Wafer to form a silicon layer doped with a dopant species?

A. Yes.

Q. Dr. Ruby, let me hand you what I have marked as Exhibit 1074, which is a paper entitled, Simplified Processing for 23 percent Efficient Silicon Concentrator Solar Cells.

(Exhibit 1074 marked.)

A. Yes.

Q. (BY MR. SELWYN) Do you recognize this document?

A. Yes.

Q. You are one of the authors of this paper, right?

A. That's right.

Q. Would you briefly describe your role in writing this paper?

A. I was the first author on this paper. I wrote it in its entirety. The others provided data, experimental

results and advice.

Q. At a high-level what is this paper about?

A. It is about using a somewhat simplified process using only a single furnace step, such as described in this patent that we've been discussing, to fabricate silicon concentrator cells, approaching 23 percent on float-zone silicon, and for the first time, an efficiency of 20 percent on solar grade Czochralski silicon.

Q. Exhibit 1074 is an example of one of your papers published by the IEEE, right?

A. Yes.

Q. It indicates it was published in January of 1993; is that right?

A. Yes, I believe so. It says 1993, something that says 1/93, and that may be the date.

Q. On the first page of Exhibit 1074, which is Page 172 of the paper. It discusses fabrication of, "Front and back point contact cells, the interdigitated back contact cell, and several variations of passivated emitter solar cells," correct?

A. Those are given as examples of other types of silicon concentrator cells with efficiencies greater than

22 percent.

Q. And the paper explains that you developed a simplified processing schedule, right?

A. Yes.

Q. And that processing schedule refers to the fabrication of silicon concentrator solar cells, correct?

A. Yes. That fabrication schedule describes, is described by the simplified three photo less process.

Q. Table 1 describes a concentrator cell processing sequence?

A. Yes, that's right.

Q. The second line the table reads, "Deposit APCVD oxide on wafer fronts (400 Celsius)," correct?

A. Yes, that's right.

Q. That's the same APCVD we discussed earlier in connection with your work at Sandia, right?

A. Yes.

Q. You were using APCVD to deposit an oxide on the front surface of the wafer?

A. Yes.

Q. The seventh line in the table reads, "Deposit APCVD oxide on wafer backs, (400 Celsius)." Do you see

that?

A. Yes, I see it.

Q. And you were using APCVD to deposit an oxide on the rear surface of the wafer, correct?

A. Yes, that's right.

Q. The solar cell made using this process sequence had front and rear contacts, correct?

A. Yes, it did.

Q. The solar cell made using this process sequence is shown in Figure 1, right?

A. Yes, it is.

Q. The grid line is the front metal contact, correct?

A. That's right.

Q. And the portion labeled "back contact" is the back metal contact?

A. It is.

Q. Would you agree that by 2008, a person of ordinary skill in the art of the '516 and '053 Patents would have known how perform APCVD?

A. Yes.

Q. Put back in front of you your declaration for the '516 Patent.

A. All right.

Q. And would you turn to Page 12, Section 4, "assumptions."

A. Assumptions.

Q. In Paragraph 13, you explain that you assumed the date of the inventions of the claims of the '516 Patent was February 20th, 2008, correct?

A. Yes.

Q. The assumed date of the inventions is the same for the '516 and the '053 Patents, correct?

A. I'm not sure. They have -- the different patents have different filing dates on them. But I think one is a continuation of the other, so I guess the earlier date applies to both.

Q. You would agree that inventions disclosed before February 20th, 2008 are prior art to the '516 and '053 Patents, correct?

A. Yes.

Q. Could you describe in your own words the invention claimed in the '516 Patent?

A. '516 Patent describes solar cell structure, which has -- I think the claims make it quite general. I think if

you look at Claim 9 in particular, it generalizes it to be something other than just a cell of N-type substrate. It says it is a cell on -- with having a textured front surface, an emitter formed over the back surface, an oxide layer between the back surface and the emitter, and metal contacts on the front and back.

Q. And can you describe in your own words the invention claimed by the '053 Patent?

A. The '053 Patent, it offers specific and then more generalized versions that it claims ownership of, I think in its most general sense such as described in Claim 16. It is a solar cell with an oxide layer on the back surface, a polysilicon layer over the oxide layer. Dopants diffused into the polysilicon. Dopants diffused into the front surface, and then metal contacts on the front and back.

Q. What, in your view, makes the '053 Patent novel as compared with the prior art?

A. Well, the use of '053, okay, forming a polysilicon layer over an oxide layer on the back surface, and then diffusing dopants into that.

Q. And what, in your view, makes the '516 Patent novel as compared with the prior art?

A. It is describes, more or less, the same structure where you have an oxide layer on the back, and over that, on top of that, you have what they call an emitter layer formed, which is another deposited silicon layer.

Q. What makes what you just described novel as compared with the prior art?

A. Well, none of the prior art used a deposited silicon layer on top of an oxide layer as an emitter.

Q. Could you turn, now, back to your declaration, Paragraph 14.

A. Paragraph 14. Okay.

Q. In Paragraph 14 you explain that you were asked to apply the skill level of a person of ordinary skill in the art, POSITA, that is proposed in the petition, correct?

A. Yes.

Q. And you agree with the definition set forth in Hanwha's IPR petition of a person of ordinary skill in the art as of the claim priority date of the '516 and '053 Patents, correct?

A. Yes.

Q. Your declaration doesn't dispute that Dr. Holman was a person of ordinary skill in the art with respect to

the '053 and '516 Patents as of 2008, correct?

A. It doesn't dispute that he was a POSITA.

Q. Turning to Paragraphs 16, 17 of your '516 Declaration, that's where you describe your understanding of claim construction standards?

A. Paragraph 16 and 17?

Q. Yes.

A. What is your question?

Q. In Paragraph 16 and 17 of your declaration you set forth the understanding you have of claimed construction, correct?

A. Yes.

Q. In your declarations you do not offer any claimed construction opinions of your own, correct?

A. I don't see any.

Q. Your declaration doesn't suggest that the petition anywhere used or applied an incorrect claimed construction in analyzing the prior art, correct?

A. Can you read that -- can you ask that question again, please?

Q. Sure. Your declaration for the '516 Patent and your declaration for the '053 Patent don't suggest that

Hanwha's petitions anywhere used or applied an incorrect claim construction in analyzing any prior art, right?

A. I don't make that distinction. I'm only looking at one of the declarations. I will get both. You're asking about both.

Q. I can ask them separately if it is easier for you and to try and save time.

A. '053 claim construction. Where would that be? Somewhere on page -- claim construction, I think the paragraphs are identical. So nowhere in those paragraphs do I dispute Hanwha's defining a term.

Q. Your declarations don't suggest that the petitions anywhere used or applied an incorrect claim construction when analyzing any prior art, correct?

A. Right.

Q. Sticking with your declarations for the '516 Patents.

A. Yes.

Q. If you can turn, please, to Paragraphs 18 through 20.

A. Okay.

Q. In Paragraphs 18 through 20 you describe your

understanding of the standards for obviousness; is that right?

A. Yes.

Q. What is your understanding of the standard required to demonstrate a motivation to combine references?

A. Say that again.

Q. What is your understanding of the standard that the law requires to demonstrate a motivation to combine references?

A. I'm really not familiar with the legal terminology. But motivation to combine in my mind means that if there is an idea in one prior art reference that could be reasonably combined with an idea from another prior art reference, that those two could be combined. And if the resulting sum, or similar to what the patent at issue here, then that could negate the validity of the patent.

Q. Do you have an understanding of the legal standard required to demonstrate a motivation to combine references?

A. I'm not that familiar with legal standards, no.

Q. Do you have an understanding of the legal standard required to demonstrate reasonable expectation of success?

A. Well, I know what reasonable expectation of

success means in plain English.

Q. What is your understanding of the plain English meaning of "reasonable expectation of success"?

A. It means that the probability of success is close to 100 percent.

Q. Do you have an understanding of the legal standard required to demonstrate reasonable expectation of success?

A. Yeah, I'm not that familiar with legal standards.

Q. Have you heard of the "term secondary considerations of non-obviousness"?

A. I don't know what that means right now.

Q. Have you heard of "objective indicia of non-obviousness"?

A. No.

Q. Your declarations don't identify any books, papers or articles that praise the '053 or '516 Patents, correct?

A. Praise?

Q. Praise, speak highly of, commend.

A. Say that again, the question?

Q. Your declarations don't identify any books, papers, or articles that praise or commend the '516 or '053 Patents, correct?

A. I don't think so.

Q. Your declarations don't discuss any solar cell that practiced the '053 or '516 or Patents, correct?

A. Well, let's see, my declarations. They do mention solar cell publicized by Feldmann which use a similar design.

Q. What are you referring to?

A. Look up Feldmann, see where it is.

Q. How do you spell it?

A. F-E-L-D-M-A-N-N. Paragraph 74.

Q. Do you understand Ground 1 of Hanwha's petition and for the '516 Patent is that Claims 1 through 4 and 6 through 12 are invalid as obvious for Froitzheim and Gan, correct?

A. That's what they claim.

Q. And your declaration for the '516 Patent doesn't dispute that the combination of Froitzheim and Gan discloses all of the elements of Claims 1 through 4 and 6 through 11, correct?

A. Well, my declaration states that the combination of Froitzheim and Gan is not obvious, and would not be a motivation to combine because it does not leave a POSITA

with a reasonable expectation of success.

Q. Right. But you don't dispute that Froitzheim and Gan together disclose all of the elements of Claims 1 through 4 and 6 through 11, right?

A. One through 4 and 6 through 11, on which patent?

Q. The '516.

A. Maybe you better break that down. You're asking too much in one question.

Q. Sure. Your objection to Hanwha's proposed combination of Froitzheim and Gan is that you say there is a lack of motivation to combine, right?

A. That's one of the reasons.

Q. You don't dispute, though, that Froitzheim and Gan together disclose the limitations of Claims 1 through 4 and 6 through 12, correct?

A. Oh, the '516 Patent?

Q. Yes?

A. One through 4 and 6 through 12?

Q. Six through 11.

A. Six through 11. So you want me to read all those claims now?

Q. If that helps you answer, sure.

A. Well, I want to answer accurately. Froitzheim and Gan?

Q. Froitzheim and Gan. All I'm asking you is your declarations don't dispute that all the elements of those claims are disclosed by the combination of Froitzheim and Gan. I understand you dispute the motivations to combine the two, but I'm trying to understand, I don't think you dispute that all of the elements of those claims are disclosed by those two references in your declarations.

A. This includes Claim 9?

Q. No, 1 through 4. Yes, it does include Claim 9. Sorry.

A. Well, if you were to combine Froitzheim and Gan, which I don't think anybody would be motivated to do, then it would include those claims of the '516 Patent. Does that answer your question.

Q. I think so. So just so we're clear, your declaration for the '516 Patent does not dispute that the combination of Froitzheim and Gan discloses each of the elements of Claims 1 through 4 and 6 through 11, correct?

A. I believe I just said that.

Q. Thank you.

Your declaration for the '516 Patent also does not dispute that the combination of Froitzheim, Gan, and Sheets discloses Claim 5 of the '516 Patent, correct?

A. Well, Sheets -- I don't think Sheets discusses a trench on a single solar cell. He's discussing trenches between different solar cells. So I don't think it includes Claim 5.

Q. Okay. But your declaration for the '516 Patent doesn't dispute that the combination of Froitzheim, Gan, and Sheets discloses each of the elements of Claim 5, correct?

A. Well, I think I just said that it doesn't include Claim 5.

Q. And you make that point in your declaration?

A. I believe I do.

Q. Okay. Let me hand you Exhibit 1004. Do you recognize that as the Froitzheim reference?

A. Yes.

(Exhibit 1004 marked.)

Q. (BY MR. SELWYN) You viewed the Froitzheim reference as part of your work in this matter?

A. I did.

Q. Approximately how much time did you spend reading

the Froitzheim reference?

A. Probably an hour.

Q. Did you review Froitzheim's entire disclosure before you signed your declaration for the '516 IPR?

A. I believe I did.

Q. Let's look at Paragraph 1 of the Froitzheim.

A. Paragraph 1.

Q. Do you see that it reads --

A. Wait a minute.

Q. Top of the page.

A. Double -- 0001?

Q. Yes. I'm sorry.

A. Okay.

Q. Do you see it reads, "The present invention relates to a solar cell and to a method of manufacturing a solar cell"?

A. Yes, I see that.

Q. Froitzheim discloses solar cells, right?

A. He's discussing a solar cell and a method to manufacturing it.

Q. Let's look at Paragraph 9, please, of Froitzheim.

A. Yes.

Q. Do you see that in Paragraph 9 he writes, "It is an object of the present invention to provide a new type of silicon solar cell that improves stability and good efficiency that shows" -- I'll try it again. Paragraph 9 of Froitzheim states that it is an object of the present invention to provide a new type of silicon solar cell that shows improved stability and good efficiency, right?

A. That's what it says.

Q. And he explains that a goal of his invention is to teach a silicon solar cell that has improved stability, right?

A. Yes.

Q. And good efficiency?

A. Right.

Q. You would agree that solar cells can be connected together into a string of solar cells?

A. Yes.

Q. And a solar module includes multiple solar cells?

A. Yes, it does.

Q. A solar module can include multiple strings of solar cells, correct?

A. Yes.

Q. And a solar array is multiple solar modules connected together, right?

A. That's right.

Q. And a solar array includes solar cells, correct?

A. Yes.

Q. Could you turn, please, to Figure 3 of Froitzheim. On the front.

A. Figure 3, on the front?

Q. It should also be somewhere inside.

Figure 3 on Froitzheim depicts a cross-section of a solar cell, right?

A. Yes, it does.

Q. And it depicts metal contacts on the front of the solar cell?

A. It does.

Q. The front contacts in Froitzheim's solar cell were screen printed, correct?

A. It could be screen printed.

Q. If you look at Paragraph 28 of Froitzheim. Does that confirm that the front contacts in Froitzheim's solar cell were screen printed?

A. Yes.

Q. Figure 3 of Froitzheim depicts metal contacts on the back of the solar cell, correct?
A. It does.
Q. And the back contacts in Froitzheim's solar cell were also screen printed, right?
A. Where is that described?
Q. Paragraph 48.
A. Yes.
Q. Metal contacts in solar cells are used to connect a solar cell to a circuit, right?
A. Yes, they are.
Q. And metal contacts in solar cells may be used to connect solar cells together?
A. Yes, they are.
Q. Metal contacts in solar cells may be used to connect solar cells in strings of multiple solar cells, correct?
A. Yes.
Q. Metal contacts in solar cells may be used to connect solar cells together to form a solar module, right?
A. That's correct.
Q. And Froitzheim's metal contacts in the solar cell

that's shown in Figure 3 may be used to connect multiple solar cells together, correct?

A. Say that one again.

Q. Of course. Froitzheim's metal contacts in the solar cell shown in Figure 3 may be used to connect multiple solar cells together, correct?

A. Yes.

Q. Froitzheim's metal contacts in the disclosed solar cells may be used to connect multiple solar cells together, correct?

A. Yes.

Q. And Froitzheim's metal contacts in its disclosed solar cells may be us used to connect multiple solar cells together to form a solar module, correct?

A. Yes.

Q. Froitzheim's metal contacts in its disclosed solar cells may be used to connect multiple solar cells together to form multiple solar modules, too, correct?

A. Yeah. That's part of connecting modules together.

Q. And Froitzheim's metal contacts in its disclosed solar cells may be used to connect multiple solar cells together to form multiple solar modules that are arranged in

an array, correct?

A. Yes.

Q. Let me show you Exhibit 1005.

(Exhibit 1005 marked.)

Q. (BY MR. SELWYN) Do you recognize that as a Gan reference?

A. Yes.

Q. Did you review Gan in its entirety before signing your declaration?

A. Yes.

Q. And Gan was an IEEE article, correct? Is an IEEE article?

A. Yes.

Q. Gan was peer reviewed by the IEEE before it was published, right?

A. Well, depending on if this was a conference article or part of a scientific journal. Where did it come from?

Q. Well, either way, it would have been peer-reviewed, right?

A. Well, it would have been peer-reviewed, but not necessarily by the IEEE.

Q. Gan's title is polysilicon Emitters for Silicon Concentrator Solar Cells, correct?

A. That's what it is entitled, yes.

Q. And Gan teaches a structure for solar cells, right?

A. Well, Gan's work involved trying to develop a particular type of metal contact to the silicon substrate involving an intervening oxide layer.

Q. Are you familiar with the concept of "analogous art"?

A. You'd have to describe that to me.

Q. Do you have an understanding of the legal standard for analogous art?

A. No.

Q. Referring back to Froitzheim for a moment.

A. Yes.

Q. Do you agree that Froitzheim shows a solar cell having a front side facing the sun, right?

A. Yes.

Q. And you'd agree that Froitzheim shows the front side collecting solar radiation during normal operation?

A. Yes.

Q. You'd agree Froitzheim teaches a backside opposite the front side?

A. Yes.

Q. And you'd agree that the solar cell that has Froitzheim's structure would generate electricity, right?

A. If he did everything right, yes.

Q. You'd agree that Froitzheim teaches a substrate having a textured front surface, right?

A. Well, it is not showing in Figure 3. Where are his other figures? None of his figures show a textured front surface.

Q. You'd agree that Froitzheim teaches an emitter layer forming a backside junction with the substrate, correct?

A. Yes.

Q. Would you turn, please, to Paragraph 116 of your declaration. I'm sorry, turn to Paragraph 113 of your '516 declaration.

A. Paragraph which?

Q. It's 113 of the '516.

A. Okay. What would you like to know about Paragraph 113?

Q. In Paragraph 113 you discuss Gan and the Gan thesis, right?

A. Yes.

Q. And you state that Gan's, "Interfacial oxide layer is formed between a crystalline silicon substrate and a polysilicon layer applied over the rear surface of the substrate." Right?

A. That's exactly what it says.

Q. And the polysilicon layer you're referring to is the emitter, right?

A. I believe he may refer to it as an emitter, yes.

Q. And by "rear surface of the substrate" you're referring to the side facing away from the sun, correct?

A. That's right.

Q. The substrate and the polysilicon layer would form a PN-junction, correct?

A. It depends on the doping used in the polysilicon layer and the substrate.

Q. You'd agree that Gan teaches a rear PN-junction, correct?

A. I think I need to take a look at the Gan paper again. Can't find it right now. Here it is.

Q. If it helps you can also refer to Paragraph 118 in the declaration.

A. 118 in my declaration.

Q. You're free to look at Gan, too.

A. It might be more succinct here. That's Paragraph 118. That's not from Gan. Let's see, Paragraph 113? Okay. Well, okay. Where does it say the substrate conductivity type is in Gan's paper? I can't seem to find that at the moment.

Q. Let me ask a new question, then we'll take a break.

You'd agree that Gan discloses an interfacial oxide, correct?

A. Yes.

Q. And interfacial means the oxide layer between -- strike that.

"Interfacial" means the oxide layer would be between the substrate and the emitter layer, correct?

A. Yes.

Q. And Gan teaches an oxide layer formed between the back surface of the substrate and the emitter layer, correct?

A. Yes.

MR. SELWYN: Why don't we take a break.

(Note: Off the record, 2:36 p.m. to 2:45 p.m.)

Q. (BY MR. SELWYN) Dr. Ruby, can you please turn in your declaration for the '516 Patent to the section entitled "Gan thesis" beginning in Paragraph 131.

A. Okay. Okay.

Q. Before signing your declarations regarding the '516 and '053 Patents did you review all of the Gan thesis?

A. Not all of it.

Q. Which sections of the Gan thesis did you review before signing your declarations?

A. I can't tell you right now exactly which sections I reviewed.

Q. How did you decide which sections in the Gan thesis to review before signing your declaration?

A. I think the law team directed me to certain sections that were more relevant to this case.

Q. How many sections of the Gan thesis did they direct you to?

A. Well, I can see here that it directs me in Paragraph 136 to a section about oxide breakup. So I don't

know exactly how many sections. I would say the relevant sections.

Q. All of the portions of the Gan thesis that you reviewed before signing your declaration were provided to you by counsel, correct?

A. Right.

Q. And are the sections of the Gan thesis that you reviewed before signing your declaration, those that are cited in your declarations.

A. Yes.

Q. Are there any sections of the Gan thesis that you reviewed that you did not cite in your declarations?

A. No.

(Exhibit 1006 marked.)

Q. (BY MR. SELWYN) Let me hand you 1006. Do you recognize Exhibit --

A. Exhibit 1006?

Q. Yes. Let me ask a new question: Do you recognize Exhibit 1006 as the Borden '575 prior art reference?

A. Yes, I do.

Q. Did you review Borden '575 before signing your declaration?

A. I did.

Q. Did you review Borden '575s entire disclosure before signing your declarations?

A. Most of it.

Q. What portions of it did you not review?

A. Well, it was short enough that I probably would have read the whole thing. I tell you what portions I did review were the claims and the diagrams.

Q. Are you certain you reviewed anything in the Borden '575 reference other than the claims and the diagrams?

A. I may have read some of the specifications.

Q. Are you sure you did?

A. Am I sure I did?

Q. Yes.

A. Yes.

Q. Which portions of the specification of Borden 575 reference did you review before signing your declaration?

A. A brief description of the drawings, the detailed descriptions, summary, the background, and the claims and the figures. So all of it.

Q. Can you turn, please, to Paragraph 002 of

Borden '575.

A. Yes.

Q. Paragraph 2 of Borden's '575 states that, "The present invention relates to forming contacts in a semiconductor device, and more particularly, to methods and apparatuses for providing a buried insulator isolation for polysilicon emitter solar cell contacts." Right?

A. Yes, that's what it says.

Q. And you would agree, Borden '575 discloses a polysilicon emitter for a solar cell, correct?

A. Yes, it does.

Q. Borden '575 relates to solar cells, correct?

A. Yes, it does.

Q. Borden '575 shows the silicon substrate, right?

A. In which figure?

Q. Any of them.

A. The figures really don't show a substrate.

Q. Well, the reference discloses a silicon substrate, right?

A. The reference? What is the reference?

Q. The Borden '575.

A. Well, he talks about having a substrate, yes.

Q. You can put that aside.
A. Yes.
Q. Let me now show you Exhibit Hanwha 1008.
(Exhibit 1008 marked.)
Q. (BY MR. SELWYN) Do you recognize Exhibit 1008 to be the Li prior art reference?
A. Yes.
Q. And you reviewed Li before signing your declaration?
A. I did.
Q. Did you review the entire disclosure of Li before signing your declarations?
A. In its entirety.
Q. Li discloses a structure for a solar cell, right?
A. You are correct.
Q. And Li teaches a substrate, right?
A. Li describes a substrate used in his solar cell.
Q. Li teaches an emitter, right?
A. He does.
Q. And Li teaches the emitter is a P-type, right?
A. Yes.
Q. You can put that aside, too.

Would you turn to Paragraph 194 of your declaration.

A. Which declaration?

Q. The '516 declaration.

A. 194?

Q. Yes.

A. Okay. What page is that on?

Q. It is on Page 106.

A. Okay.

Q. In Paragraph 194 you refer to "edge isolation"?

A. Yes, I do.

Q. What is edge isolation?

A. Edge isolation is the means by which the front doped layer is electrically isolated from the rear doped layer.

Q. What is an electrical short?

A. Electrical short would be an extremely low resistance electrical pathway.

Q. Can a solar cell short circuit?

A. Of course.

Q. What causes a solar cell to short circuit?

A. Well, you can put a wire from the front to the back. That would be one way of measuring the short circuit

current.

Q. A string of solar cells is multiple solar cells connected in a series, right?

A. Series connection of solar cells.

Q. Multiple strings of solar cells can be connected in a parallel configuration, correct?

A. That's true.

Q. And multiple strengths of solar cells can be connected in a series, correct?

A. They could be.

Q. Solar cells are connected together to increase the amount of power that can be generated, right?

A. Yes. Where the solar cells are connected together the power generated by each cell is added to those of all the others.

Q. Solar cells are designed to be connected to other solar cells, right?

A. Yes, they are.

Q. And there are multiple types of solar cells, right?

A. Yes.

Q. One type of solar cell is a full-sized solar cell,

correct?

A. Full-sized?

Q. Full sized.

A. Well, if by that you mean occupying a full area of a Silicon Wafer, then, yes.

Q. Another type of solar cell is a half-cut solar cell, correct?

A. I assume you mean by that a solar cell made on a wafer that's been cut in half.

Q. A short circuit is a potential problem for solar cells that are in a string of multiple solar cells, correct?

A. If a single solar cell is short-circuited in a string it would reduce the output of the string.

Q. A short circuit is a potential problem for full-sized solar cells that are in a string of multiple solar cells, correct?

A. Yes.

Q. And a short circuit is a potential problem for half-cut solar cells that are in a string of multiple solar cells, correct?

A. Yes.

Q. So a short-circuit is at potential problem for

various types of solar cells that are in a string of multiple solar cells, correct?

A. Yes.

Q. And a solar module can include multiple strings of solar cells?

A. Yes, they could.

Q. A short-circuit is a potential problem for a solar module of full-size solar cells, correct?

A. Yes.

Q. And a short-circuit is a potential problem for a solar module with half-cut solar cells, correct?

A. Yes. When you say "a short-circuit" you mean a single short-circuited cell or a short-circuit of the module?

Q. Either.

A. Well, it is a problem for both, yes. One a lot more than the other.

Q. A solar array is multiple solar modules connected together, correct?

A. Yes.

Q. And A short-circuit is a problem for solar cells that are on a solar array, correct?

A. A short-circuit of what, an individual module?
Q. Yes.
A. That would be a problem for the array.
Q. Edge isolation is a category of techniques to prevent a solar cell from short-circuiting, correct?
A. It is usually considered a technique for reducing a probability of a shunt between front and back contacts rather than a short-circuit. But edge isolation could prevent both.
Q. When was the first time you learned about edge isolation?
A. When I first started at Sandia.
Q. Did you publish any articles while at Sandia that mention or describe edge isolation?
A. I don't believe so.
Q. How did you learn about edge isolation while at Sandia?
A. Reading the papers of scientific articles that others had published.
Q. Would you agree that a person of ordinary skill in the art of the '516 and '053 Patents would have known about edge isolation as of 2008?

A. Oh, yes.

Q. And would you agree that by 2008, a person of ordinary skill in the art of the '516 and '053 Patents would have known how to avoid short -- short-circuits?

A. Yes.

Q. Would you agree that by 2008, a person of ordinary skill in the art would have known that trenches were one technique to prevent short-circuits?

A. It is one technique, yes.

Q. And a trench is an edge isolation technique, correct?

A. Yes, it is an example of an edge isolation technique.

Q. Trench cutting is a trench that's cut out of the cell surface, correct?

A. It's a trench that's dug into and around the periphery of the cell surface.

Q. Trench cutting is a groove that's cut out of the cell surface?

A. It is a groove. I would -- the way I would say it is cut into a cell surface.

Q. When did you first learn about trenches or grooves

cut into the cell surface?

A. When? Probably early at my time at Sandia. There were others who published papers using that technique.

Q. So trenches were known in the art before 2008, correct?

A. Oh, yes.

Q. And a person of ordinary skill of in the art of the '516 and '053 Patents would have known about trenches as of 2008, correct?

A. I believe so, yes.

Q. One -- strike that.

There are a number of different ways to create a trench in a solar cell, correct?

A. Yes.

Q. And one technique to create a trench is plasma etching?

A. That's not a method that I ever heard about. Usually, a trench is cut either by a dicing saw or a laser. Plasma etching is typically not used to create trenches, but it could be; for example, reactive ion etching is plasma etching. You could use it to create a trench, I suppose.

Q. Plasma etching is a trenching technique that a

person of ordinary skill in the art of the '516 and '053 Patents would have known as of 2008, correct?

A. I believe so.

Q. Laser machining is another technique to create a trench that a person of ordinary skill in the art of the '053 and '516 Patents would have known as of 2008, correct?

A. Yes.

Q. What techniques, other than plasma etching and laser machining existed as of 2008 to create trenches?

A. Well, as I just mentioned, dicing saw cutting.

Q. When did you first learn about dicing saws as a technique to trench a solar cell?

A. When? Well, early in my days at Sandia I read papers from the University of New South Wales in Australia where they typically used dicing saws to isolate their solar cells.

Q. You would agree that the '516 and '053 Patents don't disclose any new technique to create a trench, correct?

A. No.

Q. You agree, right?

A. I agree.

Q. And you'd agree that by 2008 a person of ordinary skill in the art of the '516 and '053 Patents would have been capable of adding a trench to a solar cell, correct?

A. It was well known. Different ways to do it.

Q. What is plasma etching?

A. Plasma etching involves putting your substrate into a low pressure device in which you would introduce reactive gases, which have the property that they chemically react with the silicon, vaporizing it, and then having it removed from the enclosure by a vacuum pump.

Q. A person of ordinary skill in the art of the '516 and '053 Patents would have known about plasma etching as of 2008, correct?

A. I believe so.

Q. What does the resulting structure look like on a solar cell that was plasma-etched to prevent shorts?

A. To prevent shorts? Well, to prevent shorts, or for isolation purposes, the wafers were generally stacked like coins, one against another, so that the plasma really only interacted with the edges of the wafers and removed, etched away the silicon at the edges of the wafers, so that the faces were left intact, the edges were removed, and

there was no way that leakage of dopants from one side or the other could wrap around the edge.

Q. As of 2008, could plasma etching be used to make a trench in a solar cell?

A. Probably so. Again, I'm not familiar with using plasma etching to make a trench. It would have been one of the lesser used methods, but I suppose it is possible.

Q. Let me hand you Hanwha Exhibit 1012.

(Exhibit 1012 marked.)

Q. (BY MR. SELWYN) Do you recognize that as the Sheets prior art reference?

A. Yes, I do.

Q. You read the Sheets prior art reference before signing your declaration?

A. Yes, I did.

Q. Did you read it in its entirety?

A. I tried to.

Q. Were you successful?

A. It is not well-written, so it was very difficult to do so.

Q. Did you read the reference in its entirety?

A. I read most of it.

Q. If you look at Paragraph 2 of Sheets, the invention.

A. What page?

Q. It is the one at the top.

A. Okay. 0002.

Q. 0002. Do you see that it states, "This invention relates to optoelectronic devices, and more particularly, to mass manufacturer of optoelectronic devices such as solar cells"?

A. That's what it says.

Q. It states that it is directed to manufacturing solar cells, right?

A. Apparently so.

Q. And it discloses that it is directed to solar cells, correct?

A. One out of many optoelectronic devices that that is directed to.

Q. Sheets discloses a trench, right?

A. Yes, he discloses trenches.

Q. And he discloses techniques such as laser machining to form trenches, correct?

A. Yes.

Q. And he discloses that laser machining is one example of a technique to form a trench, correct?

A. Yes.

Q. Let me hand you, Dr. Ruby, Hanwha 1.

(Exhibit 1007 marked.)

Q. (BY MR. SELWYN) Do you recognize Hanwha Exhibit 1007 as the Smith prior art reference?

A. Yes, I do.

Q. Did you review Smith before signing your declaration?

A. I did.

Q. And did you review it in its entirety?

A. I did.

Q. If you turn, please, sir, to the first column of Smith. Do you see where it says "field of the invention"?

A. First column of which page? Here.

Q. Column 1 --

A. Okay.

Q. -- line 16?

A. Line 16, field of the invention.

Q. And under field of the invention Smith states that the present invention relates generally to solar cells, and

more particularly, but not exclusively, to methods and apparatus for fabricating solar cells?

A. Yes, I see that.

Q. So Smith discloses methods for fabricating solar cells, right?

A. I agree.

Q. And if you look, please, sir, at around Line 36 of Column 1, do you see that Smith states, "Just like in most manufacturing processes, each step employed in the manufacture of solar cells has an associated cost."

A. I do see that.

Q. Do you agree with that?

A. Yes, I do agree with that.

Q. And then the next sentence says, "Thus, techniques for simplifying the fabrication of solar cells are generally desirable." Do you see that?

A. I see that.

Q. Do you agree with that sentence?

A. Yes, I do.

Q. Smith teaches that each step in manufacturing a solar cell has an associated cost, correct?

A. That's what he states.

Q. And he also teaches that simplifying the fabrication of solar cells is generally desirable, right?

A. Yes.

(Off the record, 3:13 p.m. to 3:20 p.m.)

Q. (BY MR. SELWYN) Dr. Ruby, just a few more questions if I might.

A. Sure.

Q. Was there anything that limited or constrained the amount of time that you could spend on this matter?

A. No.

MR. SELWYN: I pass the witness.

EXAMINATION

BY MS. ZHAO :

Q. Dr. Ruby, just a few questions. Can we turn to your '516 Declaration, Paragraph 59.

A. Fifty-nine?

Q. Yes. In Paragraph 59 you mention a TOPCon one sun cell, correct?

A. Yes, I do.

Q. You also mention literature in 2023. Do you see that?

A. Yes, I do.

Q. It says literature describing TOPCon cells?
MR. SELWYN: Objection; form.
A. I believe it is, yes.
Q. (BY MS. ZHAO) In or before 2008, were TOPCon one sun cells known to a person of ordinary skill in the art?
MR. SELWYN: Objection; form.
A. In 2008?
Q. (BY MS. ZHAO) Yes.
A. No, it was not generally known.
Q. You were also asked whether by 2008 a person of ordinary skill in the art would have known how to add a tunnel oxide to a solar cell. Do you remember?
A. Do I remember being asked that?
Q. Yes.
A. Being asked what?
Q. Whether a person of ordinary skill in the art would have known how to add a tunnel oxide to a solar cell.
A. Not generally, no.
Q. You don't remember being asked that?
A. Oh yeah, I was asked that, but it is -- it was a novel concept that was not generally known, discussed, or published. In fact, it was this Feldmann's publication in

2013 where it became more generally known.

Q. Can you turn to Paragraph 85 of your '516 Declaration.

A. Eighty-five?

Q. Yes. Earlier you were asked about the first sentence. Do you see that?

A. Yes.

Q. Let me just read the sentence for the record. It states that in a TOPCon structure a layer of polysilicon, heavily doped with N-type dopants forms on the tunnel oxide. Is it okay if I call that the TOPCon structure?

A. Yes.

Q. You were asked if the TOPCon structure was known in 2008. Do you remember?

MR. SELWYN: Objection.

A. I guess I don't remember it being asked like that.

Q. (BY MS. ZHAO) Can I ask you, was the TOPCon structure known in 2008?

MR. SELWYN: Objection.

A. I would say it was not generally known, but there may have -- there were certainly people -- there were certainly research groups that were investigating the TOPCon

structure.

Q. (BY MS. ZHAO) In or before 2008, are you aware of anyone successfully creating the TOPCon structure in a solar cell?

MR. SELWYN: Objection.

A. Successfully creating the TOPCon structure? No, I'm not aware of anyone before 2008.

Q. (BY MS. ZHAO) In or before 2008, are you aware of any solar cells in the market that included the TOPCon structure?

MR. SELWYN: Objection.

A. No, I'm not aware of any cells in the marketplace using the TOPCon structure.

MS. ZHAO: Pass the witness.

EXAMINATION

BY MR. SELWYN:

Q. Just a couple more questions, Dr. Ruby.

A. Yes.

Q. If you can turn back in your '516 Declaration to Paragraph 74.

A. Page 42. Okay.

Q. Maxeon's counsel just a moment ago referred you to

Paragraph 74.

A. She referred me to a different paragraph.

MS. ZHAO: Fifty-nine.

Q. (BY MR. SELWYN) Turn, please, to Paragraph 59 in your declaration.

A. Fifty-nine. Yes.

Q. Paragraph 59 in your declarations was one of the paragraphs that was drafted by counsel, not you, correct?

A. I think I may have drafted that paragraph because I remember finding this figure.

Q. Where did you find the figure?

A. It was a figure by MacDonald, in one of his videos, in one of his slides in his UNSW seminar.

Q. So you're sure that you drafted Paragraph 59?

A. I'm not sure.

Q. Can you turn to Paragraph 85.

A. But I agree with everything in that paragraph. Eighty-five, yes.

Q. Paragraph 85 is one of the paragraphs that was drafted by counsel and not you, correct?

A. I disagree with that. It looks like something I would have drafted.

Q. Are you sure?

A. Yes. It uses terminology that I would ordinarily use. Yes, I drafted that paragraph and I stand by what it says.

MR. SELWYN: Nothing further.

MS. ZHAO: Nothing further here either.

(Deposition concluded at 3:28 p.m.)

DEPONENT SIGNATURE/CORRECTION PAGE

If there are any typographical errors to your deposition, indicate them below:

PAGE LINE

_____ Change to _____

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Any other changes to your deposition are to be listed below with a statement as to the reason for such change.

PAGE	LINE	CORRECTION	REASON FOR CHANGE

I, DOUGLAS S. RUBY, PH.D., do hereby certify that I have read the foregoing pages of my testimony as transcribed and that the same is a true and correct transcript of the testimony given by me in this deposition on July 31, 2025, except for the changes made.

_____ _____

Date signed DOUGLAS S. RUBY, PH.D.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

_____

HANWHA SOLUTIONS CORPORATION,

Petitioner,

v.

MAXEON SOLAR PTE, LTD.,

Patent Owner

Case Nos.:

IPR 2024-01199,

IPR 2024-01203

U.S. Patent Nos.:

8,878,053,

8,222,516

_____

CERTIFICATE OF DEPOSITION

I, CHRISTINE J. ROYBAL, CCR, RPR, CSR, DO HEREBY CERTIFY that on July 31, 2025, the Deposition of DOUGLAS S. RUBY, PH.D. was taken before me at the request of, and sealed original thereof retained by:

MARK SELWYN, ESQUIRE
WILMER CUTLER PICKERING HALE AND DORR, LLP
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Palo Alto, California 94306
(650) 858-6031

I FURTHER CERTIFY that copies of this Certificate have been mailed or delivered to all Counsel, and parties to the proceedings not represented by counsel, appearing at the taking of the deposition.

I FURTHER CERTIFY that examination of this transcript and signature of the witness REQUESTED by the witness and all parties present. On _____, a letter was mailed or delivered to ATTORNEY regarding obtaining signature of the witness, and any corrections, if any, were appended to the original and each copy of the Deposition.

I FURTHER CERTIFY that the recoverable cost of the original and one copy of the deposition, including exhibits, to MARK SELWYN, ESQ. is $_____.

I FURTHER CERTIFY that I did administer the oath to the witness herein prior to the taking of this Deposition; that I did thereafter report in stenographic shorthand the questions and answers set forth herein, and the foregoing is a true and correct transcript of the proceeding had upon the taking of this Deposition to the best of my ability.

I FURTHER CERTIFY that I am neither employed by nor related to nor contracted with (unless excepted by the rules) any of the parties or attorneys in this case, and that I have no interest whatsoever in the final disposition of this case in any court.

Christine Roybal
_____
CHRISTINE J. ROYBAL, CCR, RPR, CSR,
CCR No. 50
License Expires: 12/31/25

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