Exhibit 2029

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Transcript of Zachary Holman, Ph.D.

Date: May 8, 2025
Case: Hanwha Solutions Corp. -v- Maxeon Solar Pte. Ltd. (PTAB)

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WORLDWIDE COURT REPORTING & LITIGATION TECHNOLOGY

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2 BEFORE THE PATENT TRIAL AND APPEAL BOARD

3 - - - - - - - - - - - - x

4 HANWHA SOLUTIONS :

5 CORPORATION, :

6 Petitioner, : Case Nos. IPR 2024-01199,

7 v. : IPR2024-01203

8 MAXEON SOLAR :

9 PTE, LTD., : U.S. Patent Nos. 8,878,053,

10 Patent Owner. : 8,222,516

11 - - - - - - - - - - - - X

12

13 Deposition of ZACHARY C. HOLMAN, Ph.D.

14 Conducted Virtually

15 Thursday, May 8, 2025

16 11:57 a.m. EDT

17

18

19

20 Job No.: 580887

21 Pages 1 - 267

22 Reported by: Debra A. Whitehead

1 Deposition of ZACHARY C. HOLMAN, Ph.D.,
2 conducted virtually.
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5 Pursuant to notice, before Debra Ann Whitehead,
6 E-Notary Public in and for the Commonwealth of
7 Virginia.
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1 C O N T E N T S

2 EXAMINATION OF ZACHARY C. HOLMAN, Ph.D. PAGE
3 By Ms. Zhao 6
4 By Mr. Selwyn 253
5
6 EXHIBITS MARKED IN TODAY'S SESSION
7 (None Marked)
8
9 EXHIBITS MARKED IN PRIOR SESSIONS
10 (Not Attached)

11 EXHIBIT PAGE
12 Exhibit 1003 (IPR2024-01199) 9
13 Exhibit 1003 (IPR2024-01203) 229
14 Exhibit 1004 59
15 Exhibit 1005 163
16 Exhibit 1007 198
17 Exhibit 1008 217
18 Exhibit 1012 240
19 Exhibit 1015 95
20
21
22

1 P R O C E E D I N G S
2 ZACHARY C. HOLMAN, Ph.D.,
3 having been duly sworn, testified as follows: 11:57:05
4 EXAMINATION BY COUNSEL FOR PATENT OWNER 11:57:05
5 BY MS. ZHAO: 11:57:05
6 Q Dr. Holman, good morning. I'm Jing Zhao. 11:57:18
7 I'm counsel for Patent Owner Maxeon. 11:57:22
8 Can you please state your full name, for 11:57:25
9 the record. 11:57:26
10 A Yes. My name is Zachary Charles Holman. 11:57:27
11 Q Where are you joining this call from? 11:57:31
12 A From Phoenix, Arizona. 11:57:34
13 Q Is Mr. Selwyn in the room with you? 11:57:35
14 A Yes, he's seated next to me. 11:57:43
15 Q Is anyone else in the room with you? 11:57:44
16 A Yes, another attorney for WilmerHale is 11:57:46
17 seated in the room, Bobby Hampton. 11:57:51
18 Q Do you have any documents in front of 11:57:54
19 you? 11:57:57
20 A I do not presently. 11:57:57
21 MS. ZHAO: Mr. Selwyn, I believe we 11:58:02
22 shipped some binders to Mr. Holman. Are those 11:58:04

1 available to him? 11:58:08
2 MR. SELWYN: They are. I have them right 11:58:09
3 here, I will hand them to Dr. Holman. 11:58:10
4 MS. ZHAO: Thank you. 11:58:12
5 Q Dr. Holman, do you have any medical 11:58:23
6 conditions that would affect your answers today? 11:58:25
7 A No, I do not. 11:58:31
8 Q Before I begin I would like to go over 11:58:31
9 some ground rules. Please let me know if you 11:58:33
10 don't understand any of my questions. If you 11:58:35
11 answer my question, I will assume that you 11:58:37
12 understood the question. 11:58:39
13 Is that fair? 11:58:41
14 A Yes. 11:58:42
15 Q If your attorney objects, you will still 11:58:42
16 need to answer the question. The only exception 11:58:45
17 is when your attorney instructs you not to answer. 11:58:48
18 Is that fair? 11:58:51
19 A Yes. 11:58:52
20 Q Let me know if you need breaks. But 11:58:52
21 before you go on break, you will need to answer 11:58:56
22 any pending questions I just asked. 11:58:58

1 Do you understand? 11:59:00
2 A I understand. 11:59:01
3 Q How did you prepare for your deposition 11:59:02
4 today? 11:59:06
5 A I have met with counsel and I have 11:59:09
6 reviewed my declaration and the supporting 11:59:12
7 materials in it. 11:59:16
8 Q Which counsel did you meet with? 11:59:18
9 A Counsel members of WilmerHale, including 11:59:22
10 Mark Selwyn and Bobby Hampton. 11:59:26
11 Q Approximately how long was the meeting 11:59:29
12 with counsel? 11:59:31
13 A I met with counsel for on the order of 20 11:59:34
14 hours in preparation for this deposition. 11:59:40
15 Q Did you speak with anyone else in 11:59:45
16 preparation for this deposition? 11:59:48
17 A No, I have not. 11:59:50
18 Q You are here to testify on two IPR cases. 11:59:51
19 Correct? 11:59:56
20 A That's correct. 11:59:58
21 Q One of them is numbered IPR2024-01199. 11:59:58
22 Correct? 12:00:06

1 A I believe so. That's what the binder in 12:00:13
2 front of me says. I don't have other access to 12:00:16
3 numbers, but yes. 12:00:18
4 Q You submitted a declaration for this IPR. 12:00:19
5 Correct? 12:00:22
6 A Yes, I did. 12:00:24
7 Q And that declaration is in the binder. 12:00:24
8 Right? Can you check? 12:00:28
9 A Yes, I find it in the binder. 12:00:34
10 Q Thank you. 12:00:35
11 MS. ZHAO: And for the record, I am 12:00:37
12 referring to Exhibit 1003 of IPR2024-01199. 12:00:38
13 (IPR2024-01199 Exhibit 1003, previously 12:00:45
14 marked, not attached.) 12:00:45
15 Q This declaration relates to U.S. Patent 12:00:45
16 Number 8,878,053. 12:00:48
17 Is that right, Dr. Holman? 12:00:52
18 A Yes. 12:00:57
19 Q I'm sorry, your audio cut off a little 12:00:58
20 bit. Was that a yes? 12:01:01
21 A That was a yes. 12:01:02
22 Q Thank you. 12:01:03

1 You call this patent the '053 patent in 12:01:05
2 your declaration. Right? 12:01:09
3 A Yes. 12:01:10
4 Q I will call this declaration the '053 12:01:10
5 declaration, then. 12:01:14
6 Is that okay? 12:01:15
7 A That is good. Thank you. 12:01:16
8 Q Did you prepare the '053 declaration all 12:01:18
9 by yourself? 12:01:22
10 A The '053 declaration is my words, my 12:01:26
11 opinions, and my words and my opinions only. I 12:01:28
12 did not type all of the words of the '053 12:01:32
13 declaration into the word-processing software; 12:01:37
14 others from counsel have also contributed to the 12:01:42
15 typing process. 12:01:45
16 Q Did you type any of the words in the 12:01:45
17 '053 -- 12:01:49
18 A Yes, I did. 12:01:49
19 Q How many hours have you spent drafting 12:01:50
20 the '053 declaration? 12:01:55
21 A I believe I spent approximately 120 hours 12:02:01
22 on the '053, '516, and '315 declarations together. 12:02:09

1 And approximately half of that was dedicated to 12:02:19
2 the '053 declaration, and approximately half of 12:02:22
3 that was dedicated to the '053 and '516 12:02:26
4 declarations together. 12:02:31
5 I did not account or have not accounted 12:02:34
6 specifically how much was spent on the '053 versus 12:02:37
7 '516, as they refer to the same specification and 12:02:41
8 often my work on the two of them were combined. 12:02:48
9 Q Is it possible that you spent more time 12:02:51
10 on one than the other between the '053 and the 12:02:56
11 '516? 12:02:59
12 MR. SELWYN: Objection. Form. 12:03:01
13 A Certainly it's possible. It's even 12:03:03
14 likely. If I were to guess, I believe I spent 12:03:06
15 more time on the '516 declaration than the '053. 12:03:11
16 But certainly I spent at least more than 25 hours 12:03:17
17 on each. 12:03:23
18 Q Sitting here today, do you still agree 12:03:26
19 with all the statements in the '053 declaration? 12:03:28
20 A I agree with all of the statements. In 12:03:33
21 my review I did find one typo. It appears on Page 12:03:36
22 60 of the '053 declaration, Paragraph 97. 12:03:40

1 Q Okay. 12:03:50
2 A Second sentence that presently says, "In 12:03:51
3 response to this rejection, the applicant did not 12:03:54
4 amendment the claims." That should say, "The 12:03:58
5 applicant did not amend the claims." 12:04:01
6 I did not find any other typos or errors 12:04:03
7 in my review. 12:04:06
8 Q Other than that typo, is there anything 12:04:08
9 you wish to alter in the '053 declaration? 12:04:13
10 A No. 12:04:16
11 Q Is there anything you wish to add to the 12:04:17
12 '053 declaration? 12:04:20
13 A No. 12:04:22
14 Q Let's go to Paragraph 8 of the '053 12:04:22
15 declaration. 12:04:28
16 This paragraph opens with, "While a 12:04:30
17 postdoctoral researcher." 12:04:34
18 Do you see that? 12:04:35
19 A Yes, I do. 12:04:36
20 Q What time frame are we talking about 12:04:37
21 here? 12:04:42
22 A I became a postdoctoral researcher in 12:04:43

1 2010, in September. And I continued in that role 12:04:46
2 until 2013 in March. And the years are given in 12:04:51
3 the preceding paragraph, although the months that 12:04:58
4 I've just provided are not. 12:05:06
5 Q The first sentence mentions silicon solar 12:05:06
6 cells. 12:05:11
7 Do you see that? 12:05:11
8 A Yes. 12:05:12
9 Q Can you elaborate on what silicon solar 12:05:12
10 cells are? 12:05:15
11 A Yes. What I'm referring to in this 12:05:16
12 section, and what I elaborate on in the background 12:05:18
13 section of my declaration, is solar cells based on 12:05:22
14 a silicon wafer, which is a slab of silicon to 12:05:26
15 which subsequent process steps are performed, 12:05:33
16 including diffusions, additions of layers such as 12:05:38
17 passivation layers or deposited emitters, addition 12:05:42
18 of metal contacts and so forth to turn that 12:05:48
19 silicon wafer into a functioning solar cell. 12:05:52
20 That's what I'm talking about when I say silicon 12:05:56
21 solar cells. 12:05:58
22 Q Other than silicon solar cells, are there 12:05:59

1 any other types of solar cells? 12:06:05
2 A Yes. 12:06:08
3 Q Can you tell me what they are? 12:06:08
4 A Sure. Solar cells have historically been 12:06:10
5 made with other what we call absorber materials, 12:06:14
6 that is the primary layer responsible for 12:06:17
7 absorbing light. 12:06:20
8 Q Would that be the wafer -- I'm sorry. 12:06:22
9 A That is the wafer for a silicon solar 12:06:24
10 cell, that's correct. 12:06:27
11 Q Thank you. Please continue. 12:06:27
12 A For -- for other types of solar cells, 12:06:30
13 cadmium telluride has been used as an absorber 12:06:33
14 layer, so has gallium arsenide, so has a mixture 12:06:40
15 of copper, indium, gallium, and selenium, which is 12:06:45
16 commonly referred to as CIGS, C-I-G-S, for short. 12:06:52
17 Amorphous silicon, which is not a wafer 12:07:00
18 but is a deposited thin film of silicon in an 12:07:02
19 amorphous state, has also been used as an 12:07:08
20 absorber. These are amongst the most common types 12:07:13
21 of solar cells, and solar cells are commonly 12:07:14
22 referred to by their absorber. 12:07:18

1 So a cadmium telluride solar cell is how 12:07:22
2 a POSITA, for instance, would refer to a solar 12:07:28
3 cell at a cadmium telluride absorber layer. 12:07:31
4 Silicon solar cell is how a POSITA would refer to 12:07:37
5 a solar cell that has crystalline silicon 12:07:41
6 wafer-based absorber. 12:07:43
7 Q So a solar cell using amorphous silicon 12:07:44
8 as the wafer would be called amorphous silicon 12:07:49
9 solar cell? 12:07:53
10 Is that right? 12:07:53
11 A That's correct. 12:07:55
12 Q And a POSITA would understand that that 12:07:55
13 means something different than a silicon solar 12:07:57
14 cell. Right? 12:08:01
15 A That's correct. The language that you've 12:08:02
16 used was the common language and has been the 12:08:04
17 common language for referring to those two types 12:08:07
18 of solar cells. 12:08:11
19 Q Were silicon solar cells the most common 12:08:12
20 type of solar cell in the market at the time of 12:08:16
21 your postdoctoral research? 12:08:19
22 A Yes. 12:08:22

1 Q What about in 2008? 12:08:22
2 A Yes. 12:08:26
3 Q At the bottom of Page 4, last line, you 12:08:26
4 mention an article titled "Current losses at the 12:08:34
5 front of silicon heterojunction solar cells." 12:08:38
6 Do you see that? 12:08:41
7 A Yes, I do. 12:08:41
8 Q What is a heterojunction solar cell? 12:08:43
9 A A heterojunction solar cell, and more 12:08:47
10 specifically a silicon heterojunction solar cell, 12:08:50
11 is a particular flavor of silicon solar cell. So 12:08:54
12 like all silicon solar cells, it's based on a 12:08:59
13 silicon wafer, and the layers added to the front 12:09:03
14 and rear surface place it in this subset that we 12:09:11
15 call silicon heterojunction solar cells. 12:09:14
16 In particular the heterojunction refers 12:09:18
17 to the deposition of amorphous silicon thin-film 12:09:20
18 layers, including an emitter and back-surface 12:09:25
19 field onto the wafer to form the silicon 12:09:29
20 heterojunction. 12:09:33
21 In fact, silicon heterojunction is 12:09:35
22 shorthand for amorphous silicon crystalline 12:09:37

1 silicon heterojunction solar cell. 12:09:42
2 And in these solar cells it is important 12:09:47
3 to note that the amorphous silicon is not the 12:09:50
4 absorber layer, it is the crystalline silicon. 12:09:53
5 That is to say, these are a class of silicon cell, 12:09:56
6 not amorphous silicon cells. 12:10:00
7 Q Does the heterojunction solar cell 12:10:05
8 include more than one emitter? 12:10:09
9 A No. Solar cells commonly include one 12:10:10
10 emitter. An emitter is a layer that is oppositely 12:10:14
11 doped from the absorber or, in a silicon solar 12:10:17
12 cell, a wafer. I elaborate this on the background 12:10:21
13 section of my declaration. 12:10:24
14 And a silicon heterojunction includes one 12:10:27
15 emitter, one layer that is oppositely doped the 12:10:30
16 wafer. 12:10:34
17 Q You said earlier silicon heterojunction 12:10:37
18 is shorthand for amorphous silicon crystalline 12:10:44
19 silicon heterojunction solar cell. 12:10:47
20 Where does the crystalline silicon come 12:10:51
21 into play? 12:10:54
22 A That refers to the wafer. 12:10:56

1 Q You also said heterojunction solar cell 12:11:04
2 is a particular flavor of silicon solar cells. 12:11:07
3 Are there other flavors of silicon solar cells? 12:11:10
4 A Yes. 12:11:14
5 Q Can you tell me -- 12:11:17
6 A If you refer to -- one moment, please. 12:11:18
7 Beginning on Page 70 -- excuse me, Paragraph 74 of 12:12:04
8 my declaration, I describe some of the evolution 12:12:07
9 of silicon solar cell technology. And as 12:12:12
10 additional features were added to silicon solar 12:12:21
11 cells, they were commonly grouped or referred to 12:12:24
12 by shorthand names for a particular flavor of 12:12:29
13 silicon solar cell, like the silicon 12:12:33
14 heterojunction. 12:12:36
15 Other common versions would include an 12:12:37
16 aluminum BSF solar cell -- 12:12:39
17 Q I'm sorry, where are you reading from? 12:12:42
18 A Oh, I'm elaborating on the information 12:12:44
19 rooted in Section B of my background, Overview of 12:12:50
20 Solar Cell Efficiency. And I'm answering your 12:12:56
21 question about other types or flavors of silicon 12:12:59
22 solar cell. 12:13:03

1 Q Where are you -- can you direct me to 12:13:08
2 where it says aluminum BSF solar cell? 12:13:11
3 A I wasn't referring to a particular 12:13:17
4 paragraph when I mentioned aluminum BSF. I was 12:13:19
5 answering your question about types or flavors of 12:13:22
6 silicon solar cell. And the underlying physical 12:13:27
7 principles of an aluminum BSF solar cell and the 12:13:34
8 other types of solar cells that I was going to 12:13:40
9 describe in answering your question are rooted in 12:13:42
10 this Section B of the background of my 12:13:45
11 declaration, which describes improvements to solar 12:13:50
12 cells over time. 12:13:54
13 For example, to reduce recombination, 12:13:56
14 which is described in detail in this section. 12:14:00
15 Q Okay. So we talked about heterojunction 12:14:08
16 solar cells, aluminum BSF solar cells. What other 12:14:14
17 flavors are there? 12:14:18
18 A Another flavor of solar cell was referred 12:14:22
19 to as a PERC solar cell, P-E-R-C, passivated 12:14:24
20 emitter and rear. Passivation referring to the 12:14:32
21 process of reducing surface recombination, and you 12:14:35
22 find that in this section of my declaration. 12:14:39

1 Q Do heterojunction solar cells always 12:14:46
2 include an amorphous silicon thin film layer? 12:14:50
3 A They traditionally do. As I mentioned, 12:14:57
4 heterojunction silicon solar cell has been adopted 12:15:01
5 by the community as shorthand for amorphous 12:15:03
6 silicon crystalline silicon heterojunction solar 12:15:07
7 cell. 12:15:11
8 Q Is there a homojunction silicon solar 12:15:11
9 cell as well? 12:15:14
10 A Yes. There are multiple flavors of 12:15:19
11 silicon homojunction solar cell. We recently 12:15:24
12 discussed aluminum, BSF, and PERC solar cells. 12:15:28
13 These would be types of homojunction solar cell. 12:15:32
14 Q When you say "silicon solar cell," would 12:15:36
15 a person of ordinary skill in the art typically 12:15:43
16 understand that to be a homojunction solar cell? 12:15:46
17 MR. SELWYN: Objection. Form. 12:15:50
18 A No, not necessarily. A silicon solar 12:15:56
19 cell, as I described previously, is one in which 12:16:00
20 the absorber is a silicon wafer. 12:16:01
21 Q In 2008 would you say there were more 12:16:04
22 homojunction solar cells in the market than 12:16:14

1 heterojunction solar cells? 12:16:18
2 A Yes. 12:16:20
3 MR. SELWYN: Objection. Form. 12:16:21
4 A Yes. 12:16:22
5 Q Are there different types of 12:16:22
6 heterojunction solar cells, different flavors, so 12:16:34
7 to speak? 12:16:38
8 MR. SELWYN: Objection. Form. 12:16:38
9 A Can you elaborate on perhaps what aspects 12:16:45
10 might be different or what you're interested in? 12:16:48
11 Q For example, heterojunction with 12:16:50
12 intrinsic thin layer, or HIT cells, are one type 12:16:55
13 of heterojunction cells. Right? 12:17:00
14 A In fact, most heterojunctions included an 12:17:04
15 intrinsic thin layer, also of amorphous silicon. 12:17:09
16 So a heterojunction solar cell again 12:17:14
17 includes a junction between two dissimilar 12:17:17
18 materials; that is to say amorphous silicon on one 12:17:21
19 side and crystalline silicon on the other. 12:17:24
20 The amorphous silicon was commonly added 12:17:27
21 as multiple layers, at least one of which was 12:17:32
22 intrinsic. 12:17:37

1 So when a POSITA referenced a 12:17:38
2 heterojunction solar cell, the -- they commonly 12:17:42
3 understood that to include or likely include an 12:17:48
4 intrinsic layer. The HIT, heterojunction with 12:17:52
5 intrinsic thin layer, is a trade name introduced 12:17:56
6 by Sanyo in particular. 12:18:00
7 Q Would it be accurate to say then that HIT 12:18:08
8 cells and heterojunction cells can be used 12:18:15
9 interchangeably? 12:18:17
10 MR. SELWYN: Objection. Form. 12:18:19
11 A HIT cells, HIT, that wording, refers to a 12:18:24
12 specific Sanyo, later acquired by Panasonic, 12:18:28
13 trademark and trade name for a product, and it is 12:18:33
14 an instance of a silicon heterojunction solar 12:18:36
15 cell. 12:18:40
16 So if you were to look, for example, at 12:18:41
17 the academic literature or what other companies 12:18:42
18 may have been doing, they didn't call it a HIT 12:18:46
19 solar cell generally unless they were talking 12:18:49
20 about Sanyo, later Panasonic's, product. 12:18:51
21 Q Let's go to Paragraph 10 of the '053 12:18:58
22 declaration. 12:19:02

1 A Okay. 12:19:06
2 Q In this paragraph you talk about your 12:19:07
3 research interests as a professor. Correct? 12:19:08
4 A Yes. 12:19:13
5 Q Is this referring to research you are 12:19:14
6 currently conducting? 12:19:16
7 A I do have an active research group at the 12:19:20
8 moment, but this paragraph describes my research 12:19:22
9 interests in the past 12 years as while I've been 12:19:27
10 a professor. And so my research interests and 12:19:33
11 focus areas have evolved over that time, and this 12:19:37
12 paragraph is describing the breadth of those 12:19:40
13 research interests. 12:19:43
14 Q Does the paragraph include your current 12:19:46
15 research interests? 12:19:48
16 A Yes, it does. 12:19:49
17 Q Let's cover these research interests, 12:19:50
18 starting with "Contacts to solar cells." 12:19:58
19 Can you elaborate on what that means? 12:20:01
20 A Yes. What I'm referring to there is the 12:20:03
21 physics and material science of layers that are 12:20:07
22 added to the surface of silicon solar cells or 12:20:12

1 other types of solar cells or materials that are 12:20:16
2 diffused into the surface, the wafer surface of 12:20:21
3 silicon solar cells or other types of solar cells, 12:20:25
4 in order to extract electrons at one location and 12:20:29
5 holes at another location as is necessary for a 12:20:32
6 solar cell to function. 12:20:36
7 Q What types of solar cells do you 12:20:39
8 typically use in this research? 12:20:45
9 A If you look at my publications in I 12:20:54
10 believe it's Appendix A, you will find that we 12:20:56
11 have done -- my research group has done research 12:21:00
12 on contacts to silicon solar cells, also to 12:21:04
13 cadmium telluride solar cells, and also to 12:21:09
14 Perovskite solar cells. 12:21:16
15 Q Can you tell me what Perovskite solar 12:21:17
16 cells are? 12:21:27
17 A Yes. I previously mentioned absorber 12:21:27
18 materials, including silicon, cadmium telluride, 12:21:31
19 CIGS, and gallium arsenide. 12:21:36
20 In the last decade additional -- an 12:21:40
21 additional absorber material has attracted the 12:21:43
22 interest of the academic first and subsequently 12:21:48

1 industry of solar cells. And it's called 12:21:54
2 Perovskite, which is named after a Polish 12:21:58
3 researcher. It refers to a particular crystal 12:22:00
4 structure. And that material is used as an 12:22:05
5 absorber layer. 12:22:12
6 And a common -- commonly researched 12:22:15
7 Perovskite material is methyl ammonium lead 12:22:19
8 iodide. That is one example, but the word 12:22:23
9 "Perovskite" refers to a family of materials that 12:22:27
10 have the same crystal structure as, for example, 12:22:29
11 that material. 12:22:32
12 Q Next is "interconnection of solar cells." 12:22:38
13 Can you tell me what that means? 12:22:47
14 A Yes. As I describe, I believe, at the 12:22:52
15 very beginning of the Technology Background 12:23:01
16 section of my declaration, in the Overview of 12:23:04
17 Solar Cells section, solar cells are commonly 12:23:09
18 wired together. This process is called 12:23:14
19 interconnection. So that multiple solar cells are 12:23:19
20 connected in series, which increases the voltage, 12:23:21
21 or in parallel, which increases the current. And 12:23:26
22 that these are commonly then packaged, for 12:23:29

1 example, with a piece of glass on the front and 12:23:35
2 what we call a back sheet, a polymeric layer on 12:23:38
3 the back, to form a module or panel. 12:23:41
4 And so interconnection refers to the 12:23:46
5 process by which one solar cell is electrically 12:23:47
6 connected or wired to another solar cell. 12:23:53
7 Q Is it accurate to say that a module of 12:23:59
8 solar cells is I guess a group of solar cells? 12:24:05
9 MR. SELWYN: Objection. Form. 12:24:09
10 A A module comprises more than just a group 12:24:13
11 of solar cells, but a module contains a group of 12:24:17
12 solar cells. 12:24:23
13 And I suppose I should clarify I'm using 12:24:26
14 "comprise" in the nonlegal sense as -- in that 12:24:29
15 sentence. I can clarify, perhaps. 12:24:33
16 A module has solar cells, but more than 12:24:36
17 just a group of solar cells. 12:24:39
18 Q Have you heard of the term "array of 12:24:41
19 solar cells" before? 12:24:46
20 A Yes. 12:24:49
21 Q Does it mean the same thing as a module? 12:24:51
22 A No. Actually, the word "array" is more 12:24:55

1 commonly used for modules or panels than for 12:24:59
2 cells. 12:25:06
3 So if a POSITA refers to a solar array, 12:25:07
4 they are then typically referring to a collection 12:25:10
5 of solar panels, each of which contains a 12:25:12
6 collection, or grouping, to use your word, of 12:25:16
7 solar cells. 12:25:19
8 Q A collection of solar cells would be more 12:25:20
9 accurate than grouping of solar cells. Right? 12:25:23
10 MR. SELWYN: Objection. Form. 12:25:26
11 A Either one is acceptable. 12:25:30
12 Q Next on the list is "light management in 12:25:35
13 silicon solar cells." 12:25:40
14 Can you tell me a bit more about that? 12:25:41
15 A Yes. Optimally all of the light incident 12:25:46
16 upon, let's say, a silicon solar cell that is 12:25:51
17 above -- excuse me, that has photon energies 12:25:57
18 exceeding the band gap energy of silicon -- and I 12:26:02
19 can come back in a moment to explain that if you 12:26:07
20 would like -- should be absorbed in the silicon 12:26:08
21 wafer and not in surrounding layers such as an 12:26:10
22 emitter. 12:26:17

1 And when that is done, then the solar 12:26:18
2 cell generates its maximum current. And if its 12:26:21
3 current is maximized, its efficiency will 12:26:24
4 increase. 12:26:27
5 So light management in silicon solar 12:26:28
6 cells is about maximizing the amount of useful 12:26:31
7 light that can be absorbed in the wafer, showing 12:26:33
8 that it's not, we use the word "parasitically" 12:26:38
9 absorbed elsewhere in the solar cell. 12:26:42
10 Q Next is "silicon-based tandem solar 12:26:45
11 cells." 12:26:58
12 Can you tell me more about that? 12:26:58
13 A Yes. Silicon solar cells alone, if 12:27:00
14 they're operating under typical conditions on 12:27:05
15 earth, have a maximum theoretical efficiency of 12:27:11
16 just under 30 percent. That means they can 12:27:18
17 convert 30 percent of the power in incoming light 12:27:21
18 to electrical power. Only 30 percent. 12:27:26
19 One way to increase the efficiency 12:27:30
20 further in the history of solar is one of 12:27:33
21 increasing efficiency, is to put a solar cell 12:27:38
22 having a different material and different band 12:27:44

1 gap -- I brought that word up before -- on top of 12:27:47
2 silicon, where that second material, second solar 12:27:51
3 cell, beneficially absorbs and converts into 12:27:58
4 electricity the visible light, passes through it 12:28:01
5 the infrared light, which is then absorbed and 12:28:05
6 beneficially converted into electricity by silicon 12:28:09
7 solar cell. 12:28:12
8 So these two, and it could be more than 12:28:14
9 two, but two solar cells working together are 12:28:16
10 called a tandem. And one example would be a 12:28:19
11 Perovskite silicon tandem, where the top cell, we 12:28:24
12 call it, the one closer to the sun, is Perovskite, 12:28:28
13 and the bottom cell, we call it, is silicon. 12:28:32
14 Q You said if silicon solar cells are 12:28:39
15 operating under typical conditions on earth they 12:28:51
16 have an efficiency of just under 30 percent. 12:28:53
17 What are typical conditions on earth? 12:28:56
18 A Yes, so what I meant by that is that, in 12:29:01
19 order to define an efficiency and be able to 12:29:04
20 compare the efficiency of my solar cell in my 12:29:08
21 laboratory with your solar cell in your 12:29:11
22 laboratory, we have to agree upon similar 12:29:14

1 measurement conditions. 12:29:17
2 And so since I believe about the 1990s -- 12:29:20
3 it may have been earlier I'm not exactly sure -- 12:29:27
4 the standard conditions for measurement have been 12:29:30
5 what we call AM 1.5G. AM stands for air mass. G 12:29:32
6 stands for global. So air mass 1.5 global. 12:29:41
7 This is a set of illumination conditions. 12:29:46
8 It specifies a spectrum and an intensity of that 12:29:48
9 spectrum under which measurements are done in 12:29:52
10 laboratory environments. Because in the real 12:29:55
11 world outside it could be dusk, it could be noon 12:29:58
12 in Arizona, a person could -- a solar cell could 12:30:04
13 be in space on its way to Venus. The illumination 12:30:08
14 conditions could vary, and the functional 12:30:11
15 efficiency of the solar cell vary. 12:30:14
16 So what I was referring to when I said 12:30:15
17 silicon has a efficiency, theoretical efficiency 12:30:18
18 limit just under 30 percent, is under the 12:30:23
19 standardized measurement conditions that the field 12:30:29
20 has adopted. 12:30:32
21 Q Did silicon-based tandem cells exist in 12:30:32
22 2008? 12:30:45

1 A I'm not sure. Perovskite silicon tandem 12:31:00
2 solar cells did not exist, but Perovskites are not 12:31:07
3 the only type of material that you can use in 12:31:10
4 conjunction with silicon in a tandem. 12:31:12
5 I can't offhand think of a report of a 12:31:18
6 different silicon-based tandem. But the 12:31:25
7 literature is vast, and it may be that there were 12:31:28
8 demonstrations prior to 2008. 12:31:32
9 Q Would it be accurate to say that tandem 12:31:41
10 cells are heterojunction cells? 12:31:43
11 A No. Heterojunction, and in particular 12:31:49
12 silicon heterojunction, refers to the flavor of 12:31:56
13 the -- of a silicon cell. A tandem cell is a 12:32:00
14 silicon cell plus another type of solar cell. 12:32:04
15 Q Let's go to Paragraph 16 of the '053 12:32:16
16 declaration. 12:32:18
17 A Okay, I am there. 12:32:19
18 Q Here you talk about founding three 12:32:20
19 companies. Correct? 12:32:23
20 A Yes. 12:32:27
21 Q You first talk about the company Beyond 12:32:27
22 Silicon. You state that this company is 12:32:30

1 developing Perovskite/silicon tandem solar cells. 12:32:32
2 Do you see that? 12:32:36
3 A Yes. 12:32:37
4 Q Is there something novel about this 12:32:37
5 Perovskite/silicon tandem solar cell that you were 12:32:48
6 developing? 12:32:55
7 MR. SELWYN: Objection. Form. 12:32:55
8 A The company is developing novel 12:32:56
9 structures, materials and processes for the 12:33:00
10 fabrication and manufacture of Perovskite silicon 12:33:04
11 tandem solar cells, yes. 12:33:08
12 Q Is it accurate to say that the 12:33:10
13 Perovskite/silicon tandem solar cell you're 12:33:25
14 talking about in this paragraph is the same as a 12:33:28
15 silicon-based tandem cell? 12:33:31
16 MR. SELWYN: Objection. Form. 12:33:36
17 A The Perovskite/silicon tandem solar cell 12:33:38
18 I am referring to in this paragraph is an instance 12:33:44
19 of a silicon-based tandem solar cell. 12:33:45
20 Q Has Beyond Silicon developed any products 12:33:48
21 that went into manufacturing? 12:33:53
22 A Not yet. 12:33:56

1 Q Does Beyond Silicon have any patents? 12:33:58
2 A Beyond Silicon is the exclusive -- has an 12:34:06
3 exclusive license to a granted patent from Arizona 12:34:10
4 State University, where the co-founders of Beyond 12:34:17
5 Silicon were inventors on that patent while at the 12:34:22
6 university. 12:34:25
7 Q The cofounders would include you. Right? 12:34:30
8 A That is correct. 12:34:32
9 Q So you are an inventor on the patent we 12:34:33
10 just talked about. Right? 12:34:37
11 A That is correct. 12:34:39
12 Q As a founder, what was your role in 12:34:39
13 Beyond Silicon? 12:34:44
14 A What is my role now or what has it been 12:34:46
15 since 2021? 12:34:49
16 Q Can you tell me about both? 12:34:50
17 A Sure. Since the beginning of the company 12:34:54
18 I have primarily contributed to its technology 12:35:00
19 strategy and its business-development efforts. So 12:35:04
20 that means understanding potential customers, 12:35:08
21 understanding market dynamics, understanding 12:35:13
22 potential entry points for the product that it's 12:35:15

1 developing, and shaping the development pathway of 12:35:20
2 its products accordingly. 12:35:25
3 However, being a founder means also 12:35:28
4 sometimes being the janitor at the company and 12:35:32
5 doing all sorts of other odds and ends as well. 12:35:35
6 Q Were you just talking about your role as 12:35:44
7 a founder in the initial stages of the company? 12:35:45
8 A I was describing the scope of my 12:35:51
9 contributions since 2021, including at present. 12:35:56
10 Q So you still have an active role in 12:36:04
11 Beyond Silicon today. Right? 12:36:06
12 A I do, primarily in business development 12:36:09
13 and technology strategy. 12:36:11
14 Q Next is the company SunFlex Solar. You 12:36:12
15 state that this company develops interconnected 12:36:22
16 back-contact solar cells. 12:36:26
17 Do you see that? 12:36:28
18 A Yes. 12:36:30
19 Q Can you tell me about interconnected 12:36:34
20 back-contact solar cells? 12:36:38
21 A Yes. The company doesn't make 12:36:41
22 back-contact solar cells, it makes the 12:36:44

1 interconnection method and the associated 12:36:46
2 materials. 12:36:49
3 So it purchases back-contact solar cells, 12:36:50
4 which are a particular flavor of silicon solar 12:36:55
5 cells. And it has developed materials and methods 12:37:00
6 for wiring them together, as we discussed 12:37:07
7 previously, interconnecting them. 12:37:09
8 In this case rather than wires as you 12:37:12
9 might traditionally think of them, the metal used 12:37:15
10 to connect one solar cell to adjacent solar cells 12:37:20
11 is aluminum foil. And the method by which the 12:37:24
12 aluminum foil is attached to the solar cell is 12:37:29
13 not, for example, with a soldering iron, but using 12:37:33
14 a laser welding process. 12:37:36
15 Q Can you tell me a bit more about what 12:37:40
16 back-contact solar cells are? 12:37:44
17 A Yes. A back-contact solar cell is one in 12:37:50
18 which the metal electrodes or metal contacts that 12:38:07
19 collect electrons and collect holes are both on 12:38:12
20 the back or rear or nonsunward side of the solar 12:38:17
21 cell. 12:38:27
22 Q Are back-contact solar cells typically 12:38:27

1 heterojunction cells? 12:38:31
2 A Not necessarily. Back-contact refers to 12:38:33
3 the arrangement of the metal contacts, as just 12:38:39
4 described. And heterojunction refers to layers 12:38:42
5 that are in contact with the wafer, namely 12:38:47
6 amorphous silicon layers. 12:38:52
7 So there are heterojunction back-contact 12:38:53
8 solar cells, there are also homojunction 12:38:56
9 back-contact solar cells. There are 12:38:59
10 heterojunction solar cells that are not 12:39:02
11 back-contact but have metal contacts on both 12:39:04
12 sides, and there are homojunction solar cells that 12:39:08
13 are not back-contact. 12:39:12
14 Q Were back-contact solar cells common in 12:39:15
15 2008? 12:39:18
16 A Can you elaborate by what you mean by 12:39:23
17 "common"? 12:39:25
18 Q Common in the market in 2008? 12:39:26
19 MR. SELWYN: Objection. Form. 12:39:34
20 A Back-contact solar cells were 12:39:38
21 commercially available in the market in 2008, and 12:39:41
22 they were a known technology at least in the 12:39:44

1980s, if not earlier. They were not the most 12:39:49
common solar cell available in the market in 2008. 12:39:56
Q What was the most common solar cell 12:40:03
available in the market in 2008? 12:40:08
A It would -- 12:40:10
MR. SELWYN: Objection. Form. 12:40:11
A The most prevalent solar cell in 2008 12:40:15
that you could commercially buy would be a silicon 12:40:19
solar cell that had contacts on its front and rear 12:40:21
side. And it would be a silicon homojunction 12:40:25
solar cell. 12:40:30
Many others were available, but that was 12:40:31
most found. 12:40:32
Q Is there a name for a solar cell with 12:40:35
contacts on front and rear side? 12:40:39
A In my declaration I believe I call them 12:40:45
both side contacted solar cells. That's an 12:40:50
accurate naming, but not one that would commonly 12:40:56
be used, say, in 2008. 12:40:59
Typically they would just be called 12:41:02
silicon solar cells, and one would refer to a 12:41:05
back-contact solar cell by adding words like 12:41:07

1 back-contact if one were specifying that the 12:41:12
2 contacts were on the back side. 12:41:15
3 Q Has SunFlex Solar developed any products 12:41:18
4 that went into manufacturing? 12:41:28
5 A SunFlex Solar has developed -- 12:41:30
6 MR. SELWYN: Let me just, we don't have a 12:41:32
7 Protective Order or confidentiality or, so what 12:41:33
8 you say will be in a potentially public 12:41:37
9 transcript. 12:41:42
10 Jing, I don't know if you are searching 12:41:45
11 for anything more than just general public 12:41:46
12 information, but I just caution the witness. 12:41:48
13 MS. ZHAO: I'm not searching for anything 12:41:51
14 more than public information. 12:41:52
15 Q So feel free to answer to the extent that 12:41:55
16 you can. 12:41:57
17 A Okay. Thank you for that clarification. 12:41:58
18 SunFlex Solar has developed products that 12:42:04
19 have been in pilot production but not yet for 12:42:07
20 commercial sale. 12:42:10
21 Q And can you tell me about your role in 12:42:10
22 SunFlex Solar? 12:42:15

1 A Yes. Quite similar to my role in Beyond 12:42:16
2 Silicon, I primarily focus on business development 12:42:21
3 and technology strategy. That means I'm often the 12:42:24
4 person interacting with prospective customers and 12:42:27
5 understanding what their needs are and whether or 12:42:32
6 not SunFlex Solar has either the technology 12:42:35
7 already developed or the potential to develop the 12:42:38
8 technology and have a competitive advantage in 12:42:44
9 meeting their needs. 12:42:45
10 Q I have the same questions for the third 12:42:46
11 company, Swift Coat. Can you tell me what Swift 12:42:53
12 Coat does? 12:43:01
13 A Yes. Swift Coat is a coatings technology 12:43:02
14 company. A coating is a thin layer that gets 12:43:07
15 added to a substrate. 12:43:11
16 Most of the coatings that Swift Coat has 12:43:16
17 developed are deposited on glass, and they are 12:43:18
18 used in the solar module market on the front glass 12:43:23
19 or in architectural glass or other applications of 12:43:29
20 glass. 12:43:35
21 The product that Swift Coat has focused 12:43:36
22 on most has been antireflection coatings on glass. 12:43:38

1 And when I said it's a coatings technology 12:43:44
2 company, I mean that it develops equipment and 12:43:47
3 processes on -- with that equipment to provide its 12:43:50
4 customers with full coating solutions. 12:43:54
5 Q You said a coating is a thin layer that 12:43:57
6 gets added to a substrate, but in your company the 12:44:06
7 coating is used on glass that is not directly on 12:44:12
8 the substrate. Right? 12:44:15
9 A We use the word "substrate" in our field 12:44:18
10 to refer generally to something to which layers 12:44:20
11 may be added. 12:44:24
12 So a substrate need not exclusively refer 12:44:26
13 to a silicon wafer. When we're talking about 12:44:30
14 silicon solar cells, it would be common for a 12:44:33
15 POSITA to use substrate, wafer, interchangeably. 12:44:35
16 But in other fields, including solar modules, a 12:44:41
17 substrate could refer to a piece of glass, it 12:44:44
18 could refer to a piece of paper, a piece of 12:44:47
19 aluminum foil. It is any literally substrate to 12:44:51
20 which things may be added. 12:44:55
21 Q And has Swift Coat developed any products 12:44:57
22 that went into manufacturing? 12:45:02

1 A Swift Coat is at the moment right now 12:45:06
2 transitioning its equipment and process into 12:45:11
3 manufacturing with a customer. It is on the cusp 12:45:15
4 or transition of manufacturing. 12:45:19
5 Q And can you tell me about your role in 12:45:22
6 Swift Coat? 12:45:25
7 A Yes. Similar to the other two companies, 12:45:27
8 I have focused on business development and 12:45:30
9 technology strategy, which means customer 12:45:33
10 engagement, identifying opportunities where Swift 12:45:36
11 Coat's technology may generate value, and then 12:45:42
12 aligning the company's development efforts with 12:45:44
13 those customer needs and other business 12:45:47
14 opportunities. 12:45:50
15 MS. ZHAO: I am about to dive into 12:45:56
16 another section. Are you doing okay, do you want 12:45:58
17 a five-minute break? 12:46:02
18 THE WITNESS: I'm fine to proceed. 12:46:05
19 Thanks for asking. 12:46:06
20 Q Okay. Let's go to Paragraph 43 of the 12:46:09
21 '053 declaration. 12:46:12
22 A Okay. 12:46:22

1 Q Second sentence of this paragraph states, 12:46:23
2 "A solar cell is typically made of a slab of 12:46:25
3 silicon, called a wafer, and thin layers added to 12:46:28
4 each side of the wafer." 12:46:33
5 Do you see that? 12:46:34
6 A Yes, I do. 12:46:35
7 Q Then you talk about three forms of 12:46:35
8 silicon in this paragraph. Correct? 12:46:39
9 A Yes. I say that silicon can come in 12:46:53
10 different forms, and I elaborate on three examples 12:46:55
11 starting with, "For example, silicon can be 12:47:00
12 monocrystalline." I also talk about 12:47:04
13 polycrystalline as another example and amorphous 12:47:06
14 silicon as a third example of the forms of 12:47:10
15 silicon. 12:47:12
16 Q And at the end of this paragraph on the 12:47:14
17 next page you state, "These three types of silicon 12:47:16
18 have long been used in solar cells." 12:47:19
19 Do you see that? 12:47:22
20 A Yes, I do. 12:47:25
21 Q When you say "used in solar cells" here, 12:47:26
22 do you mean used as wafers? 12:47:28

1 A Not necessarily. The words are carefully 12:47:32
2 chosen to be accurate. Monocrystalline silicon 12:47:35
3 has been used as a wafer. Polycrystalline 12:47:40
4 silicon, also called multicrystalline silicon, has 12:47:45
5 been used as a wafer; but it's also been used as 12:47:49
6 added or deposited layers. 12:47:52
7 Amorphous silicon has not been used as a 12:47:56
8 wafer. Wafers are free-standing things that you 12:47:57
9 can hold in your hand. That's not the case for 12:48:00
10 amorphous silicon. Amorphous silicon has been 12:48:03
11 deposited as a layer. That could be on a wafer, 12:48:06
12 could also be on a piece of glass. This is what I 12:48:10
13 mean when I say all three types have been used in 12:48:13
14 solar cells. 12:48:16
15 Q Earlier we talked about amorphous silicon 12:48:17
16 solar cells as sort of a flavor of solar cell. 12:48:28
17 Do you remember? 12:48:31
18 A Yes. 12:48:32
19 Q So just to clarify, when you say 12:48:32
20 "amorphous silicon solar cells," you are referring 12:48:39
21 to the use of amorphous silicon not as a wafer. 12:48:40
22 Right? 12:48:45

1 A Correct. I'm referring it -- I'm 12:48:46
2 referring to amorphous silicon as the absorber. 12:48:48
3 So again, to clarify, and repeating what 12:48:54
4 I said previously, solar cells were commonly named 12:48:58
5 after their absorber. The function of the 12:49:01
6 absorber is to absorb the light and generate 12:49:05
7 electron-hole pairs that will then be collected at 12:49:10
8 the metal contacts to generate electricity. So an 12:49:13
9 amorphous silicon solar cell is one that has an 12:49:16
10 amorphous silicon absorber. 12:49:19
11 However, we don't call that absorber a 12:49:21
12 wafer in the case of amorphous silicon, because a 12:49:24
13 wafer is something that you can hold in your 12:49:27
14 hands, that is free-standing; and amorphous 12:49:31
15 silicon doesn't come in that -- that form. 12:49:35
16 Q Let's go to Paragraph 53. 12:49:40
17 A Okay. 12:49:58
18 Q Starting on Line 2 you state that 12:49:58
19 "Diffusion involved driving dopant atoms from a 12:50:01
20 dopant source into a silicon wafer or a 12:50:05
21 polysilicon wafer at high temperatures in a 12:50:10
22 furnace." 12:50:13

1 Do you see that? 12:50:13
2 A Yes. One correction. You said "into a 12:50:14
3 silicon wafer or polysilicon wafer," but I said 12:50:18
4 "into a silicon wafer or polysilicon layer." 12:50:23
5 Q You're right. I'm sorry. 12:50:27
6 What does driving dopant into something 12:50:29
7 mean? 12:50:31
8 A That refers to a process called 12:50:33
9 diffusion, in which in this case atoms move from 12:50:36
10 regions of relatively higher concentration to 12:50:42
11 regions of relatively lower concentration governed 12:50:45
12 by a process called Fick's law, F-I-C-K, Fick's 12:50:49
13 law. 12:50:55
14 And here this is the driving dopant atoms 12:50:56
15 into a silicon wafer or polysilicon layer, is a 12:51:01
16 process of purposefully diffusing impurity atoms, 12:51:05
17 dopant atoms, into the wafer or layer. 12:51:11
18 Q And what temperature are you referring to 12:51:17
19 when you say "high temperatures in a furnace"? 12:51:20
20 A That depends. It depends on the material 12:51:25
21 through which the dopant atoms are moving, or 12:51:31
22 materials. And it depends on the type of dopant 12:51:36

1 atom as well. 12:51:41
2 So one can't say specifically without 12:51:43
3 additional information. 12:51:46
4 Q Would it be accurate to say that the 12:51:50
5 temperatures could be quite different depending on 12:52:00
6 which dopant atoms and materials are used? 12:52:04
7 MR. SELWYN: Objection. Form. 12:52:09
8 A Without knowing what "quite different" 12:52:12
9 means, I couldn't answer. 12:52:15
10 I can say that there are instances 12:52:18
11 throughout my declaration and throughout the art 12:52:23
12 that I refer to that provide some diffusion 12:52:26
13 temperatures for particular instances. 12:52:30
14 For example, there are references 12:52:34
15 included, like Froitzheim, that refer to diffusion 12:52:36
16 temperature ranges of 900 to 1200 degrees Celsius, 12:52:41
17 or Gan, which refers to temperature ranges of 900 12:52:47
18 to 1000 degrees Celsius. 12:52:53
19 And regarding your most recent question, 12:52:56
20 in my background section I talk about a process 12:52:59
21 called co-diffusion, which was a process by which 12:53:02
22 multiple types of dopants were driven in in the 12:53:08

1 same process. 12:53:14
2 So while it may be the case that 12:53:16
3 different dopant atoms diffusing perhaps into the 12:53:19
4 same or different layers or wafers could be done 12:53:22
5 so at different temperatures, there are also 12:53:29
6 instances, including in my declaration, of them 12:53:32
7 being diffused or driven in at the same time. 12:53:35
8 Q So what do you mean here when you say 12:53:39
9 "high temperatures," though? 12:53:46
10 A I mean an elevated temperature. I've 12:53:52
11 just given examples from the references that 12:53:54
12 include, for example, 900 to 1200 degrees C as a 12:54:00
13 range. That would be an example of a high 12:54:04
14 temperature. But I mean an elevated temperature. 12:54:07
15 Q What is the lowest number for a 12:54:12
16 temperature that you would consider to be 12:54:19
17 elevated? 12:54:22
18 MR. SELWYN: Objection. 12:54:24
19 Q I'm just trying to understand at what 12:54:27
20 point, at what temperature, would you consider 12:54:28
21 temperature to be elevated? 12:54:30
22 MR. SELWYN: Objection. Form. 12:54:32

1 A In this instance here I'm talking about 12:54:34
2 doping, and doping was a technique that came from 12:54:37
3 the semiconductor industry from nearly 100 years 12:54:41
4 ago and was adopted by the solar industry. And so 12:54:44
5 I believe a POSITA would be very familiar with 12:54:49
6 doping. It was used and is used in every solar 12:54:54
7 cell. 12:54:58
8 And that the way to get to accelerate the 12:55:01
9 movement of dopant atoms into a wafer or layer is 12:55:04
10 to increase the temperature. 12:55:08
11 And so what I'm talking about here when I 12:55:12
12 say "high temperatures in a furnace" is decreasing 12:55:15
13 the amount of time for this diffusion process to 12:55:19
14 happen by increasing -- increasing the 12:55:21
15 temperature. And I have provided some example 12:55:27
16 ranges which appear in the references that I've 12:55:30
17 included. 12:55:34
18 But the temperature that I'm referring to 12:55:38
19 isn't meant to be limited to that. So there may 12:55:39
20 be diffusion processes that happen below 12:55:43
21 Froitzheim's 900 degrees C. But at 55 degrees 12:55:47
22 Celsius one would be waiting a very, very long 12:55:53

1 time indeed. 12:55:56
2 Q But you would not consider 55 degrees 12:56:00
3 Celsius to be a high temperature for doping or 12:56:02
4 driving dopants? 12:56:08
5 A Within the -- within the context of this 12:56:09
6 paragraph and my reference to high temperatures 12:56:11
7 for diffusion, I am not imagining 55 degrees C. I 12:56:14
8 am imagining what a POSITA would understand about 12:56:21
9 doping silicon, which is at higher temperatures 12:56:23
10 than that, yes. 12:56:27
11 Q Within the context of this paragraph, 12:56:28
12 would you consider 200 degrees C to be a high 12:56:32
13 temperature? 12:56:35
14 MR. SELWYN: Objection. Form. 12:56:39
15 A A POSITA would understand that for many 12:56:41
16 doping processes conducted in the fabrication of 12:56:44
17 silicon solar cells, 200 degrees C is not commonly 12:56:48
18 used for diffusion. 12:56:54
19 There are other ways to dope other than 12:56:57
20 diffusion. And I talk about ways, for example, of 12:57:00
21 forming an emitter without diffusion, for example 12:57:06
22 by deposited layers, that may occur, and they 12:57:12

1 commonly do occur at temperatures as low at 200 12:57:15
2 degrees C. 12:57:18
3 But this paragraph is about diffusion and 12:57:19
4 using elevated temperatures to do so. And a 12:57:23
5 POSITA would appreciate that common practice was 12:57:26
6 not to diffuse at 200 degrees C but at higher 12:57:28
7 temperatures. 12:57:33
8 Q What about 400 degrees C? 12:57:33
9 MR. SELWYN: Objection to form. 12:57:39
10 A I will stick to my answers that I've 12:57:46
11 provided, that I have given examples, for example, 12:57:47
12 from Froitzheim, that include a range of 12:57:51
13 temperatures, for example 900 to 1200 degrees C, 12:57:56
14 that lower temperatures may -- may be used. 12:58:01
15 For your specific case of 400 degrees C, 12:58:05
16 which dopant atom are you envisioning and into 12:58:11
17 which layer, and how deep would you like the 12:58:15
18 dopant to go? 12:58:17
19 Q Is there any possible combination of 12:58:21
20 dopant atom and layer and depth that would warrant 12:58:24
21 a 400 degree C diffusion? 12:58:30
22 MR. SELWYN: Objection. Form. 12:58:34

1 A For silicon solar cells in particular? 12:58:36
2 Q In the context of your Paragraph 53, are 12:58:38
3 you referring to silicon solar cells in 12:58:49
4 particular? 12:58:55
5 A The first sentence of my Paragraph 53 12:58:55
6 says that a common doping technique was diffusion 12:58:59
7 into a silicon wafer or polysilicon layer. 12:59:03
8 Yes, I'm speaking of materials found in 12:59:07
9 silicon solar cells. 12:59:10
10 Q Okay. So my question then is, is there 12:59:13
11 any possible combination of dopant atom and layer 12:59:16
12 and depth in a silicon solar cell that would 12:59:20
13 warrant a 400 degree C diffusion? 12:59:23
14 MR. SELWYN: Objection. Form. 12:59:28
15 A I would say that 400 degrees Celsius was 12:59:40
16 not a common temperature to diffuse, for example, 12:59:49
17 boron or phosphorus from a dopant source into a 12:59:54
18 polysilicon layer or silicon wafer; and that the 12:59:58
19 references that I've provided have given suitable 13:00:02
20 temperature ranges for doing so. 13:00:07
21 But there may be other instances -- I 13:00:09
22 don't have the full references -- excuse me, the 13:00:13

1 full literature at my fingertips -- for which 13:00:15
2 doping or diffusion was done at temperatures as 13:00:21
3 low as 400 degrees C. 13:00:25
4 Q I don't mean to annoy you with this, but 13:00:38
5 I am really trying to understand what "high 13:00:40
6 temperatures" means in this sentence. So I'll ask 13:00:42
7 the same question again with respect to 600 13:00:45
8 degrees C. 13:00:48
9 MR. SELWYN: Objection. Form. 13:00:50
10 A Okay. I think my answer will be the 13:00:52
11 same. I have provided suitable temperature ranges 13:00:54
12 for instances that are relevant to, for example, 13:00:59
13 the '053 patent, for example boron doping and 13:01:10
14 phosphorus doping. And a POSITA would understand 13:01:15
15 what was common processes in 2008 for doping. And 13:01:23
16 600 degrees C is similar to my answer to 400 13:01:33
17 degrees C. May have been used for select doping 13:01:38
18 or a diffusion processes, but the references that 13:01:43
19 I have provided have explained or teach a range, 13:01:48
20 for example 900 to 1200 degrees C, that in this 13:01:56
21 case is hotter than your 600 degrees C 13:02:01
22 hypothetical. 13:02:05

1 Q So in the context of Paragraph 53, you 13:02:07
2 would not consider 600 degrees C a high 13:02:09
3 temperature. 13:02:12
4 Is that right? 13:02:13
5 MR. SELWYN: Objection. Form. 13:02:15
6 A That isn't what I said. I elaborated 13:02:17
7 that in this I'm introducing a concept of doping 13:02:21
8 and what a POSITA would have known. And that a 13:02:26
9 POSITA would have known how to drive dopant atoms 13:02:30
10 from a dopant source into a silicon wafer or a 13:02:36
11 polysilicon layer. 13:02:40
12 And I described Fick's law, which has the 13:02:42
13 underlying physics of diffusion. And I described 13:02:46
14 that lower temperatures require longer times for 13:02:48
15 atoms to diffuse. Or I believe I said it in the 13:02:57
16 form of elevated or higher temperatures cause 13:03:00
17 diffusion to occur more quickly. 13:03:03
18 And so at 600 degrees C, diffusion would 13:03:07
19 be slower than, for example, at 800 degrees C. 13:03:10
20 But there may be instances in which a POSITA 13:03:15
21 wanted slower diffusion. So I would just again 13:03:18
22 ask for additional context for your hypothetical 13:03:23

1 in order to provide an answer that I'm -- I'm more 13:03:27
2 comfortable with. 13:03:32
3 Q What instance would a POSITA want slower 13:03:33
4 diffusion? 13:03:37
5 A Well, for example, if a POSITA wanted to 13:03:49
6 diffuse dopants just into the very surface of a 13:04:02
7 region, and not very deep, then slowed, controlled 13:04:06
8 diffusion would help that. 13:04:11
9 Or if a structure contained hydrogen, and 13:04:14
10 hydrogenation was known to reduce defects at grain 13:04:23
11 boundaries, hydrogen is very mobile in silicon. 13:04:28
12 And if a POSITA did not want the hydrogen to 13:04:31
13 diffuse out while dopants diffused in, then a 13:04:35
14 POSITA might choose lower temperatures and slower 13:04:38
15 diffusions. 13:04:43
16 So that would need to be understood 13:04:44
17 within the context of the solar cell structure and 13:04:46
18 aims of the fabricator. 13:04:52
19 Q Typically with silicon solar cells, would 13:04:57
20 a POSITA want to diffuse dopants just into the 13:05:02
21 very surface of a region and not very deep? 13:05:05
22 MR. SELWYN: Objection. Form. 13:05:09

1 A That depends on the particular structure 13:05:14
2 that the POSITA is making. 13:05:17
3 I describe one instance of doping in the 13:05:21
4 background section when I describe formation of 13:05:30
5 emitters. And you would find, for example, in the 13:05:35
6 literature and common knowledge to a POSITA, 13:05:37
7 shallow emitters and also selective emitters that 13:05:39
8 are only formed over part of the wafer surface. 13:05:45
9 So even within this one instance of 13:05:50
10 emitter formation, those making solar cells 13:05:53
11 sometimes wished for deeper diffusions and 13:06:00
12 sometimes wished for more shallow diffusions. 13:06:02
13 MR. SELWYN: Jing, when you get to a good 13:06:11
14 breaking point. 13:06:13
15 MS. ZHAO: Yeah, I was just thinking 13:06:14
16 that. Should we take a break now? 13:06:15
17 MR. SELWYN: Sure. Five minutes or so. 13:06:18
18 MS. ZHAO: Sounds good. 13:06:20
19 MR. SELWYN: Thank you. 13:06:22
20 THE WITNESS: Thank you. 13:06:23
21 (A recess was taken.) 13:06:24
22 BY MS. ZHAO: 13:13:33

1 Q Let's go to Paragraph 54 of the '053 13:13:34
2 declaration. 13:13:37
3 A Okay, I'm there. 13:13:44
4 Q In this paragraph you talk about 13:13:46
5 phosphorus diffusion. Right? 13:13:47
6 A Correct. 13:13:50
7 Q And you mention on Page 29, fifth line, 13:13:50
8 applying heat to drive the phosphorus into the 13:13:56
9 silicon. 13:13:59
10 Do you see that? 13:13:59
11 A Yes. 13:14:03
12 Q Typically what is the temperature of the 13:14:03
13 heat being applied here? 13:14:05
14 MR. SELWYN: Objection. Form. 13:14:09
15 A So in this particular instance I'm 13:14:12
16 talking about, again, diffusing into a silicon 13:14:14
17 wafer or a polysilicon layer. And I cite many 13:14:28
18 references at the end of this paragraph that show 13:14:35
19 this. So we can look to those references. 13:14:39
20 So, for example, Smith I believe teaches 13:14:43
21 a temperature of around 1000 degrees Celsius. 13:14:47
22 Froitzheim teaches a temperature range, as I 13:14:52

1 described previously, of 900 to 1200 degrees 13:14:56
2 Celsius. 13:15:01
3 So these are examples provided in the 13:15:02
4 references of commonly used temperatures for 13:15:06
5 performing this step. 13:15:12
6 Q Using Froitzheim as an example, what 13:15:13
7 happens if you apply heat under 900 degrees 13:15:24
8 Celsius? 13:15:27
9 A Per my previous answer, the laws of 13:15:33
10 diffusion tell us that the movement from the 13:15:38
11 dopants into the polysilicon layer or silicon 13:15:41
12 wafer will occur more slowly. 13:15:48
13 Q Would it be accurate to say, then, if you 13:15:55
14 go above 1200 degrees for Froitzheim, then the 13:16:00
15 dopant would diffuse more quickly? 13:16:09
16 MR. SELWYN: Objection. Form. 13:16:14
17 A Yes. And in general, increasing the 13:16:17
18 diffusion temperature will cause atoms to diffuse 13:16:20
19 more quickly, or equivalently deeper, for the same 13:16:25
20 amount of time. And conversely, decreasing the 13:16:30
21 temperature will cause them to diffuse more 13:16:33
22 slowly, or equivalently shallower, for the same 13:16:38

1 amount of time. 13:16:41
2 Q Could there be a situation where the 13:16:45
3 diffusion would be too shallow for a structure? 13:16:48
4 MR. SELWYN: Objection. Form. 13:16:53
5 A I'm not sure what you mean, what "too 13:16:56
6 shallow" means or what the structure is that you 13:16:59
7 have in mind. 13:17:01
8 Q For example, for Froitzheim, if I applied 13:17:01
9 heat under 900 degrees Celsius -- 13:17:05
10 MR. SELWYN: Objection. Form. 13:17:12
11 Q -- would that result in a diffusion that 13:17:13
12 would be too shallow for Froitzheim? 13:17:17
13 MR. SELWYN: Objection. Form. 13:17:21
14 A Froitzheim teaches that 900 to 1200 13:17:22
15 degrees Celsius is a suitable range for the 13:17:25
16 process and structure that he has in mind. 13:17:27
17 Froitzheim doesn't tell us what happens 13:17:31
18 if you go below 900 degrees Celsius. One would 13:17:33
19 expect, a POSITA would expect, per my previous 13:17:39
20 answer, that the diffusion would be slower. And a 13:17:42
21 POSITA would expect that if the temperature was 13:17:47
22 low enough that there would be very little 13:17:50

1 diffusion. However, what is low enough is not 13:17:56
2 specified by Froitzheim. 13:18:01
3 Q What would happen to Froitzheim's 13:18:06
4 structure if there was very little diffusion? 13:18:08
5 MR. SELWYN: Objection. Form. 13:18:13
6 A I'm turning to Froitzheim's structure. 13:18:26
7 Q And for the record, you're looking at 13:18:44
8 Exhibit 1004. Correct? 13:18:46
9 (Exhibit 1004, previously marked, not 13:18:46
10 attached.) 13:18:46
11 A I was referring to Paragraph 107 in my 13:18:51
12 declaration, which is in the overview of the prior 13:18:56
13 art section in Froitzheim, but it shows the same 13:19:00
14 structure as Exhibit 1004, yes. 13:19:02
15 Figure 3 of Exhibit 1004 particularly. 13:19:07
16 So Froitzheim teaches diffusion of N-type 13:19:12
17 dopants into the front of the wafer and P-type 13:19:21
18 dopants into the rear of the wafer. And it's 13:19:27
19 helpful to look at the purpose of those two 13:19:34
20 layers, and therefore the purpose of the two -- of 13:19:37
21 the diffusions. 13:19:40
22 And Froitzheim teaches that the N-type 13:19:43

1 diffusion at the front reduces surface 13:19:52
2 recombination and can help the formation of 13:19:59
3 low-resistance contact to the front metal 13:20:03
4 contacts. And the P-type layer at the rear is -- 13:20:08
5 forms the emitter, and an emitter is necessary for 13:20:13
6 a solar cell to function, as it must collect 13:20:17
7 electrons in one location and holes at the other. 13:20:21
8 So if -- if the P-type layer, for 13:20:24
9 example, were not diffused successfully, and so 13:20:31
10 emitter was not formed, then a solar cell, 13:20:39
11 Froitzheim solar cell, would not work. One needs 13:20:43
12 to form an emitter, for example. 13:20:46
13 Or if the N-type layer was not diffused 13:20:49
14 into the front surface of the wafer, then some of 13:20:51
15 the features of Froitzheim's solar cell, like 13:20:54
16 reduced surface recombination, would not be 13:21:01
17 realized. 13:21:04
18 Q When you say if the P-type layer were not 13:21:08
19 diffused successfully, what do you mean by that? 13:21:10
20 A I was referring to what you suggested 13:21:15
21 before, where perhaps too low a temperature or too 13:21:17
22 low -- too short a time was used to move dopants 13:21:21

1 into the wafer, or in the case of the combination 13:21:30
2 with Gan, Gan's polysilicon layer in order to form 13:21:33
3 an emitter. 13:21:39
4 Q And when you say, "If the N-type layer 13:21:40
5 was not diffused into the front surface of the 13:21:43
6 wafer," do you also mean too low of a temperature 13:21:47
7 or too short of a time might cause that? 13:21:51
8 A For example, yes. 13:21:56
9 Q The N-type layer would be from phosphorus 13:21:57
10 diffusion. Right? 13:22:07
11 A Phosphorus is one impurity atom that 13:22:13
12 results in N-type doping in silicon, and it is an 13:22:16
13 impurity atom that is taught by Froitzheim. 13:22:20
14 Q Earlier you talked about Froitzheim's 13:22:28
15 temperature range of 900 to 1200 degrees Celsius. 13:22:31
16 Correct? 13:22:37
17 A Correct. 13:22:42
18 Q Is that specifically for diffusion of the 13:22:42
19 N-type dopant? 13:22:45
20 A No. Froitzheim discusses these diffusion 13:23:15
21 temperatures, and in Paragraph 42 of Froitzheim. 13:23:22
22 And this is following Froitzheim's discussion of 13:23:30

1 the formation of a boron dopant source layer. So 13:23:33
2 Froitzheim is speaking here about the P-type 13:23:42
3 emitter in Froitzheim's cell. 13:23:47
4 And then Paragraph 43 of Froitzheim says 13:23:50
5 that the further steps for providing the front 13:23:55
6 side N plus layer, in addition to the formation of 13:24:01
7 the front and rear side contacts, can also be 13:24:03
8 conducted according to steps described in two 13:24:06
9 other patents or patent applications which 13:24:11
10 Froitzheim incorporates by reference. 13:24:14
11 Q Have you reviewed those two patents? 13:24:18
12 A I don't recognize them from their numbers 13:24:23
13 alone. I may have done. 13:24:26
14 Q Let's go to Paragraph 58 of your 13:24:31
15 declaration. 13:24:41
16 Here at the end of the paragraph you 13:24:50
17 state that, "In the field of solar cell 13:24:52
18 technology, emitter usually refers to the region 13:24:56
19 or layer that is oppositely doped from the 13:24:59
20 substrate." 13:25:01
21 Do you see that? 13:25:02
22 A Yes. 13:25:03

1 Q What is your basis for saying that? 13:25:03
2 A This is common knowledge that a POSITA 13:25:11
3 would have. It's been true for decades and comes 13:25:14
4 to solar cells from transistors, where the word 13:25:17
5 "emitter" first got its name. So this is common 13:25:24
6 knowledge that a POSITA has. 13:25:26
7 In addition, you'll find that the '053 13:25:28
8 and '516 patents also use emitter in this way, and 13:25:34
9 that in the prosecution history of the '053 and -- 13:25:40
10 patent and another patent, the '771 patent in the 13:25:46
11 same family, that Maxeon has confirmed this 13:25:51
12 meaning for the word "emitter." 13:25:57
13 Q And on the next page, Page 33, you show a 13:25:59
14 figure of Froitzheim's cell. 13:26:02
15 Do you see? 13:26:05
16 A Yes, I do. 13:26:07
17 Q According to your definition of emitter, 13:26:08
18 the dark blue layer labeled P-type layer would be 13:26:11
19 the emitter in Froitzheim. Right? 13:26:15
20 A That is correct. 13:26:20
21 Q And this emitter would have gone through 13:26:20
22 the dopant diffusion process. Right? 13:26:25

1 A Yes. Paragraphs 40 through 42 of 13:26:32
2 Froitzheim describe the formation of this emitter, 13:26:41
3 including the diffusion of dopants into it. 13:26:45
4 (Clarification by the court reporter.) 13:27:01
5 A Into it. Into the wafer, is fine. 13:27:05
6 Q So would it be accurate to call this dark 13:27:05
7 blue layer the doped silicon emitter layer? 13:27:09
8 MR. SELWYN: Objection. Form. 13:27:17
9 A I don't think those were the use -- the 13:27:21
10 words that Froitzheim uses, and those aren't the 13:27:24
11 words that a POSITA would normally use. A POSITA 13:27:27
12 would call it an emitter or a diffused emitter. 13:27:33
13 But I didn't hear anything technically inaccurate 13:27:36
14 about your statement. 13:27:39
15 Q And the light green N plus region would 13:27:41
16 not be called an emitter. Right? 13:27:45
17 A That is correct. 13:27:49
18 Q Is there a name for this N plus region? 13:27:50
19 A Yes. It's commonly called a front 13:27:58
20 surface field, if it's at the front of a solar 13:28:02
21 cell and it has the same polarity as the wafer. 13:28:07
22 And perhaps you can give me one moment as 13:28:15

1 well. So Froitzheim uses these words in Paragraph 13:28:17
2 18 of Froitzheim. When talking about the N plus 13:28:37
3 layer he identifies it as a front surface field, 13:28:42
4 which is the language that a POSITA would use as 13:28:45
5 well. 13:28:49
6 Q Is it accurate to call the structure of 13:28:52
7 Froitzheim a silicon solar cell? 13:28:54
8 A Yes. Per our earlier discussion, the 13:28:59
9 absorber is a silicon wafer, and this would be 13:29:02
10 described as a silicon solar cell. 13:29:05
11 Q Could I also describe this as a 13:29:07
12 homojunction solar cell? 13:29:13
13 A That is correct. Because the emitter is 13:29:15
14 diffused into the wafer in Froitzheim, this would 13:29:18
15 be described as a homojunction solar cell. 13:29:25
16 Q Let's go to Paragraph 61. 13:29:28
17 A Okay. 13:29:41
18 Q In this paragraph you talk about 13:29:41
19 depositing the emitter. Right? 13:29:43
20 A That's correct. 13:29:46
21 Q Does depositing an emitter turn the solar 13:29:48
22 cell into a heterojunction solar cell? 13:29:52

1 A Not necessarily. I can elaborate, if you 13:29:56
2 would like. 13:30:04
3 Q Please do. 13:30:04
4 A In particular, hetero comes from the 13:30:07
5 Greek for different. And so in a heterojunction, 13:30:10
6 the host materials on either side of the junction 13:30:13
7 are different. So amorphous silicon is different 13:30:16
8 from crystalline silicon, that is referred to as a 13:30:20
9 heterojunction. 13:30:24
10 If crystalline silicon is deposited on 13:30:24
11 crystalline silicon, then one normally does not 13:30:27
12 call that a heterojunction. 13:30:30
13 Q With a deposited emitter, would you still 13:30:36
14 need to go through dopant diffusion? 13:30:38
15 MR. SELWYN: Objection. Form. 13:30:42
16 A You may. For example, Gan and Borden 13:30:45
17 both teach deposited emitters. And I have 13:30:51
18 included those as references in my ground. And 13:30:54
19 both of them teach diffusion. 13:30:59
20 However, it may also be possible to 13:31:04
21 deposit a layer that has dopants already in the 13:31:08
22 layer as part of the deposition process. And in 13:31:11

1 that case an additional diffusion step may not be 13:31:17
2 necessary. 13:31:19
3 That, for example, is commonly done with 13:31:22
4 the deposition of amorphous silicon in silicon 13:31:24
5 heterojunction solar cells. 13:31:27
6 Q In Paragraph 61 you mention amorphous 13:31:29
7 silicon and polycrystalline silicon emitter 13:31:43
8 layers. Correct? 13:31:46
9 A Yes. I say they were well known by 2008, 13:31:48
10 and I give reference to Li, for example, and 13:31:52
11 Okayasu. 13:31:59
12 Q Are these materials typically used for 13:32:06
13 deposed emitters? 13:32:11
14 MR. SELWYN: Objection. Form. 13:32:13
15 A Deposed emitters? Did you mean deposited 13:32:14
16 emitters? 13:32:17
17 Q Deposited -- I'm sorry, deposited 13:32:17
18 emitters. 13:32:21
19 MR. SELWYN: Objection. Form. 13:32:21
20 A Can you ask that question one more time 13:32:24
21 for me, please. 13:32:27
22 Q Let me ask one by one. Is amorphous 13:32:27

1 silicon a material that is typically used for 13:32:30
2 deposited emitters? 13:32:34
3 MR. SELWYN: Objection. Form. 13:32:38
4 A Yes, amorphous silicon can be and 13:32:39
5 commonly was used in silicon solar cells as a 13:32:42
6 deposited emitter. Li, for example, teaches this. 13:32:46
7 Q If you deposit an amorphous silicon 13:32:52
8 emitter onto a silicon substrate, would you then 13:32:58
9 have a heterojunction solar cell? 13:33:05
10 MR. SELWYN: Objection. Form. 13:33:11
11 A Yes, an amorphous silicon emitter 13:33:13
12 deposited onto a crystalline silicon wafer would 13:33:16
13 be called a heterojunction solar cell. 13:33:19
14 Q What if you use a polycrystalline silicon 13:33:23
15 emitter and you deposit that onto a crystalline 13:33:32
16 silicon wafer; would you then also have a 13:33:36
17 heterojunction solar cell? 13:33:40
18 A That particular structure of a 13:33:46
19 multicrystalline -- or polycrystalline I believe 13:33:48
20 you said -- emitter deposited onto a crystalline 13:33:51
21 silicon wafer, as for example shown in Okayasu in 13:33:54
22 Paragraph 60 of my declaration, was not commonly 13:34:01

1 referred to as a heterojunction solar cell, in 13:34:04
2 particular because there's crystalline silicon on 13:34:10
3 both sides of the junction. 13:34:14
4 Although this structure of the 13:34:15
5 crystalline silicon is different in that one of 13:34:20
6 them -- or could be different in that the wafer 13:34:22
7 could be monocrystalline or polycrystalline, and 13:34:25
8 then the emitter as specified here is 13:34:28
9 polycrystalline. 13:34:31
10 Q Now we talked about diffuse emitters, 13:34:31
11 amorphous silicon emitters, and polycrystalline 13:34:43
12 silicon emitters. Right? 13:34:46
13 A That's correct. 13:34:51
14 Q At a high level, can you tell me what the 13:34:51
15 difference is between these three emitters? 13:34:55
16 A Can you elaborate on what sort of 13:35:04
17 differences you're interested in? Differences in 13:35:05
18 the performance? Difference in the fabrication of 13:35:08
19 them? Difference in the cost to make them? 13:35:09
20 Difference in what? 13:35:12
21 Q All of the above would be great. Let's 13:35:17
22 start with differences in performance. Are there 13:35:19

1 any differences in performance between the three? 13:35:25
2 MR. SELWYN: Objection. Form. 13:35:27
3 A There could be. It depends on the 13:35:28
4 specific instance. 13:35:30
5 I don't believe I have enough information 13:35:34
6 to make any definitive statements, but there are 13:35:37
7 some trends. And you can find these in the 13:35:43
8 references of my declaration. 13:35:46
9 For example, diffused emitters could 13:35:51
10 suffer from high surface recombination in a solar 13:36:01
11 cell. Deposited emitters such as amorphous 13:36:06
12 silicon or polycrystalline silicon could provide 13:36:09
13 very good surface recombination. Recognized, for 13:36:15
14 example, by low J naught values, J sub zero 13:36:20
15 values, as for example taught by Gan. 13:36:25
16 Particularly if they included an 13:36:28
17 intrinsic amorphous silicon layer in the case of a 13:36:30
18 deposited amorphous silicon emitter, as taught by 13:36:34
19 Li and as used in heterojunctions. Or an oxide 13:36:39
20 layer, as taught by Gan or Borden, for example. 13:36:44
21 However, an amorphous silicon emitter 13:36:55
22 could have other drawbacks. And these are taught, 13:36:58

1 for example, by Li, who talks about parasitic 13:37:05
2 absorption in amorphous silicon emitters. 13:37:11
3 So there can be differences in 13:37:14
4 performance. But any particular instance of one 13:37:16
5 of these emitters may have these -- its 13:37:20
6 performance may vary from the implementations of 13:37:29
7 the emitter by others. 13:37:32
8 One moment to pause here. I just want to 13:37:36
9 let you know that our speaker just said battery 13:37:38
10 low. It's also our microphone. I have it plugged 13:37:41
11 in, so I'm not sure why it's saying that. 13:37:45
12 (Discussion off the record; technical 13:37:49
13 difficulty.) 13:37:49
14 A So perhaps you can just shout at us or 13:37:53
15 raise your hand if I go silent, and we'll find a 13:37:55
16 different setup. 13:38:00
17 Q Okay. 13:38:01
18 A I'm not sure I fully answered your 13:38:05
19 question. So if perhaps you would like more of an 13:38:07
20 answer to it, you could ask again. 13:38:09
21 Q No. That was very helpful. 13:38:11
22 Can you also talk about the difference in 13:38:15

1 fabrication between these three types of emitters? 13:38:16
2 MR. SELWYN: Objection. Form. 13:38:21
3 A Again, I can give you general guidelines 13:38:24
4 without referring to any specific instance. And 13:38:27
5 these follow what you'll find in my declaration, 13:38:31
6 which is that a diffused emitter is typically made 13:38:36
7 in a process in a furnace at high temperature -- 13:38:44
8 we've had an extended discussion about high 13:38:48
9 temperature -- in which a dopant source added onto 13:38:51
10 one or the other surface of the wafer provides 13:38:58
11 dopant atoms that diffuse into the wafer surface 13:39:03
12 and form the emitter. That's how a diffused 13:39:07
13 emitter as described here is typically made. 13:39:11
14 And a deposited emitter is commonly but 13:39:13
15 not always made in a vacuum chamber. Wafer is 13:39:18
16 loaded into a vacuum chamber. Gases are 13:39:22
17 introduced into the vacuum chamber that those 13:39:25
18 gases include silicon atoms. And the silicon 13:39:30
19 atoms rain down upon the wafer -- I'm 13:39:33
20 oversimplifying -- and a layer is grown. 13:39:38
21 And depending on the specific conditions, 13:39:41
22 that layer could be an amorphous arrangement of 13:39:43

1 silicon atoms or a crystalline, polycrystalline 13:39:46
2 arrangement of silicon atoms. 13:39:51
3 And included in that deposition process 13:39:54
4 there may also be dopant atoms that are 13:39:57
5 incorporated as the silicon emitter is deposited. 13:40:00
6 Li teaches that, for example. 13:40:06
7 Alternatively, there may be no dopant 13:40:08
8 atoms that are included in the deposition process, 13:40:11
9 and a dopant source may be added to the -- or over 13:40:18
10 the polysilicon layer, or amorphous silicon layer. 13:40:25
11 And those dopants may be diffused in per, once 13:40:30
12 again, my discussion of the diffused emitter. 13:40:35
13 So there are combinations that are 13:40:39
14 possible here, but that gives you a broad overview 13:40:41
15 of how these may be fabricated. 13:40:45
16 Q Earlier you also mentioned a difference 13:40:46
17 in cost. 13:40:51
18 Can you tell me more about that? 13:40:51
19 A Once again, without -- without detailed 13:41:00
20 scenarios, it's hard to do so. 13:41:02
21 But as described in references that I've 13:41:06
22 included, for example Smith or, for example, Li, 13:41:10

1 in general more processing steps tends to increase 13:41:15
2 costs. Higher temperature steps can also increase 13:41:20
3 costs. And these are taught in the references 13:41:25
4 that I have included. 13:41:28
5 So take that, please, in the context of 13:41:28
6 what I described previously of common processing, 13:41:31
7 common fabrication methods, for each of these. 13:41:34
8 Q So typically would diffuse emitters 13:41:39
9 involve more processing steps? 13:41:45
10 MR. SELWYN: Objection. Form. 13:41:49
11 A More processing steps than what? 13:41:51
12 Q Than deposited emitters. 13:41:54
13 MR. SELWYN: Objection. Form. 13:41:58
14 A I couldn't answer that without additional 13:42:00
15 detail. 13:42:05
16 In any given fabrication sequence, 13:42:09
17 perhaps done at a particular company, there may be 13:42:15
18 more or fewer steps. A POSITA understood from -- 13:42:20
19 from the literature how to make diffused emitters 13:42:27
20 and how to make deposited emitters, and understood 13:42:30
21 things like I've described of diffused emitter 13:42:33
22 being made commonly in a furnace process, and a 13:42:38

1 deposited emitter commonly made in a vacuum 13:42:42
2 process, vacuum deposition process. 13:42:46
3 But whether or not one required more 13:42:50
4 steps than the other could depend, for example, on 13:42:52
5 whether or not one has implemented Smith's 13:42:58
6 teachings, which I include for in situ doping, in 13:43:01
7 which multiple diffusion steps are performed in 13:43:06
8 one loading of the wafer into the tool. 13:43:11
9 (Clarification by the court reporter.) 13:43:19
10 Q If in situ doping is not used, would it 13:43:22
11 be accurate to say that diffused emitters require 13:43:27
12 more processing steps than deposited emitters? 13:43:31
13 MR. SELWYN: Objection. Form. 13:43:35
14 A No, not necessarily. Once again, more 13:43:36
15 details are needed. 13:43:40
16 I can envision scenarios in which that is 13:43:42
17 true and also in which the opposite is true. I 13:43:44
18 need more details about, for example, two process 13:43:47
19 sequences to make a comparison. 13:43:51
20 Q In 2008 which type of emitter was most 13:43:54
21 commonly used in the market? 13:44:01
22 A "In the market," you mean in commercially 13:44:05

1 available products? 13:44:08
2 Q Yep. 13:44:09
3 A Diffused emitters were more commonly used 13:44:10
4 in the market at that time. 13:44:13
5 Q Let's go to Paragraph 68. 13:44:19
6 A Okay. 13:44:33
7 Q On Page 40, starting on the second line, 13:44:33
8 you talk about "solidifying paste into the final 13:44:36
9 contacts and makes electrical contact between the 13:44:36
10 paste and an N-type or a P-type region or layer." 13:44:47
11 Do you see that? 13:44:49
12 A Yes, I do. 13:44:50
13 Q To be clear, in a particular solar cell 13:44:50
14 you would want at least one metal contact to make 13:44:54
15 electrical contact with an N-type region. Right? 13:44:58
16 A That is correct. And this is described 13:45:03
17 in many places, including, if I remember 13:45:07
18 correctly, the beginning of the '053 patent 13:45:11
19 itself, that a metal contact should make 13:45:15
20 electrical contact to an N-type region and another 13:45:20
21 metal contact should make electrical contact to a 13:45:24
22 P-type region. 13:45:27

1 Q And by N-type region you mean N-type 13:45:30
2 doped region. Right? 13:45:33
3 A That's what N-type means, yes. 13:45:35
4 Q And P-type region would be P-type doped 13:45:37
5 region. Right? 13:45:44
6 A That's correct. 13:45:45
7 Q Typically in solar cells are there more 13:45:45
8 than one N-type doped regions? 13:45:52
9 MR. SELWYN: Objection. Form. 13:45:55
10 A There can be. For example, we were 13:45:59
11 looking moments ago at Froitzheim's Figure 3, for 13:46:08
12 example, on end of page -- Paragraph 58 of my 13:46:13
13 declaration. 13:46:17
14 And in this instance you can identify 13:46:19
15 three different regions with N-type doping. The 13:46:24
16 wafer itself has an N-type background doping 13:46:29
17 level. There is a light green region that extends 13:46:33
18 across much of the front surface that has heavier 13:46:36
19 N-type doping identified as an N plus region. And 13:46:41
20 then 38 in this image has a slightly different 13:46:47
21 color green, and it has heavier doping still. It 13:46:55
22 is under the metal contacts. And Froitzheim 13:47:01

1 describes this as an optional selectively doped 13:47:03
2 region for making low-resistance contact to the 13:47:08
3 metal contacts. 13:47:13
4 We talked previously about surface 13:47:14
5 recombination as quantified by J naught, and that 13:47:19
6 is one important parameter in selecting or 13:47:24
7 designing an emitter. 13:47:28
8 The other one is its contact resistance, 13:47:30
9 and commonly parameterized by a parameter called 13:47:40
10 rho C. Rho as in the Greek letter. And that's 13:47:45
11 true for an emitter. 13:47:47
12 But those same two parameters are also 13:47:48
13 what a POSITA would look to in designing a good 13:47:53
14 front surface field, as shown here by Froitzheim. 13:47:56
15 So what Froitzheim is teaching in this 13:47:59
16 instance is a way to make lower low C, lower 13:48:01
17 contact resistance. So here's an instance of a 13:48:07
18 solar cell that has three in this case N-type 13:48:09
19 regions. 13:48:12
20 Q Is this also true for P-type doped 13:48:13
21 regions in a solar cell, can there be more than 13:48:17
22 one P-type doped region? 13:48:21

1 A There can be. In the Froitzheim solar 13:48:26
2 cell shown on Paragraph 58 of my declaration, 13:48:28
3 there is only one. 13:48:31
4 But several of the references that I have 13:48:34
5 included are motivated to switch from P-type 13:48:37
6 wafers, which were more prevalent in the industry 13:48:45
7 in 2008 than N-type wafers, to N-type wafers. We 13:48:47
8 find this in Froitzheim as part of the motivation. 13:48:54
9 We find this in Li as part of the motivation as 13:48:56
10 well. 13:48:59
11 So for a solar cell that had a P-type 13:48:59
12 wafer, there could likely be two or more P-type 13:49:02
13 regions, one of which has heavier doping and is 13:49:07
14 near a front or rear surface and to which metal 13:49:13
15 makes contact. 13:49:17
16 Q Can you give me a example of a solar cell 13:49:18
17 that has more than two P-type regions? 13:49:23
18 A Yes. In fact, the solar cell structure 13:49:27
19 of Froitzheim, once again in Paragraph 58 of my 13:49:31
20 declaration, could be made -- although this isn't 13:49:36
21 taught by Froitzheim -- with everything labeled 13:49:41
22 P-type reversed to N-type and everything labeled 13:49:44

1 N-type reversed to P-type. And in that instance 13:49:48
2 there would be three P-type regions of the solar 13:49:50
3 cell. 13:49:57
4 Q Are there any solar cells that have more 13:49:57
5 than one P-type doped region and more than one 13:50:00
6 N-typed regions -- I'm sorry, more than two? More 13:50:05
7 than two P-type doped regions and more than two 13:50:09
8 N-type doped regions? 13:50:13
9 MR. SELWYN: Objection. Form. 13:50:14
10 A So two of each is not sufficient to 13:50:16
11 answer yes to your question. You want three or 13:50:19
12 more of each. 13:50:22
13 Is that correct? 13:50:23
14 Q Let me ask this question again just for 13:50:24
15 clarity. 13:50:26
16 Are there any solar cells that have more 13:50:27
17 than two P-type doped regions and more than two 13:50:29
18 N-type doped regions? 13:50:36
19 MR. SELWYN: Objection. Form. 13:50:38
20 A I just want to clarify one more time. 13:50:40
21 That means that two of each does not meet the 13:50:42
22 criteria of your question. You want three or more 13:50:45

1 of each, because you said more than two and more 13:50:47
2 than two. So that's three or greater, or three or 13:50:50
3 greater. 13:50:54
4 Is that correct? 13:50:54
5 Q Yes. 13:50:56
6 A Such a solar cell is certainly possible. 13:51:08
7 Figure 5 of Froitzheim, which is Exhibit 1004, 13:51:12
8 shows doping 55 and 38 specifically under the 13:51:19
9 contact regions. A structure similar to this, but 13:51:37
10 incorporating some other things taught by 13:51:45
11 Froitzheim, could have what you're describing, but 13:51:47
12 I don't have a particular instance that I could 13:51:50
13 point to in mind. 13:51:53
14 So I will say a solar cell could have 13:51:54
15 that. There very well may have been one made. I 13:51:57
16 don't have an instance to point to you -- point 13:52:00
17 you to, excuse me. 13:52:03
18 Q Are you aware of any solar cells that 13:52:04
19 have a passivation layer between the metal contact 13:52:11
20 and a doped region? 13:52:15
21 A Between the metal contact and any doped 13:52:20
22 region or ... 13:52:25

1 Q The doped region where typically the 13:52:28
2 metal contact would make electrical contact with a 13:52:34
3 doped region. 13:52:39
4 A And again, there are a minimum of two of 13:52:40
5 those in each solar cell, a metal contact making 13:52:43
6 electrical contact to an N-type region and one 13:52:47
7 making contact to a P-type region. So you -- 13:52:50
8 either of those? 13:52:53
9 Q Yes. 13:52:54
10 A Okay. Yes, I am aware of such instances. 13:52:55
11 In my '053 declaration, for example, I refer to 13:53:01
12 Borden. Give me just one moment, please. 13:53:05
13 Actually, I want to clarify and make sure 13:54:08
14 I understood your question. Can you repeat again? 13:54:10
15 A passivation layer between which layer and which? 13:54:14
16 Q Metal contact and -- 13:54:16
17 A Metal contact. 13:54:19
18 Q -- a doped region specifically where the 13:54:20
19 metal contact would make electrical contact with a 13:54:23
20 doped region. 13:54:27
21 A Okay. Thank you. 13:54:29
22 So back to my '053 declaration. I 13:54:36

1 apologize. I hadn't understood your question 13:54:40
2 correctly the first time. 13:54:42
3 You can -- you can read, for example, in 13:54:47
4 Paragraph -- it's a long paragraph, 67. No. 13:54:52
5 Excuse me, 68. Page 40. "In many case the 13:54:59
6 paste," here I'm referring to paste of metallic 13:55:08
7 particles that the end of solar cell fabrication 13:55:11
8 becomes the metal contact, "was designed to fire 13:55:14
9 through an antireflection coating located between 13:55:17
10 the wafer and the paste." 13:55:20
11 So in many instances the wafer, for 13:55:23
12 example, if it had a diffused emitter, its surface 13:55:25
13 layer would be the doped layer that you're 13:55:31
14 referring to, and the antireflection coating was 13:55:32
15 frequently an electrically insulating layer used 13:55:36
16 for passivation of the wafer surface in addition 13:55:41
17 to providing antireflection. 13:55:46
18 So this is an instance of paste over an 13:55:50
19 antireflection layer that's also a passivation 13:55:53
20 layer, below which is a doped silicon region to 13:55:57
21 which the paste will make electrical contact in 13:56:03
22 particular during the firing through process. 13:56:07

1 Q When you fire the paste through -- I'm 13:56:11
2 sorry. You would be firing the paste through the 13:56:17
3 antireflection coating. Right? 13:56:19
4 A Correct. And again, the antireflection 13:56:24
5 coating is in many cases also a passivation layer, 13:56:27
6 as described in many pieces of art that I have 13:56:30
7 included. 13:56:33
8 Q And so when the paste is fired through 13:56:34
9 the antireflection coating, to then make 13:56:37
10 electrical contact with the doped silicon region, 13:56:42
11 would there still be antireflection coating 13:56:47
12 between the paste and the doped silicon region? 13:56:50
13 A Yes. If you -- if you were to take a 13:56:56
14 cross-sectional view of the solar cell after this 13:57:03
15 firing-through process, you would find that the 13:57:08
16 antireflection coating is intact in most places, 13:57:11
17 and the paste remains on top of or over the 13:57:15
18 antireflection coating in most places; but there 13:57:19
19 are some instances where metal paste particles 13:57:22
20 have made their way through the antireflection 13:57:26
21 coating, filaments of the paste, and that those 13:57:31
22 filaments touch the surface of the wafer making 13:57:35

1 electrical contact. 13:57:40
2 Q There's only electrical contact between 13:57:45
3 the paste that makes it -- makes itself through 13:57:47
4 the antireflective coating. 13:57:49
5 Is that right? 13:57:52
6 MR. SELWYN: Objection. Form. 13:57:53
7 A Yes. Let me try to explain again. 13:57:55
8 Most of the paste resides on top of or 13:57:57
9 over the antireflection coating. But in the 13:58:02
10 fire-through process some of -- some of it will 13:58:05
11 reach through the antireflection coating and touch 13:58:07
12 the wafer surface, thereby electrically connecting 13:58:11
13 the wafer to the paste through the antireflection 13:58:15
14 coating. But the majority of the antireflection 13:58:19
15 coating between the paste or metal contact and the 13:58:21
16 wafer will be intact. 13:58:28
17 Q Is it accurate to say that there would 13:58:31
18 not be current flowing through the portions where 13:58:36
19 the antireflection coating is intact? 13:58:40
20 A That is correct. The antireflection 13:58:44
21 coating, being an insulator, does not pass 13:58:46
22 current. So the current passes through the 13:58:50

1 localized regions where the paste has reached from 13:58:54
2 the metal contact down through the antireflection 13:58:57
3 coating to touch the wafer. 13:59:00
4 MS. ZHAO: We've been going for about an 13:59:05
5 hour again. Do you want to take a break? 13:59:06
6 MR. SELWYN: We're happy to take five 13:59:10
7 minutes. 13:59:11
8 MS. ZHAO: Okay. Let's do that. 13:59:11
9 (A recess was taken.) 13:59:13
10 BY MS. ZHAO: 14:06:02
11 Q Let's go to Paragraph 55 of the '053 14:06:03
12 declaration. 14:06:05
13 I'm so sorry, I meant Page 55. 14:06:18
14 A Okay, I'm there. 14:06:36
15 Q On this page you show Figure 1 of the 14:06:36
16 '053 patent. Right? 14:06:40
17 A Correct. 14:06:41
18 Q Is this a silicon solar cell? 14:06:41
19 A Yes, it is. 14:06:52
20 Q And is this a homojunction solar cell? 14:06:52
21 A The solar cell has a polycrystalline 14:07:01
22 emitter and I believe a monocrystalline silicon 14:07:05

1 wafer. It is not -- a POSITA would not have 14:07:13
2 referred to it as a heterojunction solar cell. 14:07:19
3 It may or may not have been referred to 14:07:28
4 as a homojunction solar cell at the time. And I 14:07:29
5 say that because if I am remembering correctly, 14:07:37
6 that the N-type wafer is monocrystalline and the 14:07:43
7 P-type emitter I know is polycrystalline. Then a 14:07:47
8 POSITA may or may not have used the word 14:07:53
9 "homojunction" to refer to it. A POSITA would 14:07:57
10 certainly call it a silicon solar cell. 14:07:59
11 Q Would there be a third category if a 14:08:09
12 POSITA would not have called it a heterojunction 14:08:11
13 solar cell, may not have called it a homojunction 14:08:14
14 solar cell, then is there a third name? 14:08:19
15 MR. SELWYN: Objection to form. 14:08:21
16 A No, there's not. Homojunction and 14:08:22
17 heterojunction are exclusive categories. I just 14:08:25
18 meant to say that heterojunction was used as of 14:08:29
19 the priority date in 2008 to refer to specifically 14:08:33
20 most commonly amorphous silicon crystalline 14:08:38
21 silicon heterojunctions. Other types of solar 14:08:41
22 cells that didn't have such a thing were commonly 14:08:44

1 homojunctions, but they were typically referred to 14:08:46
2 as silicon solar cells, as opposed to specifically 14:08:48
3 calling them homojunctions. 14:08:54
4 Q Let's go to Paragraph 112. 14:08:55
5 A Okay. 14:09:15
6 Q In Footnote 5 you talk about concentrator 14:09:15
7 solar cells being a category of solar cells, and 14:09:21
8 you talk about nonconcentrator solar cells in the 14:09:22
9 next sentence. 14:09:25
10 Do you see that? 14:09:26
11 A Yes, I do. 14:09:28
12 Q Besides the use of lenses, mirrors, 14:09:28
13 et cetera, are there any other differences between 14:09:34
14 concentrator solar cells and nonconcentrator solar 14:09:38
15 cells? 14:09:38
16 A There can -- 14:09:46
17 MR. SELWYN: Objection. Form. 14:09:46
18 A There can be. 14:09:49
19 So a concentrator solar cell is one 14:09:50
20 that -- or is a term that we use to describe solar 14:09:54
21 cells that are used under light concentration. 14:10:01
22 And as I mention in this footnote, one way of 14:10:05

1 achieving such concentration is by adding a system 14:10:08
2 or apparatus that uses lens or mirrors to provide 14:10:10
3 that concentration. 14:10:15
4 And nonconcentrator solar cells, also 14:10:16
5 called one-sun solar cells, are those that are 14:10:20
6 operating without such concentration. 14:10:24
7 So to come to your question, under 14:10:26
8 concentration the short-circuit current density of 14:10:31
9 a solar cell increases. It typically increases 14:10:36
10 linearly with the concentration. And one loss 14:10:40
11 in -- power loss in solar cells is due to 14:10:47
12 resistance. And in fact, one category of that 14:10:50
13 resistance is contact resistance, which I describe 14:10:52
14 in detail in the background section. 14:10:55
15 As the current goes up, the loss, power 14:10:59
16 loss due to resistance, increases. And so it's 14:11:02
17 important to decrease the resistance of the solar 14:11:06
18 cell. And the more concentration the solar cell 14:11:11
19 is going to be under, the more you want to 14:11:13
20 decrease the resistance by, for example, using 14:11:17
21 more metal, enlarging the volume of the metal 14:11:20
22 contacts. 14:11:26

1 So this is an instance of how a solar 14:11:27
2 cell is to be used for concentration may differ in 14:11:31
3 its design from one that isn't. 14:11:36
4 However, many things about solar cells 14:11:38
5 that are to be used under concentration or not are 14:11:40
6 the same. They both use absorbers. For example 14:11:44
7 silicon wafers they use diffused regions, they 14:11:50
8 have to have emitters, they have to have 14:11:54
9 passivation layers, they have to have contacts. 14:11:55
10 And so many elements are -- are the same, and 14:11:58
11 there was learning constantly between communities 14:12:06
12 that were focused on concentrator solar cells and 14:12:09
13 those focused on nonconcentrator solar cells 14:12:12
14 because so much of the underlying physics and 14:12:14
15 materials and device structures. 14:12:17
16 Q You mentioned enlarging the volume of 14:12:21
17 metal contacts. Any other differences in designs 14:12:25
18 between concentrator solar cells and 14:12:28
19 nonconcentrator solar cells? 14:12:31
20 MR. SELWYN: Objection. Form. 14:12:32
21 A There could be. It depends on, for 14:12:33
22 example, how much concentration the solar cell 14:12:37

1 would be used under. 14:12:42
2 You know, we don't distinguish, when we 14:12:44
3 use the word "concentrator solar cell," whether 14:12:46
4 it's going to operate under two-suns equivalent or 14:12:49
5 2,000-suns equivalent, although those are 14:12:54
6 different conditions. 14:12:58
7 So one thing that becomes more prevalent 14:13:00
8 under higher concentration is Auger recombination. 14:13:05
9 That's A-U-G-E-R, after the French man. And I 14:13:10
10 believe I talked about Auger recombination in my 14:13:16
11 background section. 14:13:19
12 And it is a recombination mechanism that 14:13:21
13 increases with higher carrier density. And 14:13:24
14 carrier density increases with concentration. 14:13:31
15 So, for example, having the emitter at 14:13:35
16 the front side or the back side of the solar cell 14:13:39
17 might be a design choice that a person would make 14:13:42
18 depending on the concentration that the solar cell 14:13:46
19 would operate under. 14:13:52
20 Q Besides the location of the emitter and 14:13:53
21 the size of the metal contact, what other design 14:14:00
22 differences could there be between concentrator 14:14:05

1 solar cells and nonconcentrator solar cells? 14:14:09
2 MR. SELWYN: Objection. Form. 14:14:12
3 A So far I have limited my response to 14:14:18
4 thinking about silicon solar cells. Commonly a 14:14:21
5 lot of the development work for concentrator solar 14:14:25
6 cells was directed to nonsilicon solar cells, like 14:14:28
7 gallium-arsenide-based multijunction solar cells. 14:14:33
8 So you might change the type of solar 14:14:39
9 cell altogether. And we can talk about why, if 14:14:44
10 you would like. 14:14:48
11 Also, under concentration the solar cells 14:14:49
12 will generate more heat. And solar cells like to 14:14:53
13 operate under light, but they don't like to 14:14:57
14 operate hot. So adding an apparatus around the 14:15:01
15 solar cell to remove heat is important, 14:15:10
16 particularly as the concentration goes up. For 14:15:13
17 example, a heat sink or even active cooling with 14:15:17
18 water. So these would be some other choices that 14:15:22
19 a person may consider if he or she wanted to make 14:15:27
20 a concentrator -- concentrator solar cell. 14:15:33
21 Q You mentioned multijunction solar cells. 14:15:37
22 Can you tell me what that is? 14:15:42

1 A Yes. We previously talked about tandem 14:15:44
2 solar cells, in particular in the context of 14:15:48
3 Perovskite/silicon tandem solar cells. And I told 14:15:52
4 you it was two solar cells in a tandem, one 14:15:56
5 designed to optimally to use the visible spectrum, 14:15:58
6 and one designed to use the infrared spectrum. 14:16:02
7 A multijunction solar cell is a generic 14:16:04
8 term for two or more junctions. So tandems would 14:16:06
9 fall under multijunctions, but so would stacking 14:16:09
10 three solar cells together or four. 14:16:12
11 And the idea is to better use the solar 14:16:15
12 spectrum than a single material, like silicon 14:16:20
13 alone could. 14:16:23
14 Q So if you stack two solar cells together, 14:16:26
15 you would have two junctions. Right? 14:16:32
16 A That's correct. 14:16:36
17 Q Which means each solar cell only has one 14:16:36
18 junction. 14:16:41
19 Is that always true? 14:16:41
20 MR. SELWYN: Objection. Form. 14:16:44
21 A We talk about solar cells as having one 14:16:47
22 PN junction. And we use the word "junction" to 14:16:55

1 refer to PN junction in shorthand, yes. So each 14:16:58
2 solar cell, or we would commonly call them subcell 14:17:06
3 in a multijunction solar cell, would have one 14:17:09
4 junction, one PN junction. 14:17:12
5 Q In 2008 were concentrator solar cells 14:17:14
6 common in the commercial solar cell market? 14:17:20
7 A There were multiple companies offering 14:17:28
8 concentrator solar cells, solar panels, or solar 14:17:32
9 systems. Around 2008 was a time of lots of 14:17:39
10 different offerings in the solar industry. The 14:17:44
11 industry hadn't yet seen the consolidation that 14:17:48
12 came -- the consolidation and -- yeah, that came 14:17:51
13 over the next decade. 14:17:58
14 So there were -- there were several 14:18:00
15 companies offering concentrator solutions. It was 14:18:03
16 not as common as nonconcentrator solar cells or 14:18:08
17 modules. 14:18:16
18 Q In Paragraph 112 you also mention a 14:18:17
19 backside contact solar cell. 14:18:23
20 Do you see that? 14:18:24
21 A I do. 14:18:25
22 Q And then you cite Exhibit 1015, Swanson. 14:18:26

1 Right? 14:18:31
2 (Exhibit 1015, previously marked, not 14:18:31
3 attached.) 14:18:31
4 A Yes, I also cite 1005, Gan, in the same 14:18:37
5 paragraph. 14:18:41
6 Q Do you know if Swanson discloses a 14:18:41
7 concentrator solar cell? 14:18:45
8 A I have read Swanson, but I don't have it 14:18:54
9 in front of me. If you'd like to pull it up, we 14:18:56
10 can look together. But I don't remember offhand. 14:19:00
11 MS. ZHAO: I will upload it real quick 14:19:04
12 for you. 14:19:06
13 MR. SELWYN: Is it in his binder? 14:19:09
14 MS. ZHAO: I don't think so. 14:19:11
15 MR. SELWYN: Okay. 14:19:12
16 THE WITNESS: Yeah, I don't see it. 14:19:13
17 MR. SELWYN: Okay. Go ahead, then. 14:19:14
18 MS. ZHAO: I am going to upload it to the 14:19:15
19 chat. It should be available now. Can you just 14:19:18
20 open it up for me real quick and let me know if 14:19:28
21 Swanson discloses a concentrator solar cell? 14:19:33
22 A One moment, please. Try that again. My 14:19:56

1 PDF -- there we go. Second time was a charm. 14:20:24
2 Okay, I have briefly reviewed Swanson. I 14:22:47
3 haven't reread every word. I can if you want, but 14:22:50
4 it will take a few moments. But from what I see 14:22:53
5 and what I remember of my previous reading, 14:23:00
6 Swanson describes a solar cell without any 14:23:04
7 particular description of its intended use, and 14:23:09
8 talks about the disclosure as not being limiting. 14:23:17
9 Swanson doesn't talk about use in a 14:23:23
10 concentrator. Swanson doesn't talk about use at 14:23:28
11 one sun in a flat-plate module. But that is to 14:23:33
12 say, as I mentioned before, Swanson doesn't talk 14:23:37
13 about the use for his invention being limited to 14:23:40
14 any use cases. But Swanson does include other 14:23:47
15 publications on the first and second page of the 14:23:51
16 patent that refer to concentrator solar cells. 14:23:55
17 And I believe from the titles also nonconcentrator 14:24:03
18 solar cells, both of them, including a paper from 14:24:07
19 Swanson, for example, titled The Promise of 14:24:11
20 Concentrators. 14:24:15
21 So to answer your question, I don't see 14:24:16
22 that the invention is limited to any use case; but 14:24:18

1 the other publications suggest that Swanson was 14:24:23
2 aware of both concentrator and nonconcentrator use 14:24:26
3 cases. 14:24:29
4 Q Could the structure of Swanson's solar 14:24:31
5 cell be used in a concentrator solar cell? 14:24:36
6 A Yes, it could be. It would -- the solar 14:24:44
7 cell would produce power under -- under 14:24:48
8 concentration. 14:24:50
9 Q The solar cell in the '053 patent is not 14:24:55
10 a concentrator solar cell. Right? 14:24:58
11 A The '053 patent is silent, similar to 14:25:10
12 Swanson, on the use of the solar cell. It's not 14:25:15
13 limited to a concentration or nonconcentration 14:25:21
14 scenario. 14:25:29
15 Q Could the structure of the '053 patent be 14:25:29
16 used in a concentrator solar cell? 14:25:33
17 MR. SELWYN: Objection. Form. 14:25:38
18 A Yes, the solar cell in the '053 patent 14:25:50
19 would similarly produce power under concentration. 14:25:55
20 Q Let's go to Paragraph 115 of the '053 14:26:01
21 declaration. 14:26:05
22 A Okay. 14:26:18

1 Q First I would like you to look at the 14:26:18
2 figure on the next page. Would you say the 14:26:20
3 structure is a silicon solar cell? 14:26:22
4 A Yes, Smith teaches a silicon solar cell. 14:26:27
5 Q Is it a homojunction solar cell? 14:26:30
6 A Yes, it is a homojunction solar cell. 14:26:45
7 The emitter and the wafer are made out of the same 14:26:48
8 material, they are one in the same wafer. 14:26:54
9 Q Does Smith teach a concentrator solar 14:26:57
10 cell? 14:27:03
11 A Smith, similar to Swanson, does not 14:27:15
12 describe any limitations of his invention to 14:27:23
13 particular use cases, and in particular to 14:27:28
14 concentrator or nonconcentrator applications. But 14:27:32
15 similar to Swanson, in the Other Publications 14:27:35
16 section on the first page, there is reference to 14:27:39
17 concentrator and what appears to be 14:27:43
18 nonconcentrator solar cells in -- in those other 14:27:47
19 publication titles, suggesting that Smith was at 14:27:51
20 least aware that solar cells can be used in 14:27:56
21 multiple use cases, including concentration and 14:28:00
22 nonconcentration. 14:28:04

1 Q In Paragraph 115 you say that "Smith 14:28:05
2 talks about a first in situ step where the wafer 14:28:13
3 is heated to 1000 degrees C to diffuse two types 14:28:17
4 of dopants." 14:28:21
5 Do you see that? 14:28:22
6 A Yes, I do. 14:28:28
7 Q And in the next paragraph you say that 14:28:28
8 Smith talks about a second in situ step where the 14:28:32
9 furnace conditions are changed to about 750 14:28:35
10 degrees C, then to 975 degrees C. 14:28:38
11 Do you see that? 14:28:42
12 A Yes, I do. 14:28:44
13 Q Can you help me understand what the 750 14:28:44
14 degrees C is for? 14:28:49
15 A Yes. Give me just one moment. 14:28:57
16 So it was common and well known at the 14:29:26
17 time that in the phosphorus diffusion could be 14:29:31
18 done, and with two steps. And I describe this in 14:29:38
19 Paragraph 54 of my background section of my 14:29:42
20 declaration. 14:29:46
21 And in particular I talk about vaporizing 14:29:48
22 what we call POCl, P-O-C-L, 3, phosphorus 14:29:50

1 oxychloride, in a furnace. And that a vaporized 14:29:56
2 liquid reacts with a surface of the wafer to form 14:30:02
3 a glass that has phosphorus atoms in it. And then 14:30:06
4 those phosphorus atoms are commonly diffused into 14:30:14
5 the wafer. 14:30:18
6 And those two steps, forming the glass 14:30:18
7 and diffusing or driving in the dopants, were 14:30:21
8 commonly separated. And that is I believe what 14:30:24
9 Smith is describing in this two-step process. 14:30:28
10 So I believe the 750-degree step is 14:30:32
11 directed at forming the phosphorus-containing 14:30:35
12 glass. And then the second step in this case at 14:30:40
13 975 degrees is directed at driving phosphorus 14:30:44
14 dopants -- dopant atoms into the front side of the 14:30:49
15 silicon wafer. 14:30:52
16 Q And the 1000 degrees would be to vaporize 14:30:53
17 the liquid? 14:30:59
18 A No. The 1000-degree step, which is the 14:31:02
19 first step in Smith's two-step in situ process, is 14:31:05
20 for driving dopants in glass regions on the back 14:31:13
21 side of the solar cell into the solar cell. And 14:31:19
22 subsequently Smith treats the front side of the 14:31:38

solar cell with this two-step process. 14:31:41
Maybe if I can summarize again. Smith's 14:31:44
wafer goes into the furnace already having 14:31:46
patterned boron-containing and 14:31:50
phosphorus-containing glass layers on its back 14:31:53
side. The first step diffuses those dopants into 14:31:56
the back side. Then while the wafer is in the 14:31:58
same piece of equipment, Smith teaches that's what 14:32:05
he means by in situ. A glass layer is formed on 14:32:08
the front side containing phosphorus, and the 14:32:13
phosphorus is diffused. And those two things are 14:32:18
Smith's disclosed second step. 14:32:23
Q Does the second in situ step affect the 14:32:27
dopants in the back surface in any way? 14:32:31
A Smith does not teach that there is or is 14:33:24
not any affect of the second step on the results 14:33:26
of the first step. This is in the bottom of 14:33:35
Column 3 and the top of Column 4, that Smith 14:33:40
describes the second step. 14:33:44
Smith describes that this in situ process 14:33:49
of using two steps in the same wafer loading 14:33:54
simplifies the fabrication process, and that that 14:33:58

1 would be appreciated by a POSITA. 14:34:01
2 Smith doesn't say whether there is either 14:34:06
3 beneficial or -- or negative consequences on the 14:34:07
4 second step to the -- to the first step. But 14:34:13
5 given that Smith is directed at simplifying 14:34:17
6 fabrication sequences, my reading is that Smith 14:34:21
7 didn't find, for example, that the second step was 14:34:30
8 destructive. 14:34:35
9 Q But would a POSITA understand the second 14:34:42
10 in situ step to affect the dopants in the back 14:34:46
11 surface in any way? 14:34:50
12 A I believe a POSITA would understand what 14:34:53
13 Smith teaches, which is that one wafer loading is 14:34:55
14 a simplified process sequence and provides 14:35:07
15 advantages in the manufacturing of solar cells. 14:35:09
16 And Smith doesn't disclose that there are adverse 14:35:12
17 consequences or, in fact, even beneficial 14:35:17
18 consequences, which there could be, with the 14:35:20
19 second step interacting with the results of the 14:35:24
20 first step. 14:35:26
21 So I don't believe that a POSITA would 14:35:28
22 expect from Smith that there were such effects. 14:35:32

1 Smith doesn't teach it. 14:35:37
2 Q Could 700 degrees -- would heating to 700 14:35:41
3 degrees C affect dopant in the back surface in any 14:35:46
4 way, in general? 14:35:53
5 MR. SELWYN: Objection. Form. 14:35:56
6 A This relates to our conversation earlier 14:35:58
7 about temperatures. And you'll recall that the 14:36:02
8 other things that I brought up at the time that 14:36:05
9 determined diffusion are time. It's very 14:36:09
10 important. And also what the dopant atoms are and 14:36:11
11 what the host material is. 14:36:16
12 So Smith doesn't teach a time that I see. 14:36:19
13 I believe because Smith says in the beginning that 14:36:23
14 persons of ordinary skill in the art would 14:36:31
15 recognize, however, that the invention can be 14:36:34
16 practiced without one or more of the specific 14:36:36
17 details in other instances, while no details are 14:36:39
18 not shown or described to avoid obscuring aspects 14:36:43
19 of the invention. 14:36:46
20 So I believe Smith appreciated that a 14:36:47
21 POSITA would be able to make design choices, such 14:36:49
22 that the second steps that he -- the second step 14:36:56

1 that he described wouldn't, for example, have 14:36:59
2 negative consequences on the results of the first 14:37:02
3 step. 14:37:04
4 Q How long would a POSITA apply heating of 14:37:06
5 750 degrees for in this situation? 14:37:16
6 A It doesn't teach that. A POSITA would 14:37:22
7 look to the other art if the POSITA had not 14:37:28
8 himself or herself performed similar diffusions, 14:37:33
9 and would learn from that art what an appropriate 14:37:37
10 time might be. 14:37:40
11 Q Have you performed similar diffusions 14:37:44
12 before? 14:37:47
13 A I, personally, have not performed such 14:37:48
14 diffusions. My students, however, have. 14:37:51
15 Q But do you have an idea of how much time 14:37:56
16 you would be applying this heat of 700 degrees -- 14:37:58
17 750 degrees C for? 14:38:03
18 A Yes, I do. It would depend on the 14:38:09
19 details that I described previously. But I could 14:38:15
20 disclose, for example, that when my students have 14:38:17
21 done diffusions of phosphorus into the surface of 14:38:20
22 silicon wafers, such as silicon wafers, a first 14:38:25

1 step may be on the order of minutes. It's not as 14:38:30
2 short as seconds, and it's not as long as hours. 14:38:34
3 Q Apply heat of 750 degrees C for minutes, 14:38:36
4 would that have any effect on a dopant on the back 14:38:46
5 surface? 14:38:52
6 A I believe I've already answered this 14:38:52
7 question. That -- that Smith doesn't describe -- 14:38:54
8 doesn't disclose any consequences positive or 14:39:04
9 negative. And that Smith doesn't describe details 14:39:08
10 of the time, for example, used for this, this 14:39:16
11 stuff. 14:39:26
12 And Smith describes that this multistep 14:39:27
13 process is -- provides a method for the 14:39:29
14 simplification of the manufacturing of solar 14:39:34
15 cells. 14:39:41
16 Smith also talks -- forgive me, I'm 14:39:42
17 looking for a particular place within Smith. Yes. 14:40:58
18 To come back to your question, Smith doesn't teach 14:41:14
19 that there are -- there are consequences of the 14:41:18
20 750 degree C step on the dopants on the rear side 14:41:23
21 of the solar cell. 14:41:29
22 Q Even though Smith doesn't teach the 14:41:32

1 consequences, would a POSITA know what the 14:41:35
2 consequences might be? 14:41:39
3 A A POSITA -- a POSITA would know. A 14:41:45
4 POSITA would -- would expect that 750 degrees C, 14:41:48
5 being lower than the 1000 degrees C used in the 14:41:57
6 previous step, provided that the time was not very 14:42:03
7 long, provided that the dopants being diffused in 14:42:12
8 the previous step, yes, they are phosphorus and 14:42:17
9 boron, that the diffusion at 750 degrees C of 14:42:23
10 dopants at the rear side of the solar cell would 14:42:29
11 be substantially slower than they were at 1000 14:42:32
12 degrees C when they were moved in. And so the 14:42:37
13 POSITA would not expect that they would -- that 14:42:40
14 they would move appreciably. 14:42:45
15 Q They being the dopants, right? When you 14:42:49
16 say -- 14:42:53
17 A That's correct. 14:42:54
18 Q -- they would not move, you meant the 14:42:54
19 dopants would not move. Right? 14:42:57
20 A Yes. Once again, subject to information 14:43:01
21 about how long the diffusion occurs. 14:43:08
22 Q I'd like to ask you the same questions 14:43:18

1 with respect to the 975 degrees C. 14:43:20
2 So first of all, would a POSITA know how 14:43:24
3 long to apply heat of 975 degrees for? 14:43:27
4 A Smith believes so. And Smith leaves out 14:43:35
5 details and includes a sentence indicating that 14:43:38
6 details are left out in cases in which -- in which 14:43:43
7 case -- in cases in which the step or process is 14:44:00
8 likely well known. 14:44:17
9 (Clarification by the court reporter.) 14:44:17
10 Q So in your opinion, how long would the 14:44:21
11 POSITA apply heat of 975 degrees C for? 14:44:22
12 A As I describe in my background section, 14:44:44
13 diffusion of phosphorus dopants into a wafer 14:44:49
14 surface to form an emitter is a common process 14:44:54
15 that used two steps -- commonly used two steps. 14:44:57
16 And that there was considerable literature and 14:45:05
17 teaching in the literature dating back decades on 14:45:08
18 how to do such diffusions. 14:45:12
19 And as I described previously, that the 14:45:16
20 length of time for a diffusion needs to be 14:45:19
21 considered also with temperature. Here Smith is 14:45:25
22 teaching the temperature of 975 degrees C for this 14:45:33

1 diffusion on the front side of -- of the wafer. 14:45:39
2 And literature for diffusions at the time again 14:45:46
3 were on the order of they could be as short as 14:45:50
4 minutes, they could be as long as hours. And what 14:45:55
5 a person doing the diffusion would choose depends 14:46:02
6 on the particular goals, as we described 14:46:08
7 previously, of whether they wanted a shallow 14:46:11
8 diffusion or a deep diffusion, for instance. 14:46:14
9 Q To achieve the structure disclosed in 14:46:17
10 Smith, would the heating be more on the minutes 14:46:27
11 side or the hour side? 14:46:29
12 A We can't know that, as Smith does not 14:46:33
13 disclose, to my recollection, a target depth of 14:46:40
14 the -- of Smith's front surface diffusion. And 14:46:52
15 Smith likely doesn't disclose such a depth 14:47:00
16 because, as I mentioned previously, diffusions 14:47:04
17 into the surface of wafers were very common as of 14:47:08
18 the time of Smith's writing. 14:47:14
19 Q I just want to make sure I understood 14:47:27
20 what you just said. 14:47:29
21 So would a POSITA have an idea of how 14:47:31
22 deep he would want the dopant of Smith to go in a 14:47:35

1 diffusion process? 14:47:41
2 A Yes. A POSITA would know how to do 14:47:44
3 diffusions. A POSITA would understand that Smith 14:47:48
4 is describing a diffusion to dope the front 14:47:52
5 surface of the wafer. A POSITA would have access 14:47:56
6 to many, many -- yeah, a POSITA would understand 14:48:00
7 also the design choices associated with the 14:48:12
8 diffusion. Because as I described previously, a 14:48:15
9 POSITA would understand time and temperature 14:48:18
10 matter, and also the dopant atoms that are 14:48:22
11 diffusing, and also what they're diffusing through 14:48:26
12 and/or into. 14:48:29
13 So a POSITA would have an understanding 14:48:31
14 of these things because they have been common in 14:48:35
15 the field for decades, and in the semiconductor 14:48:37
16 field for decades still before that. 14:48:43
17 Q But based on all that knowledge, do you 14:48:45
18 have an educated guess on how long the POSITA 14:48:52
19 would apply heating of 975 degrees C? 14:48:55
20 MR. SELWYN: Objection. Form. 14:48:59
21 A A POSITA would apply heating for an 14:49:02
22 appropriate time given the conditions that I just 14:49:08

1 described, depending on the particular values for 14:49:12
2 each of those things. 14:49:18
3 Q So you don't have an opinion of how long 14:49:24
4 a POSITA would apply heating for in this 14:49:27
5 situation. Right? 14:49:30
6 MR. SELWYN: Objection. Form. 14:49:31
7 A I think a POSITA would know how to apply 14:49:33
8 heating to a time that was appropriate to the 14:49:38
9 POSITA's structure, piece of equipment, dopant 14:49:41
10 atoms, material into which they're doping, 14:49:48
11 introducing the dopant atoms, et cetera. 14:49:52
12 Q But sitting here today, you could not 14:49:56
13 tell me what that time would be. Right? The time 14:49:58
14 for how long a POSITA would apply heating of 975 14:50:02
15 degrees C. Right? 14:50:06
16 MR. SELWYN: Objection. Form. 14:50:07
17 A No, I can't tell you that you should use 14:50:10
18 14-and-a-half minutes or 80 minutes without having 14:50:14
19 the information that a POSITA would have with 14:50:18
20 making ordinary design choices. 14:50:22
21 Q Would a POSITA know the consequences of 14:50:30
22 applying heating of 975 degrees C for minutes, 14:50:32

1 what the consequences of that would be on the 14:50:40
2 dopants on the back surface? 14:50:42
3 MR. SELWYN: Objection. Form. 14:50:45
4 A I think that maybe you'd like to ask the 14:51:04
5 question another way. What the consequences are, 14:51:08
6 that could be quite open ended. And you mentioned 14:51:11
7 minutes. And 1 minute and 800 minutes are both 14:51:15
8 minutes. So perhaps you could provide me a little 14:51:19
9 more guidance. 14:51:21
10 Q Let's say under ten minutes would be the 14:51:22
11 time a POSITA applied heating of 975 degrees C to 14:51:25
12 the structure of Smith. 14:51:32
13 Would a POSITA know what the consequences 14:51:34
14 would be of that heating to the dopants on the 14:51:38
15 back surface? 14:51:42
16 A What a POSITA would know is -- first of 14:51:48
17 all, a POSITA has access to Smith's teachings, 14:51:51
18 which are silent upon any beneficial or -- or 14:51:55
19 drawbacks associated with it. But are silent 14:52:01
20 likely because Smith describes at the first 14:52:05
21 paragraph of -- first in the detailed description 14:52:08
22 that a POSITA would know. 14:52:11

1 A POSITA would understand Fick's law, 14:52:14
2 which I've described previously, which says that 14:52:17
3 dopants would -- dopants move from places of high 14:52:20
4 concentration to low concentration, and that their 14:52:24
5 movement is determined by the time and 14:52:31
6 temperature. 14:52:32
7 And so if a POSITA had particular 14:52:34
8 concerns about dopants that were already in the 14:52:39
9 structure moving, then a POSITA would know to 14:52:45
10 modulate, for example, the time or the temperature 14:52:47
11 in order to achieve the desired result as taught 14:52:51
12 by Smith. 14:52:55
13 Q Earlier we talked about heating of 750 14:52:58
14 degrees for minutes. And you opined that a POSITA 14:53:02
15 would know that in that situation the dopants 14:53:10
16 would not move. 14:53:12
17 Do you remember that? 14:53:14
18 A Yes. I don't think those were my exact 14:53:17
19 words. But I conveyed that a POSITA would 14:53:19
20 understand Fick's law that time and temperature 14:53:22
21 determine diffusion of dopants; and that if 14:53:27
22 dopants were diffused into the substrate at 1000 14:53:31

1 degrees C, their movement would be much slower at 14:53:34
2 750 degrees C. 14:53:37
3 Q Would that answer change if we changed 14:53:39
4 700 degrees -- 750 degrees to 975 degrees C? 14:53:44
5 A It would change just as Fick's law 14:53:49
6 teaches. So at 975 degrees C the dopants will 14:53:52
7 move faster than at 750 degrees C, and they will 14:53:56
8 move slower than at 1000 degrees C. 14:54:01
9 Q So in a situation of 750 degrees C, where 14:54:06
10 you testified that the dopants -- a POSITA would 14:54:12
11 not expect that the dopants would move, in the 14:54:15
12 situation of 975 degrees C would a POSITA expect 14:54:20
13 the dopants to move? 14:54:24
14 MR. SELWYN: Objection. Form. 14:54:26
15 A A POSITA would understand Fick's law, 14:54:30
16 which says that if you wait long enough the 14:54:33
17 dopants would move. "Wait long enough" being -- 14:54:37
18 you know, could be -- if you wait days to 14:54:42
19 lifetimes, everything diffuses. That's what 14:54:45
20 Fick's law says. 14:54:48
21 But a POSITA would understand that Fick's 14:54:50
22 law says that less movement will happen in less 14:54:52

1 time. And so therefore, a POSITA can take Smith's 14:54:58
2 teachings and apply their existing knowledge and 14:55:03
3 their ordinary ingenuity in order to achieve an 14:55:12
4 outcome where, for example, Smith's structure is 14:55:17
5 fabricated in the way that Smith envisions. 14:55:29
6 Q Well, at 975 degrees C, how long would 14:55:31
7 you need to apply the heating for in order for the 14:55:40
8 dopants to start moving? 14:55:46
9 A Maybe you can be more specific about 14:55:54
10 "start moving." 14:55:57
11 Fick's law says that movement can occur 14:55:58
12 at any temperature, but the amount of movement 14:56:06
13 will depend on the temperature and the time. 14:56:09
14 And so when I say it can occur at any 14:56:12
15 movement, I mean that in minutes at lower 14:56:14
16 temperatures there might be 0.001, that is to say, 14:56:22
17 an immeasurable amount of movement. And at higher 14:56:26
18 temperatures for the same amount of time they 14:56:29
19 could move nanometers. And at higher temperatures 14:56:31
20 still in the same amount of time they could move 14:56:34
21 microns. 14:56:37
22 So a POSITA would understand Fick's law, 14:56:38

1 the physics that, for example, I teach my students 14:56:43
2 in class, that says that time, temperature, and 14:56:47
3 concentration gradients determine diffusion, and 14:56:54
4 that the diffusion coefficient, how fast things 14:56:57
5 move, depends on what those dopant atoms are and 14:57:01
6 what they're moving in. 14:57:06
7 So when you say "starts to move," this 14:57:09
8 isn't -- I'm unable to provide a clear answer 14:57:12
9 without talking -- without more specifics. 14:57:19
10 Q Let's say in this exact situation we have 14:57:24
11 in Smith, where we have a first step in situ 14:57:27
12 heating to 1000 degrees C, and then a second step 14:57:32
13 in situ where the furnace conditions are changed 14:57:39
14 to 750 degrees C, and then to 975 degrees C, how 14:57:42
15 long would you need to apply the heating of 750 14:57:52
16 degrees C in order for the dopants on the back 14:57:58
17 surface to become more diffused? 14:58:05
18 MR. SELWYN: Objection to form. 14:58:10
19 A Can you please define "more diffused" for 14:58:12
20 me. 14:58:15
21 Q For the dopants to go deeper into the 14:58:17
22 substrate. 14:58:27

1 A Can you please define "deeper" for me. 14:58:29
2 Q Do you -- what is your understanding of 14:58:31
3 the word "deeper"? 14:58:36
4 MR. SELWYN: Objection. Form. 14:58:39
5 A Deeper in the context of a diffusion 14:58:43
6 means further into, for example, the wafer or 14:58:47
7 layer. 14:58:50
8 Q Okay. So based on that understanding, 14:58:52
9 how long would you need to apply heating for of 14:58:56
10 750 degrees for the dopant to be diffused deeper? 14:58:59
11 MR. SELWYN: Objection. Form. 14:59:07
12 A I'm still unable to answer the question 14:59:08
13 because you asked for a number, a time, but 14:59:10
14 without specifying what "deeper" or what "further" 14:59:14
15 means. 14:59:18
16 I understand what the word "deeper" 14:59:18
17 means, but I can't understand -- I can't answer a 14:59:20
18 quantitative question with qualitative boundary 14:59:22
19 conditions. 14:59:25
20 Q Is there an amount of time where I can 14:59:26
21 apply heating of 750 degrees but the dopants do 14:59:39
22 not become -- but the dopant particles do not move 14:59:48

1 in the substrate at all? 14:59:54
2 MR. SELWYN: Objection. 14:59:56
3 Q Is that possible? 14:59:56
4 MR. SELWYN: Objection. Form. 14:59:57
5 A At room temperature atoms vibrate even -- 15:00:04
6 and certainly at higher temperatures. And we 15:00:11
7 would say that they move. They go like this, for 15:00:13
8 instance. 15:00:16
9 So I don't think that's what you mean 15:00:17
10 with your question, though. 15:00:21
11 Q What do we -- what do we mean when we 15:00:33
12 talk about diffusion of dopants? Can you remind 15:00:36
13 me? 15:00:40
14 MR. SELWYN: Objection. Form. 15:00:40
15 A Yes. We mean the movement of dopants 15:00:41
16 from a source of high concentration, for example a 15:00:45
17 dopant source as taught by Smith or Gan or others, 15:00:49
18 to a location of lower concentration, for example 15:00:55
19 a wafer surface or a layer such as polysilicon 15:01:01
20 deposited on the wafer. 15:01:07
21 Q When I apply heating of 750 degrees for 15:01:08
22 any amount of time, would that cause movement of 15:01:15

1 dopants from a source of high concentration to a 15:01:19
2 location of lower concentration? 15:01:22
3 A So when you say "movement of dopants," do 15:01:34
4 you have a distance in mind? 15:01:39
5 Q Did you have a distance in mind when you 15:01:45
6 earlier said movement of dopants from a source of 15:01:47
7 high concentration to a location of lower 15:01:49
8 concentration? 15:01:52
9 A Yes. I teach in my background section 15:01:56
10 that for emitters, for example, the -- one -- 15:02:00
11 there is a depth of an emitter. It's a 15:02:07
12 characteristic depth that describes how deep 15:02:11
13 dopant atoms might go. If you give me one moment. 15:02:17
14 For example, in Paragraph 58 when I'm 15:02:35
15 talking about PN junctions, I say, "Diffused 15:02:37
16 regions are thin relative to the wafer's 15:02:43
17 thickness, commonly extending 0.3 to 3 microns 15:02:44
18 into the wafer's surface." 15:02:48
19 Q So if I were to apply heating of 750 15:03:00
20 degrees C in order for the dopant to travel 0.3 15:03:03
21 microns into the wafer, how long would I need to 15:03:10
22 apply that heating for? 15:03:14

1 MR. SELWYN: Objection. Form. 15:03:17
2 Q In a situation of Smith specifically. 15:03:18
3 A Okay. Good. Now we have a question that 15:03:22
4 is answerable, but I don't have the information in 15:03:25
5 front of me to answer it. In particular, I would 15:03:28
6 need the diffusion coefficients of the dopants. 15:03:31
7 But at 750 degrees C, I wouldn't expect 15:03:34
8 boron or phosphorus, and a POSITA wouldn't expect 15:03:41
9 boron or phosphorus, to diffuse I believe you said 15:03:44
10 0.3 microns -- 15:03:53
11 Q Yes. 15:03:54
12 A -- in minutes. 15:04:00
13 I think that that process would take 15:04:04
14 hours or longer. 15:04:06
15 Q What about at 975 degrees C? 15:04:08
16 MR. SELWYN: Objection to form. 15:04:14
17 A The dopants will diffuse faster, as we 15:04:17
18 discussed. And I again don't have the necessary 15:04:23
19 information to calculate how long it would take 15:04:30
20 them to diffuse 0.3 microns. But I would expect 15:04:33
21 that it would be -- I would expect that it would 15:04:48
22 be less than several hours. I don't know exactly 15:05:07

1 how quickly it will happen, but I don't think it's 15:05:11
2 going to take a day, for example, for dopants to 15:05:16
3 diffuse that far, for phosphorus or boron to 15:05:20
4 diffuse that far at 975 degrees C in silicon. 15:05:24
5 Q Roughly speaking, we're talking about a 15:05:29
6 matter of hours and not minutes. 15:05:33
7 Is that correct? 15:05:35
8 A I'm sorry, I meant to give an upper 15:05:37
9 limit. So I mean that it would -- I would expect 15:05:42
10 that it would be shorter than several hours at 15:05:44
11 those -- that temperature. 15:05:50
12 Q Would it be shorter than one hour? 15:05:51
13 A It could be. I don't have the necessary 15:05:55
14 information to perform a calculation, but it could 15:05:58
15 be. 15:06:05
16 MR. SELWYN: Jing, when you get to a good 15:06:05
17 stopping point, maybe we could -- 15:06:06
18 MS. ZHAO: I was just about to say that. 15:06:08
19 MR. SELWYN: Go ahead. 15:06:10
20 MS. ZHAO: Let's -- we can go off the 15:06:11
21 record. 15:06:17
22 (A recess was taken.) 15:06:19

1 BY MS. ZHAO: 15:35:29
2 Q Let's go to Paragraph 122 of the '053 15:35:29
3 declaration. 15:35:34
4 A 122, is that correct? 15:35:46
5 Q Yes, 122, Page 77. 15:35:47
6 A I'm there. 15:35:54
7 Q About seven lines into the paragraph you 15:35:54
8 talk about "The combination of Froitzheim's back 15:35:57
9 junction solar cell and Gan's polysilicon 15:36:01
10 emitter" -- I'm going to skip the part in the 15:36:05
11 middle here -- "would have simply involved 15:36:08
12 implementing Gan's outside layer and polysilicon 15:36:10
13 emitter on the back of Froitzheim's N-type silicon 15:36:15
14 layer." 15:36:16
15 Do you see that? 15:36:16
16 A Yes. 15:36:17
17 Q I refer to this combination that you 15:36:17
18 propose here as the Froitzheim-Gan combination. 15:36:22
19 Is that okay? 15:36:26
20 A Yes. 15:36:27
21 Q I'd like to walk through Froitzheim and 15:36:27
22 Gan with you to figure out how a POSITA would 15:36:33

1 construct this Froitzheim-Gan combination. So 15:36:36
2 let's first go to Exhibit 1004, Froitzheim. And 15:36:40
3 if I can have you turn to Paragraph 38. 15:36:49
4 A Okay. 15:37:02
5 Q So here Froitzheim tells us that it will 15:37:02
6 now discuss the method of manufacturing solar 15:37:05
7 cell. 15:37:08
8 Do you see that? 15:37:08
9 A Yes. 15:37:12
10 Q And Paragraphs 39 to 50 discuss the 15:37:13
11 manufacturing steps of Froitzheim's solar cell. 15:37:16
12 Right? 15:37:21
13 A Yes. 15:37:29
14 Q Let's walk through these steps. Starting 15:37:29
15 on Paragraph 39. It talks about a silicon body 15:37:34
16 layer of N-type bulk doping. Right? 15:37:38
17 A Right. And Froitzheim says that's 15:37:44
18 typically a wafer. So it's a wafer, correct. 15:37:46
19 Q Would the Froitzheim-Gan combination use 15:37:48
20 that silicon body layer or wafer? 15:37:53
21 A So in making a combination, a POSITA, as 15:38:01
22 I understand it, making -- in determining whether 15:38:04

1 a combination would be obvious, a POSITA is not 15:38:10
2 restricted to taking particular instances, 15:38:15
3 recipes, and combining them in a wrote manner, but 15:38:20
4 rather taking the teachings and applying their 15:38:23
5 ordinary ingenuity. 15:38:26
6 So as we walk through the process that I 15:38:28
7 think may be coming, I'd like to keep that in 15:38:30
8 mind. 15:38:33
9 Froitzheim teaches a wafer. We've 15:38:35
10 described that. Gan also teaches a wafer. 15:38:36
11 Q Paragraphs 40 and 41 talk about P-type 15:38:44
12 doping on the rear surface of the body layer or 15:38:47
13 wafer. Correct? 15:38:50
14 A And Paragraph 42 as well. Forty, 41, and 15:39:03
15 42. 15:39:06
16 Q Yeah. Let me ask about 40 and 41 first. 15:39:07
17 Would the Froitzheim-Gan combination use 15:39:11
18 the processes described in Paragraphs 40 and 41? 15:39:14
19 A Paragraphs 40 through 42 describe a 15:39:22
20 doping step in which a dopant source layer is 15:39:27
21 added to a surface. In Froitzheim's case it's a 15:39:37
22 wafer. And then that dopant source layer -- the 15:39:40

1 substrate with the dopant source layer is heated 15:39:45
2 to diffuse dopants in. 15:39:48
3 And as I describe in my declaration, for 15:39:50
4 example around Paragraph 135 of my declaration, 15:40:24
5 Gan teaches an oxide layer and polysilicon layer. 15:40:26
6 The polysilicon layer is an emitter in Gan. It 15:40:33
7 can be P-type emitters are doped. They have the 15:40:36
8 opposite doping polarity of the wafer. And so a 15:40:41
9 POSITA could take the teachings of Gan and 15:40:44
10 implement them in place of Froitzheim's diffused 15:40:49
11 emitter described in Paragraphs 40 through 42 of 15:40:57
12 Froitzheim. 15:41:01
13 Q Let's look at Paragraph 42 real quick 15:41:15
14 anyway. 15:41:18
15 It talks about a temperature range of 900 15:41:22
16 to 1200 degree centigrade. Right? 15:41:24
17 A That is correct. 15:41:27
18 Q And then a preferred temperature range of 15:41:28
19 1000 to 1100 degree centigrade. Right? 15:41:31
20 A Correct. 15:41:37
21 Q Why does Froitzheim have a preferred 15:41:38
22 temperature range that is slightly different from 15:41:42

1 the temperature range of 900 to 1200? 15:41:46
2 A I am not one of the inventors. I can't 15:41:52
3 comment on exactly what they were thinking. But 15:41:55
4 it's not uncommon, in my experience in patents, to 15:41:58
5 have wider ranges, and in some cases to provide 15:42:05
6 narrow ranges -- narrower ranges within those 15:42:08
7 wider ranges. 15:42:11
8 Q But what is the purpose of providing a 15:42:12
9 narrower range, in your experience? 15:42:17
10 A I can take Froitzheim's words here. 15:42:21
11 Froitzheim says that the wafer is treated in an 15:42:29
12 atmosphere that contains oxygen at a temperature 15:42:33
13 of 900 to 1200 degrees centigrade, preferably 15:42:35
14 between 1000 and 1100 degrees centigrade, to 15:42:39
15 generate an oxide layer and to drive in the 15:42:43
16 dopant. 15:42:46
17 So I believe in this sentence Froitzheim 15:42:47
18 is providing ranges that Froitzheim believes are 15:42:49
19 suitable to achieve Froitzheim's purpose of this 15:42:52
20 step, which was to generate an oxide layer 15:42:56
21 containing boron dopant atoms and to diffuse those 15:43:01
22 atoms, in Froitzheim's case, into the wafer 15:43:06

1 surface. 15:43:09
2 Q Would it be -- excuse me. Would it be 15:43:10
3 accurate to say that the range of 1000 to 1100 15:43:16
4 degrees centigrade is more suitable for 15:43:23
5 Froitzheim's purposes than the range of 900 to 15:43:27
6 1200? 15:43:32
7 MR. SELWYN: Objection. Form. 15:43:32
8 A The words that Froitzheim used is -- uses 15:43:34
9 is preferably between 1000 and 100 -- 1100 degrees 15:43:37
10 centigrade, although Froitzheim before that gives 15:43:44
11 the range of 900 to 1200 degrees. 15:43:46
12 Q I'm just trying to understand what 15:43:51
13 "preferred temperature range" means here to a 15:43:56
14 POSITA. 15:43:58
15 A I understand "preferably" with its plain 15:44:01
16 and ordinary meaning. And I can't assign more 15:44:04
17 meaning to it than that without being one of the 15:44:07
18 inventors on the patent, which I'm not. 15:44:14
19 Q In Paragraph 42 it also talks about 15:44:17
20 treating the wafer in oxygen. Right? 15:44:21
21 A It does. That's correct. 15:44:25
22 Q And treating the wafer in oxygen 15:44:28

1 generates an oxide layer. Right? 15:44:30
2 A Yes, it's commonly used in the phosphorus 15:44:34
3 doping process that I described in my background 15:44:41
4 section. 15:44:52
5 Q Would the Froitzheim-Gan combination 15:44:52
6 include this oxide layer from Froitzheim? 15:44:55
7 A A POSITA doesn't need to take 15:45:01
8 Froitzheim's oxide layer. A POSITA is able to 15:45:04
9 take the teachings of Gan and Froitzheim 15:45:08
10 generally, and both of them teach a standard 15:45:11
11 diffusion process of phosphorus. 15:45:15
12 In Gan's case he teaches it, the 15:45:19
13 diffusion process, into -- excuse me, standard 15:45:21
14 diffusion process of boron. I misspoke 15:45:25
15 previously. 15:45:28
16 In Gan's case he teaches this boron 15:45:36
17 diffusion into a polysilicon emitter. The 15:45:39
18 polysilicon emitter that I have incorporated in, 15:45:42
19 combined with Froitzheim. And in Froitzheim's 15:45:45
20 case he teaches boron diffusion process into -- 15:45:48
21 into a wafer. 15:45:52
22 Gan's process provides a temperature 15:45:54

1 range of 900 to 1000 degrees C, which is within 15:45:58
2 Froitzheim's temperature range. There's no 15:46:02
3 incompatibility of those range -- ranges. Gan's 15:46:05
4 process for doping the polysilicon emitter would 15:46:11
5 work with Froitzheim. Froitzheim also teaches how 15:46:18
6 to dope a layer. 15:46:21
7 Q Does boron diffusion always result in an 15:46:25
8 oxide layer being formed? 15:46:40
9 MR. SELWYN: Can you say that again? I 15:46:43
10 just couldn't hear you. 15:46:44
11 Q Sorry. Does boron diffusion always 15:46:45
12 result in an oxide layer being formed? 15:46:48
13 A "Always" is a -- is a strong word. I 15:46:59
14 wouldn't want to agree with that. 15:47:03
15 But as I describe in my background 15:47:05
16 section, in order to diffuse boron, one requires a 15:47:13
17 source of boron. And a common way to diffuse 15:47:16
18 boron was from a borosilicate glass, or BSG. And 15:47:20
19 that is a mixture of boron, silicon, and oxygen. 15:47:27
20 The silicon and oxygen is what gives the name 15:47:31
21 glass. 15:47:34
22 Q I'm going to Paragraph 43 of Froitzheim. 15:47:40

1 It talks about steps for providing the front side 15:47:46
2 N plus layer. Right? 15:47:50
3 A Yes, it does. 15:47:53
4 Q Would the Froitzheim-Gan combination use 15:47:54
5 the process described in Paragraph 43? 15:47:59
6 A Froitzheim teaches how to form the N plus 15:48:06
7 layer at the -- at the front side. That's 15:48:11
8 teachings that come from -- from Froitzheim, yes. 15:48:14
9 Q I'm sorry, I'm not sure you understood my 15:48:20
10 question, so let me just make sure. 15:48:25
11 My question was, would the Froitzheim-Gan 15:48:27
12 combination use the process described in Paragraph 15:48:30
13 43? 15:48:33
14 A Okay. And my answer is that Froitzheim 15:48:40
15 teaches how to form an N plus layer, and that 15:48:45
16 Froitzheim's teachings can be used in the 15:48:54
17 Froitzheim-Gan combination to form that N plus 15:48:57
18 layer. 15:49:01
19 Q This paragraph incorporates by reference 15:49:03
20 two U.S. patents. 15:49:15
21 Do you see that? 15:49:16
22 A I do. 15:49:19

1 Q I believe earlier I asked you this, but 15:49:19
2 let me just make sure. Have you reviewed those 15:49:22
3 two patents? 15:49:24
4 A Yes. And my answer is the same as 15:49:26
5 before, I may have, but I don't recognize them by 15:49:29
6 their number alone. So I don't remember at this 15:49:32
7 time. 15:49:35
8 Q Do you have a general understanding of 15:49:35
9 how Froitzheim would form its front side N plus 15:49:38
10 layer? 15:49:42
11 A I have an understanding, yes, of how 15:49:46
12 Froitzheim would form an N plus layer. And I 15:49:48
13 described the formation of N plus layers when I 15:49:54
14 described phosphorus diffusion in my background 15:50:01
15 section, in particular Paragraphs 53 and 54 of my 15:50:06
16 background section. 15:50:10
17 Q Can you just generally walk me through 15:50:10
18 your understanding of how Froitzheim would form 15:50:19
19 its front side N plus layer? 15:50:20
20 A Phosphorus diffusions were well known in 15:50:26
21 the art at this -- at the time. And I describe 15:50:29
22 that in 54 -- Paragraph 54 of my disclosure. So I 15:50:35

1 can walk you through that. 15:50:39
2 A common method was to vaporize 15:50:43
3 phosphorus oxychloride in a furnace. And that 15:50:47
4 phosphorus oxychloride essentially with the 15:50:53
5 addition of -- that phosphorus oxychloride reacts 15:50:55
6 with the silicon wafer or polysilicon layer 15:50:59
7 surface, forming a glass, typically called BSG for 15:51:05
8 short, and then heating in a second step -- and we 15:51:14
9 discussed this when we were referring to Smith -- 15:51:18
10 can -- or will diffuse phosphorus atoms from that 15:51:23
11 glass into the adjacent layer or wafer surface. 15:51:27
12 And this was a common method for forming 15:51:33
13 N plus layers. 15:51:37
14 Q Do you have an idea of what kind of 15:51:39
15 heating would be applied for Froitzheim's 15:51:43
16 formation of the front side N plus layer? 15:51:48
17 A A POSITA would choose an appropriate time 15:51:55
18 and temperature combination per our previous 15:51:58
19 discussions to form that layer to the depth and 15:52:03
20 surface doping concentration targeted. 15:52:09
21 Q Do you have an idea of what that 15:52:16
22 appropriate time might be? 15:52:18

1 MR. SELWYN: Objection. Form. 15:52:20
2 A There are many instances in the 15:52:26
3 literature, dating back decades, on how to perform 15:52:28
4 phosphorus diffusions. Times commonly found would 15:52:33
5 be in the tens of minutes or hours time frame. 15:52:39
6 But a POSITA would not be constrained to that 15:52:42
7 range per se in implementing the teachings of 15:52:46
8 Froitzheim, as there is a lot known about how to 15:52:52
9 make phosphorus diffusions. 15:52:56
10 Q Do you have an idea of what the 15:53:01
11 appropriate temperature might be? 15:53:02
12 MR. SELWYN: Objection. Form. 15:53:04
13 A Similar to my answer before, it was well 15:53:07
14 known how to make phosphorus diffusions, and that 15:53:10
15 there were design choices, including time and 15:53:13
16 temperature combinations. And a POSITA would be 15:53:17
17 able to make appropriate choices to achieve the 15:53:22
18 surface concentration and depth of the diffusion 15:53:25
19 that he or she wanted. And one can find values in 15:53:30
20 the -- in the literature for phosphorous 15:53:38
21 diffusions that are I think ranging anywhere from 15:53:42
22 800 to 1200 degrees C. There's a wide range of 15:53:47

1 temperatures. And a POSITA may use temperatures 15:53:55
2 even outside of those, depending on precisely the 15:53:57
3 diffusion he or she was trying to achieve. 15:54:01
4 Q Sitting here today, you would not be able 15:54:03
5 to give me a specific temperature and time 15:54:08
6 combination. 15:54:13
7 Is that right? 15:54:13
8 MR. SELWYN: Objection to form. 15:54:15
9 A I would need more information about the 15:54:16
10 rest of the solar cell in order to specify a 15:54:20
11 specific time and temperature. But a large 15:54:25
12 variety of times and temperatures would likely 15:54:28
13 work. And a POSITA, in making the solar cell, 15:54:31
14 would be able to select that time and temperature 15:54:34
15 profile to achieve Froitzheim's solar cell with 15:54:38
16 Gan's polysilicon oxide emitter. 15:54:45
17 What we're talking about here, things 15:54:49
18 like phosphorous diffusion, date back to the 15:54:52
19 1950s. 15:54:56
20 Q I don't believe your declaration provides 15:54:56
21 a specific time and temperature combination 15:55:04
22 either. 15:55:09

1 Is that correct? 15:55:09
2 MR. SELWYN: Objection to form. 15:55:11
3 A Time and temperature combination for? 15:55:13
4 Q For how to make Froitzheim's -- I'm 15:55:15
5 sorry, for how to make the front side N plus layer 15:55:22
6 in the Froitzheim-Gan combination. 15:55:25
7 A Yes, Paragraph 165 of my declaration I 15:55:29
8 talk about Froitzheim's teaching here, and that 15:55:33
9 Froitzheim teaches diffusing phosphorous from the 15:55:36
10 gas phase, which I described previously, to form a 15:55:39
11 front side N plus layer. 15:55:43
12 And that there -- this was a common 15:55:45
13 process known in the art. I give many references 15:55:50
14 to others. I don't specify a single time and 15:55:52
15 temperature profile in my declaration. 15:56:00
16 Q I just want to make sure I understand 15:56:02
17 you. 15:56:24
18 Is it your position that the references 15:56:25
19 you provide in Paragraph 165 of your declaration, 15:56:27
20 those references provide specific time and 15:56:34
21 temperature combinations for how to make front 15:56:39
22 side N plus layer of the Froitzheim-Gan 15:56:43

1 combination? 15:56:47
2 A No, that's not my position. My position 15:56:51
3 is that the references I have -- excuse me -- 15:56:53
4 provided teach how to make phosphorous diffusions, 15:56:57
5 and that phosphorous diffusions have been known 15:57:03
6 for a long time. And those references, however, 15:57:05
7 aren't specifically aimed at Froitzheim or any 15:57:12
8 other reference. They teach how to make 15:57:17
9 phosphorous diffusions as was known for a long 15:57:20
10 time. 15:57:24
11 And a POSITA would be able to make design 15:57:25
12 choices in order to form the N plus layer at front 15:57:29
13 of Froitzheim's solar cell that achieves 15:57:36
14 Froitzheim's purpose with that layer. 15:57:40
15 Q But is it accurate to say that your 15:57:46
16 declaration does not provide a specific 15:57:48
17 temperature and time combination for how to make 15:57:56
18 the front side N plus layer of the Froitzheim-Gan 15:57:59
19 combination? 15:58:04
20 MR. SELWYN: Objection. Form. 15:58:07
21 A That is correct. My declaration does not 15:58:08
22 have a specific time-temperature profile, as it's 15:58:11

1 not necessary, when -- my understanding is it's 15:58:19
2 not necessary when evaluating obviousness to 15:58:23
3 assume that two steps are put together 15:58:25
4 mechanistically; but, rather, that the teachings 15:58:31
5 of the references and what a POSITA knew at the 15:58:38
6 time inform whether or not a combination is -- is 15:58:43
7 obvious. And a POSITA knew and had access to 15:58:47
8 decades of information about how to make a 15:58:53
9 phosphorous diffusion. 15:58:59
10 A POSITA doesn't require me to tell him 15:59:00
11 or her, This is the specific time and temperature 15:59:03
12 profile that we use. And Froitzheim understood 15:59:06
13 this, I believe. Which is why the Froitzheim does 15:59:10
14 not itself specify in great detail the time and 15:59:15
15 temperature combination that Froitzheim had in 15:59:22
16 mind. Because Froitzheim understood that the 15:59:25
17 people at the time already knew how to make 15:59:28
18 phosphorous diffusions. 15:59:30
19 Q You said earlier, "I would need more 15:59:32
20 information about the rest of the solar cell in 15:59:36
21 order to specify a specific time and temperature." 15:59:39
22 Right? 15:59:42

1 A What did I say that in relation to? 15:59:49
2 Q Let me just read this part of the 15:59:50
3 transcript. 15:59:52
4 My question was, "Sitting here today, you 15:59:53
5 would not be able to give me a specific 15:59:54
6 temperature and time combination. 15:59:57
7 Is that right?" 16:00:00
8 And your answer was, "I would need more 16:00:00
9 information about the rest of the solar cell in 16:00:03
10 order to specify a specific time and temperature." 16:00:06
11 You go on to elaborate on that, that you -- I just 16:00:11
12 want to ask, sitting here today, do you have that 16:00:17
13 information about the rest of the solar cell in 16:00:21
14 order to specify a specific time and temperature? 16:00:24
15 MR. SELWYN: Objection. Form. 16:00:28
16 A I can elaborate. 16:00:32
17 Froitzheim doesn't provide one specific 16:00:35
18 embodiment of Froitzheim's invention, but, rather, 16:00:39
19 Froitzheim allows for variation within his 16:00:43
20 invention. 16:00:48
21 For example, Froitzheim gives a variation 16:00:49
22 in the percentage coverage of the N plus doping 16:01:00

1 region at the front. That's in Paragraph 18. 16:01:09
2 Froitzheim allows for possibilities of multiple 16:01:12
3 passivation layer structures, so it can oxide 16:01:17
4 silicon nitride, amorphous silicon, and doped -- N 16:01:20
5 plus doped amorphous silicon. That's in Paragraph 16:01:27
6 19, et cetera. Froitzheim allows for many 16:01:31
7 embodiments of Froitzheim's invention. 16:01:34
8 But one cannot specify the particular 16:01:35
9 doping time and temperature profile, for example, 16:01:40
10 without choosing a particular instance or 16:01:43
11 embodiment of Froitzheim's invention. 16:01:47
12 So it's not that Froitzheim doesn't teach 16:01:49
13 these things or that I don't know; it's that 16:01:51
14 Froitzheim -- Froitzheim's teachings are -- allow 16:01:54
15 for multiple embodiments. And one of those 16:01:58
16 embodiments must be selected in order to, for 16:02:01
17 example, determine, as a POSITA would know how to 16:02:05
18 do based on the extensive literature, a particular 16:02:10
19 doping profile. 16:02:16
20 Q Do you select a specific embodiment of 16:02:17
21 Froitzheim to use in your Froitzheim-Gan 16:02:22
22 combination? 16:02:25

1 A I do not. I do not have to, for example, 16:02:28
2 choose the wafer thickness. What -- what I do is 16:02:31
3 show that the teachings of Froitzheim in 16:02:38
4 combination with Gan, at least for this particular 16:02:42
5 grounds that we're talking about, those in 16:02:45
6 combination teach all of the limitations of the 16:02:50
7 claims of -- the claims that are addressed in this 16:02:55
8 grounds of the '053 patent. 16:03:04
9 Q But going back to what you said earlier, 16:03:08
10 the, quote, "I would need more information about 16:03:11
11 the rest of the solar cell in order to specify a 16:03:13
12 specific time and temperature." What information 16:03:17
13 do you need in order to specify a specific time 16:03:22
14 and temperature? 16:03:25
15 MR. SELWYN: Objection. Form. 16:03:29
16 A A POSITA would require the sorts of 16:03:30
17 design choices, ordinary design choices within the 16:03:33
18 allowable embodiments of Froitzheim's invention 16:03:39
19 that I suggested previously and that you and I 16:03:43
20 were just talking about. For example, the 16:03:46
21 thickness of the wafer or the fraction of the 16:03:49
22 surface area covered by the N plus layer on the 16:03:55

1 front. That's -- that's Paragraph 18, for 16:03:58
2 instance. 16:04:02
3 So these things need to be specified in 16:04:03
4 order to understand, for example, what the surface 16:04:05
5 doping density should be, the surface 16:04:09
6 concentration of the dopant, and the depth of the 16:04:11
7 diffusion, which would then lead to a choice of a 16:04:14
8 suitable diffusion profile. 16:04:20
9 Q And those information -- that information 16:04:29
10 is not provided in your declaration. 16:04:36
11 Is that correct? 16:04:38
12 MR. SELWYN: Objection. Form. 16:04:40
13 A Which information? 16:04:42
14 Q The information you just talked about, 16:04:43
15 for example, the design choices, ordinary design 16:04:47
16 choices within the allowable embodiments of 16:04:51
17 Froitzheim's invention, for example the thickness 16:04:54
18 of the wafer or the fraction of the surface area, 16:04:58
19 and so on. 16:05:01
20 MR. SELWYN: Objection. Form. 16:05:04
21 A I do regularly in my declaration point 16:05:07
22 out that a POSITA would understand how to 16:05:12

1 implement the teachings of, for example, 16:05:21
2 Froitzheim. A POSITA does have knowledge and 16:05:26
3 ordinary ingenuity. And so a POSITA doesn't have 16:05:32
4 to be given a recipe like a robot in order to 16:05:36
5 successfully implement the teachings of the art. 16:05:40
6 And so I do say that regularly throughout 16:05:44
7 my declaration. I was trying to read my 16:05:49
8 declaration in order to answer your question and 16:05:57
9 give you additional detail about how a POSITA 16:05:59
10 might think about implementing the teachings. 16:06:02
11 Q Let me just make sure I -- you understand 16:06:06
12 my question here. 16:06:26
13 A Okay. 16:06:28
14 Q My question was, because earlier you 16:06:28
15 said -- because earlier you said, "I would need 16:06:39
16 more information about the rest of the solar cell 16:06:41
17 in order to specify a specific time and 16:06:44
18 temperature." My question was simply the 16:06:47
19 information you would need is not provided in your 16:06:51
20 declaration. 16:06:54
21 Is that correct? 16:06:55
22 MR. SELWYN: Objection. Form. 16:06:57

1 A The information that I or a POSITA would 16:07:16
2 need is provided in Froitzheim. And as I 16:07:20
3 described in my previous answer, because 16:07:25
4 Froitzheim teaches a range of allowable wafer 16:07:31
5 thicknesses, a range of allowable N plus 16:07:34
6 contact -- N plus areal coverage, et cetera, one 16:07:42
7 cannot specify a particular time and temperature 16:07:49
8 profile without also selecting, for example, a 16:07:59
9 wafer thickness. 16:08:03
10 This is standard in all solar cell 16:08:05
11 fabrication. One doesn't select a diffusion 16:08:08
12 profile before selecting a wafer, for instance. 16:08:11
13 I didn't say that in my declaration 16:08:15
14 because I didn't need to. I describe in the 16:08:17
15 background section that solar cells date back to 16:08:20
16 the 1950s, and that appreciable knowledge in the 16:08:24
17 fabrication, design and fabrication of solar cells 16:08:29
18 that a POSITA having regular and normal ingenuity 16:08:31
19 already has access to. 16:08:37
20 Q When you say, "I didn't say that in my 16:09:06
21 declaration because I didn't need to," what 16:09:08
22 specifically are you referring to? 16:09:12

1 A I didn't have to state explicitly in my 16:09:15
2 declaration that a POSITA makes design choices in 16:09:17
3 fabricating a solar cell, design choices based on 16:09:24
4 what the POSITA knows based on decades of 16:09:28
5 experience and publication in the field. 16:09:35
6 Every POSITA understands that when they 16:09:42
7 go to implement a solar cell, they will need to 16:09:45
8 make design choices, that things will need to be 16:09:48
9 specified, which will then influence subsequent 16:09:50
10 decisions, et cetera. 16:09:55
11 This is routine. This is the way that 16:09:56
12 solar cells or any other device is fabricated. 16:09:59
13 One has to make ordinary design choices. 16:10:06
14 Q Let's go to Paragraph 44 of Froitzheim. 16:10:10
15 Is it accurate to say that according to 16:10:35
16 Paragraph 44, Froitzheim first performs the P-type 16:10:37
17 dopant diffusion and then the N-type dopant 16:10:47
18 diffusion? 16:10:50
19 A Yes, in Paragraph 44 of Froitzheim, 16:11:13
20 Froitzheim describes the N plus doping occurring 16:11:20
21 after the emitter, the P-type emitter, is formed. 16:11:28
22 Q Is it accurate to say that those 16:11:34

1 diffusions are performed separately? 16:11:40
2 A One moment, please. 16:11:53
3 To answer your question, in the -- in 16:14:52
4 the -- in the method described in Paragraph 44 16:15:09
5 Froitzheim is discussing diffusion of the front 16:15:20
6 side N plus layer after diffusion of a P-type 16:15:23
7 emitter at the -- at the rear side. 16:15:31
8 Elsewhere in Froitzheim, Froitzheim talks 16:15:37
9 about the structure of the N plus layer at the 16:15:46
10 front and how it's -- and how it's arranged. But 16:15:51
11 in the fabrication sequence given that includes 16:16:04
12 Paragraph 44, Froitzheim is performing that 16:16:08
13 diffusion after the P-type diffusion into the 16:16:11
14 emitter. 16:16:17
15 Q But can I understand Paragraph 44 to mean 16:16:22
16 first he would apply heat to drive in the P-type 16:16:26
17 dopant? 16:16:29
18 MR. SELWYN: Objection to form. 16:16:37
19 A Well, that's not the first thing that's 16:16:46
20 done in the solar cell fabrication. 16:16:47
21 Q Between the diffusion of P-type dopant 16:16:52
22 and the diffusion of N-type dopant, can I 16:16:57

1 understand Paragraph 44 to mean first you apply 16:17:00
2 heat to drive in the P-type dopant? 16:17:03
3 MR. SELWYN: Objection. Form. 16:17:06
4 A In Paragraph 40 -- 40 through 44 16:17:34
5 Froitzheim describes a process that forms a P-type 16:17:47
6 diffused emitter, and then subsequently forms an 16:17:52
7 N-type, N plus front surface field. 16:17:57
8 Q The process that forms a P-type diffused 16:18:12
9 emitter in Froitzheim, does that involve heating? 16:18:15
10 A Yes, Froitzheim describes that in 16:18:23
11 Paragraph 42 of Froitzheim. 16:18:28
12 Q And the process that forms the N-type 16:18:31
13 front surface -- I'm sorry, you said N-type N plus 16:18:38
14 front surface field, that process, does that 16:18:43
15 involve heating? 16:18:45
16 MR. SELWYN: Objection. Form. 16:18:48
17 A Yes, in Paragraph 44 Froitzheim describes 16:18:54
18 forming the N plus layer, the -- a diffusion. 16:18:56
19 Q So I am just trying to understand the 16:19:06
20 process of forming the P-type diffused emitter and 16:19:07
21 the N plus front surface field. Are we talking 16:19:11
22 about two rounds of heating or just one round of 16:19:14

1 heating? 16:19:17
2 A I would need to have in front of me the 16:19:29
3 U.S. 5899704 and 6099668 patents to confirm. 16:19:32
4 Because Froitzheim teaches that the N plus layer 16:19:42
5 can be conducted according to the steps disclosed 16:19:47
6 therein. 16:19:52
7 Q Typically when you diffuse the P-type 16:19:55
8 dopant and then you diffuse the N-type dopant, 16:19:58
9 would you use two rounds of heating or one round 16:20:02
10 of heating? 16:20:05
11 MR. SELWYN: Objection. Form. 16:20:06
12 A I can't answer the question. That -- 16:20:08
13 typically I don't know what -- what process 16:20:13
14 sequence you're referring to or which solar cell 16:20:15
15 or -- it's a lack of definition that allows me to 16:20:18
16 answer the question. 16:20:24
17 Q So there is no general process of how a 16:20:24
18 structure like Froitzheim would be constructed? 16:20:28
19 MR. SELWYN: Objection. Form. 16:20:31
20 A There are multiple processes in how 16:20:33
21 diffusions occur and can be conducted. They can 16:20:39
22 be conducted sequentially. And one thing that 16:20:42

1 Froitzheim describes is that they can be conducted 16:20:47
2 sequentially, as I mentioned in my previous 16:20:51
3 answer, Paragraphs 40 through 44. They can also 16:20:56
4 be done at the same time. That was well known and 16:21:00
5 common. I describe that in my background section 16:21:06
6 when I talk about co-diffusion. 16:21:17
7 "Co-diffusion" is the one word commonly 16:21:23
8 used to describe diffusion of two or more types of 16:21:25
9 dopants simultaneously. And I provide several 16:21:28
10 pieces of -- several references where co-diffusion 16:21:34
11 was used. 16:21:40
12 What I don't know, without looking at the 16:21:41
13 patents referenced in 43 of Froitzheim, is whether 16:21:45
14 Froitzheim explicitly also anticipated -- maybe 16:21:53
15 that's the wrong word to use, but Froitzheim 16:21:56
16 taught through those incorporated references 16:21:58
17 co-diffusion. 16:22:05
18 Q When you say the process can be conducted 16:22:05
19 sequentially, do you mean two rounds of heating? 16:22:07
20 A Yes, that's -- that's what I was 16:22:16
21 referring to. Multiple heating steps, where 16:22:18
22 discussions can be conducted through multiple 16:22:29

1 sequential heating steps or by diffusing multiple 16:22:33
2 dopants at the same time with one heating step. 16:22:36
3 Or some -- something that's somewhat in between 16:22:42
4 those two options is, for example, taught by 16:22:44
5 Smith, where a wafer may experience some 16:22:49
6 temperature, some elevated temperature, and then 16:22:56
7 change to a different elevated temperature 16:22:57
8 without, for example, returning to room 16:23:00
9 temperature in between. 16:23:02
10 Q Well, let's say I have a first heating 16:23:04
11 step that diffuses a P-type dopant. 16:23:15
12 A Okay. 16:23:20
13 Q And I have a second heating step that 16:23:20
14 diffuses an N-type dopant. 16:23:24
15 Would this second heating step affect the 16:23:28
16 P-type dopant in any way? 16:23:31
17 MR. SELWYN: Objection. Form. 16:23:34
18 A It could. I think we had a discussion 16:23:38
19 about this previously. It depends on the time and 16:23:41
20 temperature of the second step and the diffusivity 16:23:50
21 of I believe you said it was P-type dopants 16:23:56
22 introduced in the first step, and also the 16:24:00

1 material in which they are -- they are located. 16:24:03
2 So they could diffuse further. That 16:24:08
3 could be a short distance or a long distance, as 16:24:14
4 we described. Or they could diffuse negligibly, 16:24:16
5 depending on the details. 16:24:22
6 Q So would the Froitzheim-Gan combination 16:24:24
7 use the process described in Paragraph 44? 16:24:31
8 A It could. Froitzheim teaches this N plus 16:24:46
9 diffusion at the front of the substrate, and that 16:24:53
10 could be used in the Froitzheim-Gan combination, 16:24:59
11 with Gan's polysilicon emitter and oxide layer at 16:25:07
12 the back of the solar cell. 16:25:11
13 So Froitzheim has all of the teachings to 16:25:12
14 implement an N plus layer at the front of a solar 16:25:15
15 cell as in the Froitzheim-Gan combination. 16:25:24
16 Q Paragraph 45 of Froitzheim mentions a 16:25:29
17 selective front surface field. 16:25:36
18 Do you see that? 16:25:38
19 A Yes, I do. 16:25:39
20 Q What is a selective front surface field? 16:25:45
21 A Froitzheim is describing a more heavily 16:25:54
22 doped N plus layer that is located only in certain 16:25:59

1 areas at the front of the solar cell. That is to 16:26:04
2 say, not across the entire front of the solar 16:26:07
3 cell. And in particular under the metal contacts. 16:26:11
4 He describes, for example, that that can reduce 16:26:18
5 the contact resistance. That is the selective 16:26:20
6 front surface field that he speaks of. 16:26:26
7 Q Would the Froitzheim-Gan combination have 16:26:30
8 a selective front surface field? 16:26:33
9 A It could, but it doesn't need to. That 16:26:40
10 is not one of the limitations of the '053 claim. 16:26:42
11 And you'll note that Froitzheim teaches the 16:26:48
12 selective front surface field -- excuse me. One 16:26:51
13 second. Sorry for the delay. I don't remember 16:26:56
14 what the last words were that I said. Perhaps 16:28:17
15 maybe, Debbie, you could remind me. 16:28:21
16 (The record was read.) 16:28:21
17 A Thank you. 16:28:42
18 The selective front surface field is 16:28:42
19 optional, that Paragraph 45 starts with "if." And 16:28:47
20 Froitzheim describes embodiments that include and 16:28:52
21 that also don't include a selective front surface 16:28:55
22 field. 16:29:00

1 Q Can we jump real quick back to your 16:29:00
2 declaration, Page 78. 16:29:03
3 A Okay, I'm there. 16:29:20
4 Q On this page you illustrate a 16:29:20
5 Froitzheim-Gan combination. Right? 16:29:24
6 A That is correct. 16:29:27
7 Q Does this illustration depict a front 16:29:28
8 surface field? 16:29:35
9 A Yes, Regions 39 and 38 make up the front 16:29:38
10 surface field. The N plus layer at the front. Or 16:29:42
11 N plus region at the front of the wafer. 16:29:47
12 Q Okay. Let's go back to Paragraph 45 of 16:29:51
13 Froitzheim. This paragraph also talked about a 16:29:54
14 deep N dopant diffusion. Right? 16:29:59
15 A That's correct. 16:30:02
16 Q What is a deep N dopant diffusion? 16:30:02
17 A So again, in Paragraph 45 Froitzheim is 16:30:09
18 not talking about a front surface field generally, 16:30:13
19 but in particular the instance of a selective 16:30:19
20 front surface field. So that is to say, going 16:30:22
21 back to Figure 3, which you found on Page 78 of my 16:30:27
22 declaration, the instances or the embodiments that 16:30:31

1 include 38 as it's labeled in that figure. 16:30:36
2 And what Froitzheim is saying in 16:30:43
3 Paragraph 45 is that the diffusion in that 16:30:45
4 reason -- in that region can be -- can be deep. 16:30:51
5 That is to say, deeper than in the surrounding 16:30:58
6 front surface field region. 16:31:04
7 So if we look on the figure, Paragraph 45 16:31:06
8 describes an embodiment in which 38 would extend 16:31:13
9 further into the wafer than 39. It's not drawn as 16:31:17
10 such in this figure, but that's what the words of 16:31:22
11 that paragraph say. 16:31:24
12 Q Thank you for correcting me. So let me 16:31:28
13 just make sure the record is clear. 16:31:30
14 When we're talking about in your 16:31:32
15 declaration on Page 78 the illustration of the 16:31:33
16 Froitzheim-Gan combination, that is illustrating a 16:31:38
17 selective front surface field. Right? 16:31:42
18 A Okay. That is different than what you 16:31:44
19 asked before. 16:31:46
20 Yes, this embodiment shows a selective 16:31:48
21 front surface field, it's 38. You'll also find 16:31:52
22 elsewhere in my declaration I point to and 16:31:57

1 reproduce Figure 1 of Froitzheim, which has a 16:32:03
2 front surface field but not a selective front 16:32:17
3 surface field. 16:32:19
4 Q Can you direct me to where you're looking 16:32:19
5 at? 16:32:21
6 A Within my declaration? 16:32:23
7 Q Yes. 16:32:24
8 A Yes. You'll have to give me one moment. 16:32:26
9 It might take me a minute to find it. I am 16:32:30
10 looking in the table of contents. 16:32:46
11 I referred to Froitzheim's Figure 1 in 16:33:30
12 the footnote of Page 66 of my declaration. I 16:33:33
13 reproduce Froitzheim's Figure 1 on Page 98 of my 16:33:39
14 declaration. 16:33:46
15 Q Froitzheim Figure 1 and Figure 3 -- 16:34:00
16 MR. SELWYN: Did you finish your answer? 16:34:04
17 Q Oh, I'm sorry. 16:34:06
18 A Just I was still looking. There are 16:34:08
19 additional instances. Paragraph 184 on Page 116 I 16:34:09
20 refer to both Figure 1 and 3 and reproduce them 16:34:16
21 both on Page 117. There may be other instances, 16:34:19
22 but I think I've pointed you to some. 16:34:25

1 Q Figures 1 and 3 illustrate different 16:34:28
2 embodiments of Froitzheim. Right? 16:34:32
3 A That is correct. 16:34:38
4 Q And the Froitzheim-Gan combination that 16:34:39
5 you propose would include either of those two 16:34:41
6 embodiments? 16:34:47
7 A Once again, the combination, in order for 16:34:50
8 it to be obvious, as I understand it, must have 16:34:55
9 been obvious to a POSITA based on the teachings. 16:34:58
10 The teachings aren't limited to one embodiment or 16:35:02
11 another embodiment. And so the reason that I 16:35:04
12 refer to both Figures 1 and 3 is that the 16:35:07
13 teachings embodied in 1 and 3, when combined with 16:35:10
14 Gan, meet the limitations of the '053 claims. 16:35:17
15 Q How do you perform a deep N dopant 16:35:30
16 diffusion? 16:35:59
17 A As I've discussed previously, the time 16:36:02
18 and temperature determine how quickly and then how 16:36:04
19 far the dopants move. So a deeper diffusion is 16:36:11
20 commonly achieved relative to a shallower 16:36:16
21 diffusion -- excuse me -- by making the diffusion 16:36:23
22 time longer or making it hotter. 16:36:26

1 Q So in the embodiment of Froitzheim Figure 16:36:30
2 3 where you have a selective front surface field, 16:36:34
3 how do you perform diffusion such that there can 16:36:39
4 be deep diffusion areas and shallower diffusion 16:36:43
5 areas? 16:36:46
6 A Froitzheim describes in Paragraph 45 that 16:36:52
7 if a selective front surface field is to be 16:37:01
8 arranged -- used, I understand, then one diffusion 16:37:05
9 is formed that results in a deep diffusion in the 16:37:16
10 areas of 38, so presumably the hotter or longer 16:37:18
11 diffusion. Subsequently the mask that limited 16:37:23
12 that diffusion to the areas of 38 is removed and 16:37:27
13 another diffusion is performed that's shallower, 16:37:34
14 that is at shorter times or lower temperatures. 16:37:38
15 But note that as the '053 claims do not include a 16:37:44
16 limitation about selective front surface field, I 16:37:50
17 have not included that in my combination 16:37:57
18 explicitly. 16:37:59
19 Q Can you talk a little bit about this 16:38:00
20 general concept of masking? 16:38:07
21 A I can talk about it within the context of 16:38:14
22 what Froitzheim is describing. 16:38:16

1 Is that suitable? 16:38:18
2 Q Yep. 16:38:19
3 A Okay. Froitzheim is describing that 16:38:24
4 dopants may be diffused into select regions, that 16:38:28
5 is to say, not the full surface of the substrate, 16:38:32
6 by having an oxide layer, typically an undoped 16:38:39
7 oxide layer, that blocks or slows the diffusions 16:38:49
8 of dopants. 16:38:56
9 And these would be thick oxide layers, 16:39:01
10 not like tunnel oxide layers. And they would be 16:39:05
11 put in certain areas that they form a mask. 16:39:10
12 Similar concept is used for example by 16:39:15
13 Smith, in defining the P and N regions at the back 16:39:17
14 side of Smith's solar cells. Smith also makes use 16:39:22
15 of undoped oxide layers to achieve that. 16:39:26
16 MS. ZHAO: We've been going for about an 16:39:43
17 hour. I just have a few more questions on 16:39:44
18 Froitzheim. So if you're doing okay, let's power 16:39:46
19 through Froitzheim and then we'll take a break. 16:39:48
20 Is that okay? 16:39:50
21 THE WITNESS: Yes, it is. Thank you for 16:39:51
22 asking. 16:39:54

1 Q Let's go to Paragraph 46. 16:39:55
2 Would the Froitzheim-Gan combination use 16:39:59
3 the process described in Paragraph 46 of 16:40:01
4 Froitzheim? 16:40:05
5 A Paragraph 46 is similar to 45, but on the 16:40:08
6 other side of the solar cell and with the opposite 16:40:15
7 doping to form the emitter. 16:40:21
8 In my combination of Gan and Froitzheim I 16:40:22
9 take Gan's oxide layer and P-type polysilicon 16:40:25
10 emitter and I use it to replace Froitzheim's 16:40:30
11 emitter. So this process step, which is 16:40:33
12 describing a particular variation of Froitzheim's 16:40:37
13 P-type emitter, would not be used in the 16:40:41
14 combination; rather, the teachings of Gan would be 16:40:45
15 used to form the emitter. 16:40:49
16 Q What about the process described in 16:40:52
17 Paragraph 47; would the Froitzheim-Gan combination 16:40:53
18 use that? 16:40:57
19 A So Paragraph 47 of Froitzheim describes 16:42:14
20 what is generally referred to as edge isolation. 16:42:18
21 And it's a method to make sure that there aren't 16:42:22
22 any shunts, which is the word we use for 16:42:27

1 electrical shorts, in the positive and negative -- 16:42:30
2 positive and negative regions or P-type and N-type 16:42:40
3 regions inadvertently touch each other. And 16:42:44
4 Froitzheim is describing a method to make sure 16:42:48
5 that that doesn't happen, your edge isolation. 16:42:51
6 And that is not a limitation of the '053 16:42:56
7 claims. And the process of forming such an edge 16:43:02
8 isolation is not a limitation of the '053 claims. 16:43:08
9 So I have not specifically addressed or 16:43:10
10 incorporated it in my combination. It may be 16:43:11
11 included, but it is not necessary to form the 16:43:15
12 combination. 16:43:19
13 Q Paragraph 47 says, "If required after the 16:43:22
14 formation of the N plus dope layer." 16:43:26
15 Do you see that? 16:43:29
16 A I do. 16:43:30
17 Q In what situation would this if come into 16:43:30
18 play? 16:43:35
19 A If the N plus doped layer or the P-type 16:43:38
20 emitter layer, which in the combination comes from 16:43:50
21 Gan, but in Froitzheim alone comes from 16:43:53
22 Froitzheim, wraps around the edge of the wafer so 16:43:56

1 as to touch the doped region of the opposite 16:43:59
2 polarity on the opposite side. 16:44:04
3 Q Is that a common situation that occurs in 16:44:07
4 the manufacturing of a solar cell? 16:44:11
5 A It can be, particularly for solar cells 16:44:15
6 that achieved both the N and P-type regions via 16:44:20
7 diffusion processes. And so edge isolation steps 16:44:25
8 were commonly used in manufacturing. They were 16:44:30
9 understood. And I expect, I would guess that the 16:44:34
10 reason that Froitzheim does not provide much 16:44:39
11 detail here is because Froitzheim understands that 16:44:42
12 a POSITA knew about edge isolation steps as of the 16:44:45
13 time Froitzheim was writing. 16:44:49
14 Q The last word of Paragraph 47 is plasma. 16:44:52
15 Is this referring to plasma etching? 16:44:57
16 A I think that that is likely. That is how 16:45:05
17 I read it. Removal of material via plasma are 16:45:07
18 commonly called etching. This is one way to do 16:45:13
19 edge isolation, and that's why Froitzheim 16:45:16
20 introduces it with a e.g., for example. 16:45:19
21 Q What about the process described in 16:45:26
22 Paragraph 48; would the Froitzheim-Gan combination 16:45:27

1 use that process? 16:45:31
2 A The Froitzheim-Gan combination can use 16:45:41
3 Froitzheim's teaching on metallization as 16:45:46
4 described in 48. Gan also teaches formation of 16:45:52
5 metal contacts to Gan's P-type polysilicon layer. 16:45:59
6 Both references teach formation of metal contacts. 16:46:06
7 These were common, as they're required on every 16:46:12
8 functioning solar cell and screen printing, which 16:46:15
9 Froitzheim mentions is one of the common ways of 16:46:23
10 forming such metal contacts. 16:46:31
11 Q What about the process described in 16:46:33
12 Paragraph 50; would the Froitzheim-Gan combination 16:46:34
13 use that process? 16:46:39
14 A Yes, the combination would make use of 16:46:55
15 Froitzheim's teaching, for example, in Paragraph 16:47:01
16 50, regarding passivation layers and 16:47:04
17 antireflection coatings. I describe starting on 16:47:23
18 Page 180 -- excuse me, Paragraph 180 of my 16:47:31
19 declaration I talk about the Froitzheim-Gan 16:47:36
20 combination and the Froitzheim's description of 16:47:42
21 the passivation layer and antireflection coating 16:47:45
22 needed for that combination. 16:47:48

1 Q Okay. One last question on Froitzheim, 16:47:51
2 then we'll take a break. 16:47:55
3 Can you go to Paragraph 34. 16:47:56
4 The second-to-last line talks about a 16:48:03
5 doping concentration intermediate. 16:48:05
6 Do you see that? 16:48:08
7 A I do see it, yes. 16:48:09
8 Q What is a doping concentration 16:48:15
9 intermediate? 16:48:17
10 A It's -- the concentration is expressed in 16:48:22
11 the number of dopant atoms per cubic centimeter. 16:48:26
12 And Froitzheim is describing a concentration, a 16:48:34
13 value with those units that is between the -- what 16:48:36
14 he calls the N-type body layer, we recognize as 16:48:41
15 the wafer, and that of the N plus doped regions 16:48:45
16 18, that refers to Figure 1 -- let me double-check 16:48:58
17 that. Yes, I confirm. Or in reference to Figure 16:49:02
18 3. No, that's referring to something else. 16:49:13
19 So what Froitzheim is saying there is 16:49:25
20 that dopant concentration that is between two 16:49:27
21 other dopant concentrations. 16:49:30
22 Q Okay. The dopant concentration that is 16:49:39

1 between two other dopant concentrations, what 16:49:41
2 would be those two other dopant concentrations? 16:49:44
3 A Okay. I have to back up a little bit. I 16:50:17
4 previously said Froitzheim is referring to Figure 16:50:21
5 1, and I am incorrect about that. I was incorrect 16:50:24
6 about that. In this paragraph Froitzheim is 16:50:27
7 contrasting his previous discussion of Figure 1 16:50:31
8 with a new discussion of Figure 3. And Froitzheim 16:50:35
9 is saying that Regions 38, those are the selective 16:50:40
10 front surface field that we described previously, 16:50:49
11 have heavier doping or higher doping, that is to 16:50:52
12 say, a larger doping concentration. Regions 39 is 16:50:55
13 a weaker doping concentration. And what he means 16:51:00
14 by "weaker" is that it is intermediate between 16:51:04
15 that of Region 38 and the wafer. Yes, and the 16:51:08
16 wafer. 16:51:20
17 So what Froitzheim is saying is wafer is 16:51:20
18 doped the lowest N-type, 39 is the next highest 16:51:26
19 N-type, and 38 has the highest dopant N-type, in 16:51:29
20 the configuration of Figure 3, which there's a 16:51:33
21 selective front surface field. 16:51:36
22 MS. ZHAO: Okay. Shall we take a break? 16:51:41

1 MR. SELWYN: Sure. 16:51:43
2 MS. ZHAO: Five minutes? 16:51:43
3 MR. SELWYN: Yeah. 16:51:44
4 (A recess was taken.) 16:51:45
5 BY MS. ZHAO: 16:57:46
6 Q Let's go to Exhibit 1005, Gan. 16:57:47
7 On Page 246 of Gan, I am looking at the 16:57:56
8 first paragraph on the left. 16:58:02
9 (Exhibit 1005, previously marked, not 16:58:02
10 attached.) 16:58:08
11 A I am as well. 16:58:08
12 Q The second sentence begins with, "Because 16:58:09
13 high bulk lifetime is needed for such a 16:58:13
14 measurement, the samples were prepared with high 16:58:16
15 resistivity FZ wafers." 16:58:19
16 Do you see that? 16:58:22
17 A Yes, I do. 16:58:23
18 Q Here the term "such a measurement" refers 16:58:24
19 to J naught. Right? 16:58:29
20 A That is correct. 16:58:35
21 Q Can you help me understand the sentence 16:58:35
22 generally. 16:58:37

1 What is "high bulk lifetime"? 16:58:38
2 A High bulk lifetime means that there are 16:58:46
3 comparatively low amounts of nonradiative 16:58:49
4 recombination within the wafer itself, such that 16:58:53
5 an electron that is excited from the valence band 16:59:00
6 to the conduction band of the silicon wafer will 16:59:03
7 remain in the conduction band for a comparatively 16:59:07
8 long period of time, its lifetime, before 16:59:13
9 recombining with a hole and returning to the 16:59:17
10 valence band. And I describe these basic 16:59:22
11 semiconductor physics in my background section. 16:59:24
12 Q Why is high bulk lifetime needed to 16:59:29
13 measure J naught? 16:59:33
14 A Because J naught is a measurement of 16:59:36
15 recombination at the surface of the wafer. And 16:59:46
16 one wants to measure that instead of recombination 16:59:51
17 within the wafer itself. So for this particular 16:59:55
18 measurement to learn about a new emitter, which is 16:59:59
19 the point of Gan's work, it's important to make 17:00:03
20 sure that you're not instead being limited by the 17:00:06
21 wafer. 17:00:09
22 Q And what are FZ wafers? 17:00:11

1 A FZ stands for float zone. It's a 17:00:19
2 particular method of making a wafer. 17:00:22
3 Q So are FZ wafers made out of silicon as 17:00:31
4 well? 17:00:34
5 A Yes. Yes, Gan is using a silicon wafer 17:00:35
6 made with a process called float zone. 17:00:39
7 Q Would the wafer in Froitzheim also be an 17:00:46
8 FZ wafer? 17:00:50
9 A Likely not. Float zone wafers are very 17:01:14
10 good for learning new things, like the performance 17:01:17
11 of a new emitter as Gan is doing, but they are 17:01:21
12 expensive. And the solar industry -- sorry, there 17:01:26
13 is a phone in here that's ringing. We will make 17:01:33
14 sure that stops. My apologies. 17:01:36
15 The solar industry has historically tried 17:01:39
16 to enhance efficiency while keeping costs low, and 17:01:46
17 so has most commonly used multicrystalline wafers 17:01:51
18 for Czochralski-grown monocrystalline wafers. 17:02:02
19 So if you look at Paragraph 24 of 17:02:03
20 Froitzheim, Froitzheim says that the silicon body 17:02:07
21 layer is made from crystalline silicon and then 17:02:11
22 can be of the mono, multi, or polycrystalline 17:02:14

1 type, preferably Czochralski-grown silicon is 17:02:17
2 used. 17:02:21
3 So Froitzheim allows for different 17:02:22
4 possibilities that would be inclusive of float 17:02:24
5 zone wafers. That was not common because of their 17:02:27
6 high cost. And Froitzheim gives a specific 17:02:30
7 example of Czochralski wafers. 17:02:35
8 And Czochralski wafers, grown wafers, are 17:02:39
9 typically abbreviated CZ, as opposed to FZ for 17:02:43
10 float zone. 17:02:47
11 If we turn back to Page 246 of Gan, you 17:02:48
12 can see that the contact resistive measurements 17:02:53
13 that Gan did were on CZ wafers instead. 17:02:57
14 Q Why is Gan using different wafers to 17:03:02
15 measure different things? 17:03:04
16 A Because Gan's purpose is to learn about 17:03:10
17 polysilicon oxide contacts to silicon. And he's 17:03:11
18 using two techniques to learn the most relevant 17:03:15
19 parameters, which are contact resistivity, that 17:03:20
20 tells you about how much resistive losses you're 17:03:24
21 going to have; J naught, which tells you about how 17:03:26
22 much surface recombination losses you're going to 17:03:30

1 have. And the techniques to use -- to measure 17:03:32
2 those two things require something different of 17:03:34
3 the wafers. 17:03:39
4 These techniques were introduced long 17:03:40
5 ago. I believe the J naught technique that Gan is 17:03:47
6 using was introduced in 1985, in his Reference 10. 17:03:53
7 And the contact resistivity techniques date back 17:04:03
8 even before that. I regularly refer to a paper 17:04:08
9 written in 1984. And yet these are still even 17:04:10
10 today the most common and best-known techniques 17:04:15
11 for measuring contact resistivity and J naught. 17:04:18
12 We use both of them in my own research lab. 17:04:22
13 So the measurement techniques to learn 17:04:25
14 about the emitter require something of the 17:04:27
15 substrate. 17:04:31
16 Q Below this paragraph we just looked at 17:04:34
17 there are 12 steps in Gan. 17:04:39
18 Do you see that? 17:04:42
19 A I do. 17:04:43
20 Q Can you tell me which of these steps 17:04:43
21 would be used in the Froitzheim-Gan combination? 17:04:46
22 A Yes. As I described previously, it's not 17:04:52

1 required for a POSITA to make a one-to-one copying 17:04:55
2 of steps for particular instances but, rather, to 17:05:01
3 take the teachings of a whole to implement them. 17:05:09
4 But as an example, Step 3, Thin thermal 17:05:14
5 oxide growth, that's referring to the formation of 17:05:18
6 Gan's tunnel oxide. That tunnel oxide is used in 17:05:22
7 my combination of Froitzheim and Gan. That's 17:05:28
8 important. 17:05:32
9 The fourth step, polysilicon deposition, 17:05:34
10 it's also important to -- or is required in my 17:05:38
11 Froitzheim-Gan combination. 17:05:43
12 And then some subsequent steps, such as 17:05:47
13 Step 9 and Step 10, are about doping that 17:05:54
14 polysilicon layer to turn it into an emitter. And 17:05:59
15 as I say in my declaration, my combination is 17:06:04
16 Gan's oxide and polysilicon emitter. And so those 17:06:07
17 steps teach how to dope the polysilicon to make an 17:06:13
18 emitter. 17:06:17
19 As we discussed previously, Froitzheim 17:06:20
20 also teaches steps about how to make a P-type 17:06:22
21 diffusion. 17:06:28
22 Q Am I understanding you correctly, Steps 17:06:29

1 3, 4, 9, and 10 are the required steps in your 17:06:36
2 Froitzheim-Gan combination? 17:06:42
3 A As I discussed previously, there are 17:06:45
4 teachings that Gan has about forming the oxide, 17:06:52
5 the polysilicon, and the doping are what we need. 17:06:54
6 These steps here embody that teaching, but the 17:06:59
7 teaching isn't limited to that. Right? 17:07:04
8 If you look at Figure 3 as an example, 17:07:06
9 you can see that the time of a first step anneal, 17:07:14
10 that's Step 5, is varied. But the five -- the 12 17:07:19
11 steps don't show the variation in time. 17:07:27
12 So Gan's teaching is bigger than just 17:07:29
13 those -- that's what's written in those steps. 17:07:33
14 And I guess in my list I didn't mention Step 5, 17:07:38
15 that first step anneal. Gan -- excuse me. No. 17:07:41
16 It's incorporated in Step 4. 17:07:46
17 Q What about Steps 6 to 7 -- I'm sorry, 6 17:07:58
18 to 8; would those not be required in the 17:08:01
19 Froitzheim-Gan combination? 17:08:03
20 A Step 6 is particular to a contact 17:08:18
21 resistivity structure and isn't required in making 17:08:20
22 a solar cell, a finished solar cell incorporating 17:08:27

1 Froitzheim's, for example. Step 7 is also 17:08:34
2 required to make the contact resistivity 17:08:43
3 measurements, what wouldn't be required in 17:08:46
4 Froitzheim's solar cell. And similarly with Step 17:08:50
5 8. 17:09:00
6 So these are -- these are steps that 17:09:00
7 Froitzheim has in order to make his measurements 17:09:02
8 that teach us about the properties of oxide 17:09:07
9 polysilicon emitters, but aren't required in 17:09:10
10 Froitzheim's solar cell to make a functioning 17:09:14
11 solar cell. 17:09:16
12 Q Step 9 discloses doped glass deposition 17:09:16
13 on both sides of the wafer. Right? 17:09:26
14 A That's correct. 17:09:30
15 Q What does "doped glass deposition" mean 17:09:30
16 to you? 17:09:33
17 A It's the same as Froitzheim's dopant 17:09:38
18 source layers. It means PSG, or BSG, that's how I 17:09:44
19 understand it. 17:09:51
20 Q And what does "deposition on both sides 17:09:55
21 of the wafer" mean to you? 17:09:57
22 A Its front and back surface. In 17:09:59

1 particular when making J naught measurements, the 17:10:02
2 best way to do them and the measurement method, 17:10:07
3 requires that you have the same surface 17:10:11
4 passivation on both sides. If you have different 17:10:13
5 surface passivation or different layers on both 17:10:16
6 sides, then what you'll measure will end up being 17:10:19
7 a interpolation of the recombination at someone 17:10:23
8 surface versus the other surface. But if you're 17:10:29
9 interested in a new oxide emitter structure, put 17:10:32
10 it on both sides in order to do a J naught 17:10:36
11 measurement. And that's why that step is one of 17:10:42
12 the ones marked with the asterisk. And the next 17:10:46
13 step -- excuse me, the next sentence indicates 17:10:48
14 that the steps marked with an asterisk are for J 17:10:50
15 naught measurement samples. 17:10:54
16 Q Would the deposition on both sides of the 17:10:55
17 wafer occur at the same time? 17:10:58
18 A Very likely. For example, if Gan put the 17:11:04
19 wafer into the furnace and inserted POCl3 vapor, 17:11:10
20 that vapor would form a glass on both sides of the 17:11:24
21 surface, both sides of the wafer, unless one side 17:11:27
22 was blocked with something else, was masked with 17:11:30

1 something else. 17:11:37
2 Gan doesn't teach that. It doesn't have 17:11:37
3 to be that the dopant source is added to both 17:11:40
4 sides at the same time. But it could be. 17:11:43
5 Q Do you understand Step 9 to mean 17:11:50
6 deposition of the same dopant source to both sides 17:11:56
7 of the wafer? 17:12:00
8 A Yes. 17:12:04
9 Q And in the Froitzheim-Gan combination, 17:12:04
10 would you also be applying Step 9 in the way Gan 17:12:08
11 describes it? 17:12:14
12 A Not to both sides of the wafer. You 17:12:18
13 would apply it to the side on which the 17:12:20
14 polysilicon emitter is formed. Just like Gan 17:12:26
15 doesn't add doped glass on both sides of the wafer 17:12:36
16 for the -- let me back up. 17:12:41
17 For the combination I would take the 17:12:50
18 teachings of Gan about his oxide and polysilicon 17:12:52
19 emitter, and I would apply it to one side of the 17:12:56
20 wafer; namely, to the back side of Froitzheim's 17:12:59
21 wafer, as that's where I'm trying to form the 17:13:02
22 emitter. 17:13:06

1 Gan here is using test structures, solar 17:13:07
2 cell-like structures, in order to measure these 17:13:12
3 important properties of the contact -- excuse me, 17:13:15
4 of an emitter that he shows with these structures, 17:13:18
5 that this emitter has very good surface 17:13:22
6 passivation as seen in J naught and very good 17:13:27
7 contact resistance as seen in rho C, such that a 17:13:32
8 POSITA would recognize the excellent performance 17:13:36
9 of this contact and be motivated to implement it 17:13:38
10 in Gan. 17:13:41
11 Q Earlier we talked about retaining some of 17:13:42
12 Froitzheim's manufacturing steps. Right? 17:13:51
13 MR. SELWYN: Objection. Form. 17:13:56
14 A We previously talked about Froitzheim's 17:13:57
15 teachings to make a solar cell, yes. 17:13:59
16 Q Where in Froitzheim's manufacturing steps 17:14:02
17 would you insert Steps 3, 4, 5, 9, and 10 of Gan? 17:14:06
18 MR. SELWYN: Objection. Form. 17:14:12
19 A So there are multiple ways in which this 17:14:31
20 could be done. But one that a POSITA would be 17:14:34
21 motivated to do would be, after etching the 17:14:42
22 surface of the wafer to texture it, which 17:14:52

1 Froitzheim describes, instead of proceeding to 17:14:55
2 Froitzheim's diffusion of boron into the back of 17:14:58
3 the wafer to form a diffused emitter, one would 17:15:03
4 follow Gan's teaching to form an oxide layer and a 17:15:08
5 polysilicon boron-doped emitter on the back side. 17:15:16
6 And subsequently one would finish the 17:15:20
7 front side of the solar cell and the metallization 17:15:25
8 per Froitzheim's teachings, for example, in 43, 17:15:30
9 49 -- excuse me, 43, 48, 49, and 50. 17:15:47
10 Q Okay. When you say a POSITA would be 17:16:05
11 motivated to do, would be after etching the 17:16:14
12 surface of the wafer to texture it, what paragraph 17:16:22
13 are you referring to in Froitzheim? 17:16:24
14 A Froitzheim describes texturing the 17:16:27
15 silicon wafer in Paragraph 39. 17:16:36
16 Q Okay. Okay. I see what you're talking 17:16:41
17 about. Thank you. 17:16:48
18 Looking at Gan, Figure 1, Gan's device 17:16:52
19 would have a PN junction that is on the front side 17:17:00
20 of the cell. Right? 17:17:03
21 A No. Figure 1 is Gan's contact 17:17:07
22 resistivity test structure. But while Gan's work 17:17:12

1 is all about understanding and showing the great 17:17:18
2 performance of polysilicon oxide contacts, Gan 17:17:22
3 also places their performance in the context of 17:17:26
4 solar cells. And when Gan does so, he teaches 17:17:32
5 that it can be implemented in a back-contact solar 17:17:52
6 cell. And back-contact solar cells, both their N 17:17:57
7 and their P regions on the back side, that is to 17:18:00
8 say they have their emitters on the back side. 17:18:06
9 So Gan teaches implementing Gan's emitter 17:18:09
10 on the back side of a solar cell, which is where 17:18:13
11 it would be sensible to locate it to replace 17:18:17
12 Froitzheim's diffused emitter, particularly 17:18:23
13 because Froitzheim is motivated to have the 17:18:28
14 emitter on the back side in the first place to 17:18:30
15 avoid parasitic absorption. 17:18:34
16 So Gan's deposited emitter on the back 17:18:37
17 side as taught by Gan would retain this beneficial 17:18:43
18 function of the arrangement taught by Froitzheim. 17:18:47
19 Q But Figure 1 of Gan, is that depicting a 17:18:51
20 back side PN junction? 17:18:55
21 A No. Figure 1 of Gan isn't depicting 17:18:59
22 solar cell. Figure 1 of Gan is depicting, as it 17:19:01

1 says in the figure caption, the device structure 17:19:07
2 for the specific contact resistivity measurement. 17:19:09
3 So as we discussed, Gan implemented the 17:19:14
4 oxide polysilicon emitter in two different 17:19:16
5 structures, one for measuring J naught, one for 17:19:22
6 measuring contact resistivity -- that's the one 17:19:26
7 depicted -- from which Gan determines important 17:19:28
8 performance values of the emitter from which Gan 17:19:33
9 goes on to say using this emitter in solar cells, 17:19:36
10 back-contact solar cells, would improve their 17:19:41
11 performance. I believe he says that one might 17:19:44
12 expect a 1 percent increase in performance if 17:19:46
13 implemented in a back-contact solar cell. 17:19:49
14 Q So is there no PN junction depicted in 17:19:51
15 Figure 1 at all? 17:19:57
16 A Figure 1, no, there is not a PN junction 17:20:10
17 depicted in Figure 1. There is an emitter on an 17:20:16
18 oxide, metal oxide polysilicon layer on a wafer, 17:20:24
19 for contact resistivity measurements. 17:20:31
20 Q Figure 1 depicts an emitter. Right? 17:20:34
21 A Yes, Figure 1 depicts this oxide and 17:20:53
22 polysilicon emitter, in this case implemented on a 17:21:00

1 wafer for the purpose of contact resistivity 17:21:03
2 measurements. 17:21:06
3 This isn't -- this isn't a solar cell; 17:21:07
4 it's a measurement test structure for learning 17:21:10
5 about emitters for use in solar cells. 17:21:13
6 Q I thought earlier you said emitters are 17:21:17
7 oppositely doped as the wafer. 17:21:20
8 Is that right? 17:21:23
9 A When used in solar cells, that is 17:21:25
10 correct. 17:21:26
11 Q So wouldn't an oppositely doped layer on 17:21:28
12 top of a wafer form a PN junction? 17:21:32
13 A Yes, it would. These contact resistance 17:21:37
14 measurements, the way in which they're done, they 17:21:44
15 are done on wafers of the same doping polarity. 17:21:46
16 That's just for the contact resistance 17:21:51
17 measurement. This is a known way to measure 17:21:54
18 contact resistance from, as I mentioned, I usually 17:21:56
19 cite a paper from the 1980s that's still used that 17:21:59
20 tells you about the contact resistance that that 17:22:02
21 will have when used in a solar cell, which is what 17:22:07
22 Gan plots, for example, on the Y axis of Figure 6. 17:22:11

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1 Q So in Figure 1 the emitter and the wafer 17:22:16
2 are not oppositely doped? 17:22:26
3 A In Figure 1 in the contact resistivity 17:22:31
4 structure, the polysilicon layer and the substrate 17:22:35
5 will have the same doping polarity for the 17:22:40
6 purposes of that measurement. When implemented in 17:22:43
7 a solar cell as an emitter, then the layer would 17:22:46
8 be on a wafer of the opposite doping polarity. 17:22:50
9 This is how we routinely measure contact 17:22:59
10 resistance in this field and in microelectronics. 17:23:02
11 Q Gan's device structure for measuring J 17:23:08
12 naught -- I'm sorry, let me back up. 17:23:17
13 Figure 1 depicts Gan's device structure 17:23:18
14 for measuring rho C. Right? 17:23:21
15 A Correct. 17:23:25
16 Q And Gan has a device structure for 17:23:25
17 measuring J naught. Right? 17:23:30
18 A Correct. 17:23:32
19 Q Would the device structure for measuring 17:23:33
20 J naught look similar to the device structure for 17:23:36
21 measuring rho C? 17:23:41
22 MR. SELWYN: Objection. Form. 17:23:43

1 A It would have some similarities, but it 17:23:47
2 would look different. It would look like a 17:23:49
3 silicon wafer with oxide polysilicon on one side 17:23:52
4 and the same oxide polysilicon on the other side 17:23:55
5 to make this symmetric structure that I talked 17:23:59
6 about before. 17:24:02
7 This is the standard measurement since 17:24:03
8 1985 for measuring J naught. 17:24:05
9 Q So -- 17:24:09
10 A J naught values for use of an emitter in 17:24:10
11 solar cells. 17:24:16
12 Q So would the device structure for 17:24:16
13 measuring J naught have a PN junction? 17:24:19
14 MR. SELWYN: Objection. Form. 17:24:27
15 A The wafer doping polarity isn't specified 17:24:28
16 that Gan used. He says that he uses a 17:24:31
17 high-resistivity wafer, which is a nearly 17:24:34
18 intrinsic wafer. 17:24:37
19 Q What do you mean by "intrinsic"? Sorry. 17:24:40
20 A Oh, excuse me. Intrinsic in the solar 17:24:43
21 field or the semiconductor field means undoped. 17:24:46
22 So the wafer has very low doping or -- yeah, very 17:24:49

1 low, low doping for a J naught measurement. 17:24:53
2 That's standard -- standard procedure at this 17:24:58
3 time. 17:25:05
4 Q So if I put a P-type doped polysilicon 17:25:05
5 emitter on an intrinsic wafer, would that form a 17:25:11
6 junction? A PN junction, sorry. 17:25:23
7 MR. SELWYN: Objection. Form. 17:25:24
8 A If the wafer was truly intrinsic, then, 17:25:25
9 no, it wouldn't form a PN junction. It would form 17:25:29
10 an intrinsic N junction or intrinsic P junction. 17:25:34
11 We oftentimes represent intrinsic layers or wafers 17:25:37
12 with an I. These structures are being used to 17:25:42
13 measure the contact resistivity and the J naught 17:25:47
14 for Figure 6. And we're a standard -- and still 17:25:52
15 are the standard methods for determining how an 17:25:57
16 emitter will perform in a solar cell when it is 17:25:59
17 used to form a PN junction. 17:26:03
18 As I said previously, these measurement 17:26:06
19 techniques are very powerful. They use -- they 17:26:09
20 require different wafers from each other and also 17:26:13
21 different wafers than might be used in the solar 17:26:20
22 cells in order to do the measurement techniques. 17:26:24

1 They are routine, accepted by the 17:26:25
2 industry, and used for about as long as I have 17:26:28
3 been on this earth. 17:26:32
4 Q Do concentrator cells have PN junctions? 17:26:33
5 A Concentrator solar cells, yes, they have 17:26:43
6 PN junctions. 17:26:45
7 Q And typically in concentrator solar cells 17:26:46
8 would you find that PN junction to be on the front 17:26:50
9 side or the back side of the substrate? 17:26:53
10 MR. SELWYN: Objection. Form. 17:26:57
11 A It could be either. 17:26:59
12 Q Is one more common than the other? 17:27:03
13 MR. SELWYN: Objection. Form. 17:27:05
14 A Are you referring to silicon concentrator 17:27:12
15 solar cells in particular or any type of 17:27:14
16 concentrator solar cell? 17:27:17
17 Q Let's say any type of concentrator solar 17:27:19
18 cell. 17:27:22
19 MR. SELWYN: Objection. Form. 17:27:23
20 A I can't definitively answer the question 17:27:34
21 for all -- for any type of solar cell. For 17:27:36
22 example, for 35 -- for multijunction solar cells 17:27:41

1 based on gallium arsenide, for instance, I believe 17:27:44
2 it's more common to have the junction on the 17:27:49
3 front. For silicon concentrator solar cells, you 17:27:57
4 find both -- you found really previous to 2008, 17:28:01
5 there aren't a lot of them made anymore -- 17:28:06
6 junctions on front side or back side. And I don't 17:28:11
7 know offhand which was more common or how you want 17:28:14
8 to measure, quantify "more common." 17:28:18
9 Q Let's go back to Exhibit 1003, the '053 17:28:24
10 declaration. We were on Paragraph 122. 17:28:27
11 A There we go. 17:28:39
12 Q Actually, if you could, go to the next 17:28:44
13 page. That would be Page 78, to the illustration 17:28:46
14 of the Froitzheim-Gan combination. 17:28:48
15 A Okay, I'm there. 17:28:51
16 Q Is this Froitzheim-Gan combination a 17:28:52
17 silicon solar cell? 17:28:57
18 A Yes, it is. 17:28:58
19 Q Would you call it a heterojunction solar 17:28:58
20 cell? 17:29:07
21 A No, I would not. 17:29:07
22 Q So it would be a homojunction solar cell? 17:29:08

1 A As I mentioned, as of 2008 at least it 17:29:14
2 would be more common just to call it a silicon 17:29:17
3 solar cell. But technically, yes, we have a 17:29:20
4 junction between a crystalline silicon wafer 17:29:22
5 that's N-type and a polysilicon emitter that's -- 17:29:25
6 it's P-type, both of them being crystalline 17:29:30
7 silicon. 17:29:33
8 Q So technically it would be a homojunction 17:29:34
9 solar cell? 17:29:37
10 MR. SELWYN: Objection. Form. 17:29:38
11 A Yes, I would be most comfortable calling 17:29:47
12 it that if the silicon wafer was also 17:29:49
13 multicrystalline or polycrystalline, as Froitzheim 17:29:52
14 allows. Because then I have polycrystalline 17:29:55
15 silicon on both sides of the junction. 17:29:59
16 Q And is this Froitzheim-Gan combination a 17:30:01
17 concentrator solar cell? 17:30:05
18 A The combination? 17:30:09
19 Q Yes. 17:30:10
20 A The combination is taken from the 17:30:10
21 teachings of Froitzheim and of Gan. And 17:30:13
22 Froitzheim does not provide any limitations about 17:30:20

1 the intended use of his solar cell. And Gan, 17:30:25
2 while Gan is interested in concentrator 17:30:34
3 applications, Gan's teachings about emitters with 17:30:36
4 low J naught or low contact resistivity could be 17:30:41
5 applied to either concentrator or nonconcentrator 17:30:44
6 solar cells. It was common at the time for 17:30:50
7 POSITAs to take learnings from one and apply it to 17:30:52
8 the other, and vice versa. 17:30:55
9 So the combination, the solar cell shown 17:30:58
10 on Page 78, could be used under concentration or 17:31:00
11 it could be used under one sun, and it would 17:31:04
12 function in both instances. 17:31:07
13 Q Let's go to Paragraph 129 of your 17:31:09
14 declaration. 17:31:17
15 A Okay, I'm there. 17:31:24
16 Q On Page 83 in the middle of the paragraph 17:31:25
17 you state, "Gan notes that this combination, 17:31:31
18 polysilicon emitter and oxide layer on the wafer 17:31:36
19 surface, has less recombination and lower contact 17:31:39
20 resistance as compared to that of diffused 17:31:43
21 emitters." 17:31:45
22 Do you see that? 17:31:45

1 A I do. 17:31:46
2 Q The result of less recombination and 17:31:47
3 lower contact resistance, that is the benefit that 17:31:52
4 Gan brings to the Froitzheim-Gan combination. 17:31:56
5 Right? 17:31:59
6 MR. SELWYN: Objection. Form. 17:32:00
7 A That is a benefit that Gan brings, that's 17:32:02
8 correct, is this oxide polysilicon emitter 17:32:07
9 structure has low recombination and low contact 17:32:13
10 resistivity, and these things will lead to an 17:32:16
11 enhancement, an increase in the efficiency of the 17:32:21
12 solar cell. 17:32:24
13 Q And Gan achieves this benefit through a 17:32:24
14 combination of polysilicon emitter and oxide 17:32:29
15 layer. Right? 17:32:33
16 A That's correct. Gan's paper, his 17:32:34
17 investigation is with the structure having both 17:32:38
18 the oxide and the polysilicon. 17:32:41
19 Q And you're not claiming here that just 17:32:44
20 implementing Gan's polysilicon emitter would lead 17:32:47
21 to the same benefits. Right? 17:32:51
22 A I am not making that claim, as those 17:32:53

1 experiments are not covered in Gan's paper. Gan 17:32:55
2 doesn't show data for a polysilicon emitter 17:33:01
3 without the oxide layer. 17:33:04
4 There are other previous papers and 17:33:06
5 publications that cover that structure. Gan 17:33:08
6 focuses on the oxide layer and polysilicon emitter 17:33:10
7 together. 17:33:15
8 Q Let's go to Page 97 of your declaration. 17:33:15
9 A Okay, I am there. 17:33:32
10 Q I have some questions about your 17:33:34
11 discussion of Claim 9 generally, which spans from 17:33:36
12 Page 97 to Page 109. So feel free to look through 17:33:38
13 those pages or any part of your declaration as you 17:33:42
14 answer my questions. 17:33:45
15 And my question is, you do not mention 17:33:49
16 Gan's oxide layer in your discussion of Claim 9. 17:33:50
17 Do you agree? 17:33:53
18 A I agree. An oxide layer is not amongst 17:34:24
19 the limitations of Claim 9. I believe it appears 17:34:26
20 in Claim 16 as a limitation. 17:34:29
21 Q In Paragraph 148 of your declaration you 17:34:31
22 talk about the combination of Froitzheim and Gan. 17:34:37

1 Do you see this? 17:34:41
2 A Yes. 17:34:45
3 Q Is this still referring to the 17:34:46
4 Froitzheim-Gan combination we discussed earlier? 17:34:47
5 A Yes. 17:34:49
6 Q So that combination would include Gan's 17:34:54
7 oxide layer. Right? 17:34:56
8 A Yes, I describe the inclusion of Gan's 17:35:07
9 oxide layer in subsequent claims that have an 17:35:12
10 oxide layer as a limitation. This claim does not. 17:35:16
11 And I haven't described it here in describing the 17:35:25
12 combination. 17:35:28
13 Q So in Paragraph 148 when you talk about 17:35:30
14 the combination of Froitzheim and Gan, do you 17:35:32
15 envision a combination that includes Gan's oxide 17:35:36
16 layer? 17:35:39
17 MR. SELWYN: Objection. Form. 17:35:42
18 A A combination that includes Gan's oxide 17:35:43
19 layer would also meet the limitation of the claim, 17:35:46
20 as would one in which it was not omitted. Because 17:35:49
21 in both cases the combined teachings of Froitzheim 17:35:52
22 and Gan include forming a layer of polysilicon 17:35:57

1 over a back surface of a silicon substrate. 17:36:00
2 Q Are you saying in this paragraph when you 17:36:03
3 talk about the combination of Froitzheim and Gan 17:36:09
4 you mean -- you could mean a combination that does 17:36:12
5 not include Gan's oxide layer? 17:36:16
6 MR. SELWYN: Objection. Form. 17:36:21
7 A This claim, which is directed towards a 17:37:02
8 method of manufacture of the structure, is about 17:37:05
9 forming a layer of polysilicon over a back surface 17:37:09
10 of a silicon substrate. And as I describe here, 17:37:13
11 Gan teaches forming a layer over a polysilicon 17:37:19
12 over a back surface of a silicon substrate, and 17:37:25
13 the combination of Gan and Froitzheim teaches 17:37:30
14 that. 17:37:34
15 Gan also then teaches -- teaches an oxide 17:37:34
16 layer. That oxide layer is not required to meet 17:37:42
17 this claim limitation. 17:37:45
18 Q I'm just trying to understand what you 17:37:46
19 mean by "the combination of Froitzheim and Gan" in 17:37:56
20 Paragraph 148. This combination that you write 17:37:59
21 about here, does it include Gan's oxide layer or 17:38:03
22 not? 17:38:08

1 MR. SELWYN: Objection. Form. 17:38:09
2 A The combination of Froitzheim and Gan 17:38:14
3 that -- combining the teachings of Froitzheim and 17:38:20
4 Gan, Froitzheim -- excuse me, Gan teaches an oxide 17:38:23
5 layer. Gan teaches a polysilicon layer. This 17:38:27
6 claim requires a polysilicon layer. Gan teaches 17:38:32
7 that. 17:38:36
8 And if one combined the teachings of Gan 17:38:37
9 and polysilicon, one has all of the elements of 17:38:40
10 the claim limitation, in particular forming a 17:38:46
11 layer of polysilicon over a back surface of a 17:38:50
12 silicon substrate. 17:38:52
13 Q So is that a no to my question? 17:38:59
14 A Can you ask your question one more time 17:39:01
15 for me, please. 17:39:03
16 Q Yep. My question was, I'm just trying to 17:39:03
17 understand what you mean by "the combination of 17:39:06
18 Froitzheim and Gan" in Paragraph 148. This 17:39:09
19 combination that you write about here, does this 17:39:13
20 include Gan's oxide layer or not? 17:39:15
21 MR. SELWYN: Objection. Form. 17:39:18
22 A What I'm combining is the teachings of 17:39:27

1 Gan and Froitzheim. And that's what's required, 17:39:32
2 as I understand it, for a POSITA to make a 17:39:38
3 combination when one is considering the 17:39:44
4 obviousness of a claim. And Gan teaches a 17:39:46
5 polysilicon layer. Gan also teaches an oxide 17:39:51
6 layer. But combining Gan's teachings with 17:39:54
7 Froitzheim, if the oxide layer is present or not, 17:39:58
8 Gan teaches forming -- Gan with Froitzheim teaches 17:40:03
9 forming a layer of polysilicon over a back surface 17:40:08
10 of a silicon straight. 17:40:09
11 Q I am still not understanding when you say 17:40:15
12 "the combination of Froitzheim and Gan" in 17:40:35
13 Paragraph 148, do you envision a combination that 17:40:38
14 has Gan's oxide layer, or does it not have Gan's 17:40:43
15 oxide layer? 17:40:46
16 MR. SELWYN: Objection. Form. 17:40:48
17 A In order to meet the claim limitation, I 17:41:06
18 don't believe that I have to envision one or the 17:41:09
19 other. I believe that Gan and Froitzheim have 17:41:12
20 teachings that meets the claim limitation with or 17:41:17
21 without the oxide layer present here, because Gan 17:41:23
22 teaches forming a layer of polysilicon over a 17:41:29

1 silicon substrate. Froitzheim teaches an emitter 17:41:33
2 on the rear side of the back surface of a -- of a 17:41:36
3 solar cell. And so the combination of Gan with 17:41:42
4 Froitzheim would teach the polysilicon -- forming 17:41:45
5 a layer of polysilicon over a back surface of a 17:41:49
6 silicon substrate. 17:41:52
7 Q When you say "the combination of 17:41:53
8 Froitzheim and Gan," are you contemplating an 17:41:58
9 embodiment that would not include Gan's oxide 17:42:03
10 layer? 17:42:05
11 MR. SELWYN: Objection. Form. 17:42:09
12 A I think that's similar if not the same to 17:42:11
13 the question that you just asked. And so my 17:42:13
14 answer remains the same, that I think that Gan 17:42:18
15 teaches the formation of a layer of polysilicon. 17:42:21
16 Gan also teaches an oxide. Whether you take the 17:42:29
17 oxide or not, Gan's teachings when combined with 17:42:32
18 Froitzheim meet the limitation of this claim. 17:42:35
19 Q But when you propose to combine Gan with 17:42:40
20 Froitzheim, are you saying you don't necessarily 17:42:42
21 need to take the oxide of Gan? 17:42:44
22 MR. SELWYN: Objection. Form? 17:42:47

1 A I think that's the same question. My 17:42:53
2 answer is the same, which is that I think that Gan 17:42:54
3 teaches a polysilicon layer formed over a silicon 17:43:00
4 substrate. And Froitzheim teaches an emitter on 17:43:03
5 the back side of a solar cell. And so 17:43:09
6 implementing Gan and Froitzheim, one would put a 17:43:11
7 polysilicon layer formed over a back surface of 17:43:15
8 the silicon substrate, and those teachings are 17:43:18
9 present regardless or with or without the 17:43:22
10 teachings of Gan's oxide layer. 17:43:25
11 Gan teaches all of the elements of the 17:43:30
12 claim when combined with Froitzheim. 17:43:33
13 Q But Gan teaches all of the elements of 17:43:41
14 the claim when combined with Froitzheim how? 17:43:43
15 MR. SELWYN: Objection. 17:43:47
16 Q Are you combining Gan's oxide layer with 17:43:47
17 Froitzheim here? 17:43:50
18 MR. SELWYN: Objection. Form. 17:43:55
19 A Per my previous answers, if the oxide 17:44:03
20 layer is included, one still has a polysilicon 17:44:07
21 layer over a back surface of a silicon substrate. 17:44:12
22 The oxide layer is not included. One still has a 17:44:15

1 polysilicon layer formed over the back surface of 17:44:19
2 the silicon substrate. So Gan's teachings in both 17:44:21
3 cases, when combined with Froitzheim, Froitzheim 17:44:24
4 provides motivation for implementing Gan on the 17:44:28
5 back surface meet the -- meet the limitations of 17:44:30
6 the claim. 17:44:35
7 Gan also has many other features, for 17:44:38
8 example, that I'm not being asked about. So I 17:44:44
9 don't think that one -- I don't think that the 17:44:47
10 requirement for obviousness is that everything 17:44:53
11 from one reference be mechanically included in 17:44:58
12 everything from another reference; but rather, the 17:45:01
13 teachings of one reference with the ordinary skill 17:45:04
14 of a POSITA, when incorporated in another 17:45:07
15 reference, provide a likely chance of success, and 17:45:11
16 the POSITA would have motivation to make the 17:45:18
17 combination. 17:45:21
18 Q Would a POSITA have motivation to make a 17:45:21
19 combination of Gan and Froitzheim without Gan's 17:45:28
20 oxide layer? 17:45:33
21 A Gan teaches that with the oxide layer, 17:45:39
22 the J naught and rho C of the resulting 17:45:45

1 oxide-polysilicon-emitter combination are very 17:45:54
2 good. 17:45:55
3 Gan references previous work in which 17:45:55
4 oxide is omitted. Gan also describes work that 17:45:57
5 Gan did and others have done in which an oxide 17:46:03
6 layer is unintentionally grown, not thermally 17:46:05
7 grown, and describes those results. 17:46:09
8 So Gan provides, I would say, clear 17:46:15
9 motivation or explicit motivation for a POSITA to 17:46:20
10 make the combination with the oxide. The same 17:46:25
11 explicit motivation is not provided with the 17:46:30
12 oxide. 17:46:34
13 But if you look at the -- my 17:46:34
14 understanding of motivation to combine as 17:46:38
15 presented in my declaration, it doesn't require -- 17:46:43
16 just that there is no rigid requirement of finding 17:47:33
17 an expressed teaching suggestion or motivation 17:47:36
18 combined within the references in order to find a 17:47:38
19 motivation; but rather that a person of ordinary 17:47:40
20 skill in the art would have had reason to combine 17:47:43
21 references or add missing features. 17:47:46
22 Q Does your declaration talk about a 17:47:52

1 POSITA's motivation to combine Froitzheim and 17:47:57
2 Gan's polysilicon emitter without Gan's oxide 17:48:02
3 layer? 17:48:06
4 A No. My combination focuses on -- excuse 17:48:15
5 me. My declaration focuses on the combination 17:48:21
6 with the oxide layer and the motivation to combine 17:48:28
7 being provided by the excellent J naught and rho C 17:48:34
8 values that that oxide and polysilicon emitter 17:48:41
9 provides as I described previously from Gan, and 17:48:44
10 the expected efficiency enhancement of that. 17:48:48
11 You can find that starting on Paragraph 17:48:52
12 121 of my declaration and extending through -- 17:49:00
13 extending to 135. 17:49:27
14 MS. ZHAO: I'm about to start a new 17:49:33
15 section. How are you doing? Do you need a break? 17:49:35
16 MR. SELWYN: Why don't we take five 17:49:37
17 minutes. 17:49:39
18 MS. ZHAO: Okay. 17:49:39
19 THE WITNESS: Yeah, that would be nice. 17:49:40
20 Thank you. 17:49:41
21 (A recess was taken.) 17:49:42
22 BY MS. ZHAO: 17:54:47

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Maxeon Exhibit 2029

1 Q Let's go to Paragraph 199 of the '053 17:54:48
2 declaration. 17:54:51
3 A Okay. 17:55:12
4 Q In the middle of the paragraph you talk 17:55:12
5 about a person of ordinary skill in the art would 17:55:15
6 have understood that the combination of 17:55:18
7 Froitzheim's manufacturing of a back-junction 17:55:21
8 solar cell, Gan's manufacturing of a polysilicon 17:55:24
9 emitter and oxide layer structure, and Smith's 17:55:27
10 solar cell manufacturing techniques, and so on. 17:55:30
11 Do you see that? 17:55:33
12 A Yes. 17:55:35
13 Q I'm going to refer to this combination as 17:55:35
14 the Froitzheim-Gan-Smith combination. 17:55:38
15 Is that okay? 17:55:46
16 A Yes, it is. 17:55:47
17 Q Let's go to Paragraph 205. 17:55:48
18 A Okay. 17:56:00
19 Q At the top of Page 129 you state that 17:56:01
20 "Smith teaches depositing dopant source layers, 17:56:04
21 such as BSG, using APCVD." 17:56:07
22 Do you see that? 17:56:12

1 A Yes, I do. 17:56:13
2 Q Is this a technique you are proposing to 17:56:14
3 add to the Froitzheim-Gan-Smith combination? 17:56:17
4 MR. SELWYN: Objection. Form. 17:56:22
5 A Did you mean add to the Froitzheim -- I 17:56:28
6 think I understand your question. 17:56:32
7 Q Let me ask it -- 17:56:33
8 A Included in the Froitzheim-Gan-Smith 17:56:35
9 combination? 17:56:37
10 Q Thank you. Yes. 17:56:37
11 A I'm proposing here that Smith teaches 17:56:43
12 certain advantages in manufacturing techniques 17:56:49
13 that would motivate a POSITA to implement some of 17:56:54
14 Smith's teachings in the Froitzheim-Gan device 17:57:02
15 combination. That's what I'm suggesting. 17:57:07
16 Q This APCVD process, is that a 17:57:14
17 manufacturing technique that a POSITA would have 17:57:20
18 been motivated to implement in the Froitzheim-Gan 17:57:23
19 device? 17:57:25
20 A So on Page 136, going on to Page 137, 17:58:00
21 Paragraph 220, I discuss that a POSITA would have 17:58:15
22 been motivated to modify the Froitzheim-Gan 17:58:21

1 combination to implement Smith's diffusion 17:58:26
2 methods. And one thing that Smith teaches is the 17:58:33
3 formation of a borosilicate glass as a source of 17:58:35
4 a -- a dopant source, a P-type dopant source. 17:58:44
5 Deposited by APCVD. I'm sorry, I'm not sure if I 17:58:57
6 said that or not. 17:59:01
7 Q Okay. Let's look at Exhibit 1007, Smith. 17:59:04
8 (Exhibit 1007, previously marked, not 17:59:04
9 attached.) 17:59:04
10 A Okay, I'm there. 17:59:19
11 Q Let me direct you to Column 2, Lines 44 17:59:20
12 to 49. 17:59:25
13 A Column 2, 42 to 49? 17:59:38
14 Q Forty-four to 49. 17:59:41
15 A Got it. Yes. 17:59:47
16 Q These lines talk about a boron-doped 17:59:49
17 silicon dioxide labeled as 104, deposited on the 17:59:53
18 back side of a wafer. Right? 17:59:58
19 A Yes. 18:00:00
20 Q The Froitzheim-Gan-Smith combination that 18:00:00
21 you propose, would it also have a boron-doped 18:00:08
22 silicon dioxide? 18:00:11

1 A Yes. And in fact, Smith already -- 18:00:20
2 excuse me, Froitzheim already teaches forming such 18:00:26
3 a dopant source, boron dopant source. And Gan 18:00:33
4 also teaches forming boron sources. Smith teaches 18:00:38
5 an improved method using APCVD of forming this 18:00:45
6 boron dopant source. 18:00:52
7 Q Going to Lines 53 to 60. They talk about 18:00:54
8 an undoped silicon dioxide labeled as 106 being 18:00:59
9 deposited over the boron-doped silicon dioxide. 18:01:05
10 Right? 18:01:08
11 A Yes, I see that. 18:01:09
12 Q Does the Froitzheim-Gan-Smith combination 18:01:10
13 have an undoped silicon dioxide, too? 18:01:14
14 A It can. And that is not a limitation of 18:02:28
15 the claims that we were looking at, but comes in 18:02:33
16 in Claim 1C, which is discussed in Paragraph 18:02:39
17 159 -- excuse me, Page 159 of my declaration. 18:02:43
18 One of the advantages that Smith teaches 18:02:51
19 about his manufacturing method is that these 18:02:55
20 undoped silicon dioxide capping layers can prevent 18:03:01
21 dopants from diffusing in undesirable directions. 18:03:09
22 And those teachings of Smith can be implemented in 18:03:14

1 the Froitzheim-Gan combination, and are 18:03:19
2 implemented in that combination. In particular to 18:03:24
3 arrive at Element 1C of Claim 1 on Page 159 of my 18:03:32
4 declaration. 18:03:39
5 Q The next paragraph in Smith, starting in 18:03:40
6 Column 2, on Line 65, talks about forming a mask, 18:03:44
7 and going into Column 3, paragraph starting on 18:03:49
8 Line 11, the mask is used to pattern the silicon 18:03:53
9 dioxide stack comprising Components 104 and 106. 18:03:56
10 Do you see that? 18:04:04
11 A Yes, I do. 18:04:08
12 Q Does the Froitzheim-Gan-Smith combination 18:04:09
13 include the process described in Column 2, Lines 18:04:12
14 65 to Column 3, Line 18? 18:04:16
15 A Make sure I get that right. Column 2, 18:04:22
16 65; Column 3, 18. 18:04:27
17 Is that correct? 18:04:28
18 Q Yep. 18:04:30
19 A Thank you. 18:04:31
20 This portion of Smith -- this portion of 18:05:22
21 Smith is teaching a method to pattern the emitter 18:05:33
22 and back surface field layer at the rear side of 18:05:39

1 Smith's solar cell to make a back-contact solar 18:05:42
2 cell. No such patterning is required by the 18:05:47
3 limitations of the '053 patent, and consequently I 18:05:50
4 have not drawn from these teachings of Smith in my 18:05:57
5 combination. 18:05:59
6 Q Going to Column 3, paragraph starting on 18:06:03
7 Line 19. This paragraph starts with a phosphorous 18:06:05
8 doped silicon dioxide being deposited over the 18:06:14
9 sample of Figure 4. 18:06:17
10 Do you see that? 18:06:19
11 A Yes, I do. 18:06:19
12 Q Does the Froitzheim-Gan-Smith combination 18:06:20
13 include a phosphorous doped silicon dioxide? 18:06:24
14 A It does. The Froitzheim-Gan-Smith 18:07:04
15 combination includes a phosphorous diffusion at 18:07:08
16 the front surface of the wafer to form the N plus 18:07:16
17 layer that Froitzheim has in his solar cell. And 18:07:20
18 in the formation of that N plus layer, a 18:07:27
19 phosphorous dopant source, phosphorous glass, for 18:07:33
20 instance, would be formed at the front side of the 18:07:36
21 wafer. 18:07:38
22 Q Then the paragraph talks about an undoped 18:07:38

1 silicon dioxide deposited over the phosphorous 18:07:45
2 doped silicon dioxide. 18:07:50
3 Do you see that? 18:07:51
4 A Yes, I do. 18:08:06
5 Q Does the Froitzheim-Gan-Smith combination 18:08:06
6 include this undoped silicon dioxide? 18:08:10
7 A This teaching of Smith, while required 18:09:00
8 for Smith's back-contact solar cell and its patent 18:09:06
9 therein, is not required for the 18:09:12
10 Froitzheim-Gan-Smith combination. And I have not, 18:09:19
11 if I remember correctly, included Smith's 18:09:39
12 teachings on an undoped silicon oxide over an 18:09:45
13 N-type silicon -- phosphorous doped silicon oxide 18:09:52
14 glass in my combination. It's not required and 18:09:57
15 not part of the claim limitations. 18:10:02
16 Q Column 3, starting on Line 40, Smith goes 18:10:10
17 into the in situ steps. Right? 18:10:13
18 A Just one moment, please. 18:10:21
19 Can you repeat that for me one more time? 18:10:31
20 Q Column 3, starting on Line 40, is where 18:10:34
21 Smith starts to talk about the in situ steps. 18:10:39
22 Right? 18:10:43

1 A That is correct. 18:10:43
2 Q Is the in situ diffusion process also a 18:10:43
3 technique you are proposing to implement in the 18:10:49
4 Froitzheim-Gan-Smith combination? 18:10:54
5 A Yes, it is. Smith teaches that one of 18:11:03
6 the advantages of his methods is this in situ 18:11:08
7 procedure in which multiple -- multiple diffusions 18:11:21
8 are performed with one loading of -- of the wafer. 18:11:27
9 And I describe this beginning on Page 149 of my 18:11:38
10 declaration. 18:11:44
11 And this, in fact this in situ process in 18:11:47
12 which the substrate in the one loading of the tool 18:11:54
13 is heated up to perform the diffusion that forms 18:12:04
14 Gan's P-type polysilicon emitter, and then without 18:12:08
15 removal from the tool per Gan's teachings with the 18:12:13
16 flow of POCl3, forms the N plus front surface 18:12:20
17 field at the -- at the front of -- front of the 18:12:32
18 wafer. And this, in fact, is why Gan -- excuse 18:12:34
19 me, Smith's undoped oxide layer over a thin type 18:12:42
20 glass, your previous question, is not required. 18:12:48
21 Because the doping of the front surface to achieve 18:12:50
22 Froitzheim's N plus front surface field layer can 18:12:55

1 occur via this in situ step that I describe 18:12:59
2 beginning on Page 139. 18:13:04
3 Q So Smith talks about a first in situ step 18:13:12
4 where the wafer is heated to about 1000 degrees C. 18:13:14
5 Right? 18:13:18
6 A Correct. 18:13:20
7 Q And in the Froitzheim-Gan-Smith 18:13:20
8 combination, would you be heating the wafer to 18:13:26
9 1000 degrees C as well? 18:13:28
10 A Once again, the particular numbers of a 18:13:33
11 method are not required in making an obvious 18:13:37
12 combination. A POSITA has ordinary ingenuity in 18:13:41
13 learning from the teachings and making the 18:13:46
14 combination. 18:13:49
15 But Smith teaches 1000 degrees Celsius 18:13:49
16 for one hour for this diffusion. Gan teaches 900 18:13:54
17 degrees to 1000 degrees and shows both values for 18:13:59
18 a diffusion to form his P-type polysilicon 18:14:03
19 emitter, and shows times that are consistent with 18:14:08
20 that one hour. Froitzheim teaches a temperature 18:14:10
21 range of 900 to 1200 degrees C. All of these are 18:14:15
22 consistent. A POSITA would be able to look at 18:14:19

1 these and recognize that these processes would 18:14:21
2 work together. 18:14:25
3 Q Is it accurate to say that a temperature 18:14:28
4 within the range disclosed by Smith or Gan or 18:14:33
5 Froitzheim would work, for the 18:14:39
6 Froitzheim-Gan-Smith combination? 18:14:45
7 A Yes, if I understood your statement 18:14:49
8 correctly, the teachings of Gan, Smith, and 18:14:54
9 Froitzheim are consistent regarding diffusion 18:15:00
10 temperatures, and a diffusion temperature 18:15:05
11 consistent with their teachings would work for the 18:15:12
12 combination. 18:15:15
13 Q And in the Froitzheim-Gan-Smith 18:15:18
14 combination, this heating would diffuse both the 18:15:26
15 boron-doped silicon dioxide and the 18:15:29
16 phosphorous-doped silicon dioxide. 18:15:33
17 Is that right? 18:15:36
18 A There are multiple ways that this could 18:15:41
19 be implemented. A POSITA can -- can learn from 18:15:44
20 the teachings within Smith. 18:15:52
21 So in the first step it is important, it 18:15:56
22 is necessary that the P-type emitter become doped, 18:15:59

1 the N diffusion of boron that needs to happen in 18:16:15
2 the first step. And a possible second step as 18:16:18
3 taught by Smith dopes the front side of the wafer 18:16:23
4 N-type, as I describe on Page 153. This all would 18:16:33
5 happen within one loading of the wafer into the 18:16:38
6 tool, per Smith's teachings about the 18:16:40
7 manufacturing value of in situ diffusion. 18:16:46
8 Q Is it possible to only dope the P-type 18:16:50
9 emitter in the first step but not the N-type -- 18:16:59
10 MR. SELWYN: Objection -- 18:17:02
11 Q (Inaudible.) 18:17:02
12 MR. SELWYN: Objection. Form. 18:17:03
13 A Yes, consistent with the teachings of 18:17:08
14 Froitzheim, Gan, and Smith, this is possible. For 18:17:10
15 example, adding the doped -- boron-doped glass on 18:17:15
16 the back of Gan's polysilicon emitter, loading the 18:17:23
17 wafer into the tool, performing Smith's first step 18:17:30
18 to diffuse the dopants into the polysilicon 18:17:34
19 emitter, and then switching to Smith's second 18:17:38
20 step, which flows POCl. And in so doing forms the 18:17:41
21 phosphorous glass and drives that phosphorous 18:17:51
22 glass -- the dopants from that phosphorous glass 18:17:54

1 into the wafer, and then removing the wafer from 18:17:58
2 the tool. That's one implementation of Smith's 18:18:02
3 teachings into the Froitzheim-Gan combination, as 18:18:05
4 I think I described in this section of my 18:18:09
5 declaration. 18:18:12
6 Q If you were to do that, would phosphorous 18:18:12
7 glass also form on the P-type dopant side of the 18:18:20
8 wafer? 18:18:23
9 A One moment, please. 18:18:35
10 Your question was would an oxide be 18:19:48
11 formed on both surfaces of the wafer during 18:19:50
12 Smith's second step. Correct? 18:19:56
13 Q I said would phosphorous glass also form 18:20:01
14 on the P-type dopant side of the wafer? Because I 18:20:06
15 thought in your answer you talked about how 18:20:15
16 performing Smith's first step to diffuse the 18:20:19
17 dopant into polysilicon emitter and then switching 18:20:23
18 to Smith's second step which flows POCl and in 18:20:26
19 doing so forms the phosphorous glass. So I just 18:20:30
20 want to know, would that phosphorous glass also be 18:20:33
21 formed on the P-type dopant side of the wafer. 18:20:37
22 A I understand. 18:20:40

1 So it will certainly be formed on the 18:20:41
2 front of the wafer because the POCl can react with 18:20:43
3 the silicon surface on the back side of the wafer 18:20:51
4 from the diffusion that already occurred into 18:20:54
5 Gan's polycrystalline emitter, there was -- there 18:20:58
6 would be presence of boron-doped glass and 18:21:03
7 potentially an undoped oxide layer per Smith, as 18:21:06
8 we've discussed previously. 18:21:12
9 The POCl may react some with those 18:21:14
10 existing oxide layers. I don't think it would 18:21:19
11 grow as much of the glass, if any, as it would on 18:21:28
12 the front side where it can react with the -- with 18:21:32
13 the silicon. 18:21:35
14 But what you're -- what we're describing 18:21:39
15 here is common to both Froitzheim and Smith. Both 18:21:41
16 of them envision forming a P-type diffusion and 18:21:47
17 subsequently doping the front of their wafers 18:21:54
18 N-type through a POCl process. Both have that. 18:21:59
19 Q So in the Froitzheim-Gan-Smith 18:22:02
20 combination, we talked about how in the first step 18:22:12
21 of the in situ -- the first in situ step you could 18:22:15
22 diffuse both P-type dopant and N-type dopant, or 18:22:20

1 you could in the first step diffuse one and in the 18:22:25
2 second step diffuse the other. Right? 18:22:28
3 MR. SELWYN: Objection. Form. 18:22:36
4 A Yes, we talked mostly about the second of 18:22:52
5 what you described. But both could be possible. 18:22:55
6 Q Is one process more preferable than the 18:23:01
7 other? 18:23:04
8 MR. SELWYN: Objection. Form. 18:23:10
9 A In my declaration I have -- I have 18:23:12
10 described -- is one preferable to the other? I 18:23:18
11 expect that there are trade-offs that a POSITA 18:23:39
12 would consider when making a design choice between 18:23:44
13 one and the other. 18:23:47
14 Q Can you talk about that trade-off a bit 18:23:50
15 more? 18:23:52
16 A For example, there could be cost 18:24:16
17 trade-offs in forming the -- an N-type glass first 18:24:19
18 and then diffusing it, versus forming the N-type 18:24:34
19 glass -- diffusing it in the first step with the 18:24:38
20 P-type dopants versus diffusing it in a second 18:24:41
21 step. 18:24:46
22 If one were interested in implementing 18:24:51

1 other aspects of Froitzheim, like Froitzheim's 18:24:53
2 selective front surface field, which has two 18:24:56
3 different dopings, one might even implement both 18:25:00
4 the phosphorous glass diffusion selectively at the 18:25:05
5 front and -- sorry, one might implement both the 18:25:10
6 co-diffusion in the first step and the second step 18:25:16
7 POCl diffusion. Recall that Froitzheim talks 18:25:22
8 about forming this selective front surface field 18:25:25
9 in a manner similar to that, a manner which would 18:25:30
10 be advantaged by implementing Smith's 18:25:33
11 combinations. 18:25:36
12 I don't go into these details in my 18:25:37
13 declaration because it's not described by the 18:25:40
14 limitations of the -- of the claim. But there are 18:25:45
15 possibilities that a POSITA could consider when 18:25:52
16 making a design trade-off. 18:25:55
17 Q You said there are cost trade-offs in 18:25:57
18 forming an N-tech glass first and then diffusing 18:26:09
19 it versus forming the N-type glass, diffusing it 18:26:12
20 in the first step with the P-type dopants, versus 18:26:15
21 diffusing in a second step. 18:26:20
22 Can you talk about what that cost 18:26:21

1 trade-off is? Is one cheaper than the other, is 18:26:24
2 that what you mean? 18:26:28
3 MR. SELWYN: Objection. Form. 18:26:28
4 A Yes, in reality, every change made in 18:26:30
5 solar cell manufacturing implies a cost trade-off. 18:26:34
6 And so POSITAs, when implementing a manufacturing 18:26:39
7 sequence, are always asking questions about, Hey, 18:26:46
8 does this enhance the efficiency, is there an 18:26:51
9 associated change in cost, et cetera. 18:26:54
10 So without knowing details, I couldn't 18:26:58
11 tell you which one was more expensive or less 18:27:00
12 expensive. It depends on the particular 18:27:03
13 implementations. But cost trade-offs would be one 18:27:05
14 example that a POSITA would consider when making 18:27:11
15 design choices about how to implement particular 18:27:18
16 teachings. 18:27:28
17 Q Smith also talks about a second in situ 18:27:28
18 step. Right? 18:27:34
19 A Smith? 18:27:36
20 Q Yes. 18:27:36
21 A Yes, that's correct. 18:27:41
22 Q Would the Froitzheim-Gan-Smith 18:27:42

1 combination use the second in situ step? 18:27:46
2 A I'm sorry, I'm confused. We were just 18:27:53
3 talking about the second in situ step. So as I 18:27:55
4 describe in particular Page 151, 152, and 153, one 18:27:59
5 implementation of Smith's teachings into the 18:28:09
6 Gan-Froitzheim combination would be to, in the 18:28:14
7 first step, diffuse boron from the glass into 18:28:18
8 Gan's polysilicon emitter. And Smith's second 18:28:25
9 step, second in situ step, to change the diffusion 18:28:31
10 conditions to diffuse phosphorous into the front 18:28:38
11 of the wafer and form N plus front surface field. 18:28:40
12 Q In the scenario where you diffuse both 18:28:44
13 dopants in the first step, would you still need 18:28:49
14 the second step? 18:28:52
15 A Not necessarily, but you could. As I 18:28:57
16 described a moment ago, if, for example, you 18:29:01
17 wanted to implement Froitzheim's selective front 18:29:03
18 surface field, this would be a great way to do it. 18:29:08
19 But I don't address that in my combination because 18:29:15
20 it's not one of the limitations of the claim. 18:29:17
21 Q Are you saying the Froitzheim-Gan-Smith 18:29:19
22 combination that you propose does not include 18:29:33

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1 Froitzheim's selective front surface field? 18:29:36
2 A I'm saying that the combination that I 18:29:43
3 propose is silent on the matter of whether there's 18:29:47
4 a front surface field because it's -- a selective 18:29:49
5 front surface field, because a selective front 18:29:54
6 surface field is not required to meet the 18:29:57
7 limitations of the claim. 18:30:00
8 One could use Froitzheim's selective 18:30:04
9 front surface field if one so desired; the 18:30:09
10 resulting device would still meet the limitations 18:30:13
11 of the claim. One could omit it; the resulting 18:30:15
12 device and process would still meet the 18:30:18
13 limitations of the claim. 18:30:21
14 Q If one were to omit the selective front 18:30:21
15 surface field in the Froitzheim-Gan-Smith 18:30:24
16 combination and if one were to diffuse both dopant 18:30:28
17 in the first in situ step, would you still need 18:30:34
18 the second in situ step? 18:30:39
19 MR. SELWYN: Objection. Form. 18:30:43
20 A There -- in the hypothetical that you 18:30:53
21 have created, I believe it could be possible to 18:30:56
22 achieve the device with one -- one diffusion, 18:31:02

1 so-called co-diffusion. 18:31:08
2 This still meets Smith's teachings of in 18:31:11
3 situ because Smith teaches that in situ -- the 18:31:17
4 steps are in situ, in that they are performed in 18:31:26
5 one loading of Wafer 102 into the wafer 18:31:29
6 processing. So that would still be the case for 18:31:36
7 the hypothetical that you've described. But I 18:31:38
8 believe it would be one diffusion rather than 18:31:41
9 Smith's two-step diffusion in that case. 18:31:43
10 Q On Line 59 of Smith, in Column 3 -- just 18:31:45
11 make sure that's the right one. Yes. Smith says 18:32:01
12 to diffuse phosphorous as an N-type dopant into 18:32:05
13 Wafer 102 and to grow a thin layer of silicon 18:32:09
14 dioxide on both sides of the wafer. 18:32:13
15 Do you see that? 18:32:16
16 A Yes, I do. 18:32:24
17 Q In the Froitzheim-Gan-Smith combination, 18:32:25
18 if you were to use a second in situ step, would 18:32:30
19 there also be a thin layer of silicon dioxide on 18:32:33
20 both sides of the wafer? 18:32:39
21 MR. SELWYN: Objection. Form. 18:32:42
22 A I think we talked about this previously, 18:34:21

1 and my answer is the same. I see the lines that 18:34:25
2 you're pointing out. I see between Figure 6 and 18:34:29
3 Figure 7 of Smith that Smith shows this oxide 18:34:35
4 growth on the front surface of the wafer where the 18:34:42
5 POCl can react with the silicon, as I was 18:34:45
6 describing previously. And Smith draws this as 18:34:49
7 101B in Figure 7. That appears it wasn't present 18:34:52
8 in Figure 6, the back side of the wafer is not 18:34:58
9 drawn as having any change between Figure 6 and 18:35:02
10 Figure 7. Although Smith's text, the region that 18:35:05
11 you read, describes a thin layer of oxide on the 18:35:11
12 back as well. So it may be that Smith is 18:35:15
13 observing what I described previously, where 18:35:18
14 there's some oxide growth on the back, not as much 18:35:19
15 on the front where the silicon is exposed. 18:35:25
16 I also look to Froitzheim in answering 18:35:27
17 your question. And as I mentioned previously, 18:35:31
18 Froitzheim's process similarly puts a wafer into a 18:35:40
19 POCl diffusion furnace after diffusing the P-type 18:35:43
20 emitter. And Froitzheim describes this diffusion 18:35:52
21 in Paragraph 44. 18:36:10
22 Froitzheim doesn't describe whether or 18:36:17

1 not there's an oxide layer that is grown on the 18:36:19
2 back side, for example, during that process, and 18:36:24
3 whether there are any consequences of that. 18:36:26
4 Q Let's go to Paragraph 281. 18:36:32
5 A Of my deposition. 18:36:42
6 Q Of your '053 declaration. 18:36:43
7 A The declaration. 281? 18:36:46
8 Q 281, Page 168. 18:36:49
9 A Okay, I have arrived. 18:36:59
10 Q We're now in the section with Li, Gan, 18:37:00
11 and Smith. So I'm going to call the structure you 18:37:03
12 are proposing in this section the Li-Gan-Smith 18:37:06
13 combination. 18:37:09
14 Is that okay? 18:37:10
15 A Yes, it is. 18:37:10
16 Q In this paragraph, 281, you talk about, 18:37:11
17 three lines in, "replacing these deposited silicon 18:37:17
18 thin film with Gan's deposited polysilicon emitter 18:37:21
19 and implementing an oxide layer." 18:37:25
20 Do you see that? 18:37:28
21 A Yes, I do. 18:37:32
22 Q In this Li-Gan-Smith combination, are we 18:37:32

1 still implementing Gan's Steps 3, 4, 5, 9, and 10 18:37:38
2 that we discussed earlier? 18:37:44
3 A We are certainly implementing Gan's 18:37:49
4 teaching for oxide layer and P-type polysilicon 18:37:52
5 emitter. And those teachings are -- one 18:38:00
6 embodiment of those teachings are shown in Gan's 18:38:06
7 3, 4, 9, 10. Were those the numbers that you 18:38:10
8 mentioned? 18:38:21
9 Q I believe you also included Step 5. 18:38:22
10 A I did. And then -- and then backed away 18:38:26
11 from that because I had forgotten that Step 4 in 18:38:30
12 fact says, first step anneal. So that's not 18:38:33
13 really required. I apologize for confusion there. 18:38:39
14 Q Okay. 18:38:42
15 A So those Steps 3, 4, 9, 10, from -- from 18:38:43
16 Gan are some of Gan's -- an embodiment of Gan's 18:38:49
17 teaching for oxide layer growth and polysilicon 18:38:52
18 deposition and dopant drivant on the emitter. 18:38:56
19 Q Let's look at Exhibit 1008, Li. 18:39:03
20 (Exhibit 1008, previously marked, not 18:39:07
21 attached.) 18:39:13
22 Q Now, on Page 4, Section 5, titled 18:39:13

1 Detailed Description of Embodiment. 18:39:19
2 A Yes. 18:39:21
3 Q The first paragraph under this section 18:39:21
4 talks about how to construct Li's solar cell. 18:39:26
5 Right? 18:39:32
6 A Yes. 18:39:32
7 Q Li starts with a high-quality N-type 18:39:32
8 monocrystalline silicon wafer. Right? 18:39:36
9 A Yes. 18:39:42
10 Q Would this be the type of wafer used in 18:39:43
11 the Li-Gan-Smith combination? 18:39:47
12 A Li is the primary reference here. And Li 18:40:02
13 teaches this wafer is suitable for making Li's 18:40:08
14 device. So this is an appropriate wafer as taught 18:40:12
15 by Li to use, including in the combination. 18:40:17
16 Q Then Li talks about cleaning the surfaces 18:40:22
17 of the wafer and texturing it. Right? 18:40:24
18 A Yes. 18:40:27
19 Q The Li-Gan-Smith combination, would it 18:40:27
20 have these processes, too? 18:40:33
21 A Yes. And Smith as well describes 18:40:34
22 texturing and cleaning of wafers. These are 18:40:43

1 standard processing steps done on nearly all 18:40:47
2 silicon solar cells. 18:40:51
3 Q Next Li talks about a highly doped N plus 18:40:53
4 layer being diffused on the front surface. Right? 18:40:58
5 A Correct. 18:41:01
6 Q Is this step retained in the Li-Smith-Gan 18:41:02
7 combination? 18:41:10
8 A This is required to make Li's solar cell 18:41:11
9 to have an N plus layer on the front side. Li 18:41:12
10 teaches that it's diffused. This teaching tells 18:41:15
11 you how to do it. This is appropriate to include 18:41:21
12 in the combination. 18:41:25
13 Q Then Li talks about a thin film having 18:41:26
14 antireflection effect being deposited or grown on 18:41:31
15 the N plus layer. Right? 18:41:34
16 A That's correct. 18:41:39
17 Q Is this step retained in the Li-Gan-Smith 18:41:39
18 combination? 18:41:43
19 A It is required to have an antireflection 18:41:44
20 coating to make Li's device in the combination. 18:41:47
21 Li teaches how to do it. Smith also teaches how 18:41:52
22 to do it. 18:41:54

1 Q And Li talks about a silicon thin film 18:41:55
2 being deposited on the back surface of the wafer. 18:41:58
3 Right? 18:42:01
4 A Yes. 18:42:04
5 Q Is this what you're replacing with Gan's 18:42:04
6 steps? 18:42:06
7 A Yes, I am replacing in this combination 18:42:12
8 Li's silicon thin film deposited emitter with 18:42:14
9 Gan's oxide polysilicon deposited emitter. 18:42:18
10 Q Li also talks about preparing a positive 18:42:23
11 electrode on the antireflection layer. Right? 18:42:26
12 A Yes. 18:42:31
13 Q Is this step retained in the Li-Gan-Smith 18:42:32
14 combination? 18:42:37
15 A The solar cell must have two metal 18:42:38
16 contacts, also called electrodes, in order to 18:42:43
17 successfully extract electricity, electrical 18:42:46
18 power. Li teaches how to do it. Smith also 18:42:50
19 teaches how to do it. 18:42:54
20 Q By the way, is the cell structure 18:43:00
21 disclosed in Li a silicon solar cell? 18:43:04
22 A Yes, it is. 18:43:07

1 Q Would you call it a heterojunction solar 18:43:08
2 cell? 18:43:11
3 A Li teaches that Li's emitter can be 18:43:14
4 amorphous silicon. And if it is amorphous 18:43:20
5 silicon, I would certainly call it a 18:43:23
6 heterojunction solar cell. 18:43:24
7 Li teaches that Li's emitter can also be 18:43:27
8 crystalline silicon, and more particularly 18:43:35
9 microcrystalline or nanosilicon, nanocrystalline 18:43:41
10 silicon. And in this case, similar to your 18:43:45
11 questions before about a polycrystalline silicon 18:43:47
12 emitter, one would normally just call this a 18:43:54
13 silicon solar cell as of 2008, as opposed to 18:43:57
14 identifying it as a homojunction. And it 18:44:00
15 definitely would not normally be called a silicon 18:44:04
16 heterojunction as I described this morning that 18:44:07
17 that term was used for amorphous silicon 18:44:10
18 crystalline silicon heterojunctions. 18:44:13
19 Q I would like to go over the steps in 18:44:16
20 Smith again, this time in the context of Li, Gan, 18:44:23
21 and Smith. So earlier we talked about Smith 18:44:27
22 disclosing a boron-doped silicon dioxide on the 18:44:29

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1 back side of the wafer. Right? You can find that 18:44:33
2 in Smith Column 2, Line 44. 18:44:44
3 A Yes, we discussed that previously. 18:44:46
4 That's correct. 18:44:50
5 Q Does the Li-Gan-Smith combination have a 18:44:51
6 boron-doped silicon dioxide? 18:44:55
7 A Yes; both Gan and Smith teach the 18:45:02
8 formation of a dopant source layer, as is required 18:45:04
9 to dope Gan's polysilicon emitter. 18:45:09
10 Q And Smith also discloses an undoped 18:45:11
11 silicon dioxide being deposited over the 18:45:16
12 boron-doped silicon dioxide. Right? 18:45:20
13 A Yes, that is correct. Smith teaches 18:45:24
14 that. 18:45:26
15 Q Does the Li-Gan-Smith combination have an 18:45:27
16 undoped silicon dioxide too that is deposited over 18:45:31
17 the boron-doped silicon dioxide? 18:45:36
18 A Just one moment. Sorry for the delay. 18:46:29
19 Okay. That undoped layer could be 18:47:23
20 included. I have not included it in my 18:47:27
21 combination, as my Ground 3 that uses Li as the 18:47:31
22 primary reference covers Claims 9 through 20, and 18:47:34

1 those claims do not have as a limitation an 18:47:40
2 undoped capping layer. But that's found in Claim 18:47:44
3 1. And so I have not included it here. Smith 18:47:49
4 does teach it. It and other teachings could, of 18:47:54
5 course, be included. They weren't required for my 18:48:00
6 combination. 18:48:02
7 Q Smith also talks about a 18:48:03
8 phosphorous-doped silicon dioxide. Right? 18:48:09
9 A That is correct. 18:48:13
10 Q Does the Li-Gan-Smith combination 18:48:15
11 includes a phosphorous-doped silicon dioxide? 18:48:18
12 A Li as the primary reference as an N plus 18:48:23
13 layer at the front, similar to Froitzheim, a front 18:48:26
14 surface field, and it is diffused. And so one can 18:48:32
15 follow -- well, both Li and Smith have teachings 18:48:37
16 about how to form an N plus layer. And Smith 18:48:45
17 gives you two teachings, as we discussed in the 18:48:51
18 previous combination. One in which an oxide is 18:48:55
19 formed and then it goes into a furnace, and 18:48:58
20 another in which the oxide is formed by flowing 18:49:00
21 POCl during a furnace step. 18:49:04
22 Q Does -- 18:49:07

1 A Pardon me. Go ahead. 18:49:09
2 Q No. Please. 18:49:10
3 A Go ahead. I'm finished. 18:49:12
4 Q Smith also talked about an undoped 18:49:13
5 silicon dioxide being deposited over the 18:49:16
6 phosphorous-doped silicon dioxide. Right? 18:49:19
7 A Correct. 18:49:22
8 Q Would the Li-Gan-Smith combination 18:49:23
9 include an undoped silicon dioxide deposited over 18:49:26
10 the phosphorous-doped silicon dioxide? 18:49:30
11 A Similar to my previous answer, one could 18:49:39
12 use this. It is a teaching of Smith. It's not a 18:49:41
13 teaching of Smith that is required to meet the 18:49:44
14 limitations of any of Claims 9 through 20, which 18:49:48
15 are the claims addressed by my Ground 3 18:49:51
16 combination with Li. 18:49:54
17 Q Does that mean your combination does not 18:49:55
18 include it? 18:50:03
19 A My combination does not require it. 18:50:04
20 Q Going back to Smith's first in situ step, 18:50:07
21 where the wafer is heated to about 1000 degrees C. 18:50:15
22 In the Li-Gan-Smith combination, would you be 18:50:20

1 heating the wafer to 1000 degrees C as well? 18:50:22
2 A Yes, I describe on Page 191 implementing 18:50:52
3 in Smith's in situ teachings into -- into Li. And 18:50:57
4 that would include Li and Gan -- excuse me, that 18:51:04
5 would include diffusing dopants into Gan's emitter 18:51:10
6 at the back of Li's solar cell. 18:51:17
7 One thing to note is that that step is a 18:51:23
8 high-temperature processing step, would be done 18:51:29
9 naturally -- a natural place to do it would be 18:51:36
10 after the surfaces are cleaned and textured by 18:51:38
11 standard industrial process, as described by Li, 18:51:41
12 and not -- not at the point in the process in 18:51:48
13 which Li describes depositing an emitter. That is 18:51:53
14 to say, we are replacing structurally Li's emitter 18:51:56
15 with Gan's emitter using Smith's manufacturing 18:52:01
16 methods. But a POSITA, with his or her normal 18:52:04
17 ingenuity, would understand that higher 18:52:08
18 temperature processing steps usually precede lower 18:52:10
19 temperature processing steps in fabrication, and 18:52:15
20 so would make adjustments to the order in which 18:52:19
21 the -- the fabrication order. 18:52:22
22 Q What is the lower temperature processing 18:52:28

1 steps in Li? 18:52:30
2 A Li teaches, for example, a thin film 18:52:36
3 having an antireflection effect such as silicon 18:52:40
4 nitride or silicon dioxide. It's deposited or 18:52:44
5 grows on the N plus layer. 18:52:47
6 As you will find in other references, 18:52:50
7 Froitzheim, Smith -- Smith is a great example 18:52:56
8 since it's used in the combination, that 18:53:00
9 antireflection coating in the metal contact steps 18:53:03
10 typically occur at the end. 18:53:07
11 Q So is it accurate to say that in the 18:53:15
12 Li-Gan-Smith combination you would not be 18:53:17
13 diffusing both types of dopants during the first 18:53:19
14 step of -- during the first in situ step. Right? 18:53:24
15 A I don't think I said anything to that 18:53:30
16 effect. Similar to the combination of 18:53:32
17 Froitzheim-Gan and Smith, Li has a diffusion step 18:53:38
18 already described to form the N plus front surface 18:53:41
19 field. That step still needs to happen. And it 18:53:47
20 could happen using Smith's in situ teachings 18:53:51
21 either in a one two-step, where the first step is 18:53:57
22 the boron diffusion of the emitter and the second 18:54:02

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1 step is the phosphorous diffusion of the front 18:54:05
2 surface field, per Smith's teachings. Or the two 18:54:07
3 could happen together in a co-diffusion, which 18:54:12
4 would still meet Smith's intent or definition of 18:54:15
5 in situ. 18:54:19
6 I think either of these is possible. 18:54:20
7 Q I thought earlier you said the N-type 18:54:26
8 layer requires a lower temperature, or did I 18:54:31
9 misunderstand you? 18:54:34
10 A I didn't. Or if I did, I didn't mean to. 18:54:38
11 I tried to say that the antireflection coating and 18:54:42
12 the metal contact layers are typically done after 18:54:45
13 high-temperature diffusion steps, as for example 18:54:49
14 you would find in Smith. 18:54:53
15 Q So Smith's second in situ step involves 18:54:55
16 the heating to 750 degrees and then to 975 18:55:21
17 degrees. Right? 18:55:27
18 A It does. 18:55:29
19 Q So the Li-Gan-Smith combination, would it 18:55:29
20 also use the second in situ step? 18:55:34
21 A As I mentioned, it could. That's part of 18:55:38
22 Li -- excuse me, Smith's teachings. And it is a 18:55:41

1 way of forming an N plus layer at the surface. Li 18:55:46
2 describes an N plus layer at the surface. It 18:55:50
3 doesn't say how to make it beyond that it's a 18:55:54
4 diffusion. 18:56:01
5 And alternatively, as we were just 18:56:02
6 discussing, another method would be to use Smith's 18:56:05
7 teachings of forming phosphorous glass and then 18:56:11
8 co-diffusing that phosphorous at the front side at 18:56:19
9 the same time the boron is diffused at the back 18:56:22
10 side. 18:56:25
11 In Smith's teachings those two regions 18:56:25
12 are adjacent on the back side of the wafer, but 18:56:29
13 the same teachings can be implemented trivially 18:56:34
14 with the phosphorous layer at the front. So 18:56:38
15 either of these is consistent with -- or is within 18:56:40
16 Smith's teachings and is in situ diffusion as 18:56:43
17 defined by Smith. 18:56:49
18 MS. ZHAO: Okay. I'm done with the '053 18:56:50
19 declaration. Shall we take a five-minute break? 18:56:55
20 MR. SELWYN: Sure. 18:56:58
21 THE WITNESS: Yes, please. 18:56:59
22 (A recess was taken.) 18:57:00

1 BY MS. ZHAO: 19:06:56
2 Q Dr. Holman, the other IPR you are 19:06:58
3 testifying on today is IPR2024-01203. 19:07:02
4 Is that right? 19:07:09
5 A Yes. 19:07:11
6 Q You submitted a declaration for that IPR? 19:07:12
7 A I did. 19:07:17
8 Q And you have that declaration in one of 19:07:17
9 your binders. Right? 19:07:20
10 A Yes. 19:07:22
11 Q And for the record, I am referring to 19:07:22
12 Exhibit 1003. 19:07:26
13 (Exhibit 1003, IPR2024-01203, previously 19:07:26
14 marked, not attached.) 19:07:26
15 Q This declaration relates U.S. Patent 19:07:28
16 Number 8,222,516. 19:07:30
17 Is that right? 19:07:32
18 A Yes. 19:07:37
19 Q You call this patent the '516 patent. 19:07:37
20 Right? 19:07:40
21 A Correct. 19:07:41
22 Q So I'll refer to your declaration as the 19:07:41

1 '516 declaration. 19:07:45
2 Is that okay? 19:07:46
3 A Yes. 19:07:53
4 Q Did you prepare the '516 declaration all 19:07:54
5 by yourself? 19:07:56
6 A The '516 declaration represents my 19:07:56
7 opinions, my ideas, and my opinions and ideas 19:07:59
8 only. I didn't type all of the words into 19:08:02
9 word-processing software myself. But I have 19:08:06
10 reviewed, edited every word and signed the 19:08:09
11 declaration accordingly. 19:08:13
12 Q How many hours have you spent on 19:08:14
13 preparing the '516 declaration? 19:08:18
14 A I think I did this estimate before. 19:08:26
15 Approximately 60 hours between the -- split 19:08:32
16 between the '516 and '053. There is a fair amount 19:08:34
17 of overlap between them. 19:08:40
18 Q Sitting here today, do you still agree 19:08:43
19 with all the statements you made in the '516 19:08:46
20 declaration? 19:08:48
21 A Yes. 19:08:48
22 Q Is there anything you wish to alter in 19:08:48

1 the '516 declaration? 19:08:51
2 A No. 19:08:55
3 Q Is there anything you wish to add to the 19:08:56
4 '516 declaration? 19:08:57
5 A No. 19:08:59
6 Q Let's take a look at the table of 19:08:59
7 contents. 19:09:05
8 A Okay. 19:09:05
9 Q I am on Page 2 of the table of contents. 19:09:09
10 Ground 1 involves a combination of Froitzheim and 19:09:14
11 Gan. 19:09:18
12 Do you see that? 19:09:18
13 A Yes. 19:09:20
14 Q Earlier with, respect to the '053 19:09:20
15 declaration, we discussed a Froitzheim-Gan 19:09:25
16 combination that would retain certain 19:09:27
17 manufacturing steps from Froitzheim. Correct? 19:09:31
18 A Correct. 19:09:35
19 Q Now, the combination of Froitzheim and 19:09:35
20 Gan in the '516 declaration, does it involve the 19:09:38
21 same manufacturing steps from Froitzheim? 19:09:42
22 A The '516 declaration is aimed at 19:09:49

1 evaluating the obviousness of the claims of the 19:09:53
2 '516 patents, which are not a method claim. 19:09:55
3 They're not about manufacturing steps, but rather 19:09:59
4 about the structure that's made. 19:10:02
5 Q So are we talking about a different 19:10:06
6 combination of Froitzheim-Gan here in the '516 19:10:08
7 declaration? 19:10:12
8 MR. SELWYN: Objection. Form. 19:10:15
9 A We are talking about a combination of the 19:10:16
10 teachings of Froitzheim and Gan. The same 19:10:17
11 Froitzheim as in the '053 declaration and the same 19:10:20
12 Gan as in the '053 declaration, but we are looking 19:10:24
13 to their teachings of structure; whereas the '053 19:10:28
14 declaration is focused on their teaching of method 19:10:36
15 because the '053 claims are method claims. 19:10:41
16 Q If I can have you go to Gan real quick. 19:10:44
17 Would the combination of Froitzheim and 19:10:50
18 Gan in the '516 declaration still use Steps 3, 4, 19:10:53
19 9, and 10 of Gan? 19:11:00
20 A Again, the '516 declaration is evaluating 19:11:23
21 the obviousness of claims that are structure 19:11:27
22 claims, or describing a particular device. The 19:11:34

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1 teachings of Gan and Froitzheim include teaching 19:11:40
2 how to make such a device. But in the '516 19:11:46
3 declaration I'm focusing on the devices that are 19:11:52
4 made and the teaching of those -- those devices. 19:11:57
5 So I haven't specifically addressed which of Gan's 19:12:02
6 processing steps, for example, would be included 19:12:07
7 in the combination. But Gan does teach -- teaches 19:12:12
8 the combination -- Gan and Froitzheim teach the 19:12:16
9 combination and how to make it. 19:12:21
10 Q Would a POSITA know how to make a Gan and 19:12:23
11 Froitzheim combination of the '516 declaration 19:12:37
12 based on reading your declaration? 19:12:42
13 A Yes. As I described in my declaration, 19:12:47
14 Gan's teaches an oxide layer and a polysilicon 19:12:51
15 layer, and oxide layers have been known in 19:12:58
16 microelectronics and then in solar cells for 19:13:03
17 decades. Similarly with polysilicon layers. And 19:13:06
18 teachings of how to make those do appear in Gan, 19:13:10
19 but also can be found in the literature for 19:13:14
20 decades. And I review other references, ways to 19:13:20
21 make oxide and polysilicon layers in my background 19:13:25
22 section that include other references that teach 19:13:30

1 how to make them. 19:13:32
2 So the structure that Gan describes, and 19:13:33
3 it's how it would be incorporated into Froitzheim, 19:13:39
4 are things that a POSITA would already understand, 19:13:44
5 but are also taught in those references. 19:13:47
6 Q Would a POSITA making the Gan and 19:13:49
7 Froitzheim combination of the '516 declaration, 19:13:56
8 would that POSITA understand that Gan Step 3 must 19:14:00
9 be used? 19:14:05
10 A Gan's Step 3 teaches the growth of a 19:14:17
11 thermal oxide. Thermal oxides have been described 19:14:19
12 in the literature back to at least the 1950s. And 19:14:25
13 a POSITA would understand that to form Gan's 19:14:31
14 structure an oxide must be -- must be formed. 19:14:36
15 A POSITA would understand that one method 19:14:43
16 of forming it is thermal oxide growth, which is 19:14:45
17 described in Gan's Step 3. Although other methods 19:14:50
18 are also possible and were well known. 19:14:54
19 Q Is it your position then that a POSITA 19:14:57
20 making the Gan-Froitzheim combination of the '516 19:15:04
21 declaration would not necessarily need to use 19:15:09
22 Gan's oxide layer? 19:15:14

1 MR. SELWYN: Objection. Form. 19:15:20
2 A No. I'm referring -- I'm relying on 19:15:22
3 Gan's oxide layer and Gan's teaching to form the 19:15:27
4 structure, the Froitzheim-Gan combination. I'm 19:15:33
5 simply saying that Gan's teachings of making an 19:15:39
6 oxide layer and making a polysilicon layer were 19:15:42
7 well known. It was well known in the 19:15:45
8 microelectronics and solar industry how to make 19:15:48
9 tunnel oxide layers and polysilicon layers. 19:15:51
10 So a POSITA would not be limited to the 19:15:55
11 teachings of Gan and Froitzheim in a method of 19:15:58
12 implementing the combination. They would have 19:16:06
13 other knowledge as well. 19:16:09
14 And I have referred in my declaration to 19:16:17
15 many references for both the formation of oxides 19:16:19
16 and the formation of polysilicon. For example, 19:16:22
17 Paragraph 133 -- 136 of my declaration says, "A 19:16:35
18 person of ordinary skill in the art would have 19:16:39
19 known how to add oxide layers to silicon surfaces, 19:16:41
20 as doing so was well known and routine by 2008." 19:16:44
21 And similarly, "A person of ordinary 19:16:49
22 skill in the art would have also readily 19:16:50

1 understood how to manufacture a polysilicon 19:16:52
2 emitter," as those were well known and routine. 19:16:55
3 Q Can you go to Page 79 of your 19:17:02
4 declaration? 19:17:06
5 A I'm there. 19:17:18
6 Q This is, here on this page you provide an 19:17:19
7 illustration of the Froitzheim-Gan combination. 19:17:21
8 Correct? 19:17:24
9 A Yes. 19:17:26
10 Q And you draw an oxide layer in orange. 19:17:27
11 Correct? 19:17:34
12 A Correct. 19:17:34
13 Q This is referring to Gan's oxide layer. 19:17:34
14 Correct? 19:17:38
15 A That's correct. 19:17:50
16 Q Now, which of the 12 steps in Gan 19:17:50
17 disclose the formation of that oxide layer? 19:17:53
18 A Gan describes in Step 3 how to form an 19:18:14
19 oxide layer, thin thermal oxide growth at 800 19:18:17
20 degrees C, parentheses, ten minute oxygen flow. 19:18:21
21 And as I mentioned, many other -- many, 19:18:25
22 many other reports of how to form tunnel oxide 19:18:31

1 layers have the same function as Gan's. 19:18:36
2 Q Going back to Page 79 of your 19:18:40
3 declaration, you also illustrate a P-type 19:18:43
4 polysilicon layer in dark blue. Right? 19:18:50
5 A Correct. 19:18:52
6 Q This would be Gan's polysilicon layer. 19:18:52
7 Is that right? 19:18:55
8 A That's what I describe, the 19:18:58
9 implementation of Gan's oxide layer and 19:18:59
10 polysilicon emitter into Froitzheim's back 19:19:02
11 junction solar cell is shown in the below figure, 19:19:05
12 which is the one you're referring to. 19:19:08
13 Q Now, which steps in Gan's 12 steps 19:19:09
14 disclose the formation of a polysilicon layer? 19:19:14
15 A Gan describes the deposition of a 19:19:26
16 polysilicon layer in Step 4 of his sequence, and 19:19:29
17 the subsequent doping of that to form an emitter 19:19:36
18 in Steps 9 and 10. In Paragraph 136 of my 19:19:39
19 declaration, forming such polysilicon emitters 19:19:48
20 were routine by 2008. And a POSITA would have 19:19:53
21 understood from the robust literature, and I cite 19:20:01
22 several instances like Tarr that says it's been 19:20:05

1 known for over a decade as of 1985 how to make a 19:20:09
2 polysilicon emitter at -- that meets the 19:20:18
3 specifications of Gan's polysilicon emitter. 19:20:20
4 Q Can we go to Page 171 of your '516 19:20:24
5 declaration. 19:20:31
6 A Page 171. Okay. 19:20:46
7 Q Here you illustrate a combination of Li 19:20:48
8 and Gan. Right? 19:20:52
9 A That is correct. 19:21:04
10 Q You have in this illustration an oxide 19:21:04
11 layer in orange. Right? 19:21:11
12 A Correct. 19:21:18
13 Q This is referring to Gan's oxide layer. 19:21:18
14 Right? 19:21:21
15 A Yes. As I say in Paragraph 272, the 19:21:29
16 implementation of Gan's tunnel oxide layer and 19:21:31
17 polysilicon emitter to Li is shown in the figure 19:21:36
18 below. In the below figure. 19:21:38
19 Q And in this figure you also show a 19:21:41
20 polysilicon emitter in dark blue. Right? 19:21:45
21 A Correct. 19:21:48
22 Q And this is referring to Gan's 19:21:48

1 polysilicon emitter. Right? 19:21:53
2 A I can read the same sentence again. The 19:21:56
3 implementation of Gan's tunnel oxide layer and 19:21:58
4 polysilicon emitter to Li is shown in the below. 19:22:01
5 Q Well, is that a yes to my question? 19:22:11
6 A This is an oxide layer and polysilicon 19:22:15
7 emitter as taught by Gan implemented in Li, yes. 19:22:18
8 Q Let's go to Paragraph 214 of the '516 19:22:22
9 declaration. 19:22:32
10 A 214. Okay, I'm looking at Paragraph 214. 19:22:42
11 Q In this paragraph you discuss Sheats 19:22:45
12 isolation trench 516. Right? 19:22:50
13 A Yes, that is correct. 19:22:55
14 Q Is this the isolation trench you propose 19:23:02
15 to incorporate with Froitzheim and Gan? 19:23:04
16 A Yes. In Ground 2, which is about Ground 19:23:10
17 5, I propose a combination of Froitzheim, Gan, and 19:23:13
18 Sheats. And Sheats' contribution is the isolation 19:23:18
19 trench shown in this figure on Page 139. 19:23:24
20 Q And you provide Sheats' Figure 5D in this 19:23:30
21 paragraph. Right? 19:23:33
22 A Correct. 19:23:35

1 Q Figure 5D shows three rectangular blocks 19:23:35
2 listed on top of Layers 508 and 510. Right? 19:23:42
3 A Yes. 19:23:52
4 Q And the isolation trench 516 is 19:23:52
5 illustrated in two of those three rectangular 19:23:54
6 blocks. Right? 19:23:58
7 A That is correct. 19:24:00
8 Q Is it accurate to say that those three 19:24:01
9 rectangular blocks represent three solar cells? 19:24:05
10 A I am turning to Sheats. Just give me one 19:24:32
11 moment. 19:24:34
12 (Exhibit 1012, previously marked, not 19:24:34
13 attached.) 19:24:34
14 A Yes, it would be appropriate to call each 19:25:28
15 of the blocks a solar cell, and more particularly 19:25:32
16 the layer identified as 504 is the intended 19:25:39
17 absorber layer of the solar cell, going back to 19:25:45
18 our previous discussion. 19:25:48
19 Q Why does the rectangular block in the 19:25:52
20 middle not have an isolation trench? 19:25:55
21 MR. SELWYN: What was the question? I 19:26:01
22 didn't hear your question. 19:26:02

1 THE WITNESS: Why. Why does the block in 19:26:03
2 the middle not have an isolation trench. 19:26:05
3 A So Sheats describes this process and the 19:29:55
4 structure in -- I guess it begins Paragraph 56 of 19:30:01
5 Sheats. And what Sheats is doing is connecting 19:30:09
6 that middle block to what Sheats calls the back 19:30:13
7 plane, which is labeled 510 on the drawing. 19:30:20
8 And Sheats describes that there can be 19:30:29
9 electrical shorts between the top transparent 19:30:51
10 conductive layer 502 and the bottom electrode 506, 19:31:00
11 and identifies such shorts with the number 511 and 19:31:16
12 517 in the drawing. 19:31:22
13 And the left and right side blocks, which 19:31:28
14 do not have this electrical connection 516 to the 19:31:32
15 back plane, are meant to continue operating as 19:31:39
16 functioning solar cells. And so this electrical 19:31:42
17 short is bad and drains or reduces the power 19:31:44
18 output. And so Sheats adds these isolation 19:31:48
19 trenches 516 in order to remove that short. 19:31:52
20 However, the middle block 517 -- sorry, 19:32:00
21 the middle block and the shorts on it 517 Sheats 19:32:05
22 describes as not necessarily bad. Because the 19:32:11

1 purpose of that middle block is not to continue 19:32:14
2 operating as a -- as a solar cell, but rather to 19:32:16
3 act as a wire connecting to the back plane 510, 19:32:19
4 which is why it has that weld or other electrical 19:32:26
5 connection 512. 19:32:31
6 And so Sheats is not motivated to remove 19:32:34
7 the shunts 517 of the middle block. 19:32:39
8 Q Go to Paragraph 224 of your declaration. 19:32:50
9 A Okay. 19:33:08
10 Q Here in the first sentence you state, "A 19:33:08
11 person of ordinary skill in the art would have 19:33:09
12 been motivated to modify Froitzheim to incorporate 19:33:11
13 a polysilicon emitter and tunnel oxide layer as 19:33:15
14 taught by Borden 575." 19:33:18
15 Do you see that? 19:33:21
16 A Yes. 19:33:22
17 Q I am going to call this structure the 19:33:22
18 Borden -- I'm sorry, the Froitzheim-Borden 575 19:33:26
19 combination. 19:33:29
20 Is that okay? 19:33:30
21 A Yes. 19:33:31
22 Q On Page 146, above Paragraph 224, you 19:33:31

1 illustrate this Froitzheim-Borden 575 combination. 19:33:40
2 Right? 19:33:44
3 A Above Paragraph 226. 19:33:48
4 Q Yes. 19:33:50
5 A Yes. 19:33:51
6 Q And the orange line labeled as oxide 19:33:51
7 layer is referring to the tunnel oxide layer as 19:33:56
8 taught by Borden 575. Right? 19:34:00
9 A Borden teaches two oxide layers, and this 19:34:05
10 oxide layer shown in the figure is purposefully 19:34:10
11 labeled oxide layer. As I say in the text, we 19:34:15
12 require Borden 575's tunnel oxide layer in order 19:34:21
13 to make a functioning solar cell. But Borden 19:34:27
14 teaches that its tunnel oxide layer doesn't 19:34:32
15 necessarily have to cover the entire wafer 19:34:35
16 surface, and that its other oxide layer may also 19:34:39
17 occupy some of the wafer surface. 19:34:42
18 So this figure labeling the oxide layer 19:34:45
19 as oxide layer recognizes that Borden's tunnel 19:34:49
20 oxide layer is required, as described in the text, 19:34:53
21 but doesn't limit Borden's teachings to his tunnel 19:34:56
22 oxide layer. 19:35:00

1 Q So in the Froitzheim-Borden 575 19:35:01
2 combination, are you incorporating Borden 575's 19:35:15
3 other oxide layer as well? 19:35:26
4 A I -- I leave that possibility, as Borden 19:35:32
5 teaches both. I am incorporating at least 19:35:35
6 Borden's tunnel oxide layer. 19:35:38
7 And you can see, for example, that in the 19:35:40
8 footnote on Page 155 I indicate that Borden also 19:35:45
9 teaches the other oxide layer, which he calls a 19:35:50
10 buried oxide, between the polysilicon emitter and 19:35:54
11 substrate. 19:35:57
12 Q Do you discuss a POSITA's motivation to 19:35:58
13 incorporate Borden's 575 buried oxide layer 19:36:10
14 anywhere? 19:36:17
15 A I discuss a POSITA's motivation to 19:36:17
16 incorporate the tunnel oxide layer taught by 19:36:23
17 Borden. Because as I just mentioned, one requires 19:36:26
18 Borden's tunnel oxide layer to make a working 19:36:32
19 combination because the tunnel oxide layer allows 19:36:35
20 current to flow. That is to say, it has low 19:36:38
21 contact resistivity, low C. But the combination 19:36:44
22 doesn't have to necessarily be limited to Borden's 19:36:50

1 tunnel oxide. Borden teaches a second oxide, a 19:36:54
2 buried oxide, and it can -- Borden's full 19:36:59
3 teachings also results in a combination that meets 19:37:05
4 the limitation of -- limitations of the claims. 19:37:08
5 Q But my question was, do you discuss a 19:37:12
6 POSITA's motivation to incorporate Borden's buried 19:37:19
7 oxide layer anywhere? 19:37:22
8 A I do not. I discuss a POSITA's 19:37:24
9 motivation to include Borden's tunnel oxide layer, 19:37:27
10 as it is the tunnel oxide layer that is necessary 19:37:30
11 to make a working solar cell. I'm explaining why 19:37:33
12 I have labeled in the figure this oxide layer, as 19:37:38
13 opposed to tunnel oxide layer, because it is 19:37:41
14 possible for a POSITA to take more than just 19:37:45
15 Borden's tunnel oxide layer because Borden teaches 19:37:49
16 more than that, as I have acknowledged in the 19:37:52
17 footnote on Page 155. 19:37:58
18 Q Let's go to Exhibit 1006, Borden 575. 19:38:03
19 And I would like to direct you to Paragraph 22. 19:38:15
20 A Okay. 19:38:29
21 Q Paragraph 22 specifies a thin tunnel 19:38:29
22 oxide would be included between the substrate 200 19:38:33

1 and the polysilicon 210 in the contact holes 212. 19:38:36
2 Right? 19:38:41
3 A Correct. 19:38:45
4 Q Are contact holes incorporated in the 19:38:45
5 Froitzheim-Borden 575 combination? 19:38:48
6 A Contact holes are not included in my 19:39:00
7 combination because contact holes are not recited 19:39:01
8 in the claims. It's not one of the limitations of 19:39:06
9 the claims, at least at the back side of the solar 19:39:08
10 cell. 19:39:16
11 Borden teaches this tunnel oxide layer. 19:39:16
12 Borden teaches another oxide layer that can have 19:39:20
13 contact holes in it, with a tunnel oxide in those 19:39:26
14 contact holes. Contact holes are not part of the 19:39:29
15 recited claims. 19:39:33
16 Q Borden's tunnel oxide layer and -- I'm 19:39:34
17 sorry, Borden 575's tunnel oxide layer and Borden 19:39:42
18 575's buried oxide layers are different 19:39:47
19 components. Right? 19:39:52
20 MR. SELWYN: Objection. 19:39:55
21 A What do you mean by "different 19:39:56
22 components"? 19:39:58

1 Q For example, let's go to Paragraph 26 of 19:39:58
2 Borden 575. 19:40:05
3 A Okay, I'm there. 19:40:15
4 Q This paragraph discloses a Step S402, 19:40:16
5 where the buried oxide is formed. Right? 19:40:21
6 A Yes. 19:40:27
7 Q And later a Step S406, where a tunnel 19:40:27
8 oxide is grown. Correct? 19:40:31
9 A Yes. 19:40:37
10 Q So when Borden talks about -- I'm sorry, 19:40:37
11 when Borden 575 talks about a buried oxide and 19:40:39
12 then a tunnel oxide, it is referring to two 19:40:43
13 different things. Right? 19:40:46
14 A When you say "two different things," I 19:40:57
15 need more clarity. In the sense that after both 19:40:59
16 have been formed, if I were to cut the solar cell 19:41:02
17 in half, I likely couldn't distinguish between the 19:41:05
18 composition of one oxide and another oxide. 19:41:12
19 There's not -- there's not a clear differentiation 19:41:15
20 between them. 19:41:20
21 What I read Borden describing here is a 19:41:20
22 fabrication sequence for these layers. 19:41:23

1 Q So would a POSITA understand the terms 19:41:27
2 "buried oxide" and "tunnel oxide" to be 19:41:31
3 interchangeable? 19:41:36
4 A No. Borden teaches that they have -- 19:41:38
5 each has a function in Borden 575's structure. 19:41:45
6 Q What is the function of the tunnel oxide 19:41:48
7 in Borden '75? 19:41:52
8 A It's what you read previously. This 19:41:57
9 oxide provides passivation between the substrate 19:41:59
10 and the polysilicon while allowing for tunnel 19:42:02
11 current flow. 19:42:06
12 Q What is the function of the buried oxide 19:42:07
13 in Borden 575? 19:42:10
14 A The buried oxide provides at least one of 19:42:11
15 the things the tunnel oxide provides, in 19:42:25
16 particular in Paragraph 16 Borden says, "The oxide 19:42:28
17 provides an excellent passivation layer over most 19:42:32
18 of the surface." 19:42:35
19 Q Does the buried oxide provide any other 19:42:37
20 functions? 19:42:41
21 A Borden also describes a secondary 19:43:08
22 function of the buried oxide. It's first 19:43:10

1 mentioned in Paragraph 16, the last sentence. 19:43:17
2 "The oxide isolates the contacts from the 19:43:26
3 substrate." And again in Paragraph 24. "It 19:43:29
4 should be noted that according to aspects of the 19:43:38
5 invention, the contact metal 202 is blocked from 19:43:40
6 reaching the substrate 200 by the buried oxide 19:43:44
7 214." 19:43:48
8 So I read that to mean that the buried 19:43:50
9 oxide has a secondary benefit of preventing the 19:43:53
10 metal contact, which is intended to touch the 19:43:57
11 polysilicon emitter, it does, from also touching 19:44:01
12 the wafer. 19:44:05
13 Q Okay. I understand that to mean that the 19:44:08
14 buried oxide cuts off current flow when it 19:44:18
15 isolates the metal contact from the substrate? 19:44:23
16 A No. What Borden is referring to is that 19:44:31
17 if, for example, the metal contact is made by 19:44:35
18 screen printing paste and firing, which is a 19:44:40
19 common way of forming metal contacts, that that -- 19:44:42
20 the paste that -- the filaments that go into the 19:44:46
21 polysilicon will not also be able to go through 19:44:51
22 the buried oxide. So it's actually a physical 19:44:55

1 prevention of metal from going to the wafer. That 19:44:58
2 is what Borden is describing. 19:45:02
3 Q But in preventing the metal from going to 19:45:04
4 the wafer, does it effectively also cut off 19:45:14
5 current flow from the wafer to the metal? 19:45:17
6 MR. SELWYN: Objection to form. 19:45:22
7 A Whether there's current flow from the 19:45:25
8 wafer to the metal will depend on the thickness of 19:45:27
9 the buried oxide. Because if it becomes thin 19:45:31
10 enough, it will also act as a tunnel oxide, that 19:45:33
11 is to say, current would flow. 19:45:37
12 Q Do you understand Borden 575 to disclose 19:45:40
13 a buried oxide that is thin enough to act as a 19:45:46
14 tunnel oxide? 19:45:51
15 A I do. 19:45:54
16 Q Can you tell me where that is disclosed 19:45:59
17 in Borden? 19:46:01
18 A Yes. I find it in Claims 3 and 10, for 19:46:05
19 instance. 19:46:13
20 Q Can you elaborate on how Claim 3 teaches 19:46:13
21 a buried oxide that is thin enough to act as a 19:46:41
22 tunnel oxide? 19:46:45

1 A Claim 3 -- I'm sorry, I gave you the 19:46:49
2 wrong numbers. I apologize. Claim 4 and Claim 19:46:52
3 10. 19:46:56
4 Q Okay. Claim 4 recites an insulating 19:46:58
5 layer. Right? 19:47:03
6 A That's correct. 19:47:05
7 Q And you understand the insulating layer 19:47:06
8 to mean the buried oxide layer? 19:47:09
9 A I do. Claim 4 depends from Claim 3, 19:47:14
10 which discloses a thermally grown silicon oxide 19:47:18
11 layer as the insulator. Sorry, a thermally grown 19:47:25
12 silicon dioxide layer. Claim 2 -- I messed up my 19:47:29
13 numbers. I apologize. Claim 3 depends from Claim 19:47:34
14 2, which describes that the insulating layer 19:47:38
15 comprises silicon dioxide. 19:47:42
16 And Claim 2 depends from Claim 1, which 19:47:45
17 describes that the -- an insulating layer between 19:47:48
18 the emitter layer and a surface of the substrate. 19:47:54
19 The insulating layer being patterned to include 19:47:58
20 contact holes. That's how Borden describes the 19:48:02
21 buried oxide layer. 19:48:06
22 Q So if the buried oxide layer is less than 19:48:08

1 about 20 -- is that angstroms? Is that how you 19:48:12
2 say it? 19:48:15
3 A Angstroms, correct. 19:48:16
4 Q Less than about 20 angstroms thick, then 19:48:16
5 you would understand it to act as a tunnel oxide. 19:48:19
6 Is that right? 19:48:23
7 MR. SELWYN: Objection. Form. 19:48:26
8 A I understand and a POSITA would that, per 19:48:59
9 my Paragraph 84 of my background section, that 19:49:06
10 very thin oxide layers can also act as tunnel 19:49:16
11 oxide layers and allow current to flow. And I 19:49:20
12 recite from the literature instances of that. And 19:49:25
13 you can see one, for example, that contains a 20- 19:49:28
14 to 40-angstrom interfacial layer of silicon 19:49:34
15 dioxide, which is so thin as to be permeable to 19:49:38
16 electrons. 19:49:48
17 (Clarification by the court reporter.) 19:49:51
18 A So this is one instance. There are many 19:49:53
19 more of that below 20 angstroms, and indeed in 19:49:55
20 this reference even below 40 angstroms, oxides can 19:49:59
21 begin to allow current to flow. 19:50:05
22 MR. SELWYN: And can we just pause for a 19:50:10

1 second and get a time check on how much we have 19:50:11
2 left on the 7 hour record? 19:50:14
3 MS. ZHAO: That actually was my last 19:50:17
4 question, unless you have anything. I may have 19:50:19
5 some followup. But otherwise I'm done. 19:50:22
6 MR. SELWYN: Okay. I do have a few 19:50:24
7 questions. 19:50:25
8 Let's just take three minutes so I can 19:50:28
9 organize myself and then we can resume. 19:50:30
10 MS. ZHAO: Sounds good. 19:50:32
11 (A recess was taken.) 19:50:34
12 EXAMINATION BY COUNSEL FOR PETITIONER 19:53:49
13 BY MR. SELWYN: 19:53:49
14 Q Good afternoon, Dr. Holman. 19:53:50
15 A Good after moon. 19:53:51
16 Q Dr. Holman, can you put back in front of 19:53:52
17 you your '516 declaration. 19:53:55
18 A Okay. 19:54:02
19 Q And let me direct you for context to 19:54:02
20 Paragraph 121 of your '516 declaration. 19:54:06
21 A Okay, I'm there. 19:54:20
22 Q Dr. Holman, do you remember being asked 19:54:21

1 questions earlier today about different types of 19:54:23
2 emitters? 19:54:28
3 A Yes. 19:54:29
4 Q How, if at all, does Froitzheim's emitter 19:54:29
5 differ from Gan's emitter? 19:54:34
6 A Froitzheim discloses a -- or teaches a 19:54:36
7 diffused emitter in which dopants are diffused 19:54:42
8 into the back side of the silicon wafer, whereas 19:54:45
9 Gan teaches a deposited polycrystalline silicon 19:54:52
10 emitter in which dopants are diffused into the 19:54:58
11 polycrystalline layer. 19:55:01
12 Q Now, would a POSITA have been motivated 19:55:02
13 to combine Froitzheim and Gan despite those 19:55:05
14 differences? 19:55:09
15 A Yes. Both pieces of art are seeking to 19:55:09
16 improve solar cell efficiency. And Gan teaches 19:55:18
17 that his polysilicon emitter and oxide structure 19:55:24
18 results in low contact resistivity and low J 19:55:30
19 naught. These are desirable things for a emitter. 19:55:37
20 Gan's emitter can be implemented 19:55:45
21 successfully at the back of Froitzheim's solar 19:55:48
22 cell, and in fact can be done so without changing 19:55:53

1 equipment or other -- making other large changes, 19:55:58
2 because the two pieces of art teach similar 19:56:03
3 methods. And Gan teaches that his emitter can be 19:56:06
4 used at the back of a solar cell, such as a 19:56:12
5 back-contact solar cell. 19:56:15
6 And, indeed, Gan gives explicit 19:56:17
7 motivation within his paper, when he talks about 19:56:22
8 that his deposited polysilicon emitter can replace 19:56:33
9 and -- can replace a diffused emitter and improve 19:56:45
10 the solar cell, and he says, for example, that 19:56:49
11 more than one absolute percent of cell efficiency 19:56:52
12 could be expected if it was -- if his polysilicon 19:56:56
13 emitter was implemented. 19:57:00
14 Q How, if at all, does Froitzheim's emitter 19:57:01
15 differ from Borden's 575 emitter? 19:57:06
16 A The answer is the same. Froitzheim's 19:57:11
17 emitter is a diffused emitter into the back side 19:57:14
18 of Froitzheim's wafer, whereas Borden 575's 19:57:19
19 emitter is like Gan's, deposited polysilicon. 19:57:24
20 Q Now, despite those differences, would a 19:57:28
21 POSITA have been motivated to combine Froitzheim 19:57:31
22 and Borden 575? 19:57:34

1 A Yes. And for similar reasons. Borden 19:57:38
2 teaches that his oxide layer and polysilicon 19:57:44
3 structure result in good surface passivation. And 19:57:50
4 while current is still allowed to flow, which are 19:57:57
5 ways of expressing and, as Gan did, that there's 19:58:00
6 low contact resistivity and low J naught, and 19:58:05
7 these are the characteristics of a good emitter. 19:58:08
8 Similarly, Borden, or also, Borden 19:58:14
9 teaches that his emitter can be used at the back 19:58:18
10 side of a solar cell, and Froitzheim has his 19:58:21
11 emitter at the back side of a solar cell, and 19:58:27
12 gives a reason for having it there. 19:58:30
13 And the processing steps of Borden and 19:58:32
14 Froitzheim are compatible. So a POSITA would have 19:58:36
15 been motivated to implement a better emitter into 19:58:42
16 the back side of Froitzheim. And Borden's emitter 19:58:46
17 fits the bill. 19:58:51
18 Q How, if at all, does Li's emitter differ 19:58:52
19 from Gan's emitter? 19:58:56
20 A Li's emitter is a deposited emitter like 19:58:59
21 Gan's emitter. But Li -- Li's emitter is a 19:59:04
22 silicon thin film, I believe he calls it. And he 19:59:19

1 describes that that thin film can be amorphous 19:59:23
2 silicon, microcrystalline silicon, or 19:59:27
3 nanocrystalline silicon. And Gan's emitter 19:59:30
4 includes an oxide layer and a polycrystalline 19:59:37
5 silicon emitter. 19:59:42
6 So they're both deposited, but they have 19:59:43
7 different -- different structures and potentially 19:59:48
8 different materials. Li gives some choice there. 19:59:51
9 Q And despite those different structures 19:59:55
10 and possibly different materials, would a POSITA 19:59:57
11 have been motivated to combine Li and Gan? 19:59:59
12 A Yes, as I describe in my declaration 20:00:03
13 starting on Paragraph 270. Gan's deposited 20:00:09
14 emitter is quite similar to Li's deposited 20:00:18
15 emitter. So a substitution of one for the other 20:00:22
16 is -- is an easy change to make, and a POSITA 20:00:26
17 would have understood how to do it. 20:00:32
18 Both Li and Gan are looking to increase 20:00:34
19 solar cell efficiency. Li doesn't provide 20:00:40
20 specifics about the performance of his emitter, 20:00:45
21 but Gan shows that his oxide polycrystalline 20:00:49
22 silicon structure provides low contact resistivity 20:00:56

1 and low J naught, which are the hallmarks of a 20:00:59
2 good emitter. And Gan teaches that it can be used 20:01:04
3 at the back side of silicon solar cells, which is 20:01:08
4 where Li has his emitter. 20:01:12
5 So a POSITA would have been motivated to 20:01:15
6 implement Gan's oxide polysilicon emitter 20:01:20
7 structure into Li's solar cell to realize 20:01:25
8 efficiency improvements because of Gan's excellent 20:01:29
9 emitter performance. 20:01:37
10 Q Now, please, sir, would you turn to your 20:01:39
11 '053 declaration. 20:01:43
12 A Okay. 20:01:49
13 Q And may I ask you to direct your 20:01:49
14 attention to Paragraph 163, which discusses 20:01:51
15 Element 9D. 20:02:10
16 A Okay, I am looking at it. 20:02:10
17 Q Does Froitzheim teach about diffusing 20:02:11
18 dopants into the front surface of the silicon 20:02:14
19 substrate? 20:02:17
20 A Yes. Froitzheim teaches how to make a 20:02:17
21 solar cell and teaches how to make his solar cell 20:02:25
22 which has N plus regions at the front of the 20:02:30

1 wafer. And he teaches how to make those -- that N 20:02:32
2 plus region. In particular he talks about 20:02:39
3 diffusing phosphorous from the gas phase into the 20:02:41
4 front side of the wafer to form the N plus. 20:02:45
5 Q In Paragraph 165 of your '053 declaration 20:02:51
6 you discuss Froitzheim's teaching of, quote, 20:02:56
7 "diffusing phosphorous from the gas phase to form 20:03:00
8 a front side N plus layer." 20:03:04
9 Do you see that? 20:03:07
10 A Yes. That was where I was just reading 20:03:08
11 from. 20:03:09
12 Q Is this a front surface field? 20:03:09
13 A It is. So the N plus region that is 20:03:14
14 created has the same doping polarity of the wafer. 20:03:17
15 If it was at the back of the solar cell, we would 20:03:22
16 call it a back surface field. If it's at the 20:03:25
17 front of the solar cell instead, we call it a 20:03:31
18 front surface field. 20:03:34
19 Q Now, please, Dr. Holman, turn to 20:03:34
20 Paragraph 191 in your '053 declaration. 20:03:35
21 A Okay. 20:03:43
22 Q You see that Paragraph 191 discusses 20:03:43

1 Claim Element 16C through E? 20:03:46
2 A Yes, I do. 20:03:52
3 Q Does Froitzheim disclose, quote, 20:03:53
4 "diffusing dopants into a front surface of the 20:03:56
5 silicon substrate" for the purpose of Claim 16 for 20:04:00
6 the same reasons as for Claim 9? 20:04:03
7 A Yes. As I describe here, and I described 20:04:06
8 previously, Froitzheim discloses or teaches 20:04:10
9 diffusing dopants into the front side of the 20:04:14
10 wafer, phosphorous dopants in particular, to make 20:04:19
11 an N plus. 20:04:21
12 Q Now would you please turn back to 20:04:25
13 Paragraph 176 of your '053 declaration. 20:04:27
14 A Okay. 20:04:35
15 Q And do you see that that's discussing 20:04:35
16 Claim 12? 20:04:38
17 A I do. 20:04:40
18 Q Does Froitzheim teach, quote, "forming a 20:04:41
19 second dopant source layer over the silicon 20:04:46
20 substrate, diffusing dopants from the second 20:04:48
21 dopant source layer into the silicon substrate"? 20:04:52
22 A Yes. In particular this second dopant 20:05:00

1 source layer of Claim 12 is taught by Froitzheim 20:05:05
2 in the diffusion of the phosphorous that forms the 20:05:13
3 N plus layer at the front of Froitzheim as we were 20:05:16
4 just discussing, the first dopant source layer, 20:05:20
5 which is not mentioned in this part of the claim, 20:05:24
6 would then have been the P-type diffusion at the 20:05:26
7 back that forms the emitter. 20:05:29
8 Q In Paragraph 177 of the '053 declaration 20:05:31
9 you discuss Froitzheim's teaching of, quote, 20:05:35
10 "forming N plus regions by diffusing phosphorous 20:05:38
11 into the front side of the silicon substrate, the 20:05:41
12 N-type silicon layer." 20:05:45
13 Did I read that right? 20:05:47
14 A Yes, that's what it says. 20:05:48
15 Q Is this a front surface field? 20:05:49
16 A Yes, it is. 20:05:52
17 Q Can you explain why? 20:05:52
18 A Yes. Because the resulting diffused 20:05:54
19 region has the same doping polarity as the wafer. 20:05:59
20 It's not the opposite doping polarity like an 20:06:03
21 emitter would have. And within solar cells we use 20:06:08
22 the word "emitter" to describe the layer of the 20:06:12

solar cell that has the opposite doping of the 20:06:14
wafer, and we use the word "front surface field" 20:06:16
or "back surface field," depending on its 20:06:20
location, to describe the layer that has the same 20:06:23
doping polarity as the solar cell wafer. 20:06:25
Q Do you believe that Claim 12 is obvious 20:06:27
in view of Froitzheim's teachings -- let me try 20:06:30
that again. 20:06:37
Is Claim 12 obvious in view of 20:06:38
Froitzheim's teachings of a front surface field? 20:06:41
A Yes, as I've described here beginning on 20:06:43
Paragraph 176. 20:06:47
Q Now would you please turn to Paragraph 20:06:50
194 of your '053 declaration. 20:06:53
A Okay, I'm looking at Paragraph 194. 20:07:00
Q And do you see that that includes a 20:07:03
discussion of Claim 18? 20:07:05
A Yes. 20:07:07
Q Does Froitzheim disclose and render 20:07:07
obvious, quote, "forming a second dopant source 20:07:11
layer over the silicon substrate and diffusing 20:07:14
dopants in the second dopant source layer into the 20:07:18

1 silicon substrate" for the purpose of Claim 18 for 20:07:21
2 the same reasons as for Claim 12? 20:07:24
3 A Yes, just as we discussed. 20:07:26
4 Q Now, earlier, in response to a question 20:07:34
5 that Ms. Zhao asked you, you said, "Froitzheim is 20:07:37
6 describing a more heavily doped N plus layer that 20:07:42
7 is located only in certain areas at the front of 20:07:45
8 the solar cell. That is to say, not across the 20:07:49
9 entire front of the solar cell. And in particular 20:07:52
10 under the metal contacts. He describes, for 20:07:56
11 example, that that can reduce the contact 20:07:59
12 resistance. That is the selective front surface 20:08:02
13 field that he speaks of." 20:08:06
14 Do you recall testimony to that effect? 20:08:06
15 A Yes, that sounds right. 20:08:08
16 Q And when asked would the Froitzheim-Gan 20:08:10
17 combination have a selective front surface field, 20:08:16
18 you stated, "It could but it doesn't need to." 20:08:18
19 Do you remember that? 20:08:21
20 A Yes. 20:08:21
21 Q In view of our discussion just now about 20:08:22
22 Claims 9, 12, 16, and 18, can you explain what you 20:08:24

1 meant that the Froitzheim-Gan combination did not 20:08:29
2 have to have a selective front surface field? 20:08:31
3 A Yes. Froitzheim teaches a front surface 20:08:35
4 field formed by diffusing dopants into the front 20:08:40
5 surface. And the selective front surface field is 20:08:45
6 a bonus, if you will, that Froitzheim offers as a 20:08:51
7 possibility, where in addition to the front 20:08:55
8 surface field there is select regions under the 20:08:59
9 contacts that get extra doping. 20:09:03
10 And so Froitzheim teaches that. It is a 20:09:06
11 possibility. A POSITA could use it. But it's not 20:09:10
12 necessary to meet any of the limitations of the 20:09:13
13 claim, because Froitzheim already teaches a front 20:09:16
14 surface field, as we just discussed. 20:09:20
15 MR. SELWYN: Thank you, Dr. Holman. I 20:09:24
16 have no further questions at this time. 20:09:26
17 MS. ZHAO: I have no further questions 20:09:28
18 either. Thank you so much, Dr. Holman. 20:09:30
19 (Off the record at 8:09 p.m. EDT.)
20
21
22

1 ACKNOWLEDGMENT OF DEPONENT

2 I, ZACHARY C. HOLMAN, Ph.D., do hereby
3 acknowledge that I have read and examined the
4 foregoing testimony, and the same is a true,
5 correct and complete transcription of the
6 testimony given by me, and any corrections appear
7 on the attached Errata sheet signed by me.
8
9 _____ _____
10 (DATE) (SIGNATURE)
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C E R T I F I C A T E

I, Debra Ann Whitehead, E-Notary Public in and for the Commonwealth of Virginia, do hereby certify:

That ZACHARY C. HOLMAN, Ph.D., the witness whose deposition is hereinbefore set forth, was duly sworn by me before the commencement of such deposition and that such deposition was taken virtually and is a true record of the testimony given by such witness.

I further certify that the adverse party, HANWHA SOLUTIONS CORPORATION, was represented by counsel at the deposition.

I further certify that the deposition of ZACHARY C. HOLMAN, Ph.D., occurred virtually, on Thursday, May 8th, 2025, from 11:57 a.m. to 8:09 p.m. EDT.

IPR2024-01203
Maxeon Exhibit 2029

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

IN WITNESS WHEREOF, I have hereunto set my hand this 15th day of May, 2025.

My commission expires:
October 31, 2027

E-NOTARY PUBLIC IN AND FOR THE
COMMONWEALTH OF VIRGINIA

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