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Transcript of Alexander Glew, Ph.D., P.E.

Date: October 16, 2024

Case: Cirrus Logic, Inc., et al. -v- Greenthread, LLC (PTAB)

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Transcript of Alexander Glew, Ph.D., P.E.
Conducted on October 16, 2024

1 (1 to 4)

1 UNITED STATES PATENT AND TRADEMARK OFFICE 2 BEFORE THE PATENT TRIAL AND APPEAL BOARD 3 4 CIRRUS LOGIC, INC., and 5 OMNIVISION TECHNOLOGIES, INC., 6 Petitioners, 7 v. 8 GREENTHREAD LLC, 9 Patent Owner. 10 ----- 11 IPR2024-00001 (Patent 10,734,481 B2) 12 IPR2024-00016 (Patent 10,510,842 B2) 13 IPR2024-00017 (Patent 8,421,195 B2) 14 IPR2024-00018 (Patent 9,190,502 B2) 15 IPR2024-00019 (Patent 11,316,014 B2) 16 IPR2024-00020 (Patent 11,121,222 B2) 17 IPR2024-00021 (Patent 11,121,222 B2) 18 ----- 19 Videoconference deposition of ALEXANDER GLEW PH.D., P.E. 20 via Zoom on Wednesday, October 16, 2024, 7:35 a.m. PDT 21 Job No. 557304 Pages 1 - 320 22 Reported by MARLA SHARP, OR 17-0446, CA 11924, WA 3408	3 1 A P P E A R A N C E S 2 (All parties appeared via videoconference.) 3 4 ON BEHALF OF THE PETITIONER 5 COVINGTON & BURLING LLP, ESQ. 6 BY: ANUPAM SHARMA, ESQ. 7 ROBERT T. HASLAM, ESQ. 8 (joined at 12:04) 9 3000 El Camino Real 10 5 Palo Alto Square, 10th Floor 11 Palo Alto, California 94306 12 650-632-4700 13 asharma@cov.com 14 sweidenfeller@cov.com 15 16 BY: RAJESH PAUL, ESQ. 17 One City Center, 850 Tenth Street, NW 18 Washington, DC 20001 19 202-662-6000 20 rpaul@cov.com 21 22
2 1 2 3 4 Video-recorded videoconference deposition of 5 ALEXANDER GLEW PH.D., P.E., held via Zoom pursuant 6 to notice, before Marla Sharp, a certified 7 stenographic reporter licensed in California, 8 Oregon, and Washington. 9 10 11 12 13 14 15 16 17 18 19 20 21 22	4 1 A P P E A R A N C E S (continued) 2 (All parties appeared via videoconference.) 3 4 ON BEHALF OF THE PETITIONER OMNIVISION 5 TECHNOLOGIES INC. 6 BENESCH FRIEDLANDER COPLAN & ARONOFF LLP 7 BY: DAVID H. BLUESTONE, ESQ. 8 71 South Wacker Drive, Suite 1600 9 Chicago, Illinois 60606 10 312-212-4949 11 dbluestone@beneschlaw.com 12 13 ON BEHALF OF THE PATENT OWNER 14 MCKOOL SMITH, P.C. 15 BY: ALAN J. WHITEHURST, ESQ. 16 1999 K Street, NW, Suite 600 17 Washington, DC 20006 18 202-370-8300 19 awhitehurst@mckoolsmith.com 20 21 22

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3 ALEXANDER GLEW, PhD, PE	3 DOCUMENT TECH CUENCA: Zoom will now prompt
4 BY MR. SHARMA 10, 313	4 you for your consent to video record this meeting
5 (afternoon session) 83	5 for backup purposes.
6 BY MR. WHITEHURST 271	6 And thank you to everyone for attending
7	7 this proceeding remotely, which we anticipate will
8 DEPOSITION EXHIBITS	8 run smoothly. Please remember to speak slowly and
9 EXHIBIT DESCRIPTION PAGE	9 do your best not to talk over one another.
10 Exhibit 1 Declaration of Alexander D. Glew 13	10 Please be aware that we are recording this
11 (43 pages)	11 proceeding for backup proceedings. Any
12	12 off-the-record discussions should be had away from
13 Exhibit 2 US Patent No. 8,421,195 (14 pages) 17	13 the computer. Please remember to mute your mike for
14	14 those conversations.
15 Exhibit 3 Semiconductor Devices with Graded 176	15 Please have your video enabled to help the
16 Dopant Regions (391 pages)	16 reporter identify who is speaking. If you're unable
17	17 to connect with video and are connecting via phone,
18 Exhibit 4 Excerpt of "Physics and Technology 191	18 please identify yourself each time before speaking.
19 of Semiconductor Devices"	19 We'll provide a complimentary unedited
20 (5 pages)	20 recording of this deposition with the purchase of a
21	21 transcript. I apologize in advance for any
22 Exhibit 5 US Patent No. 6,043,114 (36 pages) 226	22 technical-related interruptions. Thank you.

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9 1 Marla. 2 ALEXANDER GLEW, PhD, PE, 3 having been first duly sworn, 4 was examined and testified as follows: 5 MR. SHARMA: Good morning. Just quickly 6 make introductions. This is Anupam Sharma from 7 Covington & Burling, representing the petitioners. 8 Here with me, my colleague Raj Paul, also from 9 Covington & Burling. 10 We also have few client representatives, 11 Michael LeStrange and Emre Yuzak from 12 GlobalFoundries. And also Kent Cooper from Cooper 13 Law Firm as counsel to GlobalFoundries. 14 MR. WHITEHURST: Good morning. This is 15 Alan Whitehurst from McKool Smith for the patent 16 owner, GreenThread, and also for the witness, 17 Dr. Glew. 18 MR. BLUESTONE: And David Bluestone of 19 Benesch, Friedlander, Coplan & Aronoff for 20 co-petitioner OmniVision Technologies Inc. 21 /// 22 ///	11 1 in. 2 Q And do you have any documents with you in 3 the room? 4 A Yes. I have a binder of documents. 5 Q And what does the binder contain? 6 A Declarations, various pieces of prior art 7 from this matter, items I thought we might need for 8 the deposition. 9 Q Understood. These are clean copies without 10 any markings? 11 A Yes. 12 Q Yes. So as we go through the process, we 13 will be showing documents on the screen. But if you 14 feel it will be easier for you to look at your hard 15 copies in your binder, please feel free to do so. 16 A Thank you. 17 Q And, Dr. Glew, as you understand it, you 18 have submitted seven declarations in this case? 19 A Yes. That's my understanding, yes. 20 Q And, just for the record, I will quickly 21 read out the seven IPRs that are at issue and 22 confirm that you are testifying for all of those in
10 1 EXAMINATION 2 BY MR. SHARMA: 3 Q Good morning, Dr. Glew. 4 A Good morning. 5 Q Is there any reason you cannot give 6 truthful and accurate testimony today? 7 A No, there's not. 8 Q Okay. So, Dr. Glew, appreciate your 9 flexibility and apologies for starting a little 10 late. I will try to take a break about every one 11 hour, but if we go a little longer and if you need a 12 break, do not hesitate to let us know. 13 A Okay. 14 Q And we'll try to take lunch at a time that 15 suits you. I know you are three hours ahead of us, 16 so whatever works best for you. We can work around 17 your schedule. 18 Dr. Glew, is anybody else in the room 19 besides you? 20 A The attorney, Alan Whitehurst. 21 Q Anybody else besides Mr. Whitehurst? 22 A There is a technical person plugging things	12 1 the consolidated deposition. And the IPR numbers 2 are IPR2024 -- that's common to all the IPRs -- and 3 the IPR numbers are '1, '16, '17, '18, '19, '20, 4 '21. 5 Dr. Glew, is it your understanding that 6 you're testifying in all these IPRs today? 7 A Yes, that is my understanding. 8 Q Dr. Glew, are you aware that a company 9 called ON Semiconductor has filed IPRs against the 10 patents? 11 A Generally, yes. 12 Q Okay. And you submitted declarations in 13 those IPRs also? 14 A Yes, I did. 15 Q Okay. Is it your understanding that you 16 were deposed for those IPRs in July of 2024? 17 A Yes. My recollection is approximately 18 July 16th, I was deposed in that matter. 19 Q And it's fair to assume that you gave 20 truthful and accurate testimony in that deposition 21 on July 16th? 22 A To the best of my knowledge, yes.

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13 1 Q Okay. Now, sitting here today, you have no 2 reason to believe that the testimony that you gave 3 in July is incorrect? 4 A As I sit here today, off the top of my 5 head, I have no reason to believe that the testimony 6 that I gave on July 16th in the ON Semi matter is 7 inaccurate. 8 MR. SHARMA: Let's bring up the first 9 exhibit, Brendon, that is from IPR2024-0016 [sic]. 10 And that's Dr. Glew's declaration, Exhibit No. 2057. 11 (Deposition Exhibit 1 was marked for 12 identification.) 13 DOCUMENT TECH CUENCA: Sure thing, Counsel. 14 Stand by. 15 MR. SHARMA: For the record, the exhibit is 16 from IPR2024-0016. And the PTAB exhibit number is 17 GreenThread Exhibit 2057. And we'll use the -- for 18 the exhibit that we use in the PTAB -- we'll use the 19 exhibits from the PTAB so it's consistent with the 20 record at the PTAB. 21 BY MR. SHARMA: 22 Q Is that okay with you, Dr. Glew?	15 1 A If you refer to them as that, I will 2 understand you to mean those six patents. 3 Q Okay. And if you talk about a specific 4 claim, then I will flag the patent number so you 5 know which patent to look at in terms of the claims. 6 (Interruption by the reporter.) 7 BY MR. SHARMA: 8 Q If -- to the extent I refer to the claims 9 of the patent, I will specify what patent number I'm 10 talking about so that you can look at the claims of 11 that particular patent. 12 Is that okay with you? 13 A Yes. If you are specifying a claim, I will 14 need to know which patent it's from, and you will 15 tell me which patent it's from. 16 Q Yeah. 17 A Also, though, if you're referring to the 18 specification, you may need to do the same or pick a 19 common specification because the line numbers change 20 in the specifications. 21 Q Okay. So that's a good idea. So let's go 22 ahead and get that out of the way.
14 1 A Let me try to understand that. You're 2 going to use the PTAB exhibit number? 3 Q Yes. In this case your declaration is 4 marked by GreenThread as Exhibit 2057. If you see 5 in the bottom right of the screen. 6 A Actually, I see "Glew Exhibit 1" in yellow. 7 Where am I seeing -- 8 Q Down below that in the footnote -- or the 9 footer. 10 A Oh, okay. Yes. All right. It's rather 11 small on the laptop. Okay. Got it. 12 Q Dr. Glew, do you recognize this exhibit? 13 A Yes. That is my declaration on the '016 14 IPR. 15 Q There are six patents at issue, and all the 16 six patents have the same specification. 17 Is that your understanding? 18 A Yes, it is my understanding that all of the 19 patents in that family share the same specification. 20 Q Okay. Then to the extent we talk about the 21 specification or the disclosure of the patent, is it 22 okay if we refer to them as GreenThread patents?	16 1 Let's introduce Exhibit 1 -- the '195 2 patent. And it should be on the folder. 3 DOCUMENT TECH CUENCA: Yes. Stand by. 4 THE WITNESS: And I do not -- I do not see 5 the files in the chat room. I'm sorry if I'm 6 interrupting. Am I supposed to? 7 DOCUMENT TECH CUENCA: Oh, yeah. Sorry 8 about that, Counsel -- Dr. Glew. Let me do that 9 real quick as well. 10 MR. WHITEHURST: Because the witness is 11 using a stand-alone computer, it would greatly 12 assist the witness if we could put all the exhibits 13 in the chat. That way it'll be readily accessible 14 to him from the Zoom application that he's currently 15 using. 16 THE COURT REPORTER: Mr. Whitehurst, you're 17 going to have to speak louder for me next time. 18 MR. SHARMA: Hey, Brendon, if you can 19 kindly drop two exhibits for Dr. Glew and 20 Mr. Whitehurst. Yeah. 21 DOCUMENT TECH CUENCA: Of course. Doing 22 that now. The patent '195 should be up in the chat,

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17 1 and Exhibit No. 1 should be in the chat. 2 (Deposition Exhibit 2 was marked for 3 identification.) 4 MR. SHARMA: And the one -- for the record, 5 the '195 patent shown over here, the complete number 6 is US 8,421,195, we'll refer to as "'195 patent" for 7 short. And the exhibit number is Exhibit 1001 from 8 IPR IPR2024-00017. 9 BY MR. SHARMA: 10 Q And, Dr. Glew, if that's okay with you, we 11 can use '195 patent as the common patent to discuss 12 the specification of the disclosure of the 13 GreenThread patents. 14 Is that okay for you? 15 A Yes, that's fine. 16 Q And as you go through the process, feel 17 free to either use the -- use the declaration hard 18 copy or the hard copy of the '195 patent if that's 19 easy for you to look at. 20 Brendon, if you can go back to the 21 Exhibit 2057. 22 So, Dr. Glew, what was the process in	19 1 Q Sure. Sure. Let us know when you are 2 there. 3 DOCUMENT TECH CUENCA: Counsel, can you 4 hear me? 5 THE WITNESS: Okay. Technical issue 6 resolved. 7 So, I'm sorry, the question again? 8 BY MR. SHARMA: 9 Q There's no question yet. 10 A Okay. 11 Q Okay. So what we are showing over here is 12 paragraph 35 of your expert declaration as part of 13 section B titled "Overview of Challenged Patent." 14 And, Dr. Glew, do you need a hard copy of 15 the declaration with you, or you are okay with two? 16 A I believe I have a hard copy. Yes. Okay. 17 I have my hard copy. This is the '017 declaration 18 -- '016? 19 Q '016, yeah. 20 A I'm sorry. Okay. I have a hard copy also. 21 I have before me a hard copy, clean. 22 Q Okay. Yeah, that way if you need to go
18 1 drafting your expert declarations in these IPRs? 2 A I reviewed materials given to me by the 3 attorneys, discussed the matters with the attorneys, 4 gave -- told them what I thought of the materials 5 vis-a-vis the questions they were posing, and then 6 drafted a report back and forth with attorneys 7 helping with the graphics and editing. 8 Q Did you draft portions of the declaration 9 yourself? 10 A Yes, in this matter. Most of it was from 11 previous matters already, though. This was largely 12 duplicative of previous work related to these -- 13 this patent family. 14 Q But you reviewed the declarations complete 15 in full before they are submitted in this case, 16 which was on August 16th, 2024? 17 A Yes, I did. 18 Q And if you can go to paragraph 35 of the 19 report, which is on page 15. 20 A I'm having trouble signing in to Adobe 21 right now. I may need a minute to resolve a minor 22 technical issue on this end.	20 1 back and forth, feel free to look at the hard copy 2 or you can request Brendon to go back and forth, you 3 know, so... 4 A Oh. Hang on one second. 5 One more issue here. 6 (Discussion held off the record.) 7 THE WITNESS: Hello. I have before me 8 declaration '016 of -- that I gave, thank you, in 9 hard copy. 10 MR. SHARMA: Brendon, if you could go to 11 the next page, page 16, and zoom a little bit on the 12 figure. 13 BY MR. SHARMA: 14 Q So, Dr. Glew, I have here with me -- shown 15 is -- on page 16 a figure that you reproduced. 16 Are you able to see the figure on the 17 screen? 18 A Yes, I see the figure on the screen and in 19 the hard copy. 20 Q Yeah. And the figure shown below is a 21 annotated version of Figure 5(b) of the GreenThread 22 patents; is that correct?

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21 1 A Yes. That's a good way to characterize it, 2 yes. 3 Q And in this figure you have taken 4 Figure 5(b) from the patent and have added some text 5 and some color coding to the figure; is that 6 correct? 7 A Yes, that is correct. 8 Q The bottom of the figure is a little 9 cropped over there, but if you compare that to 10 Figure 5B of the patent, the grayer portion of the 11 bottom is referred to as "P superscript dash 12 substrate" in Figure 5(b); is that correct? 13 A The bottom portion of Figure 5(b) from the 14 patent is labeled "P superscript minus substrate," 15 which is truncated in the figure on page 16 of my 16 declaration. 17 Q And the portion "P superscript dash 18 substrate" for Figure 5(b) corresponds to the gray 19 portion of a figure shown in your report; is that 20 correct? 21 A Yes. I believe that's what I just tried to 22 represent.	23 1 "Graded dopant region to pull 2 minority carriers from surface." 3 That's how it's characterized in the 4 illustration 5B. 5 BY MR. SHARMA: 6 Q But the pink layer shown in 5B, does that 7 correspond to the drift layer mentioned in 8 claim 1 -- 9 A Of the -- 10 Q -- of the '195 patent? 11 MR. WHITEHURST: Object to form. 12 THE WITNESS: This is an example where this 13 could be a portion of a drift layer. 14 BY MR. SHARMA: 15 Q Okay. Are you done? 16 A Yes. 17 Q And the -- in Figure 5B shown over here, 18 the pink layer would be graded with a p-type dopant? 19 A I have in front of me the '195 patent. 20 Could you repeat the question? 21 Q Yeah. And if you go back to the report -- 22 yeah, so if you see in the line above the figure in
22 1 Q Okay. And the -- these substrate shown in 2 gray in Figure 5(b) of your report refers to a 3 substrate that has been doped by a p-type impurity; 4 is that correct? 5 (Interruption by the reporter.) 6 MR. SHARMA: Okay. Sure. I'll do that. 7 BY MR. SHARMA: 8 Q And the "P superscript dash substrate" that 9 is shown in gray in your report implies that it is 10 substrate that has been doped with a p-type 11 impurity; is that correct? 12 A Generally that is correct, yes. The "P 13 superscript minus" indicates that it's lightly p 14 doped. That's how I understand the minus. But 15 that, yes, it is a p-doped substrate. 16 Q And the pink portion that is shown above 17 refers to the drift layer of the claim, so the '195 18 patent? 19 (Interruption by the reporter.) 20 MR. SHARMA: Yeah, d-r-i-f-t. 21 MR. WHITEHURST: Object to form. 22 THE WITNESS: It is labeled here:	24 1 your report, Exhibit 2057, you mention: 2 "The specification explains that the 3 NMOS transistor in 5B can be 4 surface-channel MOSFET." 5 Did I see that right? 6 A I'm sorry. Which paragraph are you reading 7 from? 8 Q I'm reading from the screen, so 9 paragraph 35. 10 Are you able to see the sentence? 11 A Yes. Yes, I'm reading 35. 12 Q Okay. So my question is based on the -- 13 let me ask you a different question. 14 What's shown in Figure 5B of your report, 15 the annotated figure, that depicts a NMOS 16 transistor; is that correct? 17 A Yes, this is an NMOS. It's an NPN 18 transistor, yes. 19 Q Okay. So my question is -- the pink 20 portion over there shown in Figure 5B that you 21 mentioned can correspond to a drift layer. 22 My question: Is that doped with a p-type

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25 1 impurity? 2 A The pink layer can -- is part -- can 3 maybe -- for example, part of a drift layer. It 4 isn't necessarily an entire drift layer in and of 5 itself. 6 It is meant to be graded simply so that it 7 can pull minority carriers from the surface, the 8 minority carriers being positive charges for an NPN 9 transistor in its operating mode. 10 Q I'll come back to that one question again. 11 But is the dopant type on the pink layer -- 12 is that p-type dopant? 13 MR. WHITEHURST: Object to form. 14 THE WITNESS: Specifically the patent, I 15 don't believe it describes that it has to be one 16 type or the other. When reading the patent, it 17 doesn't say this or that. It just says it has to be 18 constructed in order to pull minority carriers from 19 the surface. 20 The minority carriers in this case would be 21 p-type. In order for an NPN transistor to function 22 in the "on" state, it would need to have electrons	27 1 the patent describes. I don't think it's more 2 specific than that. 3 Q Okay. And in the -- and shown in the 4 figure in your report right below the figure, you 5 mention that: 6 "Meanwhile the p-type silicon 7 between the source and drain (shaded 8 blue) has abundance of positively 9 charged holes (green circles)." 10 Do you see that? 11 Q Does that mean that the green layer shown 12 in Figure 5B, annotated version, is of p-type? 13 MR. WHITEHURST: Object to form. 14 THE WITNESS: I'm sorry. The sentence you 15 read me -- and I'm going to read it back -- says: 16 "Meanwhile, the p-type silicon 17 between the source and drain has an 18 abundance of positive charged holes." 19 So it specifically calls it a p-type. 20 BY MR. SHARMA: 21 Q Yes. 22 A So, yes, I'm referring it -- to it -- I'm
26 1 move from the source to the drain. 2 So simply a construction that pulls 3 n-type -- or electrons up and -- pulls p-type down 4 and pushes n-type up. 5 BY MR. SHARMA: 6 Q Okay. And does the green layer shown over 7 there correspond to the well region of claim 1 of 8 the '195 patent? 9 A I would say that it doesn't specifically 10 call it the "well region." In modern technology, 11 one would think of this as the well region because 12 wells are where they would be. 13 They're -- in older technologies, one might 14 have a single well where an epitaxial layer may 15 function as the well for one type of device and then 16 the other type of device may require a well. 17 So, to put it in big pictures, there's dual 18 wells, where there are n-wells and p-wells. Or 19 there's an -- the older technology where there was 20 only one type of well, and the other type just 21 relied upon the epi layer. 22 So it could be either, I think, from what	28 1 referring to it as a p-type. My understanding is, 2 yes, it would be p-type, which is a type of silicon 3 that is doped so that it has an abundance of holes. 4 Q And, just to confirm, I -- the layer that 5 is shown in green has been doped by p-type dopants 6 so it has abundance of holes; is that correct? 7 A As I've written in paragraph 35 of my 8 declaration: 9 "Meanwhile, the p-type silicon 10 between the source and drain (shaded 11 blue) has an abundance of positively 12 charged holes (green circles)." 13 So, yes, it's a p-type with -- which has 14 been doped to have an abundance of positively 15 charged holes, or holes, simply. 16 Q And then the annotated Figure 5B shows two 17 portions called -- colored in red. On the left it 18 says "Source N+." On the right, it says "Drain N+." 19 Does the left portion show the source 20 region that has been doped with n-type impurities? 21 MR. WHITEHURST: Object to form. 22 THE WITNESS: Yes. In the figure in

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29 1 paragraph 35 of my '016 IPR declaration, the 2 leftmost red feature at the surface of the device 3 labeled "Source N+" has been highly doped with a 4 species that is rich in electrons, that has more 5 electrons than silicon. 6 BY MR. SHARMA: 7 Q And, likewise, in the annotated Figure 5B 8 of your report, the drain shown in red has been 9 doped with n-type impurities; is that correct? 10 MR. WHITEHURST: Object to form. 11 THE WITNESS: Yeah, similar to the red item 12 previously discussed on the left, the red item on 13 the right, also labeled "Drain N+," has been doped 14 with a species that is rich in electrons -- that has 15 more electrons than silicon in its valence shell. 16 Something like phosphorus or arsenic, typically. 17 BY MR. SHARMA: 18 Q And in the report you mentioned that the 19 p-type silicon between the source and drain has 20 abundance of positively charged holes. Do you see 21 that? 22 A Yes, I see that.	31 1 There are more holes present than electrons in the 2 doped silicon region. 3 But there's no charge carrying going on. 4 It's off. 5 BY MR. SHARMA: 6 Q Right. There's no net flow of current when 7 the transistor's not operating or it's not connected 8 to power? 9 A Correct, there's no net flow of current 10 when it's not operating, when it's not powered. 11 Q And, likewise, in the same situation when 12 the transistor's not operating, there will be fewer 13 electrons because the silicon has been doped p-type; 14 is that correct? 15 A In the "off" state when there is no voltage 16 or power applied to the NPN transistor, the area in 17 which the transistor is embedded will be in the 18 environment of having more holes due to the p-type 19 doping than electrons. 20 Q Yeah, same thing for the -- are you 21 familiar with the PNP transistor? 22 A Yes. It's -- it operates similar to this
30 1 Q Okay. In this case, is it correct to state 2 that the holes are the majority carriers? 3 A No. The nomenclature is context sensitive. 4 For this type of transistor, this MOSFET transistor, 5 when the device operates, it needs to move electrons 6 from the source to the drain. 7 And so operating a MOSFET device, one needs 8 to attract electrons up, because that's the majority 9 carrier in a MOSFET device and push holes downward 10 because those are not the carriers in this type of 11 MOSFET device. 12 Q So maybe let's take each context at a time. 13 So let's assume the transistor is not 14 operating and there's no gate voltage applied. 15 We're just looking at a semiconductor that has been 16 fabricated to -- according to the requirements of 17 the '195 patent. 18 In that case, when the transistor is not 19 operating, are the holes the majority carriers? 20 MR. WHITEHURST: Object to form. 21 THE WITNESS: Well, when it's not 22 operating, there really are no carriers functioning.	32 1 but backwards, essentially. 2 Q And in the PNP transistor, if you're 3 looking at the silicon between the source and the 4 drain, there will be less holes and more electrons? 5 A Yes, and let me explain what I understand 6 so that it's clear in the answer. 7 In a PNP transistor, it would typically be 8 formed in an n-type silicon region, an n-well. 9 The P source and drain in this hypothetical 10 would be highly doped or counterdoped to the well or 11 material that it's in. 12 And the channel region between the source 13 and drain would be doped similarly to the well that 14 it's in. 15 So an n-channel would be in an n-well or N 16 material, which is electron rich. It would have 17 more electrons than holes due to the doping. 18 Q Just want to confirm that you know what I 19 meant by "PNP transistor," I was referring to a 20 MOSFET. 21 Is your answer still true for the -- in 22 that case?

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33 1 A Yes. In a PNP MOSFET transistor, it would 2 be as I described, an n-channel formed in an n-type 3 well or N area. 4 Q Okay. 5 A And the source and drain would be 6 counterdoped from that material. So only the source 7 and drain in a PNP would be P. The channel and the 8 rest of the well would be n-type. It's the opposite 9 of an NPN transistor. 10 Q And just for completeness, then, in the NPN 11 MOSFET like the one shown in Figure 5B, annotated, 12 on your report, the source and drain would be 13 n-type; is that correct? 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: Looking at, for example, the 16 figure shown in paragraph 35 of my report that we 17 were discussing, the N source and N drain would be 18 n-type, electron rich. 19 BY MR. SHARMA: 20 Q And the channel between the source and 21 drain of an NPN MOSFET would be of p-type; is that 22 correct?	35 1 Would it be possible to take a quick break? 2 MR. SHARMA: Yeah, sure. That's fine. So 3 about ten minutes? 4 MR. WHITEHURST: Ten minutes sounds great. 5 MR. SHARMA: Okay. It's so about 8:17 my 6 time. We'll reconvene at 8:30 which will be at 7 11:30 your time. 8 THE WITNESS: That's fine with me. 9 MR. WHITEHURST: Can we get a -- 10 THE COURT REPORTER: We're off the record. 11 MR. WHITEHURST: -- confirmation that we're 12 going off the record, please? 13 (Recess taken from 8:17 a.m. 14 to 8:31 a.m.) 15 BY MR. SHARMA: 16 Q Dr. Glew, when we were -- before we broke, 17 we were talking about the transistor that's shown in 18 Figure 5B of your report that is not operating, 19 i.e., there's no gate voltage applied. Let's 20 continue with that one. 21 (Interruption by the reporter.) 22 MR. SHARMA: No gate voltage applied.
34 1 A Yes. In an NPN transistor, MOSFET type, 2 the channel is P, or hole rich, and is the same type 3 of semiconductor as the well or material in which it 4 is formed. 5 And for further clarity, when I say "MOS," 6 I mean metal oxide semiconductor, referring to the 7 gate. We see in Figure 35 -- excuse me -- 8 paragraph 35 the figure. 9 There's a gold material labeled "Gate." 10 That would be presumed to be a metal. Then there's 11 something labeled an "Oxide." Then there's 12 something labeled "Semiconductor," and that is the 13 blue area which we will refer to as the channel, 14 which is between the source and drain. 15 The channel is not labeled in this figure 16 "channel," which is one reason I'm mentioning this. 17 But the channel is the region between the red source 18 and the red drain. 19 MR. WHITEHURST: Counsel, I know we haven't 20 been on the record that long, but we got a late 21 start and we've all been sitting in the conference 22 room for a while.	36 1 BY MR. SHARMA: 2 Q Dr. Glew, in that scenario, do the arrows 3 shown in Figure 5B denote the direction of movement 4 of the minority carriers from surface? 5 (Interruption by the reporter.) 6 MR. SHARMA: Of the minority carriers from 7 the surface. 8 THE WITNESS: Well, when the device isn't 9 on, there isn't necessarily any movement of 10 carriers. The voltage applied to the gate, the item 11 shown in gold, is necessary to cause current flow in 12 a transistor. 13 BY MR. SHARMA: 14 Q Okay. Okay. And in Figure 5B, the term 15 "graded dopant region," does it refer to both the 16 green and the pink layer? 17 MR. WHITEHURST: Object to form. 18 THE WITNESS: I understand that you're 19 asking about the region labeled pink in paragraph 35 20 of my report; is that correct? 21 BY MR. SHARMA: 22 Q Yes. I'm referring to the text in

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37 1 Figure 5B which says "graded dopant region." And 2 I'm asking whether, in Figure 5B, both the green and 3 the pink are part of the graded dopant region. 4 A It's my understanding that there are two 5 things to consider here. There is the well in green 6 in which the transistors are formed. So well has a 7 type. For example, is this is a p-type well in 8 green. 9 And then there is an additional region 10 under the well which would have a different doping 11 level. 12 Together, the well and the additional 13 graded dopant region would work to pull minority 14 carriers from the surface above. 15 The arrows are shown in both the green and 16 the pink region. So the green and pink region would 17 together be fabricated to have that effect when the 18 device is operating. 19 Q Okay. Let me -- thank you very much. 20 Now let me stay with the assumption the 21 device is not operating, and let me ask my questions 22 again.	39 1 pull minority carriers from surface" exists acts 2 together with any grading in the well region, the 3 green region, to pull minority carriers from the 4 surface. 5 BY MR. SHARMA: 6 Q So the green region shown in Figure 5B 7 would have been doped in a manner to aid movement of 8 the minority carriers downwards; is that correct? 9 MR. WHITEHURST: Object to form. 10 THE WITNESS: The green region, also known 11 as the well, typically, is p-type doped in order to 12 form transistor therein, including the source, 13 channel, and drain are all formed in the p-type 14 well. 15 There is a separate region underneath it, 16 specifically just to help aid in pulling carriers 17 from the surface. 18 Together, the pink region and the green 19 region are fabricated, doped in order to facilitate 20 this pulling of, in this case, holes downward away 21 from the channel region of the transistor to allow 22 electrons to accumulate in the channel region to
38 1 Even if the device is not operating, the 2 green and the pink would have -- be referred to as 3 the "graded dopant region"; is that correct? 4 MR. WHITEHURST: Object to form. 5 (Interruption by the reporter.) 6 MR. WHITEHURST: Yes, ma'am. Object to 7 form. 8 THE WITNESS: The Figure 5B shows 9 horizontal lines to distinguish between different 10 regions. I understand that the grading could start 11 in the well region, the green region. 12 But the well has certain electrical 13 requirements. In order to form transistor in it, 14 its doping level would necessitate specific 15 reasonably high levels, usually, compared to the 16 rest of the material underneath it. Not always, but 17 generally. 18 However, there is a region below the well 19 region that is also graded. 20 The region below the well region is 21 distinguished by the two horizontal lines and 22 wherein the text, quote, "Graded dopant region to	40 1 connect the electron-rich source and drain, the 2 counterdoped regions shown in red that are 3 essentially the contacts and opposite semiconductor 4 type from the channel. 5 BY MR. SHARMA: 6 Q Okay. Doctor, you mentioned the holes will 7 be pushed downwards. 8 Now, is that true that would happen here 9 if -- let me start again. 10 So when you say holes will be moved 11 downwards, are you assuming that the transistor's 12 operating? 13 A Yes. When the voltage is applied to the 14 gold contact, the gate electrode, that will push -- 15 that positive voltage shown by plus signs on the 16 gate, the plus signs/positive voltage will push 17 holes downward when it's operating. 18 Q Okay. So let's stick with the assumptions 19 we had before that there is no gate voltage and the 20 transistor's not operating, i.e., no power's being 21 applied to the transistor. 22 Under that assumption, let's start. In

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41 1 that case the green and the pink would have been 2 doped to aid movement of the minority carriers from 3 the surface to the substrate; is that correct? 4 A My understanding is there's no movement 5 until the voltage is applied to the gate electrode. 6 Once the gate electrode is on, then there is 7 movement. Meanwhile, the gradient that exists when 8 the transistor's in the "off" state merely provides 9 a force but not enough force to move the charges. 10 If it did, then it would just be -- the 11 transistor would just be on all the time or it would 12 leak current. 13 The goal of these transistors is to have 14 zero current when they're off and easy flow of 15 current when they're on. 16 So the doping should not inadvertently turn 17 on the transistor or cause the transistor to leak 18 current across the channel, meaning across the 19 transistor. That would be catastrophic to any 20 large-scale device. There would be a massive heat 21 generation. 22 And in this case, for example, 5B is a	43 1 That is the gradient of the dopant concentration, 2 "k" being Boltzmann's constant, "T" being absolute 3 temperature, "Q" being unit charge of an electron. 4 So that electromotive force exists due to 5 the gradient. But it's not enough in the "off" 6 state to actually cause current to flow because that 7 would degrade the performance of the transistor. 8 And degrading the performance of the 9 transistor is the opposite effect that this 10 invention hopes to achieve. This invention hopes to 11 improve the performance of the transistor. 12 So, yeah, leakage of current in the "off" 13 state would be very bad. 14 BY MR. SHARMA: 15 Q Okay. So in the scenario where this 16 transistor's not operating and there's no gate 17 voltage applied but there is a electro- -- and I'm 18 sorry. Let me start again. 19 So the word you used was electro- -- 20 "electrical force" or "electric field." 21 A Sure. Either's fine. I'll understand what 22 you mean.
42 1 DRAM. So the refresh time would be diminished. It 2 would -- the transistor wouldn't hold its bit, 0 or 3 1, long enough if it was leaking current. 4 So it would -- if there actually was motion 5 of current while it was off, then there would be 6 essentially a highly degraded device or a 7 nonfunctional device present. 8 Q Okay. But still -- so stick with the 9 assumption -- the scenario we have that there's no 10 gate voltage applied, transistor's not operating. 11 You mention that even in that situation, 12 there wouldn't be a gradient from the surface to the 13 substrate and it will be just -- the force will be 14 present; is that correct? 15 A The gradient -- the dopant gradient, to be 16 more precise, will cause force on charged particles. 17 The force goes as kT over Q, you know, Boltzmann's 18 constant, time and absolute temperature over the 19 unit charge -- 20 (Interruption by the reporter.) 21 THE WITNESS: -- goes as kT over Q times 22 the gradient of the distribution of the dopants.	44 1 Q Okay. Let's call it a field that is 2 created by the gradient electrical field or the 3 static electrical field. 4 Is that okay? Can we -- are you okay with 5 the terminology? 6 A That's a long term. What are we -- the 7 "electric field" would be fine. 8 Q Oh, okay. I want to differentiate electric 9 field that may be created by a gate voltage versus 10 electric field that may be created by the gradient. 11 And just to differentiate between the two 12 if there's a confusion, is it okay if we refer to 13 the field created by the gradient as the static 14 electric field? 15 A I guess I have a little issue with that 16 because "static field" is just a real general term. 17 Doesn't distinguish dopants. 18 Q Okay. 19 A Maybe -- I'd like to use terms that aren't 20 at issue in this matter so we're not stepping on, 21 you know, meaning of other things. 22 Q Okay. And --

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45 1 A Maybe -- maybe a dopant -- the dopant 2 electric field. 3 Q Okay. 4 A We can coin a new acronym. DEF. 5 Q Okay. Yeah, how about we call electric 6 field by -- caused by the gradient as the field we 7 discussed just now. 8 And if we talk about the electric field 9 created by the gate, we can say "electric field 10 created by the gate voltage." 11 Are you okay with that? 12 MR. WHITEHURST: Object to form. 13 THE WITNESS: Normally, I would call the 14 gate voltage -- the gate voltage or the field 15 effect, you know, we call it a MOSFET because the 16 field effect is the field effect from the gate. 17 BY MR. SHARMA: 18 Q Mm-hmm. 19 A So the "gate field effect" for the gate. 20 Q Okay. 21 A And for the dopants -- 22 Q Okay. I think you proposed --	47 1 it is the field created by the gradient of the 2 dopants. 3 Q Okay. So while the transistor is not 4 operating and no gate voltage is applied, there will 5 be a dopant electric field present in the transistor 6 shown in Figure 5B; is that correct? 7 A Yes. Figure 5 indicates that there is a 8 field generated -- a dopant electrical field 9 generated due to the dopant gradient. 10 Q Okay. And in this case the dopant gradient 11 we discussed earlier is -- are the p-type dopant 12 gradients; is that correct? 13 A Are you referring -- if you're referring to 14 the green region shown in Figure 35, that's a 15 p-well. So the p-well is p-type. And, you know, 16 it's a p-type gradient there. 17 As for the pink region distinguished by the 18 two straight horizontal lines with the text "Graded 19 dopant region to pull minority carriers from 20 surface" written within the two horizontal lines and 21 in pink in paragraph 35, I think the patent is 22 silent as to whether it's N or P. It is possible to
46 1 A -- "dopant effect" -- 2 Q All right. 3 A -- or the "dopant field effect." I -- 4 Q You mentioned dopant electric field -- 5 MR. WHITEHURST: I don't think the witness 6 was through speaking. 7 BY MR. SHARMA: 8 Q Yeah, I apologize, Dr. Glew. I assumed 9 that you were done talking. So I'll be more 10 careful. 11 Are you done now? 12 A I'm not sure, since we were both speaking 13 at the same time, what made it on the record and 14 what didn't. 15 Q Okay. So let's start from scratch again. 16 So we'll -- let's refer to the field 17 created by the gradient as the "dopant electric 18 field." I think that's a term you used few minutes 19 ago. 20 Are you comfortable with that? 21 A I'm fine with that, yes. I will understand 22 when we use the term "dopant electrical field" that	48 1 create gradients using both N and P. I don't think 2 it precludes that necessarily. 3 Q So in Figure 5B shown over here, the doping 4 type in the green would be n-type [sic]; is that 5 correct? 6 A I'm sorry. Could you repeat that question? 7 Q Yeah. In the Figure 5B shown, the dopant 8 type in the green layer would be p-type; is that 9 correct? 10 A Yes. My understanding, and as we've shown 11 it here, is that the green section, the topmost 12 section in 5B is a p-type region, a well, if you 13 will, a p-well essentially, if it's a modern 14 technology. 15 And that is hole rich, yes. It is a p-type 16 material. 17 Q And in the figure that's shown in your 18 report, Figure 5B, your testimony is that the pink 19 layer could either be n-type or p-type? 20 A My testimony is I don't see it -- and if 21 you see it please point it out to me -- a limitation 22 of what the type is. It is possible to create

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49 1 dopants -- graded dopants to move carriers with both 2 n- and p-type materials, you know. 3 So in that it doesn't tell you that it has 4 to be one type or the other. I don't see physically 5 a limitation that it had to be P or N. 6 There would have to be a gradient, though, 7 of course, necessary -- or it is necessary that 8 there be a gradient that could pull the minority 9 carriers from the surface. And the minority 10 carriers in this case would be holes. 11 Q Minority carriers would be holes if the 12 transistor is operating, right. 13 A Well, I would describe -- since this is a 14 transistor, I would always think of the minority 15 carriers in this type of transistor as holes. 16 You know, it has the word "minority 17 carrier." So there's only carriers when it's 18 operating, really. There's no motion -- there 19 shouldn't be motion of current in the "off" state. 20 That would be very deleterious to the performance 21 and function of a MOSFET device. 22 Q Okay. But assuming for now, you know, the	51 1 region of this NPN transistor, then there would be 2 current flow. And that would potentially wipe out 3 the memory bits stored in the transistor. 4 If we note, in this transistor, there is a 5 box labeled "Storage capacitor or sensor element" 6 and 5(b) is labeled "CMOS Substrate for a DRAM or 7 image sensor, with one embodiment of the invention." 8 So this is meant to store very, very small 9 amounts of charge, to store a memory bit, 0 or 1, or 10 a pixel bit for an image which, again, is 0 or 1. 11 So if there was actual current flow in the "off" 12 state, whatever data was in the storage capacitor 13 would be erased. 14 So I just do not see a situation where 15 there should be current -- one would fabricate a 16 transistor to have current leakage. 17 Q Yeah. So, Dr. Glew, there may not be any 18 net movement of carriers or there may not be any net 19 flow of current, but the carriers are in motion even 20 though the transistor's not operating, correct? 21 MR. WHITEHURST: Object to form. 22 THE WITNESS: Could you repeat that
50 1 transistor's not operating, as you testified 2 earlier, there will be more holes and less electrons 3 in the green layer; that's correct, right? 4 A The green layer is a p-type layer, so it 5 is, by definition, hole rich. 6 The channel region becomes electron rich 7 and hole poor when the -- only when the gate 8 electrode is powered, when there's voltage to the 9 gate electrode shown in gold in paragraph 35. 10 Q Okay. And in this case the gradient -- 11 and, again, I'm talking about situation where the 12 transistor's not operating -- in that case the 13 gradient would be such that it is pushing the 14 minority carriers away from the surface towards the 15 substrate as shown by the arrows? 16 A You're saying when it is off? 17 Q Yes. 18 A When it is off, there is no motion of 19 carriers. Again, I've made this point a number of 20 times. If there was a motion of carriers, meaning 21 an enhancement of the electron concentration, a 22 depletion of the hole concentration in the channel	52 1 question? 2 BY MR. SHARMA: 3 Q Okay. The question was: There may not be 4 any net movement of carriers or there may not be any 5 net flow of current, but the carriers are in motion 6 even though the transistors is not operating; is 7 that correct? 8 MR. WHITEHURST: Object to form. 9 THE WITNESS: To me, the question makes no 10 sense. It's nonsensical. 11 The movement of carriers is current. So I 12 just can't fathom what you're asking. 13 BY MR. SHARMA: 14 Q Okay. So if the transistor's sitting there 15 and it is not operating but there is a dopant 16 electric field, is your testimony that the electrons 17 would not be in motion? 18 A It's my testimony that when the current -- 19 excuse me -- when the transistor is off, there 20 should be no net current flow in the transistor and 21 that the channel region should not become electron 22 rich and hole poor.

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53 1 Q Right. So in that situation there may not 2 be any net movement of current, but the electrons 3 and holes will be in motion; is that correct? 4 MR. WHITEHURST: Object to form. 5 THE WITNESS: What type of motion are you 6 referring to? 7 BY MR. SHARMA: 8 Q I'm referring to motions that are caused 9 by, say, motion of drift and diffusion. 10 MR. WHITEHURST: Is there a question 11 pending? 12 (Interruption by the reporter.) 13 MR. WHITEHURST: Is there a question 14 pending? 15 MR. SHARMA: I was responding to Dr. Glew's 16 question. 17 MR. WHITEHURST: My question to you: Is 18 there a question pending? 19 MR. SHARMA: No. I was just responding to 20 it. I'm going to ask my next question. 21 BY MR. SHARMA: 22 Q Dr. Glew, are you familiar with the	55 1 For example, if one puts a drop of pool in 2 the corner -- a drop of ink in the corner of a 3 swimming pool, it won't stay there as a black drop 4 of ink. It will diffuse through the pool because 5 the concentration of ink is lower on the other side. 6 That's diffusion as an example. 7 Q Okay. So now, again, coming back to the 8 transistor shown in Figure 5B, while the 9 transistor's not operating but there's a dopant 10 electrical field that is being applied on the 11 electrons, in that situation will the electrons 12 drift from the surface towards the substrate? 13 A As I've said before, there shouldn't be a 14 net motion of electrons or holes from the surface 15 because that would cause the channel to begin 16 conducting current between the source and drain. 17 The result of current flow through the source -- 18 from the source to the drain through the channel 19 would result in degradation of the performance of 20 the transistor. 21 Q Okay. 22 A 5B is described as a DRAM or image sensor
54 1 phenomena of drift and diffusion? 2 A Yes. 3 Q Okay. 4 A Generally. 5 Q So what's your understanding of drift of 6 electrons? 7 A When there is a sufficient potential 8 applied to a material with electrons that are free 9 to move, they may drift in a direction. There's 10 various forms of potential energy that can cause 11 drift. 12 That was a -- you asked about diffusion 13 also? 14 Q Yeah. So what's your understanding of 15 diffusion? 16 A Diffusion is typically a motion of material 17 based upon concentration gradients. 18 Q Okay. 19 A That generally follows something known as 20 Fick's law, F-i-c-k. So mathematically one thinks 21 of diffusion as a Fickian phenomena relating to 22 differences in concentration.	56 1 and shows a capacitor there. 2 The capacitor stores an extremely small 3 number of charges. So any current flow into the 4 capacitor will erase the information that was stored 5 in the capacitor, which is usually just a 0 or a 6 1 -- 7 Q Okay. So -- 8 A -- or in the case of -- well, I'll stop 9 there. 10 Q Yeah. Thank you. And that was not the 11 question I asked. I think you keep going to net 12 motion. And let me repeat my question again. 13 What I asked was: As the transistor that 14 is shown in Figure 5B and the transistor's not 15 operating, there's no gate voltage, but there is the 16 dopant electric field applied, and will it cause the 17 electrons to drift from the surface to the 18 substrate? 19 A I don't understand your question. You said 20 that the electrons would move but there would be no 21 current or net flow, which -- so this question makes 22 no sense to me.

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57 1 Q Okay. If the electrons move or drift from 2 the surface to the substrate, there will be net 3 accumulation of electrons at the bottom, correct? 4 MR. WHITEHURST: Object to form. 5 THE WITNESS: Are you referring to 6 Figure 5? 7 BY MR. SHARMA: 8 Q Yes. 9 A Okay. Again, this is -- question's even 10 more malformed and difficult to follow at this 11 point. 12 Figure 5 refers to the minority carriers 13 being moved downward, but the minority carriers in 14 an NPN transistor are holes. The channel requires 15 electrons. So there would be no reason to remove, 16 in this scenario, as shown, the electrons. They're 17 refer to removing, in this case, holes. 18 Q But coming back to the question I asked, if 19 the electrons move or drift from the surface to the 20 substrate based on dopant electric field and there's 21 charge accumulation in the bottom, would that be 22 compensated by diffusion of the electrons back to	59 1 A There is Brownian motion of a sort. 2 Q Is the Brownian motion different than the 3 random motion you mentioned? 4 A I wouldn't call it "Brownian motion." We 5 think of it more as a random walk. 6 Q Let's go back to the issue that you raised 7 before. 8 Will the diffusion balance drift? In that 9 context, if the dopant electric field in the green 10 layer is applied on the electrons, will the 11 electrons drift and then diffuse back to the surface 12 and maintain no net flow of current? 13 MR. WHITEHURST: Object to the form. 14 THE WITNESS: In these type of devices, the 15 assumption is that there is either no or a 16 minimal -- a negligible amount of flow, of current. 17 DMOS devices -- or, excuse me, CMOS devices 18 in DRAM or image sensors don't hold their charge or 19 signal forever. They do need to be refreshed. 20 Nothing is perfect. 21 But the assumption is typically that there 22 should be minimal or no significant leakage across
58 1 surface? 2 MR. WHITEHURST: Object to form. 3 THE WITNESS: Your question is can 4 diffusion balance drift? 5 BY MR. SHARMA: 6 Q Yes. 7 A I would say, in general, there's a certain 8 amount of random motion in solid-state devices. 9 Charge neutrality of this material requires that the 10 net charge remain neutral. You know, there's, in 11 the end, no extra holes or electrons. There's just 12 local concentration gradients. 13 So there is a tendency in random motion for 14 the electrons and holes to distribute -- 15 redistribute themselves subject to any forces that 16 are at play in the material. 17 Whether it's a thermal gradient or a dopant 18 gradient or other types of gradients that provide 19 energy, random motion is usually equilibrated by 20 balance of forces. 21 Q And the random motion you mention, is that 22 also referred to as Brownian motion?	60 1 the transistor channel. The transistor channel is 2 meant to not have current flow in the "off" state. 3 And there's great effort into making sure 4 that a transistor that is off stays off and doesn't 5 leak current to lose memory bits. 6 You know, I didn't prepare more comments or 7 analysis for the purposes of this report, so I 8 haven't really gone into detail on that in this 9 report. 10 And, you know, any sort of analysis of this 11 scenario is, frankly, quite detailed. 12 BY MR. SHARMA: 13 Q Okay. Just look -- well, asking the simple 14 question over here. Maybe -- and you said there was 15 no net motion of electrons when the transistor is 16 off. 17 And my question is: Will the drift 18 movement due to drift of electrons be canceled by 19 diffusion of the electrons in the reverse direction 20 so that there is no net flow of currents? Do you 21 agree with that? 22 MR. WHITEHURST: Objection. Scope,

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61 1 relevance. 2 THE WITNESS: I can't agree with what 3 you've said other than to say there should be no net 4 flow of current in a performing device. 5 As for causes and effects from different 6 physical phenomena, I haven't analyzed that for the 7 purposes of this report. I wasn't rebutting any 8 comments along these lines. 9 And an analysis of that nature is probably 10 a bit more detailed than we can present in a simple 11 hypothetical. 12 BY MR. SHARMA: 13 Q Well, is it fair to -- let me ask you this, 14 then. 15 In the Figure 5B and the layer that is 16 shown in green and when the transistor is not 17 operating and there's dopant electric field present, 18 will the electrons drift from the surface to the -- 19 towards the substrate? 20 MR. WHITEHURST: Objection. Scope, 21 relevance. 22 THE WITNESS: Again, all I can say is that	63 1 Q Dr. Glew, you mentioned there wouldn't be 2 any net drift. 3 I'm just asking you, do you have a position 4 whether there will be any drift from the surface to 5 the substrate of the electrons based on the dopant 6 electric field when the transistor is not operating? 7 MR. WHITEHURST: Objection. Scope, 8 relevance. 9 THE WITNESS: As I've said before, there 10 should be no net current flow that would degrade the 11 performance of the device, which is meant not to 12 have current flow when it's off. 13 I haven't performed an analysis of -- along 14 the hypothetical you're asking of counterbalances of 15 drift or the drift itself. 16 I -- my -- I'm done. 17 BY MR. SHARMA: 18 Q I'm sorry. You said you were done? 19 A I've finished, yes. 20 Q Okay. Let me also ask you, in the same 21 situation when the transistor is not operating and 22 there is a dopant electric field present as shown in
62 1 there should be no net current flow. Otherwise, the 2 performance would be degraded and the memory bit or 3 image bit being stored in the device described in 4 Figure 5 would not persist. Memory would be lost. 5 BY MR. SHARMA: 6 Q Okay. 7 A So beyond that I haven't opined on the 8 solid-state physics causes and possibilities in my 9 report. 10 Q So maybe I should state that you don't have 11 a position or you have not analyzed whether the 12 electrons will drift from the surface towards the 13 substrate when a dopant electric field is present 14 but the transistor is not operating? Is that a fair 15 statement? 16 A I think it's a fair statement to say it's 17 my opinion that there will be no net drift in that 18 this is a functional transistor intended to store 19 memory bits or image bits. 20 Beyond that, I haven't performed an 21 additional analysis of the balance of any stat- -- 22 any "off" state activity.	64 1 Figure 5B, will there be a diffusion of electrons 2 from the substrate towards the surface layer? 3 MR. WHITEHURST: Object to the form. 4 THE WITNESS: The answer I gave before I 5 think applies again. Whether it's a net motion of 6 holes or electrons, that constitutes current flow. 7 So the intent of a working transistor is 8 not to have current flow when the dev- -- transistor 9 of the device is off. 10 Note that there is a storage capacitor, and 11 there's -- you know, there's problems associated 12 with transistors, whether it's increasing the "on" 13 time, decreasing the "off" time, or current leakage. 14 But the channel is engineered, designed to exist in 15 a certain state when it's off and not to change. 16 So whether it's a net accumulation of holes 17 or electrons, it's a deleterious effect that impacts 18 the performance of the transistor if the 19 concentration of any of the charge carriers in the 20 channel changes in the "off" state. 21 BY MR. SHARMA: 22 Q So in that case, since you don't want any

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65 1 net accumulation of holes/electrons, and let's 2 assume -- let me strike that. 3 So in the transistor shown in Figure 5B 4 when there's dopant electric field present, will the 5 net movement of electrons due to drift be canceled 6 by the diffusion of electrons in the reverse 7 direction so as to maintain no net movement of 8 current? Is that correct? 9 MR. WHITEHURST: Object to form. 10 THE WITNESS: I don't believe I've 11 addressed "off" state diffusion and balance with 12 drift in my report while I was rebutting the 13 positions I was asked to rebut. That goes beyond 14 anything I've thought and considered for the 15 purposes of this report. 16 All I can say is that the net effect should 17 be zero, the concentration of carriers in the 18 channel in the "off" state should not change from 19 the design that was built. 20 BY MR. SHARMA: 21 Q And is the transistor shown in Figure 5B in 22 the "off" state?	67 1 THE COURT REPORTER: I'm sorry. Our 2 witness has frozen, right? 3 THE WITNESS: I'm not -- I'm not frozen on 4 my end. 5 THE COURT REPORTER: Okay. I lost you at 6 "the red circles with the negative sign" what? 7 THE WITNESS: -- representing electrons 8 have accumulated at the surface and are connecting 9 the source and drain, period. 10 Due to technical difficulties, I've tried 11 to re-create my comments as best as I remembered. 12 BY MR. SHARMA: 13 Q In Figure 5B of your report on 14 paragraph 35, if the gate voltage was not applied, 15 the electrons and holes would still be present 16 between the source and the drain but the 17 distribution would be even; is that correct? 18 MR. WHITEHURST: Objection to scope, 19 relevance. 20 THE WITNESS: What do you mean by "even"? 21 BY MR. SHARMA: 22 Q There will not be any accumulation of
66 1 A Are you talking about the one in my report 2 or the one in the patent proper? 3 Q Yeah, I'm talking about the transistor 5B, 4 annotated version, shown on -- in your report, 5 Exhibit 2057. 6 A Okay. 7 Q And it's on paragraph 35, just to... 8 A Yes. Okay. In paragraph 35, the 9 transistor is shown on, or activated. One sees 10 positive charges in the gold box. That indicates a 11 positive charge has been brought to the gate 12 electrode. 13 The oxide doesn't allow current flow. 14 That's the gate oxide. So current doesn't flow from 15 the electrode into the transistor. That's how 16 MOSFET works. But it establishes an electric field. 17 That's the field-effect transistor, a FET. This is 18 a MOSFET. 19 So, yes, this is shown as charged, and it's 20 actually -- looks like it has charged up the 21 negative red circles, the red circles with the 22 negative sign --	68 1 charge anywhere. 2 A The charges wouldn't accumulate. There -- 3 this is a p-type region, so there would actually be 4 an uneven number of carriers -- or of holes and 5 electrons. It would be a hole-rich region. It 6 would be more of the green circles with the positive 7 sign in them that represent holes. 8 So distribution would be generally 9 distributed but more holes than electrons. 10 Q Okay. And if you had a PMOS transistor, in 11 that case there would be more electrons and less 12 holes in the channel between the source and the 13 drain; is that correct? 14 MR. WHITEHURST: Object to form. 15 (Interruption by the reporter.) 16 MR. WHITEHURST: Object to form. 17 THE WITNESS: Lots of people use lots of 18 different terminology in industry. There are no 19 diction police. So I will assume you're meaning a 20 PNP transistor. 21 BY MR. SHARMA: 22 Q Yes.

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69 1 A Okay. So in a PNP transistor, the channel 2 region is N. It's formed in an n-well. The PNP 3 transistors have a surplus of electrons in the 4 channel region because it's an n-region -- it's a 5 n-region. 6 Q Going back to the dopant electric field 7 we're discussing in Figure 5B. We said that it will 8 apply a force on the electrons pushing it down. 9 Will the same force be influencing the 10 holes but in the opposite direction? 11 A I could just generally say that, yes, an 12 electric field acts in one direction on an electron 13 and in the opposite direction on a hole. 14 Q And if the transistor is not operating in 15 that situation, have you analyzed the impact of 16 drift and diffusion on holes in the presence of 17 dopant electric field shown in Figure 5B of your 18 report? 19 A From my perspective, there's no need to do 20 so because this is an operating -- a functional 21 transistor. So there's not meant to be any net flow 22 of electrons or holes in the "off" state. In the	71 1 electrons based on the dopant electric field will be 2 canceled by the -- or counterbalanced by the 3 movement due to diffusion; is that correct? 4 A I didn't rebut any points in my report on 5 that. I don't believe the opposing expert brought 6 that up for rebut- -- so there was no need to rebut 7 that. 8 I can say in general that in the static 9 state, when the transistor is off, there should be 10 no net current flow. Any current flow would degrade 11 the performance and change the intended design. 12 Therefore, whatever's going on in this -- 13 in a hypothetical device that's not really well 14 defined at this point, it would have to balance out 15 so that there was no net current flow. 16 Q When you mentioned it would balance out, 17 are you talking about the movement due to drift and 18 diffusion? 19 MR. WHITEHURST: Object to form. 20 THE WITNESS: Any drift diffusion or any 21 other effects taking place in the wafer cannot 22 affect -- should not affect the static "off" state
70 1 "off" state any net accumulation would change the 2 performance. 3 So it should be static, essentially, in the 4 "off" state. 5 Q Okay. Yeah. If the transistor is off and 6 there's no net flow of currents, have you analyzed 7 whether the drift of holes in one direction will be 8 canceled by the diffusion of holes in the other 9 direction? 10 A I think I just answered that question. But 11 in the "off" state, there should be no net current 12 flow. So anything that is going on would have to 13 cancel out anything else that was going on. 14 I wasn't rebutting a point like that in my 15 report. I don't believe that's in my report. If 16 you could point out to where it is, I'd be happy to 17 review it. 18 Q Okay. So, again, in the "off" state in the 19 figure shown in -- sorry -- let me start again. 20 In the figure shown in -- sorry. 21 In the NMOS transistor shown in Figure 5B, 22 in the "off" state, movement due to drift of	72 1 of the transistor. There should be no net current 2 flow. 3 So all of these forces that you've brought 4 up in this hypothetical as well as other effects 5 that may be going on would have to balance out to no 6 net current flow or a minimal net current flow so 7 that the performance of the transistor was not 8 degraded. 9 BY MR. SHARMA: 10 Q Okay. And in the "off" situation, you 11 mentioned diffusion and drift. You mentioned there 12 would be other forces. 13 Are you aware of any other force or 14 movement besides drift and diffusion? 15 MR. WHITEHURST: Objection. Scope, 16 relevance. 17 (Interruption by the reporter.) 18 MR. WHITEHURST: Objection. Scope, 19 relevance. 20 THE WITNESS: You had mentioned drift and 21 diffusion, so I was answering it in the question. 22 As for other effects, I'd have to think

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73 1 about that. But, you know, solid-state devices are 2 complicated, so there's potentially things like 3 thermal effects. Chips get warm when they operate. 4 So there are thermoelectric effects. 5 But, you know, this is not something I 6 covered in my report, so nothing I've thought about 7 for today's deposition and nothing I rebutted. 8 MR. SHARMA: Brendon, if you could, let's 9 move up couple of pages. Let's go to paragraph 33 10 of Dr. Glew's report. 11 BY MR. SHARMA: 12 Q Dr. Glew, we are looking at paragraph 33 of 13 your report, Exhibit 2057. Do you see that? 14 A I see this, yes. 15 Q Okay. You mentioned that: 16 "Silicon is an example of a 17 semiconductor." 18 Do you see that? 19 A Yes. 20 Q Yeah. So silicon in the crystal form will 21 have a structure where each silicon is bonded with 22 four other silicons through a covalent bond; is that	75 1 comes about from the doping levels. 2 Q Okay. So you mentioned that semiconductors 3 can be doped. 4 So if we dope a silicon substrate with the 5 boron atoms, we'll end up with a p-type 6 semiconductor? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: Yeah, boron -- you know, if 9 we got out a periodic table of the elements, I could 10 illustrate it probably more easily. 11 But boron has -- is in the third column and 12 has three electrons in its valence shell. Silicon 13 has four. So -- boron is electron poor compared to 14 silicon, so it contributes holes when it's 15 substituted for a silicon atom in a silicon crystal. 16 BY MR. SHARMA: 17 Q And that would create a p-type silicon; is 18 that correct? 19 A Yes. When boron is introduced into 20 silicon, it substitutes for a silicon atom and it 21 has fewer electrons in the valence shell; therefore, 22 it produces a p-type.
74 1 correct? 2 A Yes. It's a diamond cubic structure. 3 Q And, obviously, nobody in industry uses 4 pure silicon to make wafers; is that correct? 5 A Wafers are -- how should I put this? I 6 don't know that nobody uses pure silicon, but it 7 would -- it is something I've seen in high-volume 8 manufacturing. Silicon wafers are doped. 9 Q Okay. You said, "It's something I have 10 seen in high-volume manufacturing." 11 Did you mean something you have not seen in 12 high-volume manufacturing? 13 A What I mean is that I can't be certain of 14 what people are doing in the laboratory or in 15 research environments or in specialized military 16 applications. 17 Q Okay. 18 A But my knowledge is wafers in manufacturing 19 environments are doped. Yes, they are doped, and 20 they have a certain resistance to them. You buy 21 them by the resistance, you know. One 22 ohm-centimeter or something like that. And that	76 1 Bear in mind, one doesn't specify the 2 doping levels typically when buying wafers. One 3 specifies the resistance of the wafer, and that 4 comes about from the doping level. One does specify 5 n-type or p-type, though, when procuring wafers. 6 Q In your report in paragraph 33 you said 7 dopers can be phosphorus also? 8 A Yes. 9 Q And if you dope silicon with phosphorus, 10 you end up with an n-type silicon? 11 A Yes. Let me briefly review paragraph 33 as 12 we're discussing it. 13 Yes, phosphorus is a dopant that creates 14 n-type dope silicon when phosphorous is substituted 15 for a silicon atom. Phosphorous comes from the 16 fifth column of the periodic table. It has five 17 valence electrons; hence, it is electron rich 18 compared to silicon. 19 Q Same would be true if silicon is doped with 20 arsenic, the doping result would cause a n-type 21 semiconductor; is that correct? 22 A Yes. Arsenic is also in the fifth column.

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77 1 It's two rows down -- excuse me -- yeah, arsenic is 2 two rows down from phosphorous, so in the fifth 3 column. So it is also electron rich compared to 4 silicon. It's a much larger molecule than 5 phosphorus. 6 Q Okay. And -- 7 A And phosphorus -- phosphorus is in the same 8 row as silicon. Arsenic is not. 9 Q Okay. And in your paragraph 33 you mention 10 if a dopant has one less valence electron it creates 11 a hole; is that correct? 12 A I'm sorry. Could you repeat that? 13 Q Oh, I'm just reading from your report, the 14 middle of paragraph 33. You mention that: 15 "If the dopant has one less 16 electron, then it creates what is called 17 a 'hole...'" 18 Did I read that correctly? 19 A Yes, you've read that correctly. 20 Q Okay. And likewise -- 21 A You've read part of the sentence, but yes. 22 Q Yeah. And, likewise, if the dopant has	79 1 bonded silicon to silicon. 2 Q And let's talk -- let's assume that the 3 silicon has been doped with a group 5 impurity like 4 phosphorus or arsenic, and you have an extra 5 electron in the valence shell. 6 Is your position that this extra electron 7 is still bound to either silicon or the phosphorus 8 atom? 9 A Yes. It's not a covalent bond. It's a 10 weaker bond. So a covalent bond is a very strong 11 bond. You know -- you know, something in the excess 12 of 10 electron volts. 13 The extra electron, the ninth electron, 14 perhaps, if you want to call it, introduced by the 15 phosphorus atom is weakly bonded to the environment. 16 So it's easier to strip off. 17 You know, silicon without a dopant is a 18 very -- like most semiconductors, a pure 19 semiconductor is actually a very good insulator 20 because it's very hard to remove covalently bonded 21 electrons. 22 The extra electrons from n-type like
78 1 extra electron, that would create an excess 2 electron -- an extra electron; is that correct? 3 A Effectively, yes. It's -- when it 4 substitutes -- phosphorus, for example, substitutes 5 for a silicon, it has five valence electrons. 6 Silicon only has four. So there's now an extra 7 electron, effectively. 8 Silicon, when it bonds covalently, has four 9 electrons for each, and they each contribute four 10 electrons covalently. They bond two-by-two, and 11 that forms eight electrons in the valence shell and 12 it's full. 13 When you add in something from the fifth 14 column that's electron rich, then, all of a sudden, 15 there's nine electrons in the valence shell. So 16 eight of them can bond, but one of the electrons 17 doesn't have a bonding partner. So it's potentially 18 easier to strip away from the electrons. 19 It doesn't come off on its own and float 20 around. There's still a bonding energy, a binding 21 energy, if you will. But it is -- it is removable 22 much more easily than an electron from a covalently	80 1 phosphorus, that ninth electron, is a weak bond and 2 easier to strip away. 3 Q Okay. Let's call this ninth electron the 4 "extra electron" just to differentiate it from the 5 other eight electrons. 6 A Okay. 7 Q And I think you mentioned in the middle of 8 the paragraph 33 -- and let me read that: 9 "The extra electrons or holes 10 disturb the local charge equilibrium in 11 the silicon and become mobile in 12 response to electric fields." 13 Did I read that correctly? 14 A Yes, you did. 15 Q Yeah. And the extra electron you're 16 talking about over here is the electron that is the 17 ninth electron if the silicon has been doped with 18 phosphorus or arsenic; is that correct? 19 A Yes. Phosphorus or arsenic are in the 20 fifth column and provide an extra electron. 21 Bear in mind, phosphorus is neutral. 22 Silicon is neutral. Arsenic is neutral. There's no

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81 1 net charge here. It's just that this electron -- 2 this extra electron is easier to strip away from the 3 atom pair or the crystal. 4 Effectively, in solid state, the atoms are 5 bonded to their nearest neighbors in a crystal. 6 It's not like a gas that people learn about in high 7 school chemistry. It's a more complex environment. 8 The crystal in silicon has four neighbors 9 it's bonding to. So the crystal with a phosphorus 10 atom substituted for silicon, it's now bonded to 11 four nearest silicon neighbors and it has this extra 12 electron. So the chemistry and physics is a bit 13 more complicated than that. 14 Q We've been going for an hour, so I'll check 15 with you. I can go on longer. If you want a break, 16 we can take a break now. 17 A Five minutes. 18 MR. SHARMA: Okay. We can go off the 19 record. 20 (The luncheon recess was taken from 21 9:40 a.m. to 10:39 a.m.) 22 - - -	83 1 basically -- swap places with nearest neighbors. 2 And it depends on, you know, obviously, the 3 number of vacancies and opportunity to do so, too. 4 Q Okay. And when the electron in an n-type 5 semiconductor swaps positions, it has to move from 6 one position to the other position, right? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: Well, there are a lot of 9 motions that I wouldn't -- or activities in the 10 crystal I don't really consider motion in the 11 context we've been using the term "motion." 12 BY MR. SHARMA: 13 Q Oh, okay. 14 A Atoms, crystals oscillate, meaning they 15 vibrate and they have different vibrational modes. 16 Wagging and breathing in and out, sort of 17 expanding, contracting. 18 So there's a lot of different energy modes, 19 phonon modes for atoms and crystals. And then, of 20 course, the electrons get dragged along with the 21 motion of the crystal -- or the oscillation of the 22 crystal, and then they swap places with their
82 1 EXAMINATION 2 (resumed) 3 BY MR. SHARMA: 4 Q Dr. Glew, before we broke for lunch, we 5 were talking about paragraph 33 of your report, 6 Exhibit 2057, and you were talking about the extra 7 electrons that are present in the n-type 8 semiconductor. 9 Do you recall that? 10 A Generally, yes. 11 Q Okay. In the n-type semiconductor, are 12 these extra electrons constantly in motion? 13 MR. WHITEHURST: Object to the form. 14 THE WITNESS: Electrons oscillate at very 15 high frequencies with their neighbors. 16 BY MR. SHARMA: 17 Q So that's another way of saying that they 18 are in motion, correct? 19 A No, not really. I use the term 20 "oscillation." So electrons can trade places with 21 their neighboring electrons. It's not as if they go 22 from one side of the crystal to the other. They're	84 1 nearest neighbors. 2 But there's no net motion associated with 3 this. 4 Q Okay. So maybe another way to say the same 5 thing would be that these extra electrons in an 6 n-type semiconductor are not stationary? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: As I said, the electrons -- 9 you know, the atoms oscillates or vibrate, crystals 10 vibrate in multiple modes and the electrons vibrate 11 with the atoms, of course. And electrons trade 12 places with their nearest neighbor periodically. 13 So I understand they do that. 14 BY MR. SHARMA: 15 Q Okay. And the extra electrons in the 16 n-type semiconductor cannot trade places if they are 17 stationary, correct? 18 MR. WHITEHURST: Object to the form. 19 THE WITNESS: Not sure I understood your 20 question. Could you repeat that, please? 21 BY MR. SHARMA: 22 Q Sure. Just looking at your previous answer

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85 1 and just confirming that when the extra electrons in 2 n-type trade places with other electrons, they can 3 do so if they are stationary, correct? 4 MR. WHITEHURST: Object to form. 5 THE WITNESS: I'm using the phrase 6 "swapping with" -- "positions with nearest 7 neighbors," oscillating. I don't think of that as a 8 net motion. 9 BY MR. SHARMA: 10 Q I'm not referring to net motion. I'm just 11 talking about simple motion, just moving from 12 point A to point B. 13 A Well, they move -- they may swap with their 14 nearest neighbor, then swap back to their same 15 position. So there isn't necessarily any real 16 motion associated with this. 17 You know, there's rotation and vibration 18 and a lot of things going on, characteristic 19 frequencies for crystals, lattice vibrations, you 20 might hear that phrase, or phonons also, the 21 vibrations in different modes. 22 So there's a lot of vibration in a crystal	87 1 wouldn't use that term here. 2 As I said, I was talking about nearest 3 neighbor swapping of positions. You know, these are 4 bound -- these are all bound to electrons. Covalent 5 electrons are bound strongly to the atoms. Excuse 6 me. So they're bound to atoms. 7 The covalent, the eight in the valence 8 shell are bound to the silicon atoms strongly. The 9 extra electron is bound weakly, but they are still 10 bound to electrons. So they will swap with nearest 11 neighbors adjacent to them and they -- meanwhile, 12 the crystal itself is vibrating. And the electrons 13 vibrate with the atoms that they're associated with 14 in the crystal. 15 So I don't really think of this as motion, 16 per se. It's -- this is crystal oscillation and 17 activity. 18 BY MR. SHARMA: 19 Q Okay. So let's look at the last sentence 20 of your paragraph 33 of your expert report, 21 Exhibit 2057. 22 A Yeah.
86 1 structure at the very -- at very high frequencies. 2 Q Okay. Would it be correct to say that the 3 electrons in the n-type semiconductor -- and I'm 4 referring to the extra electron -- are moving in all 5 directions? 6 MR. WHITEHURST: Object to form. 7 (Interruption by the reporter.) 8 MR. WHITEHURST: Object to form. 9 THE WITNESS: I really wouldn't call it 10 motion. I would say there's vibration, oscillation, 11 and position swapping with nearest neighbors. 12 The extra electron may swap positions with 13 an electron that isn't extra. It may -- you know, 14 in a covalent bond. Things will... 15 BY MR. SHARMA: 16 Q Okay. And then you don't associate such 17 motion to Brownian motion of electrons; is that 18 correct? 19 MR. WHITEHURST: Objection. Scope, 20 relevance. 21 THE WITNESS: You know, one might use the 22 term "Brownian motion." I'm not really -- I	88 1 Q In the last sentence of paragraph 33 you 2 say early on: 3 "When the dopant concentration is 4 graded in a particular direction..." 5 Did I read the first portion correctly? 6 A Yes. Up to the comma, yes. 7 Q And I think you testified earlier today 8 that when you have a graded dopant concentration, it 9 will create an electric field. Is that correct? 10 A Yes. The dopant concentration creates an 11 electric field. You know, it's generally 12 proportional to kT over Q times the gradient of the 13 dopant density with a negative sign out front, of 14 course, which is easy to forget. 15 Q And that's the same dopant electric field 16 we discussed before the lunch; is that correct? 17 A I think -- my general recollection is, yes, 18 that's -- when we talked about a dopant field, we 19 were talking about the field created from a dopant 20 gradient concentration. 21 Q And then in the same sentence you mentioned 22 that the dopant concentration is graded in a

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89 1 particular direction. 2 Will the direction of the electric field be 3 dictated by the direction of the dopant 4 concentration? 5 A Yes. The gradient of the field -- gradient 6 is actually a vector. So you have a derivative in 7 the X, the Y, and the Z direction. So if the 8 gradient is only in the X -- well, how should I put 9 this? 10 If the change in concentration of dopants 11 is only in the X direction, then the gradient is 12 only in the X direction. 13 But if the dopant concentration varies in 14 three dimensions, then there will be a 15 three-dimensional force resulting from the gradient 16 of that concentration change. So the gradient is 17 the operator that -- the first derivative taken in 18 each direction X, then Y, then Z resolved as a 19 vector. 20 Q And the dopant electric field that is 21 created by gradient in the concentration is always 22 present in the doped semiconductor; is that correct?	91 1 field created by the dopant concentration, is it 2 correct to state that the field will always be 3 present providing the dopant concentration stays the 4 same? 5 MR. WHITEHURST: Object to form. 6 THE WITNESS: In the -- I understand the 7 question would be in the absence of all other 8 fields. Or are you saying ignoring all other 9 fields? 10 BY MR. SHARMA: 11 Q Ignoring or absent, same thing, so... 12 MR. WHITEHURST: Objection -- objection to 13 form. 14 THE WITNESS: I will say in the absence of 15 all other fields, the field that results from a 16 concentration gradient depends just on that 17 concentration gradient itself. 18 BY MR. SHARMA: 19 Q And that field is always present -- oh, so 20 you mean the concentration does not change; is that 21 correct? 22 MR. WHITEHURST: Same objection.
90 1 MR. WHITEHURST: Object to form. 2 THE WITNESS: Could you repeat that 3 question? 4 BY MR. SHARMA: 5 Q Sure. I'm talking about the electric field 6 created by a graded dopant concentration in a 7 semiconductor. 8 And I want to confirm that -- whether the 9 electric field is always present in the 10 semiconductor. 11 MR. WHITEHURST: Object to form. 12 THE WITNESS: My understanding is that the 13 electric field resulting from a concentration 14 gradient would remain the same as long as the 15 concentration gradient itself remained the same. 16 There are other forces acting in the area 17 potentially that could swamp it or render it 18 negligible. But the field just depends on the 19 gradient. 20 BY MR. SHARMA: 21 Q And for argument's sake, ignoring any other 22 forces in the area and just focusing on the electric	92 1 THE WITNESS: As long as a concentration 2 gradient does not change, the resulting field from 3 the concentration gradient is simply related to the 4 gradient of that concentration, assuming there are 5 no other fields present to disturb that field. 6 BY MR. SHARMA: 7 Q And the influence of the field on a hole or 8 electron would depend upon the direction of the 9 electric field; is that correct? 10 A Could you repeat that question? 11 Q Okay. What I'm asking is: The influence 12 of the field, i.e., the electric field on a hole or 13 an electron would depend upon the direction of the 14 electric field? 15 A I thought I answered this earlier. 16 Basically, the electric field that results from a 17 concentration gradient of dopants is a gradient. 18 It's a vector. 19 So it has an X and a Y and a Z component. 20 So if the gradient is only in the Z direction, let's 21 say, up and down, then the resulting field is in 22 that direction.

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93 1 However, if the gradient is occurring in 2 two or three dimensions, then there will be 3 components of the electrical gradient in all three 4 directions. 5 Q And if the gradient is in all three 6 directions, it will impact a charge in all three 7 directions; is that correct? 8 A Yes. If a vector of an electric field from 9 a concentration gradient has components in all three 10 directions, X, Y, and Z, then it would apply a force 11 to the charged carrier in all three directions also. 12 Q Okay. And the force that is applied on an 13 electron will be opposite direction to the force 14 applied on a hole; is that correct? 15 A Yes. A field of one type will operate 16 exactly opposite on an electron or a hole. 17 Q And that's what you state in the second 18 half of your sentence over here, in the last 19 sentence of paragraph 33, where you mention: 20 "...charge carriers will move in 21 gradient (or opposite direction) 22 depending upon the charge carrier's	95 1 mentioned in the previous sentence? 2 MR. WHITEHURST: Objection. Form. 3 THE WITNESS: What I'm referring to is, as 4 I wrote, charge carriers. So something that is 5 moving and carrying a charge. 6 There are potentially other charge carriers 7 and electrons and holes but much less common. For 8 example, very small atoms like sodium are charged, 9 and they can move. But they're not usually 10 desirable in transistors. 11 You may have exceptions like that. But 12 largely it's going to be carriers or holes that are 13 carrying charge at the time, meaning moving. 14 BY MR. SHARMA: 15 Q In paragraph 33 of your report, you mention 16 only electrons and holes, right? You don't mention 17 other types of charge carriers? 18 A Well, in the penultimate sentence I note: 19 "...other charge carriers will move 20 in the gradient direction..." 21 So, basically, an electric field acts on 22 any charge. So I think mainly we're concerned with
94 1 polarity." 2 Is that correct? 3 A I'd say that's correct. I didn't see where 4 you were reading from, but let me... 5 Q I'm reading from the last sentence of 6 your -- penultimate sentence of your paragraph 33. 7 A Yes. Yes, that sounds right, what you 8 read. 9 Q Okay. If the gradient is one direction or 10 a particular direction, then the impact on the hole 11 and electron would be opposite depending upon the 12 polarity; is that correct? 13 A Yes. The polarity of the charge will cause 14 the resulting force from a field to be opposite for 15 an opposite polarity. 16 Q In the last sentence you mention that: 17 "This phenomena is called 'carrier 18 drift.' 19 Do you see that? 20 A Yes. 21 Q Okay. Are you referring to the movement in 22 the gradient direction or the opposite direction	96 1 holes and electrons in this matter. And I could 2 point out that there are potentially other charge 3 carriers. I'm not sure they're of much concern to 4 us. 5 Q Okay. So let's limit our discussion to 6 holes and electrons; is that fair? 7 A We can limit the discussion to holes and 8 electrons, sure. 9 Q So in this case -- 10 A If I have to go outside of that, I'll try 11 to let you know. 12 Q Thank you. So when you mention that a 13 carrier -- let's assume electron -- and when a 14 carrier moves in a particular direction based on the 15 field created by the dopant concentration, would you 16 call that to be a movement of electron or drifting 17 of electron? 18 MR. WHITEHURST: Object to form. 19 THE WITNESS: And I understood the question 20 to be that when there is actually hole or electron 21 motion and it is a hole or electron acted upon by a 22 dopant concentration gradient-generated

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97 1 electroforce, then that is what I'm referring to in 2 this last sentence calling this "carrier drift." 3 BY MR. SHARMA: 4 Q And that carrier drift will occur in a 5 doped semiconductor as long as there's a grading of 6 the concentration in the particular direction; is 7 that correct? 8 A I'm sorry. But the audio quality's not 9 stellar. Could you repeat that? 10 Q Sure. 11 MR. WHITEHURST: We're having -- I'm sorry, 12 but I think we're both having trouble hearing your 13 questions, so if you could please speak up, we would 14 greatly appreciate it. 15 MR. SHARMA: Yes. I moved my microphone 16 closer to me, so hopefully that -- does that -- that 17 any better now? 18 MR. WHITEHURST: A little bit better, but 19 it's still hard to hear you. 20 MR. SHARMA: Yeah. 21 MR. WHITEHURST: Can we -- 22 MR. BLUESTONE: Might want to check	99 1 MR. SHARMA: Okay. Is that better now? 2 MR. WHITEHURST: Not really. 3 MR. SHARMA: Okay. Let me see if I can 4 jack up my microphone to the max. 5 MR. BLUESTONE: Marla, do you hear him 6 okay? I have no issues hearing him. 7 MR. WHITEHURST: David, we can hear you 8 loud and clear. 9 MR. BLUESTONE: I get that. I'm just 10 curious if Marla's getting the same thing when 11 Anupam's talking, if she can hear him okay. 12 MR. SHARMA: Yeah, Marla, are you able to 13 hear me? 14 (Interruption by the reporter.) 15 MR. SHARMA: Okay. I've gotten as close to 16 mike as I can. 17 Okay. Let's try this. 18 BY MR. SHARMA: 19 Q Go back to my question. Okay. 20 My question, Dr. Glew, was: In light of 21 what you said at the end of paragraph 33, in a doped 22 semiconductor, as long as there is a dopant
98 1 something on your end, Alan, because I hear him 2 almost better than you. 3 THE WITNESS: I hear you great right now. 4 MR. WHITEHURST: David, you're coming 5 through loud and clear. So -- 6 MR. BLUESTONE: Okay. Cool. 7 MR. WHITEHURST: -- it's something -- 8 MR. BLUESTONE: All right. Just making 9 sure we're talking about -- 10 MR. WHITEHURST: -- our speakers because we 11 can hear you great. 12 (Interruption by the reporter.) 13 MR. WHITEHURST: I said I don't believe 14 it's an issue of our speakers because we could hear 15 Mr. Bluestone loud and clear. But for the 16 questioner, we're having difficulty hearing him. 17 MR. SHARMA: Okay. Let me repeat my 18 question. And as you go on, Dr. Glew, if you have 19 trouble hearing me, ask me, and I will repeat my 20 question. 21 MR. WHITEHURST: You sound very muted like 22 you're in a tunnel. It's hard to hear you.	100 1 concentration that is graded, it will act upon the 2 electrons and holes present in the semiconductor; is 3 that -- 4 MR. WHITEHURST: Object to form. 5 BY MR. SHARMA: 6 Q -- correct? 7 THE WITNESS: I'm sorry. Did you say based 8 upon the last sentence, or is this a general 9 question? 10 BY MR. SHARMA: 11 Q Based on last couple of sentences of your 12 paragraph 33. 13 A Okay. 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: So I think it's reasonable to 16 summarize what I've written in the last couple 17 sentences generally along the lines of a dopant 18 concentration gradient will act upon all charge 19 carriers in their vicinity. 20 BY MR. SHARMA: 21 Q And the direction of the dopant 22 concentration would depend upon the type of dopant;

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101 1 is that correct? 2 A Yes. The electric field depends upon the 3 dopant to the extent we're talking about dopant 4 chemicals that are electron rich compared to the 5 semiconductor or dopant chemicals, elements, that 6 are electron poor compared to the semiconductor, 7 which for silicon would be more than four or less 8 than four electrons in the valence shell. 9 For other semiconductors and compound 10 semiconductors, it could be a bit different. 11 Q Okay. Yeah, and I'm talking about the 12 silicon and the dopants we talked earlier today like 13 arsenic, phosphorus, and boron. 14 In that situation, the type of the dopant 15 would dictate the direction of the electric field? 16 A Yes. The type of – the dopant element 17 would dictate the polarity or direction of the 18 electric field. We have that all-important negative 19 or positive sign to think about. 20 Q Now, in the middle of paragraph 33 you 21 mention that: 22 "The extra electrons or holes	103 1 BY MR. SHARMA: 2 Q So if electric field is applied to a doped 3 semiconductor, let's assume n-type, in this case, 4 the extra electron will become mobile in response to 5 that field; is that correct? 6 MR. WHITEHURST: Object to form. 7 THE WITNESS: No, not necessarily. The 8 electric field would need to be sufficient to make 9 them mobile. 10 BY MR. SHARMA: 11 Q So just the mere presence of electric field 12 will not make the extra electron mobile; is that 13 correct? 14 A I've given this explanation before. But, 15 no, in a semiconductor, merely having an electric 16 field does not necessarily make the extra electrons 17 or holes from dopants mobile. 18 There are three types of materials 19 electrically: Conductors, insulators, and 20 semiconductors. In semiconduc- – in conductors, 21 let me start with that, fields do not make charges 22 move. It just doesn't happen. Material would
102 1 disturb the local charge equilibrium in 2 the silicon..." 3 Do you see that? 4 A Yes. 5 Q And then you mention: 6 "...and can become mobile in 7 response to electric fields." 8 Do you see that? 9 A I see where I've written that, yes. 10 Q When you mention that "become mobile in 11 response to electric fields," are you referring to 12 the extra electrons and holes mentioned earlier in 13 the sentence? 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: Yes, that the extra electrons 16 or holes due to the gradient that they cause can 17 produce or change the charge equilibrium, and they 18 themselves can also become mobile under certain 19 circumstances. 20 (Interruption by the reporter.) 21 THE WITNESS: Can become mobile under 22 certain circumstances.	104 1 probably be destroyed before the carriers would 2 move. It electrically insulates. 3 Metals are the opposite. A very small 4 force would cause the electrons to move. They have 5 what they call a sea of free electrons. 6 Semiconductors are somewhere in the middle. 7 So they're good conductors when they're highly 8 doped. We're not usually talking about that here. 9 They act like metals. They're almost insulators 10 when they're not doped. Undoped silicon's a pretty 11 good insulator. 12 Somewhere in the middle we start having 13 useful electrical properties, from an electronic 14 sense, for semiconductors where they can conduct 15 under certain circumstances. Charges can move. 16 They obviously don't move all the time; otherwise, 17 they would simply behave like metals. 18 But under certain circumstances electric 19 fields could cause carriers in semiconductors such 20 as silicon to move. 21 Q So let's discuss a doped semiconductor and, 22 in particular, discuss a n-type doped semiconductor

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105 1 that might be used in manufacturing a silicon. 2 So in that case if electric field is 3 applied, it is your position that mere presence of 4 the electric field will not cause the extra electron 5 to move? 6 A Yes. It's my opinion, position -- it's a 7 fact, I think -- that the mere presence of 8 electrical field isn't sufficient to cause electrons 9 to become charge carriers. 10 There's a -- essentially a threshold 11 voltage to cause motion as well as resistance to the 12 materials. As I noted before, semiconductor wafers 13 are bought by resistance values, actually. One has 14 a rough idea what the doping concentration is, but 15 they're really bought by resistance. 16 Q Okay. So in a n-type doped semiconductor 17 that -- what one would use in a commercial 18 application, and what is the minimum electric field 19 needed to move certain extra electron? 20 (Interruption by the reporter.) 21 MR. SHARMA: Sure. 22 ///	107 1 embedded somewhere in a dopant profile in a crystal. 2 Q You mentioned threshold voltage. 3 Are you referring to a voltage that would 4 be applied between the source and a drain for a 5 transistor to conduct? 6 A Well, I could use threshold voltage in a 7 couple of contexts. That would be one, and that is 8 one that I had mentioned previously. But there's 9 also a threshold voltage to liberate an extra 10 electron from a crystal structure. 11 Q Okay. So when you mentioned threshold 12 voltage earlier, were you referring to the second 13 one, that is, the threshold voltage that you require 14 to liberate an extra electron from the crystal 15 structure? 16 A My recollection right now is that I 17 probably mentioned both in that passage. I 18 certainly mentioned the threshold voltage to turn on 19 a transistor. You know, I talk about the channel. 20 And I believe I mentioned the voltage necessary to 21 cause motion of electrons that are a result of a 22 dopant.
106 1 BY MR. SHARMA: 2 Q In an n-type doped semiconductor, something 3 that would use in a commercial application, what is 4 the minimum electric field you need to move the 5 extra electron? 6 A This is a very incomplete hypothetical 7 scenario. People put a certain amount of work into 8 engineering and developing materials to understand 9 what the threshold voltage is to cause current flow. 10 In transistors, there's a never-ending effort to 11 reduce the threshold voltage and to move in a 12 channel. 13 So there's, you know, a complex set of 14 circumstances necessary to describe an integrated 15 circuit and a more complex set of analyses and 16 calculations sometimes necessary to understand where 17 the threshold voltage is to cause motion. 18 You know, I could tell you roughly what 19 voltages are for common transistors. You know, at 20 that point we're looking at the channel region, 21 though, not necessarily electrons sitting in a 22 free -- I say freely somewhere -- or not freely, but	108 1 Q Do you recall mentioning threshold voltage 2 in your expert declaration? Is that correct? 3 A I'm not sure if I used the phrase 4 "threshold voltage." I certainly spoke of that 5 concept, that there's certain voltage required to 6 cause motion, you know. A small enough voltage 7 won't make an electron free or liberate it from the 8 atoms it's bonded to. A larger voltage will. 9 I think the term "threshold" is a 10 reasonable term to kind of shorthand that 11 description. 12 Q Okay. So looking at a n-type doped 13 silicon, what is the threshold voltage needed to 14 liberate an electron -- or the extra electron in the 15 presence of a doped electric field? 16 A Don't believe I gave that value in my 17 report. These are weakly bonded electrons, so it's 18 significantly less than the covalent energy of an 19 electron in a silicon environment. 20 Q So, sitting here, can you describe for us 21 how would you determine the threshold voltage needed 22 to liberate the extra electron in an n-type

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109 1 semiconductor when you apply an electric field? 2 A Well, there are a couple of ways to think 3 about this. One is to conduct an experiment, you 4 know, look at different doping levels and use 5 appropriate sensors to determine the current flow at 6 different voltage differentials. 7 So these are, you know, the same type of 8 measurement you would use to make silicon-resistance 9 measurements potentially. 10 That's an experimental way to do it, 11 assuming, you know, you would have this 12 concentration gradient available to -- at the 13 surface or have probes you could attach to the 14 regions of interest. 15 Alternatively, there are a few papers -- 16 I'm sure more than a few papers available on 17 electrical properties at different doping levels. 18 This wasn't something that came up to rebut exactly 19 with, you know, precise numbers. But there are ways 20 to go about doing it. 21 Q Thank you. 22 A There's also computer models that are	111 1 think it's something in my report. 2 Q Okay. 3 A And, off the top of my head, couldn't tell 4 you precisely which book it's in, but probably on my 5 bookshelf. If not, it's certainly in the local 6 library. 7 Q Yeah. So sitting here, can you point to a 8 book or a paper that might describe the threshold 9 voltage needed to liberate the extra electron when a 10 dopant electric field is applied? 11 A Could you repeat the question? 12 Q Yeah. I was saying, sitting here right 13 now, can you point to a book or a technical paper 14 that describes how to determine the threshold 15 voltage that is needed to liberate the extra 16 electron when a dopant electric field is applied? 17 A I would say generally, to do it 18 experimentally, any book on characterization of 19 semiconductor electrical properties would show you 20 how to do this. It's essentially a resistance 21 measurement. At some point there's a resistance of 22 a certain value, and at a higher voltage that
110 1 pretty good, computer simulations now that 2 characterize doping concentrations, the electrical 3 properties of the materials thereof. 4 Q Okay. Are you aware of any book from 5 the -- that is on semiconductor device physics that 6 explains how to liberate electrons -- free electrons 7 when they apply a dopant gradient -- doped electric 8 field? 9 A I have bookshelves of semiconductor books. 10 They would describe techniques for measuring 11 resistance, which is, you know, current flow at a 12 different voltage. Those would be sufficient 13 experimentally to determine it. 14 At some voltage, there would be no current 15 flow. At another voltage, one would start seeing 16 current flow when one achieves thresholds. 17 There are models of resistance based upon 18 dopant concentrations that people have published. 19 Probably it's in some of the textbooks. 20 So, again, this was not -- the precise 21 values to liberate an electron wasn't something I 22 needed to rebut from the opposing expert, so I don't	112 1 resistance will break down because current starts 2 flowing. 3 So any book -- any book suggesting how to 4 do that resistance measurement. Hall -- you know -- 5 you know, a Hall effect-type measurement, would -- 6 which is kind of in a lot of textbooks, would give 7 you that. 8 In terms of having the tables already done 9 for you, that would be -- it would originate 10 initially in journal articles and may have made it 11 into some textbooks. But, again, I wasn't asked to 12 rebut this point. 13 The opposing expert didn't really go into 14 that kind of detail, so I don't have anything at my 15 fingerprints in my report or off the top of my head. 16 Q Yeah. And I'm asking you now because you 17 mentioned threshold voltage. So I just wanted to 18 follow up on that, what you understood by that. 19 You also mentioned there's a software model 20 that would help you determine the threshold voltage 21 that is needed to liberate the extra electron in a 22 doped semiconductor when you apply an electric

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113 1 field. 2 Do you -- does any software model or 3 software tool come to your mind right now? 4 A Well, T- -- the technical CAD programs, 5 usually called "TCAD programs," will generally give 6 the resistance values at different doping 7 concentrations. 8 So one would see -- similar to an 9 electrical measurement, one would see resistance 10 going from a relatively high value, you know, 11 essentially inhibiting any meaningful amount of 12 current at a specific voltage to a lower value. 13 So they basically have incorporated the 14 data that's been published from the journal articles 15 as well as any other experiments their clients have 16 fed them. 17 Q Okay. Well -- 18 A So the TCAD -- most of the TCAD programs 19 should have the resistance values versus dopant 20 concentrations for the basic dopants. 21 Q Okay. So TCAD -- you are referring to the 22 TCAD simulation software that is provided by a	115 1 And so at the breakdown voltage where 2 current starts flowing, then the resistance 3 effectively -- measurement becomes very different 4 look to the curve. 5 So that transition from infinite resistance 6 to a very finite resistance shows you where the 7 electrons are starting to flow. 8 I made similar measurements when I was in 9 school. I had some dielectrics I was making that 10 were leaky. So at some point there would be no 11 current flow. But eventually, a little more 12 voltage, the carriers would come off, and it would 13 no longer be a dielectric. It would be a poor 14 conductor but a conductor nonetheless. 15 So it's -- that's the type of data you see 16 for -- to determining when the carriers are freed. 17 Q Okay. So what you're mentioning over here 18 is that if I have a doped silicon n-type and I 19 figure out the voltage that's needed for it to 20 conduct current, that is the threshold voltage 21 you're talking about; is that correct? 22 A That's -- that's one aspect of it.
114 1 vendor such as Synopsys? 2 A Yes. 3 Q S-y-n-o-p-s-y-s. 4 A Yes. Synopsys is one of the big ECAD and 5 TCAD suppliers, yeah, in our area. 6 Q You mentioned -- 7 A Cadence -- cadence also has that software. 8 Q Okay. Now, you mentioned that TCAD would 9 have resistance for a particular dopant 10 concentration. 11 So I think that's a separate issue you're 12 talking about. I think I'm asking you about the 13 threshold voltage needed to separate the extra 14 electron when you apply a field. 15 And -- so is there a software tool that 16 would help you determine that? 17 A Well, I think your question is mistaken. 18 They are related. When one has no motion of 19 carriers, one sees, effectively, an infinite or a 20 very high resistance. And then beyond a certain 21 voltage, one would see a breakdown and current would 22 start flowing.	116 1 Q Are there any other aspects that I did not 2 enumerate? 3 A Well, as I noted in paragraph 33 -- this is 4 about halfway down: 5 "The extra electrons or holes 6 disturb the local charge equilibrium in 7 the silicon and can become mobile in 8 response to electric fields." 9 So other electric fields -- in addition to 10 the field that you might apply, there are other 11 electrical fields that will contribute to the 12 liberation of an electron -- an extra electron from 13 the crystal that becomes a conductor. 14 So you may also be concerned with whatever 15 else is going on in the integrated circuit at the 16 time. For example, the transistor turning on or 17 other activities in the transistor. 18 Q Yeah. I'm just talking about a transistor 19 that is turned off. 20 (Interruption by the reporter.) 21 BY MR. SHARMA: 22 Q Oh, I'm just talking about a transistor

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117 1 that is turned off. It's not active. 2 So let me understand more fully over here, 3 Dr. Glew. 4 When you say "resistance," are you talking 5 about something that is measured in ohms? 6 MR. WHITEHURST: Object to form. 7 THE WITNESS: Resistance can be measured in 8 ohms. Sometimes it's measured in another unit 9 called "ohm-centimeters." It has to do with surface 10 divided by volume. Because a lot of times you're 11 making a measurement of a solid material. You know, 12 it has a diameter, but it has a volume. 13 There are also -- sometimes they use 14 different units. They'll invert it and call them 15 "mohs." But something along those lines. 16 BY MR. SHARMA: 17 Q Now, usually, if you have a piece of 18 silicon, then the resistance would be a function of 19 the cross section area, length, thickness, and also 20 the resistivity of the silicon? 21 MR. WHITEHURST: It may help if you reask 22 that question. You were turned away from the	119 1 it was also -- seems counterproductive in that 2 generally one's trying to avoid current flow when 3 the circuit is off. 4 So this is exactly the opposite of what 5 we're usually concerned with, both in industry and, 6 I think, in this matter. 7 Q And are you familiar with concept of 8 resistivity? 9 A Generally, yes. 10 Q Is that same as the inherent resistance of 11 the material? 12 MR. WHITEHURST: Objection. Scope, 13 relevance. 14 THE WITNESS: Could you repeat that 15 question? "Is that the same as..." 16 BY MR. SHARMA: 17 Q What -- yeah, let me ask the question 18 again. 19 Is resistivity of doped silicon same as 20 inherent resistance of the doped silicon? 21 A I'm familiar with the term "intrinsic." 22 I'm -- do you mean -- did you say "intrinsic" or
118 1 microphone at the time. 2 MR. SHARMA: Yeah. I agree. Yeah. 3 MR. WHITEHURST: It was hard to hear you. 4 MR. SHARMA: Well, agreed. A fair point. 5 My apologies. Let me ask that question again. 6 BY MR. SHARMA: 7 Q So if you have a piece of doped silicon, 8 Dr. Glew, then the resistance of that piece would 9 depend upon the length, width, thickness, and the 10 resistivity of that piece of silicon; is that 11 correct? 12 A This is why oftentimes one sees wafers and 13 other things, materials characterized in 14 ohm-centimeters because the area versus the volume 15 is taken into account. 16 So we have the unit of ohm-centimeter, the 17 area divided by the volume. That's the -- a unit 18 that I had mentioned a few moments ago. 19 Q Okay. 20 A All of this seems rather -- how should I 21 put this? -- hypothetical at this point. This 22 wasn't something that I addressed in my report, and	120 1 "inherent"? 2 Q I meant "inherent." 3 MR. WHITEHURST: Objection. Scope, 4 relevance. 5 THE WITNESS: How are you using the term 6 "inherent" is -- differently from "intrinsic"? 7 BY MR. SHARMA: 8 Q Do you equate inherent resistance to 9 intrinsic resistance? 10 A Well, in semiconductors, we have what are 11 called "intrinsic semiconductors." So the intrinsic 12 resistance of silicon is undoped silicon. I'm not 13 sure if that's what you're asking. That's something 14 that's -- one would understand. 15 Q Okay. So, in your mind, Dr. Glew, is 16 intrinsic resistance of silicon different than 17 inherent resistance of silicon? 18 MR. WHITEHURST: Objection. Scope, 19 relevance. 20 THE WITNESS: Not sure how you're using the 21 term "inherent." 22 ///

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121 1 BY MR. SHARMA: 2 Q Have you heard the term "inherent 3 resistance of silicon" before? 4 A I'm familiar with the term "inherent 5 properties." I'm familiar with "intrinsic 6 properties." I'm familiar with resistance of 7 silicon as it's doped. 8 There are calculations for determining the 9 resistance of doped silicon, the variation with -- 10 as temperature changes, of the resistance. 11 But I'm not sure how you're using the term 12 "inherent." Do... 13 Q I'm asking you: Do you have understanding 14 of the term "inherent resistance of silicon"? 15 If you don't have one, that's fine. You 16 can state that. 17 MR. WHITEHURST: Objection. Scope, 18 relevance. 19 THE WITNESS: It's not a term that I used 20 in my report. I'm not sure how you're using this 21 term. If you can clarify how this is different from 22 intrinsic or if you just simply mean the doped --	123 1 Q Okay. So what's your understanding of the 2 term "intrinsic resistance of silicon"? 3 A Well, you know, silicon has an intrinsic 4 resistance when it's undoped in that -- then as one 5 increases the number of carriers, electrons or 6 holes, based upon a change in temperature, for 7 example, or a -- dopants, then that resistance 8 changes. 9 And one can calculate based upon the number 10 of electrons -- based upon the properties how many 11 electrons are actually free. And that determines -- 12 you know, helps you determine the resistance of the 13 material. 14 It's not a metal. All the electrons are 15 not free to move. It's not an insulator. There is 16 some -- it's a very high resistance, but there is 17 inherent resistance in silicon based upon the fact 18 it's a semiconductor with a very, very small 19 fraction of its electrons in the conduction band. 20 Q And is the intrinsic resistance of silicon 21 same as resistivity of silicon? 22 MR. WHITEHURST: Object to form.
122 1 the resistance based on the dopant levels, I can 2 answer that. 3 BY MR. SHARMA: 4 Q Okay. So in your practice of -- as an 5 expert, you have not used the term or run across the 6 term "inherent resistance of silicon" before; is 7 that correct? 8 MR. WHITEHURST: Objection. Scope, 9 relevance. 10 THE WITNESS: I would say that there's a -- 11 inherently resistance to silicon. It has a 12 resistance. Whether it's doped or undoped, there is 13 a resistance. It has to have resistance. It's 14 inherent that it has resistance. 15 I've probably used that term, but I haven't 16 used it in a very precise technical way that you 17 seem to be alluding to -- 18 BY MR. SHARMA: 19 Q Okay. 20 A -- as in a calculation that is like the 21 intrinsic silicon temperature-dependent calculation 22 that one would be familiar with.	124 1 THE WITNESS: I wouldn't use them -- those 2 terms the same. I would use "intrinsic" to mean a 3 calculation based upon the number of electrons in 4 the conduction band. 5 Whereas "resistivity" is simply the 6 resistance of the -- that you would determine. 7 BY MR. SHARMA: 8 Q And the inherent resistance -- or, sorry, 9 let me strike that. 10 And the intrinsic resistance of silicon 11 would depend upon the dopant concentration of the 12 silicon; is that correct? 13 A Intrinsic silicon -- let's -- I'll start 14 with undoped -- has a certain value at a certain 15 temperature. As one increases the temperature, the 16 resistance drops because more electrons go from the 17 valence to the conduction band. 18 Additionally, if one adds dopants, then 19 that would add potentially free carriers. And the 20 resistance could change then also. 21 Q And you mentioned threshold voltage that is 22 needed to move the electrons.

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125 1 Is that threshold voltage something that is 2 applied externally to a transistor? 3 MR. WHITEHURST: Object to form. 4 THE WITNESS: Well, one can apply it 5 externally if one's making a measurement to 6 characterize the materials. If one is creating a 7 structure, one can dope highly enough to potentially 8 exceed those thresholds. 9 The problem with doing it internally in 10 excess of threshold is that then the current would 11 always be flowing, so there would be no "off" 12 switch. 13 So -- yeah. 14 BY MR. SHARMA: 15 Q Okay. So in the semiconductor that we 16 described in Figure 5B, that is something that, used 17 in a application, the threshold voltage would be 18 something that would be applied externally; is that 19 correct? 20 A Are we talking about figure -- paragraph 33 21 or the patent figure? Thirty-six. I'm sorry. 22 Q Yeah. So, yeah, since we're in your	127 1 all of this. What I think I agreed to, at least -- 2 I think we were talking about Figure 36, was that in 3 figure -- paragraph 36 -- excuse me, not Figure 36 4 but paragraph 36 -- that there would be motion of 5 electrons and holes when the circuit was activated. 6 Paragraph 35 there would not necessarily be 7 any motion of electrons or holes or carriers. It's 8 in a static state just sitting there. There should 9 be no current flow from the source to the drain. 10 It should -- and the capacitor or sensor -- 11 image sensor should be storing its pixel, and it 12 shouldn't bleed off or receive additional electrons 13 to charge up the capacitor. 14 BY MR. SHARMA: 15 Q Okay. In this Figure 5B that we're seeing 16 on -- in paragraph 35 of your report, is a threshold 17 voltage applied between the source and the drain? 18 A Well, in paragraph -- excuse me -- yeah, 19 paragraph 35, there is no voltage shown applied in 20 that -- to the gate in that figure, which would 21 provide the field effect on the channel. 22 Paragraph 36 shows the voltage applied to
126 1 report, yeah, let's refer to Figure 5B, annotated, 2 as shown in paragraph 35 of your report. 3 A Thirty-five. 4 Q Yeah. 5 A Okay. Thirty-five is a transistor that is 6 off. Thirty-six is a transistor that is on. And 7 we're talking about paragraph 35, the off 8 transistor. 9 Q Yes, the off transistor. 10 A Okay. Yeah, I'd probably need a little 11 more information to understand the question. 12 So you're asking -- you're presuming that 13 there is enough potential to exceed the threshold to 14 free electrons? Is that in this hypothetical? 15 Q Yeah, it is. The one we looked at today in 16 Figure 5B, we agreed there's a dopant concentration 17 over here and there would be free electrons. 18 And if I want those electrons to move, will 19 I have to apply a threshold voltage that is external 20 to the device? 21 MR. WHITEHURST: Object to form. 22 THE WITNESS: I don't think we agreed to	128 1 the gate and, hence, the field effect to the 2 channel. 3 Q And the voltage applied to the gate is the 4 threshold voltage you were referring to earlier 5 today; is that correct? 6 A I've real- -- 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: I've really used "threshold" 9 in two different ways. 10 So there's a threshold voltage to turn on 11 the transistor so that there is current flow from 12 the source to gate. 13 There's also another threshold -- and maybe 14 we should pick a different word. But there's 15 another minimum voltage that would be required to 16 free an extra electron from the crystal structure of 17 silicon. 18 BY MR. SHARMA: 19 Q Okay. So the first threshold voltage you 20 mentioned that's applied to the gate to have a 21 current flow from source to drain, that threshold 22 voltage is applied externally to the device; is that

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129 1 correct? 2 A Yes. The voltage that would be applied to 3 the gate shown in paragraph 35 or 36 -- actually 4 applied in paragraph 36 is applied externally. 5 Q Okay. And then you mentioned the second 6 threshold voltage that is needed to free the extra 7 electron from the n-type semiconductor. 8 Where is that threshold voltage applied? 9 MR. WHITEHURST: Object to form. 10 THE WITNESS: Well, I don't actually think 11 that it is -- I don't think I opined that it is 12 applied. I mean, perhaps you could -- internally. 13 I'm not -- maybe you could direct me to 14 somewhere in my report where you think I wrote this. 15 But I don't believe it was my position that there 16 was internal threshold voltage applied. 17 THE COURT REPORTER: "There was" or 18 "wasn't"? 19 THE WITNESS: I don't believe I opined that 20 there was a threshold voltage applied -- I -- 21 BY MR. SHARMA: 22 Q Okay.	131 1 concentration gradient which creates the electric 2 field which causes other electrons to move -- or 3 holes, depending on the polarity. 4 BY MR. SHARMA: 5 Q So the second threshold you're talking 6 about is -- that's caused by the dopant gradient; is 7 that correct? 8 MR. WHITEHURST: Object to form. 9 THE WITNESS: No. I never -- I don't 10 believe I ever testified or wrote that there was a 11 threshold voltage that would cause the dopant -- 12 BY MR. SHARMA: 13 Q Yeah. 14 A -- the extra electrons from the dopants to 15 be liberated. 16 Q No, yeah. 17 A The extra electrons from the dopants, I 18 opined, create the -- or holes, create the electric 19 field because there's a charge grad- -- there's a 20 gradient of the dopants. 21 Q Yes. Let me ask my question again. 22 MR. WHITEHURST: Well, I don't think the
130 1 A -- internally. 2 Q So is it -- the second threshold voltage 3 that is needed to free the electron, is that part of 4 the device? 5 MR. WHITEHURST: Object to form. 6 THE WITNESS: There isn't necessarily a 7 threshold voltage based upon the doping 8 concentration that frees the extra electrons from 9 the dopants. 10 There are intrinsic electrons based upon 11 the nature of silicon. It's not an insulator, but 12 there are -- you know, there's a small number of 13 free electrons. And that increases with 14 temperature. 15 The dopants exist in certain positions, and 16 they create an electric field because they're not -- 17 because there's a gradient. If they were all -- if 18 all the dopant electrons were freed, there wouldn't 19 be a gradient. They would just move. There 20 wouldn't be extra electrons. 21 So the extra electrons need to be in place, 22 they need to be extra, in order to create the dopant	132 1 witness -- 2 Had you finished your answer, Dr. Glew? 3 THE WITNESS: Not quite. 4 So -- 5 BY MR. SHARMA: 6 Q That -- 7 A -- in order for this gradient to exist, the 8 electrons -- 9 MR. WHITEHURST: Counsel, he never finished 10 his answer. 11 BY MR. SHARMA: 12 Q I'm going to withdraw the question so we 13 don't need to -- 14 MR. WHITEHURST: You don't want to hear his 15 answer? 16 MR. SHARMA: I'm withdrawing the question, 17 so -- to ask a different question. 18 BY MR. SHARMA: 19 Q Dr. Glew, just going back to the second 20 threshold, that's the threshold voltage that is 21 needed for a dopant concentration gradient to free 22 the extra electron in an n-type semiconductor; is

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133 1 that correct? 2 A I spoke of a certain threshold or energy or 3 voltage required to free an electron from -- a 4 weakly bound electron from a dopant that's 5 incorporated into a silicon crystal lattice. 6 I never wrote or opined that one needed to 7 do this or that the patent required that. In fact, 8 in many ways just the opposite, that the gradient 9 exists because the extra electrons don't move. They 10 have to be in situ in the crystal structure to 11 create the gradient. And if they were ever freed, 12 they would no longer be the gradient. 13 Q And then if you apply a strong enough 14 gradient, then the electrons will become free and 15 they'll start to move; is that correct? 16 MR. WHITEHURST: Object to form. 17 THE WITNESS: In paragraph 33, I gave some 18 background on technology regarding dopants. The 19 questions that you're asking me are going well 20 beyond just my report and anything I rebutted. 21 I don't believe I ever opined that there 22 was a need in this patent to create such a high	135 1 (Recess taken from 11:46 a.m. 2 to 12:08 p.m.) 3 BY MR. SHARMA: 4 Q Okay. Dr. Glew, before we took break, we 5 were talking about threshold voltage. 6 MR. WHITEHURST: Counsel, before we -- now 7 that we're back on the record, before you -- 8 MR. SHARMA: Oh. 9 MR. WHITEHURST: -- start your 10 questioning -- 11 MR. SHARMA: Yes. 12 MR. WHITEHURST: -- if we could update 13 appearances -- 14 MR. SHARMA: Yeah. 15 MR. WHITEHURST: -- with Mr. Haslam. 16 MR. SHARMA: Yes. 17 MR. HASLAM: Yeah. Hi, this is Bob Haslam 18 with Covington & Burling. I joined the deposition 19 after it was going on. And I may drop off later. I 20 represent Cirrus Logic and GlobalFoundries. 21 MR. WHITEHURST: Thank you, Counsel. 22 MR. HASLAM: You're welcome.
134 1 dopant concentration that it would essentially 2 destroy itself, that it would cause its own 3 electrons to move; therefore, no longer having the 4 same dopant concentration. 5 Furthermore, there's a limit to how much 6 dopant one could put in a crystal before the 7 stresses become excessive and it's not a stable 8 film. 9 So this would require some thought that 10 would go well beyond the scope of what I prepared 11 for and opined on in my report. 12 MR. SHARMA: Okay. 13 MR. WHITEHURST: Counsel, we've been going 14 over an hour. Is this a good time for a break? 15 MR. SHARMA: Yeah. Let's take a 16 five-minute break if that's okay with you. Or do 17 you want ten minutes? 18 THE WITNESS: Ten minutes would be good. 19 MR. SHARMA: Okay. So it's, my time, 20 11:46. Come back at 12 -- 11:56. 21 THE WITNESS: Okay. 22 MR. SHARMA: Thank you.	136 1 BY MR. SHARMA: 2 Q Okay. Dr. Glew, when we broke, we were 3 talking about threshold voltages. So let me get 4 some clarification on that. 5 The first threshold that you mentioned 6 applied between source and drain, that threshold 7 voltage applied when the transistor's operating; is 8 that correct? 9 A Yes. A threshold voltage is commonly 10 understood to be the voltage necessary to turn on a 11 transistor. That is one way I've used the term 12 "threshold." 13 Q Okay. And then you also mentioned second 14 type of threshold. 15 Is it also applicable when the transistor 16 is operating? 17 A It doesn't require the transistor be 18 operating. The way I used the second term was the 19 voltage necessary to liberate an electron from a 20 crystal. And specifically I believe I was talking 21 about the extra electrons that arose from dopants. 22 Q Okay. And that extra -- sorry.

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137 1 And the voltage that is applied is applied 2 to free the electrons when transistors are 3 operating, right? 4 A I'm sorry? Could you rephrase that? 5 Q Okay. I'm just talking about the second 6 voltage you mentioned. 7 And that threshold voltage is applied to 8 free the electrons when the transistor is operating; 9 is that correct? 10 A Not exactly. There is a voltage required 11 to free electrons, whether they're weakly bonded or 12 other types, in this case the weakly bonded extra 13 electrons. 14 But I never opined that one necessarily did 15 that. 16 Q Okay. So, sitting here, your opinion is 17 that the second voltage can be -- does not have to 18 be applied externally to work -- to free the extra 19 electrons? 20 MR. WHITEHURST: Objection. Scope, 21 relevance. 22 THE WITNESS: As a matter of physics, the	139 1 Dopant levels are actually very low. 2 Secondly, one would have to know the 3 environment that the dopants were in to know if they 4 were going to be freed before one exceeded the 5 doping capability of the crystal lattice. 6 So, you know, not having opined on it and 7 not really having enough information off the top of 8 my head or even in the hypothetical, I don't think I 9 can necessarily answer that. 10 Q Okay. So let's move on to the next page in 11 the report, that's paragraph 36. And we can look at 12 the annotated figure on page 17. 13 So, Dr. Glew, this is Figure 5(b) from the 14 GreenThread patent that you excerpted and annotated; 15 is that correct? 16 A Yes, this is 5(b) with additions to it. 17 Q Okay. And this depicts, as in previous 18 page, a PNP field-effect transistor. 19 A No. 20 MR. WHITEHURST: Sorry. 21 BY MR. SHARMA: 22 Q NPN. Let me start it again.
138 1 extra electrons from the dopants, for example, the 2 fifth electron from phosphorus that replaces silicon 3 in the crystal lattice, is an extra electron that is 4 weakly bonded to the crystal lattice. 5 There is no voltage necessarily applied to 6 free it. So I'm not sure I can -- I follow your 7 question about external or internal application. 8 BY MR. SHARMA: 9 Q Okay. So can you free the extra electron 10 by creating a graded dopant that will free the 11 electrons? 12 A First of all, I didn't opine on this in my 13 expert report. I don't recall seeing this as 14 something from the opposing expert or in the 15 petition. 16 Secondly, there's a number of reasons why 17 it would be difficult to answer this question off 18 the top of my head. 19 One can only introduce so many dopants into 20 a crystal lattice before the lattice isn't usable. 21 It has too much stress or so forth and so on. 22 There's a certain limitation to dopant levels.	140 1 As in the previous figure, Figure 5B shown 2 in page 17 shows a NPN field-effect transistor. 3 (Interruption by the reporter.) 4 MR. SHARMA: Field-effect transistor. 5 THE WITNESS: Effectively, yes, as 6 Figure 5(b)'s description is a "CMOS Substrate for a 7 DRAM or image sensor, with one embodiment of the 8 invention," this is a MOSFET, a 9 metal-oxide-semiconductor field-effect transistor. 10 BY MR. SHARMA: 11 Q And Figure 5B on page 17 shows the 12 transistor in operation; is that correct? 13 A Yes. Figure shown in paragraph 36 on 14 page 17 of my '842 patent response IPR '016 shows 15 voltage applied to the gate electrode and the 16 channel in an operating state to be on. 17 Q Okay. And you compare the Figure 5B from 18 page 16 to page 17. And you focus on the gold 19 portion in the top, which is labeled as "Gate," and 20 it shows bunch of plus signs in the figure on 17. 21 Do you see that? 22 A I see that, yes.

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141 1 Q The addition of plus signs on page 17 2 indicates that a voltage has been applied to the 3 gate; is that correct? 4 A Yes, it indicates that a voltage -- in 5 fact, a positive voltage has been applied to the 6 gate, as indicated by the plus signs. 7 Q Okay. And then as shown in Figure 5(b) on 8 page 17, you see bunch of red electrons have 9 collected below the gate oxide; is that correct? 10 A Yes. The figure shows a bunch of red 11 circles with minus signs in them representing 12 electrons. 13 Q And those electrons are closer to the gate 14 oxide because of the positive voltage applied on the 15 gate; is that correct? 16 A Yes, that is correct. The field effect 17 draws the negative charges closer to the positive 18 field. The oxide separates the voltage from the 19 electrons so no actual current flows to the gate 20 electrode, but the electric field exerts its force 21 on negative charges to attract. 22 Q Okay. And the positive voltage on the gate	143 1 Q And in Figure 5B, the minority carriers, 2 being the holes, will be pulled from the surface 3 into the substrate; is that correct? 4 MR. WHITEHURST: Object to form. 5 THE WITNESS: Could you repeat that 6 question? 7 BY MR. SHARMA: 8 Q Okay. Sure. Yeah, in Figure 5B, the 9 minority carriers that are holes are pulled from the 10 surface into the substrate; is that correct? 11 MR. WHITEHURST: Object to form. 12 THE WITNESS: In the figure of 13 paragraph 36, an annotated Figure 5B, the electrons 14 are pulled from the surface area toward the 15 direction of the substrate, as the arrows indicate. 16 BY MR. SHARMA: 17 Q And there will be a dopant electric field 18 present in the transistor shown on Figure 5B on 19 page 17? 20 MR. WHITEHURST: Can you speak up, please? 21 We're really having trouble hearing you. 22 MR. SHARMA: Sure. I'll repeat myself
142 1 has also pushed the holes away from the surface, 2 and, therefore, the green holes are shown towards 3 the bottom of the channel; is that correct? 4 A Yes. Essentially, the positive voltage 5 generating the electric field effect pushes away 6 positive charges, represented by the blue-green 7 circles with the plus signs in them that represent 8 holes. 9 Q Okay. And in Figure 5B on page 17, where 10 it refers to "minority carriers" in the pink 11 section, is it referring to the holes that are shown 12 above in the -- 13 A Yes. The arrows and the text refers to 14 pulling minority carriers from the surface, meaning 15 the holes. 16 Q Okay. And in this transistor, in this 17 situation over here, the majority carriers would be 18 the electrons; is that correct? 19 A Yes. The electrons are negative, as are 20 the source and drain. So the current can flow 21 between source and drains when the electrons 22 accumulate at the surface in the "on" state.	144 1 louder. 2 BY MR. SHARMA: 3 Q There will be a dopant electric field 4 present in the transistor shown on Figure 5B on 5 page 17; is that correct? 6 A Yes. As indicated in the figure, there is 7 a: 8 "Graded dopant" regent -- "region to 9 pull minority carriers from surface," 10 end quote. 11 Q And this dopant field is aiding movement of 12 the holes from the surface towards the substrate; is 13 that correct? 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: The graded dopant region 16 general -- has a field which pulls the minority 17 carriers from the surface in the direction of the 18 substrate, downward. 19 BY MR. SHARMA: 20 Q Okay. And in this case the threshold 21 voltage would have been applied between the source 22 and drain for the transistor to conduct; is that

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145 1 correct? 2 A Yes. In general, the voltage applied to 3 the gate electrode needs to at least be the 4 threshold voltage of the transistor, yes. 5 Q And in this situation the dopant electric 6 field would be able to free the extra carriers so 7 they can move from the surface towards the 8 substrate; is that correct? 9 MR. WHITEHURST: Object to form. 10 THE WITNESS: No, not really. The dopant 11 field that is graded is pulling minority carriers 12 that have been enabled, freed, when the gate 13 electrode has a voltage applied to it of sufficient 14 magnitude. 15 BY MR. SHARMA: 16 Q Okay. 17 A If the gate electrode wasn't necessary and 18 the graded dopant region was always acting to pull 19 down holes and push up electrons, then the 20 transistor would always be on, or if not always 21 completely on, it would be leaky. It would be 22 leaking across from the source to drain.	147 1 BY MR. SHARMA: 2 Q Okay. As part of the process, the voltage 3 would free the electrons and the holes from the 4 atoms; is that correct? 5 A Sort of. I mean, I would put it that the 6 gate voltage needs to free the electrons and holes 7 from the crystal lattice. Of course, there's atoms 8 there, but I think of it more as the properties of 9 the crystal in this sense. 10 Q Okay. And once those electrons had been 11 freed from the lattice due to the gate voltage, 12 those electrons will then move up towards the gate 13 as shown in Figure 5B; is that correct? 14 A Yes. The figure indicates, in annotated 15 Figure 5B of paragraph 36, that the electrons are -- 16 as indicated by the red circles with the minus sign 17 through them, are attracted to the upper surface and 18 reside just under the gray oxide region. 19 Q Okay. And then the gate oxide -- or, 20 sorry, start again. 21 And the gate voltage would have also freed 22 the holes, and, since the voltage is positive, the
146 1 So it can't -- or it shouldn't enable 2 operation of the transistor on its own. That would 3 render the transistor either nonfunctional or at 4 least less effective in storing bits on the DRAM 5 storage capacitor or storing pixel information on an 6 image sensor. 7 Q Okay. So maybe -- I think maybe it's a 8 two-step operation, then. Let me break it down into 9 two steps. 10 And -- so in the first step a threshold 11 voltage would be applied. That will be between the 12 source and the drain. And the threshold voltage has 13 to be high enough for the electrons or the carriers 14 to conduct in the channel? In this case the 15 carriers would be electrons. Is that correct? 16 MR. WHITEHURST: Object to form. 17 THE WITNESS: Partly. The gate electrode 18 voltage needs to be sufficient to attract the 19 electrons to the surface to form continuity between 20 the source and the drain but also to push away the 21 holes so that the electrons and the holes don't 22 recombine.	148 1 holes have moved to the bottom of the blue region in 2 Figure 5; is that correct? 3 MR. WHITEHURST: Object to form. 4 THE WITNESS: Essentially, yes, the gate 5 electrovoltage being positive repels the holes away 6 from the surface and pushes them downward as shown, 7 the holes represented by the blue-green circles with 8 the plus signs in them. 9 BY MR. SHARMA: 10 Q Okay. And the device shown in Figure 5B 11 that is operating -- or that embodies invention will 12 have the dopant electric field set up in the manner 13 to move the minority carriers, or the holes, from 14 the bottom of the blue region towards the substrate 15 that is shown in gray; is that correct? 16 A Essentially, yes, as described in the image 17 itself in the original text, the: 18 "Graded dopant region to pull 19 minority carries from the surface." 20 So the minority carriers for this 21 transistor are holes, so they are what would be 22 drawn downward in the general direction of the

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149 1 substrate. 2 Q Now, if you were to switch it to a 3 p-type -- 4 (Interruption by the reporter.) 5 MR. SHARMA: Sure. 6 BY MR. SHARMA: 7 Q Dr. Glew, were you done? 8 A Yes. 9 Q Okay. Now, in Figure 5B, instead of having 10 a n-type FET, you had a p-type FET, then the 11 minority carriers would be electrons; is that 12 correct? 13 A In a PNP transistor, the minority carriers 14 would be electrons. The holes would be necessary to 15 conduct between the source and drain of a PNP 16 transistor. 17 Q Okay. And, as you testified earlier today, 18 where the term "minority carriers" or "majority 19 carriers" makes sense only when the transistor is 20 operating; is that correct? 21 MR. WHITEHURST: Object to form. 22 THE WITNESS: No. That's -- I don't	151 1 are the holes; is that true? 2 A Yes. The minority carriers for the 3 operation of a NPN transistor are defined by the 4 transistor type itself, which was holes for an NPN. 5 Q Okay. And then in this transistor that is 6 shown in annotated Figure 5B, the majority carriers 7 would be the electrons? 8 A Yes. Annotated Figure 5B in both 9 paragraphs 35 and 36 has holes as the minority. 10 Q Let's go to page 28 of your declaration, 11 Exhibit 2057. 12 Okay. It's numbered page 27, so the PDF 13 page will be higher. So numbered page 28. 14 A I'm on page -- numbered page 27 with 15 footnote 4 on the bottom. 16 Q Yeah. Yeah. Sorry, actually, I meant 17 numbered page 28, which is the next one. 18 A Okay. 19 Q Okay. I want to go over page -- 20 paragraph 50, which is at the bottom of page 28. 21 Focus on the phrase over here which starts on 22 page 28 and goes over to page 29. You mention:
150 1 believe that's exactly how I testified. 2 And the way I would put it is that a 3 certain transistor type has a minority and majority 4 carrier. It's the majority -- majority carrier for 5 the -- in order to operate the transistor. Whether 6 it's operating or not, it doesn't change. 7 BY MR. SHARMA: 8 Q Okay. In Figure 5B, when the transistor is 9 not operating, so you're in the land of Figure 5B on 10 page 16, what is the minority carrier in Figure 5B 11 on page 16? 12 A It doesn't change whether -- between 13 paragraph 35 and 36 as long as it's the same device. 14 For an NPN transistor, the majority carrier 15 is electrons because that's what's necessary to 16 enable the operation of the device. So the term 17 "minority," "majority" comes from the type of device 18 we're looking at. 19 Q Okay. So in both 5B that is shown in 20 Figure 16 and -- sorry -- shown in page 16 and 21 page 17, irrespective of whether the transistor is 22 working or operating or not, the minority carriers	152 1 "...whether there are any external 2 forces (e.g., opposing forces, e.g., due 3 to the intrinsic resistance of 4 silicon)..." 5 Do you see that? 6 A I see where you've cited to, yes. 7 Q Yeah. Okay. You mention opposing forces, 8 and you gave an example of intrinsic resistance of 9 silicon. Do you see that? 10 A Yes, I see that. 11 Q Okay. Did you have any other opposing 12 force in mind when you mentioned "e.g.,...intrinsic 13 resistance of silicon"? 14 A Let me briefly review the paragraph. 15 I gave an example of external forces such 16 as intrinsic resistance. Other opposing forces 17 potentially could be stress of the device. 18 Q Okay. So let's look at some portions of 19 paragraph 50 over here. 20 MR. WHITEHURST: Sorry, Counsel, I'm just 21 having trouble hearing you. 22 MR. SHARMA: Try to maximize my speaker

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153 1 volume and -- 2 MR. WHITEHURST: Are we moving on to 3 paragraph 50? Is that what I heard you say? 4 MR. SHARMA: Yeah, I'm going to ask him 5 more questions on paragraph 50. If you'll give me a 6 minute. 7 BY MR. SHARMA: 8 Q Dr. Glew, are you done looking at 9 paragraph 50 or -- 10 A Give me one more minute. 11 Q Okay. Sure. Just let me know when you're 12 done. 13 A Okay. I've read paragraph 50. 14 Q So let's go to the last sentence of 15 paragraph 50. 16 And, Brendon, would you mind scrolling up. 17 Yeah. 18 So in last sentence of paragraph 50, you 19 mention parameters that a POSITA should know 20 "whether the drift field associated with a 21 concentration gradient would aid carrier movement." 22 Do you see that?	155 1 said resistance diminishes current with voltage. 2 Are you talking about the formula voltage 3 equals product of current and resistance? 4 A Yes. We might call that sometimes Ohm's 5 law. But, yes, the resistance will diminish current 6 flow with a given voltage. At some point it will 7 become negligible. 8 Q So the formula Ohm's law is, as you 9 mentioned, that voltage equals product of current 10 and resistance. 11 Did I get that right? 12 A Yes. 13 Q Okay. And -- what we call V equals IR? 14 A Yes. 15 Q So in paragraph 50, in the last sentence, 16 when you mention "intrinsic resistance of silicon," 17 are you talking about resistance in Ohm's formula, 18 which is V equals IR? 19 A I would say generally yes. One could 20 formulate resistance in different units. But the 21 end effect is that the more resistance of silicon, 22 the less current there is at a given voltage.
154 1 A Yes. 2 Q And your reference to intrinsic resistance 3 of silicon here is same as what we discussed earlier 4 today; is that correct? 5 A I've mentioned intrinsic resistance of 6 silicon before. I don't think it would have changed 7 between now and then. 8 Q Okay. So, Dr. Glew, as you've mentioned in 9 paragraph 50, how does the intrinsic resistance of 10 silicon impact movement of carriers when a dopant 11 electric field is present? 12 MR. WHITEHURST: Object to form. 13 THE WITNESS: Well, in a general sense, 14 resistance diminishes current with voltage. More 15 specifically, at extremely low voltages, may be 16 negligible current. 17 BY MR. SHARMA: 18 Q Are you done or are you still thinking? 19 A Yes. No, no, I'm done. 20 Q Oh, sorry. I thought you were still 21 thinking. 22 So in this case we are talking about -- you	156 1 Q Okay. 2 A I equals V over R. 3 Q Right, yeah, okay. Inversely 4 proportionally? 5 A Yes. 6 Q How does the resistance impact movement of 7 the extra carriers that are present in a doped 8 silicon? 9 A Well, this is -- this question presumes 10 that the extra carriers from the dopants are 11 actually moving. So let me parse this a bit. 12 Q Sure. 13 A The channel itself may be doped a little 14 bit to produce some extra carriers, but the dopants 15 that are introduced to create an electric field are 16 not generally intended to move in any quantity. 17 If the extra electrons in the dopants 18 imparted to create an electric field moved, then 19 there wouldn't be an electric field because there 20 wouldn't be this gradient of extra electrons in a 21 vicinity. 22 So the question, actually, at its face

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157 1 value, is rather complicated. 2 Q So as we saw earlier in Figure 5B, when the 3 transistor is operating, you mentioned that the 4 minority carriers are being pulled from the surface. 5 Do you recall that? 6 A Generally, yes. 7 Q How is the movement of those minority 8 carriers impacted by the resistance? 9 A Resistance makes it more difficult for 10 carriers to move. 11 Q So if there's high resistance, then the 12 carriers that are being pulled down towards the 13 substrate will have more difficulty moving; is that 14 correct? 15 A Generally, yes. The more resistance, the 16 fewer carriers or the less current at a given 17 voltage. 18 Q And that will be true for carriers moving 19 between the source and the drain also; is that 20 correct? 21 A Yes. Resistance, if there was resistance, 22 of a given value in the channel region would	159 1 Q Then just coming back to paragraph 50, you 2 mention presence of any other external forces. And 3 when I asked you earlier, you thought one force 4 might be stress; is that correct? 5 A I recall that I answered about stress 6 previously for a different question. What's the 7 question now? 8 Q Let me ask you again, then. 9 You mentioned "presence of any other 10 external forces" in the last sentence of your 11 paragraph 50. Do you see that? 12 A At the bottom of 50. Okay. 13 Q Yes. 14 A Yes, I see that. 15 Q Okay. And what other external forces are 16 you referring to in paragraph 50? 17 A You know, potentially something like stress 18 or something like that. The reality is that usually 19 stress is used to reduce resistance. There's a lot 20 of what they call "strain engineering." 21 So strain is introduced, which introduces 22 stress, to allow the decrease in resistance in
158 1 diminish the source-drain current. It would have 2 some other time effects, capacitance formation 3 but -- as well. 4 Well, not capacitance formation but R -- 5 capacitance time resistance time delay issues. 6 Q So for the -- and, similarly, the -- in the 7 Figure 5B shown on page 17, minority carriers that 8 have been pulled from the surface towards the 9 substrate will also have a tough time moving if the 10 resistance is higher; is that correct? 11 A Generally, the higher the resistance, the 12 more difficult current has in moving, yes. 13 Q Okay. And, likewise, if the resistance 14 goes down, then the minority carriers that are 15 moving from the surface towards the substrate will 16 have an easier time moving; is that correct? 17 A Generally, yes, the lower the resistance in 18 the path from the surface in the direction of the 19 substrate, the easier a time that holes or minority 20 carriers will have in moving in the downward 21 direction, increasing the current flow at a given 22 voltage.	160 1 transistors. Sometimes it's used in the channel. 2 Sometimes it's used in the source-drain. 3 Q So are you referring to the stress in the 4 lattice structure of silicon? 5 A Yes. 6 Q And how does that stress in the lattice 7 structure of silicon impact movement of carriers 8 under a dopant electric field? 9 A Well, it's not specific to a dopant 10 electric field. Basically, it reduce- -- it's 11 typically done to reduce the resistance of the 12 silicon. 13 Q So you explained earlier that the intrinsic 14 resistance of silicon is the resistance in the Ohm's 15 law, and the stress is impacting that resistance, R; 16 is that correct? 17 MR. WHITEHURST: Object to form. 18 THE WITNESS: I'm sorry. You said the 19 stress is impacting the resistance -- and I didn't 20 catch the last word. 21 BY MR. SHARMA: 22 Q Oh, impacting resistance, R, in Ohm's law?

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161 1 A Well, I would say the stress is often used 2 to reduce the resistance of the silicon, whether one 3 thinks of resistance in terms of Ohm's law or uses 4 ohm-centimeter or a different unit. But, yeah, 5 generally stress or strain engineering is used to 6 reduce resistance. 7 Q Okay. 8 A Sometimes in the channel region that we're 9 concerned with, other times in the source-drain. 10 Q I'm just trying to understand the 11 connection between these forces. Make sure I get 12 this right. 13 You're saying that there will be stress in 14 the silicon lattice and the silicon stress would 15 impact the resistance, R, in Ohm's law, which then 16 impacts movement of carriers pursuant to electric 17 field; is that correct? 18 MR. WHITEHURST: Object to form. 19 THE WITNESS: I would say generally, yes, 20 stress is -- stress/strain engineering is used to 21 reduce the resistance that is the flow of current 22 under an electric field in the silicon.	163 1 Dr. Glew, does the magnitude of the 2 concentration gradient impact the voltage -- or 3 threshold voltage necessary to free an electron in a 4 n-type semiconductor? 5 MR. WHITEHURST: Objection. Scope, 6 relevance. 7 THE WITNESS: Could you repeat the 8 question, please? 9 BY MR. SHARMA: 10 Q Sure. Let me ask a slightly different 11 question. 12 Is the magnitude of the concentration 13 gradient related in any manner to the threshold 14 voltage required to free the extra electron in an 15 n-type semiconductor? 16 MR. WHITEHURST: Objection. Scope. 17 Relevance. 18 THE WITNESS: I don't believe I opined in 19 my report that the extra electrons needed to be 20 freed. Instead, I opined that the extra electrons 21 created the concentration gradient. So they would 22 need to stay put in order to create this
162 1 BY MR. SHARMA: 2 Q And then the other factor you mentioned is 3 the magnitude of concentration gradient. Do you see 4 that? 5 A Yes, I see that. 6 Q Yeah. And how does the magnitude of the 7 concentration gradient impact movement of carriers 8 pursuant to a dopant electric field? 9 A Well, the magnitude of the concentration 10 gradient is proportional to the electric field 11 that's established. 12 Q So higher the gradient, the stronger the 13 field; is that correct? 14 A Yes. The higher the gradient, the change 15 with distance, the stronger the field. 16 The higher the change in concentration per 17 distance of the gradient, the higher the electric 18 field generated by the gradient. 19 Q Okay. And the magnitude of the gradient 20 would impact the free -- electrons that have been 21 freed in a -- okay. Let me strike this. Start 22 again.	164 1 concentration gradient. 2 If one desired to free dopant electrons, 3 then that value doesn't change. That's a matter of 4 the crystal lattice and the weak bond that forms 5 between this extra electron and the crystal lattice. 6 BY MR. SHARMA: 7 Q So the magnitude of the concentration 8 gradient has nothing to do with the voltage needed 9 to free the extra electron in the n-type 10 semiconductor; is that correct? 11 MR. WHITEHURST: Objection. Form, scope, 12 relevance. 13 THE WITNESS: As I said before, I never 14 opined on that. I don't believe the petitioner or 15 the opposing expert, Dr. Banerjee, opined on this. 16 In general, all I can say is that the extra 17 electrons are weakly bonded to the crystal lattice. 18 That doesn't necessarily change with the 19 concentration of the dopants. 20 The dopant concentration is extremely low 21 compared to the crystal lattice density. You know, 22 the dopants aren't going to be generally anywhere

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165 1 near each other in the crystal lattice. 2 Dopant concentrations are a million -- a 3 millionth or less of the typically -- maybe 10,000 4 less than the crystal lattice, so they don't really 5 interact with each other. The dopants are far apart 6 in the crystal lattice, so they don't affect each 7 other. 8 So one treats the dopants -- one would 9 generally treat the dopants as if they were point 10 effects, meaning there was a single dopant in the 11 crystal lattice. And any -- and the only thing that 12 it saw around it would be other silicon atoms -- not 13 other -- well, silicon atoms, "it" being a dopant. 14 So, yeah, I don't think that the 15 concentration would even be a second-order effect on 16 the energy necessary to liberate a dopant electron 17 from the lattice up until, you know, maybe when it 18 hit extremely, extremely high concentrations. 19 BY MR. SHARMA: 20 Q Just on the paragraph 50, you mentioned 21 stress being another external force. 22 But, sitting here today, nothing else comes	167 1 (Recess taken from 12:55 p.m. 2 to 1:12 p.m.) 3 BY MR. SHARMA: 4 Q Welcome back, Dr. Glew. 5 A Hello. 6 Q Okay. So in the last sentence of 7 paragraph 50 of your report, you mention the POSITA 8 needs to know parameters of the device. 9 And the three parameters you mention are 10 the magnitude of concentration gradient, intrinsic 11 resistance of silicon, and other forces that you 12 mention relate to the stress in the lattice; is that 13 correct? 14 A Well, what I've mentioned here are the 15 magnitude of the concentration gradient, the 16 intrinsic resistance of silicon, and the presence of 17 any other external forces. 18 But the presence of any external forces 19 comprises the universe of what is known in 20 semiconductor circuits. For example, the resistance 21 of the silicon is one thing when you buy it, but 22 after it's been processed, there's damage to it from
166 1 to your mind besides the stress in lattice; is that 2 correct? 3 MR. WHITEHURST: Object to form. 4 THE WITNESS: Off the top of my head now, 5 no, I didn't do that further consideration. 6 MR. SHARMA: Okay. 7 MR. WHITEHURST: Counsel, we've been 8 going -- 9 MR. SHARMA: Brendon, if you could scroll 10 up little. 11 Sorry. What, Alan? You're on -- 12 MR. WHITEHURST: We've been going on an 13 hour. Is this a good time to take a break? 14 MR. SHARMA: Sure. I'm fine with that if 15 that's what Dr. Glew wants. 16 THE WITNESS: That's fine, yeah. 17 MR. SHARMA: So ten minutes? 18 THE WITNESS: Sure, that'll be fine. 19 MR. WHITEHURST: Yeah. Let's -- we'll try 20 to get back as quickly as possible, keep everything 21 moving. 22 MR. SHARMA: Thank you.	168 1 the implantation. 2 The ions that are implanted in order to 3 dope the silicon create a lot of damage, which 4 manifests itself in disruptions to the crystal 5 lattice. 6 So these are sites that create points where 7 current can get hung up, slow down, or recombine. 8 There are a number of other problems in 9 terms of semiconductor wafers. There are structures 10 affected, essentially internal diode forms, and 11 numerous other problems that can cause current to 12 become stopped or to become slowed due to 13 misdirection and recombination. 14 The stress that I talked about has its pros 15 and cons, whereas stress that in -- that -- how 16 should I put this? -- stress that benefits holes 17 hurts electrons and vice versas. 18 So whereas tension may be good for one 19 device, it's bad for the minority carrier. So one 20 has to accommodate not only the stress that benefits 21 the majority, but inhibits the minority. 22 And, of course, these are complex

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169 1 structures. There are numerous dopants introduced, 2 somewhere between 20 and 40, maybe even more in this 3 day and age. 4 So there's a lot of migration of dopants in 5 the formation of transistors. When the dopants are 6 annealed in order to repair their dislocations and 7 the damage caused by the implantation, it causes 8 further migration of other dopants. So that gives 9 you recombination potentially. 10 So, yeah, those are the types of things 11 that I had in mind when I had thought of things that 12 would be relevant to a device and whether or not the 13 carriers in question would be benefited by a field 14 associated with a concentration gradient of dopants. 15 Q So you had all these things in mind that 16 you just explained, but you did not put those in the 17 report; is that correct? 18 A Let me review my report briefly, see what I 19 note. 20 Well, I'm going to direct you to page 23 of 21 this report. There's a paragraph that's actually a 22 quote from another piece of art, Wieczorek. And it	171 1 here of the type of problems that occur in the 2 region of the transistor and the channel. 3 Q And, just for the record, Dr. Glew, what 4 paragraph number were you referring to? 5 A I'm on page 23. This is paragraph 44. 6 Q Okay. Let's go to -- 7 A Yeah. 8 Q Let me ask you a couple of quick questions. 9 A And the -- 10 MR. WHITEHURST: Are you through -- 11 THE WITNESS: Yeah, I'm -- 12 MR. WHITEHURST: I don't believe he's 13 through, Counsel. 14 MR. SHARMA: Oh, sorry. I thought you 15 were. 16 MR. WHITEHURST: He's still talking. 17 THE WITNESS: Yeah. And then I'm going to 18 review my -- continue reviewing my report. There's 19 another example or two I think I have. 20 Okay. I would direct one toward 21 paragraph 8 on page 4 just to note that I have 22 experience and have worked with epitaxial
170 1 notes: 2 "Due to the up-diffusion of the 3 dopant atoms during the heat 4 treatment" -- 5 (Interruption by the reporter.) 6 THE WITNESS: Quote: 7 "Due to the up-diffusion of the 8 dopant atoms during the heat 9 treatment..." 10 It goes on from there. End quote. 11 So one of skill in the art would understand 12 that this heat treatment that's necessary after 13 dopant implantation is due to the damage caused by 14 the crystal -- to the crystal by the dopant 15 implantations. 16 Arsenic, for example, a common p-type -- 17 excuse me -- n-type dopant is a large atom and 18 causes a significant amount of damage, even more so 19 than the other smaller atoms such as phosphorus or 20 boron for the p-type. 21 So this is one example of, I think, what is 22 well known to one of skill in the art and evidenced	172 1 deposition, which is something often used in 2 semiconductor processing as well as rapid thermal 3 processing. 4 Rapid thermal processing I also mention in 5 paragraph 9, which is commonly inclusive of rapid 6 thermal annealing. 7 So these are methods that I'm familiar with 8 to try to mitigate the damage caused by ion 9 implantation. 10 Furthermore, with epitaxial layers, for 11 example, an epitaxial layer is a CVD single-crystal 12 layer deposited on top of silicon, but the epitaxial 13 layer is not the silicon wafer. And it has some 14 mismatch between the silicon wafer itself as well as 15 the epitaxial layer. 16 So that creates surface states between the 17 two films that cause imperfections that would 18 further hang up carriers from transitioning from epi 19 into a layer further below in addition to any stress 20 issues associated with the mismatch between the 21 epitaxial layer and the silicon layer. 22 So epitaxial has some alignment with the

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173 1 underlying crystal but not -- it's not extension of 2 the underlying crystal. 3 So those are other things I had in mind 4 when I had penned that paragraph there that we were 5 discussing. 6 BY MR. SHARMA: 7 Q Understood. Are you familiar with a 8 concept called "drift velocity"? 9 A Generally, yes. 10 Q Did you discuss that in this expert report? 11 A Well, I discussed carrier drift a couple of 12 times. 13 Q Sure. 14 A I'm not sure I got into much detail about 15 the velocity, the relationship between the voltage 16 potential and the speed. 17 Q One place where you discuss carrier drift 18 was in paragraph 33 that we looked at today, right? 19 A Thirty-three as well 37 -- 20 Q Okay. 21 A -- and 50, yeah. 22 Q And are you also familiar with the concept	175 1 Dr. Glew, in the interest of time. Let me ask you a 2 more pointed question. 3 On page 8, in the second bullet point, you 4 mention that -- sorry, in the first bullet point you 5 mention that you looked at the file histories of the 6 GreenThread patents; is that correct? 7 A Yes. They were provided to me. 8 Q Okay. Yeah. So let's go to the file 9 history for '195 patent. 10 Brendon, if you can drop that in the chat 11 box and bring it up on the screen. 12 DOCUMENT TECH CUENCA: Sure thing, Counsel. 13 And you said 1959? 14 MR. SHARMA: The file is '195. And the 15 exhibit number is 1016. 16 (Deposition Exhibit 3 was marked for 17 identification.) 18 MR. WHITEHURST: You're going to mark this 19 as the next exhibit? 20 MR. SHARMA: Yeah. I think we are just 21 using the exhibit numbers from the PTAB, so I'll 22 flag it when we get online -- when the exhibit is
174 1 of electron mobility? 2 A Commonly abbreviated as "mu," but yes. 3 Q Okay. 4 A Usually centimeters per second per volt or 5 something like that. Depends on -- 6 Q Okay. Likewise, then you're familiar with 7 the concept of hole mobility also, then, right? 8 A Yes. Similar concept, but applied to holes 9 as electrons. 10 Q Let's go to page 7 or page 8 of your 11 report. 12 And in section 3, Dr. Glew, in 13 paragraph 16, you mention all the documents you have 14 reviewed and considered in coming with your opinion; 15 is that correct? 16 A I'm sorry. The question is was this all -- 17 page 7, 8, was this all the documents I considered? 18 Q Yeah. That lists all the documents you 19 considered in coming up with your opinion? 20 MR. WHITEHURST: Object to form. 21 BY MR. SHARMA: 22 Q Here, let me withdraw that question,	176 1 up. 2 MR. WHITEHURST: (Inaudible) because we 3 already have a Glew -- 4 (Interruption by the reporter.) 5 MR. SHARMA: Oh. Go ahead, Alan, why don't 6 you finish what you're saying so... 7 MR. WHITEHURST: I was just commenting that 8 we had marked the two previous documents as Glew 1 9 and Glew 2. So I was asking whether this is Glew 3. 10 MR. SHARMA: Yes. We can mark it as Glew 3 11 when the file history comes. But then also I'll 12 flag the PTAB number also. 13 DOCUMENT TECH CUENCA: Yes. And would you 14 mind telling me the title of the exhibit again, 15 please? 16 MR. SHARMA: Yeah. Exhibit 1016, file 17 history. 18 DOCUMENT TECH CUENCA: Okay. Got it. 19 It'll be up soon. 20 All right. It is now in the chat, and it 21 is now up. 22 MR. SHARMA: Okay. So we have marked this

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177 1 as Exhibit Glew 3. It's also Exhibit 1016 from 2 IPR IPR2024-00017. 3 Brendon, could you go to page 6? 4 I apologize, you know, as -- this is on 5 page 289 of the PDF, Brendon, so... 6 THE WITNESS: I'm sorry. Page 290 -- 289 7 of 391? 8 MR. SHARMA: Yeah, page 289. 9 DOCUMENT TECH CUENCA: Oh, sorry about 10 that, Counsel. 11 MR. SHARMA: No, so it's my bad. I had the 12 page wrong. 13 BY MR. SHARMA: 14 Q Dr. Glew, here are couple of pages of the 15 file history. 16 And if you can scroll down to page No. 10. 17 Dr. Glew, over here do you see if it is 18 signed by David Mundt? 19 A I see a signature, yes. 20 Q Okay. I understand that Mr. Mundt was 21 acting as counsel for GreenThread. 22 Is that your understanding also?	179 1 Dr. Glew, did you agree with the statements 2 GreenThread had made to the patent office? 3 MR. WHITEHURST: Are you referring to a 4 particular statement, Counsel? 5 MR. SHARMA: Yeah, starting with this one. 6 MR. WHITEHURST: I'm just going to make a 7 general objection to form. 8 THE WITNESS: I don't recall opining on 9 this particular office action in my report. I would 10 have to read it first before I comment on it. Then 11 I would -- then I may or may not be able to comment 12 on it depending on if it was part of the file 13 history that I had given some consideration to. 14 Is there something in particular you want 15 to direct me toward while I read it? 16 BY MR. SHARMA: 17 Q Okay. I will in a minute. 18 But maybe let me ask you, sitting here 19 right now, when you reviewed the file history for 20 the '195 patent, you must -- did you review all the 21 office actions by the examiner and responses by 22 GreenThread?
178 1 MR. WHITEHURST: Object to form. 2 THE WITNESS: I don't really know of 3 Mr. Mundt other than this -- it looks like he signed 4 it as a patent attorney or patent agent. 5 BY MR. SHARMA: 6 Q Okay. And when Mr. Mundt submitted this 7 response to the patent office, he was subject to a 8 duty of candor by the patent office. 9 Would you agree with that? 10 MR. WHITEHURST: Objection. Scope, 11 relevance. 12 THE WITNESS: I understand that that's a 13 general requirement when filing patents. I'm not an 14 attorney, though, so I don't usually give opinions 15 on the law. 16 MR. SHARMA: Let's scroll back up to page 17 No. 6 of this response, Brendon. 18 BY MR. SHARMA: 19 Q This is the response that was given by 20 GreenThread in response to an office action from the 21 examiner. 22 And when you reviewed the file history,	180 1 A I would say I glanced at the file history. 2 There was nothing outstanding that I saw at the 3 time. I didn't -- I included -- I don't think I 4 included any comments in my report on the file 5 history. It didn't seem relevant to what the -- any 6 of the issues I was rebutting at the time. 7 Q And if you found something that was 8 relevant or pertinent, you would have included that 9 in your report; is that correct? 10 MR. WHITEHURST: Object to form, scope, 11 relevance. 12 (Interruption by the reporter.) 13 MR. WHITEHURST: Objection. Form, scope, 14 relevance. 15 THE WITNESS: If it was necessary, if it 16 was something I had -- was able to rebut with other 17 documents, I may have relied on those. 18 BY MR. SHARMA: 19 Q Okay. Let me direct you to the third 20 paragraph that is shown on the screen. 21 A Okay. 22 Q And the first sentence begins with:

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181 1 "Applicant respectfully disagrees 2 with this position..." 3 Do you see that paragraph? 4 A Yes. 5 Q In this one GreenThread states that: 6 "...a unidirectional drift 7 (electric) field necessarily affects all 8 the present minority carriers in the 9 same way -- moving all minority carriers 10 in the same direction because of the 11 unidirectional drift due to the 12 existence of the electric field." 13 Do you see that? 14 A I see that. 15 Q Yeah. Sitting here, do you agree with 16 GreenThread's statement? 17 MR. WHITEHURST: Object to form. 18 THE WITNESS: I think generally I do, but I 19 want to -- let me review a little bit more of this 20 office action first. 21 I guess while I -- before I finish reading 22 this office action, let me clarify the question.	183 1 supported by at least the Applicant's 2 disclosure in paragraph 11 and original 3 claim 6." 4 So it changed from "all carriers" to "aid 5 carriers" of minority carriers. 6 So I am comfortable with what they agreed 7 to with here, yes. 8 Q And then you mentioned there's a quote from 9 Andy Grove's textbook titled "Physics and Technology 10 of Semiconductor Devices." Do you see that? 11 A Let me move back to that. 12 I see the quote, yes. 13 Q Yeah. Are you familiar with this textbook 14 that's mentioned here? 15 A I believe so. It's an older textbook. My 16 adviser at Stanford was friends with Andy Grove, and 17 we always used to have Barrett and other people 18 over. 19 This is not one I've used, but Andy Grove 20 was a kind of key icon in early semiconductor. I 21 don't know most of the book off the top of my head, 22 though, no.
182 1 This is a quote from Andy Grove who was at 2 Intel. So I'm -- this isn't necessarily a -- okay. 3 Are you asking about whether I agree with 4 Andy Grove, or are you asking me about whether I 5 agree with applicants? I'm not sure what you're 6 trying to -- 7 BY MR. SHARMA: 8 Q Yeah. The -- 9 A -- which paragraph -- 10 Q The quote from Andy Grove is later within 11 the parentheses. I'm asking about the sentence that 12 precedes the quote from Andy Grove. 13 A In reviewing this office action, in part, 14 it appears that, on page 7, the applicants amended 15 their claims to overcome the objection and moved the 16 word from "all" to -- I'll quote: 17 "In particular, Applicant has 18 removed the word 'all' from the rejected 19 claim language which now reads: 20 'unidirectional electric drift field to 21 aid the movement of minority 22 carriers...' This claim language is	184 1 Q Do you know whether Andy Grove's book is a 2 well-regarded book? 3 MR. WHITEHURST: Objection. Scope, 4 relevance. 5 THE WITNESS: I think Andy Grove was a 6 well-regarded individual, helped found Intel. This 7 is a very old book at this point. 8 BY MR. SHARMA: 9 Q In the office action over here, GreenThread 10 quoted two sentences from the book. They were from 11 pages 224 to 225. Do you see that? 12 A I see that, yes. 13 Q Do you agree with the two sentences that 14 are mentioned from Andy Grove's book? 15 MR. WHITEHURST: Objection. Scope, 16 relevance. 17 THE WITNESS: I would say I think generally 18 it sounds reasonable. Again, it's only two 19 sentences from a book. It refers to "this same 20 electric field." I don't know what he's -- exactly 21 what he's referring to with this electric field. 22 So maybe it's the field generator from the

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185 1 dopant concentration gradient we're supposed to 2 assume or something. I'm not -- yeah, so seems 3 reasonable without seeing the rest of the book and 4 the rest of the cite and what he's referring to in 5 this sentence. It's -- I can't go beyond that. 6 BY MR. SHARMA: 7 Q Okay. Look at the last sentence of the 8 same paragraph, starts with "Depending on the 9 particular slope." Do you see that? 10 A Yes. 11 Q And in this sentence when GreenThread 12 mentions "particular slope," is it mentioning the 13 slope is either up or the slope is down? 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: Are you asking me if this 16 electric field is the same field that GreenThread is 17 referring to? 18 BY MR. SHARMA: 19 Q No. I'm asking whether, when GreenThread 20 mentions particular slope of the graded 21 concentration dopants, is it referring to the slope 22 being up or the slope being down?	187 1 the concentration of dopant." Do you see that? 2 A I see that, yes. 3 Q Okay. In this sentence, when GreenThread 4 mentions "particular slope of the graded 5 concentration of dopant," is GreenThread referring 6 to the slope being up or the slope being down? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: In this particular sentence 9 on page, oh, 6 of 10, the word "down" is in quotes. 10 I see that. 11 Is that what you're asking me? 12 BY MR. SHARMA: 13 Q Yeah. I'm asking is when GreenThread 14 mentions particular slope, is it referring to the 15 slope being up or the slope being down? 16 MR. WHITEHURST: Object to form. 17 THE WITNESS: The word "up" is also in 18 quotes. So your question's not making a lot of 19 sense to me. 20 BY MR. SHARMA: 21 Q Okay. Yeah. My question -- I'll repeat 22 again.
186 1 MR. WHITEHURST: Object to form. 2 THE WITNESS: I guess I'm confused now 3 because I thought you were asking me about these two 4 sentences from Andy Grove. There's a 225-page book, 5 at least. 6 BY MR. SHARMA: 7 Q Yes. 8 A And here's two sentences you're asking me 9 about, but I don't know how GreenThread got into 10 this discussion of Andy Grove's passage. 11 Q No, I moved on from the next sentence, 12 which is at the bottom of that paragraph. 13 A Okay. 14 MR. WHITEHURST: Is there a question 15 pending? 16 MR. SHARMA: Yes. 17 THE WITNESS: Okay. Could you repeat the 18 question? 19 BY MR. SHARMA: 20 Q Sure. When you see the last sentence of 21 the paragraph after the quote from Andy Grove, 22 GreenThread mentions that "the particular slope of	188 1 In this last sentence of the paragraph 2 where GreenThread mentions particular slope, is it 3 talking about the direction of the slope as being 4 up, in double quotes, or the slope being down, in 5 double quotes? 6 MR. WHITEHURST: Object to form. 7 THE WITNESS: Without further review of the 8 file history and the material here, I couldn't tell 9 you. 10 BY MR. SHARMA: 11 Q Okay. So just looking at the passage over 12 here, you don't know what the particular slope 13 refers to in this sentence; is that correct? 14 MR. WHITEHURST: Do you want him to look at 15 the rest of the file history to answer your 16 question? 17 (Interruption by the reporter.) 18 MR. WHITEHURST: Yes. Counsel, do you want 19 him to review the file history in order to answer 20 your question? 21 MR. SHARMA: Unfortunately, Alan, it would 22 take all day. So question is --

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189 1 MR. WHITEHURST: Well, I mean, he just said 2 he would need time to review it to answer your 3 question. Do you want him to review it? 4 MR. SHARMA: No, I don't want him to review 5 it. So -- 6 MR. WHITEHURST: Okay. Then are you 7 withdrawing your question? 8 MR. SHARMA: No. Dr. Glew can answer based 9 on what he sees in front of him. He's not able to 10 answer, he can say so. 11 THE WITNESS: I believe I already said that 12 without further review of this document, I can't 13 answer that question. I would need additional 14 consideration to understand how to parse this 15 sentence. 16 BY MR. SHARMA: 17 Q Understood. Okay. 18 Let's introduce another exhibit. 19 I will come back to the file history, but 20 let's hang on to it. 21 And the next exhibit is Grove excerpt.pdf. 22 THE WITNESS: I'm sorry. I couldn't make	191 1 BY MR. SHARMA: 2 Q Dr. Glew, if you see in the front of you, 3 in the first paragraph of the page in the middle, it 4 starts with "This same electric field will be of 5 such direction." Do you see that? 6 A I'm sorry. I see "In the case of the pnp 7 transistor." 8 Q Yeah. In the same paragraph, if you go to 9 the middle of the paragraph, it starts with the 10 sentence "This same electric field." 11 MR. WHITEHURST: You might want to download 12 a copy of the textbook -- 13 THE WITNESS: Yes, I -- 14 MR. WHITEHURST: -- so you can review and 15 make sure -- 16 MR. SHARMA: Yeah, and -- 17 MR. WHITEHURST: -- the surrounding text. 18 (Interruption by the reporter.) 19 MR. WHITEHURST: Yes. I was asking whether 20 he was able to download a copy of the PDF. I'm 21 still trying to get mine to download. 22 ///
190 1 out any of that. The next exhibit is -- 2 MR. SHARMA: Yeah, it was more instruction 3 to Brendon. So let's see if the file history comes 4 up. 5 DOCUMENT TECH CUENCA: It's the Grove 6 excerpt? 7 MR. SHARMA: Yes. 8 DOCUMENT TECH CUENCA: Okay. 9 (Deposition Exhibit 4 was marked for 10 identification.) 11 BY MR. SHARMA: 12 Q So, Dr. Glew, we mark here as Glew 4 is an 13 excerpt from Andy Grove's textbook "Physics and 14 Technology of Semiconductor Devices." 15 And we have excerpted pages 224 and 225 16 that GreenThread cited in the office action. 17 Brendon, would you go to page -- 18 DOCUMENT TECH CUENCA: I'm sorry, Counsel, 19 which page? 20 MR. SHARMA: Yeah, page 225. And if you 21 zoom in. Yeah, if you zoom in to the paragraph 22 below.	192 1 BY MR. SHARMA: 2 Q Dr. Glew, do you have the exhibit with you 3 now? 4 A Yes, I have the exhibit. I'm not sure that 5 my counsel does. 6 Q Okay. 7 MR. WHITEHURST: One second here. 8 BY MR. SHARMA: 9 Q In the meantime, while counsel's 10 downloading, do you see in the middle of the 11 paragraph it begins with "This same electric field"? 12 A I see that passage, yes. 13 Q Yeah. So the two sentences that 14 GreenThread quoted in the file history -- 15 A I don't think my counsel has -- 16 MR. WHITEHURST: So I have the PDF now. 17 Are we on page 4 of 5? Is that correct? 18 MR. SHARMA: Yeah. 19 MR. WHITEHURST: And, I'm sorry, is there a 20 question pending? 21 MR. SHARMA: Yeah. I'm going to ask the 22 question. Waiting for you to get the PDF. Okay.

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193 1 Assuming you have the PDF now, Alan, right? 2 MR. WHITEHURST: I do. Thank you. 3 MR. SHARMA: You're welcome. 4 BY MR. SHARMA: 5 Q Okay. So, Dr. Glew, in the middle of the 6 paragraph there are two sentences. Start with "This 7 same electric field." And -- do you see the 8 sentence? 9 A Yes. 10 Q And then the next sentence ends with: 11 "...due to the existence of this 12 electric field." 13 Do you see that? 14 A Yes. 15 Q These are the two sentences that 16 GreenThread quoted in the file history that we saw 17 just now. 18 Do you recall that? 19 A Generally, yes. 20 Q Now that you have slightly more context 21 now, do you agree with these two sentences from 22 Andy Grove's textbook?	195 1 go, I think this is reasonable. 2 Q And are the teachings over here on bipolar 3 transistors applicable to field-effect transistors? 4 MR. WHITEHURST: Object to form. 5 THE WITNESS: In some aspects, yes. In 6 some aspects, no. There's no emitter or base or 7 collector in a bipolar -- in a MOSFET device. They 8 have source, channel, and drain. So the structures 9 are different. 10 Whereas bipolar devices work with minority 11 carriers and diffusion, a MOSFET works with a gate 12 electrode and a channel. They're a different 13 structure. 14 BY MR. SHARMA: 15 Q In this paragraph Andy Grove refers to an 16 electric field. 17 Do you see that in the second sentence -- 18 MR. WHITEHURST: Are you looking at where 19 the section begins with "b. Graded Base Regions," 20 or are we looking at the next page? 21 MR. SHARMA: I'm looking at page which is 22 on the -- shown on the screen, which is page 4 of 5
194 1 MR. WHITEHURST: Objection. Scope, 2 relevance. 3 THE WITNESS: Let me review these -- let me 4 review at least starting at section b on 320 -- 5 where this section starts. 6 BY MR. SHARMA: 7 Q Sure. 8 A So the question is do I disagree with 9 Andy Grove's passage here? 10 Q Yes. 11 A I don't have any reason to disagree with 12 Andy Grove's passage. This passage is regarding 13 a -- not a MOSFET device but a bipolar device with a 14 base collector and emitter. 15 The first sentence of the background of the 16 '195 patent starts with: 17 "Bipolar junction transistors are 18 minority carrier devices..." 19 So they are a bit different than MOSFETs. 20 So with that understanding, the -- I don't -- yeah, 21 I don't see any reason to disagree with his 22 textbook. You know, as far as bipolar transistors	196 1 of Exhibit -- 2 MR. WHITEHURST: And so have you had a 3 chance to read the entire document? 4 BY MR. SHARMA: 5 Q So, Dr. Glew, do you see a reference to 6 "electric field" now? 7 A Let me clarify where you're pointing. This 8 is under Figure 7.14? 9 Q Yes. 10 A "Thus an electric field must be 11 present, pushing the electrons 12 toward the emitter-base junction"? 13 Q Yes. 14 A I see that, yes. What is the question? 15 Q Yeah. It says over here -- and is the 16 electric field created by the impurity concentration 17 gradient mentioned in the same paragraph? 18 MR. WHITEHURST: Object to form. 19 THE WITNESS: Okay. And what is the 20 question again? I'm sorry. 21 BY MR. SHARMA: 22 Q Yeah, the question was: Is the electric

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197 1 field mentioned in Andy Grove's book on page 4 of 5 2 created due to the impurity concentration gradient? 3 MR. WHITEHURST: Object to form. 4 THE WITNESS: Do you have the rest of the 5 chapter available? 6 BY MR. SHARMA: 7 Q No, I don't. This is all I have, so... 8 A Yeah. I'd probably need to review this 9 chapter to understand what exactly is going on here. 10 Q Okay. Let me ask you the next question. 11 So, just to verify, that by -- without 12 looking at the rest of the chapter, you can't tell 13 whether the electric field mentioned over here is 14 due to the impurity concentration gradient; is that 15 correct? 16 A Yes. This is a bipolar device, so I'd need 17 to get some more context on what they're talking 18 about with this stuff. 19 Q Okay. And then let me ask you next 20 question on this one. 21 Later on, the book states in the middle: 22 "Thus the injected minority carriers	199 1 pages 224 and 225, right? 2 A I believe they were, yes. 3 Q Okay. 4 Brendon, can you go back to file history, 5 that Exhibit 1016? If you scroll down a little bit 6 more. 7 And do you see sentence that begins with 8 "Yet, this argument appears to not consider" at the 9 bottom of page 6 of 10, Dr. Glew? 10 A I see that text you've read, yes. 11 Q Yeah. And this sentence goes on from 12 page 6 to page 7. Do you see that? 13 A Yes. 14 Q Let me read you a portion of the sentence 15 over here which goes on to page 7. And in this 16 portion GreenThread states: 17 "...whereby the 'direction' of the 18 electrical field and the resulting 19 direction of the carrier movement 20 depends solely on the slope of the 21 graded concentration of dopant." 22 Do you see that?
198 1 will now move...only by diffusion but 2 also by drift due to the existence of 3 this electric field." 4 Do you see that? 5 MR. WHITEHURST: Object to form. 6 THE WITNESS: You're still under 7 Figure 117? 8 BY MR. SHARMA: 9 Q Yes. Figure 7.14. 10 A I see what you've read. 11 Q Okay. Now, without having the benefit of 12 the rest of the chapter, do you agree with the 13 statement made over here? 14 MR. WHITEHURST: (Inaudible.) 15 (Interruption by the reporter.) 16 MR. WHITEHURST: Yes. Object to form. 17 THE WITNESS: Without having the benefit of 18 the rest of the chapter, I can't agree to what 19 they're discussing here for this bipolar device. 20 BY MR. SHARMA: 21 Q Okay. But the two pages that were cited -- 22 mentioned in the office action by GreenThread were	200 1 A Yes. 2 Q Do you agree with the statement that 3 GreenThread made over there? 4 A Well, I -- without reading the rest of the 5 document, I can't agree to all of it. I can agree 6 to the part I understand without any context, which 7 is that an electric field can have a direction -- 8 electric fields have directions. 9 You know, when it -- as it, you know, goes 10 on, I can't one way or the other agree or disagree 11 without looking at more of the document because I 12 don't have it, off the top of my head, the history 13 associated with this long discussion -- very long 14 back-and-forth discussion between the patent office 15 and the patentee with respect to this one passage. 16 MR. WHITEHURST: Counsel, we've been going 17 for an hour. Is this a good time for a break? 18 MR. SHARMA: Let me ask you just couple 19 more questions, then we're done with this, Doctor, 20 if you don't mind, just five more minutes. So... 21 MR. WHITEHURST: Do you want a break? 22 THE WITNESS: I think a break would be

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201 1 good, yeah. 2 MR. SHARMA: Okay. You want to go? Okay. 3 Let's take a break, then. 4 (Interruption by the reporter.) 5 MR. WHITEHURST: I said we're going off the 6 record. 7 (Recess taken from 2:09 p.m. 8 to 2:26 p.m.) 9 MR. SHARMA: Brendon, if you can go on to 10 page 136 of the file history. 11 BY MR. SHARMA: 12 Q Dr. Glew, what we have in front of us on 13 the screen -- are you able to see the screen? 14 A Yes. 15 Q Okay. What I have is an office action from 16 the examiner. And the mailing date is December 30, 17 2009. Do you see that? 18 A Yes. 19 Q Okay. 20 Brendon, if you go down to page 139 towards 21 the bottom. Yeah. If you keep scrolling, you can 22 see both 139 and 140.	203 1 reads on the claim." 2 Do you see that sentence? 3 A I see that sentence. 4 Q Yeah. Do you recall reviewing the sentence 5 or seeing this -- running into this when you were 6 reviewing the '195 file history? 7 (Interruption by the reporter.) 8 MR. SHARMA: Sure. 9 BY MR. SHARMA: 10 Q Dr. Glew, do you recall seeing the 11 statement from the examiner when you were reviewing 12 the '195 file history? 13 A This excerpt alone is about 400 pages. I 14 don't recall particular sentences from it. So no, 15 not off the top of my head. 16 Q Okay. But -- 17 A I understand that this was a -- generally a 18 subject of back-and-forth between the office and the 19 applicant. 20 Q And you mentioned earlier that you had 21 glanced at the '195 file history. 22 So when you glanced it, you would have
202 1 Yeah. Ask you a sentence over here from 2 the examiner's statement, and I check with you if 3 you -- sitting here, you can give your opinion on 4 that. 5 If you look at the last two lines of 6 page 139, do you see a sentence that begins with 7 "Note that applicant"? 8 A This is the paragraph starting with 9 "However"? Yes. Okay. 10 Q Yeah. Yeah. 11 A Okay. Is there a question pending? 12 Q Yeah. Do you see a sentence that begins 13 "Note that applicant"? 14 A Yes. 15 Q Okay. So in this paragraph I think the 16 examiner is talking about some prior art. And the 17 examiner remarks over here in the second sentence 18 begins with: 19 "Note that applicant has not claimed 20 a specific magnitude of the drift 21 electric field and hence any magnitude 22 of the drift...field, however small,	204 1 considered this portion in reviewing -- in coming up 2 with your opinions; is that correct? 3 A If I had considered it a necessary part of 4 some point I was rebutting, I would have probably 5 cited to it. You know, there are a lot of 6 back-and-forth between the office and the applicant 7 that get resolved eventually. 8 And citing to something in the middle of a 9 discussion isn't always the most useful way to 10 understand an issue. 11 Q Okay. Now, in paragraph 50 of your expert 12 report, Exhibit 2057, you mention that magnitude 13 plays an important role. Do you recall that? 14 A In paragraph 50? 15 Q Yes. 16 A Okay. Of my report? 17 Q Yes. 18 A Okay. I am there. 19 Q You mention in paragraph 50 that magnitude 20 plays an important role. Do you see that? 21 A Yes. 22 Q So, sitting here today, do you know whether

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205 1 you agree or disagree with the examiner? 2 MR. WHITEHURST: Object to form. 3 THE WITNESS: I understand the examiner was 4 probably referring to a claim at this point in the 5 patent application process. So without further 6 review of what the status of the claims were at this 7 point in time, I can't tell you one way or the 8 other. 9 I think generally the claims were resolved 10 so that they clearly wouldn't read on any -- any 11 electric field, no matter how small it was. So 12 that's my general understanding without further 13 review. 14 As you noted, I wrote in paragraph 50 that 15 the magnitude matters, that a small magnitude would 16 not necessarily make a difference. A larger 17 magnitude might make a difference in a general 18 scenario. 19 You know, in an example like Grove where he 20 talks about a -- you know, a strongly -- region -- 21 (Interruption by the reporter.) 22 THE WITNESS: -- a quite strongly graded	207 1 DOCUMENT TECH CUENCA: Oh, I'm sorry, 2 Counsel. 3 MR. SHARMA: Keep going. Page number -- 4 column No. 4. Just keep going. There we go. 5 That's, two, three. Okay. Zoom in. Claim 1. 6 BY MR. SHARMA: 7 Q Dr. Glew, if you refer to the hard copy of 8 '195 patent, let me ask you, you see claim 1? 9 A Yes, I see claim 1. 10 Q Yeah. And the preamble says: 11 "A CMOS semiconductor device 12 comprising..." 13 Do you see that? 14 A I see that. 15 Q Yeah. Is this an apparatus claim? 16 A Yes, this is an apparatus claim. It is not 17 a process claim. 18 Q If a device has been manufactured according 19 to the claims of '195 patent and the semiconductor 20 device is sitting on the shelf, i.e., it's not 21 plugged in, will claim 1 read on such a device? 22 A As I understand the claims, a device,
206 1 region, that's one thing. You know, then there are 2 going to be situations where it's so weakly graded, 3 that it would make no difference at all. 4 BY MR. SHARMA: 5 Q So just to verify, so did you consider this 6 portion of the file history when you were rendering 7 opinions shown in paragraph 50 of your report? 8 A As I said, I glanced at the file history, 9 focusing probably more on the final versions of the 10 claims and the arguments that got there. 11 I don't -- in rebutting opposing expert or 12 Dr. Banerjee, I don't think he particularly brought 13 up this point -- or specifically brought up this 14 passage. So I'm not sure I specifically rebutted 15 any comments on this passage from him. 16 MR. SHARMA: Okay. Let's move to '195 17 patent, Brendon, that's on the screen, the real 18 Exhibit 2 of Glew that is '195 patent, which is also 19 Exhibit 1001. If you can go to page -- let me 20 see -- or column 4. And go to claim 1, Brendon, on 21 column 4. Keep going on column 4, Brendon. That 22 should be almost the last page, if you keep going.	208 1 whether it was plugged in or not, would still be 2 able to meet the claim elements. 3 Q If such a device would not have any power 4 to it, there wouldn't be any gate voltage applied. 5 But you believe that claim 1 would meet the 6 requirements? 7 A Yes. I understand that the -- a device, 8 plugged in or not, would be able to exhibit each of 9 the claim elements required by claim 1 of the '195. 10 Q Okay. And claim 1, starting from line 8 11 down to line 29, lists bunch of limitations. Do you 12 see that? 13 A I mean -- you said line 8? You mean -- 14 Q Yeah. Line -- sorry. I misspoke. Yeah, 15 if you look at column 4, line about 13 to 29 lists 16 claim 1 of '195 patent. Do you see that? 17 A Yes, I see claim 1 of the '195 patent 18 there. 19 Q And in that portion from line 12 to 20 line 29, claim 1 recites several structural steps. 21 Sorry. Let me say that -- start again. 22 The column 4 of '195 patent, from lines 12

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209 1 to 28, recites several structural elements or 2 structural limitations; is that correct? 3 A One could characterize them as structural 4 limitations, yes. This is an apparatus, and these 5 are structures described in the claim. 6 Q And the structure limitations that are 7 recited in claim 1 do not require any particular 8 steps to be performed; is that correct? 9 A It's not a process patent claim. It's an 10 apparatus. So the limitations -- the requirements 11 do not require a specific process. The realities of 12 manufacturing are that one must make it, but that's 13 not -- how one makes it isn't claimed in the 14 elements of this apparatus claim. 15 Q Yeah. And how a CMOS device operates is 16 also not claimed in claim 1; is that correct? 17 A I would say generally how a CMOS apparatus 18 or CMOS device operates isn't exactly a claim 19 element. There are aspects of these claims that 20 describe what some of these structures do. 21 But I wouldn't characterize that as the 22 general operation of a CMOS.	211 1 claims. 2 Q Okay. Okay. Just looking at the 3 disclosure of the '195 patent, does the patent 4 discuss enhanced resistance of silicon? 5 A Are you talking about the specification or 6 a claim element? What exactly -- 7 Q Specification. 8 (Interruption by the reporter.) 9 MR. SHARMA: Sure. Let me start from 10 scratch so that this -- we are clear. 11 BY MR. SHARMA: 12 Q Looking at the specification of the '195 13 patent, Dr. Glew, does the patent discuss inherent 14 resistance of silicon? 15 MR. WHITEHURST: Object to form. 16 (Interruption by the reporter.) 17 MR. WHITEHURST: Yes. Object to form. 18 THE WITNESS: Well, it discusses base 19 resistance. 20 Base resistance is going to be lower than 21 the bare silicon resistance because it's doped. So 22 I think clearly -- one of skill in the art would
210 1 Q And none of the structural limitations of 2 claim 1 specify a particular step that needs to be 3 performed like a method claim; is that correct? 4 A Claim 1 is not a process or method claim. 5 It's really an apparatus claim. It's describing 6 structures here. 7 Q All the claims that GreenThread has 8 asserted in this litigation are apparatus claims; is 9 that correct? 10 A Hadn't thought about it that way, but I -- 11 sounds about right. I -- yeah. 12 Q Were you done, Dr. Glew? 13 A Yeah. You know, to be positive on that, 14 I'd have to review all the claim elements. But -- 15 I'm done. 16 Q Okay. Sitting here right now, you don't 17 believe that GreenThread is asserting any method 18 claims; is that correct? 19 A Sitting here right now, I recall apparatus 20 claims. But to be sure of that, I'd have to 21 review -- you know, I can't testify that there 22 aren't method claims, but I don't recall method	212 1 understand that silicon has resistance, and it does 2 discuss resistance of devices. 3 BY MR. SHARMA: 4 Q Dr. Glew, are you referring to column 2, 5 line 54, 55? 6 A Yes. At approximately -- actually, in the 7 '195, I think it's 56, it reads: 8 "The 'average' base resistance is 9 optimized so that conductivity 10 modulation and lifetime (for minority 11 carriers) in base region are not 12 compromised." 13 So, yes, it does have that in it. 14 Q Mm-hmm. And that's discussing a transistor 15 that is not a CMOS transistor; is that correct? 16 A Yes. The discussion there is a -- well, 17 it's an integrated-gate bipolar transistor, an IGBT, 18 so it has elements of CMOS and elements of bipolar. 19 So it's got that gate in it that's similar to 20 bipolar -- or excuse -- similar to CMOS. But it's 21 not a pure CMS device, no. 22 Q And does the '195 patent discuss how

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213 1 resistance impacts movement of minority carriers 2 from surface layer to substrate? 3 A I'm not sure that I, off the top of my 4 head, know of a citation from the patent where it 5 discusses resistance in the context of -- from the 6 surface toward the base for minority carriers. 7 It does discuss, in that passage I just 8 cited to at column 2, line 56, that conductivity 9 modulation is not compromised when the base 10 resistance is optimized. 11 So there's the teaching of better 12 performance through optimization resistance. 13 I don't think one of skill in the art needs 14 to be taught that resistance affects current flow. 15 Q Just so I get your position right, so you 16 understand -- your statement is -- look at column 2, 17 line 53 to 56 -- when the patent is talking about 18 average base resistance, to a person skilled in the 19 art, it is talking about how resistance would impact 20 movement of minority carriers from surface there to 21 substrate? 22 (Interruption by the reporter.)	215 1 Q Can you point me somewhere in column 2 or 2 column 3 where the patent mentions how much 3 magnitude of concentration gradient is needed to aid 4 carrier movement? 5 (Interruption by the reporter.) 6 MR. SHARMA: To aid carrier movement, 7 a-i-d. 8 THE WITNESS: Well, you know, going to 9 column 2, starting at line 35, the '195 patent reads 10 as follows: 11 "The relative doping concentrations 12 of emitter and collector varies" -- 13 "regions varies from 10 to the 18th to 14 10 to the 20th per centimeter cubed, 15 whereas as the base region is 10 to the 16 14th to 10 to the 16th centimeters cubed 17 depending on the desired characteristics 18 of the BJT. In graded base p-n-p 19 transistors, the donor dopant 20 concentrations may be 10 to 100 times at 21 the emitter-base junction, relative to 22 the base-collector junction."
214 1 BY MR. SHARMA: 2 Q -- movement from -- movement of minority 3 carriers from surface to the substrate? 4 A That's not exactly a fair characterization 5 of what I said. 6 Essentially there is a teaching in the 7 patent about the benefit of optimizing resistance to 8 optimize conductivity modulation. However, one of 9 skill in the art does not need to be taught about or 10 informed how resistance affects current flow. 11 Q Does the '195 patent discuss magnitude of 12 the concentration gradient? 13 A Well, you know, in a general sense, the 14 patent discusses concentration gradients. So I 15 think inherent in the discussion that there is even 16 a gradient, a change in magnitude from one position 17 to the next, there is the acknowledgment and 18 teaching that the concentration matters. 19 Not only does the concentration matter, the 20 gradient in the concentration matters. 21 So I think at face value, that is the 22 teaching of this patent.	216 1 Then it goes on to describe: 2 "The gradient can be linear, quasi 3 linear, exponential or 4 complimentary [sic] error function. The 5 relative slope of the donor 6 concentration throughout the base, 7 creates a suitable aiding drift electric 8 field, to help the holes (p-n-p 9 transistor) transverse from emitter to 10 collector. Since the aiding drift field 11 helps hole conduction, the current gain 12 at a given frequency is enhanced, 13 relative to a uniformly-doped-(base) 14 BJT. The improvement in the cut-off 15 frequency (or, frequency at unity gain, 16 $f_{sub T}$) can be as large as 2X to 5X. 17 Similar performance improvements are 18 also applicable to n-p-n transistors." 19 I read from column 2, lines 35 through 20 line 50. So that would be one example at the 21 beginning of the detailed description of the 22 invention that gives concentrations and shapes of

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217 1 the gradients that might be used to give the 2 performance. 3 BY MR. SHARMA: 4 Q The paragraph you read on column 2 from 5 line 35 to 50 does specify the minimum magnitude of 6 the gradient needed to aid movement of the carriers? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: It gives typical slopes. For 9 example, linear, quasi linear, exponential, or 10 complementary error function. 11 It gives examples of dopant concentrations 12 as: 13 "10 to 100 times at the emitter-base 14 junction, relative to the base-collector 15 junction (1X)." 16 It doesn't describe that it can go as low 17 as X, if that is your question. 18 BY MR. SHARMA: 19 Q Yeah, that is my question. As described, 20 this is a minimum magnitude of the gradient one 21 needs to aid carrier movement? 22 Is that described in passage you read	219 1 Does the '195 patent mention stress in the 2 lattice? 3 A It doesn't explicitly refer to stress in 4 the patent. One of skill in the art, a POSITA, 5 would understand that every film in a semiconductor 6 has stress. 7 I'm not aware of a -- of stressless films, 8 for the most part. Given that there are dozens to 9 hundreds of layers in a semiconductor device, nearly 10 all of them will have stress. So this is a common 11 thing in semiconductors. Some will be tensile. 12 Some will be compressive. 13 Q But the '195 patent does not explicitly or 14 expressly mention stress of the lattice impacting 15 how the carriers move; is that correct? 16 MR. WHITEHURST: Object to form. 17 THE WITNESS: I don't, off the top of my 18 head, see a citation to stress; however, one of 19 skill in the art would understand that stress and -- 20 often called "strain engineering" is routine and 21 used to help one type of carrier while, 22 unfortunately, adversely impacting the carrier of
218 1 from -- on column 2 from line 35 to 50? 2 A It doesn't give the minimum value in terms 3 of a number. It does require that it provide aid or 4 help. It uses language such as "creates a suitable 5 aiding drift electric field, to help the 6 holes...transverse from emitter to collector." 7 And then it refers to it as an "aiding 8 drift field." So it needs to be sufficient to 9 provide aid and some sort of performance increase. 10 Q And you mentioned on column 2, line 40, the 11 specification states various types of gradients: 12 linear, quasi linear, exponential, or 13 complementary error function. Do you see that? 14 A Yes. 15 Q The specification does not describe a slope 16 the gradient must have in order to aid carrier 17 movement; is that correct? 18 A It provides the shape of the line from 19 which a slope would derive, but it doesn't give -- 20 doesn't put numbers on the gradient, if that's your 21 question. 22 Q Yeah, that was my question.	220 1 opposite polarity. 2 BY MR. SHARMA: 3 Q So let's go back to column 2, line 35. And 4 you mention the doping concentration that I 5 mentioned over there on line 35 and 36 and 37. Do 6 you see that? 7 A I see that generally, yes. 8 Q Okay. It simply mentions the concentration 9 at one end and also the concentration at the other 10 end. Do you see that? 11 A Yes. 12 Q And the line 35, 36 gives you that doping 13 concentration of the emitter and collector; is that 14 correct? 15 A Your question was it gives you the 16 concentrations? What was -- I'm -- 17 Q Yeah. In lines 35 and 36, it states: 18 "The relative doping concentrations 19 of emitter and collector..." 20 Do you see that? 21 A Yes. 22 Q It does not specify what the slope of the

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221 1 doping concentration is going to be. 2 MR. WHITEHURST: Object to form. 3 THE WITNESS: The shape of the slope is 4 described later at column 2, line 40, roughly. 5 BY MR. SHARMA: 6 Q But lines 35 to 38 of column 2 don't 7 specify the magnitude of the slope; is that correct? 8 A Lines 35 through 38 describe ranges of 9 dopant concentrations in the emitter and collector 10 as well as the base region. 11 Later on at row 40, it describes the shape 12 of the gradient: linear, quasi linear, 13 exponential, or complementary error function. 14 Q Okay. But none of them provide the 15 magnitude of the slope or the magnitude of gradient; 16 is that correct? 17 MR. WHITEHURST: Object to form. 18 THE WITNESS: No. I think one of skill in 19 the art would adjust accordingly, as line 35 through 20 38 reads -- and I'll just read the end of it: 21 "...depending on the desired 22 characteristics of the BJT."	223 1 frequency (or, frequency at unity gain, 2 fT) can be as large as 2X to 5X. 3 Similar performance improvements are 4 also applicable to NPN transistors." 5 So given the concentration, the slope of 6 the gradient and the performance to achieve 2X to 7 5X, one of skill in the art should be able to 8 properly engineer this device here to create 9 something. 10 BY MR. SHARMA: 11 Q And the magnitude of gradient would depend 12 upon the size of the emitter-collector and the base 13 regions; is that correct? 14 THE WITNESS: What this passage or 15 paragraph from 35 to row 50 of line 2 describes is 16 that, given a performance improvement of 2 to 5X and 17 typical gradients of certain shapes -- linear, quasi 18 linear, exponential, or complementary error 19 function -- that would determine the shape and 20 amount of doping gradients. 21 So I think size -- the size of the 22 transistors is a matter of something that would be
222 1 So the characteristics of the device will 2 drive the actual concentrations that one needs. 3 BY MR. SHARMA: 4 Q Right. But that does not mention how you'd 5 decide the magnitude of the concentrations of the 6 gradient; is that correct? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: Well, given the 9 characteristics of the device that one desires, one 10 would pick the concentration. That's presumed that 11 one of skill in the art would be able to do. And it 12 says: 13 "Depending on the desired 14 characteristics of the BJT." 15 So one would establish the concentration as 16 a normal course of one's duties. Next, it describes 17 that one can provide a certain slope to the 18 concentration gradient. At line 40, describes 19 "linear, quasi linear, exponential or 20 complimentary [sic] error function." 21 And then at line 47 it reads: 22 "The improvement in cut-off	224 1 included in the design based on those main 2 parameters. 3 BY MR. SHARMA: 4 Q Okay. But the paragraph you read just now 5 on column 2 does not specify the size of the 6 emitter, collector, or the base region; is that 7 correct? 8 MR. WHITEHURST: Object to form. 9 THE WITNESS: I believe that one of skill 10 in the art would base the concentration of the 11 dopants on the size. The larger the size, the 12 longer it takes carriers to traverse the emitter, 13 collector, and base. 14 So given the concentration ranges, the 15 shapes of the gradients, and the performance 16 improvement to achieve 2X to 5X, one would be able 17 to determine a properly engineered product as a 18 normal course of one's duties as an engineer in this 19 field. 20 BY MR. SHARMA: 21 Q And this would be true as of the filing 22 date of the patent, which is September 3, 2004?

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225 1 A Yes, it would. These -- you know -- how 2 should I put this? These devices existed at this 3 time, and people were engineering these devices. 4 This is suggesting a new way to design devices based 5 upon gradients, gradients having a certain shape, 6 achieving improvements in cutoff frequencies of a 7 certain magnitude, 2X to 5X. 8 MR. SHARMA: Let's go on to a different 9 exhibit. Brendon, could you bring up Exhibit 10 No. 1007? 11 DOCUMENT TECH CUENCA: Sure thing, Counsel. 12 Stand by. 13 (Deposition Exhibit 5 was marked for 14 identification.) 15 BY MR. SHARMA: 16 Q So what we have here is US Patent No. 17 6,043,114 with the first inventor listed as 18 Mr. Kawagoe. It's marked as Exhibit 5. It is also 19 Exhibit 1007 in the IPR proceedings. 20 Let's go to Figure 23 of Kawagoe. 21 THE WITNESS: Okay. I have Kawagoe in 22 front of me. And I'm looking at Figure 23. Okay.	227 1 differently, but, just so the record's clear, let me 2 make my objection -- 3 THE COURT REPORTER: You have to speak up, 4 Mr. Whitehurst. 5 MR. WHITEHURST: Yes. Can you hear me 6 better now? 7 THE COURT REPORTER: Yes. Thank you. 8 MR. WHITEHURST: And my objection was based 9 on scope and relevance because this -- this goes 10 beyond the petition in this -- these IPRs. 11 BY MR. SHARMA: 12 Q Dr. Glew, can you answer the question? 13 A Could you repeat the question? 14 Q Yeah. My question was: In Figure 23 of 15 Kawagoe, does "4P" refer to a PMOS transistor? 16 MR. WHITEHURST: Objection. Scope, 17 relevance. 18 THE WITNESS: Can you -- I'm sorry. Can 19 you direct me to my report and where I analyze that 20 transistor? 21 BY MR. SHARMA: 22 Q Without looking at your report, can you
226 1 BY MR. SHARMA: 2 Q Dr. Glew, Figure 23 shows two transistors, 3 a PMOS on the left and an NMOS on the right; is that 4 correct? 5 A Yes. There are two transistors shown in 6 Figure 23. 7 Q And the transistor on the left marked "4P" 8 is a PMOS transistor; is that correct? 9 A I have noted that there is an n-well, "6n," 10 in Figure 23. 11 I don't believe I've analyzed that 12 transistor beyond -- well, I've noticed that there's 13 an n-well there, yes. 14 Q So do you know in Figure 23, does "4P" 15 refer to a PMOS transistor? 16 MR. WHITEHURST: Objection. Scope, 17 relevance. This goes beyond the petition in this 18 IPR. 19 THE COURT REPORTER: "This goes beyond the 20 petitioner's IPR"? 21 MR. WHITEHURST: That's correct. 22 I believe that I stated it slightly	228 1 answer my question? And if you cannot, you can 2 state so. 3 A That would -- I don't believe I've analyzed 4 that transistor in my report, and I wouldn't be able 5 to do so at this time. 6 Q Okay. So, sitting here right now, without 7 the benefit of your report, you do not know whether 8 4P in Figure 23 refers to a PMOS transistor; is that 9 correct? 10 MR. WHITEHURST: Object to form. 11 THE WITNESS: No. I have the benefit of my 12 report. I have my report in front of me. It's -- I 13 have it electronically from you, and I have a hard 14 copy. But with the benefit of my report, it doesn't 15 appear that I've analyzed that transistor that you 16 refer to. 17 BY MR. SHARMA: 18 Q Okay. Let's move on to the transistor on 19 the right. 20 Do you know, in Figure 23, does "4N" refer 21 to NMOS transistor? 22 A My understanding is that 6P is a p-well and

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229 1 4N generally refers to -- likely refers to an n-type 2 transistor, yes. 3 The text describes that 4NB and 4NA are 4 sources and drains of electron-rich material. 5 Q And the substrate shown in Figure 23 is a 6 p-type; is that correct? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: As I've noted in paragraph 59 9 of my report, all three materials are p-type without 10 any n-type. "(1) the channel of NMOS 4N made from 11 the p-well." 12 The p-well and the P substrate are all 13 doped p-type. So that is my understanding on 14 page 36, the end of paragraph 59, in my report. 15 BY MR. SHARMA: 16 Q Figure 23 shows element in the middle, 17 No. 3. Do you see that? 18 A Yes, I see item No. 3 in Figure 23. 19 Q And Kawagoe calls element No. 3 to be an 20 insulating film. 21 Did you agree with that? 22 A I describe in paragraph 63 of my report on	231 1 BY MR. SHARMA: 2 Q And you refer to LOCOS as L-O-C-O-S, all 3 uppercase; is that correct? 4 A The patent refers to LOCOS at column 11, 5 line 30. 6 Q And in the LOCOS method, is it correct that 7 the silicon in the substrate is oxidized to create 8 silicon dioxide? 9 A Yes. Usually a gas or steam is used to 10 oxidize the silicon to form silicon oxide from the 11 preexisting silicon but adding the oxygen from the 12 vapor source. 13 Q Let's go to column 8, line 40. 14 THE COURT REPORTER: Mr. Sharma, pardon the 15 interruption, but is there any way you could move 16 your camera or move the document that you're reading 17 from so that I can see you a little bit better? 18 MR. SHARMA: Okay. How's that? 19 THE COURT REPORTER: That's great. But you 20 look down, and all I can see is the top of your 21 head. 22 MR. SHARMA: Sometimes I'm reading from the
230 1 page 38 and 39 that: 2 "Field insulating film 3 is formed 3 'over the principal surface of the 4 epitaxial layer 2E." 5 So, yes, that's my understanding, that 3 is 6 a field insulating film. 7 Q Okay. And if you go to column 11, line 28, 8 of Kawagoe patent -- 9 A Let me get there. 10 Yes, I am at 11/28. 11 Q Yes. If you look at paragraph from 11/28 12 to 11/35, does Kawagoe explain how the field 13 insulating film 3 is created? 14 A It generally describes in that section 15 using LOCOS, which is local oxidation of silicon. 16 I'm familiar with that method. Silicon is basically 17 oxidized with a gas, the thermal oxidation method or 18 the like it describes, about 180 angstroms thick. 19 (Interruption by the reporter.) 20 THE WITNESS: Angstroms, a-n-g-s-t-r-o-m-s. 21 Ten to the minus 10 meters is an angstrom. 22 ///	232 1 document, so I have to look down a little bit. 2 BY MR. SHARMA: 3 Q Okay. Dr. Glew, are you at column 8, 4 line 40? 5 A Yes. 6 Q In column 8, line 43 to 45, Kawagoe 7 mentions a channel stopper region. Do you see that? 8 A Yes, I see that. 9 Q Okay. Do you know what is the purpose of 10 the channel stopper region is? 11 A A channel -- a channel stopper region is to 12 stop the spread of the channel. So the field oxide 13 that we see here, we're only seeing in one 14 dimension. The wells -- like, for example, 6p is 15 essentially rectangular. 16 So there would be a field oxide all the way 17 around the rectangle. And we're seeing one view. 18 On the -- out of the page or in the page, though, 19 the channel may spread. And so there is sometimes a 20 material put there to stop the spread of the 21 channel. 22 Q Okay. And here Kawagoe states in line 43

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1 of column 8 that: 2 "A channel stopper region is formed 3 below the field insulating film 3." 4 Do you see that? 5 A I see that, yes. 6 Q And that's the same field insulating film 3 7 that's shown in Figure 23 of Kawagoe; is that 8 correct? 9 A It may -- it may actually only be under 10 parts of field oxide 3, the FOX. 11 So the channel, as we see into the page, is 12 in the middle of the transistor. So the greater 13 risk is actually in the page and out of the page on 14 the view we don't see from this channel bleeding 15 into the devices in the next channel adjacent to it 16 where they are closest. 17 Q Okay. But Kawagoe does not put any 18 requirements on the channel stopper region. 19 It simply states that formed below the 20 field insulating film 3, correct? 21 (Interruption by the reporter.) 22 ///	1 Q Do you have any reason to doubt that 2 Kawagoe is incorrect when it says the channel 3 stopper region is formed below the field insulating 4 film 3? 5 A I'm not doubting Kawagoe. I'm just 6 understanding Kawagoe in that it needs the -- the 7 channel stopper needs to be next to the channel. 8 Here it's next to the source-drain, which is fine. 9 The channel stopper would be under another 10 portion of the field oxide because the field oxide 11 is actually a rectangle. It goes around the 12 rectangular well. 13 But the long side of the -- or let's say 14 the side that's cut away here that we don't see, 15 that's the side that the channel is exposed to the 16 channel of the device next to it in the adjacent 17 well. 18 Here, the field oxide is next to the source 19 or drain of 4N. So it's not really very close to 20 the adjacent channel. 21 So I don't understand that it's necessarily 22 shown under items 3 shown in this figure because
1 BY MR. SHARMA: 2 Q That the channel stopper region is formed 3 below the field insulating film 3; is that correct? 4 A He provides a small amount of detail that 5 one of skill in the art would understand. Where 3 6 is shown right now, it's not next to the channel. 7 It's next to the source or drain of 4N. 8 In order to protect the channel, it would 9 need to be on the side of the device that's not 10 shown in this cutaway. This cutaway is just a 11 portion of a rectangular well. 12 So on the side -- on the edge that is in 13 the page or out of the page of this rectangle 14 that's -- we're seeing a cutaway of, that is where 15 the channel needs to be blocked so that -- because 16 it's adjacent to the transistors in the well next to 17 it there. 18 If it was -- the reason it's not shown 19 here, in part probably, is because this is not where 20 the channel stopper needs to go. It needs to go 21 under the field oxide but in these views that are 22 cut away.	1 it's cut away. But it would be shown under other 2 parts of item 3 where it's adjacent to the channel. 3 Q And do you agree that the purpose of field 4 insulating film 3 is to isolate the transistors 5 shown in Figure 23? 6 A Basically, field oxides like LOCOS like 7 this that are of an older generation were there in 8 order to keep current leaking from one well to the 9 adjacent well. At that time wells were fairly 10 large, so the field oxides were fairly shallow. 11 In the future what happened was that this 12 didn't work anymore, wasn't deep enough, so the 13 industry largely went to shallow trench isolation, 14 which was a trench that went much deeper and was 15 actually deposited. 16 As this patent describes, the '114 Kawagoe, 17 the field oxide is about 18 nanometers thick, which 18 is only maybe 100 atoms, you know, 100 to 200 atoms. 19 It's a very thin layer. It's difficult to make 20 oxidation of silicon very thick. 21 So this may have worked a long time ago, 22 but this doesn't work nowadays. So there are

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237 1 actually trenches that are filled with the deposited 2 oxide and nitride usually that are much deeper. 3 Q Okay. Let's go to Figure 17 of Kawagoe. 4 A Okay. I am at Figure 17. 5 Q Figure 17 shows the impurity distribution 6 diagram of an IC that is shown in Figure 16; is that 7 correct? 8 A The '114 patent describes at column 14, 9 line 47, essentially, that -- in that paragraph, 10 that Figure 17 is an impurity distribution diagram 11 in the semiconductor integrated circuit device of 12 Figure 16. 13 Yes. 14 Q And Figure 17, the y-axis shows impurity 15 concentration; is that fair? 16 A The y-axis in Figure 17 is labeled 17 "Impurity Concentration" in atoms per centimeter 18 cubed. 19 Q And the x-axis shows depth from the surface 20 in microns; is that correct? 21 A Yes. Well, there's a typo, d-e-p-h-t. 22 Assuming that is a typo, that would be depth in the	239 1 p-well; is that correct? 2 A I'm sorry. Could you repeat that? 3 Q Yeah. So the curve that starts at N 4 subscript W shows the impurity concentration of the 5 p-well; is that correct? 6 A NW is the concentration of the well of the 7 well -- of the p-well. 8 Q And the concentration shown in Figure 17 of 9 p-well generally slopes downwards as one moves from 10 the surface into the substrate? 11 A I would, yes, generally characterize -- 12 (Interruption by the reporter.) 13 THE WITNESS: I would -- 14 MR. WHITEHURST: No, I did not make an 15 objection. Sorry. 16 THE WITNESS: I would generally 17 characterize that line as sloping downward from the 18 surface. 19 BY MR. SHARMA: 20 Q And the gradient shown in Figure 17 21 starting at N sub W would create an electric field; 22 is that correct?
238 1 units of microns, although there are no numbers on 2 the x-axis. So the micron moniker is sort of 3 meaningless. 4 Q And the bottom arrow in Figure 17 is 5 labeled "6p(6n)." Do you see that? 6 A I see that, yes. 7 Q Do you understand that to be referring to a 8 p-type -- a p-type well and an n-type well? 9 A Figure 16 indicates an n-well 6n and a 10 p-well 6p. I understand that's -- it would be 11 referring to that as Figure 17 refers to Figure 16. 12 Q So focusing on just the 6p, the p-well part 13 in Figure 17, do you see the curve "N subscript W" 14 labeled on the x-axis? 15 A I see the label "NW," yes. 16 Q Okay. And Kawagoe shows there is a curve 17 starting at NW generally sloping downwards and 18 eventually intersects the line labeled "W subscript 19 W" on the x-axis. Do you see that? 20 A I see that, yes. 21 Q And there's a curve that starts at N 22 subscript W shows the impurity concentration of	240 1 A I -- dopant concentration sloped as NW 2 is -- would create an electric field, yes. Whether 3 it was sufficient to do anything in the well is 4 another matter. 5 Q And in the p-well shown in Figure 17, you 6 have both holes and electrons present; is that 7 correct? 8 A There's no p-well, per se, shown in 9 Figure 17. This is a chart. 10 Q Does arrow that labels 6p -- does it 11 represent the start and end of the p-well? 12 A This arrow shows the -- a dimension of WW. 13 6p has that width. 14 If I look at Figure 16, I'm not seeing a 15 WW. 16 Figure 17 is simply a graph of the 17 concentration of the n-well -- of the p-well. 18 Q Okay. If you look at Figure 23, it shows a 19 6p p-well. 20 MR. WHITEHURST: Counsel, we've been going 21 about an hour and 20 minutes, but I don't want to 22 slow you down. But I do want to check how long

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241 1 we've been on the record. 2 Are you close to finishing, or do you still 3 have a fair amount outstanding? 4 Counsel, could you hear me? 5 MR. SHARMA: I could barely hear you, Alan, 6 so... 7 MR. WHITEHURST: I'm sorry. I said we've 8 been going about an hour and 20 minutes. And I 9 don't want to slow you down, but I do want to check 10 how long we've been on the record. 11 Are you close to finishing, or do you still 12 have a fair amount to cover? 13 MR. SHARMA: No, I don't have much to 14 cover, but I'm not about done yet either. So 15 let's -- if we've been going for an hour 20 minutes, 16 let me ask two more questions, then we can take a 17 break. So... 18 BY MR. SHARMA: 19 Q Dr. Glew, Figure 23 shows 6p, which is a 20 p-well? 21 A Yes. 22 Q Okay.	243 1 BY MR. SHARMA: 2 Q Is any carrier or electron or hole under 3 the influence of a field? 4 MR. WHITEHURST: Object to form. 5 THE WITNESS: Could you repeat that 6 question? 7 BY MR. SHARMA: 8 Q My question was: Will the gradient shown 9 in Figure 17 impact the electrons and holes shown in 10 p-well of Figure 23? 11 MR. WHITEHURST: Object to form. 12 THE WITNESS: And then let me ask again, 13 then. You're asking the word "impact" to mean what? 14 BY MR. SHARMA: 15 Q What's your understanding of word "impact"? 16 A I don't know how you're using it. 17 MR. WHITEHURST: We've been going for a 18 while. Unless you're going to clarify what "impact" 19 is, this is probably a good time to take a break. 20 BY MR. SHARMA: 21 Q Let me -- so in that case, it's just the 22 electrons and holes are present in the gradient
242 1 A I see that. 2 Q Okay. And the 6p shown in Figure 23 will 3 contain both electrons and holes? 4 A A p-well is majority holes. 5 Q So it will contain a majority of holes and 6 minority of electrons; is that correct? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: Generally, a p-type material 9 will have a majority of holes and a minority of 10 electrons. Basically -- or, in other words, a 11 p-type material has more holes than electrons. 12 So an intrinsic semiconductor has a equal 13 number of holes and electrons. A p-type doped 14 semiconductor region will have more holes than 15 electrons. 16 BY MR. SHARMA: 17 Q And the electric field that's created by 18 the gradient toward Figure 17 would impact both 19 electrons and holes in 6p p-well? 20 MR. WHITEHURST: Object to form. 21 THE WITNESS: How are you using the word 22 "impact"?	244 1 created by the -- or shown in Figure 17; is that 2 correct? 3 A Is that a new question? 4 Q No. I'm just clarifying what I mean by 5 "impact." 6 MR. WHITEHURST: Why don't -- so the 7 record's clear -- because I'm looking at the 8 transcript and it's not clear -- why don't you reask 9 a question that Dr. Glew can try to answer. 10 BY MR. SHARMA: 11 Q So let me repeat my question again. 12 Will the gradient shown in Figure 14 impact 13 the holes/electrons -- 14 MR. WHITEHURST: Object to form. 15 MR. SHARMA: I'm not done yet, Alan. 16 Start again. 17 BY MR. SHARMA: 18 Q Does the electric field created by the 19 gradient shown in Figure 17 act upon the electrons 20 and holes present in 6p-well in Figure 23? 21 MR. WHITEHURST: Object to form. 22 THE WITNESS: I can say, in general, an

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245 1 electric field will act on the charged particles. 2 There may or may not be any effect, meaning if the 3 charged particles are not free to move, then they 4 just stay where they are with a force acting on 5 them. 6 BY MR. SHARMA: 7 Q Okay. 8 A But any electric field will act on all 9 charged particles within its vicinity. 10 MR. SHARMA: Okay. Let's take a break. I 11 didn't realize we had gone for an hour and 20 12 minutes. So let's go off the record. 13 (Recess taken from 3:49 p.m. 14 to 4:14 p.m.) 15 MR. SHARMA: Okay. Brendon, can we go back 16 to the -- 17 MR. WHITEHURST: Can we get a read-on so we 18 know -- so it's 7:14. Can we get a "back on the 19 record"? 20 THE COURT REPORTER: Back on the record. 21 MR. WHITEHURST: Thank you. 22 MR. SHARMA: If you go to Figure 17,	247 1 disclosure of Kawagoe patent in embodiment 4 and 2 Figure 17, the device is not capable of aiding 3 carrier movement; is that correct? 4 A What I've written in my report regarding 5 this starts generally about page -- really 26 and 6 carries on for a few pages. 7 To summarize to some extent of what I've 8 written here over the course of a few pages in my 9 declaration, there's no disclosure of aiding carrier 10 movement. And not all electrical forces are 11 necessarily sufficient to aid carrier movement. 12 Kawagoe only discloses impeding 13 solar-generated alpha ray strikes from entering the 14 well. 15 Q And maybe put to the side Kawagoe for a 16 moment. 17 If you have any device with a gradient of 18 the dopant concentrations, would that device be 19 typical of aiding carrier movement? 20 MR. WHITEHURST: Object to form. 21 THE WITNESS: No. Not all devices with 22 doped -- graded dopant concentrations are able to
246 1 Brendon. 2 BY MR. SHARMA: 3 Q Dr. Glew, if a semiconductor -- 4 semiconductor device fabricated to make the dopant 5 concentration shown in Figure 17 of Kawagoe patent, 6 is that device capable of aiding carrier movement? 7 MR. WHITEHURST: Object to form. 8 THE WITNESS: Kawagoe doesn't disclose that 9 it aids carrier movement, only that it impedes 10 carrier movement into the well. 11 There's a specification in Kawagoe, and 12 there's no indication that it aids carrier movement. 13 The chart shown in Figure 17 lists impurity 14 concentration in atoms per centimeter cubed, but it 15 doesn't actually give number values. So there's 16 really no support that Kawagoe aids carrier 17 movement. 18 Not all electric fields generated by a 19 dopant gradients are sufficient to aid carrier 20 movement. 21 BY MR. SHARMA: 22 Q So your position is, by looking at the	248 1 aid carrier movement. It depends upon the magnitude 2 of the slope. 3 First, recall that the gradient is a 4 derivative. So when we say "gradient," we mean the 5 magnitude of the slope, the derivative in the 6 direction desired. 7 Then, of course, there are the factors of 8 the integrated circuit itself, which I've discussed 9 before, which can make it difficult for carriers to 10 move and impede their motion. 11 So the magnitude of the slope resulting in 12 a sufficient electric field being generated as well 13 as the encumbrances put upon charge carriers by the 14 materials and structure of the integrated circuit 15 determine whether or not the doping concentration 16 gradient aids in their motion. 17 MR. SHARMA: Okay. Then let's go back to 18 Dr. Glew's report, Exhibit 2057. And let's go to 19 page 30. 20 BY MR. SHARMA: 21 Q Dr. Glew, do you see a figure shown on the 22 screen which is from paragraph 52 of your report?

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249 1 A Yes, I do. 2 Q And do you see you have labeled the bottom 3 portion yellow and you have added the word "Kawagoe 4 carriers" over there. Do you see that? 5 A Yes, I recognize the annotations made to 6 the figure on page 5- -- page 30 of my report in 7 paragraph 52. 8 Q Are you referring to holes and electrons as 9 Kawagoe carriers in this figure? 10 A As I've noted in my report, at least at 11 paragraph 52: 12 "Dr. Banerjee" noted "in a footnote 13 that 'SEUs generate electrons produced 14 in the large substrate body below the 15 wells' -- far below the active region." 16 I understand that Kawagoe describes at 17 column 16, lines 7 through 11 that: 18 "Specifically, the electrons 19 produced by the alpha ray are attracted 20 to the substrate body 2S by the 21 concentration gradient and prevented 22 from entering the p-well..."	251 1 A Okay. Yes. I am on page 32. 2 Q And you see Figure 2, which is excerpted 3 from Exhibit 1009, which is the Wang reference? 4 A I see this figure, yes. 5 Q Okay. And in the text below the Figure 2, 6 you mention: 7 "Wang shows some carriers in the 8 active region." 9 Do you see that? 10 A Yes. I see my comment at the bottom of 11 paragraph 53. 12 Q Okay. Are you referring to Figure 2(a) of 13 Wang reference which shows carriers in the active 14 region? 15 A Let me review this paragraph. 16 I think I'm generally referring to the 17 disclosure as a whole. It does not disclose they 18 are problematic. 19 Do we have -- I may need to look at one 20 with -- I don't have Wang handy. I don't know if we 21 could... 22 Q Yes, we can do that.
250 1 So I am referring to electrons. 2 I further describe my analysis of 3 paragraphs 54 on page 32, paragraph 55 on page 33. 4 I've completed my answer. 5 Q Okay. So you didn't mean to imply that the 6 holes and electrons will exist only in the portion 7 labeled yellow on -- shown on paragraph 52; is that 8 correct? 9 MR. WHITEHURST: Object to form. 10 THE WITNESS: As I've noted in 11 paragraph 52, Dr. Banerjee confirms that alpha rays 12 produce electrons, not holes. So I think -- I don't 13 think there's any disagreement among the experts 14 that the alpha rays are producing electrons. 15 BY MR. SHARMA: 16 Q Okay. And you testified earlier that in -- 17 let me strike that. 18 Okay. Let's move on to the next page on 19 page 32 of your report. 20 Can you move on to two pages further? 21 A I'm sorry. Do you want me on page 32 or -- 22 Q Yeah. We're now page 32.	252 1 Brendon, could you upload Exhibit 1009? 2 DOCUMENT TECH CUENCA: Sure thing, Counsel. 3 Stand by. Let me stop sharing for one second. It 4 seems I do not have 1009. I'll double-check in the 5 downloads. 6 MR. SHARMA: Yeah. We uploaded that during 7 the depo. So it may not have been there last night. 8 So it's there now. 9 DOCUMENT TECH CUENCA: Gotcha. Give me one 10 second. 11 Okay. And give me another second just to 12 put it in the chat as well. 13 All right. It is in the chat as well. 14 (Deposition Exhibit 6 was marked for 15 identification.) 16 THE WITNESS: This is Exhibit 1009? 17 MR. SHARMA: Yeah. Let me mark Glew 18 Exhibit 6, which is a article titled "Single Event 19 Upset: An Embedded Tutorial," with the first author 20 as Wang. It's also marked as Exhibit 1009. 21 BY MR. SHARMA: 22 Q Let me ask you the question.

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253 1 If you could go to Figure 2, Brendon, and 2 can zoom in. Yeah. Yep. Go back up. Yeah. 3 And, Dr. Glew, the question is: Does 4 Figure 2(a) of Wang reference show holes and 5 electrons in the active region? 6 A Does it show holes or electrons in the 7 active region or does it show holes and electrons or 8 problems? 9 Q No. All I'm asking is whether Figure 2(a) 10 shows holes/electrons in the active region. 11 A The way I characterized Wang's Figure 2 in 12 my report, at paragraph 53, toward the bottom of 13 page 31, is that: 14 "Wang's Figure 2 -- just like 15 Kawagoe -- shows that SEU carriers are 16 primarily generated deep in the device. 17 Exhibit 1009, Figure 2. Wang shows some 18 carriers in the active region, but does 19 not disclose they are problematic." 20 And I go on in my report with another 21 reference to show why a small level of carriers 22 isn't necessarily problematic --	255 1 (or electrons) due to the alpha ray is 2 lowered." 3 So what actually happens is, with alpha 4 rays, they are so energetic, they simply rip 5 electrons off of atoms. 6 So, you know, I did a lot of work with 7 alpha particles in the past. So you literally rip 8 electrons off of atoms. And the resulting -- the 9 result of a atom that's lost its electron is the 10 atom itself is positive. 11 So that's the whole -- that's the negative 12 positive pair is electron and positive ion, 13 essentially, although it's in a solid state. 14 Q Okay. 15 A So that's how I would understand the 16 representation in Figure 2. 17 Q Okay. And what does the negative sign 18 denote in Figure 2(a)? 19 A Well, negative signs would be electrons. 20 The electrons are ripped off the atom by the alpha 21 particle. 22 Q And if you look at the description in
254 1 Q Okay. And Figure -- 2 A -- based upon next reference. 3 Q Okay. And Figure 2 -- 4 (Interruption by the reporter.) 5 THE WITNESS: "Based upon." 6 BY MR. SHARMA: 7 Q And in Figure 2(a), do the plus sign 8 indicate holes? 9 A No, they do not. 10 Q What does the plus sign indicate in 11 Figure 2(a)? 12 A I'm going to refer, actually, back to 13 Kawagoe. Paragraph -- column 16, line 6, he 14 describes that there are -- let me move back under 15 the camera -- I'll start reading at 2 for a complete 16 sentence. Sixteen, row -- column 16, row 2: 17 "Thus, the impurity concentration of 18 the p-well is given such that a gradient 19 that is gradually lowered in the 20 depth-wise direction from the surface of 21 the epitaxial layer 2E, so that the 22 influence to be caused by the carriers	256 1 Figure 2 on the -- below figure -- the figures, it 2 references No. 4 with the square brackets. Do you 3 see that? 4 A I'm sorry. You're saying the middle 5 figure -- middle of Figure 2, No. 4? 6 Q I'm talking about the legend on Figure 2. 7 A Okay. I'm looking at Figure 2. There's 8 "A" through -- oh, the description? 9 Q Yes. 10 A Okay. 11 Q Do you see No. 4 at the end of the 12 description of Figure 2? 13 A Yes. 14 Q Okay. Do you understand that to be -- that 15 Wang is citing reference No. 4 over there? 16 A My understanding is that for -- at least 17 for item D, he's citing No. 4. 18 Q Okay. Let's go to -- 19 A Figure D for the -- how long it takes these 20 events to unfold. 21 Q Okay. Then let's go to the end of the 22 document.

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257 1 A The end of -- the end of Wang? 2 Q Yes. And see that here it says 3 "References" below? 4 A Yes. 5 MR. SHARMA: Zoom in on the one 6 "References" little bit. 7 THE WITNESS: Yes. 8 BY MR. SHARMA: 9 Q And No. 4 is listed as a article by 10 Baumann, B-a-u-m-a-n-n. And the title is "Soft 11 Errors in Commercial Integration Integrated 12 Circuits." And it lists the title -- lists the 13 title of the journal it was published, and it 14 mentions 2004 at the end. Do you see that? 15 A I see that, yes. 16 Q Does it indicate that the article that's 17 mentioned in No. 4 was published in 2004? 18 A I would generally take it that this 19 reference -- at least the author footnoted this such 20 that this was when it was published. 21 Q Okay. And part of your review, did you 22 review the Baumann article mentioned in No. 4 in the	259 1 A Yes, I am. 2 Q And here you are giving opinions on the 3 Wieczorek reference. And let me spell that. 4 W-i-e-c-z-o-r-e-k. Do you see that? 5 A Yes, I see paragraph 56. 6 Q Mm-hmm. And in paragraph 56 and 57 you 7 conclude that the Wieczorek reference does not 8 render the claims obvious; is that correct? 9 A I can say that's generally a reasonable 10 summary. 11 Q And the arguments you offer in paragraph 57 12 are same as the arguments you offered earlier in the 13 context of Kawagoe reference; is that correct? 14 A I would say that aspect of the argument is 15 probably similar, yes. There may have been other 16 bases in Kawagoe also, but the argument I presented 17 in paragraph 57 is similar to the argument I made -- 18 one of the arguments I made in Kawagoe. 19 Q And let's go to page 38 of your report. 20 This is a figure that is excerpted from 21 Dr. Banerjee's report, Exhibit 1003. 22 Do you see the figure?
258 1 list of references? 2 A Your question is did I review reference 3 No. 4, Baumann? 4 Q Yes. 5 A No, I did not review Baumann. It was 6 simply a footnote to the speed of resolution of the 7 solar event. 8 Q Would you be surprised to learn that 9 Figure 2 that is shown in Wang was present in the 10 Baumann reference that was published in 2004? 11 MR. WHITEHURST: Objection. Scope, 12 relevance. 13 THE WITNESS: Wang has footnoted Figure 2 14 to reference No. 4. So I would expect that at least 15 some aspects of Figure 2 came from reference No. 4. 16 BY MR. SHARMA: 17 Q Let's go back to Dr. Glew's report, 18 Exhibit 2057. 19 And let's go to paragraph 57 -- 56, sorry, 20 on page 34. 21 So, Dr. Glew, are you in paragraph 56 and 22 57 on page 34 of your report?	260 1 A Yes. 2 Q Okay. And this one Dr. Banerjee annotated 3 in green "Second Active Region" in transistor 4P 4 shown on the left. 5 A I understand that's, yes, Dr. Banerjee's 6 annotation. 7 Q Okay. Did you analyze transistor 4P from 8 Figure 23 when evaluating this figure from 9 Dr. Banerjee's report? 10 A Only to the extent that I've characterized 11 in paragraph 62 and 63, I believe. 12 Q So in paragraphs 62 and 63 you did not 13 evaluate whether the transistor -- what kind of 14 transistor is shown by 4P in Figure 23? 15 MR. WHITEHURST: Form. 16 THE WITNESS: As I've already answered, 17 I've analyzed this figure to the extent I've 18 characterized my analysis in -- or written my 19 analysis in paragraph 62 and 66, which was basically 20 whether or not these -- was relating to whether or 21 not the .5-micrometer thick epitaxial layers and the 22 wells therein were separated. No, I'm sorry. Yeah.

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261 1 Yeah, separated. 2 As section D describes: 3 "Dr. Banerjee's Kawagoe-based 4 analysis is incorrect regarding the 5 'first active region and second active 6 region are each separated by at least 7 one isolation region..." 8 So I was analyzing the separation. I think 9 we already discussed this somewhat. But the FOX, or 10 the field oxide No. 3, shown in yellow does not 11 separate these two regions. 12 MR. SHARMA: Okay. Brendon, could you 13 bring up Exhibit 10- -- 2057 for the '195 patent? 14 DOCUMENT TECH CUENCA: Sure thing, Counsel. 15 Stand by. And you said Exhibit 2057? 16 MR. SHARMA: Yes. For the '195 patent, for 17 the IPR '0017. 18 DOCUMENT TECH CUENCA: I see. Thank you. 19 (Deposition Exhibit 7 was marked for 20 identification.) 21 DOCUMENT TECH CUENCA: Okay. It's now up. 22 ///	263 1 THE WITNESS: Okay. Okay. All right. 2 Page 26. If there's a question pending, please -- 3 BY MR. SHARMA: 4 Q Yeah. I can ask the question. 5 In paragraphs 48 through 51 of 6 Exhibit 2057, you render opinions regarding the 7 Payne reference; is that correct? 8 A Yes. I start in paragraph 48 and carry on 9 through 51, yes. 10 Q Yeah. And the opinions you offer regarding 11 the Payne reference in paragraphs 48 to 51 are the 12 same as the opinions you offer regarding the Kawagoe 13 reference; is that correct? 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: I don't have a copy of Payne. 16 If we could put that in the chat room, that would be 17 helpful. 18 DOCUMENT TECH CUENCA: Okay. Stand by. 19 And that is Exhibit 1005, correct, Counsel? 20 MR. SHARMA: Yes. 21 (Deposition Exhibit 8 was marked for 22 identification.)
262 1 BY MR. SHARMA: 2 Q So that's Dr. Glew's declaration, 3 Exhibit 2057, offered in IPR2042 -- sorry -- offered 4 in IPR2024-0017 [sic]. 5 Dr. Glew, let's go to paragraph 48. 6 DOCUMENT TECH CUENCA: I'm sorry, Counsel, 7 you said 28? 8 MR. SHARMA: Forty-eight on page 26. 9 DOCUMENT TECH CUENCA: Okay. 10 BY MR. SHARMA: 11 Q Dr. Glew, in paragraphs 48 through 51, you 12 offer opinions regarding the Payne reference; is 13 that correct? 14 A I'm sorry. I must have the wrong document 15 in front of me. Which IPR are we in? 16 Q '195, which is No. 0017. 17 A One seven. 18 Okay. Have we -- okay. Is my -- have we 19 put this in the chat? 20 DOCUMENT TECH CUENCA: Yes. 21 THE WITNESS: This is Exhibit 2057? 22 DOCUMENT TECH CUENCA: Yes.	264 1 DOCUMENT TECH CUENCA: Okay. It's in the 2 chat. 3 THE COURT REPORTER: Is this a new exhibit? 4 MR. WHITEHURST: We should mark it as a new 5 exhibit. 6 MR. SHARMA: Yeah. What's the number, 7 Brendon? 8 DOCUMENT TECH CUENCA: It is No. 8. 9 BY MR. SHARMA: 10 Q So Exhibit No. 8, Patent No. US 4,684,971 11 with the first inventor as Payne, also as 12 Exhibit 1005 in the IPR IPR2024-0017. 13 And, Dr. Glew, my question is: Are you 14 offering the same opinion regarding the aid the 15 movement of carrier limitation as you did for the 16 Kawagoe reference? 17 MR. WHITEHURST: Object to form. 18 THE WITNESS: Let me briefly review Payne. 19 I would say that there are definitely 20 similarities in the arguments that I made for Payne 21 versus Kawagoe. 22 I argued, for example, that a POSITA would

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265 1 need to know other parameters of relevant devices, 2 for example, concentration gradient, intrinsic 3 resistance of silicon, presence of any other 4 external factors to know whether a drift field 5 associated with a concentration gradient would aid 6 the movement of minority carriers. 7 I previously described a number of the 8 other presence of external factors such as -- 9 external forces such as fields caused by, you know, 10 the dislocations and imperfections in the crystal 11 due to implantation as well as basic crystal 12 imperfections and so forth and so on. 13 That aspect of the argument is 14 substantially similar. 15 Also -- also he did not perform any 16 analysis of the magnitude of the field generated by 17 the concentration gradient. He wrote, and I cite in 18 paragraph 49: 19 "Payne's downward-sloping 20 graded-dopant concentration aids," 21 et cetera. 22 So, basically, he focused on	267 1 on those paragraphs. 2 Q Yeah. And as shown in Figure 53, you made 3 the same arguments about Onoda as you made for 4 Payne; is that correct? 5 A Yes. As I cite in 53, similar to his Payne 6 analysis, Dr. Banerjee relies on that it's a 7 downward slope and that he believes GreenThread's 8 made an admission. 9 But I go on in 54 to describe why that 10 alone is not sufficient, similar to previous 11 descriptions. 12 MR. SHARMA: Brendon, can we bring up next 13 exhibit? I got PTAB-IPR2023. 14 DOCUMENT TECH CUENCA: Sure thing. Stand 15 by. 16 Okay. It's up. And let me put it in the 17 chat as well. 18 (Deposition Exhibit 9 was marked for 19 identification.) 20 DOCUMENT TECH CUENCA: Okay. It's in the 21 chat. 22 MR. SHARMA: Great.
266 1 downward-sloping nature of Payne's concentration 2 gradient, as I describe at the beginning of 3 paragraph 50 on page 27. 4 He did not analyze any other aspects of the 5 gradient, the magnitude of the force it produces on 6 carriers or whether or not there are external 7 forces, opposing intrinsic -- opposing forces due to 8 the intrinsic resistance and imperfections of 9 silica. 10 So to that extent, yes. 11 MR. SHARMA: Okay. And let's go to -- 12 Brendon, can we go back to Dr. Glew's report? 13 BY MR. SHARMA: 14 Q And, Dr. Glew, if you go to paragraph 53. 15 And in this portion you offer opinions 16 regarding the Onoda reference; is that correct? 17 A My section on Onoda starts at paragraph 52. 18 I thought I heard "53" from you. 19 Q Yeah. So let me ask the question again. 20 In paragraph 52 to 54 of your report, you 21 offer opinions on Onoda reference; is that correct? 22 A Yes. I analyze and offer opinions on Onoda	268 1 Marking Exhibit No. 9 -- sorry. Marking 2 Exhibit Glew 9, which is deposition transcript of 3 Dr. Glew in IPR Case No. IPR2023, and numbers are 4 1242, 1243, 1244, says "Deposition of Alexander 5 Glew, PhD," dated July 16th, 2024. 6 BY MR. SHARMA: 7 Q Dr. Glew, is this a deposition transcript 8 from the ON Semi IPR that we discussed earlier 9 today? 10 (Interruption by the reporter.) 11 BY MR. SHARMA: 12 Q -- deposition transcript from the ON Semi 13 IPR that we discussed earlier today? 14 MR. WHITEHURST: Object to form. 15 THE WITNESS: This appears to be a 16 transcript of my deposition, yes, from July 16th, 17 2024, in the matter of Semiconductor Component 18 Industries, Petitioner, versus GreenThread LLC, 19 Patent Owner, with IPRs 2023-1242, '43, and '44. 20 BY MR. SHARMA: 21 Q Okay. And as we discussed earlier today, 22 sitting here, you have -- you have no reason to

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269 1 doubt that you gave truthful, accurate testimony on 2 July 16, 2024? 3 A I have no reason to doubt my testimony from 4 July 16th. 5 Q And did you review the deposition 6 transcript after your depo was taken on July 16th? 7 A I have reviewed it. I have reread it, yes. 8 Q Okay. And do you recall submitting an 9 errata to this deposition transcript? 10 A I don't recall submitting an errata. 11 Q Dr. Glew, are you aware that GreenThread 12 continues to prosecute patents that are from the 13 same family as the asserted patents? 14 MR. WHITEHURST: Objection. Scope. 15 THE WITNESS: I would say that I'm 16 generally aware that they are still working on these 17 patents. I couldn't -- I don't have any knowledge 18 beyond that. 19 BY MR. SHARMA: 20 Q Okay. Are you aware of application 21 No. 17-728588? 22 MR. WHITEHURST: Object to form.	271 1 I have a few follow-up questions I'd like to ask 2 you. I don't want you to feel rushed in any way. 3 If you need additional time to review any of the 4 documents or you need any additional information, 5 please let me know. 6 A Okay. 7 Q I want to make sure that you have 8 everything you need to answer my questions fully. 9 I'm going to start with what was marked as 10 Exhibit 1. This is your declaration. It's a 11 declaration for the '842 patent. And it relates to 12 the IPR ending in '16. Do you see that? 13 A Yes. I have it electronically, and I have 14 a hard copy. 15 Q And I believe you submitted seven 16 declarations. 17 A Yes, I did, seven declarations. 18 Q And this is one of the seven. Let's turn 19 to paragraph 50 of Exhibit 1. It should be on a 20 page that has 28 at the bottom, but it's going to 21 be -- according to the exhibit stamp, this is 22 Exhibit 2057. And paragraph 50 begins on page 31 of
270 1 I'll note you have less than two minutes 2 left. 3 THE WITNESS: I have no particular 4 knowledge of that application. I haven't seen any 5 of their applications. 6 BY MR. SHARMA: 7 Q Okay. And do you recall -- 8 Okay. That's all the questions I have. 9 MR. WHITEHURST: Great. Let's take a quick 10 break before we do redirect. We can go off the 11 record now. 12 (Recess taken from 5:05 p.m. 13 to 5:33 p.m.) 14 MR. WHITEHURST: If you can put in "going 15 back on the record," I'll proceed. 16 THE COURT REPORTER: Back on the record. 17 MR. WHITEHURST: Thank you. 18 --- 19 EXAMINATION 20 BY MR. WHITEHURST: 21 Q Dr. Glew, I certainly appreciate your 22 testimony today. I know it's been a long day. But	272 1 43. 2 Do you see that? 3 A Yes, I do. 4 Q Do you recall being asked questions about 5 this paragraph earlier today? 6 A Generally, yes. 7 Q Your testimony is very important today. I 8 want to give you an opportunity to fully read 9 paragraph 50. You can read it to yourself, but 10 please let me know when you're done. 11 A Okay. I've finished reading paragraph 50. 12 Q Do you recall writing this paragraph? 13 A Yes. 14 Q Do you believe this paragraph is accurate? 15 A Yes, it is accurate. 16 Q Do you see anything you would change about 17 this paragraph? 18 A No. The paragraph is fine. 19 Q I want to focus on the second to last 20 sentence of this paragraph. I believe it starts 21 "The magnitude." Do you see that? 22 A Yes, I see that.

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273 1 Q Could you please read aloud that sentence? 2 A "The magnitude of the 3 concentration gradient plays a 4 substantial role, because a small 5 gradient may not be sufficient to 6 overcome the resistance of the 7 material in which the gradient 8 exists." 9 Q Do you stand by this sentence? 10 A Yes, I do. 11 Q Do you believe this sentence is an accurate 12 statement? 13 A It's an accurate statement, yes. 14 Q What did you mean when you wrote this 15 sentence? 16 A The concentration gradient, that is, the 17 slope, the amount that the number of dopants changes 18 per centimeter, determines the magnitude of the 19 electrical field which, in turn, determines the 20 amount of force on a charged particle. 21 So the larger the gradient, the larger the 22 force on charged particles.	275 1 presence of any other external 2 forces) to know whether a drift 3 field associated with a 4 concentration gradient would aid 5 carrier movement." 6 Q Do you believe this is an accurate 7 statement? 8 A Yes, this is an accurate statement. 9 Q Is there anything you would change about 10 this sentence? 11 A No. This sentence is fine. I like it the 12 way it is. 13 Q What did you mean when you wrote this 14 sentence? 15 A What I meant was that the magnitude of the 16 concentration gradient is important. It gives the 17 total amount of electrical force, electrical field 18 that applies to charged particles. 19 The intrinsic resistance of silicon is 20 important because with too great a resistance of 21 silicon, there may not be any motion of electrons or 22 holes as desired.
274 1 Furthermore, a small gradient yields a 2 small force, which isn't necessarily strong enough 3 to overcome any of the resistance and structural 4 imperfections that cause that resistance in a 5 silicon device. 6 Q What happens when the gradient is not 7 sufficient to overcome the resistance of the 8 material in which the gradient exists? 9 MR. SHARMA: Objection. Form. 10 THE WITNESS: When the gradient is small, 11 the electrical field is small. And if it's too 12 small, then the charged particles merely remain in 13 place. They don't move and cause current flow. 14 They are essentially just locked. 15 BY MR. WHITEHURST: 16 Q Can you please read aloud the last sentence 17 in this paragraph? 18 A "Therefore, a POSITA would need 19 to know other parameters of the 20 relevant device (for example, 21 magnitude of concentration gradient, 22 intrinsic resistance of silicon,	276 1 And beyond just the basic resistance of 2 silicon, there are a number of other external 3 factors that could potentially exist, perhaps not 4 always all of them in the same device, but they can 5 exist. 6 For example, I spoke of stress. Well, 7 stress that enhances the electrical speed, the 8 mobility of electrons in a channel actually inhibits 9 the motion of holes, and vice versa. 10 So strain engineering can solve some 11 problems but cause other problems. 12 Silicon is not perfect. There are 13 imperfections to begin with, meaning the crystal 14 isn't a perfect crystal, and it becomes even more 15 damaged when there's ion implantation. 16 The dopants we talk about are blasted at 17 the surface somewhere between 20,000 and half a 18 million volts, and they cause significant damage. 19 Heating of it, annealing of the crystal structure to 20 repair the damage from the implantation helps, but 21 there's still damage left after that. 22 Furthermore, there are numerous structures

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277 1 associated with transistors. And there are numerous 2 implants, 20 to -- 20 or more, maybe 50 in some 3 cases nowadays. And all of these cause 4 interactions. 5 The dopants used for source and drain are 6 opposite the dopants used in the channel. So any 7 bleeding of source-drain dopants could cause 8 problems with mobility. 9 Furthermore, there may be internal diode -- 10 you know, inadvertent diodes. There may be 11 resistance in capacitance form that causes a slowing 12 of motion. 13 So there are a number of things that can 14 cause degradation of the motion of charged particles 15 associated with the desired benefits of this 16 invention. 17 The concentration gradient would, in some 18 cases, be able to overcome that internal structural 19 problems and resistance. In other cases it may not. 20 Q Now, earlier today you were asked questions 21 about the prosecution history for the '195 patent. 22 Do you recall that?	279 1 It looks like this is a rather large PDF. 2 I believe it has 391 pages. 3 Is that -- can you confirm how many pages 4 are in this PDF? 5 A I have 391 pages, yes. 6 Q So we're talking about a rather long 7 document. I'd like to start with page 284 of the 8 391 pages. If you could please turn to page 284 and 9 let me know when you're there. 10 A I'm at PDF page 284 of 391. 11 Q And can you just tell me at a high level 12 what this document is? 13 A This is a document dated January 12th, 14 2007. It is a response to Amendment E. It's 15 response to a nonfinal office action of 16 December 20th, 2011. 17 I'm sorry. I misspoke. It was filed 18 January 12th, 2007. This is responsive to an office 19 action on December 20th, 2011. 20 Q Thank you for clarifying that. 21 Now, if we could turn -- it looks like this 22 response had 10 pages.
278 1 A Generally. 2 Q When you were asked those questions, did 3 you see anything in the '195 patent prosecution that 4 would change your opinions in paragraph 50? 5 A No. I generally saw material that 6 reinforced my opinions. I thought the patent office 7 got it right in this instance, and what they wrote 8 was right, I think, in line with what I wrote. 9 Q I want to give you an opportunity to fully 10 look at the '195 prosecution history. I know there 11 was some discussion earlier about needing more time. 12 And I want to give you that opportunity to fully 13 answer these questions. 14 The '195 prosecution history, I believe, 15 was marked as Exhibit 3. 16 If we could please pull up Exhibit 3 so 17 that I can confirm that or have the witness confirm 18 it. 19 A I have in front of me what I believe is 20 Exhibit 3, also marked Exhibit 1016. 21 Q And let's see if I can make it a little bit 22 bigger here. Bear with me one second.	280 1 Does that look accurate to you? 2 A Yes. This document cites, for example, 3 page 2 of 10. 4 Q And let's turn to page 3 of 10. 5 A I am on page 3 of 10. 6 Q And just so the record is clear, this is 7 Exhibit 3 to your deposition, but it was previously 8 marked Cirrus Exhibit 1016. And we're looking at 9 page 286 of 391. 10 Are you looking at the same page I am? 11 A Yes, I am. 12 Q Can you tell me what is at the top of the 13 page -- well, let me rephrase that. 14 Do you see a claim 10? 15 A Yes, I see a claim 10 titled "Currently 16 Amended." 17 Q Do you see any differences between claim 10 18 and the claims that are at issue in the IPR? 19 A Yes. There -- this is not the final 20 version of the claims. There are some differences. 21 Q But you understand that claim 10 was the 22 claim that was pending at the time that this

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1 response was filed? 2 A Yes. And there are portions that are -- 3 MR. BLUESTONE: Objection. Leading. 4 BY MR. WHITEHURST: 5 Q Let me reask that question. 6 Dr. Glew, what is your understanding of 7 claim 10? 8 A Claim 10 has sections that are underlined 9 which I understand are additions to the claim, so 10 these are amendments, and sections that are 11 stricken -- struck through, so those would be 12 deletions to this claim. So there's editing going 13 on of this claim right now. 14 So this is a claim that, as indicated next 15 to the No. 10, it is "Currently Amended." 16 I have filed one patent myself. I'm 17 familiar with how to do this. So this is -- this is 18 an amendment to a claim. This claim is being 19 amended. 20 Q Thank you for clarifying that. If we could 21 please turn to what has been labeled in the response 22 as page 6 of 10. And I believe it's page 289 of the	281 283 1 copy, but yes. 2 Q All right. Just so the record is clear, 3 the witness has in front of him a paper copy of his 4 declaration. And he has it open to paragraph 50. 5 And he has on the screen in front of him the PDF 6 copy of Exhibit 3 to this deposition. 7 Dr. Glew, do you see a paragraph in the 8 "Remarks" section that begins with "The Office 9 Action"? 10 A Yes. It would be the second paragraph. 11 Q Would you please read that paragraph to 12 yourself and let me know when you're done? 13 A I've read it. 14 Q Do you see where this paragraph is quoting 15 to an office action? Do you see that? 16 A Yes, I see a passage in quotes. 17 Q Can you please read aloud the quote that 18 appears in this paragraph that we're looking at? 19 A "Movement of minority carriers 20 is affected by multiple forces and 21 fields," et cetera, "it does not 22 appear that simply the presence of
282 1 391-page PDF. 2 Are you looking at the same page I am? 3 A Yes. I'm looking at 289 of 391, 6 of 10. 4 Q Do you see where it says "remarks"? 5 A Yes. I see a section titled "remarks." 6 Q What is your understanding of the "remarks" 7 section? 8 A The applicant is commenting on giving his 9 arguments or discussion of amendments he's making to 10 try to overcome the last office action that he's 11 dealing with. 12 This is titled in the header "Response to 13 a" non-file office action -- "non-final office 14 action of December 20, 2011." So he's essentially 15 rebutting. 16 Q So what would help us is if you have on the 17 screen in front of you the remarks that you just 18 testified about and paragraph 50 from your 19 declaration. 20 I believe you have a hard copy of that in 21 front of you. Is that correct? 22 A Yes. I have a hard copy as well as a soft	284 1 'a unidirectional drift field' in 2 itself can achieve 'drawing all 3 minority carriers from said surface 4 layer to said substrate.'" 5 Q What is your understanding of this quote? 6 A Well, this quote describes that there are 7 multiple forces and fields that will impede or stop 8 the motion of minority carriers, a current flow. 9 And that is simple unidirectional drift 10 field, in and of itself, cannot achieve drawing all 11 minority carriers from said surface to said 12 substrate. 13 So this absolutely confirms what I've been 14 writing in my report and what I've given in 15 paragraph 50, that these other factors that exist 16 within solid-state devices render a simple 17 unidirectional field insufficient to move all the 18 carriers. 19 Q Just so the record's clear, does this 20 paragraph that we're discussing change or affect any 21 of the opinions in paragraph 50 of your declaration? 22 A It doesn't change any of my opinions that I

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285 1 wrote in paragraph 50, in my '016 declaration. In 2 fact, it only further confirms and provides 3 additional support for my opinion -- my opinions 4 given in paragraph 50. 5 Q Now, we've been looking at paragraph 50 6 from your declaration for the '842 patent. 7 Do you recall a similar paragraph in your 8 other six declarations? 9 A Yes. All of my other declarations have a 10 paragraph that's substantially similar. 11 Where this one may refer to Kawagoe but -- 12 and the other ones may refer to different patents, 13 but they all have a substantially similar paragraph 14 citing the reasons why a unidirectional field, in 15 and of itself, isn't sufficient to cause the -- 16 cause the carrier movement -- the aiding of the 17 carrier movements. 18 Q And would your testimony just now apply to 19 all seven of your declarations? 20 A Yes. I've used similar language in all 21 seven declarations. And my testimony would be the 22 same.	287 1 begins with "The office action also states"? 2 BY MR. WHITEHURST: 3 Q Dr. Glew, do you remember earlier being 4 asked about the Grove reference and this paragraph? 5 A I remember being asked about this 6 paragraph, and I was asked if -- it was asked about 7 the Grove reference and he said no. He was asking 8 about the passage before the Grove reference. Then 9 later I was asked about the Grove reference itself. 10 So I think there were a number of questions on this 11 paragraph. 12 Q I agree. I agree. I want you to take your 13 time, fully read this paragraph, and let me know 14 when you're done. 15 A I've read it. 16 Q Does this paragraph that you just read 17 change or affect of your opinions in paragraph 50 of 18 your declaration? 19 A No. This paragraph does not change any of 20 my opinions in paragraph 50 and only further 21 supports them and strengthens the support. 22 Q Why does this paragraph only further
286 1 Q I want to go to the next paragraph. 2 Do you see a paragraph that begins 3 "Applicant respectfully disagrees"? 4 A Yes, I see it. 5 MR. SHARMA: Objection. Form. 6 MR. WHITEHURST: What was the basis for the 7 objection? I just want to reask the question to 8 remove the objection. What was the basis? Counsel, 9 can you tell me why you objected to form so I can 10 fix it? 11 MR. SHARMA: It's outside the scope. 12 MR. WHITEHURST: Outside the scope? You 13 asked him about this paragraph. Then it should have 14 been objection to scope, not to form. 15 Are you contending that you didn't ask the 16 witness about this paragraph? 17 MR. SHARMA: No. I think you are pointing 18 to "The Office Action also states." We did not ask 19 questions on that one. 20 (Interruption by the reporter.) 21 MR. SHARMA: Sure. 22 Are you asking questions on paragraph that	288 1 support and strengthen your opinions in 2 paragraph 50? 3 A In this paragraph, it reads specifically: 4 "Depending on the particular slope 5 of the graded concentration of dopant, 6 all minority carriers are either swept 7 'down' (from the surface layer to the 8 substrate) or 'up.'" 9 Q Why does that sentence strengthen or 10 further support your opinions in paragraph 50? 11 A Well, this describes that a particular 12 slope of the graded concentration of dopants is 13 important. The slope is the gradient. It is the 14 change with distance. It is the first derivative. 15 One of skill in the art understands that these are 16 synonymous. 17 So the graded concentration in a particular 18 slope -- and slope is a value, a number. It is not 19 a polarity -- is important. And the effect depends 20 on this. Makes that point very clear. 21 Q Why is the value important? 22 A The value of the concentration gradient,

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289 1 that is, the slope, the first derivative, determines 2 the strength of the electric field. 3 The electric field goes as k times T over Q 4 times the derivative of the concentration with 5 position, D rho, dx, however one wants to think of 6 it. 7 So the concentration gradient is 8 determining the strength of the field and the effect 9 of the strength on charge carriers. 10 Q What would a high value of the slope mean? 11 A A high value of slope gives a high 12 electrical field and a high force on charged 13 particles. 14 Q What would a low value of the slope mean? 15 A A low value of slope would give a low value 16 of electrical field and a low force on the charged 17 particles. It may not even be sufficient to cause 18 motion of a charged particle in a real semiconductor 19 device. 20 Q Do you have an opinion whether a low value 21 of electric field -- let me strike that. 22 Do you have an opinion whether a low slope	291 1 cites to "Physics and Technology of Semiconductor 2 Devices," A.S. Grove, pages 224 to 225. 3 Q And do you see in the middle of this 4 paragraph a quote from Grove? 5 A Yes. 6 Q Do you remember being asked questions about 7 this quote? 8 A Yes, I was asked about this quote. 9 Q And do you remember saying that you needed 10 more time to fully answer the questions? Do you 11 recall that? 12 A Yes, generally. 13 Q I want to pull up for you now what was 14 previously marked as Exhibit 4, and I want to give 15 you a chance to fully read what was previously 16 marked as Glew Exhibit 4. 17 Do you have a copy of the exhibit in PDF 18 form on your computer there? 19 A Yes, I do. I have a five-page document of 20 Grove -- Grove -- from Grove's book, "Semiconductor 21 Devices." 22 Q And so the record is clear, you have this
290 1 value would aid carrier movement? 2 A A low slope value may or may not aid 3 carrier movement. It would depend upon the 4 condition of the semiconductor device. 5 Q Can you give me any examples of a situation 6 where a low slope value would not aid carrier 7 movement? 8 A Yes. If there were sufficient 9 imperfections in the crystal structure of the 10 silicon, it could create an electric field that 11 would oppose motion of charged particles if there 12 was only a very small electric field propelling 13 the -- trying to propel the charged particles. 14 The fields that can exist could come about 15 from stress. It could come about from imperfections 16 from doping. It could come about from damage due to 17 the deposition of a layer or a film, excessive 18 stress in adjacent structures, stress due to 19 isolation trenches, things like that. 20 Q Do you see in the middle of this paragraph 21 a citation to Grove? 22 A Yes. I was asked about this earlier. It	292 1 PDF up on your screen now; is that correct? 2 A Yes. 3 Q I want you to read this to yourself right 4 now and let me know when you're done. 5 A I have read section b from this, which was 6 the section I was discussing previously. 7 Q So let's turn to the third page of this 8 PDF. 9 Are you looking at the same page I am? 10 A Yes. That is where section b begins. 11 Q And I believe at the top left-hand corner 12 of this page, you should see the number 224. 13 A Yes. This is page 224. 14 Q And then a little past halfway down you 15 should see a section header that is lowercase "b. 16 Graded Base Regions." Do you see that? 17 A Yes, I see that. 18 Q And do you see a paragraph right after this 19 header? 20 A Yes, I do. 21 Q Do you see the second sentence of this 22 paragraph that begins with the preposition "In"?

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293 1 A Yes, I see that. 2 Q Can you please read that sentence aloud? 3 A "In double-diffused transistors, 4 the distribution of impurities in 5 the base region is not uniform, but 6 is quite strongly graded." 7 Q What does that sentence mean to you? 8 A The dopant gradient is quite strong. It's 9 a very high level of change in position of the 10 gradient value. It says "quite strongly graded." 11 So this is a highly-graded dopant concentration, 12 meaning it has a very high numerical value to the 13 slope. It's a steep slope to the dopant gradient. 14 This has the effect of having very strong 15 electrical fields applied to charge carriers. 16 Q What is Figure 7.13 showing? 17 A This shows dopant concentrations with 18 position. The y-axis is given in logarithmic 19 values. Net impurity concentration, so number of 20 donors minus number of acceptors per cubic 21 centimeter. And we see extremely high levels, 22 actually, up to 10 to the 20th. But in the emitter	295 1 value and very high levels of dopants. 2 Q Going back to the previous page where the 3 header "Graded Base Regions" is, do you see a 4 paragraph that begins with the word "Note"? 5 A I'm sorry. Which page are we on? 6 Q I'm looking at page 3 of the PDF, which has 7 the number 224 in the top left-hand corner. 8 A Yes. 9 Q Are you looking at the same page I am? 10 A Yes. 11 Q Now, looking past halfway down the page, do 12 you see the section header "Graded Base Regions"? 13 A Yes. And I now see a line that starts 14 "Note the very." 15 Q If you could please read that sentence 16 aloud. 17 A "Note the very significant 18 variation of impurity concentration 19 across the base region." 20 Q Now, what does this sentence mean to you? 21 A What this means is that the variation of 22 impurity concentration, that is, the gradient, is
294 1 the base is above 10 to the 18th per centimeter 2 cubed. 3 (Interruption by the reporter.) 4 THE WITNESS: The emitter is extremely high 5 at above 10 to the 20th per centimeter cubed and 6 rolls off fast. The base has a concentration above 7 10 to the 18th and rolls -- has an extremely steep 8 slope to it. 9 And the collector starts off steep, 10 flattens out, then has a fairly high slope after 11 that. 12 BY MR. WHITEHURST: 13 Q Would you be able to calculate the slope 14 value? 15 A I could, yes. The values are given in 16 numerical form, both in number per centimeter cubed 17 and in micrometers distance on the x-axis. 18 Q So looking at Figure 7.13, you can tell 19 that there's a high slope value? 20 A First of all, it's already been described 21 as very high slope value. And by inspection, 22 looking at it, I can see that it's very high slope	296 1 very significant. It has a meaningful impact on the 2 device across the base region. The effect upon the 3 charge carriers will be notable. 4 Q Now, I want you to turn to the next page, 5 which should be page 4 of the PDF. And I believe 6 you should see in the top right-hand corner the 7 number 225. 8 A Yes. I am on page 225. 9 Q Do you see a paragraph below Figure 7.14? 10 A Yes, I see a paragraph. 11 Q Do you see in the middle of that paragraph 12 the sentence that is quoted in the response to the 13 office action? 14 A Yes, I do. 15 Q Could you please read aloud those two 16 sentences? 17 A "This same electric field will 18 then be of such direction as to aid 19 the motion of injected holes. Thus 20 the injected minority carriers will 21 now move not only by diffusion but 22 also by drift due to the existence

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297 1 of this electric field." 2 Q Does -- do these -- strike that. 3 Do these two sentences change or affect any 4 of your opinions in paragraph 50 of your 5 declaration? 6 A No, they do not. 7 Q Why not? 8 A Well, this excerpt from the book in this 9 scenario in section b describes that there's a very 10 high gradient of dopants, a very high electrical 11 field, and that this high electrical field causes 12 motion of carriers. 13 I would expect that a very high field 14 generally would. 15 Q Now, going back to the Exhibit 3, if we 16 could go back to page 289 of the PDF. 17 A I am there. That's, I think, where we left 18 off. 19 Q And do you see where this paragraph is 20 citing to the two sentences that you just read from 21 Grove? 22 A Yes.	299 1 your opinions in paragraph 50? 2 A No, it does not. It only further 3 strengthens them. 4 Q Why does this paragraph further strengthen 5 your opinions in paragraph 50? 6 A Well, this describes that the office action 7 states: 8 "Such a unidirectional field may 9 attempt to apply a force on all minority 10 carriers in a specific direction, it 11 does not appear to ensure (without 12 knowing other parameters of the device) 13 that it will draw 'all' minority 14 carriers," et cetera, end quote. 15 So this makes it clear that the examiners 16 are convinced that you can't necessarily move the 17 carriers with an electric field unless you know 18 other parameters, that these other parameters may 19 interfere with the motion of the charge carriers. 20 The applicants argue back, but in the end 21 they submit and change the claim language. 22 Q Do you agree with the examiner's statement
298 1 Q Do you see any relation between these two 2 sentences and the sentence that begins "Depending on 3 the particular slope"? 4 A The sentence beginning with "Depending on 5 the particular slope," it describes previously in 6 the book that there's this very high level of 7 gradient that causes motion and that the motion can 8 sweep down or up, depending on the polarity, the 9 carriers, the injected minority carriers. 10 Q Now, your testimony about paragraph 50 11 would apply to the other declarations as well? 12 A Yes. My testimony about paragraph 50 would 13 apply to all of the declarations, as to all seven. 14 Q I want to continue to the next paragraph in 15 this "Remarks" section in Exhibit 3. 16 Do you see a paragraph that begins "The 17 Office Action also states"? 18 A Yes, at the bottom of page 6 of 10. 19 Q Would you please read that paragraph to 20 yourself and let me know when you're done? 21 A I've read it. 22 Q Does this paragraph change or affect any of	300 1 in the office action? 2 A Yes, I think the examiner got it absolutely 3 right. I agree with the examiner. 4 Q And why do you think the examiner was 5 right? 6 A Well, because there are parameters that 7 will inhibit a current flow. And one needs to know 8 these other parameters, potentially, in order to be 9 able to cause the carriers to move in a specific 10 direction. 11 Q Turning to page 290 of the PDF, do you see 12 where the paragraph that began on the previous page 13 continues? 14 A Yes. 15 Q And do you see the third line where it says 16 "slope"? 17 A Yes. 18 Q Let me ask this a better way. 19 Do you see on the first line where it says 20 "whereby"? 21 A Yes. 22 Q Can you read aloud that clause through the

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1 end of the sentence? 2 A "...whereby the 'direction' of 3 the electrical field and the 4 resulting direction of the carrier 5 movement depends solely on the slope 6 of the graded concentration of 7 dopant." 8 Q What does this sentence mean to you? 9 A Well, it describes first that you have to 10 get the polarity right, you have to push in the 11 right direction, and secondly, that the movement 12 depends solely -- that means that's the main factor, 13 it has exclusive control, and that is the slope of 14 the graded concentration of dopant. 15 So the slope of the graded concentration of 16 dopant is the main and, basically, only factor upon 17 which the carrier movement depends. 18 And that's consistent with my understanding 19 of, you know, the strength of the field is directly 20 proportional to the concentration gradient. That is 21 the first derivative of the change in concentration. 22 Q Continuing down, do you see the next	1 gradient could not overcome. 2 They've changed that language to "aid." 3 The language now reads "unidirectional electric 4 drift field to aid the movement of minority 5 carriers." 6 They are recognizing or acknowledging the 7 examiner's point that not all fields will move the 8 carriers. 9 BY MR. WHITEHURST: 10 Q So you recall being asked questions about 11 this office action, correct? 12 A Yes, I was asked very specifically about 13 this office action. 14 Q And this office action relates to 15 then-pending claim 10, correct? 16 A Yes. As we reviewed earlier in this 17 examination, there is a amended claim 10 in this. 18 Q Does this paragraph that begins with 19 "However" relate to the claim that you were asked 20 about earlier? 21 A The language has changed, but it relates to 22 the claim. It has some of the same language and
1 paragraph that begins with the word "However"? 2 A Yes. 3 Q Please read that paragraph aloud, and let 4 me know when you're done. 5 A (Reading to self.) 6 I'm done. 7 Q Does this paragraph change or affect any of 8 your opinions in paragraph 50 of your declaration? 9 MR. SHARMA: Objection. Scope. 10 THE WITNESS: This does not change any of 11 my opinions in paragraph 50, and it only strengthens 12 them. 13 BY MR. WHITEHURST: 14 Q Why does this further strengthen your 15 opinions? 16 MR. SHARMA: Same objection. 17 THE WITNESS: In this paragraph it 18 describes the applicants have removed the word "all" 19 from the claim language. They have agreed the claim 20 language that they can't move all of the carriers 21 because there would be impediments of which the 22 all-important slope, the all-important concentration	1 some different language. For example, it has the 2 language "to aid the movement" now that has been 3 shown underlining -- in underlining to show that it 4 has been added to the claim. 5 Q Well, let's go back and look at that claim, 6 which should be in paragraph -- strike that. 7 Let's go back and look at the claim which 8 should be on page 286 of the PDF. Let me know when 9 you're there. 10 A I'm there. 11 Q And this claim has language that's 12 underlined and language that's been struck through. 13 Do you see that? 14 A Yes, I do. 15 Q And this paragraph -- now let's go back to 16 page 290 of the PDF. Let me know when you're there. 17 A I'm there. 18 Q This paragraph that begins with the word 19 "However" relates to the amendments that we were 20 just looking at. 21 Do you agree with that statement? 22 A Yes.

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305 1 Q And I believe you previously acknowledged 2 that the word "all" was removed? 3 A Yes. The applicants has removed the word 4 "all" from the rejected claim language. 5 Q Does that change or affect any of the 6 opinions in paragraph 50 of your declaration? 7 A No, it doesn't change any of my opinions. 8 It only further strengthens them. 9 Q Why does that further strengthen your 10 opinions in paragraph 50 of your declaration? 11 A Well, they have accepted the examiner's 12 requirement that the unidirectional electric field 13 is not, in and of itself, sufficient to move all of 14 the carriers, that there may be impediments, 15 resistances, structural imperfections, other 16 reasons, forces, that would not allow motion. 17 So the drift field may aid movement of 18 carriers, but it certainly can't move all the 19 carriers. 20 Q Now, looking at the header -- strike that. 21 Looking at the header of this page, do you 22 see that this is a response to a nonfinal office	307 1 paragraph. Please read it to yourself and let me 2 know when you're done. 3 A Okay. I've read it. 4 Q And before I ask you questions about this 5 paragraph, could you turn back to page 136 of the 6 PDF? 7 A I have turned to 136. 8 Q And do you see on this page where it says 9 "Mail Date"? 10 A Yes. It says "Mail Date" of "12/30/2009." 11 Q What's your understanding of that date? 12 A That is the date that they put it in the 13 mail. They probably have a mailing certificate. 14 Q Let's go back to the paragraph you just 15 read that begins with the word "However." And this 16 paragraph is on page 139 of the PDF. 17 A I am there. 18 Q Does this paragraph change or affect any of 19 your opinions in paragraph 50 of your declaration? 20 A No, it does not. 21 Q Why not? 22 A Well, this is an earlier action by the
306 1 action of December 20th, 2011? 2 A Yes, that is the language in the header on 3 each page. 4 Q Now, I want to turn to another portion of 5 the prosecution history that you were also asked 6 about. If you could please turn to page 139 of the 7 PDF. And let me know when you're there. 8 A I am there. 9 Q Do you see that this is part of an office 10 action by the examiner? 11 A I'm turning to page 137. It's titled 12 "Office Action Summary." That's page 1 of this 13 document. I'm on page, I guess, 3 of the document 14 now, which is page 139. 15 Q And do you see at the bottom of that page a 16 paragraph that begins with "However"? 17 A Yes. 18 Q Do you recall being asked questions about 19 this paragraph earlier today? 20 A I generally recall being asked questions 21 about text in this vicinity. 22 Q I want to give you a chance to read this	308 1 patent office where the patent office and applicant 2 are working out their positions on this patent. 3 It does teach that the dopant concentration 4 can be adjusted to create electrical fields and that 5 the specific magnitude of the drift field is an 6 issue here. The magnitude of the drift field is a 7 function of the concentration gradient. 8 Q And why do you think the examiner referred 9 to the magnitude? 10 MR. SHARMA: Objection. Calls for 11 speculation. 12 THE WITNESS: Well, as -- 13 BY MR. WHITEHURST: 14 Q Let me rephrase that. 15 Looking at the last sentence, do you see 16 the word "magnitude"? 17 A Yes. 18 Q What is your understanding of the word 19 "magnitude" in this sentence? 20 A As I discussed probably a few moments ago, 21 the magnitude of the drift electric field is the 22 strength of the electric field and the strength that

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309 1 it will apply to a charged carrier. 2 And it says specifically: 3 "...a specific magnitude of the 4 drift electric field and hence any 5 magnitude of drift electric field..." 6 So, clearly, it's talking about the 7 strength of the field. It relates that to the 8 dopant concentration gradient and that this affects 9 charged particles. 10 Q And did the claims that were at issue in 11 2009 -- are any of those claims at issue in the 12 IPRs? 13 A No. The claims have all been changed since 14 then. This was a fairly early office action. 15 MR. WHITEHURST: Dr. Glew, I greatly 16 appreciate your time today. I know it's been a long 17 day. And I pass the witness. 18 MR. SHARMA: Could we just take a quick 19 two-minute break? 20 MR. WHITEHURST: I don't know why we can't 21 stay on the record. The witness is ready to go. We 22 haven't been going that long. Why don't we just	311 1 to talk. Okay? 2 MR. WHITEHURST: Okay. 3 MR. BLUESTONE: Why don't we go off the 4 record. 5 MR. WHITEHURST: Well, we're going to stay 6 here. We can stay on. We can go off the record if 7 you insist and refuse to proceed. But, I mean, it's 8 been a long day. I mean, the most you can -- 9 MR. BLUESTONE: Yeah, Alan -- and, Alan, we 10 would have had our two minutes done already. You've 11 been talking for five minutes when we're asking for 12 two. So why don't we go off the record. Okay? 13 MR. SHARMA: Okay. Thank you. Go off the 14 record. We'll come back in two minutes. 15 THE COURT REPORTER: Do you agree to go off 16 the record, Mr. Whitehurst? 17 MR. WHITEHURST: We can stay on the record. 18 That way, the record will show how long has 19 transpired. 20 (Messrs. Sharma, Bluestone, Paul, and 21 Cooper left the proceedings.) 22 MR. WHITEHURST: Waiting for them to come
310 1 stay on the record. 2 MR. BLUESTONE: Alan, I want to get a 3 chance to talk to Anupam too so we're not talking 4 over each other if we're going to ask further 5 questions. We'll keep it brief. 6 MR. WHITEHURST: It's only one questioner 7 here, David. 8 I passed the witness. We haven't gone that 9 long. 10 Any reason why you can't ask your 11 questions, Counsel, without conferring with 12 Mr. Bluestone? 13 MR. SHARMA: Yeah, I would like to confer 14 with my cocounsel, Mr. Bluestone. 15 MR. WHITEHURST: Well, we think this is 16 gamesmanship. I passed the witness. It's only one 17 questioner. Are you -- 18 MR. BLUESTONE: Alan -- 19 MR. WHITEHURST: Are you refusing to 20 proceed? 21 MR. BLUESTONE: Alan, we've extended the 22 courtesy of breaks, so you can give us two minutes	312 1 back, I believe the transcript should read "That 2 way, the record will show how long has transpired." 3 THE COURT REPORTER: It's a rough draft 4 you're looking at. 5 MR. WHITEHURST: Thank you. 6 (Messrs. Sharma, Bluestone, Paul, and 7 Cooper entered the proceedings.) 8 MR. SHARMA: Okay. We're back on the 9 record? 10 THE COURT REPORTER: We never went off the 11 record. 12 MR. WHITEHURST: We never went off the 13 record. 14 MR. SHARMA: Okay. 15 MR. WHITEHURST: So that we could show how 16 long it lasted. We're still on the record. 17 MR. SHARMA: No problem. 18 - - - 19 FURTHER EXAMINATION 20 BY MR. SHARMA: 21 Q Dr. Glew, do you know what section 112, 22 paragraph 1 rejection is?

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313 1 (Interruption by the reporter.) 2 BY MR. SHARMA: 3 Q Dr. Glew, do you know what section 112, 4 paragraph 1 rejection is? 5 A My general recollection it has something to 6 do with enablement. 7 Q And does it pertain to written description? 8 MR. WHITEHURST: Object to form. 9 THE WITNESS: The written description, the 10 drawings, illustrations, et cetera, should inform 11 the public some -- to whatever extent is necessary 12 if they're skill of the art on how to practice the 13 invention. Something like that, you know -- 14 MR. WHITEHURST: Are you testing his 15 knowledge of 112? You want to tell him what 112 is? 16 THE WITNESS: I don't see that I've -- I'm 17 looking at my report. I don't see a description of 18 112 for this case. I don't think I've analyzed 19 anything under 112. 20 BY MR. SHARMA: 21 Q When we were asking questions on page 289 22 of the file history, did you realize that the --	315 1 MR. WHITEHURST: We'll do whatever they do. 2 THE COURT REPORTER: Okay. 3 And anyone else? 4 MR. BLUESTONE: Same for OmniVision, Marla. 5 - - - 6 (Signature having not been reserved, the 7 deposition of ALEXANDER GLEW PH.D., 8 P.E., concluded at 6:42 p.m. PDT) 9 10 11 12 13 14 15 16 17 18 19 20 21 22
314 1 GreenThread was responding to a 112 rejection? 2 A I know it does say that. Beyond that, I 3 haven't given it a lot of thought. 4 MR. SHARMA: Thank you. That's all the 5 questions we have. 6 MR. WHITEHURST: Thank you. This concludes 7 the deposition of Dr. Glew. And we can go off the 8 record. 9 THE COURT REPORTER: Before we go off the 10 record, if I could get orders for the transcript? 11 Mr. Sharma, two weeks' delivery for you? 12 MR. SHARMA: I think we prefer one week, by 13 end of next week. 14 THE COURT REPORTER: Okay. Do you need a 15 rough draft? 16 MR. SHARMA: Yes, please. 17 THE COURT REPORTER: Okay. 18 And Mr. Whitehurst? 19 MR. WHITEHURST: Do you know if we have a 20 standing order? 21 THE COURT REPORTER: I wasn't informed of 22 one.	316 1 WITNESS CERTIFICATION 2 3 CIRRUS LOGIC, INC., and OMNIVISION TECHNOLOGIES, 4 INC. vs. GREENTHREAD LLC 5 WITNESS: ALEXANDER GLEW PH.D., P.E. 6 DATE: October 16, 2024 7 JOB NO.: 557304 8 9 I, ALEXANDER GLEW PH.D., P.E., having remotely 10 appeared for my deposition on October 16, 2024, 11 hereby certify under penalty of perjury under the 12 laws of the United States of America that the 13 foregoing is true and correct. 14 IN WITNESS WHEREOF, I have hereunto subscribed 15 my name this _____ day of _____ 201____, at 16 _____, 17 (city) (state) 18 19 20 21 _____ 22 ALEXANDER GLEW PH.D., P.E.

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317	1 CERTIFICATE OF CERTIFIED SHORTHAND REPORTER 2 I, Marla Sharp, certified stenographic 3 reporter licensed in California, Oregon, and 4 Washington, hereby certify that the foregoing 5 video-recorded videoconference deposition of 6 ALEXANDER GLEW, PH.D., P.E., was taken remotely 7 before me on October 16, 2024; that the witness was 8 remotely duly sworn by me; that all of the 9 testimony, colloquy, and objections made were 10 recorded stenographically by me and thereafter 11 transcribed, said transcript being a true copy of my 12 shorthand notes thereof; that review of the 13 transcript was neither requested nor waived before 14 completion of the deposition; () that the witness 15 has failed or refused to approve the transcript; and 16 that I am neither financially interested in the 17 action nor a relative or employee of any attorney of 18 any of the parties. 19 In witness whereof, I have subscribed my 20 name and signature this date, October 21, 2024. 21  22 Marla Sharp, RPR, CLR, CCRR CA CSR 11924, OR CSR 17-0446, WA CSR 3408	319	1 ERRATA SHEET CONTINUED 2 CASE: CIRRUS LOGIC, INC., and OMNIVISION 3 TECHNOLOGIES, INC. vs. GREENTHREAD LLC 4 WITNESS: ALEXANDER GLEW PH.D., P.E. 5 DATE: October 16, 2024 6 JOB NO.: 557304 7 PAGE LINE CORRECTION AND REASON 8 _____ 9 _____ 10 _____ 11 _____ 12 _____ 13 _____ 14 _____ 15 _____ 16 _____ 17 _____ 18 _____ 19 _____ 20 _____ 21 _____ 22 (DATE) (SIGNATURE)
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