

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT AND APPEAL BOARD

_____))
MONOLITHIC POWER SYSTEMS, INC., IPR2024-00550
U.S. Patent No.
Petitioner, 10,510,842
IPR2024-00551
U.S. Patent No.
v. 10,734,481
IPR2024-00552
U.S. Patent No.
GREENTHREAD, LLC, 11,121,222
Patent Owner. IPR2024-00553
U.S. Patent No.
11,316,014
_____))

VIDEOTAPED DEPOSITION OF
STEPHEN A. CAMPBELL, PH.D.
November 22, 2024
9:13 a.m. Central Standard Time

Reported by: Lori J. Goodin, RPR, CRR, RSA,
California CSR #13959

DIGITAL EVIDENCE GROUP
1730 M Street, NW, Suite 812
Washington, D.C. 20036
(202) 232-0646

1 REMOTE VIDEOTAPED DEPOSITION of
2 STEPHEN A. CAMPBELL, PH.D., Witness, in the
3 above-titled action, held on Friday, November 22,
4 2024, commencing at approximately time 9:13 a.m.
5 before Lori J. Goodin, RPR, CRR, RSA, California
6 CSR #13959, Registered Professional Reporter,
7 Certified Realtime Reporter, Realtime Systems
8 Administrator, and Certified Shorthand Reporter,
9 and Notary Public of the State of Florida, State
10 of California, State of Maryland, District of
11 Columbia, State of Delaware and Commonwealth of
12 Pennsylvania.

13

14

15

16

17

18

19

20

21

22

1 REMOTE APPEARANCES:

2 ON BEHALF OF PETITIONER:

3 PERKINS COIE, LLP

4 BY: MIGUEL J. BOMBACH, ESQUIRE

5 11452 El Camino Real, Suite 300

6 San Diego, California 92130

7 858-720-5700

8 mbombach@perkinscoie.com

9

10 ON BEHALF OF PATENT OWNER:

11 MCKOOL SMITH, P.C.

BY: ALAN WHITEHURST, ESQUIRE

12 1999 K Street, NW, Suite 600

Washington, D.C. 20006

13 202-370-8300

awhitehust@mckoolsmith.com

14

15 Also Present:

16 Justin Jiang, Perkins Coie

Dan Holmstock, Videographer/Document Tech

17

18

19

20

21

22

Page 4

1 INDEX TO EXAMINATION

2 WITNESS: STEPHEN A. CAMPBELL, PH.D.

3

4	EXAMINATION BY	PAGE
---	----------------	------

5	MR. WHITEHURST	7
---	----------------	---

6	MR. BOMBACH	150
---	-------------	-----

7	MR. WHITEHURST	154
---	----------------	-----

8

9 INDEX TO EXHIBITS

10	EXHIBIT	DESCRIPTION	PAGE
----	---------	-------------	------

11	Exhibit 1	Dr. Campbell's Deposition	
12		Transcript, 10/17/24	14

13	Exhibit 2	Monolithic IPR Petition	
14		of U.S. Patent No.	
15		10,510,842, 3/18/24	22

16	Exhibit 3	Dr. Campbell's Declaration,	
17		3/18/24	31

18	Exhibit 4	Patent Owner's Response in	
19		IPR2024-00468, 11/8/24	31

20	Exhibit 5	U.S. Patent 10,510,842	31
----	-----------	------------------------	----

21

22

1 FRIDAY, NOVEMBER 22, 2024, 9:13 a.m. CDT

2 PROCEEDINGS

3 * * *

4 THE VIDEOGRAPHER: We are now on the
5 record. This is Video Number 1 in the video
6 recorded deposition of Dr. Stephen A.
7 Campbell, taken in the matter of Greenthread,
8 LLC v Monolithic Power Systems, Inc., with
9 the following IPR numbers: IPR 2024-00550,
10 new one -551, new one -552, and finally -553.

11 These are pending before the United
12 States Patent and Trademark Office before the
13 Patent Trial and Appeal Board.

14 This deposition is being conducted
15 by this Zoom video remote conferencing on
16 November 22nd, 2024. The time on the video
17 screen is 9:13 a.m. Central Standard Time.

18 My name is Daniel Holmstock. I am
19 the legal videographer and digital exhibit
20 technician from Digital Evidence Group.

21 Our court reporter today is Lori
22 Goodin, also in association with Digital

1 Evidence Group.

2 All parties have stipulated to the
3 witness being sworn in remotely.

4 Counsel, will you please state your
5 appearances and whom you represent, followed
6 by the court reporter administering the oath.

7 MR. WHITEHURST: Good morning,
8 everyone. Alan Whitehurst here, from McKool
9 Smith for the patent owner, Greenthread.

10 MR. BOMBACH: Miguel Bombach here
11 for Petitioner, Monolithic Power Systems.
12 Along with me is my colleague, Justin Jiang.

13 * * *

14

15

16

17

18

19

20

21

22

1 Whereupon,

2 STEPHEN A. CAMPBELL, PH.D.,

3 a witness called for examination, having been
4 first duly sworn, was examined and testified as
5 follows:

6 * * *

7 DIRECT EXAMINATION

8 BY MR. WHITEHURST:

9 Q. Dr. Campbell, good morning. My name
10 is Alan Whitehurst.

11 A. Good morning, Mr. Whitehurst.

12 Q. Would you please state your full
13 name for the record.

14 A. Stephen Alan Campbell.

15 Q. And, where are you this morning,
16 Dr. Campbell?

17 A. I am at my home. The address is
18 3248 Sandeen Road, Arden Hills, Minnesota.

19 Q. Is anybody in the room with you?

20 A. No.

21 Q. Do you have any documents with you?

22 A. No.

1 Q. No problem. I will make it easy for
2 you.

3 Do you have a screen there that if
4 we upload an exhibit, you can see the exhibit on
5 the screen?

6 A. I have the screen that I am
7 currently looking at with the Zoom. So, yes.

8 Q. Now, you have been deposed before,
9 correct?

10 A. This will be my second deposition.

11 Q. So, you understand how the
12 deposition process works?

13 A. I do.

14 Q. And you realize that you are under
15 oath right now?

16 A. Yes.

17 Q. And, you have an obligation to
18 provide truthful answers?

19 A. Yes.

20 Q. Now, I have premarked some exhibits
21 to make things easier.

22 The first exhibit has to do with

1 your previous deposition.

2 Do you recall that deposition?

3 A. I do.

4 Q. And do you remember the general time
5 frame?

6 A. I couldn't give you the exact date.
7 But, it was early November, late October.
8 Roughly a month ago.

9 Q. And, did you receive a transcript of
10 your previous deposition?

11 A. Yes, I did.

12 Q. Did you review that transcript?

13 A. Yes, I did.

14 Q. Did you have any thoughts after you
15 read the transcript?

16 A. I was asked to provide an errata.
17 And for the most part, that was just words that
18 were not transposed properly.

19 Q. And, I reviewed that errata. And,
20 to the best of your recollection, the errata is
21 about typographical errors, correct?

22 A. That's correct.

1 Q. But, other than the typographical
2 errors, did everything else look good to you?

3 A. Yes. It seemed to be an accurate
4 reflection of the testimony that I gave.

5 Q. So, you stand by your previous
6 testimony?

7 A. In reviewing the content, I -- what
8 I just said was that it was an accurate
9 reflection of what I said.

10 There were a couple of things --
11 well, one thing in particular that in retrospect
12 I realized was not correct, and we can talk about
13 that. I would be happy to.

14 And another -- well, I want to make
15 sure I get this right. Ah, there was another one
16 that I thought was -- my comments were taken out
17 of context and led to an incorrect implication.

18 Q. So, after you reviewed the
19 deposition, you saw one thing that you didn't
20 believe was correct.

21 Is that what you said?

22 A. One thing that was not correct on my

1 part, that is to say. I said the wrong thing.

2 Q. And, then you said there were some
3 comments that were taken out of context.

4 Is that accurate?

5 A. Yes.

6 Q. But, other than those two things,
7 did you see anything else that you believed to be
8 incorrect?

9 A. Incorrect in the sense that it
10 didn't reflect my testimony or incorrect
11 factually?

12 Q. Incorrect factually.

13 A. No, I don't remember anything.

14 Q. So, when you reviewed the
15 transcript, you only saw one thing that you
16 believed was incorrect factually?

17 A. I'm sorry. I'm going to have to
18 amend what I said.

19 The thing that I felt was incorrect,
20 that is to say the part about taken out of
21 context, that was the review -- my review of the
22 Greenleaf response to the deposition.

1 So, the only thing that -- so, there
2 was really just one thing that I thought was
3 wrong, and I -- and I made that mistake.

4 Q. So --

5 A. Other than that, it is factual.

6 Q. So, let me make sure I understand
7 your testimony --

8 A. Yes, please.

9 Q. -- so far.

10 You previously testified in a
11 deposition.

12 A. Uh-huh.

13 Q. And that deposition had to do with
14 some IPRs against the Greenthread patents.

15 A. Yes.

16 Q. And, you reviewed the transcript
17 from that deposition.

18 A. Yes.

19 Q. And after you reviewed that
20 transcript, you corrected some typographical
21 errors.

22 A. Yes.

1 Q. And after you reviewed it,
2 everything appeared to be factually accurate
3 except for one thing; is that correct?

4 A. Yes. That is correct.

5 Q. Okay. Putting everything else
6 aside, what was the one thing that you thought
7 was factually inaccurate?

8 A. In the first deposition, I was asked
9 whether or not I had submitted more than one
10 declaration regarding Greenleaf patents.

11 I was rather focused on and was told
12 that this deposition just involved the -- what we
13 call the second batch of patents. And I forgot
14 that I had submitted a deposition quite a while
15 ago -- I'm sorry, the declaration, quite a while
16 ago for the first batch of patents.

17 And so I incorrectly said that I did
18 not provide any documents, other than my second
19 declaration. And, indeed, there is a first
20 declaration that involved other patents and ones
21 that are described here.

22 Q. Thank you very much for clarifying

1 that. I certainly appreciate it.

2 But, other than this one issue,
3 everything else looked factually accurate to you?

4 A. Yes.

5 Q. And you stand by that testimony?

6 A. Yes.

7 Q. Just so the record is complete, I
8 mentioned that I premarked some exhibits.

9 Let's go ahead and introduce at this
10 time Exhibit 1.

11 (Campbell Exhibit Number 1
12 marked for identification.)

13 BY MR. WHITEHURST:

14 Q. Dr. Campbell, are you able to --
15 let's make this easy for you.

16 MR. WHITEHURST: Mr. Videographer,
17 is there a way to drop this exhibit in a link
18 for Dr. Campbell?

19 THE VIDEOGRAPHER: I sure did. I
20 pasted the exhibit link again into the Zoom
21 chat. If you would just click on that,
22 Doctor, and you should see a link that has

1 three exhibits already there, EX1, EX2, and
2 EX3, respectively.

3 THE WITNESS: All right. So, I'm
4 looking at one that ends with KCM3MJRD or QD,
5 is that the one you want me to open?

6 THE VIDEOGRAPHER: Just to be sure,
7 you know what I am going to do, I am going to
8 paste a direct link to this document.

9 MR. WHITEHURST: Bear with us here
10 one minute, Dr. Campbell, and we will get
11 everything correct for you.

12 THE VIDEOGRAPHER: Doctor, click
13 that link there and see if that takes us to
14 just the single file that we are talking
15 about.

16 THE WITNESS: This is in the chat?

17 THE VIDEOGRAPHER: Correct.

18 THE WITNESS: I want 923. All
19 right. That must be the new one.

20 THE VIDEOGRAPHER: Are you situated,
21 Doctor?

22 THE WITNESS: Yes, it is just

1 reading. Okay, I am -- I can see the
2 document.

3 BY MR. WHITEHURST:

4 Q. Okay, Dr. Campbell. Let's go to the
5 first page of that document, just so that you and
6 I are on the same page literally.

7 A. I am on Page 1.

8 Q. Correct. Good. Do you see at the
9 top left of Page 1 the date, October 17th, 2024?

10 A. Yes.

11 Q. Does this jog your memory on when
12 your previous deposition was?

13 A. Yes. That seems correct. I mean, I
14 would have to look at my calendar to make sure.
15 But, as I said, it was either in late October or
16 early November; and, indeed, it was late October.

17 Q. And there in the middle of the page
18 it says, "Monolithic Power Systems, Inc. versus
19 Greenthread LLC."

20 Do you see that?

21 A. Yes, I do.

22 Q. And then in the top right, it should

1 say Stephen A. Campbell, Ph.D.?

2 A. Correct.

3 Q. And, of course, that is you.

4 A. Yes.

5 Q. And you can see that this deposition
6 transcript had to do with three IPRs having the
7 numbers 2024-00468.

8 Do you see that?

9 A. I do.

10 Q. And then the next number ends in
11 469?

12 A. Yes.

13 Q. And then the third IPR ends in the
14 number 470?

15 A. Yes.

16 Q. And we could scroll through this.
17 You will see that the transcript goes roughly 57
18 pages.

19 Do you see that?

20 A. Do you want me to go to Page 57?

21 Q. Yes, sir. Yes, please.

22 A. I am there.

1 Q. I believe it ends on Page 56.

2 Do you see that?

3 A. Yes. I see that it ends on Page 56.

4 Q. And the deposition ended at

5 10:34 a.m.

6 Do you see that?

7 A. I do.

8 Q. And then you will see that there is
9 an index and some other appendices to the
10 deposition transcript.

11 And then, next, you should see
12 Exhibit 1 from your previous deposition.

13 Do you see that?

14 THE VIDEOGRAPHER: It is PDF
15 Page 169.

16 THE WITNESS: PDF Page 169. Thank
17 you. All right. I am on Page 169.

18 Could you tell me again what the
19 question was?

20 BY MR. WHITEHURST:

21 Q. Yes. Do you see where it says
22 "Campbell Exhibit 1"?

1 A. Yes.

2 Q. And do you remember this
3 declaration?

4 A. Yes.

5 Q. And do you recall this declaration
6 being Exhibit 1 to your previous deposition?

7 A. I will say yes. Although, I
8 would -- when I read through the final, once we
9 got to the end of it, I didn't really look at
10 what was appended to it. But, yes, that is what
11 it says.

12 It looks like it is our declaration.

13 Q. And, when you say "our declaration,"
14 what did you mean?

15 A. My declaration.

16 Q. And do you recall being asked
17 questions during your previous deposition about
18 this declaration?

19 A. Yes, I do.

20 Q. And if we could go to Exhibit 2 from
21 your previous deposition, which is also part of
22 Exhibit 1 in this deposition.

1 MR. WHITEHURST: Mr. Videographer,

2 can you please tell us what page --

3 THE VIDEOGRAPHER: PDF Page 221.

4 BY MR. WHITEHURST:

5 Q. Dr. Campbell, if you could please go

6 to Page 221.

7 A. Yes. I am on Page 221.

8 Q. And, do you know what I mean when I

9 say the '476 patent?

10 A. Yes.

11 Q. And do you see that Exhibit 2 to

12 your previous deposition was the '476 patent?

13 A. Yes.

14 Q. And do you recall being asked

15 questions about the '476 patent?

16 A. Yes.

17 Q. Now, if we could go back to the

18 first page of what we have marked as Exhibit 1 to

19 this deposition.

20 This is the transcript here on the

21 screen that you reviewed?

22 A. Again, are you saying go to the

1 first page of this document?

2 Q. Yes, sir.

3 A. Yes. This is the document that I
4 reviewed.

5 Q. And this is the transcript that you
6 did the errata for?

7 A. Yes.

8 Q. And, this is the transcript that you
9 mentioned earlier when you said there was one
10 thing you wanted to clarify?

11 A. Yes.

12 Q. And, other than the one thing that
13 you clarified, you stand by this deposition and
14 believe everything is factually accurate?

15 A. To the best of my knowledge, yes,
16 everything is accurate.

17 Q. And there is nothing you would like
18 to change about your previous deposition? Other
19 than --

20 A. There is --

21 Q. -- the one -- I'm sorry. I spoke
22 over you, so let me just make sure I got that

1 correct.

2 And other than the one thing that
3 you clarified, there is nothing you would like to
4 change about your previous deposition?

5 A. At this time, there is nothing I
6 would like to change about my deposition.

7 MR. WHITEHURST: Let's go to what I
8 previously marked, before the deposition
9 started, as Exhibit 2. We will get that on
10 the screen for you, Dr. Campbell.

11 And we will also put it in the chat
12 so that you can access it and control the
13 document if you like.

14 (Campbell Exhibit Number 2
15 marked for identification.)

16 THE WITNESS: I will just work off
17 of the Zoom screen.

18 BY MR. WHITEHURST:

19 Q. Very well.

20 And, can you describe for me what it
21 is that I have marked as Exhibit 2?

22 A. Can we go ahead a page or two to

1 make sure my answer is correct?

2 Q. Absolutely.

3 MR. WHITEHURST: So -- just so the
4 record is clear, when we -- let's go back to
5 Page 1, and we will --

6 BY MR. WHITEHURST:

7 Q. So, Dr. Campbell, you should see on
8 the screen Page 1 of a petition.

9 Do you see that?

10 A. Yes, I see that. I am going to
11 change my mind here, and I will look at the
12 exhibit not inside the Zoom but separately.

13 So, if you will bear with me for a
14 few minutes, I will take a look at Exhibit 2.

15 Q. I will give you a second to do that.

16 A. All right. This appears to be my
17 declaration.

18 Q. And why do you say that?

19 A. Just looking through the document.
20 Again, I haven't reviewed that for a while, but
21 it looks like the document that we produced.

22 MR. WHITEHURST: Okay. If we could

1 go to Page 1. Page 1 not --

2 THE VIDEOGRAPHER: I'm looking for
3 the actual page number. Hold on one second.
4 Here we are.

5 MR. WHITEHURST: Well, let's go to
6 the cover page. Page 1 in the PDF, please.

7 BY MR. WHITEHURST:

8 Q. Dr. Campbell, do you see Page 1 in
9 this exhibit?

10 A. I do. And to be honest with you,
11 I'm a little bit unsure if this is actually my
12 declaration.

13 Q. Okay. Can you read for me the first
14 line, do you see where it says "Petition"?

15 A. Yes, "Petition for Inter Partes
16 Review of U.S. Patent Number" --

17 Q. Do you know -- okay. I'm sorry, I
18 interrupted you.

19 Can you read the first two lines,
20 please?

21 A. "Petition for Inter Partes Review of
22 U.S. Patent Number 10,510,842.

1 Q. Do you know what a petition for
2 inter partes review is?

3 A. I'm not a lawyer. I am a technical
4 expert. So, no, I do not know.

5 Q. Have you ever seen this document
6 before?

7 A. I am not certain.

8 Q. Okay. So, as far as you know, you
9 don't recall whether you have ever seen this
10 document before; is that correct?

11 A. Again, it looks like, it is very
12 similar to the declaration I provided.

13 But, you are asking me can I say
14 with 100 percent certainty that this is it? No,
15 I can't.

16 Q. Thank you for clarifying that.

17 MR. WHITEHURST: Let's mark as
18 Exhibit 3, Mr. Videographer, it is going to
19 be a document -- let's go off the record for
20 one second.

21 THE VIDEOGRAPHER: Yes, sure. No
22 problem. The time is 9:37 a.m. We are going

1 off the record.

2 (Recess taken -- 9:37 a.m.)

3 (After recess -- 9:41 a.m.)

4 THE VIDEOGRAPHER: The time is
5 9:41 a.m., and we are back on the record.

6 BY MR. WHITEHURST:

7 Q. So, Dr. Campbell, I just want to
8 make sure something is accurate.

9 When we started out the deposition
10 today, we were talking about your transcript.
11 And you said there was something inaccurate, and
12 there was something you would like to clarify.

13 And then I believe I heard you say
14 that they had to do with the same thing.

15 Did I hear you correctly?

16 A. No.

17 Q. Okay. You said there was something
18 incorrect. And what was the one thing that was
19 incorrect?

20 A. That was whether or not the
21 declaration that you have shown on the screen as
22 Exhibit 3 was my only document that was provided.

1 And as I explained before, I did not
2 recall that I had it. At that time, I was a
3 little flustered. That was, of course, the
4 declaration for the first batch of patents.

5 That is what I wanted to correct.

6 Q. And you said you wanted to clarify
7 something.

8 Did it have to do with your report?

9 A. It had to do with Greenleaf's
10 response to the second declaration -- well, to my
11 deposition, to my first deposition.

12 Q. And can you explain what you mean by
13 that?

14 A. I would have to pull up that
15 document in order to be able to describe it.

16 Q. I'm confused.

17 When you say "that document," what
18 document do you mean?

19 A. I am talking about the Greenleaf
20 response to my deposition.

21 Q. And what response was that?

22 A. I received a written document that

1 critiqued the deposition and raised concerns.

2 Again, I am not a lawyer. I am here
3 to provide technical advice.

4 And I thought that their
5 characterization of my deposition, in at least
6 one aspect, was incorrect.

7 Q. One second. Dr. Campbell, what was
8 that issue?

9 A. Again, I would have to have the
10 document in front of me to ensure that I am
11 giving fully correct answers.

12 I can't do it from memory with
13 100 percent certainty that I am giving you the
14 correct answer.

15 Q. Can you tell me at a high level what
16 the issue was?

17 A. It had to do with the movement of
18 minority carriers.

19 That is probably as low level as I'm
20 willing to go.

21 MR. WHITEHURST: Miguel, this is a
22 little early to take our first break, but

1 maybe we will take a quick break here real
2 quick.

3 And, Dr. Campbell, you understand
4 the rules say that you are not supposed to
5 talk with your attorney during breaks.

6 You realize that, correct?

7 THE WITNESS: Yes, I do.

8 MR. WHITEHURST: Terrific. Let's
9 take a quick break. We will be back in like
10 15 minutes.

11 THE VIDEOGRAPHER: The time is
12 9:46 a.m. We are off the record.

13 (Recess taken -- 9:46 a.m.)

14 (After recess -- 10:07 a.m.)

15 THE VIDEOGRAPHER: The time is
16 10:07 a.m., and we are back on the record.

17 BY MR. WHITEHURST:

18 Q. Welcome back, Dr. Campbell.

19 A. Thank you. Before we start with
20 additional questions, can I make a clarification
21 and a correction to my previous testimony today?

22 Q. What would you like to clarify and

1 correct?

2 A. First, is the document that you
3 showed me, and I said it might be my declaration.

4 After -- I have no excuse for this,
5 but that clearly was not my declaration. It
6 contained figures from the declaration.

7 But -- so my answer to that question
8 is, I don't know what that document is.

9 Q. All right.

10 A. The second one, clarification, is in
11 my testimony I sometimes refer to "our
12 declaration." I don't want -- and I want to make
13 sure to emphasize this, that the technical
14 content of those declarations is completely mine.

15 However, portions of the declaration
16 involve legal descriptions. And I did not write,
17 nor did I supervise or approve those parts.

18 That is what I wanted to say.

19 Q. Thank you very much for letting us
20 know that.

21 Is there anything else you would
22 like to mention?

1 A. That is it. We can go ahead and
2 continue.

3 Q. Thank you.

4 MR. WHITEHURST: And, during the
5 break, we did some housekeeping. And just so
6 the record is clear, we are going to -- we
7 marked earlier the transcript from your
8 previous deposition as Exhibit 1.

9 We have marked as Exhibit 2 a
10 Monolithic IPR petition.

11 We have marked as Exhibit 3, a
12 declaration by Dr. Campbell.

13 (Campbell Exhibit Number 3
14 marked for identification.)

15 MR. WHITEHURST: We have marked as
16 Exhibit 4, a redacted copy of a Patent
17 Owner's response.

18 (Campbell Exhibit Number 4
19 marked for identification.)

20 MR. WHITEHURST: And we have marked
21 as Exhibit 5, U.S. Patent Number 10,510,842.

22 (Campbell Exhibit Number 5

1 marked for identification.)

2 BY MR. WHITEHURST:

3 Q. Dr. Campbell, I wanted to go back to
4 what we were discussing before.

5 You explained that you reviewed your
6 deposition transcript, and you thought everything
7 was factually accurate except for the one thing
8 that you mentioned about having only submitted
9 one declaration.

10 Do you recall that?

11 A. Yes.

12 Q. And then you said everything else in
13 your transcript you believed to be factually
14 accurate, and you stood by it.

15 But, I believe you said that while
16 you thought it was factually accurate, that maybe
17 Greenthread had mischaracterized it. Is that a
18 fair recap of what you said earlier?

19 A. No.

20 Q. How would you put it?

21 A. Again, as I said earlier, the
22 mischaracterization was not in the declaration

1 but rather the response to the deposition.

2 Q. So, you believe everything in your
3 transcript, other than the one thing you
4 mentioned, was factually accurate.

5 Is that right?

6 A. As far as I know, yes.

7 Q. And then you read a patent owner's
8 response, and you saw something you disagreed
9 with?

10 A. Yes. In response to the deposition,
11 not the declaration.

12 Q. And who gave that patent owner's
13 response to you?

14 A. It was forwarded to me by employees
15 of Perkins Coie.

16 Q. And did they tell you to look at a
17 particular portion of that patent owner's
18 response?

19 A. No. They wanted me to read it and
20 respond to -- and respond to it.

21 Q. If I gave you a copy of the patent
22 owner's response, could you show me the portion

1 that you disagree with?

2 A. Yes.

3 MR. WHITEHURST: Let's go to what we
4 have marked as Exhibit 4. It is a redacted
5 copy of Patent Owner's Response in IPR
6 2024-00468.

7 Dr. Campbell, do you recognize this
8 document?

9 A. I do.

10 Q. And do you recall reviewing this
11 patent owner's response?

12 A. Yes, I do.

13 Q. Are you able to access this document
14 on your computer and turn to different pages?

15 A. I should be able to do that. This
16 is Exhibit 4?

17 Q. Yes, sir.

18 A. All right. I now have it on my
19 screen.

20 Q. Would you please tell me what it is
21 that you disagreed with?

22 A. This will take a few minutes.

1 All right. I am looking at what is
2 labeled Page 8 that is shown as Page 21 in the
3 PDF file.

4 Q. So, you are going to start on
5 Page 8, And the portion that you disagree with,
6 where does it end?

7 A. It probably goes to the beginning of
8 Page 9.

9 Q. Okay. Other than what begins at the
10 bottom of Page 8 to the top of Page 9, were there
11 any other portions that you disagreed with?

12 A. There were several places. This
13 was, to my mind, one of the more egregious.

14 So, I only brought this up in error,
15 originally, thinking that it was part of my
16 deposition that I wanted to clarify.

17 But, it was the response to the
18 deposition that I wanted to clarify.

19 So, no, this is not the only thing
20 that I see that I would disagree with in this
21 document.

22 Q. But, other than the portions of your

1 testimony that are discussed here at the bottom
2 of Page 8 and the top of Page 9, there is nothing
3 else that you would like to clarify about your
4 previous testimony?

5 A. There is nothing that I would like
6 to clarify about my previous testimony. It is
7 just that I disagree with what they are saying.

8 Q. So, other than the portions of your
9 testimony that are mentioned here at the bottom
10 of Page 8 and the top of Page 9, you stand by the
11 remainder of your testimony. And there is
12 nothing you would like to change about it?

13 A. That is correct.

14 Q. Now, at the bottom of Page 8, there
15 is a cite to Exhibit 1003, Paragraph 32.

16 Do you see that?

17 A. Yes.

18 Q. And that is a citation to your
19 declaration, correct?

20 A. I would have to look up
21 Exhibit 1003. But -- I would have to look that
22 up.

1 Q. You doubt that these are words from
2 your declaration?

3 A. You asked me, can I verify that that
4 is the exhibit.

5 And without the exhibit number laid
6 out, it could be. It could not. I don't know.

7 Q. Do you remember writing the words
8 "an electric field that is properly constructed
9 will push the minority carriers away from the
10 surface"?

11 Do you remember writing those words?

12 A. That is correct. That -- yes.
13 Those are my -- those are words that I used.

14 Q. So, you said that when you wrote
15 your declarations, the technical parts were
16 written by you, correct?

17 A. Yes.

18 Q. And when --

19 A. Well, we have to define "written."
20 In the end, I did wind up typing those words into
21 the document.

22 But, yes, I -- I created these

1 words, and somebody at Perkins Coie put it into
2 the document.

3 Q. Do you remember typing the words "an
4 electric field that is properly constructed will
5 push the minority carriers away from the
6 surface"?

7 A. Yes. I absolutely agree with that.

8 Q. So, you typed into your declaration
9 the words "an electric field that is properly
10 constructed will push the minority carriers away
11 from the surface."

12 Isn't that right?

13 A. I typed that phrase into a document
14 that I sent to Perkins Coie, and they integrated
15 it into the declaration.

16 Q. Now, when you wrote your
17 declaration, you could have typed the words "an
18 electric field will push the minority carriers
19 away from the surface."

20 You could have written that, right?

21 A. Yes, I could have. You are right.

22 Q. But, you didn't write that, did you?

1 A. No, I did not.

2 Q. Instead, you wrote "an electric
3 field that is properly constructed will push the
4 minority carriers away from the surface.

5 Right?

6 A. Yes.

7 Q. So, when you typed your declaration,
8 you included the words "that is properly
9 constructed," right?

10 A. Yes. I did.

11 Q. And, I want to make sure I properly
12 understand what you typed.

13 You are not testifying today that
14 all electric fields will push the minority
15 carriers away from the surface, are you?

16 A. No. If the direction of the
17 electric field is opposite, they will push them
18 to the surface.

19 So, the only requirement is that
20 they are -- that the electric field is in the
21 direction that pushes them away from the surface.

22 Q. So, in order for an electric field

1 to push minority carriers away from the surface,
2 it has to be properly constructed, right?

3 A. That is to say by properly
4 constructed what I meant is that it is of the
5 correct direction.

6 Q. So, not all electric fields will
7 push the minority carriers away from the surface,
8 right?

9 A. Yes.

10 Q. Only electric fields that are
11 properly constructed will push the minority
12 carriers away from the surface, right?

13 A. I guess that depends on what you
14 mean by "properly constructed."

15 Well, you seem to be pushing me to
16 say something that I don't believe.

17 And what I am saying is properly
18 constructed in this paragraph means that the
19 electric field is in the correct direction that
20 will push them away.

21 Q. So, if an electric field is in the
22 wrong direction, it is not going to push the

1 minority carriers away from the surface, right?

2 A. That's correct.

3 Q. So, only an electric field that is
4 in the right direction is going to push the
5 minority carriers away from the surface.

6 A. Correct.

7 Q. How do you tell what the right
8 direction is?

9 A. To a POSITA, this is obvious. A
10 gradient of the doping profile that decreases
11 going from the top surface, meaning where the
12 transistors are, towards the bottom surface,
13 substrate, will always -- will create an inherent
14 electric field that will always push minority
15 carriers away from the surface.

16 Q. Now, you understand, you testified
17 in your previous deposition that electric fields
18 affect holes and electrons differently, didn't
19 you?

20 A. I don't recall that exact wording.

21 But, they affect holes and electrons
22 differently in the sense that holes and electrons

1 have different charge.

2 So, a given electric field will push
3 electrons in one direction and holes in the other
4 direction.

5 Q. And the polarity determines which
6 direction the hole or electron, moves, right?

7 A. For a given electric field, yes.

8 Q. So, if an electric field is
9 pushing --

10 A. Sorry. May I modify that slightly,
11 because, again, I don't want to be misconstrued.

12 The electric field will provide a
13 force that would tend to move them in one
14 direction or the other.

15 There may be other forces acting
16 upon the carriers, and you have to add all of the
17 forces.

18 Q. Why do you have to add all of the
19 forces?

20 A. Newton's first law. You have -- the
21 movement of an object is dependent on the sum of
22 all forces on that object.

1 Q. And I apologize. You are the
2 doctor. I am not.

3 What is Newton's first law?

4 A. Newton's first law is that the sum
5 of all of the forces is equal to the mass of an
6 object, times its acceleration.

7 In the case of particles -- or,
8 sorry, carriers in the -- in a material like
9 silicon, the mass becomes the transport effective
10 mass. It is of the actual weight, but it is
11 modified depending on the material that they are
12 in.

13 Q. When did you learn Newton's first
14 law?

15 A. Senior year in high school, and then
16 again freshman year in college.

17 Q. And why is Newton's first law
18 relevant here?

19 A. Because we are discussing the
20 movement of carriers as a result of forces.

21 Q. And what do you mean when you say
22 "forces"?

1 A. What do I mean when I say forces? I
2 am kind of stunned. That is a philosophical
3 question almost.

4 Q. And I apologize, but I'm just trying
5 to understand Newton's first law better here.
6 And, hopefully, you can help me out.

7 When you say --

8 A. I can give you examples of forces.

9 Q. Okay.

10 A. The electric field force is one of
11 them. Gravity is another. Mechanical forces
12 like neural forces or applied mechanical forces.

13 There are probably others, but those
14 are the most common ones.

15 Q. Can you think of any other forces?

16 A. Oh. Nuclear forces. That is a
17 realm of physics that I don't really practice in.

18 Otherwise, I would have to think
19 about it a while. But, those are the most
20 common.

21 Q. So, when I asked you about an
22 electric field pointing downward, you mentioned

1 these other forces in Newton's law.

2 I'm confused. Why did you say that
3 Newton's law and these other forces were
4 relevant?

5 A. Oh. Okay. I am sorry. I didn't
6 really follow your line of questioning.

7 In the particular case of a minority
8 carrier transport, the electric fields are the
9 dominant forces. In the Greenleaf patent, they
10 seem to -- they actually say that the fusion is a
11 force, and that is incorrect.

12 And so, when I say other forces in
13 regard to minority carrier transport, one has to
14 deal with, well, with the energy associated with
15 thermal motion, if you will. That is the motion
16 on -- well -- okay.

17 All right. So, we have electric
18 fields, one of which might be an inherent field
19 due to a doping gradient. Another might be due
20 to some applied voltage on devices.

21 And then, as I mentioned, you can
22 have mechanical forces. And mechanical forces

1 that are of interest in this application would be
2 collisions between minority carriers and other
3 minority carriers, or minority carriers and
4 phonons. Phonons are the vibration of the atoms
5 in the crystal lattice.

6 Newton also has to be concerned
7 about the movement of carriers as a result of
8 charged particles, ions and electrons.

9 But, majority carriers, those are,
10 again, electric fields. They -- there is a force
11 there because of the two charges. One charge
12 creates an electric field, the other one ceases.

13 So, these are the ones that are most
14 dominant.

15 And also point out that $F = MA$
16 only describes the acceleration which is the
17 change in the velocity.

18 So, for example, if I were to have a
19 minority carrier that is moving towards the
20 surface at a high velocity, and there is a weak
21 electric field that is pushing it down, it may
22 not have enough force to prevent the minority

1 carrier from reaching the surface.

2 Though, that may be an unlucky
3 minority carrier. The minority carriers do not
4 all have the same velocity. They do not all move
5 in the same direction.

6 The analogy that I use when I teach
7 these courses, is it is like a bunch of marbles
8 on a table that you are vibrating. The addition
9 of recalling electric field aids the movement
10 towards one side of the table in the same way
11 that it would move the -- it would tend to move
12 the carriers toward the bottom and not the top.

13 But again, it is tends to.

14 Q. You mentioned when you teach
15 courses -- and I apologize, Dr. Campbell, I
16 didn't get a chance to look at your CV before the
17 deposition today.

18 What types of courses do you teach?

19 A. I -- although my degree is in
20 physics, I spent 35 years in the University of
21 Minnesota in the Electrical Engineering
22 Department.

1 And so the courses that I taught are
2 Transistor Physics, Device Physics, it is called.
3 And Process Technology, how you make
4 semiconductor devices, I wrote the book on that.
5 It is the most widely used book in the world on
6 that topic.

7 Q. And do most of your students
8 understand Newton's first law?

9 A. Yes. Freshman physics is a
10 requirement for electrical engineering degree as
11 it would be for most every engineering degree.

12 Q. And, do you cover Newton's first law
13 in your freshman year of physics class?

14 A. I don't teach freshman physics, or I
15 haven't for a long, long time. I go to the
16 physics department. And yes, every physics
17 department teaches Newton's first law as the --
18 basically the first thing that you learn. You
19 learn what vectors are.

20 And once you have vectors, then you
21 talk about forces and velocity, and acceleration.

22 Q. What courses do you currently teach?

1 A. I am retired from university for
2 three years now so I no longer teach.

3 Q. Did you ever work in the industry?

4 A. I spent five years developing
5 technology for a company that was originally
6 called Sperry and now is referred to as Unisys,
7 developing CMOS technologies.

8 Q. Did you actually design CMOS
9 devices?

10 A. Yes.

11 Q. Is that how you learned about CMOS
12 devices, or did you already know CMOS devices
13 before that?

14 A. No. That was how I learned about
15 it, working in the industry.

16 Q. When you were designing CMOS
17 devices, how did you learn about these forces?

18 A. About the forces -- okay. So, the
19 forces that I named?

20 Q. Yes.

21 A. I knew about the forces from basic
22 physics. Again, once you start with FMA, then

1 you describe what the forces are, and how they
2 worked.

3 As, in terms of minority carrier
4 response and electric field effects, I learned
5 that within, I don't know, a few months of
6 starting on the job. This is very standard
7 stuff.

8 Q. When you say "standard stuff," you
9 mean the forces in the semiconductor devices?

10 A. Yes. And the movement of minority
11 carriers and the creation of electric fields.

12 That is, again, a topic that is
13 standard in the device classes that I teach, the
14 movement of minority carriers.

15 Q. When you were working in industry,
16 did some forces affect the semiconductor device
17 more than others?

18 A. Yes.

19 Q. Do you recall some of the forces
20 that affected the semiconductor devices the most?

21 A. Well, if the device is operating
22 properly, the gate electrode produces an electric

1 field that produces a very strong effect on the
2 movement of carriers.

3 And, the voltage on the drain,
4 again, has a very strong effect.

5 If you are asking what is the
6 strongest, that is the strongest -- those two are
7 the strongest.

8 Q. What do you mean when you say -- you
9 mentioned the electric field produces a very
10 strong effect on the movement of carriers.

11 And, you -- I think you mentioned
12 part of a semiconductor device.

13 Did you?

14 A. Yes. So, I was describing the -- a
15 MOSFET, a MOS device, that we were testing --

16 Q. What's -- and I apologize.

17 What is a MOSFET?

18 A. A MOSFET is a transistor. A
19 transistor is a device that you can turn on and
20 off with an electrical signal.

21 It consists of four elements. A
22 source, which provides the mole carriers. That

1 is why we call it a source. A drain, which is
2 where the carriers go to and are removed from the
3 device.

4 A gate, which turns the device on or
5 off depending on the voltage. And, the
6 substrate, the substrate or the channel is where
7 the carriers would be moving from, between the
8 source and drain.

9 And, finally, there is an insulator
10 between the -- between the channel and the gate.

11 In a special case that the substrate
12 is silicon and the insulator layer is silicon
13 dioxide, that is a MOS field effect transistor or
14 a MOSFET.

15 Q. And did you work on MOSFETs?

16 A. Yes.

17 Q. And when you were working on
18 MOSFETs, what field affected the MOSFETs --

19 Or, strike that. And I apologize.
20 I think I used the wrong word. We were talking
21 about forces. So let me rephrase my question.

22 When you were working on these

1 MOSFETs, what forces affected the minority
2 carriers?

3 A. The obvious one was the one that is
4 being discussed in these patents, the existence
5 of an inherent electric field due to a doping
6 gradient.

7 That is not as strong -- excuse me.
8 That is not as strong of a force as the electric
9 field created by the gate.

10 But, if we are talking about
11 minority carriers, the doping gradient is used to
12 prevent minority carriers from diffusing up to
13 the surface.

14 Q. And why did you want to keep
15 minority carriers from diffusing up to the
16 surface?

17 A. There are three potential problems
18 when you have too many minority carriers that
19 actually reach the device.

20 The first is primarily for memory
21 devices. But, it has concerns for the
22 transistors themselves.

1 And that is called a "soft error."

2 If minority carriers are collected by a structure
3 on the surface, it can change the voltage of that
4 structure.

5 In memory applications, we store a
6 charge on, well, depending on which application,
7 but we store charge on things like capacitors.
8 That is a very common one.

9 If we put a voltage on that
10 capacitor, using the circuit, that puts some
11 charge on the capacitor, a positive charge, on
12 one side and a negative charge on the other.

13 And that charge, that voltage,
14 represents a logical bit, so 1 or 0, depending on
15 the voltage.

16 If minority carriers are captured by
17 that capacitor, it changes the charge on the --
18 at least one of the electrodes, and that changes
19 the voltage.

20 If you collect enough minority
21 charge, it -- the circuit interprets the voltage
22 changes far enough that the circuit interprets

1 the logical 1 to be a logical 0. So, that is a
2 soft error.

3 The second is an effect called
4 "latch-up." Oh, wait. We call it a soft error
5 because the next time the circuit writes
6 information to that spot, to that element, there
7 is no damage. It just has to overwrite the wrong
8 information.

9 Latch-up is a more destructive
10 problem when you put a CMOS device, CMOS is a
11 circuit design that has N-channel devices and
12 P-channel devices.

13 And these are just the opposite.
14 One conducts electrons and the other conducts
15 holes.

16 If you make such a structure, you
17 inadvertently -- and strike the word
18 "inadvertent" and say unintentionally create
19 parasitic bipolar transistors, two of them to be
20 exact.

21 And these bipolar transistors are
22 connected in such a way that if you turn one of

1 them on the other one will turn on. And they --
2 and you can't turn them off without powering down
3 the circuit, and they conduct a lot of current.

4 So, latch-up -- I'm sorry.

5 THE WITNESS: I'm just trying to get
6 it to voicemail, sorry.

7 Once that element is latched, it can
8 pass a lot of current through the devices and
9 actually damage or even destroy the devices.

10 Minority carriers, coming up from,
11 let's say, alpha-particle radiation, can be
12 collected by one of those transistors and
13 start the process for turning one on which
14 causes the other one to turn-on and now you
15 have it latched.

16 So, you want to not provide -- not
17 allow a large enough number of minority
18 carriers to reach -- reach where these
19 parasitic devices are formed.

20 And the third one is
21 "punch-through." Punch-through is a
22 structure in which the current starts to flow

1 from source to drain without the independent
2 of or not fully dependent on the gate
3 voltage. And that, of course, degrades the
4 device performance.

5 And, again, this happens because the
6 charge from the minority carriers comes up
7 and changes the electric fields near the
8 transistor at the source of the drain. And
9 that causes the source and drain to be able
10 to conduct current, not on the surface of the
11 device but in the bulk of the device.

12 Again, that is a soft-error problem
13 in the sense that once the minority carriers
14 go away, it is unlikely to damage the
15 transistor. But, again, it creates a logical
16 error in the circuitry.

17 BY MR. WHITEHURST:

18 Q. Is this --

19 A. That was a long deposition, but --

20 Q. Well, I wanted to be careful not to
21 interrupt. I wanted to let you finish your
22 answer, and I certainly appreciate it.

1 Is this something you worked on when
2 you were designing MOSFETs?

3 A. Our MOSFETs in that technology were
4 relatively crude. This was in the 1980s. And,
5 as a result, the devices were large, which means
6 that the capacitances were large and the charge
7 on those capacitances were large.

8 This is -- and so, the result of
9 that is, you would need quite a bit of minority
10 carriers in order to cause a defect.

11 That said, it is something that we
12 were concerned about. And we had to make sure
13 and we tested for it, and we understood how to
14 design to prevent those minority carriers from
15 causing a problem.

16 But, it turned out that it was not a
17 major problem for a 19 -- early 1980's-era
18 technology. When you get to more recent
19 technologies, it becomes more problematic.

20 Q. I want to go back to your previous
21 answer because I want to make sure I understand.

22 You mentioned a few words that I

1 didn't know what you meant. You mentioned a
2 P-channel.

3 Do you recall that?

4 A. Yes.

5 Q. What is a P-channel?

6 A. So, let's start off with "channel."

7 Again, the basic structure of the transistor is
8 that you have a gate, an insulator, and a
9 semiconductor where a channel is going to form.

10 You can modify the carrier
11 concentration at the surface of the semiconductor
12 by applying voltages to the gate.

13 Let's say, for example, I have a
14 P-type substrate. All right. So, we have
15 missing electrons which are also known as holes.

16 If I were to make a insulator on the
17 surface of that semiconductor, and put a gate on
18 top of the insulator. If I were to apply a
19 positive voltage on the gate, it would create an
20 electric field that points down from the positive
21 voltage to the ground which is the wafer. The
22 wafer is being held at ground voltage, 0 voltage.

1 So, the electric field is pointing
2 down. Holes are positively charged, and so holes
3 are pushed away from the surface.

4 If you apply a large enough electric
5 field, the surface will actually invert. And it
6 will -- you will be -- if you are pushing holes
7 down, you are pulling electrons up.

8 Again, as we discussed earlier,
9 electrons and holes have opposite polarity, and
10 so they respond in opposite directions to an
11 electric field.

12 When you have enough electrons, and
13 for this level of discussion we will leave it
14 qualitative, you have created a channel of
15 electrons that can flow from source to drain.
16 That would be a -- an N-channel. It is N,
17 because electrons are negatively charged. And so
18 you have a layer of electrons that forms an
19 N-channel.

20 And if I were to put a negative
21 voltage on the gate, holes would accumulate at
22 the surface and now you would be able to conduct

1 holes.

2 However, the source and the drain
3 have to be the right polarity. They have to be
4 the same polarity as the channel.

5 So, if you are going to make an
6 N-channel device, you have to have N-type source
7 and drains.

8 If you have a P-channel device, you
9 have to have P-type source and drain.

10 Is that helpful?

11 Q. It is, but, of course, no good deed
12 goes unpunished. Now I've got a bunch of
13 follow-up questions for you, and I hope you can
14 help me figure it out.

15 A. Certainly.

16 Q. One thing you mentioned, you
17 mentioned the electric field pointing from
18 positive to ground. I think that is what you
19 said.

20 A. Yes.

21 Q. What did you mean when you said the
22 electric field points from positive to ground?

1 A. The electric field is a vector. It
2 has an intensity and a direction.

3 By definition, the positive
4 corresponds to the highest voltage.

5 And so if I were to construct the
6 electric field for the geometry that I described,
7 it would -- the arrow, the vector, would point
8 from the highest potential, the gate, when the
9 gate has a positive voltage, to a substrate which
10 I -- I asserted at 0 voltage. The gate voltage
11 is higher so the arrow points from the gate
12 towards the substrate.

13 Q. Why does an electric field point
14 from the positive highest voltage to 0?

15 A. It is a convention that is
16 absolutely universally adapted.

17 If -- if you didn't, you would just
18 have to put a negative side in the equation. It
19 would all still work, but that is the convention
20 that people still use.

21 Q. What do you mean when you say
22 "universally adopted"?

1 A. I mean that when people were first
2 understanding electromagnetics, this would
3 probably be in the 1700s, they were developing
4 the force equations that we described with
5 Newton's first law. There was a force. And I
6 mentioned, one of them is electrostatic force.

7 It was decided that we will have
8 constructed the vector field as going from
9 positive to negative.

10 Q. Do you recall who first developed --
11 sorry, if it is a bad question.

12 A. No, I'm sorry. I never taught the
13 history of this technology. I only --

14 Q. So, this isn't Benjamin Franklin
15 flying the kite with the key?

16 A. I don't think it was Benjamin
17 Franklin, but it wouldn't surprise me if it was
18 someone of his era.

19 Q. So, somebody in the era of Benjamin
20 Franklin came up with this universally adopted
21 law -- would you call it a law?

22 A. It is a convention.

1 Q. Convention. And, what would you
2 call the convention?

3 A. What would I call it?

4 Q. And I apologize. Is there a
5 convention for what you describe that the
6 electric field points from the positive highest
7 voltage to 0?

8 And I apologize, let me --

9 A. In order to -- go ahead.

10 Q. Let me try to ask a better question.
11 And I apologize, I did not mean to ask you a bad
12 question.

13 What would you call the convention
14 about electric fields pointing from the highest
15 positive voltage to 0?

16 A. What would I call that convention?
17 Is that the question?

18 Q. Yes, sir.

19 A. I would call it what you just said,
20 the words that you said. There isn't a short
21 name for it.

22 Q. When did you --

1 A. I guess you could call it -- I mean,
2 I could make something up.

3 But, you are asking me what is the
4 common name for it? There is no such name.

5 Q. When did you learn that the electric
6 field points from the positive highest voltage
7 to 0?

8 A. Let me clarify here. It is not
9 necessarily 0. The electric field points from
10 the highest potential to the lower potential, if
11 you are talking about two elements, right. It
12 doesn't have to be 0.

13 And when did I learn it? In high
14 school, again, physics, my senior year of high
15 school.

16 Q. So, this is something that is taught
17 in high school physics?

18 A. Yes. Absolutely.

19 Q. Is it taught at the college level as
20 well?

21 A. Yes.

22 Q. So, it is something that you used

1 when you were working in the industry?

2 A. Yes. All the time.

3 Q. And, do electrical engineers follow
4 this convention that the electric field points
5 from, I believe you said, highest potential to
6 lowest potential?

7 A. Yes. Universally, anyplace in the
8 world.

9 Q. Why is that?

10 A. Because if you don't have that,
11 there would be a great deal of confusion in
12 trying to understand each other's work. We
13 publish papers. And one has to have a universal
14 convention or you can't understand what other
15 people have done.

16 Q. So, that is why everyone follows the
17 same convention that the electric field points
18 from the highest potential to the lowest
19 potential?

20 A. That is how -- that is why I use it,
21 and I am pretty sure that is why everybody else
22 uses it.

1 Q. Now, like I said, I have some
2 follow-up questions, and I certainly appreciate
3 your help.

4 I think you mentioned something
5 about N-channel having electrons; is that right?

6 A. Yes, that's correct.

7 Q. What did you mean when you were
8 talking about an N-channel having electrons?

9 A. With the CMOS technology, there are
10 two device flavors, NMOS and PMOS.

11 The N and the P refer to the charge
12 on the carriers in the channel when the device is
13 on. So, N stands for negative, and P stands for
14 positive. Electrons are negative. In the
15 absence of an electron, a/k/a a hole is positive.

16 I think that answers your question,
17 but if not, please elaborate.

18 Q. So, in an NMOS device -- let me make
19 sure I understand this.

20 A. Uh-huh.

21 Q. Does an NMOS device have an
22 N-channel?

1 A. Yes. That is correct. When the
2 device is on.

3 Q. Why do you have to turn the NMOS
4 device on in order to get an N-channel?

5 A. The whole idea of a transistor is to
6 be able to turn it on and off, that is to say
7 conduct electricity or not conduct electricity
8 through the use of an electrical signal.

9 The electrical signal is applied to
10 the gate. When you put a large enough voltage on
11 the gate, and in this case for an NMOS device, a
12 positive voltage on the gate, you form the
13 N-channel, which makes the electrical contact
14 from the source and the drain.

15 So, all three, the source, the
16 channel and the drain, are all N-type now. And
17 so that conducts current.

18 Q. And you mentioned something about a
19 source and a drain.

20 What is the source in an NMOS?

21 A. An NMOS device would have a very
22 heavily doped region adjacent to the gate. Well,

1 both the source and the drain are heavily doped,
2 and they are adjacent to the drain, adjacent to
3 the gate. The source is on one side. The drain
4 is on the other.

5 And they are very heavily doped as
6 heavily doped as you can make them. Doped
7 meaning the concentration of electrons in the
8 source and the drain is very, very high, very
9 high end.

10 Q. There were -- there were a couple of
11 things that you mentioned that I didn't fully
12 understand.

13 You mentioned NMOS forming an
14 N-channel when you turn it on. What does an NMOS
15 look like when it is off?

16 A. When it is off, the -- there is no
17 channel being formed. And so, the area under the
18 gate is P-type. That is how it is doped. It --
19 the channel area is doped P-type in an NMOS
20 device.

21 Q. So, why is it -- I apologize. I'm
22 sorry. Keep going.

1 A. Just one more sentence. The
2 existence of the P region in there blocks current
3 flow from the source to the drain because you are
4 forming p-n junctions. One of them will be
5 before biased, and the other will be reversed
6 bias. And the reverse bias does not conduct
7 electricity.

8 Q. And why do you have P-type between
9 the source and drain in an NMOS?

10 A. If you had N-type, you couldn't shut
11 the device off.

12 Now, there are applications where
13 you want the device to be on at 0 volts, gate
14 voltage. It is called a depletion device. They
15 are almost never used.

16 So, what we are saying is the normal
17 situation is a 0 voltage on the gate with respect
18 to the substrate is in the off state, because you
19 want to be able to turn the transistors off in
20 order to launch.

21 Q. Did you ever build an NMOS device?

22 A. Well, we would have to describe what

1 we mean by "build."

2 In a semiconductor lab, nobody goes
3 into the lab and goes through all of the steps
4 independently.

5 I design the devices. I model the
6 devices. I gave a recipe to our technicians who
7 make the devices. And they made devices for me,
8 and then I tested the devices.

9 I certainly went into the lab to
10 look at them, to look at the devices as they were
11 being built. I consulted with the technicians
12 who did the actual fabrication.

13 But, in terms of actually moving
14 away from machine to machine, no, I didn't do
15 that.

16 Q. So, I guess build is not the right
17 word.

18 But, when you did the recipe or the
19 process that you just described, when you wanted
20 to build an NMOS, what did you typically use as
21 the starting point?

22 A. The starting point for making

1 transistors is the substrate. You buy a wafer.
2 So, that is the starting point. You have a blank
3 wafer, silicon. It has some doping in it
4 already. Most common is a very lightly doped
5 P-type wafer.

6 Q. So, if you were building an NMOS
7 device, did you start with P-type or N-type?

8 A. P-type.

9 Q. When you are building an NMOS
10 device, why do you start with P-type?

11 A. It isn't required. One could change
12 the doping later. But, you do have issues making
13 electrical contact that way.

14 So, why -- well, if you are making
15 N-channel devices, I will say that -- I will
16 start over.

17 It isn't a requirement. You can
18 start with N-channel -- sorry, an N-type wafer.
19 In the end, if you are going to make CMOS, you
20 are going to put wells in, and the wells will be
21 doped regions that are higher concentrations than
22 the substrate.

1 So, in that sense, it doesn't really
2 matter what the substrate doping is in terms of
3 just -- if all you are considering is making a
4 functional device, it doesn't really matter what
5 the substrate is.

6 Q. Are wells P-type or N-type?

7 A. Yes. We have P-wells and N-wells.

8 Q. And if you were building an NMOS
9 device, what type of well would you use?

10 A. If you want the transistor to turn
11 off when there is no voltage on the gate, you
12 have to have a P-well.

13 Q. And why would you want to use a
14 P-well?

15 A. The P-well makes the area under the
16 gate positively charged. That is to say it has
17 net holes in it.

18 And that means that the current
19 cannot flow from the source to the drain due to
20 the formation of the two diodes, the one diode
21 between the source and the substrate region and
22 the other in the substrate region and the drain.

1 Q. So, when you were designing NMOS
2 devices, did you typically start with the P-well?

3 A. If I was designing just NMOS
4 devices, we would start with a P wafer. And
5 again this is not required. You are just asking
6 me what we did.

7 We would start with a P-type wafer
8 and then add more boron underneath the transistor
9 to get the turn-on voltage to be what we want.

10 So, there is no well. Some people
11 would call that a well, and that is fine. But
12 yeah, it is just a doped region.

13 Q. And when you were building an NMOS
14 device, did you do anything other than add boron
15 to a P-type wafer?

16 A. Yes. Of course. We have to provide
17 isolation between transistors, assuming that you
18 are going to have more than one transistor.

19 So, this defines what the patents
20 call an active region where the transistor will
21 be. And although it isn't a term used in the
22 patents, the area that is not active is called

1 the "field region."

2 And in those areas we grow a thick
3 layer of an insulating SiO₂ to -- silicon
4 dioxide, sorry. It electrically isolates one
5 transistor from another.

6 So, if we go through the process, we
7 define these active areas and grow oxide in the
8 field areas, we have to put the dopants in to get
9 the turn-on voltage to be correct.

10 And then we grow the gate oxide, and
11 then we deposit the gate electrode material and
12 pattern it. And then we put in the source and
13 drain impurities, and then we make electrical
14 contacts.

15 Q. How did you form the source and
16 drain for an NMOS device?

17 A. Well, once you have defined the
18 gate -- so, again I won't repeat what I said
19 before, the source and the drain need to be
20 adjacent to the gate.

21 So, what we do is to pattern the
22 gate. You could think of it as a long rectangle

1 that is sitting on top of one of the active
2 areas, and normally it goes all of the way across
3 the active area and up on to the field region on
4 both sides.

5 Once you have that patterned, you
6 use a technology called "ion implantation" where
7 you in a vacuum system put in a gas of an N-type
8 impurity, the most common are arsenic and
9 phosphorous, either one. You ionize the gases,
10 and you use an electric field to accelerate those
11 ions towards the surface of the wafer. They slam
12 into the wafer with some energy depending on how
13 deep you want them to go.

14 And then you have to anneal the
15 wafer. You have to heat it up to, let's say,
16 1,000 degrees centigrade to repair the damage
17 from the implant and to get these dopant atoms on
18 to silicon sites so they act as a dopant.

19 Q. But, in order to form the NMOS
20 device, you would typically start with the
21 P-type?

22 A. That is one way to do it. You could

1 start with an N-type, too.

2 Q. How did you mostly do it?

3 A. In the company that I was working
4 for, they tended to use P-type wafers.

5 Q. And you would form the NMOS devices
6 in the P-type wafers?

7 A. Correct.

8 Q. Now, is a PMOS device the other way
9 around?

10 A. That's correct.

11 Q. Would you build the PMOS device in
12 an N-type wafer?

13 A. If you were building a strictly PMOS
14 circuit, that is one option for you. But, that
15 is really uncommon. PMOS is used almost
16 exclusively in the complementary CMOS technology
17 where you have both NMOS and PMOS on the same
18 wafer.

19 Q. So, is that why you used, I believe
20 you called them N-wells?

21 A. Yes. That is exactly the reason for
22 it.

1 Q. So, did you build PMOS in N-wells?

2 A. Yes.

3 Q. So, to form a PMOS device, you would
4 start with an N-type well?

5 A. You would form an N-well, yes.
6 Through the same kind of process I described for
7 the source and the drain. You would implant
8 phosphorous, usually phosphorus and anneal it to
9 form the well.

10 Q. Oh, I think I understand it now.

11 So, you would build an NMOS in a
12 P-well --

13 A. Yes.

14 Q. -- and an PMOS in an N-well?

15 A. Correct.

16 Q. And why did you do that?

17 A. Again, you have to have the
18 substrate underneath the gate to be the opposite
19 polarity of what you are trying to induce.

20 So, in a PMOS device, you are trying
21 to induce holes that substrate has to be
22 negatively charged, N-type, in order for the

1 device to be able to turn off.

2 Q. Let's go back to the NMOS devices
3 and make sure I understand something.

4 You talked about turning on an NMOS
5 device in order, I think you said electricity
6 flow -- or that is probably not right.

7 How would you describe it,
8 Dr. Campbell?

9 A. You turn the NMOS device on by
10 applying a positive voltage to the gate.

11 And the result of that, if the
12 voltage is high enough, that is to say above the
13 turn-on voltage, the electricity can flow from
14 the -- well, in this case electrons are flowing.
15 So, electrons will flow from the source to the
16 drain.

17 And since electrons are negatively
18 charged, we say that the current is flowing from
19 the drain to the source.

20 Q. Are the electrons carrying the
21 electricity?

22 A. The movement of the electrons is the

1 electricity.

2 Q. What -- I have seen it. What do --
3 what is a charge carrier?

4 A. A charge carrier is something that
5 moves. It is a carrier, as opposed to ions.
6 Ions are stuck where they are, and the charge
7 carrier, the word "charge" just means that it
8 could be positive, it could be negative.

9 Q. So --

10 A. It is a term that includes both
11 electrons and holes. Both are charge carriers.

12 Q. In an NMOS device, what is the
13 charge carrier?

14 A. It is electrons.

15 Q. And, I know I have seen these terms
16 before, majority carrier and I believe minority
17 carrier; is that right?

18 A. Yes.

19 Q. So, in an NMOS device, when you have
20 these electrons carrying the charge, what is the
21 majority carrier?

22 A. You have to qualify that by saying

1 where. In most of the device -- sorry. In the
2 substrate below the channel, the majority carrier
3 is holes. In the channel, the majority carrier
4 is electrons.

5 In the source and drain, the
6 majority carrier is electrons.

7 Q. So, let me make sure I understand
8 this correctly.

9 Let's talk about the surface first,
10 okay.

11 A. Sure.

12 Q. Do you know what I mean when I say
13 surface?

14 A. I know what I mean when you say
15 surface. But, I don't know if it is the same as
16 what you mean.

17 Q. Fair enough. What do you mean when
18 you say "surface"?

19 A. When I say surface, I am referring
20 to the surface of the silicon, top-most portion
21 of the silicon wafer.

22 Q. When you are talking about the NMOS

1 device having an N-channel, what is the majority
2 carrier?

3 A. In the channel?

4 Q. Yes.

5 A. If the transistor is on, it is
6 electrons. If the transistor is off, it is
7 holes.

8 The turn-on voltage that I have used
9 before, the criteria for the turn-on voltage is
10 when you have as many electrons in the channel as
11 you had holes when the voltage was off.

12 Q. So --

13 A. Just an aside.

14 Q. Yes.

15 A. It is not required.

16 Q. Do you recall looking at the patent
17 and seeing a figure that had some arrows going
18 down? Do you recall that?

19 A. I recall several figures like that.
20 You would have to show me the particular figure
21 if you want me to comment upon it.

22 MR. WHITEHURST: Okay. Let's -- we

1 have been going for a while, do you feel
2 comfortable going or do you want to take a
3 break?

4 Miguel, I thought I saw you nod your
5 head.

6 MR. BOMBACH: Yeah, if we could have
7 a quick break, I think that would be good.

8 MR. WHITEHURST: Dr. Campbell, I
9 think you're doing great. But I think your
10 counsel wants to take a break. So, we will
11 give Miguel a chance to take a break, and
12 then we will come back. I certainly
13 appreciate all of your answers, but I do have
14 a lot of follow-up questions.

15 But like I said, I do want to keep
16 your deposition short today. I don't -- but,
17 hopefully, I can get it -- let's take a quick
18 break, and hopefully I can wrap things up
19 pretty quickly.

20 THE WITNESS: Sounds good.

21 THE VIDEOGRAPHER: The time is
22 11:14 a.m. We are going off the record.

1 (Recess taken -- 11:14 a.m.)

2 (After recess -- 11:33 a.m.)

3 THE VIDEOGRAPHER: The time is

4 11:33 a.m. We are back on the record.

5 BY MR. WHITEHURST:

6 Q. Mr. Campbell, welcome back. I hope
7 you had a good break.

8 A. Yes, thank you.

9 Q. So, I do want to try to keep this
10 short. But I want to see if we can -- or see if
11 you can help me understand better the minority
12 carriers.

13 And it may be helpful if we pull up
14 the '842 patent, which we have marked as
15 Exhibit 5. And, hopefully, you can see that on
16 your screen.

17 A. Yes, I can see it.

18 Q. Yes, you and I both. I am getting
19 out my reading glasses here. It is not fair that
20 the print keeps getting smaller and smaller.

21 MR. WHITEHURST: Let's go to

22 Figure 5B, which I believe is Page 11 of this

1 PDF. Yes. And then so you can help both the
2 witness and myself see it better, let me --
3 just -- actually, if you could zoom back out,
4 I just want to get everything on the record
5 real quick.

6 BY MR. WHITEHURST:

7 Q. And, Dr. Campbell, hopefully I get
8 this right. Correct me if I don't.

9 We are looking at U.S. Patent
10 Number 10,510,842. We are looking at what is
11 Sheet 9 of 10. It has got a stamp at the bottom
12 that says MPS Exhibit 1001, and more specifically
13 it is Page 11 of 15.

14 MR. WHITEHURST: Now, if we could
15 put that in landscape mode, please.

16 BY MR. WHITEHURST:

17 Q. Below the figure, before we zoom in,
18 is Figure 5B. And, it reads, "CMOS substrate for
19 a DRAM or image sensor with one embodiment of the
20 invention."

21 And, Dr. Campbell, do you see
22 Figure 5B on your screen?

1 A. Yes, I do.

2 MR. WHITEHURST: Now that we've
3 gotten all of that out of the way, let's zoom
4 in on just the picture part of Figure 5B up
5 at the top two-thirds of the page.

6 BY MR. WHITEHURST:

7 Q. And, Dr. Campbell, can you tell me
8 what is illustrated here in Figure 5B?

9 A. This is the NMOS transistor on the
10 left that is labeled "access transistor." And a
11 capacitor on the right. The combination of the
12 two, the NMOS transistor and a capacitor, is an
13 element of a DRAM. That is one DRAM.

14 Q. Now, for lack of a better term, do
15 you see a region that kind of looks like a
16 three-point arc in basketball.

17 Do you see that?

18 A. Yes.

19 Q. That is kind of a semicircle. But,
20 I think it looks like a three-point arc.

21 Do you see where -- and this is
22 where I really need my reading glasses, do you

1 see where it says "N," and I believe that is a
2 lower case "T."

3 Do you see that?

4 A. It looks like a lower case T to me.
5 I just assumed it was a typo. Normally, the
6 convention would be N+. Plus meaning that it is
7 very heavily N-type. I don't know about the T.

8 Q. And that was my next question
9 whether it would be accurate to say that this was
10 a typo and that would, it would make more sense
11 for it to say N+.

12 Would you agree with that?

13 A. Yes, I would agree with that.

14 Q. And then going to the right you see
15 another "Nt," and same question again.

16 Would you understand that Nt to mean
17 N+?

18 A. Yes, I would.

19 Q. And, apologies if I already asked
20 you this question, but what is an access
21 transistor?

22 A. So, the information in this DRAM bit

1 is the voltage across the storage capacitor on
2 the right.

3 You need -- if you want to read that
4 voltage or write that voltage, you have to get
5 access to that capacitor.

6 And so when you are reading or
7 writing, you would turn on the transistor, and
8 from that you could tell what the state of the
9 capacitor was.

10 Q. Is this what you called earlier an
11 NMOS transistor?

12 A. If you ignore the storage capacitor,
13 then yes, that is an NMOS transistor.

14 Q. And how would you turn this NMOS
15 transistor on?

16 A. Assuming that the top rectangle out
17 of the two rectangles is a conductor, a gate, and
18 the bottom one is an insulator, that would apply
19 a positive voltage on the gate electrode in
20 excess of the DRAM voltage.

21 Q. And why would you apply a positive
22 voltage?

1 A. To bring the electrons at the
2 surface in a very narrow well called the channel.

3 Q. And so when you are turning it on,
4 you are using the positive voltage to try to
5 create an N-channel. Would that be right?

6 A. That is correct.

7 Q. Can you walk me through how a
8 positive voltage on the gate would create an
9 N-channel in this NMOS transistor?

10 A. Okay. As you apply a positive
11 voltage on the gate, you create an electric field
12 that points downward from the gate.

13 This tends to push the majority
14 carriers, the holes, away from the surface
15 because they -- the electric field is pointing
16 downward, and the holes are positively charged.

17 This -- as a result, this movement
18 of the holes away from the surface changes the --
19 and here I'm sorry, there is no other way to say
20 this, it changes the band position.

21 The semiconductor has two bands.
22 And, if you are P-type, you are close to one

1 band, but when you push the holes away, it is no
2 longer P-type. And now electrons can flow from
3 the N regions, the N+ regions into that area and
4 form a channel.

5 Q. I want to make sure I understand
6 what you meant when you said the electric field
7 is pointing downward and the holes are positively
8 charged.

9 First of all, what would an --
10 strike that.

11 If a positive voltage is at the gate
12 of this NMOS transistor, what would the electric
13 field look like?

14 Or, how would you draw it into this
15 figure if you were going to show the electric
16 field due to a positive voltage at the gate?

17 A. The arrows that you see below the
18 transistor would be a first order approximation.
19 They would start from the bottom of the gate
20 electrode, go through the gate oxide, and
21 terminate somewhere in the region between the
22 source and the drain.

1 One limitation of such diagram is
2 that it doesn't indicate intensity, right. It
3 just indicates direction. The electric field
4 would be strongest at the surface of the silicon
5 and would decrease as you go further into the
6 substrate.

7 Q. So, you mentioned an arrow going
8 from the positive field in a downward direction.

9 And what effect would that electric
10 field pointing from the positive voltage in a
11 downward direction towards the substrate have on
12 the carriers?

13 A. The electric field pushes the holes
14 away from the surface of the device. This is the
15 first necessary part of turning the transistor
16 on. When you turn -- when you push enough holes
17 away, electrons are free to flow into that
18 channel from the source and drain.

19 Q. And what effect would it have on the
20 electrons?

21 A. The electrons, of course, are
22 negatively charged, and so they are going to be

1 attracted to that electric field. The result is
2 the channel is very narrow. Most pictures that
3 you see of a transistor in operation, the channel
4 is just wildly larger than it really is. It is
5 really very thin.

6 Q. So, are the electrons attracted to
7 the positive voltage?

8 A. Yes. The only reason they don't go
9 to the gate is because there is an insulator
10 there. They can't get through the insulator.

11 Q. And sorry to ask this. But why are
12 the electrons attracted to the positive voltage?

13 A. Because the positive voltage creates
14 a downward electric field. And electrons are --
15 see a force that is in the opposite direction of
16 the electric field because they are negatively
17 charged.

18 Q. So, when an electric field points
19 downward, it will try to push the holes towards
20 the substrate -- let me -- let me re-ask that. I
21 apologize.

22 So, when an electric field points

1 downward, it will try to push holes downward; is
2 that right?

3 A. "Try to" is unnecessary verbiage.
4 It pushes electrons down. It creates a force
5 that will tend to push holes down. I'm sorry. I
6 think I said electrons. That was a mistake.

7 Q. Why did you say the electric field
8 will tend to push the holes downward?

9 A. If I did, it is loose verbiage. It
10 is -- they will push the holes. They will
11 provide a force that tends to push the holes
12 down.

13 Q. Got it.

14 A. There are forces that overcome that,
15 but always, always, always push the holes down,
16 try to find that.

17 Q. So, I think I understand what you
18 are saying.

19 The electric field will try to push
20 holes downward, but you have to look at the other
21 forces to determine whether the hole actually
22 goes downward?

1 A. Yes.

2 Q. Okay. Let's talk about the
3 electrons. I assume the electrons would be the
4 opposite of what you said?

5 A. Yes.

6 Q. If the electric field is pointing in
7 a downward direction, the electric field will try
8 to pull the electrons upward, but you have to
9 look at the other forces in order to determine
10 what actually happens.

11 Is that correct?

12 A. While what you are saying is true,
13 it is a bit misleading, because normally there
14 are very few electrons, trillions, a factor of at
15 least a billion but often a trillion lower than
16 the holes.

17 So, yes, it would attract those
18 electrons. But, primarily the electrons come
19 from the source of the drain, once the holes are
20 out of the picture at the surface.

21 Q. Got it.

22 So, the positive voltage doesn't

1 have as much effect on the electrons because
2 there is not many of them.

3 Is that what you are trying to say,
4 or did I misunderstand?

5 A. It has the same effect on the
6 electrons, except being in the opposite
7 direction. It is just that there are fewer of
8 them, far fewer of them.

9 Q. Oh, I understand now. So, let me
10 make sure I state that correctly.

11 So, when an electron field is
12 pointing in a downward direction, it will create
13 a force on an electron in an upward direction.
14 But under Newton's first law, you would have to
15 look at the other forces in order to determine
16 what actually happens?

17 A. Yes, that is always true.

18 Q. So, when you apply a positive
19 voltage to the gate of the transistor, the goal
20 here is to form an N-channel; is that right?

21 A. That is the intention of the
22 transistor, to be able to turn it into an on

1 condition.

2 Q. And you do that by pushing holes
3 away from the surface, right?

4 A. Yes.

5 Q. Now, we see some other arrows on
6 this figure.

7 Do you see that?

8 A. Yes, I do.

9 Q. I believe there are two on the left,
10 two in the middle, and five on the right.

11 Do you see that?

12 A. Yes, I do.

13 Q. What are these arrows showing?

14 A. If I recall this figure from the
15 patent correctly, these are electric fields that
16 are due to a dopant gradient -- well, it says
17 "graded dopant" that is creating an electric
18 field to pull minority carriers away.

19 Now, in this case the minority
20 carriers would be electrons. This is a P-type.
21 If that is an NMOS transistor -- back up even
22 further.

1 It is not labeled, what it is,
2 right. It does not say what the carrier
3 concentration is or even if it is P-type or
4 N-type.

5 Q. Well, let's --

6 A. It is an NMOS transistor, so one
7 would assume that it is P-type.

8 Q. Okay.

9 A. And if it is P-type, the minority
10 carriers are electrons.

11 Q. Okay. So, if this is an NMOS
12 transistor, presumably it is built in P-type
13 silicon, correctly?

14 A. Presumably, yes.

15 Q. Now, this graded dopant region is
16 creating an electric field that is shown by these
17 nine arrows, correct?

18 A. Actually, no. That was the point I
19 was trying to make.

20 If you -- so, if that is P-type,
21 then the minority carriers are electrons.

22 And if you are moving electrons

1 down, you would have to have an electric field
2 pointing up.

3 Q. Okay.

4 A. So, many of those arrows are
5 velocity vectors are minority carriers,
6 indicating the flow of the electrons.

7 Q. Let's talk about that. Now, you
8 described earlier what happens when an NMOS
9 transistor turns on.

10 Do you recall that?

11 A. Yes.

12 Q. And we talked about what happens
13 when an N channel forms.

14 Do you recall that?

15 A. Yes.

16 Q. And when you form an N-channel, what
17 is the majority carrier in the channel?

18 A. For an NMOS device, it would be
19 electrons.

20 Q. Okay. So, if we are talking about
21 turning this transistor on and it forms an
22 N-channel, the majority carrier in the N-channel

1 is an electron, correct?

2 A. Correct.

3 Q. What is the minority carrier in the
4 N-channel?

5 A. Holes.

6 Q. Okay. Now, when you form -- strike
7 that.

8 When you turn an NMOS transistor on,
9 you form an N-channel where the majority carrier
10 is an electron and the minority carrier is a
11 hole.

12 Did I get that right?

13 A. You did get that right.

14 Q. And, if you are trying to turn this
15 transistor on more quickly, you want to get the
16 electrons to the N-channel, right?

17 A. That is a rather incorrect view. As
18 I have said several times now, the electrons that
19 form in the channel flow from the source and
20 drain. There are not enough electrons in -- as
21 minority carriers to create a channel, so --

22 Q. Let me ask this a different way.

1 If you were designing a transistor
2 and you were trying to increase its performance,
3 to turn it on more quickly, would you want an
4 electric field that -- that pulls holes from the
5 surface or pushes holes towards the surface?

6 A. I'm trying to envision what you are
7 describing.

8 Q. And I apologize. I mean, I want to
9 help you out here. I want to make sure make
10 question is clear, and I apologize if it is not.
11 And I can break it up.

12 A. No -- okay --

13 Q. So, first of all, let's talk about
14 a -- specifically an NMOS transistor.

15 Do you follow me so far?

16 A. So far so good.

17 Q. And Figure 5B shows an NMOS
18 transistor, correct?

19 A. Yes.

20 Q. And, we are going to apply a
21 positive voltage to the gate in order to turn it
22 on.

1 Does that make sense so far?

2 A. Yes.

3 Q. And, the positive voltage, I
4 believe, is applied to create an N-channel.

5 Did I get that right?

6 A. Yes.

7 Q. And, if you form the N-channel
8 quickly, the transistor would turn on more
9 quickly.

10 Is that right?

11 A. Yes.

12 Q. And if you form the N-channel more
13 slowly, the transistor would turn on more slowly.

14 Is that right?

15 A. Yes. Well, this is what I am trying
16 to say. Well, okay, yeah, I will take that as a
17 yes.

18 Q. Okay. But you hesitated. I mean,
19 did I -- I don't want to put words in your mouth.
20 I want to make sure I --

21 A. No, I'm okay with what you said.

22 Q. Okay.

1 A. That is okay.

2 Q. Okay. So, I think we are on the
3 same page. I just want to make sure. If you
4 have an NMOS transistor, the more quickly you can
5 form the N-channel, the more quickly it will turn
6 on.

7 Do you agree with that?

8 A. Yes.

9 Q. Now, if you are trying to form the
10 N-channel more quickly, what direction should the
11 electric field point?

12 A. So, here is where we have the
13 disagreement. The holes are a majority carriers.
14 Majority carriers respond infinita seconds,
15 essentially a million times smaller than --
16 faster than the transistor behave.

17 So, as soon as you apply the
18 voltage, those holes are gone.

19 What matters is how long does it
20 take for the electrons from the source to the
21 drain to move into the channel. That is one of
22 the reasons why you like smaller devices.

1 You know we are at 3-nanometer now,
2 and that is part of the reason, being able to get
3 the lateral flow of the electrons to be faster.

4 Q. So, it is your testimony that one
5 way to speed it up would be to use smaller
6 devices with higher voltages on the gates; is
7 that fair?

8 A. Higher voltages, yeah, probably,
9 that would help.

10 In reality, you are limited. You
11 rupture the gate oxide if you put a high voltage
12 on it.

13 Q. So, one way to turn the transistor
14 on more quickly is to use a smaller device; is
15 that right?

16 A. Yes. Absolutely.

17 Q. Another way to turn on the device
18 more quickly would be to apply a greater voltage
19 on the gate; is that right?

20 A. If -- so, this is all theoretical.
21 The only thing that matters is the voltage on the
22 gate. And, the gate is a capacitor. And so in

1 the real world if you put a voltage on the gate,
2 you have to apply -- you have to apply current
3 because it has to charge up the capacitor.

4 And so, would it go faster if you
5 had a higher voltage, not really. It would go
6 faster if you had more current flowing into the
7 gate.

8 Q. I see. And if you apply a higher
9 voltage to the gate, I think you said it could be
10 bad for the transistor.

11 A. Yeah. It degrades the oxide.

12 Q. So, you really don't want to apply a
13 higher voltage at the gate if you can avoid it;
14 is that right?

15 A. Yes. That's correct. It causes
16 reliability problems in the transistor.

17 Q. Got it.

18 A. I'm consulting a company on exactly
19 this topic at the moment.

20 Q. But you could provide more current,
21 and I apologize -- would you apply more current
22 to the source or to the drain?

1 A. To the gate.

2 Q. To the gate.

3 A. Yes. You want to get it up to the
4 threshold, which is the turn-on voltage as fast
5 as possible.

6 Q. Got it.

7 So, applying a higher voltage is bad
8 for the transistor, but you could apply a higher
9 current?

10 A. Yes, in principle.

11 Q. Now, if you apply a higher current,
12 isn't that going to increase power consumption?

13 A. No. Because you are putting this
14 charge on the capacitor. And again, to get the
15 voltage you want, there is a certain charge you
16 need.

17 If you are passed more current, it
18 is just going to flow for a shorter period of
19 time.

20 Q. So, if there is -- a -- so, let me
21 make sure I understand this.

22 Is there a limit on how high a

1 current you want to apply, or do you just want to
2 apply the biggest current you can possibly apply?

3 A. So, again going back to the real
4 world, this is not what limits the circuit speed.

5 This is a very, very tiny fraction
6 of the circuit speed. So, people don't really
7 worry about this is what I'm trying to say.

8 Q. Let's go back to when you were
9 working on transistors in the industry.

10 A. Sure.

11 Q. Let's say you had a fixed size. You
12 follow me so far?

13 A. Yes.

14 Q. And you had a fixed voltage. You
15 didn't want to increase it or decrease it. You
16 had a fixed voltage.

17 A. Yes.

18 Q. And you had a fixed current, and you
19 had a set current and couldn't change it.

20 Do you understand what I'm saying so
21 far?

22 A. Yes.

1 Q. So, you have everything set.

2 Could you use a graded-dopant region
3 to build a transistor that would turn on more
4 quickly?

5 A. No, not measurably.

6 Q. Would it -- okay. You said
7 measurably.

8 Is it possible to use an electric
9 field from a graded-dopant region to get
10 electrons to the surface more quickly?

11 A. I mean, we are talking about parts
12 per million. Designing these devices is always a
13 trade-off. If you are trying to optimize the
14 part per million thing, you are barking up the
15 wrong tree.

16 So, perhaps, but nobody would care.
17 It would --

18 Q. You are saying looking at magnet --
19 I -- I just want to make sure I understand. The
20 electric --

21 A. If you optimize the device for this
22 particular concern, which I don't think is a

1 concern, you are giving up something else. It is
2 always trade-offs when you design these devices.

3 Q. But, all other things equal, you
4 could use an electric field to get holes away
5 from the surface, right?

6 A. Well, if we do, that is how the
7 transistor turns on, yes.

8 Q. And, you could use an electric field
9 to get electrons to the surface, right?

10 A. Yes.

11 Q. And, if you had an electric field
12 pointing in the direction shown by the arrows in
13 Figure 5B. Do you follow me so far?

14 A. Yes. Those arrows are electric
15 fields. Go ahead.

16 Q. So, looking at Figure 5B and looking
17 at an electric field pointing in the direction of
18 the arrows shown in Figure 5B. Do you follow me
19 so far?

20 A. Yes.

21 Q. So, we have Figure 5B, and we had an
22 electric field pointing in the direction of the

1 arrows.

2 The electric field shown in
3 Figure 5B would cause holes to move in at a
4 downward direction and electrons move in an
5 upwards direction.

6 Did I get that right?

7 A. Yes.

8 MR. BOMBACH: Objection, form.

9 BY MR. WHITEHURST:

10 Q. And you answered "yes," correctly?

11 A. Yes.

12 Q. Okay. Just so the record is clear,
13 the electric field shown in Figure 5B would cause
14 holes to move in a downward direction and
15 electrons move in an upward direction, right?

16 A. Yes.

17 Q. And why is that?

18 A. Because holes are positively charged
19 and electrons are negatively charged.

20 Q. So, if an electric field shown in
21 Figure 5B is moving holes in a downward
22 direction, would you agree that it is pulling

1 holes from the surface?

2 A. Sure. Pulling, pushing, what
3 difference does it make? It is not like it is on
4 one side of the holes.

5 Q. Okay. So, if an electric field
6 shown in Figure 5B is moving holes in a downward
7 direction, it would either be pulling holes from
8 the surface or pushing holes from the surface; is
9 that right?

10 A. I would consider that to be the same
11 thing. And yes, that is right in both cases.

12 Q. So, you could describe it as pulling
13 holes from the surface or pushing holes from the
14 surface, right?

15 A. Yes.

16 Q. Before we conclude your deposition,
17 I wanted to make sure I understood our discussion
18 of Newton's first law.

19 A. Sure.

20 Q. And I apologize. I wish I knew this
21 stuff better.

22 But, I believe you said when you

1 were working on the MOSFETs, that there were
2 certain forces that affected them.

3 Do you recall that discussion that
4 we were having this morning?

5 A. Yes.

6 Q. And I believe we got to talk about,
7 you know, a voltage at the gate, and we talked
8 about an electric field created by dopants. But
9 we didn't get to talk about some of the other
10 forces that you mentioned.

11 And I just wanted to give you an
12 opportunity to. What are some of the other
13 forces that you encountered when you were working
14 in the industry besides voltages from the gate?

15 A. So, some of these forces are not --
16 sorry, let's start over.

17 The way that you design the device
18 is to use modeling software in which you tell the
19 software what the structures are and how big they
20 are and what kind of voltages you are going to
21 apply and so forth.

22 The modeling software then takes

1 into account or calculates the electric fields at
2 every point in the device.

3 And, from the electric field, it
4 gets velocities of the carriers. This is what I
5 use.

6 Now, what about the other forces?
7 You might ask and rightly so.

8 I mentioned scattering due to
9 lattice collisions. And I talk about charges,
10 again, scattering from carriers seeing each
11 other, electrons seeing electrons or electrons
12 seeing holes.

13 All of that is generally kind of
14 masked into parameters that go into what is
15 called a mobility. It tells you a relationship
16 between electric field and velocity.

17 And so, those are kind of built in
18 because it is silicon, and silicon at this
19 temperature.

20 And so, those are in the model, but
21 the user of the model doesn't necessarily have to
22 deal with those other effects that are going on.

1 It is just masked as a parameter.

2 If there were a doping profile, of
3 course, the model would create the electric field
4 through that doping profile just like it would
5 the electric field due to applied voltages.

6 Q. So, when you were modeling these
7 semiconductor devices, did you design them for a
8 particular temperature?

9 A. We designed them for a temperature
10 range. You have different ranges for commercial
11 products and DoD products.

12 So yes, you model them at multiple
13 temperatures, and most particularly the corners
14 to ensure that it will operate properly. And
15 then you make the devices, and you test them at
16 those corner temperatures to make sure they work
17 at all within the range that it is specified for.

18 Q. And why were these temperature
19 ranges important?

20 A. Presumably because the client is
21 going to use them in an environment that could go
22 over those ranges when the device is on.

1 So, it is not only the environment
2 in the off state but when you start operating the
3 device in some environment, what would the
4 operating temperature be.

5 Q. And you mentioned DoD, I assume you
6 mean Department of Defense?

7 A. Yes. That is correct.

8 Q. And would DoD products typically
9 have a different temperature range?

10 A. A larger temperature range. They
11 are usually interested in higher temperatures.

12 Q. And you mentioned doping profile.
13 Would you -- strike that.

14 Would you typically use different
15 doping profiles for DoD products?

16 A. My role working at the company was
17 really centered on the commercial side.

18 I didn't do designs for the DoD.
19 That was another group. So, I couldn't say.

20 Q. So, you don't know what doping
21 profiles were used in the DoD product?

22 A. That is correct. I know what are

1 used in the commercial but not in the DoD.

2 Q. But, the DoD products were typically
3 for a higher temperature range?

4 A. Yes.

5 Q. Can you think of any situation where
6 you might want to use a different doping profile
7 for a higher temperature range?

8 A. Yes. It is certainly possible.

9 Q. Why is it possible that you would
10 want to use a different doping profile for a
11 higher temperature range?

12 A. The higher temperature range
13 introduces the higher concentration of minority
14 carriers nowhere near what you get with an
15 alpha-particle strike but still more than you
16 would have in a lower temperature.

17 You would also change the threshold
18 voltage, and you want to make sure that over that
19 temperature range, the threshold voltage stays
20 within the range specified.

21 Q. Would you have to use a steeper
22 profile for DoD products?

1 A. Again, I didn't design DoD products,
2 so I can't tell you.

3 Q. But if you were getting more
4 carriers, would it be helpful to have a steeper
5 profile?

6 MR. BOMBACH: Objection, form.

7 THE WITNESS: It is not obvious to
8 me.

9 BY MR. WHITEHURST:

10 Q. What -- what would you want to do
11 with the profile for a higher temperature range
12 product?

13 What are some of the things that you
14 could do to improve it?

15 A. The problems with higher temperature
16 rarely include gradients or doping profiles.

17 It is -- in my understanding and as
18 I will say it for the fourth time now, I didn't
19 work on that project.

20 But, my understanding from talking
21 to people who did, the primary problems are
22 interconnected. Yeah, that is by far the worst

1 one.

2 Q. Let's talk about some of the
3 products you did work on.

4 A. Sure.

5 Q. Did you ever work on products that
6 were designed for a higher temperature range?

7 A. No. Just commercial.

8 Q. Did you ever work on products that
9 were for a lower temperature range?

10 A. I don't know if there is such a
11 thing. But, no, I haven't.

12 Q. Did you, when you -- well, let me
13 ask this a different way.

14 When you worked on products, were
15 they all for the same temperature range?

16 A. Yes. That is the standard
17 commercial range.

18 Q. So, you only worked on the
19 commercial temperature range?

20 A. Yes.

21 Q. I understand. And I apologize, I'm
22 just trying to figure things out. I wasn't

1 trying to ask the same question multiple times.

2 And I will certainly move on.

3 What I am trying to understand
4 better is why different products might be
5 designed differently.

6 Is that a fair question?

7 A. It is fair. When you asked me the
8 question before, you said, is it possible that
9 they would have different doping profiles? And I
10 said yes, it is possible.

11 I didn't say that they have
12 different doping profiles. And I don't know that
13 they have different doping profiles.

14 Q. I completely understand.

15 When you were working on products,
16 did you ever change the doping profile?

17 A. Yes, of course.

18 Q. And, what were you trying to
19 achieve?

20 A. Fundamentally, you are trying to get
21 the right threshold voltage, that is the primary
22 parameter. It has to be within this range, and

1 you have to be able to hold that range over a
2 large number of transistors. And it has to stay
3 in that range over a range of temperatures.

4 And then to increase the
5 performance, you want to improve the contact
6 resistance, so you try to make the source and
7 drain very heavily doped, but they can't be too
8 deep because that causes a problem with the
9 transistors.

10 And you have to modify how you put
11 the impurities in and how you anneal them
12 afterwards because they diffuse and get bigger.
13 The well profile has to be optimized because they
14 don't want the depletion regions to punch all of
15 the way through the well.

16 So, yeah, we do a lot of dopant.

17 Q. You mentioned annealing and
18 diffusing.

19 What did you mean by that?

20 A. Annealing means heating it to a high
21 temperature, and diffusion is the movement of
22 dopant atoms at high temperature.

1 Q. So, why would you anneal and
2 diffuse?

3 A. You have to anneal because the plant
4 process damages the silicon, and the damaged
5 silicon will destroy the device.

6 So, that is number one. And number
7 two, equally as important, as-implanted, the
8 impurities that dopants are just randomly
9 positioned and for those atoms to act as dopants,
10 they have to be out of crystal lattice. They
11 have to replace the silicon atom and the
12 annealing allows that to happen.

13 Q. And what happens when they diffuse?

14 A. The position of the dopant atoms
15 goes beyond the areas that was asked off for the
16 implant. The implant is in let's say a rectangle
17 area. When you anneal it, the dopant atoms will
18 diffuse down because most of them are near the
19 surface.

20 When you have a concentration
21 gradient, they will diffuse. And they diffuse
22 laterally, so the figures get -- the features

1 get a little bit bigger.

2 Q. When you diffuse, are you trying to
3 spread things out more equally?

4 A. There are applications where you
5 might want to do that, but usually you are trying
6 to have very well confined dopant profiles.

7 Q. When you anneal, do you get
8 diffusion?

9 A. Yes.

10 Q. And the diffusion allows things to
11 kind of return to a more even state?

12 A. Even state?

13 Q. How would you -- and I apologize.
14 How would you describe what happens
15 when they diffuse?

16 A. Technically, you would say they have
17 been activated, which means they sit on a silicon
18 lattice, and therefore, act as a dopant.

19 And, they -- well, I mean, we just
20 say they diffuse laterally and vertically.

21 Q. What do you mean when you say
22 diffuse vertically?

1 A. So, let's define a term called the
2 "junction depth." The junction depth is where
3 the concentration of, let's say, the drain is
4 equal to the concentration of the well. The
5 drain is an opposite type as the well.

6 So, when we have certain
7 concentration of donors and exactly the same
8 concentration of receptors at that -- at that
9 depth, that is the junction depth.

10 When you anneal, the impurities that
11 form the drain diffuse downward, and that moves
12 the junction depth deeper. Usually it is not a
13 desirable thing, and you try to minimize the
14 diffusion.

15 Q. You mentioned "ion implantation."

16 Do you remember that?

17 A. I do.

18 Q. What is ion implementation?

19 A. Not implementation, "implantation."

20 Q. Oh, I'm sorry. Did I misspeak?

21 What --

22 A. It is called implant.

1 Q. Implant. And I apologize. We will
2 just say implant.

3 So, when you implant from above the
4 silicon device, what typically happens?

5 A. So, typically we start off the
6 process by applying a photo mask to block off
7 some areas where you don't want the implant to
8 go. And you leave open areas where you do want
9 the dopant to go.

10 And you put it in a very large
11 machine called an ion implanter. The wafers are
12 at one end of the machine, and at the other end
13 of the machine, there are gases that contain the
14 thing you want to implant.

15 Let's say phosphorous, you want to
16 implant phosphorous, the gas that you use is
17 phosphene, an extremely hazardous gas, but
18 nevertheless that is what they use.

19 They send a little bit of that gas
20 into a plasma. The plasma rips apart the
21 molecule and creates phosphorous ions. They
22 knock one electron off a phosphorous atom. And

1 they use electric fields to accelerate that ion
2 to whatever energy that they want. And
3 ultimately that ion strikes the wafer and gets
4 incorporated into the wafer.

5 Q. When you do ion implanting, do you
6 sometimes get more ions at the surface?

7 A. It all depends on the energy that
8 you use. The first order, it forms a Gaussian,
9 so it is exponential. And there is a depth at
10 which peak concentration is, and you move that up
11 and down with the energy of the implant. So,
12 that is one of the parameters.

13 When we talked about designing the
14 doping profiles, that is what you do, you design.
15 You are deterring the dose and the energy for all
16 of the implants.

17 Q. What is a Gaussian?

18 A. A Gaussian is a profile that goes
19 like exponent to the X minus the peak position
20 quantity squared, divided by a straggle factor.

21 It is a very, very rapid, very steep
22 gradient.

1 Q. What happens to a Gaussian after
2 annealing and diffusing?

3 A. It becomes less sharp.

4 Q. What do you mean?

5 A. If you look at both the implant
6 profile, and then after all of the thermal
7 processes, what is the final profile.

8 Q. And I was trying to ask, what do you
9 mean when it becomes less sharp?

10 A. I mean the gradient is not as steep.

11 Q. So, after the annealing and the
12 diffusion, the gradient is not as steep?

13 A. Yes. Compared to the as-implanted
14 profile.

15 Q. So, you could have a doping profile
16 that is steep, and then after you anneal it and
17 diffuse, it would be less steep?

18 A. Yes.

19 Q. Do you ever do annealing and
20 diffusion where you get rid of the steepness all
21 together?

22 A. Meaning to make it uniform?

1 Q. Yes.

2 A. No. That is not how you make a
3 uniform profile.

4 Q. How would you make a uniform
5 profile?

6 A. You detect the growth.

7 Q. When you say less sharp, what would
8 you describe as less sharp? I mean, I'm just
9 trying to figure out what you meant by less
10 sharp.

11 A. It is not a quantitative
12 description. It is just a comparative. The
13 doping profile after anneal does not have as
14 steep a gradient as it did before anneal.

15 Q. Is it possible to do annealing and
16 diffusing where the polarity of the slope might
17 change?

18 A. So, as I mentioned before when you
19 do an implant and you have a Gaussian, there is a
20 peak at someplace. And at one side of the
21 Gaussian is going to have the opposite slope as
22 the other side.

1 And you can play with this. You can
2 do multiple implants, so you have a peak there,
3 plus a peak here, plus a peak here.

4 And, I have seen people do that to
5 try to make it quasi-uniform, but it is never
6 totally uniform because at the edges there is
7 always going to be an exponential decay.

8 Q. I understand it will never be
9 totally uniform. You are always going to have
10 slight variations due to manufacturing, right?

11 A. No, it is just because they are
12 doing a discrete number of implants. I have
13 never seen them do a continuous range of
14 energies. It is always three or four different
15 energies. And so you get bumps, one from each
16 energy.

17 Q. So, when you do a Gaussian, let me
18 make sure I understand that, would a Gaussian
19 kind of look like a bell curve?

20 A. Yes, kind of.

21 Q. I think I understand what you are
22 saying.

1 So, you know, you have a Gaussian,
2 which may look like a bell curve. On one side
3 you are going to have a negative slope and on the
4 other side you are going to have a positive
5 slope.

6 Is that a fair statement?

7 A. That is correct.

8 Q. And, when you do the annealing, the
9 negative slope is going to get closer to 0; is
10 that a fair statement?

11 A. Yes.

12 Q. And when you do the annealing, the
13 positive slope is going to get closer to 0; is
14 that right?

15 A. I'm sorry. In those two, when you
16 said it is closer to 0, what is it that gets
17 closer to 0?

18 Q. So, I'm trying to understand does
19 the annealing and diffusing process affect both
20 sides of the Gaussian?

21 A. Yes.

22 Q. Why does it affect both sides of the

1 Gaussian?

2 A. Because the diffusion depends on the
3 first order on just temperature.

4 It can also -- well, it is impacted
5 by the damage caused by the implant. And the
6 damage profile is different than the dopant
7 profile.

8 So, it isn't perfectly just
9 dependent on temperature but mostly.

10 Q. But, if you have a Gaussian, it is
11 going to -- let me strike that.

12 If you have a Gaussian and you do
13 a -- an annealing process, it will tend to make
14 the Gaussian flatter on both sides?

15 A. So, let's back up a bit. And I
16 wanted to make a comment earlier but given the
17 flow, it was hard to cut in.

18 When you said it looks like a bell
19 curve, it does in the -- in the maximum part of
20 the bell curve.

21 It does not look like it in the
22 tails of the bell curve.

1 Q. I understand. And, I will stop
2 using the word "bell curve" so that we are just
3 talking about a Gaussian.

4 And I want to help our court
5 reporter out today, I'm sure she can fix this
6 later, but it would probably help her if you
7 spelled Gaussian on the record for her.

8 A. G-A-U-S-S-I-A-N.

9 MR. WHITEHURST: And, Ms. Court
10 Reporter, where the record has been saying
11 Gaussian, G-A-L-C-I-O-N, Dr. Campbell, that
12 should be spelled G-A-U-S-S-I-A-N, correct?

13 THE WITNESS: Correct.

14 BY MR. WHITEHURST:

15 Q. I just want to help both of us out
16 so you don't have to do a long errata later.
17 Just trying to help you out. Those erratas are
18 never fun.

19 Going back to the Gaussian, when you
20 do the annealing and diffusion, it will tend to
21 make both sides less steep, right?

22 A. Yes.

1 Q. And why does it make both sides less
2 steep?

3 A. The diffusion process is driven by
4 concentration gradients.

5 So, diffusion always causes things
6 to move from areas of high concentration to areas
7 of lower concentration.

8 Q. And why did --

9 A. When you are talking about
10 wildebeests on the plane or atoms in a silicon,
11 diffusion is diffusion.

12 Q. I'm not going to ask you about
13 wildebeests, but why do atoms in silicon move
14 from areas of high concentration to areas of
15 lower concentration?

16 A. Well, diffusion is due to the random
17 movement of individual atoms, in this case atoms.

18 So, they move randomly, every which
19 way.

20 But, in the areas of high
21 concentrations, you have more of them. And if
22 you have more of them and everyone is moving

1 randomly, they will tend to move in net away from
2 areas of high concentration to areas of low
3 concentration.

4 Does that make sense?

5 Q. It kind of does. I mean, let me ask
6 it a slightly more specific way.

7 If an electron sees an area with
8 lots of electrons, and it sees another area with
9 low electrons, where is it going to tend to move?

10 A. That is a different story because
11 with electrons, you have electrostatic forces
12 that are active. With the dopant atoms, you
13 don't.

14 So, I like to use this analogy with
15 my students in the class, diffusion is turn
16 off -- put all of you into one side of the room,
17 tell you to stand up, turn off the lights, and
18 ask you to start moving around.

19 After a while, there will be pretty
20 much random distribution of people.

21 But, if you didn't take your eyes
22 off, if there are forces acting, then you don't

1 just have diffusion. You have diffusion plus
2 electrostatic forces.

3 Q. And that is why you have to look at
4 Newton's law, I think you said?

5 A. Exactly.

6 Q. When you were designing MOSFETs and
7 you did the recipes, did you do the recipes with
8 the Gaussians, or did you do the recipes for what
9 it would look like after the annealing and
10 diffusion?

11 Does my question make sense?

12 A. Yes.

13 Q. Which --

14 A. We always designed for after the
15 diffusion.

16 In the wells -- in the wells, we
17 always had a gradient doping that goes from
18 higher concentration near the surface and lower
19 concentration as it goes in.

20 Q. When you were working on the
21 MOSFETs, why did you design for after the
22 diffusion?

1 A. Because the only thing that matters
2 is how the device operates when it is fully
3 processed, when it is done.

4 It doesn't matter how it would
5 theoretically operate halfway through the
6 process.

7 Q. So, I think I understand what you
8 are saying. In order to understand how a device
9 would operate, you would want to see what it
10 would look like after the annealing?

11 A. Yes. So, I probably should have
12 explained this previously. There are actually
13 two modeling systems, one that models the process
14 flow, and so you do the implants and yada, yada,
15 yada.

16 And at the end of that is the
17 device, the physical device, the doping profiles,
18 how quick this is and that is where everything
19 is. Then you take that output/input into a
20 device modeler.

21 And there you apply the voltages.
22 And it does what we described before doing F

1 equal MA.

2 So, in the first one it is called
3 the TCAD, technology computer-aided design.

4 And the TCAD, you are -- you are
5 following through all of the process steps, and
6 you are very interested in how the profiles
7 change with various steps.

8 But, in the end what matters is the
9 device performance. You tweak the TCAD to get
10 the device performance to what you need.

11 Q. And I believe you talked about, you
12 have the process flow, and then you had the
13 device modeler.

14 Did I get that right?

15 A. That's correct.

16 Q. And what would you call the profile
17 in the process flow?

18 A. I'm sorry. What would we call the
19 what?

20 Q. What would you call the profile that
21 is in the process flow before the annealing?

22 A. As-implanted profile.

1 Q. So, when you are looking at the
2 process flow, you look at what is called an
3 implanted profile; is that right?

4 A. Yes, as-implanted profile.

5 Q. As-implanted profile. Thank you.

6 So, I assume that would be A-S,
7 space, I-M-P-L-A-N-T-E-D; is that right?

8 A. We are going to make an engineer out
9 of you yet, yes.

10 Q. I'm trying. Thanks, and I certainly
11 appreciate you being patient.

12 So, the process flow uses what's
13 called an as-implanted profile.

14 And then the device modeler uses a
15 different profile?

16 A. The process modeling looks at both
17 the as-implanted profile, but then the
18 post-annealing profile as well.

19 Q. And why?

20 A. The post-annealed profiles are
21 turned over to the device modeling.

22 Q. And why are the post-anneal profiles

1 important?

2 A. Because that is what the device
3 actually sees.

4 Q. And it is the post-anneal profile
5 that determines how the device actually operates?

6 A. Exactly.

7 Q. I think we are coming to the end or
8 getting close. But, I had a note here I wanted
9 to make sure I understood it.

10 You mentioned electric fields and
11 velocity of the carriers.

12 Do you remember that?

13 A. I'm sorry. There was a disturbance
14 outside my door.

15 Could you repeat that?

16 Q. Quite all right. I had a note here,
17 and I hope I get it correctly.

18 You mentioned electric fields and
19 velocity of the carriers.

20 Do you recall that, when I was
21 asking you --

22 A. Yes.

1 Q. What are some of the electric fields
2 that you encountered when you were working with
3 MOSFETs?

4 A. So, there are intrinsic fields due
5 to doping gradients. That could be doping
6 gradients in a -- in a region where all of the
7 dopants are the same by polarity.

8 Or it could be in a junction where
9 you have an N region and a P region adjacent to
10 each other.

11 So, those are -- those are two. And
12 then the others are primarily the voltages that
13 are applied to the gate and to the drain.
14 Usually the source is held at ground.

15 Q. Any others?

16 A. Any other electric fields? No, I
17 don't think there are any.

18 Q. When you were talking about Newton's
19 law, what are the fields that you would look at
20 for a semiconductor device?

21 A. Unless you are doing something
22 really unusual, it is the electric fields. We

1 don't really have any impact on the magnetic
2 fields. And I'm not sure what other fields you
3 are interested in.

4 Q. What would affect the velocities of
5 the carriers?

6 A. So, the primary thing is the
7 electric field. The velocity increases linearly
8 with electric field until you get to very high
9 fields, and then you have what is called velocity
10 saturation. It can't go any faster than that.
11 It is the speed limit.

12 But, the slope of that linear region
13 depends on how good the crystal is, how many ions
14 you have in the area, how dense the electrons
15 are.

16 All of these things can cause
17 scattering, and it will slow the carrier down.

18 Q. What else affects the carriers? And
19 I apologize. Maybe we can just list them out.

20 What would -- when you were
21 designing MOSFETs, what would affect the movement
22 of the carriers?

1 A. The electric fields, temperatures --
2 temperature, sorry. If there were magnetic
3 fields around, we don't usually design for that,
4 but if there were, that would affect it.

5 If there light exposure -- again,
6 usually these things are packaged, and so there
7 is no light. But, if you are not encapsulating
8 them, then that is something to be aware of.

9 I may be missing a few things, but
10 that is what I can think of at the top of my
11 head.

12 Q. Did the type of semiconductor affect
13 it?

14 A. Oh, you mean whether it is silicon
15 or some other material?

16 Q. Yes.

17 A. Oh, absolutely. I'm sorry. I
18 thought we were just talking about silicon. Yes,
19 absolutely. That has a big impact.

20 Q. Why would the type of semiconductor
21 be important?

22 A. Well, there are a lot of reasons for

1 that, but the one is that the mobility would be
2 different.

3 So, both the diffusion of carriers
4 and the movement of carriers in response to the
5 electric field would be different.

6 Gallium arsenic, for example, has a
7 higher mobility so we use it in microwave
8 circuits for -- for very high frequencies.

9 It has a different bandgap. Again,
10 gallium arsenic has a wider bandgap -- and,
11 again, I'm sorry I'm talking engineering-ese, but
12 in layman's term, they operate at higher
13 temperatures.

14 The quality of materials is
15 different and that means, again, you have defects
16 and mobility problems, good or bad.

17 The dopants are different. Allowed
18 the temperatures are different. You can't grow
19 an oxide on gallium arsenic because it's crap.

20 Because if you have gallium and
21 arsenic, and if you oxidize the gallium, you are
22 going to have a bunch of arsenic left behind, so

1 you can't make MOSFETs with gallium arsenic.

2 The -- yeah, the whole process flow
3 is different and the advantages and disadvantages
4 have to be weighed.

5 Q. I apologize. What did you mean when
6 you said "mobility would be different"?

7 A. I said that the velocity of a
8 carrier is proportional to the electric field, at
9 least at low-to-moderate fields. Velocity goes
10 up as the electric field goes up. The slope of
11 that curve is mobility.

12 So, for electrons of gallium
13 arsenide, they move faster in an electric field
14 than they would in silicon. That is the
15 advantage. That is why they do high frequency
16 stuff in gallium arsenic.

17 Q. I think I understand it. So, when
18 you say "different," you mean sometimes they move
19 easier and sometimes they move --

20 A. Exactly, yes. We sometimes call
21 that the "effective mass." The electrons are
22 effectively lighter than gallium arsenic, they

1 move faster.

2 Q. And when do they move less?

3 A. Slower? Less, meaning not as often
4 or less as in slower?

5 Q. I guess we should break it up. I
6 was just trying --

7 When you say they move less, you
8 know, how are -- how are some of the ways that
9 they -- the carriers would move less?

10 A. I think when you are referring to
11 carriers moving less, you are talking about
12 slower.

13 And so what would cause them to move
14 more slowly? Defects in the semiconductor,
15 higher temperatures.

16 The dopant atoms themselves are
17 scattering centers. And so they move more slowly
18 if you have a lot of dopant atoms.

19 Q. What are other ways that you could
20 move less? For example, could you move less far?

21 A. Again, I'm not understanding. Move
22 less far? You mean -- it would be difficult to

1 move a distance?

2 Q. I apologize, I'm not an expert on --

3 A. That's fine.

4 Q. -- these things like you are.

5 A. We are doing our best to understand
6 each other's language.

7 Q. And I apologize when I don't use the
8 language that I should.

9 I'm trying to just understand
10 better, you know, what -- how different
11 semiconductors operate differently. Maybe that's
12 the way to ask the question.

13 We were talking about, you know, the
14 movement of the carriers in different
15 semiconductors.

16 Why is the movement of the carriers
17 different in different semiconductors, is what
18 I'm trying to ask.

19 A. Okay. Got it. This is,
20 unfortunately, not an easy thing to explain
21 because it relies on quantum mechanics and band
22 structure. I don't have an easy way to explain

1 this.

2 It is -- it is the nature of the
3 electronic bonds when they form this material
4 that gives rise to very low effective mass on
5 a -- and short of trying to calculate or explain
6 band structure calculations, that is hopeless.
7 I'm sorry.

8 Q. What about the word "resistance,"
9 would that be a way to describe it?

10 A. Sure. Resistance depends on the
11 number of carriers you have and their mobility.
12 So, in the case of gallium arsenide, you have
13 better mobility.

14 So, if you can put as many carriers
15 in as in silicon, then you would have lower
16 resistivity or higher connectivity.

17 Q. I think I understand it better now.

18 So, different semiconductors have
19 different resistances; is that right?

20 A. Different resistances -- if they
21 have the same doping concentration, they would
22 have different resistances.

1 Q. What semiconductors would have a
2 higher resistance?

3 A. Well, gallium arsenide is a great
4 one for this. If you don't put any dopants in,
5 you can make it 10 million centimeters.

6 It's extremely -- I mean, it isn't
7 like silicon dioxide, but it is very insulating.

8 Q. And what is an example of a
9 resistance -- strike that.

10 What is an example of a
11 semiconductor that has a lower resistance?

12 A. Again, it is the product of the
13 number of dopants and the mobility. So, with
14 silicon you can dope it like crazy with the right
15 dopants. And so it can get very low resistance
16 even though the mobility is just so-so.

17 There are other materials, and I
18 work primarily in the silicon area not in the
19 compound silicon area, so I couldn't tell you who
20 has the record, which material has the record.

21 Q. So, it sounds like you could have
22 the same amount of dopants, but those dopants

1 will have a different effect in different
2 semiconductors.

3 Is that what you are saying?

4 A. Yes, that is correct.

5 Q. And why would the same amount of
6 dopants have a different effect in different
7 semiconductors?

8 A. Because the different semiconductors
9 have different mobilities. The carriers are
10 effectively lighter or heavier.

11 So, you have more of them, but they
12 are more sluggish in one material compared to
13 another.

14 Q. What happens in the gallium
15 arsenide, are the carriers more sluggish?

16 A. Compared to silicon?

17 Q. Yes.

18 A. No, they are less sluggish.

19 Q. So, the carriers are more sluggish
20 in silicon than gallium arsenide?

21 A. Yes, that is correct.

22 Q. And what happens when the carriers

1 get more sluggish?

2 A. You don't get as much current for
3 the same geometry and voltage.

4 Q. Does that mean you have to put more
5 dopants in?

6 A. Well, it depends on where we are
7 discussing. Usually when we talk about the
8 current, it is a transistor current, the current
9 in that channel. And, adding doping, more doping
10 in the channel just changes the on voltage. It
11 doesn't change the number of carriers in the
12 channel.

13 Q. But if we were talking about silicon
14 where it is more sluggish, if you are trying to
15 get a carrier to move, do you have to put more
16 force on it?

17 A. Right. To get it to move to the
18 same velocity, you would need a larger electric
19 field which is more force.

20 Q. Why do you have to put more force on
21 a sluggish carrier?

22 A. F equal MA. You know, again, if the

1 mass goes up, then the force has to go up to get
2 the same acceleration.

3 Q. And, what happens if you don't put
4 enough force on a sluggish carrier?

5 A. Then you get less current.

6 Q. What else might happen under F
7 equals MA?

8 A. That is it.

9 Q. So, silicon is -- wait. I -- what
10 are some other semiconductors that have high
11 resistances like silicon?

12 A. I wouldn't say silicon has a high
13 resistance. I said it is so-so.

14 Q. It's so-so.

15 A. There are a lot of the, let's call
16 them, emerging materials where they don't know
17 how to make really good crystals. There is lots
18 of defects in the material. And that causes it
19 to be sluggish.

20 And, again, those are all compound
21 semiconductors. I don't work in that. I
22 couldn't tell you which ones are worse than

1 others.

2 MR. WHITEHURST: We have been going
3 for a while. Let's take a quick break.

4 And, Counsel, I'm going to look at
5 my list and maybe we can wrap things up here
6 pretty soon.

7 Thank you, Dr. Campbell. We will go
8 off the record now.

9 THE VIDEOGRAPHER: The time is
10 12:54 p.m., we are going off the record.

11 (Recess taken -- 12:54 p.m.)

12 (After recess -- 1:04 p.m.)

13 THE VIDEOGRAPHER: The time is
14 1:04 p.m., and we are back on the record.

15 MR. WHITEHURST: Dr. Campbell, I
16 just want to thank you for your time today.
17 I certainly appreciate your testimony, and I
18 have no further questions.

19 CROSS-EXAMINATION

20 BY MR. BOMBACH:

21 Q. Okay. I have a quick couple
22 questions for the point of clarity.

1 Dr. Campbell, are you aware of
2 Newton's second law?

3 A. Newton's second law. I don't recall
4 it. I'm sorry.

5 Q. Okay. Newton's --

6 A. I don't know Newton's second law.

7 MR. WHITEHURST: I don't remember it
8 either, Dr. Campbell, if it makes you feel
9 any better.

10 BY MR. BOMBACH:

11 Q. And I guess, Newton's -- would it
12 trigger your memory, if I said Newton's second
13 law describes --

14 MR. WHITEHURST: Oh, objection,
15 leading the witness. That is -- that is
16 pretty blatant. He already said he doesn't
17 remember. What are we going to do? I
18 mean --

19 MR. BOMBACH: Okay.

20 MR. WHITEHURST: -- it goes beyond
21 the scope, too.

22 I didn't ask about second law. That

1 is completely out of bounds.

2 BY MR. BOMBACH:

3 Q. Okay. Then, I will pull up an

4 exhibit. Give me one second. Give me --

5 MR. BOMBACH: Could we go off the

6 record for one second?

7 THE VIDEOGRAPHER: Sure. The time

8 is 1:05 p.m., we are going off the record.

9 (Recess taken -- 1:05 p.m.)

10 (After recess -- 1:11 p.m.)

11 THE VIDEOGRAPHER: The time is

12 1:11 p.m., and we are back on the record.

13 BY MR. BOMBACH:

14 Q. Dr. Campbell, for clarity, what is

15 Newton's second law?

16 MR. WHITEHURST: He already said he

17 doesn't know, Counsel.

18 THE WITNESS: I'm sorry, I don't

19 know Newton's second law.

20 BY MR. BOMBACH:

21 Q. You do not know what Newton's second

22 law is?

1 A. Is that the one where a body in
2 motion can be used to stay in motion, by a
3 force -- I don't know.

4 Q. Okay. So, sitting here today, you
5 are not entirely sure which one the second law
6 is?

7 A. Correct.

8 Q. Okay. And then, what is Newton's
9 first law?

10 A. I thought it was F equals MA , but it
11 sounds like I am going to be schooled
12 differently.

13 Q. So, I guess sitting here today, you
14 are not 100 percent sure what the exact
15 definition of the -- Newton's first and second
16 law is?

17 A. I thought I was until I heard an
18 objection being raised.

19 Q. Okay.

20 A. I am ready to listen.

21 MR. BOMBACH: No, I think I am -- I
22 have no further questions.

1 REDIRECT EXAMINATION

2 BY MR. WHITEHURST:

3 Q. Dr. Campbell, you understand
4 physics, correct?

5 A. Yes. I certainly do. I have a
6 Ph.D. in it.

7 Q. And whether we are talking about
8 Newton's first law or second law or third law,
9 you understand how forces work?

10 A. Yes, absolutely.

11 Q. And, we talked earlier about net
12 effect of the forces.

13 Do you recall that?

14 A. Yes.

15 Q. And why is it important to look at
16 the net effect of the forces?

17 A. Because that is what determines the
18 movement, in this case, of the minority carriers.

19 MR. WHITEHURST: Thank you for your
20 time today. That concludes the deposition.
21 We can go off the record.

22 THE VIDEOGRAPHER: All right. Stand

1 by. The time is 1:13 p.m., November 22nd,
2 2024. We are going off the record,
3 completing today's video-recorded session.
4 (Whereupon, signature not having been waived,
5 the deposition suspended at 1:13 p.m. CDT)

6 * * *

1 CERTIFICATE OF NOTARY

2

3 I, LORI J. GOODIN, RPR, CRR,

4 CA CSR # 13959 the Notary for this deposition, do

5 hereby certify that the witness whose testimony

6 appears in the foregoing deposition was sworn by

7 me; that I am neither counsel for, related to,

8 nor employed by any of the parties to the action

in which this deposition was taken; and, further, that I am

9 not a relative or employee of any attorney or

counsel employed by the parties hereto, or

10 financially or otherwise interested in the

outcome of this action.

11

12 _____
LORI J. GOODIN, RPR, CRR

Notary Public in and for:

13

14 STATE OF FLORIDA, COUNTY OF SARASOTA

Notary Commission Number: GG987804

15 My Commission expires: May 12, 2028

STATE OF CALIFORNIA, CA CSR# 13959

16 My Commission expires: February 22, 2025

STATE OF MARYLAND, COUNTY OF ANNE ARUNDEL

17 My Commission expires: August 2, 2025

DISTRICT OF COLUMBIA, WASHINGTON DC

18 My Commission expires: June 1, 2026

19 STATE OF DELAWARE, COUNTY OF KENT

20 My Commission expires: September 9, 2025

21 COMMONWEALTH OF PENNSYLVANIA, COUNTY OF LEHIGH

22 My Commission expires: April 5, 2025

1 Stephen A. Campbell, Ph.D., c/o
PERKINS COIE

2 11452 El Camino Real #300
San Diego, California 92130

3
Case: Monolithic Power Systems Inc. v. Greenthread, LLC

4 Date of deposition: November 22, 2024

Deponent: Stephen A. Campbell, Ph.D.

5

6 Please be advised that the transcript in the above
referenced matter is now complete and ready for signature.

7 The deponent may come to this office to sign the transcript,
8 a copy may be purchased for the witness to review and sign,
9 or the deponent and/or counsel may waive the option of
10 signing. Please advise us of the option selected.

11 Please forward the errata sheet and the original signed
12 signature page to counsel noticing the deposition, noting the
13 applicable time period allowed for such by the governing
14 Rules of Procedure. If you have any questions, please do
15 not hesitate to call our office at (202)-232-0646.

16

17

18 Sincerely,

19 Digital Evidence Group

20 Copyright 2024 Digital Evidence Group

21 Copying is forbidden, including electronically, absent
22 express written consent.

1 Digital Evidence Group, L.L.C.
1730 M Street, NW, Suite 812
2 Washington, D.C. 20036
(202) 232-0646

3

4 SIGNATURE PAGE

Case: Monolithic Power Systems Inc. v. Greenthread, LLC
5 Witness Name: Stephen A. Campbell, Ph.D.
Deposition Date: November 22, 2024

6

I do hereby acknowledge that I have read
7 and examined the foregoing pages
of the transcript of my deposition and that:

8

9 (Check appropriate box):

() The same is a true, correct and
10 complete transcription of the answers given by
me to the questions therein recorded.

11 () Except for the changes noted in the
attached Errata Sheet, the same is a true,
12 correct and complete transcription of the
13 answers given by me to the questions therein
14 recorded.

15

16

17

DATE

WITNESS SIGNATURE

18

19

20

21

22

DATE

NOTARY

1 Digital Evidence Group, LLC
2 1730 M Street, NW, Suite 812
3 Washington, D.C. 20036
4 (202)232-0646

5

6 ERRATA SHEET

7

8 Case: Monolithic Power Systems Inc. v. Greenthread, LLC

9 Witness Name: Stephen A. Campbell, Ph.D.

10 Deposition Date: November 22, 2024

11 Page No. Line No. Change

12

13

14

15

16

17

18

19

20

21

22

Signature

Date

A				
A-S 136:6	activated 121:17	allows 120:12	appearances 3:1	146:19
a.m 1:15 2:4 5:1	active 74:20,22	121:10	6:5	areas 75:2,7,8
5:17 18:5 25:22	75:7 76:1,3	alpha-particle	appeared 13:2	76:2 120:15
26:2,3,5 29:12	132:12	56:11 115:15	appears 23:16	123:7,8 131:6,6
29:13,14,16	actual 24:3 43:10	amend 11:18	156:6	131:14,14,20
83:22 84:1,2,4	71:12	amount 146:22	appended 19:10	132:2,2
a/k/a 67:15	adapted 62:16	147:5	appendices 18:9	arrow 62:7,11
able 14:14 27:15	add 42:16,18	analogy 47:6	applicable	91:7
34:13,15 57:9	74:8,14	132:14	157:13	arrows 82:17
60:22 68:6	adding 148:9	and/or 157:9	application 46:1	90:17 96:5,13
70:19 79:1	addition 47:8	ANNE 156:16	54:6	97:17 98:4
95:22 103:2	additional 29:20	anneal 76:14	applications 54:5	108:12,14,18
119:1	address 7:17	78:8 119:11	70:12 121:4	109:1
above-titled 2:3	adjacent 68:22	120:1,3,17	applied 44:12	arsenic 76:8
absence 67:15	69:2,2 75:20	121:7 122:10	45:20 68:9	141:6,10,19,21
absent 157:21	138:9	125:16 126:13	101:4 113:5	141:22 142:1
absolutely 23:2	administering	126:14	138:13	142:16,22
38:7 62:16	6:6	annealing 119:17	apply 59:18 60:4	arsenide 142:13
65:18 103:16	Administrator	119:20 120:12	88:18,21 89:10	145:12 146:3
140:17,19	2:8	125:2,11,19	95:18 100:20	147:15,20
154:10	adopted 62:22	126:15 128:8	102:17 103:18	ARUNDEL
accelerate 76:10	63:20	128:12,19	104:2,2,8,12,21	156:16
124:1	advantage	129:13 130:20	105:8,11 106:1	as-implanted
acceleration 43:6	142:15	133:9 134:10	106:2,2 111:21	120:7 125:13
46:16 48:21	advantages 142:3	135:21	134:21	135:22 136:4,5
149:2	advice 28:3	answer 23:1	applying 59:12	136:13,17
access 22:12	advise 157:10	28:14 30:7	79:10 105:7	aside 13:6 82:13
34:13 86:10	advised 157:6	57:22 58:21	123:6	asked 9:16 13:8
87:20 88:5	affect 41:18,21	answered 109:10	appreciate 14:1	19:16 20:14
account 112:1	50:16 128:19	answers 8:18	57:22 67:2	37:3 44:21
accumulate	128:22 139:4	28:11 67:16	83:13 136:11	87:19 118:7
60:21	139:21 140:4	83:13 158:10	150:17	120:15
accurate 10:3,8	140:12	158:13	appropriate	asking 25:13
11:4 13:2 14:3	ago 9:8 13:15,16	anybody 7:19	158:9	51:5 65:3 74:5
21:14,16 26:8	agree 38:7 87:12	anyplace 66:7	approve 30:17	137:21
32:7,14,16 33:4	87:13 102:7	apart 123:20	approximately	aspect 28:6
87:9	109:22	apologies 87:19	2:4	asserted 62:10
achieve 118:19	Ah 10:15	apologize 43:1	approximation	associated 45:14
acknowledge	ahead 14:9 22:22	44:4 47:15	90:18	association 5:22
158:6	31:1 64:9	51:16 52:19	April 156:22	assume 94:3 97:7
act 76:18 120:9	108:15	64:4,8,11 69:21	arc 86:16,20	114:5 136:6
121:18	aids 47:9	92:21 100:8,10	Arden 7:18	assumed 87:5
acting 42:15	Alan 3:11 6:8	104:21 110:20	area 69:17,19	assuming 74:17
132:22	7:10,14	117:21 121:13	73:15 74:22	88:16
action 2:3 156:8	allow 56:17	123:1 139:19	76:3 90:3	atom 120:11
156:10	allowed 141:17	142:5 144:2,7	120:17 132:7,8	123:22
	157:13	Appeal 1:1 5:13	139:14 146:18	atoms 46:4 76:17

119:22 120:9 120:14,17 131:10,13,17 131:17 132:12 143:16,18 attached 158:11 attorney 29:5 156:9 attract 94:17 attracted 92:1,6 92:12 August 156:17 avoid 104:13 aware 140:8 151:1 awhitehust@m... 3:13	18:1 21:14 26:13 32:15 33:2 40:16 66:5 77:19 80:16 84:22 87:1 96:9 101:4 110:22 111:6 135:11 believed 11:7,16 32:13 bell 127:19 128:2 129:18,20,22 130:2 Benjamin 63:14 63:16,19 best 9:20 21:15 144:5 better 44:5 64:10 84:11 85:2 86:14 110:21 118:4 144:10 145:13,17 151:9 beyond 120:15 151:20 bias 70:6,6 biased 70:5 big 111:19 140:19 bigger 119:12 121:1 biggest 106:2 billion 94:15 bipolar 55:19,21 bit 24:11 54:14 58:9 87:22 94:13 121:1 123:19 129:15 blank 72:2 blatant 151:16 block 123:6 blocks 70:2 Board 1:1 5:13 body 153:1 Bombach 3:4 4:6 6:10,10 83:6 109:8 116:6 150:20 151:10	151:19 152:2,5 152:13,20 153:21 bonds 145:3 book 48:4,5 boron 74:8,14 bottom 35:10 36:1,9,14 41:12 47:12 85:11 88:18 90:19 bounds 152:1 box 158:9 break 28:22 29:1 29:9 31:5 83:3 83:7,10,11,18 84:7 100:11 143:5 150:3 breaks 29:5 bring 89:1 brought 35:14 build 70:21 71:1 71:16,20 77:11 78:1,11 107:3 building 72:6,9 73:8 74:13 77:13 built 71:11 97:12 112:17 bulk 57:11 bumps 127:15 bunch 47:7 61:12 141:22 buy 72:1	64:3,13,16,19 65:1 74:11,20 135:16,18,20 142:20 149:15 157:15 called 7:3 48:2 49:6 54:1 55:3 70:14 74:22 76:6 77:20 88:10 89:2 112:15 122:1 122:22 123:11 135:2 136:2,13 139:9 Camino 3:5 157:2 Campbell 1:13 2:2 4:2 5:7 7:2 7:9,14,16 14:11 14:14,18 15:10 16:4 17:1 18:22 20:5 22:10,14 23:7 24:8 26:7 28:7 29:3,18 31:12,13,18,22 32:3 34:7 47:15 79:8 83:8 84:6 85:7,21 86:7 130:11 150:7 150:15 151:1,8 152:14 154:3 157:1,4 158:5 159:9 Campbell's 4:11 4:16 capacitances 58:6,7 capacitor 54:10 54:11,17 86:11 86:12 88:1,5,9 88:12 103:22 104:3 105:14 capacitors 54:7 captured 54:16 care 107:16 careful 57:20 carrier 45:8,13	46:19 47:1,3 50:3 59:10 80:3 80:4,5,7,13,16 80:17,21 81:2,3 81:6 82:2 97:2 98:17,22 99:3,9 99:10 139:17 142:8 148:15 148:21 149:4 carriers 28:18 37:9 38:5,10,18 39:4,15 40:1,7 40:12 41:1,5,15 42:16 43:8,20 46:2,3,3,7,9 47:3,12 50:11 50:14 51:2,10 51:22 52:2,7 53:2,11,12,15 53:18 54:2,16 56:10,18 57:6 57:13 58:10,14 67:12 80:11 84:12 89:14 91:12 96:18,20 97:10,21 98:5 99:21 102:13 102:14 112:4 112:10 115:14 116:4 137:11 137:19 139:5 139:18,22 141:3,4 143:9 143:11 144:14 144:16 145:11 145:14 147:9 147:15,19,22 148:11 154:18 carrying 79:20 80:20 case 43:7 45:7 52:11 68:11 79:14 87:2,4 96:19 131:17 145:12 154:18 157:3 158:4 159:8
B back 20:17 23:4 26:5 29:9,16,18 32:3 58:20 79:2 83:12 84:4,6 85:3 96:21 106:3,8 129:15 130:19 150:14 152:12 bad 63:11 64:11 104:10 105:7 141:16 band 89:20 90:1 144:21 145:6 bandgap 141:9 141:10 bands 89:21 barking 107:14 basic 49:21 59:7 basically 48:18 basketball 86:16 batch 13:13,16 27:4 bear 15:9 23:13 beginning 35:7 begins 35:9 BEHALF 3:2,10 behave 102:16 believe 10:20	C c/o 157:1 CA 156:4,15 calculate 145:5 calculates 112:1 calculations 145:6 calendar 16:14 California 1:19 2:5,10 3:6 156:15 157:2 call 13:13 52:1 55:4 63:21 64:2			

cases 110:11 cause 58:10 109:3,13 139:16 143:13 caused 129:5 causes 56:14 57:9 104:15 119:8 131:5 149:18 causing 58:15 CDT 5:1 155:5 cease 46:12 centered 114:17 centers 143:17 centigrade 76:16 centimeters 146:5 Central 1:15 5:17 certain 25:7 105:15 111:2 122:6 certainly 14:1 57:22 61:15 67:2 71:9 83:12 115:8 118:2 136:10 150:17 154:5 certainty 25:14 28:13 CERTIFICATE 156:1 Certified 2:7,8 certify 156:5 chance 47:16 83:11 change 21:18 22:4,6 23:11 36:12 46:17 54:3 72:11 106:19 115:17 118:16 126:17 135:7 148:11 159:11 changes 54:17,18 54:22 57:7 89:18,20 148:10 158:11	channel 52:6,10 59:6,9 60:14 61:4 67:12 68:16 69:17,19 81:2,3 82:3,10 89:2 90:4 91:18 92:2,3 98:13,17 99:19,21 102:21 148:9 148:10,12 characterization 28:5 charge 42:1 46:11 54:6,7,11 54:11,12,13,17 54:21 57:6 58:6 67:11 80:3,4,6 80:7,11,13,20 104:3 105:14 105:15 charged 46:8 60:2,17 73:16 78:22 79:18 89:16 90:8 91:22 92:17 109:18,19 charges 46:11 112:9 chat 14:21 15:16 22:11 Check 158:9 circuit 54:10,21 54:22 55:5,11 56:3 77:14 106:4,6 circuitry 57:16 circuits 141:8 citation 36:18 cite 36:15 clarification 29:20 30:10 clarified 21:13 22:3 clarify 21:10 26:12 27:6 29:22 35:16,18 36:3,6 65:8	clarifying 13:22 25:16 clarity 150:22 152:14 class 48:13 132:15 classes 50:13 clear 23:4 31:6 100:10 109:12 clearly 30:5 click 14:21 15:12 client 113:20 close 89:22 137:8 closer 128:9,13 128:16,17 CMOS 49:7,8,11 49:12,16 55:10 55:10 67:9 72:19 77:16 85:18 Coie 3:3,16 33:15 38:1,14 157:1 colleague 6:12 collect 54:20 collected 54:2 56:12 college 43:16 65:19 collisions 46:2 112:9 Columbia 2:11 156:17 combination 86:11 come 83:12 94:18 157:7 comes 57:6 comfortable 83:2 coming 56:10 137:7 commencing 2:4 comment 82:21 129:16 comments 10:16 11:3 commercial 113:10 114:17	115:1 117:7,17 117:19 Commission 156:14,15,16 156:17,18,20 156:22 common 44:14 44:20 54:8 65:4 72:4 76:8 Commonwealth 2:11 156:21 company 49:5 77:3 104:18 114:16 comparative 126:12 compared 125:13 147:12,16 complementary 77:16 complete 14:7 157:6 158:10 158:12 completely 30:14 118:14 152:1 completing 155:3 compound 146:19 149:20 computer 34:14 computer-aided 135:3 concentration 59:11 69:7 97:3 115:13 120:20 122:3,4,7,8 124:10 131:4,6 131:7,14,15 132:2,3 133:18 133:19 145:21 concentrations 72:21 131:21 concern 107:22 108:1 concerned 46:6 58:12 concerns 28:1 53:21	conclude 110:16 concludes 154:20 condition 96:1 conduct 56:3 57:10 60:22 68:7,7 70:6 conducted 5:14 conductor 88:17 conducts 55:14 55:14 68:17 conferencing 5:15 confined 121:6 confused 27:16 45:2 confusion 66:11 connected 55:22 connectivity 145:16 consent 157:22 consider 110:10 considering 73:3 consists 51:21 construct 62:5 constructed 37:8 38:4,10 39:3,9 40:2,4,11,14,18 63:8 consulted 71:11 consulting 104:18 consumption 105:12 contact 68:13 72:13 119:5 contacts 75:14 contain 123:13 contained 30:6 content 10:7 30:14 context 10:17 11:3,21 continue 31:2 continuous 127:13 control 22:12 convention 62:15
---	---	--	--	--

62:19 63:22 64:1,2,5,13,16 66:4,14,17 87:6 copy 31:16 33:21 34:5 157:8 Copying 157:21 Copyright 157:20 corner 113:16 corners 113:13 correct 8:9 9:21 9:22 10:12,20 10:22 13:3,4 15:11,17 16:8 16:13 17:2 22:1 23:1 25:10 27:5 28:11,14 29:6 30:1 36:13,19 37:12,16 40:5 40:19 41:2,6 67:6 68:1 75:9 77:7,10 78:15 85:8 89:6 94:11 97:17 99:1,2 100:18 104:15 114:7,22 128:7 130:12,13 135:15 147:4 147:21 153:7 154:4 158:9,12 corrected 12:20 correction 29:21 correctly 26:15 81:8 95:10 96:15 97:13 109:10 137:17 corresponds 62:4 counsel 6:4 83:10 150:4 152:17 156:7,9 157:9 157:12 COUNTY 156:14,16,19 156:21 couple 10:10 69:10 150:21 course 17:3 27:3	57:3 61:11 74:16 91:21 113:3 118:17 courses 47:7,15 47:18 48:1,22 court 5:21 6:6 130:4,9 cover 24:6 48:12 crap 141:19 crazy 146:14 create 41:13 55:18 59:19 89:5,8,11 95:12 99:21 101:4 113:3 created 37:22 53:9 60:14 111:8 creates 46:12 57:15 92:13 93:4 123:21 creating 96:17 97:16 creation 50:11 criteria 82:9 critiqued 28:1 CROSS-EXA... 150:19 CRR 1:18 2:5 156:3,12 crude 58:4 crystal 46:5 120:10 139:13 crystals 149:17 CSR 1:19 2:6 156:4,15 current 56:3,8,22 57:10 68:17 70:2 73:18 79:18 104:2,6 104:20,21 105:9,11,17 106:1,2,18,19 148:2,8,8,8 149:5 currently 8:7 48:22	curve 127:19 128:2 129:19 129:20,22 130:2 142:11 cut 129:17 CV 47:16 D D.C 1:21 3:12 158:2 159:3 damage 55:7 56:9 57:14 76:16 129:5,6 damaged 120:4 damages 120:4 Dan 3:16 Daniel 5:18 date 9:6 16:9 157:4 158:5,17 158:22 159:10 159:22 DC 156:17 deal 45:14 66:11 112:22 decay 127:7 decided 63:7 declaration 4:16 13:10,15,19,20 19:3,5,12,13,15 19:18 23:17 24:12 25:12 26:21 27:4,10 30:3,5,6,12,15 31:12 32:9,22 33:11 36:19 37:2 38:8,15,17 39:7 declarations 30:14 37:15 decrease 91:5 106:15 decreases 41:10 deed 61:11 deep 76:13 119:8 deeper 122:12 defect 58:10 defects 141:15	143:14 149:18 Defense 114:6 define 37:19 75:7 122:1 defined 75:17 defines 74:19 definition 62:3 153:15 degrades 57:3 104:11 degree 47:19 48:10,11 degrees 76:16 Delaware 2:11 156:19 dense 139:14 department 47:22 48:16,17 114:6 dependent 42:21 57:2 129:9 depending 43:11 52:5 54:6,14 76:12 depends 40:13 124:7 129:2 139:13 145:10 148:6 depletion 70:14 119:14 deponent 157:4,7 157:9 deposed 8:8 deposit 75:11 deposition 1:13 2:1 4:11 5:6,14 8:10,12 9:1,2 9:10 10:19 11:22 12:11,13 12:17 13:8,12 13:14 16:12 17:5 18:4,10,12 19:6,17,21,22 20:12,19 21:13 21:18 22:4,6,8 26:9 27:11,11 27:20 28:1,5	31:8 32:6 33:1 33:10 35:16,18 41:17 47:17 57:19 83:16 110:16 154:20 155:5 156:4,6,8 157:4,12 158:5 158:7 159:10 depth 122:2,2,9,9 122:12 124:9 describe 22:20 27:15 50:1 64:5 70:22 79:7 110:12 121:14 126:8 145:9 described 13:21 62:6 63:4 71:19 78:6 98:8 134:22 describes 46:16 151:13 describing 51:14 100:7 description 4:10 126:12 descriptions 30:16 design 49:8 55:11 58:14 71:5 108:2 111:17 113:7 116:1 124:14 133:21 135:3 140:3 designed 113:9 117:6 118:5 133:14 designing 49:16 58:2 74:1,3 100:1 107:12 124:13 133:6 139:21 designs 114:18 desirable 122:13 destroy 56:9 120:5 destructive 55:9 detect 126:6
---	--	---	---	---

determine 93:21 94:9 95:15 determines 42:5 137:5 154:17 deterring 124:15 developed 63:10 developing 49:4 49:7 63:3 device 48:2 50:13 50:16,21 51:12 51:15,19 52:3,4 53:19 55:10 57:4,11,11 61:6 61:8 67:10,12 67:18,21 68:2,4 68:11,21 69:20 70:11,13,14,21 72:7,10 73:4,9 74:14 75:16 76:20 77:8,11 78:3,20 79:1,5 79:9 80:12,19 81:1 82:1 91:14 98:18 103:14 103:17 107:21 111:17 112:2 113:22 114:3 120:5 123:4 134:2,8,17,17 134:20 135:9 135:10,13 136:14,21 137:2,5 138:20 devices 45:20 48:4 49:9,12,12 49:17 50:9,20 53:21 55:11,12 56:8,9,19 58:5 71:5,6,7,7,8,10 72:15 74:2,4 77:5 79:2 102:22 103:6 107:12 108:2 113:7,15 diagram 91:1 Diego 3:6 157:2 difference 110:3	different 34:14 42:1 99:22 113:10 114:9 114:14 115:6 115:10 117:13 118:4,9,12,13 127:14 129:6 132:10 136:15 141:2,5,9,15,17 141:18 142:3,6 142:18 144:10 144:14,17,17 145:18,19,20 145:22 147:1,1 147:6,6,8,9 differently 41:18 41:22 118:5 144:11 153:12 difficult 143:22 diffuse 119:12 120:2,13,18,21 120:21 121:2 121:15,20,22 122:11 125:17 diffusing 53:12 53:15 119:18 125:2 126:16 128:19 diffusion 119:21 121:8,10 122:14 125:12 125:20 129:2 130:20 131:3,5 131:11,11,16 132:15 133:1,1 133:10,15,22 141:3 digital 1:20 5:19 5:20,22 157:19 157:20 158:1 159:1 diode 73:20 diodes 73:20 dioxide 52:13 75:4 146:7 direct 7:7 15:8 direction 39:16	39:21 40:5,19 40:22 41:4,8 42:3,4,6,14 47:5 62:2 91:3 91:8,11 92:15 94:7 95:7,12,13 102:10 108:12 108:17,22 109:4,5,14,15 109:22 110:7 directions 60:10 disadvantages 142:3 disagree 34:1 35:5,20 36:7 disagreed 33:8 34:21 35:11 disagreement 102:13 discrete 127:12 discussed 36:1 53:4 60:8 discussing 32:4 43:19 148:7 discussion 60:13 110:17 111:3 distance 144:1 distribution 132:20 District 2:10 156:17 disturbance 137:13 divided 124:20 doctor 14:22 15:12,21 43:2 document 15:8 16:2,5 21:1,3 22:13 23:19,21 25:5,10,19 26:22 27:15,17 27:18,22 28:10 30:2,8 34:8,13 35:21 37:21 38:2,13 documents 7:21 13:18	DoD 113:11 114:5,8,15,18 114:21 115:1,2 115:22 116:1 doing 83:9 127:12 134:22 138:21 144:5 dominant 45:9 46:14 donors 122:7 door 137:14 dopant 76:17,18 96:16,17 97:15 119:16,22 120:14,17 121:6,18 123:9 129:6 132:12 143:16,18 dopants 75:8 111:8 120:8,9 138:7 141:17 146:4,13,15,22 146:22 147:6 148:5 dope 146:14 doped 68:22 69:1 69:5,6,6,18,19 72:4,21 74:12 119:7 doping 41:10 45:19 53:5,11 72:3,12 73:2 113:2,4 114:12 114:15,20 115:6,10 116:16 118:9 118:12,13,16 124:14 125:15 126:13 133:17 134:17 138:5,5 145:21 148:9,9 dose 124:15 doubt 37:1 downward 44:22 89:12,16 90:7 91:8,11 92:14 92:19 93:1,1,8	93:20,22 94:7 95:12 109:4,14 109:21 110:6 122:11 Dr 4:11,16 5:6 7:9,16 14:14,18 15:10 16:4 20:5 22:10 23:7 24:8 26:7 28:7 29:3 29:18 31:12 32:3 34:7 47:15 79:8 83:8 85:7 85:21 86:7 130:11 150:7 150:15 151:1,8 152:14 154:3 drain 51:3 52:1,8 57:1,8,9 60:15 61:2,9 68:14,16 68:19 69:1,2,3 69:8 70:3,9 73:19,22 75:13 75:16,19 78:7 79:16,19 81:5 90:22 91:18 94:19 99:20 102:21 104:22 119:7 122:3,5 122:11 138:13 drains 61:7 DRAM 85:19 86:13,13 87:22 88:20 draw 90:14 driven 131:3 drop 14:17 due 45:19,19 53:5 73:19 90:16 96:16 112:8 113:5 127:10 131:16 138:4 duly 7:4 E earlier 21:9 31:7 32:18,21 60:8
--	--	--	--	--

88:10 98:8 129:16 154:11 early 9:7 16:16 28:22 58:17 easier 8:21 142:19 easy 8:1 14:15 144:20,22 edges 127:6 effect 51:1,4,10 52:13 55:3 91:9 91:19 95:1,5 147:1,6 154:12 154:16 effective 43:9 142:21 145:4 effectively 142:22 147:10 effects 50:4 112:22 egregious 35:13 either 16:15 76:9 110:7 151:8 EI 3:5 157:2 elaborate 67:17 electric 37:8 38:4 38:9,18 39:2,14 39:17,20,22 40:6,10,19,21 41:3,14,17 42:2 42:7,8,12 44:10 44:22 45:8,17 46:10,12,21 47:9 50:4,11,22 51:9 53:5,8 57:7 59:20 60:1 60:4,11 61:17 61:22 62:1,6,13 64:6,14 65:5,9 66:4,17 76:10 89:11,15 90:6 90:12,15 91:3,9 91:13 92:1,14 92:16,18,22 93:7,19 94:6,7 96:15,17 97:16 98:1 100:4	102:11 107:8 107:20 108:4,8 108:11,14,17 108:22 109:2 109:13,20 110:5 111:8 112:1,3,16 113:3,5 124:1 137:10,18 138:1,16,22 139:7,8 140:1 141:5 142:8,10 142:13 148:18 electrical 47:21 48:10 51:20 66:3 68:8,9,13 72:13 75:13 electrically 75:4 electricity 68:7,7 70:7 79:5,13,21 80:1 electrode 50:22 75:11 88:19 90:20 electrodes 54:18 electromagnetics 63:2 electron 42:6 67:15 95:11,13 99:1,10 123:22 132:7 electronic 145:3 electronically 157:21 electrons 41:18 41:21,22 42:3 46:8 55:14 59:15 60:7,9,12 60:15,17,18 67:5,8,14 69:7 79:14,15,17,20 79:22 80:11,14 80:20 81:4,6 82:6,10 89:1 90:2 91:17,20 91:21 92:6,12 92:14 93:4,6	94:3,3,8,14,18 94:18 95:1,6 96:20 97:10,21 97:22 98:6,19 99:16,18,20 102:20 103:3 107:10 108:9 109:4,15,19 112:11,11,11 132:8,9,11 139:14 142:12 142:21 electrostatic 63:6 132:11 133:2 element 55:6 56:7 86:13 elements 51:21 65:11 embodiment 85:19 emerging 149:16 emphasize 30:13 employed 156:8 156:9 employee 156:9 employees 33:14 encapsulating 140:7 encountered 111:13 138:2 ended 18:4 ends 15:4 17:10 17:13 18:1,3 energies 127:14 127:15 energy 45:14 76:12 124:2,7 124:11,15 127:16 engineer 136:8 engineering 47:21 48:10,11 engineering-ese 141:11 engineers 66:3 ensure 28:10 113:14	entirely 153:5 environment 113:21 114:1,3 envision 100:6 equal 43:5 46:15 108:3 122:4 135:1 148:22 equally 120:7 121:3 equals 149:7 153:10 equation 62:18 equations 63:4 era 63:18,19 errata 9:16,19,20 21:6 130:16 157:11 158:11 159:6 erratas 130:17 error 35:14 54:1 55:2,4 57:16 errors 9:21 10:2 12:21 ESQUIRE 3:4,11 essentially 102:15 everybody 66:21 Evidence 1:20 5:20 6:1 157:19 157:20 158:1 159:1 EX1 15:1 EX2 15:1 EX3 15:2 exact 9:6 41:20 55:20 153:14 exactly 77:21 104:18 122:7 133:5 137:6 142:20 examination 4:1 4:4 7:3,7 154:1 examined 7:4 158:7 example 46:18 59:13 141:6 143:20 146:8	146:10 examples 44:8 excess 88:20 exclusively 77:16 excuse 30:4 53:7 exhibit 4:10,11 4:13,16,18,20 5:19 8:4,4,22 14:10,11,17,20 18:12,22 19:6 19:20,22 20:11 20:18 22:9,14 22:21 23:12,14 24:9 25:18 26:22 31:8,9,11 31:13,16,18,21 31:22 34:4,16 36:15,21 37:4,5 84:15 85:12 152:4 exhibits 4:9 8:20 14:8 15:1 existence 53:4 70:2 expert 25:4 144:2 expires 156:15 156:16,17,18 156:20,22 explain 27:12 144:20,22 145:5 explained 27:1 32:5 134:12 exponent 124:19 exponential 124:9 127:7 exposure 140:5 express 157:22 extremely 123:17 146:6 eyes 132:21 F F 46:15 134:22 148:22 149:6 153:10 fabrication 71:12
---	--	---	---	--

factor 94:14 124:20	95:11 96:18 97:16 98:1	30:2 42:20 43:3 43:4,13,17 44:5	95:13 148:16 148:19,20	free 91:17
factual 12:5	100:4 102:11	48:8,12,17,18	149:1,4 153:3	frequencies 141:8
factually 11:11 11:12,16 13:2,7 14:3 21:14 32:7 32:13,16 33:4	107:9 108:4,8 108:11,17,22 109:2,13,20 110:5 111:8	53:20 63:1,5,10 81:9 90:9,18 91:15 95:14 100:13 110:18	forces 42:15,17 42:19,22 43:5 43:20,22 44:1,8 44:11,12,12,15 44:16 45:1,3,9 45:12,22,22 48:21 49:17,18 49:19,21 50:1,9 50:16,19 52:21 53:1 93:14,21 94:9 95:15 111:2,10,13,15 112:6 132:11 132:22 133:2 154:9,12,16	frequency 142:15 freshman 43:16 48:9,13,14 Friday 2:3 5:1 front 28:10 full 7:12 fully 28:11 57:2 69:11 134:2 fun 130:18 functional 73:4 Fundamentally 118:20 further 91:5 96:22 150:18 153:22 156:8 fusion 45:10
fair 32:18 81:17 84:19 103:7 118:6,7 128:6 128:10	112:3,16 113:3 113:5 139:7,8 141:5 142:8,10 142:13 148:19	124:8 129:3 135:2 153:9,15 154:8	50:16,19 52:21 53:1 93:14,21 94:9 95:15 111:2,10,13,15 112:6 132:11 132:22 133:2 154:9,12,16	
far 12:9 25:8 33:6 54:22 95:8 100:15,16 101:1 106:12 106:21 108:13 108:19 116:22 143:20,22	fields 39:14 40:6 40:10 41:17 45:8,18 46:10 50:11 57:7 64:14 96:15 108:15 112:1 124:1 137:10 137:18 138:1,4 138:16,19,22 139:2,2,9 140:1 140:3 142:9	fix 130:5 fixed 106:11,14 106:16,18 flatter 129:14 flavors 67:10 Florida 2:9 156:14 flow 56:22 60:15 70:3 73:19 79:6 79:13,15 90:2 91:17 98:6 99:19 103:3 105:18 129:17 134:14 135:12 135:17,21 136:2,12 142:2 flowing 79:14,18 104:6 flustered 27:3 flying 63:15 FMA 49:22 focused 13:11 follow 45:6 66:3 100:15 106:12 108:13,18 follow-up 61:13 67:2 83:14 followed 6:5 following 5:9 135:5 follows 7:5 66:16 forbidden 157:21 force 42:13 44:10 45:11 46:10,22 53:8 63:4,5,6 92:15 93:4,11	foregoing 156:6 158:7 forgot 13:13 form 59:9 68:12 75:15 76:19 77:5 78:3,5,9 90:4 95:20 98:16 99:6,9,19 101:7,12 102:5 102:9 109:8 116:6 122:11 145:3 formation 73:20 formed 56:19 69:17 forming 69:13 70:4 forms 60:18 98:13,21 124:8 forth 111:21 forward 157:11 forwarded 33:14 four 51:21 127:14 fourth 116:18 fraction 106:5 frame 9:5 Franklin 63:14 63:17,20	
fast 105:4 faster 102:16 103:3 104:4,6 139:10 142:13 143:1	figure 61:14 82:17,20 84:22 85:17,18,22 86:4,8 90:15 96:6,14 100:17 108:13,16,18 108:21 109:3 109:13,21 110:6 117:22 126:9			G
features 120:22 February 156:16 feel 83:1 151:8 felt 11:19 fewer 95:7,8 field 37:8 38:4,9 38:18 39:3,17 39:20,22 40:19 40:21 41:3,14 42:2,7,8,12 44:10,22 45:18 46:12,21 47:9 50:4 51:1,9 52:13,18 53:5,9 59:20 60:1,5,11 61:17,22 62:1,6 62:13 63:8 64:6 65:6,9 66:4,17 75:1,8 76:3,10 89:11,15 90:6 90:13,16 91:3,8 91:10,13 92:1 92:14,16,18,22 93:7,19 94:6,7	figures 30:6 82:19 120:22 file 15:14 35:3 final 19:8 125:7 finally 5:10 52:9 financially 156:10 find 93:16 fine 74:11 144:3 finish 57:21 first 7:4 8:22 13:8,16,19 16:5 20:18 21:1 24:13,19 27:4 27:11 28:22			G-A-L-C-I-O-N 130:11 G-A-U-S-S-I-A... 130:8,12 gallium 141:6,10 141:19,20,21 142:1,12,16,22 145:12 146:3 147:14,20 gas 76:7 123:16 123:17,19 gases 76:9 123:13 gate 50:22 52:4 52:10 53:9 57:2 59:8,12,17,19 60:21 62:8,9,10 62:11 68:10,11 68:12,22 69:3 69:18 70:13,17 73:11,16 75:10 75:11,18,20,22 78:18 79:10 88:17,19 89:8 89:11,12 90:11 90:16,19,20 92:9 95:19

100:21 103:11 103:19,22,22 104:1,7,9,13 105:1,2 111:7 111:14 138:13 gates 103:6 Gaussian 124:8 124:17,18 125:1 126:19 126:21 127:17 127:18 128:1 128:20 129:1 129:10,12,14 130:3,7,11,19 Gaussians 133:8 general 9:4 generally 112:13 geometry 62:6 148:3 getting 84:18,20 116:3 137:8 GG987804 156:14 give 9:6 23:15 44:8 83:11 111:11 152:4,4 given 42:2,7 129:16 158:10 158:13 gives 145:4 giving 28:11,13 108:1 glasses 84:19 86:22 go 14:9 16:4 17:20 19:20 20:5,17,22 22:7 22:22 23:4 24:1 24:5 25:19 28:20 31:1 32:3 34:3 48:15 52:2 57:14 58:20 64:9 75:6 76:13 79:2 84:21 90:20 91:5 92:8 104:4,5 106:8 108:15 112:14	113:21 123:8,9 139:10 149:1 150:7 152:5 154:21 goal 95:19 goes 17:17 35:7 61:12 71:2,3 76:2 93:22 120:15 124:18 133:17,19 142:9,10 149:1 151:20 going 11:17 15:7 15:7 23:10 25:18,22 31:6 35:4 40:22 41:4 41:11 59:9 61:5 63:8 69:22 72:19,20 74:18 82:17 83:1,2,22 87:14 90:15 91:7,22 100:20 105:12,18 106:3 111:20 112:22 113:21 126:21 127:7,9 128:3,4,9,13 129:11 130:19 131:12 132:9 136:8 141:22 150:2,4,10 151:17 152:8 153:11 155:2 good 6:7 7:9,11 10:2 16:8 61:11 83:7,20 84:7 100:16 139:13 141:16 149:17 Goodin 1:18 2:5 5:22 156:3,12 gotten 86:3 governing 157:13 graded 96:17 97:15 graded-dopant 107:2,9 gradient 41:10	45:19 53:6,11 96:16 120:21 124:22 125:10 125:12 126:14 133:17 gradients 116:16 131:4 138:5,6 Gravity 44:11 great 66:11 83:9 146:3 greater 103:18 Greenleaf 11:22 13:10 27:19 45:9 Greenleaf's 27:9 Greenthread 1:8 5:7 6:9 12:14 16:19 32:17 157:3 158:4 159:8 ground 59:21,22 61:18,22 138:14 group 1:20 5:20 6:1 114:19 157:19,20 158:1 159:1 grow 75:2,7,10 141:18 growth 126:6 guess 40:13 65:1 71:16 143:5 151:11 153:13	123:17 head 83:5 140:11 hear 26:15 heard 26:13 153:17 heat 76:15 heating 119:20 heavier 147:10 heavily 68:22 69:1,5,6 87:7 119:7 held 2:3 59:22 138:14 help 44:6 61:14 67:3 84:11 85:1 100:9 103:9 130:4,6,15,17 helpful 61:10 84:13 116:4 hereto 156:9 hesitate 157:15 hesitated 101:18 high 28:15 43:15 46:20 65:13,14 65:17 69:8,9 79:12 103:11 105:22 119:20 119:22 131:6 131:14,20 132:2 139:8 141:8 142:15 149:10,12 higher 62:11 72:21 103:6,8 104:5,8,13 105:7,8,11 114:11 115:3,7 115:11,12,13 116:11,15 117:6 133:18 141:7,12 143:15 145:16 146:2 highest 62:4,8,14 64:6,14 65:6,10 66:5,18 Hills 7:18	history 63:13 hold 24:3 119:1 hole 42:6 67:15 93:21 99:11 holes 41:18,21,22 42:3 55:15 59:15 60:2,2,6 60:9,21 61:1 73:17 78:21 80:11 81:3 82:7 82:11 89:14,16 89:18 90:1,7 91:13,16 92:19 93:1,5,8,10,11 93:15,20 94:16 94:19 96:2 99:5 100:4,5 102:13 102:18 108:4 109:3,14,18,21 110:1,4,6,7,8 110:13,13 112:12 Holmstock 3:16 5:18 home 7:17 honest 24:10 hope 61:13 84:6 137:17 hopefully 44:6 83:17,18 84:15 85:7 hopeless 145:6 housekeeping 31:5
		H		I
		halfway 134:5 happen 120:12 149:6 happens 57:5 94:10 95:16 98:8,12 120:13 121:14 123:4 125:1 147:14 147:22 149:3 happy 10:13 hard 129:17 hazardous		I-M-P-L-A-N-... 136:7 idea 68:5 identification 14:12 22:15 31:14,19 32:1 ignore 88:12 illustrated 86:8 image 85:19 impact 139:1 140:19

impacted 129:4 implant 76:17 78:7 120:16,16 122:22 123:1,2 123:3,7,14,16 124:11 125:5 126:19 129:5 implantation 76:6 122:15,19 implanted 136:3 implanter 123:11 implanting 124:5 implants 124:16 127:2,12 134:14 implementation 122:18,19 implication 10:17 important 113:19 120:7 137:1 140:21 154:15 improve 116:14 119:5 impurities 75:13 119:11 120:8 122:10 impurity 76:8 inaccurate 13:7 26:11 inadvertent 55:18 inadvertently 55:17 include 116:16 included 39:8 includes 80:10 including 157:21 incorporated 124:4 incorrect 10:17 11:8,9,10,12,16 11:19 26:18,19 28:6 45:11 99:17 incorrectly 13:17	increase 100:2 105:12 106:15 119:4 increases 139:7 independent 57:1 independently 71:4 index 4:1,9 18:9 indicate 91:2 indicates 91:3 indicating 98:6 individual 131:17 induce 78:19,21 industry 49:3,15 50:15 66:1 106:9 111:14 infinita 102:14 information 55:6 55:8 87:22 inherent 41:13 45:18 53:5 inside 23:12 insulating 75:3 146:7 insulator 52:9,12 59:8,16,18 88:18 92:9,10 integrated 38:14 intensity 62:2 91:2 intention 95:21 inter 24:15,21 25:2 interconnected 116:22 interest 46:1 interested 114:11 135:6 139:3 156:10 interprets 54:21 54:22 interrupt 57:21 interrupted 24:18 intrinsic 138:4 introduce 14:9	introduces 115:13 invention 85:20 invert 60:5 involve 30:16 involved 13:12 13:20 ion 76:6 122:15 122:18 123:11 124:1,3,5 ionize 76:9 ions 46:8 76:11 80:5,6 123:21 124:6 139:13 IPR 4:13 5:9,9 17:13 31:10 34:5 IPR2024-00468 4:19 IPR2024-00550 1:3 IPR2024-00551 1:5 IPR2024-00552 1:7 IPR2024-00553 1:9 IPRs 12:14 17:6 isolates 75:4 isolation 74:17 issue 14:2 28:8 28:16 issues 72:12 J J 1:18 2:5 3:4 156:3,12 Jiang 3:16 6:12 job 50:6 jog 16:11 junction 122:2,2 122:9,12 138:8 junctions 70:4 June 156:18 Justin 3:16 6:12 K K 3:12	KCM3MJRD 15:4 keep 53:14 69:22 83:15 84:9 keeps 84:20 KENT 156:19 key 63:15 kind 44:2 78:6 86:15,19 111:20 112:13 112:17 121:11 127:19,20 132:5 kite 63:15 knew 49:21 110:20 knock 123:22 know 15:7 20:8 24:17 25:1,4,8 30:8,20 33:6 37:6 49:12 50:5 59:1 80:15 81:12,14,15 87:7 103:1 111:7 114:20 114:22 117:10 118:12 128:1 143:8 144:10 144:13 148:22 149:16 151:6 152:17,19,21 153:3 knowledge 21:15 known 59:15 L L.L.C 158:1 lab 71:2,3,9 labeled 35:2 86:10 97:1 lack 86:14 laid 37:5 landscape 85:15 language 144:6,8 large 56:17 58:5 58:6,7 60:4 68:10 119:2	123:10 larger 92:4 114:10 148:18 latch-up 55:4,9 56:4 latched 56:7,15 late 9:7 16:15,16 lateral 103:3 laterally 120:22 121:20 lattice 46:5 112:9 120:10 121:18 launch 70:20 law 42:20 43:3,4 43:14,17 44:5 45:1,3 48:8,12 48:17 63:5,21 63:21 95:14 110:18 133:4 138:19 151:2,3 151:6,13,22 152:15,19,22 153:5,9,16 154:8,8,8 lawyer 25:3 28:2 layer 52:12 60:18 75:3 layman's 141:12 leading 151:15 learn 43:13 48:18 48:19 49:17 65:5,13 learned 49:11,14 50:4 leave 60:13 123:8 led 10:17 left 16:9 86:10 96:9 141:22 legal 5:19 30:16 LEHIGH 156:21 let's 14:9,15 16:4 22:7 23:4 24:5 25:17,19 29:8 34:3 56:11 59:6 59:13 76:15 79:2 81:9 82:22 83:17 84:21
---	--	--	---	--

86:3 94:2 97:5 98:7 100:13 106:8,11 111:16 117:2 120:16 122:1,3 123:15 129:15 149:15 150:3 letting 30:19 level 28:15,19 60:13 65:19 light 140:5,7 lighter 142:22 147:10 lightly 72:4 lights 132:17 limit 105:22 139:11 limitation 91:1 limited 103:10 limits 106:4 line 24:14 45:6 159:11 linear 139:12 linearly 139:7 lines 24:19 link 14:17,20,22 15:8,13 list 139:19 150:5 listen 153:20 literally 16:6 little 24:11 27:3 28:22 121:1 123:19 LLC 1:8 5:8 16:19 157:3 158:4 159:1,8 LLP 3:3 logical 54:14 55:1,1 57:15 long 48:15,15 57:19 75:22 102:19 130:16 longer 49:2 90:2 look 10:2 16:14 19:9 23:11,14 33:16 36:20,21 47:16 69:15	71:10,10 90:13 93:20 94:9 95:15 125:5 127:19 128:2 129:21 133:3,9 134:10 136:2 138:19 150:4 154:15 looked 14:3 looking 8:7 15:4 23:19 24:2 35:1 82:16 85:9,10 107:18 108:16 108:16 136:1 looks 19:12 23:21 25:11 86:15,20 87:4 129:18 136:16 loose 93:9 Lori 1:18 2:5 5:21 156:3,12 lot 56:3,8 83:14 119:16 140:22 143:18 149:15 lots 132:8 149:17 low 28:19 132:2,9 145:4 146:15 low-to-moderate 142:9 lower 65:10 87:2 87:4 94:15 115:16 117:9 131:7,15 133:18 145:15 146:11 lowest 66:6,18 M M 1:21 158:1 159:2 MA 46:15 135:1 148:22 149:7 153:10 machine 71:14 71:14 123:11 123:12,13 magnet 107:18	magnetic 139:1 140:2 major 58:17 majority 46:9 80:16,21 81:2,3 81:6 82:1 89:13 98:17,22 99:9 102:13,14 making 71:22 72:12,14 73:3 manufacturing 127:10 marbles 47:7 mark 25:17 marked 14:12 20:18 22:8,15 22:21 31:7,9,11 31:14,15,19,20 32:1 34:4 84:14 Maryland 2:10 156:16 mask 123:6 masked 112:14 113:1 mass 43:5,9,10 142:21 145:4 149:1 material 43:8,11 75:11 140:15 145:3 146:20 147:12 149:18 materials 141:14 146:17 149:16 matter 5:7 73:2,4 134:4 157:6 matters 102:19 103:21 134:1 135:8 maximum 129:19 mbombach@p... 3:8 McKool 3:11 6:8 mean 16:13 19:14 20:8 27:12,18 40:14 43:21 44:1 50:9	51:8 61:21 62:21 63:1 64:11 65:1 67:7 71:1 81:12,14 81:16,17 87:16 100:8 101:18 107:11 114:6 119:19 121:19 121:21 125:4,9 125:10 126:8 132:5 140:14 142:5,18 143:22 146:6 148:4 151:18 meaning 41:11 69:7 87:6 125:22 143:3 means 40:18 58:5 73:18 80:7 119:20 121:17 141:15 meant 40:4 59:1 90:6 126:9 measurably 107:5,7 mechanical 44:11,12 45:22 45:22 mechanics 144:21 memory 16:11 28:12 53:20 54:5 151:12 mention 30:22 mentioned 14:8 21:9 32:8 33:4 36:9 44:22 45:21 47:14 51:9,11 58:22 59:1 61:16,17 63:6 67:4 68:18 69:11,13 91:7 111:10 112:8 114:5,12 119:17 122:15 126:18 137:10 137:18	microwave 141:7 middle 16:17 96:10 Miguel 3:4 6:10 28:21 83:4,11 million 102:15 107:12,14 146:5 mind 23:11 35:13 mine 30:14 minimize 122:13 Minnesota 7:18 47:21 minority 28:18 37:9 38:5,10,18 39:4,14 40:1,7 40:11 41:1,5,14 45:7,13 46:2,3 46:3,19,22 47:3 47:3 50:3,10,14 53:1,11,12,15 53:18 54:2,16 54:20 56:10,17 57:6,13 58:9,14 80:16 84:11 96:18,19 97:9 97:21 98:5 99:3 99:10,21 115:13 154:18 minus 124:19 minute 15:10 minutes 23:14 29:10 34:22 mischaracteriz... 32:22 mischaracteriz... 32:17 misconstrued 42:11 misleading 94:13 missing 59:15 140:9 misspeak 122:20 mistake 12:3 93:6 misunderstand 95:4
---	--	--	---	--

mobilities 147:9	109:14,15	76:7 77:1,12	151:2,3,5,6,11	146:13 148:11
mobility 112:15	118:2 124:10	78:4,22 87:7	151:12 152:15	156:14
141:1,7,16	131:6,13,18	97:4	152:19,21	numbers 5:9
142:6,11	132:1,9 142:13	N-well 78:5,14	153:8,15 154:8	17:7
145:11,13	142:18,19	N-wells 73:7	nine 97:17	NW 1:21 3:12
146:13,16	143:1,2,7,9,13	77:20 78:1	NMOS 67:10,18	158:1 159:2
mode 85:15	143:17,20,20	name 5:18 7:9,13	67:21 68:3,11	
model 71:5	143:21 144:1	64:21 65:4,4	68:20,21 69:13	O
112:20,21	148:15,17	158:5 159:9	69:14,19 70:9	oath 6:6 8:15
113:3,12	movement 28:17	named 49:19	70:21 71:20	object 42:21,22
modeler 134:20	42:21 43:20	narrow 89:2 92:2	72:6,9 73:8	43:6
135:13 136:14	46:7 47:9 50:10	nature 145:2	74:1,3,13 75:16	objection 109:8
modeling 111:18	50:14 51:2,10	near 57:7 115:14	76:19 77:5,17	116:6 151:14
111:22 113:6	79:22 89:17	120:18 133:18	78:11 79:2,4,9	153:18
134:13 136:16	119:21 131:17	necessarily 65:9	80:12,19 81:22	obligation 8:17
136:21	139:21 141:4	112:21	86:9,12 88:11	obvious 41:9
models 134:13	144:14,16	necessary 91:15	88:13,14 89:9	53:3 116:7
modified 43:11	154:18	need 58:9 75:19	90:12 96:21	October 9:7 16:9
modify 42:10	moves 42:6 80:5	86:22 88:3	97:6,11 98:8,18	16:15,16
59:10 119:10	122:11	105:16 135:10	99:8 100:14,17	office 1:1 5:12
mole 51:22	moving 46:19	148:18	102:4	157:7,15
molecule 123:21	52:7 71:13	negative 54:12	nod 83:4	Oh 44:16 45:5
moment 104:19	97:22 109:21	60:20 62:18	normal 70:16	55:4 78:10 95:9
Monolithic 1:3	110:6 131:22	63:9 67:13,14	normally 76:2	122:20 140:14
4:13 5:8 6:11	132:18 143:11	80:8 128:3,9	87:5 94:13	140:17 151:14
16:18 31:10	MPS 85:12	negatively 60:17	Notary 2:9 156:1	okay 13:5 16:1,4
157:3 158:4	multiple 113:12	78:22 79:17	156:4,12,14	23:22 24:13,17
159:8	118:1 127:2	91:22 92:16	158:22	25:8 26:17 35:9
month 9:8		109:19	note 137:8,16	44:9 45:5,16
months 50:5	N	neither 156:7	noted 158:11	49:18 81:10
morning 6:7 7:9	N 60:16 67:11,13	net 73:17 132:1	noticing 157:12	82:22 89:10
7:11,15 111:4	87:1,6,11,17	154:11,16	noting 157:12	94:2 97:8,11
MOS 51:15	90:3,3 98:13	neural 44:12	November 1:14	98:3,20 99:6
52:13	138:9	never 63:12	2:3 5:1,16 9:7	100:12 101:16
MOSFET 51:15	N-channel 55:11	70:15 127:5,8	16:16 155:1	101:18,21,22
51:17,18 52:14	60:16,19 61:6	127:13 130:18	157:4 158:5	102:1,2 107:6
MOSFETs 52:15	67:5,8,22 68:4	nevertheless	159:10	109:12 110:5
52:18,18 53:1	68:13 69:14	123:18	Nt 87:15,16	144:19 150:21
58:2,3 111:1	72:15,18 82:1	new 5:10,10	Nuclear 44:16	151:5,19 152:3
133:6,21 138:3	89:5,9 95:20	15:19	number 5:5	153:4,8,19
139:21 142:1	98:16,22,22	Newton 46:6	14:11 17:10,14	once 19:8 48:20
motion 45:15,15	99:4,9,16 101:4	Newton's 42:20	22:14 24:3,16	49:22 56:7
153:2,2	101:7,12 102:5	43:3,4,13,17	24:22 31:13,18	57:13 75:17
mouth 101:19	102:10	44:5 45:1,3	31:21,22 37:5	76:5 94:19
move 42:13 47:4	N-type 61:6	48:8,12,17 63:5	56:17 85:10	ones 13:20 44:14
47:11,11	68:16 70:10	95:14 110:18	119:2 120:6,6	46:13 149:22
102:21 109:3,4	72:7,18 73:6	133:4 138:18	127:12 145:11	open 15:5 123:8

operate 113:14 134:5,9 141:12 144:11 operates 134:2 137:5 operating 50:21 114:2,4 operation 92:3 opportunity 111:12 opposed 80:5 opposite 39:17 55:13 60:9,10 78:18 92:15 94:4 95:6 122:5 126:21 optimize 107:13 107:21 optimized 119:13 option 77:14 157:9,10 order 27:15 39:22 58:10 64:9 68:4 70:20 76:19 78:22 79:5 90:18 94:9 95:15 100:21 124:8 129:3 134:8 original 157:11 originally 35:15 49:5 other's 66:12 144:6 outcome 156:10 output/input 134:19 outside 137:14 overcome 93:14 overwrite 55:7 owner 1:9 3:10 6:9 owner's 4:18 31:17 33:7,12 33:17,22 34:5 34:11 oxide 75:7,10	90:20 103:11 104:11 141:19 oxidize 141:21 P P 67:11,13 70:2 74:4 138:9 P-channel 55:12 59:2,5 61:8 p-n 70:4 P-type 59:14 61:9 69:18,19 70:8 72:5,7,8 72:10 73:6 74:7 74:15 76:21 77:4,6 89:22 90:2 96:20 97:3 97:7,9,12,20 P-well 73:12,14 73:15 74:2 78:12 P-wells 73:7 P.C 3:11 p.m 150:10,11,12 150:14 152:8,9 152:10,12 155:1,5 packaged 140:6 page 4:4,10 16:5 16:6,7,9,17 17:20 18:1,3,15 18:16,17 20:2,3 20:6,7,18 21:1 22:22 23:5,8 24:1,1,3,6,6,8 35:2,2,5,8,10 35:10 36:2,2,10 36:10,14 84:22 85:13 86:5 102:3 157:12 158:4 159:11 pages 17:18 34:14 158:7 papers 66:13 paragraph 36:15 40:18 parameter 113:1	118:22 parameters 112:14 124:12 parasitic 55:19 56:19 part 9:17 11:1,20 19:21 35:15 51:12 86:4 91:15 103:2 107:14 129:19 partes 24:15,21 25:2 particles 43:7 46:8 particular 10:11 33:17 45:7 82:20 107:22 113:8 particularly 113:13 parties 6:2 156:8 156:9 parts 30:17 37:15 107:11 pass 56:8 passed 105:17 paste 15:8 pasted 14:20 patent 1:1,1,3,5,7 1:9,9 3:10 4:14 4:18,20 5:12,13 6:9 20:9,12,15 24:16,22 31:16 31:21 33:7,12 33:17,21 34:5 34:11 45:9 82:16 84:14 85:9 96:15 patents 12:14 13:10,13,16,20 27:4 53:4 74:19 74:22 patient 136:11 pattern 75:12,21 patterned 76:5 PDF 18:14,16 20:3 24:6 35:3	85:1 peak 124:10,19 126:20 127:2,3 127:3 pending 5:11 Pennsylvania 2:12 156:21 people 62:20 63:1 66:15 74:10 106:6 116:21 127:4 132:20 percent 25:14 28:13 153:14 perfectly 129:8 performance 57:4 100:2 119:5 135:9,10 period 105:18 157:13 Perkins 3:3,16 33:15 38:1,14 157:1 petition 4:13 23:8 24:14,15 24:21 25:1 31:10 Petitioner 1:4 3:2 6:11 Ph.D 1:13 2:2 4:2 7:2 17:1 154:6 157:1,4 158:5 159:9 philosophical 44:2 phonons 46:4,4 phosphene 123:17 phosphorous 76:9 78:8 123:15,16,21 123:22 phosphorus 78:8 photo 123:6 phrase 38:13 physical 134:17 physics 44:17	47:20 48:2,2,9 48:13,14,16,16 49:22 65:14,17 154:4 picture 86:4 94:20 pictures 92:2 places 35:12 plane 131:10 plant 120:3 plasma 123:20 123:20 play 127:1 please 6:4 7:12 12:8 17:21 20:2 20:5 24:6,20 34:20 67:17 85:15 157:6,10 157:11,14 plus 87:6 127:3,3 133:1 PMOS 67:10 77:8,11,13,15 77:17 78:1,3,14 78:20 point 46:15 62:7 62:13 71:21,22 72:2 97:18 102:11 112:2 150:22 pointing 44:22 60:1 61:17 64:14 89:15 90:7 91:10 94:6 95:12 98:2 108:12,17,22 points 59:20 61:22 62:11 64:6 65:6,9 66:4,17 89:12 92:18,22 polarity 42:5 60:9 61:3,4 78:19 126:16 138:7 portion 33:17,22 35:5 81:20
---	--	---	--	---

portions 30:15 35:11,22 36:8 POSITA 41:9 position 89:20 120:14 124:19 positioned 120:9 positive 54:11 59:19,20 61:18 61:22 62:3,9,14 63:9 64:6,15 65:6 67:14,15 68:12 79:10 80:8 88:19,21 89:4,8,10 90:11 90:16 91:8,10 92:7,12,13 94:22 95:18 100:21 101:3 128:4,13 positively 60:2 73:16 89:16 90:7 109:18 possible 105:5 107:8 115:8,9 118:8,10 126:15 possibly 106:2 post-anneal 136:22 137:4 post-annealing 136:18 post-annealed 136:20 potential 53:17 62:8 65:10,10 66:5,6,18,19 power 1:3 5:8 6:11 16:18 105:12 157:3 158:4 159:8 powering 56:2 practice 44:17 premarked 8:20 14:8 Present 3:15 presumably 97:12,14	113:20 pretty 66:21 83:19 132:19 150:6 151:16 prevent 46:22 53:12 58:14 previous 9:1,10 10:5 16:12 18:12 19:6,17 19:21 20:12 21:18 22:4 29:21 31:8 36:4 36:6 41:17 58:20 previously 12:10 22:8 134:12 primarily 53:20 94:18 138:12 146:18 primary 116:21 118:21 139:6 principle 105:10 print 84:20 probably 28:19 35:7 44:13 63:3 79:6 103:8 130:6 134:11 problem 8:1 25:22 55:10 57:12 58:15,17 119:8 problematic 58:19 problems 53:17 104:16 116:15 116:21 141:16 Procedure 157:14 PROCEEDIN... 5:2 process 8:12 48:3 56:13 71:19 75:6 78:6 120:4 123:6 128:19 129:13 131:3 134:6,13 135:5 135:12,17,21	136:2,12,16 142:2 processed 134:3 processes 125:7 produced 23:21 produces 50:22 51:1,9 product 114:21 116:12 146:12 products 113:11 113:11 114:8 114:15 115:2 115:22 116:1 117:3,5,8,14 118:4,15 Professional 2:6 profile 41:10 113:2,4 114:12 115:6,10,22 116:5,11 118:16 119:13 124:18 125:6,7 125:14,15 126:3,5,13 129:6,7 135:16 135:20,22 136:3,4,5,13,15 136:17,18 137:4 profiles 114:15 114:21 116:16 118:9,12,13 121:6 124:14 134:17 135:6 136:20,22 project 116:19 properly 9:18 37:8 38:4,9 39:3,8,11 40:2 40:3,11,14,17 50:22 113:14 proportional 142:8 provide 8:18 9:16 13:18 28:3 42:12 56:16 74:16 93:11	104:20 provided 25:12 26:22 provides 51:22 Public 2:9 156:12 publish 66:13 pull 27:14 84:13 94:8 96:18 152:3 pulling 60:7 109:22 110:2,7 110:12 pulls 100:4 punch 119:14 punch-through 56:21,21 purchased 157:8 push 37:9 38:5 38:10,18 39:3 39:14,17 40:1,7 40:11,20,22 41:4,14 42:2 89:13 90:1 91:16 92:19 93:1,5,8,10,11 93:15,19 pushed 60:3 pushes 39:21 91:13 93:4 100:5 pushing 40:15 42:9 46:21 60:6 96:2 110:2,8,13 put 22:11 32:20 38:1 54:9 55:10 59:17 60:20 62:18 68:10 72:20 75:8,12 76:7 85:15 101:19 103:11 104:1 119:10 123:10 132:16 145:14 146:4 148:4,15,20 149:3 puts 54:10 putting 13:5	105:13 Q QD 15:4 qualify 80:22 qualitative 60:14 quality 141:14 quantitative 126:11 quantity 124:20 quantum 144:21 quasi-uniform 127:5 question 18:19 30:7 44:3 52:21 63:11 64:10,12 64:17 67:16 87:8,15,20 100:10 118:1,6 118:8 133:11 144:12 questioning 45:6 questions 19:17 20:15 29:20 61:13 67:2 83:14 150:18 150:22 153:22 157:14 158:10 158:13 quick 29:1,2,9 83:7,17 85:5 134:18 150:3 150:21 quickly 83:19 99:15 100:3 101:8,9 102:4,5 102:10 103:14 103:18 107:4 107:10 quite 13:14,15 58:9 137:16 R radiation 56:11 raised 28:1 153:18 random 131:16 132:20
---	--	--	--	---

randomly 120:8 131:18 132:1	recall 9:2 19:5,16 20:14 25:9 27:2 32:10 34:10 41:20 50:19 59:3 63:10 82:16,18,19 96:14 98:10,14 111:3 137:20 151:3 154:13	reflection 10:4,9 regard 45:13 regarding 13:10 region 68:22 70:2 73:21,22 74:12 74:20 75:1 76:3 86:15 90:21 97:15 107:2,9 138:6,9,9 139:12	39:19 48:10 72:17 resistance 119:6 145:8,10 146:2 146:9,11,15 149:13 resistances 145:19,20,22 149:11 resistivity 145:16 respect 70:17 respectively 15:2 respond 33:20,20 60:10 102:14 response 4:18 11:22 27:10,20 27:21 31:17 33:1,8,10,13,18 33:22 34:5,11 35:17 50:4 141:4 result 43:20 46:7 58:5,8 79:11 89:17 92:1 retired 49:1 retrospect 10:11 return 121:11 reverse 70:6 reversed 70:5 review 9:12 11:21,21 24:16 24:21 25:2 157:8 reviewed 9:19 10:18 11:14 12:16,19 13:1 20:21 21:4 23:20 32:5 reviewing 10:7 34:10 rid 125:20 right 8:15 10:15 15:3,19 16:22 18:17 23:16 30:9 33:5 34:18 35:1 38:12,20 38:21 39:5,9	40:2,8,12 41:1 41:4,7 42:6 45:17 59:14 61:3 65:11 67:5 71:16 79:6 80:17 85:8 86:11 87:14 88:2 89:5 91:2 93:2 95:20 96:3 96:10 97:2 99:12,13,16 101:5,10,14 103:15,19 104:14 108:5,9 109:6,15 110:9 110:11,14 118:21 127:10 128:14 130:21 135:14 136:3,7 137:16 145:19 146:14 148:17 154:22 rightly 112:7 rips 123:20 rise 145:4 Road 7:18 role 114:16 room 7:19 132:16 roughly 9:8 17:17 RPR 1:18 2:5 156:3,12 RSA 1:18 2:5 rules 29:4 157:14 rupture 103:11
ranges 113:10,19 113:22 rapid 124:21 rarely 116:16 re-ask 92:20 reach 53:19 56:18,18 reaching 47:1 read 9:15 19:8 24:13,19 33:7 33:19 88:3 158:6 reading 16:1 84:19 86:22 88:6 reads 85:18 ready 153:20 157:6 real 3:5 29:1 85:5 104:1 106:3 157:2 reality 103:10 realize 8:14 29:6 realized 10:12 really 12:2 19:9 44:17 45:6 73:1 73:4 77:15 86:22 92:4,5 104:5,12 106:6 114:17 138:22 139:1 149:17 realm 44:17 Realtime 2:7,7 reason 77:21 92:8 103:2 reasons 102:22 140:22	recalling 47:9 recap 32:18 receive 9:9 received 27:22 receptors 122:8 recess 26:2,3 29:13,14 84:1,2 150:11,12 152:9,10 recipe 71:6,18 recipes 133:7,7,8 recognize 34:7 recollection 9:20 record 5:5 7:13 14:7 23:4 25:19 26:1,5 29:12,16 31:6 83:22 84:4 85:4 109:12 130:7,10 146:20,20 150:8,10,14 152:6,8,12 154:21 155:2 recorded 5:6 158:10,14 rectangle 75:22 88:16 120:16 rectangles 88:17 redacted 31:16 34:4 REDIRECT 154:1 refer 30:11 67:11 referenced 157:6 referred 49:6 referring 81:19 143:10 reflect 11:10	regions 72:21 90:3,3 119:14 Registered 2:6 related 156:7 relationship 112:15 relative 156:9 relatively 58:4 relevant 43:18 45:4 reliability 104:16 relies 144:21 remainder 36:11 remember 9:4 11:13 19:2 37:7 37:11 38:3 122:16 137:12 151:7,17 remote 2:1 3:1 5:15 remotely 6:3 removed 52:2 repair 76:16 repeat 75:18 137:15 rephrase 52:21 replace 120:11 report 27:8 Reported 1:18 reporter 2:6,7,8 5:21 6:6 130:5 130:10 represent 6:5 represents 54:14 required 72:11 74:5 82:15 requirement	result 43:20 46:7 58:5,8 79:11 89:17 92:1 retired 49:1 retrospect 10:11 return 121:11 reverse 70:6 reversed 70:5 review 9:12 11:21,21 24:16 24:21 25:2 157:8 reviewed 9:19 10:18 11:14 12:16,19 13:1 20:21 21:4 23:20 32:5 reviewing 10:7 34:10 rid 125:20 right 8:15 10:15 15:3,19 16:22 18:17 23:16 30:9 33:5 34:18 35:1 38:12,20 38:21 39:5,9	S San 3:6 157:2 Sandeen 7:18 SARASOTA 156:14 saturation 139:10 saw 10:19 11:15 33:8 83:4 saying 20:22 36:7

40:17 70:16 80:22 93:18 94:12 106:20 107:18 127:22 130:10 134:8 147:3 says 16:18 18:21 19:11 24:14 85:12 87:1 96:16 scattering 112:8 112:10 139:17 143:17 school 43:15 65:14,15,17 schooled 153:11 scope 151:21 screen 5:17 8:3,5 8:6 20:21 22:10 22:17 23:8 26:21 34:19 84:16 85:22 scroll 17:16 second 8:10 13:13,18 23:15 24:3 25:20 27:10 28:7 30:10 55:3 151:2,3,6,12,22 152:4,6,15,19 152:21 153:5 153:15 154:8 seconds 102:14 see 8:4 11:7 14:22 15:13 16:1,8,20 17:5 17:8,17,19 18:2 18:3,6,8,11,13 18:21 20:11 23:7,9,10 24:8 24:14 35:20 36:16 84:10,10 84:15,17 85:2 85:21 86:15,17 86:21 87:1,3,14 90:17 92:3,15 96:5,7,11 104:8	134:9 seeing 82:17 112:10,11,12 seen 25:5,9 80:2 80:15 127:4,13 sees 132:7,8 137:3 selected 157:10 semicircle 86:19 semiconductor 48:4 50:9,16,20 51:12 59:9,11 59:17 71:2 89:21 113:7 138:20 140:12 140:20 143:14 146:11 semiconductors 144:11,15,17 145:18 146:1 147:2,7,8 149:10,21 send 123:19 senior 43:15 65:14 sense 11:9 41:22 57:13 73:1 87:10 101:1 132:4 133:11 sensor 85:19 sent 38:14 sentence 70:1 separately 23:12 September 156:20 session 155:3 set 106:19 107:1 sharp 125:3,9 126:7,8,10 sheet 85:11 157:11 158:11 159:6 short 64:20 83:16 84:10 145:5 shorter 105:18 Shorthand 2:8 show 33:22 82:20	90:15 showed 30:3 showing 96:13 shown 26:21 35:2 97:16 108:12 108:18 109:2 109:13,20 110:6 shows 100:17 shut 70:10 side 47:10 54:12 62:18 69:3 110:4 114:17 126:20,22 128:2,4 132:16 sides 76:4 128:20 128:22 129:14 130:21 131:1 sign 157:7,8 signal 51:20 68:8 68:9 signature 155:4 157:6,12 158:4 158:17 159:22 signed 157:11 signing 157:10 silicon 43:9 52:12 52:12 72:3 75:3 76:18 81:20,21 91:4 97:13 112:18,18 120:4,5,11 121:17 123:4 131:10,13 140:14,18 142:14 145:15 146:7,14,18,19 147:16,20 148:13 149:9 149:11,12 similar 25:12 Sincerely 157:18 single 15:14 SiO2 75:3 sir 17:21 21:2 34:17 64:18 sit 121:17	sites 76:18 sitting 76:1 153:4 153:13 situated 15:20 situation 70:17 115:5 size 106:11 slam 76:11 slight 127:10 slightly 42:10 132:6 slope 126:16,21 128:3,5,9,13 139:12 142:10 slow 139:17 slower 143:3,4,12 slowly 101:13,13 143:14,17 sluggish 147:12 147:15,18,19 148:1,14,21 149:4,19 smaller 84:20,20 102:15,22 103:5,14 Smith 3:11 6:9 so-so 146:16 149:13,14 soft 54:1 55:2,4 soft-error 57:12 software 111:18 111:19,22 somebody 38:1 63:19 someplace 126:20 soon 102:17 150:6 sorry 11:17 13:15 21:21 24:17 42:10 43:8 45:5 56:4 56:6 63:11,12 69:22 72:18 75:4 81:1 89:19 92:11 93:5 111:16 122:20	128:15 135:18 137:13 140:2 140:17 141:11 145:7 151:4 152:18 sounds 83:20 146:21 153:11 source 51:22 52:1,8 57:1,8,9 60:15 61:2,6,9 68:14,15,19,20 69:1,3,8 70:3,9 73:19,21 75:12 75:15,19 78:7 79:15,19 81:5 90:22 91:18 94:19 99:19 102:20 104:22 119:6 138:14 space 136:7 special 52:11 specific 132:6 specifically 85:12 100:14 specified 113:17 115:20 speed 103:5 106:4,6 139:11 spelled 130:7,12 spent 47:20 49:4 Sperry 49:6 spoke 21:21 spot 55:6 spread 121:3 squared 124:20 stamp 85:11 stand 10:5 14:5 21:13 36:10 132:17 154:22 standard 1:15 5:17 50:6,8,13 117:16 stands 67:13,13 start 29:19 35:4 49:22 56:13 59:6 72:7,10,16 72:18 74:2,4,7
--	---	---	--	---

76:20 77:1 78:4 90:19 111:16 114:2 123:5 132:18 started 22:9 26:9 starting 50:6 71:21,22 72:2 starts 56:22 state 2:9,9,10,11 6:4 7:12 70:18 88:8 95:10 114:2 121:11 121:12 156:14 156:15,16,19 statement 128:6 128:10 States 1:1 5:12 stay 119:2 153:2 stays 115:19 steep 124:21 125:10,12,16 125:17 126:14 130:21 131:2 steeper 115:21 116:4 steepness 125:20 Stephen 1:13 2:2 4:2 5:6 7:2,14 17:1 157:1,4 158:5 159:9 steps 71:3 135:5 135:7 stipulated 6:2 stood 32:14 stop 130:1 storage 88:1,12 store 54:5,7 story 132:10 straggle 124:20 Street 1:21 3:12 158:1 159:2 strictly 77:13 strike 52:19 55:17 90:10 99:6 114:13 115:15 129:11 146:9	strikes 124:3 strong 51:1,4,10 53:7,8 strongest 51:6,6 51:7 91:4 structure 54:2,4 55:16 56:22 59:7 144:22 145:6 structures 111:19 stuck 80:6 students 48:7 132:15 stuff 50:7,8 110:21 142:16 stunned 44:2 submitted 13:9 13:14 32:8 substrate 41:13 52:6,6,11 59:14 62:9,12 70:18 72:1,22 73:2,5 73:21,22 78:18 78:21 81:2 85:18 91:6,11 92:20 Suite 1:21 3:5,12 158:1 159:2 sum 42:21 43:4 supervise 30:17 supposed 29:4 sure 10:15 12:6 14:19 15:6 16:14 21:22 23:1 25:21 26:8 30:13 39:11 58:12,21 66:21 67:19 79:3 81:7 81:11 90:5 95:10 100:9 101:20 102:3 105:21 106:10 107:19 110:2 110:17,19 113:16 115:18 117:4 127:18	130:5 137:9 139:2 145:10 152:7 153:5,14 surface 37:10 38:6,11,19 39:4 39:15,18,21 40:1,7,12 41:1 41:5,11,12,15 46:20 47:1 53:13,16 54:3 57:10 59:11,17 60:3,5,22 76:11 81:9,13,15,18 81:19,20 89:2 89:14,18 91:4 91:14 94:20 96:3 100:5,5 107:10 108:5,9 110:1,8,8,13,14 120:19 124:6 133:18 surprise 63:17 suspended 155:5 sworn 6:3 7:4 156:6 system 76:7 systems 1:3 2:7 5:8 6:11 16:18 134:13 157:3 158:4 159:8 T T 87:2,4,7 table 47:8,10 tails 129:22 take 23:14 28:22 29:1,9 34:22 83:2,10,11,17 101:16 102:20 132:21 134:19 150:3 taken 5:7 10:16 11:3,20 26:2 29:13 84:1 150:11 152:9 156:8 takes 15:13	111:22 talk 10:12 29:5 48:21 81:9 94:2 98:7 100:13 111:6,9 112:9 117:2 148:7 talked 79:4 98:12 111:7 124:13 135:11 154:11 talking 15:14 26:10 27:19 52:20 53:10 65:11 67:8 81:22 98:20 107:11 116:20 130:3 131:9 138:18 140:18 141:11 143:11 144:13 148:13 154:7 taught 48:1 63:12 65:16,19 TCAD 135:3,4,9 teach 47:6,14,18 48:14,22 49:2 50:13 teaches 48:17 Tech 3:16 technical 25:3 28:3 30:13 37:15 Technically 121:16 technician 5:20 technicians 71:6 71:11 technologies 49:7 58:19 technology 48:3 49:5 58:3,18 63:13 67:9 76:6 77:16 135:3 tell 18:18 20:2 28:15 33:16 34:20 41:7 86:7 88:8 111:18 116:2 132:17	146:19 149:22 tells 112:15 temperature 112:19 113:8,9 113:18 114:4,9 114:10 115:3,7 115:11,12,16 115:19 116:11 116:15 117:6,9 117:15,19 119:21,22 129:3,9 140:2 temperatures 113:13,16 114:11 119:3 140:1 141:13 141:18 143:15 tend 42:13 47:11 93:5,8 129:13 130:20 132:1,9 tended 77:4 tends 47:13 89:13 93:11 term 74:21 80:10 86:14 122:1 141:12 terminate 90:21 terms 50:3 71:13 73:2 80:15 Terrific 29:8 test 113:15 tested 58:13 71:8 testified 7:4 12:10 41:16 testifying 39:13 testimony 10:4,6 11:10 12:7 14:5 29:21 30:11 36:1,4,6,9,11 103:4 150:17 156:5 testing 51:15 thank 13:22 18:16 25:16 29:19 30:19 31:3 84:8 136:5 150:7,16
--	---	--	--	---

154:19	12:2 13:6 28:4	Trademark 1:1	try 64:10 84:9	96:9,10 120:7
Thanks 136:10	32:6,16 83:4	5:12	89:4 92:19 93:1	128:15 134:13
theoretical	140:18 153:10	transcript 4:12	93:3,16,19 94:7	138:11
103:20	153:17	9:9,12,15 11:15	119:6 122:13	two-thirds 86:5
theoretically	thoughts 9:14	12:16,20 17:6	127:5	type 73:9 122:5
134:5	three 15:1 17:6	17:17 18:10	trying 44:4 56:5	140:12,20
thermal 45:15	49:2 53:17	20:20 21:5,8	66:12 78:19,20	typed 38:8,13,17
125:6	68:15 127:14	26:10 31:7 32:6	95:3 97:19	39:7,12
thick 75:2	three-point 86:16	32:13 33:3	99:14 100:2,6	types 47:18
thin 92:5	86:20	157:6,7 158:7	101:15 102:9	typically 71:20
thing 10:11,19,22	threshold 105:4	transcription	106:7 107:13	74:2 76:20
11:1,15,19 12:1	115:17,19	158:10,12	117:22 118:1,3	114:8,14 115:2
12:2 13:3,6	118:21	transistor 48:2	118:18,20	123:4,5
21:10,12 22:2	time 1:15 2:4	51:18,19 52:13	121:2,5 125:8	typing 37:20 38:3
26:14,18 32:7	5:16,17 9:4	57:8,15 59:7	126:9 128:18	typo 87:5,10
33:3 35:19	14:10 22:5	68:5 73:10 74:8	130:17 136:10	typographical
48:18 61:16	25:22 26:4 27:2	74:18,20 75:5	143:6 144:9,18	9:21 10:1 12:20
103:21 107:14	29:11,15 48:15	82:5,6 86:9,10	145:5 148:14	
110:11 117:11	55:5 66:2 83:21	86:12 87:21	turn 34:14 51:19	U
122:13 123:14	84:3 105:19	88:7,11,13,15	55:22 56:1,2	U.S 1:3,5,7,9 4:14
134:1 139:6	116:18 150:9	89:9 90:12,18	68:3,6 69:14	4:20 24:16,22
144:20	150:13,16	91:15 92:3	70:19 73:10	31:21 85:9
things 8:21 10:10	152:7,11	95:19,22 96:21	79:1,9 88:7,14	Uh-huh 12:12
11:6 54:7 69:11	154:20 155:1	97:6,12 98:9,21	91:16 95:22	67:20
83:18 108:3	157:13	99:8,15 100:1	99:8,14 100:3	ultimately 124:3
116:13 117:22	times 43:6 99:18	100:14,18	100:21 101:8	uncommon 77:15
121:3,10 131:5	102:15 118:1	101:8,13 102:4	101:13 102:5	underneath 74:8
139:16 140:6,9	tiny 106:5	102:16 103:13	103:13,17	78:18
144:4 150:5	today 5:21 26:10	104:10,16	107:3 132:15	understand 8:11
think 44:15,18	29:21 39:13	105:8 107:3	132:17	12:6 29:3 39:12
51:11 52:20	47:17 83:16	108:7 148:8	turn-on 56:14	41:16 44:5 48:8
61:18 63:16	130:5 150:16	transistors 41:12	74:9 75:9 79:13	58:21 66:12,14
67:4,16 75:22	153:4,13	53:22 55:19,21	82:8,9 105:4	67:19 69:12
78:10 79:5 83:7	154:20	56:12 70:19	turned 58:16	78:10 79:3 81:7
83:9,9 86:20	today's 155:3	72:1 74:17	136:21	84:11 87:16
93:6,17 102:2	told 13:11	106:9 119:2,9	turning 56:13	90:5 93:17 95:9
104:9 107:22	top 16:9,22 35:10	transport 43:9	79:4 89:3 91:15	105:21 106:20
115:5 127:21	36:2,10 41:11	45:8,13	98:21	107:19 117:21
133:4 134:7	47:12 59:18	transposed 9:18	turns 52:4 98:9	118:3,14 127:8
137:7 138:17	76:1 86:5 88:16	tree 107:15	108:7	127:18,21
140:10 142:17	140:10	Trial 5:13	tweak 135:9	128:18 130:1
143:10 145:17	top-most 81:20	trigger 151:12	two 11:6 22:22	134:7,8 142:17
153:21	topic 48:6 50:12	trillion 94:15	24:19 46:11	144:5,9 145:17
thinking 35:15	104:19	trillions 94:14	51:6 55:19	154:3,9
third 17:13 56:20	totally 127:6,9	true 94:12 95:17	65:11 67:10	understanding
154:8	trade-off 107:13	158:9,11	73:20 86:12	63:2 116:17,20
thought 10:16	trade-offs 108:2	truthful 8:18	88:17 89:21	143:21

understood 58:13 110:17 137:9	V v 1:6 5:8 157:3 158:4 159:8	60:21 62:4,9,10 62:10,14 64:7 64:15 65:6 68:10,12 70:14 70:17 73:11 74:9 75:9 79:10 79:12,13 82:8,9 82:11 88:1,4,4 88:19,20,22 89:4,8,11 90:11 90:16 91:10 92:7,12,13 94:22 95:19 100:21 101:3 102:18 103:11 103:18,21 104:1,5,9,13 105:4,7,15 106:14,16 111:7 115:18 115:19 118:21 148:3,10	70:19 73:10,13 74:9 76:13 82:21 83:2,15 84:9,10 85:4 88:3 90:5 99:15 100:3,8,9 101:19,20 102:3 104:12 105:3,15 106:1 106:1,15 107:19 115:6 115:10,18 116:10 119:5 119:14 121:5 123:7,8,14,15 124:2 130:4,15 134:9 150:16	73:6 133:16,16 went 71:9 Whitehurst 3:11 4:5,7 6:7,8 7:8 7:10,11 14:13 14:16 15:9 16:3 18:20 20:1,4 22:7,18 23:3,6 23:22 24:5,7 25:17 26:6 28:21 29:8,17 31:4,15,20 32:2 34:3 57:17 82:22 83:8 84:5 84:21 85:6,14 85:16 86:2,6 109:9 116:9 130:9,14 150:2 150:15 151:7 151:14,20 152:16 154:2 154:19
unfortunately 144:20	vacuum 76:7	voltages 59:12 103:6,8 111:14 111:20 113:5 134:21 138:12	wanted 21:10 27:5,6 30:18 32:3 33:19 35:16,18 57:20 57:21 71:19 110:17 111:11 129:16 137:8	widely 48:5 wider 141:10
uniform 125:22 126:3,4 127:6,9	variations 127:10	volts 70:13	wants 83:10	wildebeests 131:10,13
unintentionally 55:18	various 135:7	W	Washington 1:21 3:12 156:17 158:2 159:3	wildly 92:4 willing 28:20
Unisys 49:6	vector 62:1,7 63:8	wafer 59:21,22 72:1,3,5,18 74:4,7,15 76:11 76:12,15 77:12 77:18 81:21 124:3,4	wasn't 117:22	wind 37:20
United 1:1 5:11	vectors 48:19,20 98:5	wafers 77:4,6 123:11	way 14:17 47:10 55:22 72:13 76:2,22 77:8 86:3 89:19 99:22 103:5,13 103:17 111:17 117:13 119:15 131:19 132:6 144:12,22 145:9	wish 110:20
universal 66:13	velocities 112:4 139:4	wait 55:4 149:9	ways 143:8,19	witness 2:2 4:2 6:3 7:3 15:3,16 15:18,22 18:16 22:16 29:7 56:5 83:20 85:2 116:7 130:13 151:15 152:18 156:5 157:8 158:5,17 159:9
universally 62:16 62:22 63:20 66:7	velocity 46:17,20 47:4 48:21 98:5 112:16 137:11 137:19 139:7,9 142:7,9 148:18	waived 155:4	we've 86:2	word 52:20 55:17 71:17 80:7 130:2 145:8
university 47:20 49:1	verbiage 93:3,9	walk 89:7	weak 46:20	wording 41:20
unlucky 47:2	verify 37:3	want 10:14 15:5 15:18 17:20 26:7 30:12,12 39:11 42:11 53:14 56:16 58:20,21 70:13	weighed 142:4	words 9:17 37:1 37:7,11,13,20 38:1,3,9,17 39:8 58:22
unnecessary 93:3	versus 16:18		weight 43:10	
unpunished 61:12	vertically 121:20 121:22		welcome 29:18 84:6	
unsure 24:11	vibrating 47:8		wells 72:20,20	
unusual 138:22	vibration 46:4			
upload 8:4	video 5:5,5,15,16			
upward 94:8 95:13 109:15	video-recorded 155:3			
upwards 109:5	videographer 5:4 5:19 14:16,19 15:6,12,17,20 18:14 20:1,3 24:2 25:18,21 26:4 29:11,15 83:21 84:3 150:9,13 152:7 152:11 154:22			
use 47:6 62:20 66:20 68:8 71:20 73:9,13 76:6,10 77:4 103:5,14 107:2 107:8 108:4,8 111:18 112:5 113:21 114:14 115:6,10,21 123:16,18 124:1,8 132:14 141:7 144:7	Videographer/... 3:16			
user 112:21	VIDEOTAPED 1:13 2:1			
uses 66:22 136:12,14	view 99:17			
usually 78:8 114:11 121:5 122:12 138:14 140:3,6 148:7	voicemail 56:6			
	voltage 45:20 51:3 52:5 54:3 54:9,13,15,19 54:21 57:3 59:19,21,22,22			

64:20 101:19 work 22:16 49:3 52:15 62:19 66:12 113:16 116:19 117:3,5 117:8 146:18 149:21 154:9 worked 50:2 58:1 117:14,18 working 49:15 50:15 52:17,22 66:1 77:3 106:9 111:1,13 114:16 118:15 133:20 138:2 works 8:12 world 48:5 66:8 104:1 106:4 worry 106:7 worse 149:22 worst 116:22 wouldn't 63:17 149:12 wrap 83:18 150:5 write 30:16 38:22 88:4 writes 55:5 writing 37:7,11 88:7 written 27:22 37:16,19 38:20 157:22 wrong 11:1 12:3 40:22 52:20 55:7 107:15 wrote 37:14 38:16 39:2 48:4	year 43:15,16 48:13 65:14 years 47:20 49:2 49:4 Z zoom 5:15 8:7 14:20 22:17 23:12 85:3,17 86:3 0 0 54:14 55:1 59:22 62:10,14 64:7,15 65:7,9 65:12 70:13,17 128:9,13,16,17 1 1 4:11 5:5 14:10 14:11 16:7,9 18:12,22 19:6 19:22 20:18 23:5,8 24:1,1,6 24:8 31:8 54:14 55:1 156:18 1,000 76:16 1:04 150:12,14 1:05 152:8,9 1:11 152:10,12 1:13 155:1,5 10 85:11 146:5 10,510,842 1:4 4:15,20 24:22 31:21 85:10 10,734,481 1:6 10/17/24 4:12 10:07 29:14,16 10:34 18:5 100 25:14 28:13 153:14 1001 85:12 1003 36:15,21 11 84:22 85:13 11,121,222 1:8 11,316,014 1:10 11/8/24 4:19 11:14 83:22 84:1	11:33 84:2,4 11452 3:5 157:2 12 156:15 12:54 150:10,11 13959 1:19 2:6 156:4,15 14 4:12 15 29:10 85:13 150 4:6 154 4:7 169 18:15,16,17 1700s 63:3 1730 1:21 158:1 159:2 17th 16:9 19 58:17 1980's-era 58:17 1980s 58:4 1999 3:12 2 2 4:13 19:20 20:11 22:9,14 22:21 23:14 31:9 156:17 20006 3:12 20036 1:21 158:2 159:3 202 1:22 158:2 202-370-8300 3:13 202)-232-0646 157:15 202)232-0646 159:4 2024 1:14 2:4 5:1 5:16 16:9 155:2 157:4,20 158:5 159:10 2024-00468 17:7 34:6 2024-00550 5:9 2025 156:16,17 156:20,22 2026 156:18 2028 156:15 21 35:2	22 1:14 2:3 4:15 5:1 156:16 157:4 158:5 159:10 221 20:3,6,7 22nd 5:16 155:1 232-0646 1:22 158:2 3 3 4:16 25:18 26:22 31:11,13 3-nanometer 103:1 3/18/24 4:15,17 300 3:5 157:2 31 4:17,19,20 32 36:15 3248 7:18 35 47:20 4 4 4:18 31:16,18 34:4,16 469 17:11 470 17:14 476 20:9,12,15 5 5 4:20 31:21,22 84:15 156:22 551 5:10 552 5:10 553 5:10 56 18:1,3 57 17:17,20 5B 84:22 85:18 85:22 86:4,8 100:17 108:13 108:16,18,21 109:3,13,21 110:6 6 600 3:12 7 7 4:5	8 8 35:2,5,10 36:2 36:10,14 812 1:21 158:1 159:2 842 84:14 858-720-5700 3:7 9 9 35:8,10 36:2,10 85:11 156:20 9:13 1:15 2:4 5:1 5:17 9:37 25:22 26:2 9:41 26:3,5 9:46 29:12,13 92130 3:6 157:2 923 15:18
--	--	--	---	--