

1 UNITED STATES PATENT AND TRADEMARK OFFICE
2 BEFORE THE PATENT TRIAL AND APPEAL BOARD

3 WESTERN DIGITAL TECHNOLOGIES,)
4 INC.,)
5)
6 Petitioner,)
7 Vs.)
8)
9 GODO KAISHA IP BRIDGE 1,)
10)
11 Patent Owner.)
12 /

8

9

10

11

Case No. IPR2024-01494

12

U.S. Patent Number 11,968,909

13

14

VIDEOTAPED DEPOSITION OF CAROLINE A. ROSS, Ph.D.

15

(Taken Virtually by Petitioner)

16

Friday, September 19th, 2025

17

9:02 a.m. EDT

18

19

20

21

22

Certified Stenographic Court Reporter
Amy A. Brauser, RPR, RMR, CRR

1 VIRTUAL APPEARANCES

2 ON BEHALF OF THE PETITIONER WESTERN DIGITAL
3 TECHNOLOGIES, INC.:4 DOUGLAS R. WILSON, Esquire
5 SPENCER RIRIE, Esquire
6 Armond Wilson LLP
7 4685 MacArthur Court, Suite 390
8 Newport Beach, California 92660
9 (949) 932-0778
10 doug.wilson@armondwilson.com
11 spencer.ririe@armondwilson.com

12 ON BEHALF OF THE PATENT OWNER GODO KAISHA IP BRIDGE 1:

13 GERALD B. HRYCYSZYN, Esquire
14 Wolf Greenfield
15 600 Atlantic Avenue, 23rd Floor
16 Boston, Massachusetts 02210
17 (617) 646-8313
18 gerald.hrycyszyn@wolfgreenfield.com

19 ALSO PRESENT:

20 Mitchell Mahon, Videographer
21
22

1 VIDEOTAPED DEPOSITION OF CAROLINE A. ROSS,
2 Ph.D., a witness called on behalf of Petitioner,
3 before Amy A. Brauser, RPR RMR CRR, Certified
4 Stenographic Court Reporter and Notary Public, in
5 and for the Commonwealth of Virginia, on Friday, the
6 19th day of September, 2025, commencing at 9:02 a.m.

7 * * * * *

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

1

INDEX OF EXAMINATIONS

2

By Mr. Wilson Page 6

3

4

5

(NO EXHIBITS MARKED)

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

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

2 THE VIDEOGRAPHER: We are going on the
3 record. This is File Number 1 of the
4 deposition of Dr. Caroline A. Ross, taken in
5 the matter of Western Digital versus IP
6 Bridge, Cause Number IPR2014-01494. Sorry.
7 The date is September 19th, 2025. This
8 deposition is being held remotely via Zoom
9 video conference.

10 My name is Mitchell Mahon. I'm the
11 legal videographer for Digital Evidence Group.
12 The court reporter is Amy Brauser in
13 association with Digital Evidence Group. The
14 time is 9:02.

15 Will counsel, please, introduce
16 themselves for the record?

17 MR. WILSON: Douglas Wilson of Armond
18 Wilson LLP for Petitioner Western Digital.
19 And with me is Spencer Ririe.

20 MR. HRYCYSZYN: Jerry Hrycyszyn with
21 Wolf Greenfield for IP Bridge.

22

1 CAROLINE ANNE ROSS, Ph.D.,
2 after having been first duly sworn by the certified
3 stenographer, was examined and testified as follows:

4 EXAMINATION

5 BY MR. WILSON:

6 Q. Good morning, Dr. Ross.

7 A. Good morning.

8 Q. And you understand today's deposition
9 is for IPR0224-01494?

10 A. Yes, I do.

11 Q. Okay. And that involves U.S. Patent
12 Number 11,968,909?

13 A. Yes.

14 Q. And if I refer to that as the
15 '909 Patent, you'll know what I mean?

16 A. I will.

17 Q. Okay. You understand you're under oath
18 this morning, correct?

19 A. Yes.

20 Q. And if I ask a question and you don't
21 understand the question, please ask for
22 clarification.

1 A. Understood.

2 Q. Okay. If you answer a question without
3 asking for clarification, I'll assume that you
4 understood it. Okay?

5 A. Okay.

6 Q. Is there any reason, medical or
7 otherwise, why you cannot testify fully, truthfully
8 and accurately as you sit here today?

9 A. There's no reason.

10 Q. Okay. And can you, please, state your
11 full name?

12 A. Caroline Anne Ross.

13 Q. Okay. And again, you are testifying
14 today on behalf of IP Bridge, correct?

15 A. Correct.

16 Q. And you've been retained by Wolf
17 Greenfield on behalf of IP Bridge?

18 A. Yes.

19 Q. And you're being compensated by IP
20 Bridge for your time today?

21 A. Yes, although I'm being paid by Wolf
22 Greenfield.

1 Q. Okay. Now, today we have a single
2 declaration, Exhibit 2053, for the 1494 IPR.

3 Do you have that declaration in front
4 of you?

5 A. I do.

6 Q. And if you can turn to page 106.
7 That's your signature on page 106?

8 A. Yes, it is.

9 Q. And it's dated July 12th, 2025,
10 correct?

11 A. Correct.

12 Q. And the next page, you see Appendix A,
13 materials considered, starting at page 107 and
14 running through page 110?

15 A. Yes.

16 Q. Okay. And if we go back up in your
17 declaration to Paragraph 11 on page 7, you identify
18 the materials considered as the documents cited or
19 referenced in your declaration, including in
20 Appendix A, correct?

21 A. Yes, it identifies the materials I
22 reviewed and considered, the Petition, the

1 institution decision, and Appendix A.

2 Q. Okay. Is that a complete list of the
3 materials that you considered and relied on in
4 forming the opinions expressed in Exhibit 2053?

5 A. Yes, that's right.

6 Q. And Exhibit 2053 is a complete
7 statement of the opinions that you are offering in
8 this IPR 1494, correct?

9 A. Correct.

10 Q. Now, what did you do to prepare for
11 your deposition this morning?

12 A. For this morning, I read through many
13 of those documents again.

14 Q. Okay. You reviewed your declaration,
15 Exhibit 2053?

16 A. Yes.

17 Q. Did you find anything that you thought
18 needed to be corrected?

19 A. I didn't find anything in this
20 document. I did find something in the
21 '167 declaration from yesterday.

22 Q. So you're saying since yesterday

1 or . . .

2 A. Yes. Based on one of the questions you
3 asked me.

4 Q. So there's something in your
5 '167 declaration that you thought of after the
6 deposition yesterday that you think needs to be
7 corrected in your '167 declaration?

8 A. Yes, I did.

9 Q. Okay. What is that?

10 A. So Paragraph 296 on page 104 where I'm
11 talking about the thin crystallized layers of
12 cobalt iron boron, which Yuasa's APL paper says
13 could have formed next to the MgO barrier layer,
14 I'd said in my declaration in that paragraph that
15 this satisfies the entirely crystallized
16 limitation. But thinking about that some more,
17 given that not all of the cobalt iron boron is
18 crystallized, I think that is inconsistent with my
19 other opinions. So I believe that's an error.

20 Q. Okay. Did you reach that decision in
21 consultation with counsel for IP Bridge?

22 A. No. I was thinking about it after we

1 had exchanged questions and answers about this
2 yesterday, and I wanted to think about it some more
3 later in the day. But I do believe that the thin
4 crystallized layer is crystallized, fully
5 crystallized, adjacent to the MgO, but not
6 throughout the entire cobalt iron boron layer. So
7 that statement is, I believe, an error.

8 Q. Okay. And so just so we're clear, you
9 think the claims, both -- or the '167 claims
10 specifically, when they say that a layer is
11 entirely crystallized, you think that means that
12 all of the cobalt iron boron that is present has to
13 be fully crystallized in order to constitute an
14 entirely crystallized cobalt iron boron layer,
15 correct?

16 A. What I'm -- what I'm saying is in
17 relation to this Paragraph 296, where I'm
18 commenting on how Yuasa's APL paper provides a
19 nexus to the claims as part of the secondary
20 considerations.

21 So what I'm -- what my opinion is, is
22 that the thin cobalt iron boron layer adjacent to

1 the MgO doesn't satisfy the entirely crystallized
2 limitation.

3 Q. Okay. So let's -- so I'm just trying
4 to understand why you've changed your opinion.

5 You're saying you now feel like if only
6 a portion of the cobalt iron boron layer is
7 crystallized, that it doesn't meet the entirely
8 crystallized limitation in the '167 claims,
9 correct?

10 A. What I'm saying is that Yuasa's thin
11 monolayers or several layers of cobalt iron boron
12 crystallized material that he describes in his APL
13 paper don't meet the entirely crystallized claim.

14 So my opinion is -- what I'm explaining
15 to you now is related to that secondary
16 consideration of what the Yuasa APL paper actually
17 says.

18 Q. Right. And I'm trying to understand
19 why that is the case. Is it the case that you
20 believe that the entire cobalt iron boron layer
21 that exists there needs to be crystallized to meet
22 the entirely crystallized limitation?

1 A. Well, what I'm -- my opinion is that in
2 Yuasa's APL paper, he shows images of his structure
3 where he says he can't exclude the possibility of
4 there being crystallized regions adjacent to the
5 MgO barrier layer, which he describes as a few
6 monolayers or monolayers of crystallized cobalt
7 iron boron.

8 There's clearly amorphous cobalt iron
9 boron remaining in that structure. So, therefore,
10 this doesn't satisfy the entirely crystallized
11 limitation.

12 Q. Okay. So I think what you're saying,
13 and correct me if I'm wrong, is if you have a
14 cobalt iron boron layer in which there remains some
15 amorphous cobalt iron boron, then that cobalt iron
16 boron layer is not entirely crystallized --

17 A. I'm just --

18 Q. -- in your opinion?

19 A. Oh, sorry. I'm just saying that I
20 don't believe Yuasa's example, the paper in -- the
21 APL paper, is a secondary consideration that
22 satisfies that claim.

1 I don't want to correct the opinions
2 beyond that paragraph, because the other opinions I
3 have in the document I stand by. But this
4 particular paragraph is where I believe I made an
5 error when I said that the crystallized monolayers
6 adjacent to the MgO barrier satisfy the entirely
7 crystallized limitation.

8 Q. Right. I understand that you believe
9 you made an error. And I'm trying to understand
10 why, the rationale behind the error you believe you
11 made. And I believe what you're saying is that if
12 you have, as Yuasa did, a cobalt iron boron layer
13 in which a portion of that layer remains amorphous,
14 it is not entirely crystallized as required by some
15 of the claims of the '167 Patent, correct?

16 MR. HRYCYSZYN: Objection, beyond the
17 scope.

18 THE WITNESS: So I'm not offering any
19 opinions about the construction or the
20 meaning of "entirely crystallized." What I
21 am giving a revised opinion on is whether
22 Yuasa's APL paper reveals an entirely

1 crystallized layer. And since Yuasa's
2 description has a layer of -- or some
3 monolayers of crystallized material and some
4 region of noncrystallized material, then it
5 doesn't satisfy the entirely crystallized
6 limitation.

7 So that's the extent of my opinion on
8 this Paragraph 296.

9 BY MR. WILSON:

10 Q. Okay. And you agree, then, that the
11 Yuasa APL 2005 paper, Exhibit 2006, does not
12 provide any objective evidence of nonobviousness of
13 Claims 2, 4, 6 and 12 through 13 of the
14 '167 Patent, correct?

15 A. I'm not remembering which exact claim,
16 but the entirely crystallized phrases within the
17 claims are not -- the APL paper does not give an
18 example of entirely crystallized cobalt iron boron.

19 Q. Okay.

20 Okay. Any other corrections to
21 Exhibit 2053 for the '909 Patent or your other
22 declarations?

1 A. No, I didn't find any corrections to be
2 made in the '909 declaration.

3 Q. Okay. And as you sit here right now,
4 you are confident in all the opinions you express
5 in Exhibit 2053 for the '909 Patent, correct?

6 A. Yes.

7 Q. Now, you worked with the law firm Wolf
8 Greenfield in preparing Exhibit 2053 for the
9 '909 Patent?

10 A. Yes, I did.

11 Q. Did you work with anyone other than
12 lawyers at Wolf Greenfield?

13 A. No, I didn't.

14 Q. Okay. So you didn't work with anyone
15 at IP Bridge in preparing your declaration?

16 A. No, I don't know anybody at IP Bridge.

17 Q. Okay. Approximately how much time did
18 you spend preparing your declaration, Exhibit 2053?

19 A. I don't recall exactly. It's probably
20 the order of 30 hours, roughly.

21 Q. Okay.

22 Okay. You understand the '909 Patent

1 has claims that are directed to a tunnel barrier
2 height, correct?

3 A. Yes.

4 Q. Okay. Have you ever been involved in
5 the measurement of tunnel barrier height of a
6 magnetic tunnel junction?

7 A. I have fabricated them and measured
8 their IV characteristics. I don't recall whether I
9 extracted barrier heights out of that data.

10 Q. Okay. When is the earliest example you
11 recall fabricating an MTJ in which you measured its
12 IV characteristics?

13 A. My declaration on Paragraph 8 has a
14 list of papers which I've coauthored on tunnel
15 junctions. So those are some of the examples.

16 Q. In any of those papers, did you
17 fabricate an MTJ and measure its current voltage
18 characteristics?

19 A. Most -- all of these are about the
20 fabrication and patterning of magnetic tunnel
21 junctions. I believe most of them have electrical
22 data, although I don't recall exactly.

1 Q. Okay. So the earliest paper listed in

2 Paragraph 8 is 2015, correct?

3 A. That's the earliest one listed in

4 Paragraph 8.

5 Q. So is that the earliest you believe you

6 fabricated a magnetic tunnel junction and measured

7 its current voltage characteristics?

8 A. I don't actually recall if I've

9 measured or made tunnel junctions prior to 2015.

10 Q. Okay. In your declaration you

11 reference a paper by Slonczewski. Are you familiar

12 with that?

13 A. Yes.

14 Q. Okay. Have you ever in your

15 publications referred to Slonczewski's model?

16 A. Are you asking if I've cited

17 Slonczewski in any of my papers?

18 Q. Yes.

19 A. I don't actually recall what the

20 citations are in any of these papers.

21 Q. Okay. Were you aware of -- and just

22 for reference, Slonczewski in this proceeding is

1 Exhibit 2041. But were you aware of Slonczewski's
2 paper, Exhibit 2041, before this case?

3 A. Yes.

4 Q. Okay. And you've reviewed
5 Slonczewski's paper, Exhibit 2041, before this
6 case, correct?

7 A. By reviewing it, do you mean have I
8 read it prior to this case?

9 Q. Yes.

10 A. I've been aware of it. I don't recall
11 when.

12 Q. Okay. And you don't recall ever citing
13 Slonczewski's paper, Exhibit 2041, in any of your
14 work on MTJs, correct?

15 A. I don't recall citing it.

16 Q. Okay.

17 And you're also aware of the Butler
18 paper, which is Exhibit 1044, correct?

19 A. I'm certainly aware of the Butler
20 paper.

21 Q. Okay. Do you recall citing the Butler
22 paper in any of your work on magnetic tunnel

1 junctions?

2 A. I don't remember whether I've cited it
3 or not.

4 Q. Okay. Were you familiar with the
5 Butler paper before this case?

6 A. Yes. It's extremely famous.

7 Q. Okay. And so you have reviewed
8 Butler's paper, Exhibit 1044, and were familiar
9 with its content before this case, correct?

10 A. Yes.

11 Q. Okay. Is there any publication you're
12 aware of that you were involved in as an author in
13 which you reported the resistance area product of a
14 magnetic tunnel junction?

15 A. I don't recall. I would have to look
16 back through my papers to remind myself what
17 electrical data we may have reported. So I don't
18 recall at this point whether we cited or measured
19 RA data.

20 Q. Now, you're familiar with Exhibit 1031,
21 which is Simmons' paper on tunneling, correct?

22 A. Yes.

1 Q. And you were familiar with
2 Exhibit 1031, Simmons' paper, before this case,
3 correct?

4 A. Yes, broadly speaking.

5 Q. And you reviewed Simmons' paper as part
6 of preparing your declaration, Exhibit 2053, in
7 this case, correct?

8 A. Yes.

9 Q. Now, if you take a look at
10 Exhibit 1017, which is the '909 Patent.

11 Now, if you take a look at Column 7,
12 starting at about line 39, there's a discussion of
13 Simmons' paper there.

14 Do you see that?

15 A. Yes.

16 Q. Okay. And on the top right in
17 Column 8, equation 2 there is Simmons' formula,
18 correct?

19 A. That is Simmons' formula in a specific
20 circumstance, which is a low-bias voltage.

21 Q. Okay. If we take a look at
22 Exhibit 1031, which is Simmons' paper.

1 A. I will have to ask for some help to
2 find this on the computer.

3 Q. Okay.

4 (Brief pause.)

5 THE WITNESS: Okay.

6 BY MR. WILSON:

7 Q. So you have Simmons' paper,
8 Exhibit 1031?

9 A. I do.

10 Q. Okay. And as you just articulated, the
11 equation, the Simmons' equation that's -- that's
12 recited in the '909 Patent is Simmons' equation for
13 a low-voltage range. You'll find that on page 1796
14 of Simmons in the lower right-hand corner.

15 (Witness reviews document.)

16 A. I'm not seeing exactly this one. Is
17 this equation 24 in Simmons?

18 Q. It is, yes.

19 A. Okay. It's written a little
20 differently.

21 Q. Okay. Well, with a little time to
22 review it, do you agree that that's equation 24 in

1 Simmons? Equation 2 in the '909 Patent is
2 equation 24 in Simmons?

3 (Witness reviews document.)

4 A. Well, equation 24 has a parameter
5 capital A, which is defined somewhere else. And
6 that appears in Column 8 of the '909 Patent. It is
7 written out explicitly. So 24 doesn't include
8 everything that's in equation 2 of the '909 Patent.

9 Q. Okay. If you take a look on page 1795.
10 In the lower left-hand corner, do you see the
11 definition of A?

12 (Witness reviews document.)

13 A. Yes, there's a definition of A. This
14 is in a current voltage relationship for
15 generalized barrier.

16 Q. Okay. With that definition of A, do
17 you believe that equation 24 in Simmons is the same
18 as equation 2 in the '909 Patent?

19 A. I would have to look back at -- back
20 through Simmons because the definition of capital A
21 in Simmons' equation 10 has a term "beta" in it
22 which is defined in the appendix. And so the --

1 there's yet another part of that Simmons equation
2 in this paper.

3 Q. Okay. Fair to say that the '909 Patent
4 attributes this equation 2 in Column 8 to Simmons,
5 correct?

6 A. Yes. It says the Simmons formula can
7 be described as follows in the low-bias voltage
8 regime, in Column 8.

9 Q. Okay. You would agree that Simmons'
10 paper and the '909 Patent are in the same field of
11 art, correct?

12 A. Simmons is describing tunneling, but
13 not magnetic tunnel junctions. So the science of
14 tunneling in Simmons is a part of tunnel junctions,
15 but the field of the '909 Patent as in Column 1
16 relates to a magnetic tunnel junction device and a
17 method of manufacturing the same.

18 Q. Okay. So in your opinion, Simmons is
19 not in the same field of art as the '909 Patent?

20 A. I haven't considered whether Simmons is
21 in the same field of art since Simmons is the
22 common way of describing tunneling phenomena.

1 Yuasa has used it in his analysis for the
2 '909 Patent.

3 Q. Okay. Doesn't that suggest that
4 they're in the same field of art?

5 A. I don't know if -- if I can answer
6 that. I didn't consider that question.

7 Q. Okay.

8 A. I just considered Simmons since it's
9 cited by the '909 Patent.

10 Q. Okay. Simmons is reasonably pertinent
11 to the problem to be solved by the '909 Patent,
12 correct?

13 A. Simmons describes a theoretical model,
14 which many people use to analyze tunneling
15 phenomena. So it's a very broadly applied model.

16 Q. Okay. When you refer to Simmons'
17 model, are you referring to Figure 1 in Simmons on
18 page 1794?

19 A. Hang on.

20 (Witness reviews document.)

21 A. Well, Simmons' Figure 1 is a general
22 schematic of what the energy levels are in a stack

1 as you go from one electrode through an insulating
2 barrier and then into another electrode. That's a
3 general expression of how one might start to
4 describe "tunneling phenomena."

5 Q. Okay.

6 A. And Simmons goes on to analyze that
7 model and calculate the -- analytically calculate
8 what the IV curves would be under various
9 situations.

10 Q. Okay. So in Simmons' insulator in
11 Figure 1 is not any particular material, correct?

12 A. Simmons' insulator is a nonconducting
13 material.

14 Q. Okay. It's -- it's not specifically
15 magnesium oxide, correct?

16 A. I don't believe Simmons defines what
17 material he's thinking about.

18 Q. Right. Simmons' insulator is just a
19 generic nonconducting material, correct?

20 A. Yes.

21 Q. And Simmons' electrodes are not assumed
22 to be ferromagnetic, correct?

1 A. Simmons' electrodes are just metals.

2 Q. And as you mentioned earlier, Simmons'
3 Figure 1 model is not of a magnetic tunnel
4 junction, correct?

5 A. That's right. It could be. It doesn't
6 have specific materials. It's -- Simmons doesn't
7 exclude magnetic electrodes, but Figure 1 doesn't
8 specify the materials.

9 Q. Okay. In fact, Simmons was published
10 in 1963, correct?

11 A. Yes.

12 Q. And that was before the discovery of
13 the tunnel magnetoresistance effect, correct?

14 A. It was before the 1975 Jullière model.

15 Q. Which is when the tunnel
16 magnetoresistance effect was discovered, correct?

17 A. That's generally agreed to be the start
18 of tunneling magnetoresistance.

19 Q. So Simmons' concept of barrier height,
20 of tunnel barrier height, was defined before
21 magnetic tunnel junctions were discovered, correct?

22 A. Yes.

1 Q. You would agree that all metals have a
2 conduction band, correct?

3 A. All metals have a partially filled band
4 with a Fermi level partway in the band. It's not
5 always described as a conduction band.

6 Q. Okay. All metals have a Fermi level,
7 correct?

8 A. Every material has a Fermi level.

9 Q. Okay. And as you just said, I believe,
10 the Fermi level lies in what can be called the
11 conduction band in a metal, correct?

12 A. In a metal which is characterized by
13 having mobile electrons. The Fermi level is within
14 a band of allowed states such that that band is
15 partially occupied. And those electrons near the
16 top, near the Fermi level, are the ones which
17 provide the conductivity.

18 Q. Okay. Insulators also have a
19 conduction band, correct?

20 A. Insulators have bands as well. You can
21 call them conduction bands and valence bands and so
22 forth, but in an insulator there aren't any, or

1 very few carriers in the conduction band or the
2 upper band that would allow for conductivity.

3 Q. Okay. In insulators, by definition,
4 there is a gap between the valence band and the
5 conduction band, correct?

6 A. The Fermi level is in the gap between
7 two bands. So that one -- the lower band is fully
8 occupied and the upper band is empty. That's what
9 characterizes insulators and also semiconductors.

10 Q. Okay. And in general, when you have a
11 metal -- let me strike that.

12 In general, when you have a metal
13 insulator interface, the difference between the
14 Fermi level of the metal and the conduction band in
15 the insulator is what is defined as the barrier
16 height, correct?

17 A. That's certainly a common way of
18 looking at it.

19 Q. So let's take a look at Exhibit 2039.

20 MR. HRYCYSZYN: Do you need help or
21 were you able to get it?

22 THE WITNESS: You find it.

1 MR. HRYCYSZYN: You said 2039?

2 MR. WILSON: Yes, 2039. It's Soukup's
3 dissertation.

4 BY MR. WILSON:

5 Q. Okay. You have in front of you
6 Exhibit 2039?

7 A. Yes.

8 Q. And this is the dissertation, the Ph.D.
9 dissertation, of Rodney Soukup?

10 A. Yes.

11 Q. Okay. And you're familiar with
12 Exhibit 2039, correct?

13 A. Broadly.

14 Q. Okay. You reviewed it and cited it in
15 your declaration, Exhibit 2053, correct?

16 A. I reviewed it to get some additional
17 insight into the Soukup paper.

18 Q. Okay. If we take a look at page 125,
19 which is PDF page 139, if you're trying to jump
20 straight there.

21 Do you have that page?

22 A. You said page 125?

1 Q. Yes. Numbered page 125 in the exhibit.

2 A. Okay. It's labeled as Appendix 2.

3 Q. Right. That's the right page.

4 You see the first sentence at the top
5 of that page, Soukup says: (Reading)

6 The barrier height is defined
7 as the energy difference between the
8 bottom of the conduction band and the
9 Fermi level at the interface.

10 Did I read that correctly?

11 A. Yes.

12 Q. And that's the definition that we just
13 established for barrier height, correct?

14 A. Right.

15 Q. And if you take a look back at the
16 '909 Patent, Exhibit 1017, Column 3, line 24. It
17 says: (Reading)

18 In a preferred embodiment, the
19 band discontinuity value, parentheses,
20 the height of the tunnel barrier,
21 close parentheses, between the bottom
22 of the conduction band of the MgO(001)

1 layer and the Fermi energy of the
2 Fe(001) layer is smaller than an ideal
3 value of a perfect single crystal
4 without defect.

5 Did I read that correctly?

6 A. You did.

7 Q. And so the '909 Patent defines the
8 height of the tunnel barrier in the same way as
9 Soukup, correct?

10 A. Yes.

11 Q. And you've reviewed Soukup's paper,
12 correct?

13 A. Exhibit 1028?

14 Q. Yes, Exhibit 1028.

15 A. Yes, I've reviewed it.

16 Q. And you understand that Soukup reports
17 barrier heights for the MgO barriers made as part
18 of his experiment, correct?

19 A. He reports -- excuse me. He reports
20 barrier heights calculated using several different
21 approaches, primarily using a Schottky model in
22 which the IV relationship is different from

1 tunneling.

2 Q. Okay. But the concept that Soukup is
3 defining as the barrier height is the same as in
4 the '909 Patent, correct?

5 A. The concept that Soukup is considering
6 is a model of Schottky which considers electrons
7 hopping over a barrier of a certain shape. So the
8 barrier height that Soukup is describing is with
9 reference to a Schottky mechanism.

10 Q. Right. The Schottky mechanism is the
11 mechanism by which electrons get around or over the
12 barrier. But the barrier height that Soukup is
13 calculating is the same barrier height defined in
14 the '909 Patent, correct?

15 (Witness reviews document.)

16 A. Soukup isn't defining his barrier
17 height other than through relationship with
18 conductivity models, Poole-Frenkel, Schottky and so
19 forth.

20 Q. Okay. The different models that are
21 used, whether it's Simmons, Poole-Frenkel or
22 Schottky, are trying to get at the same concept of

1 barrier height, correct?

2 A. They're trying to get at a barrier
3 height which is defined in the respective models.
4 So in Soukup -- sorry. In the Simmons paper that
5 we just looked at, it was the maximum height shown
6 in that Figure 1.

7 Some of the models have different
8 shapes of the barriers, so one would have to go
9 back and look at the models which are being used
10 here to see how each one of those models defines
11 the barrier height.

12 Q. Okay. They all define the barrier
13 height as the difference between the Fermi level in
14 the electrode and the conduction band in the
15 insulator, correct?

16 A. I would have to go back and check
17 whether that's the working definition, because in
18 some of these models, the barrier is not
19 rectangular so that definition would be different
20 on both sides of the barrier.

21 Q. Well, even if the barrier is not
22 rectangular, the concept that's being addressed by

1 barrier height is still the difference between the
2 Fermi level and the electrode and the height of --
3 sorry, let me strike that.

4 Even if the barrier is not rectangular,
5 the concept that's being addressed by barrier
6 height is the difference between the Fermi level
7 and the electrode in the bottom of the conduction
8 band and the insulator, correct?

9 A. Well, as I've said, each model has its
10 own approximation to what the barrier looks like in
11 terms of the potential as a function of distance
12 through the stack. And they're not all
13 rectangular. Some have triangular shapes or
14 parabolic shapes. So each one will define its
15 barrier height in its own way.

16 Q. Okay. So even if the barrier is not
17 rectangular, there are different ways of
18 approximating the bottom of the conduction band
19 given that it might change through the thickness of
20 the barrier. But the concept that's being
21 addressed by barrier height is the difference
22 between the Fermi level and the electrode and the

1 bottom of the conduction band, whether that be the
2 average bottom of the conduction band or some other
3 mathematical model for the bottom of the conduction
4 band in the insulator, correct?

5 A. Well, that's a very long set of
6 questions, I think.

7 I would say that the difference between
8 the bottom of the conduction band and the Fermi
9 level is certainly relevant to the barrier height,
10 but whether it's exactly defined as the barrier
11 height depends on which model you're looking at.

12 Q. Well, all of the models are trying to
13 get at that difference between the Fermi level and
14 the electrode and the bottom of the conduction band
15 and the insulator, even if they make different
16 approximations for the bottom of the conduction
17 band, correct?

18 A. Well, scientifically, these are all
19 models which approximate a complex physical
20 structure with a simple physical model that's
21 amenable to being analyzed.

22 So as an example, you can have band

1 bending near the interface, which means that the
2 levels are not actually flat right at the
3 interface. So then your definition is more nuanced
4 than just looking at that difference between the
5 bottom of the conduction band and the Fermi level.

6 Q. Right. And that's, in fact, what
7 Simmons shows in Figure 1, correct?

8 A. Can you remind me which exhibit is
9 Simmons?

10 Q. Exhibit 1031.

11 (Witness reviews document.)

12 A. So Figure 1 in Simmons actually doesn't
13 label a conduction band. He's measuring the vacuum
14 level, mentioning the vacuum level and the Fermi
15 level.

16 Q. Okay. Do you see Figure 1?

17 A. I see Figure 1.

18 Q. And Figure 1, there is a barrier there
19 that is not shown as a uniform rectangle, correct?

20 A. Yes, there's a barrier there.

21 Q. And do you see the symbol $\phi(x)$?

22 A. There is a ϕ , brackets, x .

1 Q. Okay. That is what Simmons is
2 referring to as the barrier height, correct?

3 A. I would have to look at the paper to
4 see his definitions there.

5 Q. Well, if you look right under the
6 figure, do you see the notations?

7 A. I see electrode 1, insulator
8 electrode 2.

9 Q. No, I'm -- go down the column. Do you
10 see the heading "Notation"?

11 A. Okay.

12 Q. And do you see about four lines up from
13 the bottom, there is a phi with a bar over it?

14 A. Yes.

15 Q. And that is defined as the mean barrier
16 height, which is the average barrier height,
17 correct?

18 A. That's what it says.

19 Q. And above that, you see a phi sub 0?

20 A. Yes.

21 Q. Which is the height of a rectangular
22 barrier, correct?

1 A. Correct, that's what it says.

2 Q. So Simmons is distinguishing between
3 the average height of the barrier and the height of
4 a rectangular barrier, correct?

5 A. Well, none of this is in Figure 1.

6 Q. But Simmons does distinguish between
7 the height of a rectangular barrier, an idealized
8 construct, and the mean barrier height, correct?

9 A. Well, he's given them different
10 symbols.

11 Q. Okay. A person of ordinary skill in
12 the art, or even a scientist at this stage, was --
13 understood of that the concept that's being
14 addressed by barrier height is the difference
15 between the Fermi level and the electrode and the
16 barrier height, or sorry, and the bottom of the
17 conduction band of the insulator regardless of how
18 that bottom of the conduction band is measured or
19 approximated, correct?

20 (Witness reviews document.)

21 A. Simmons' model considers a rectangular
22 barrier and a real barrier and approximates a real

1 barrier with some mean height as a rectangle
2 because otherwise the analysis becomes beyond what
3 one could do analytically. But I don't recall
4 whether Simmons himself equates the barrier height
5 with the difference between the conduction band and
6 the Fermi level. He's defining it in terms of the
7 work function, which is a different thing.

8 Q. Okay. Well, whether it's defined in
9 terms of the work function or the way we've
10 described it with reference to the bottom of the
11 conduction band of the insulator, the concept is
12 the same, correct?

13 A. Which concept?

14 Q. The concept of barrier height.

15 A. Barrier height is approximated in these
16 models of Simmons or Schottky or Poole-Frenkel as a
17 parameter that is present in the IV curve. So one
18 fits the IV curve and obtains a barrier height.

19 Q. Right. And the barrier height concept
20 in those models, whether it's Poole-Frenkel or
21 Schottky or Simmons is the same concept, correct?

22 A. I disagree.

1 Q. What's different about them?

2 A. The barrier height is an approximation
3 that's placed into a model which has a number of
4 physical approximations. For example, in Schottky,
5 one is considering how the distribution of
6 electrons around the Fermi level has the
7 probability of transitioning over the top of a
8 barrier, whereas in a tunneling model, one is
9 considering a quantum mechanical phenomenon where
10 the wave function of the electron is continuous on
11 either side of a barrier.

12 So these models have different physical
13 bases, and each one of them defines a barrier
14 height which one obtains from fitting of one's data
15 to that model.

16 Q. Okay. So if -- let's talk about the
17 concept of barrier height in Soukup, Soukup's
18 paper, which you're familiar with, correct?

19 A. Yes.

20 Q. Okay. In some cases, he finds that
21 tunneling is the dominant current mechanism. In
22 others, he believes it might be, but is not certain

1 that it is Schottky emission, correct?

2 A. Soukup finds that -- all of his devices
3 can be described as Schottky conduction, and one of
4 them, I believe -- one particular device, PYG381,
5 he modeled with a tunneling conduction.

6 Q. Okay. Now, if Schottky emission is the
7 actual dominant current flow mechanism in a
8 particular barrier under a particular set of
9 conditions, you cannot use the Simmons model to
10 calculate the barrier height of that particular
11 situation, correct?

12 A. I would say that if you had a scenario
13 of Schottky conductivity, the data would fit to
14 Schottky's equation. And if you had a scenario of
15 tunneling, it would fit to Simmons' equation.

16 Q. In other words, what you're saying is,
17 if you have a situation that is Schottky field
18 emission across a barrier, Simmons would give you
19 an incorrect result for barrier height, correct?

20 A. It will give you a different result.

21 Q. Well, that result would be incorrect,
22 right?

1 A. Well, it depends what is physically
2 going on. All of these are approximations.

3 Q. Okay. Well, what if what is physically
4 going on is Schottky emission, then applying
5 Simmons' equation to calculate the barrier height
6 using those current voltage data, would give you an
7 incorrect barrier height, right?

8 A. It would certainly give you a
9 different -- or I would say I would expect it to
10 give a different result.

11 Q. Okay. And a person of ordinary skill
12 in the art would consider that to be an incorrect
13 result, right?

14 A. A person of skill in the art would, as
15 Soukup did, take some data and then look at how
16 various models fit to that data and then conclude
17 what the mechanism is.

18 Q. And if a model doesn't fit the data,
19 such as in the case when Schottky field emission is
20 what's actually occurring, and I'm applying this
21 Simmons model to that data, then the Simmons
22 equation wouldn't hold for that data and it would

1 give me an incorrect result for barrier height,
2 correct?

3 A. I agree with you that if the conduction
4 mechanism were Schottky conduction, then I wouldn't
5 expect the Simmons model to give me a fit to that
6 data, and therefore, it would be difficult to
7 extract a value of barrier height out of a model if
8 one didn't have a good fit.

9 MR. WILSON: Okay. We've been going
10 for about an hour. I'm happy to take a break
11 now or we can keep going. Whatever you guys
12 want to do.

13 MR. HRYCYSZYN: It's up to you,
14 Dr. Ross.

15 THE WITNESS: We could take a few
16 minutes.

17 MR. WILSON: Okay. Ten minutes?

18 MR. HRYCYSZYN: That works. So back at
19 10:16?

20 MR. WILSON: Sure.

21 THE VIDEOGRAPHER: We are going off the
22 record. The time is 10:06.

1 (Recess taken.)

2 THE VIDEOGRAPHER: We're going back on
3 the record. The time is 10:16.

4 BY MR. WILSON:

5 Q. Now, Dr. Ross, you are familiar with
6 Butler, Exhibit 1044, correct?

7 A. Yes.

8 Q. All right. Let's take a look at
9 Butler.

10 MR. HRYCYSZYN: I think it's
11 Exhibit 1044.

12 THE WITNESS: I have it.

13 BY MR. WILSON:

14 Q. Okay. Now, this Butler, Exhibit 1044,
15 is the same Butler you referred to earlier as being
16 very famous, correct?

17 A. Yes.

18 Q. For what is Butler, Exhibit 1044,
19 famous?

20 A. They made predictions about the
21 behavior of these epitaxial iron MgO iron stacks,
22 which suggested a different type of

1 magnetoresistance or magnetic -- I should say a
2 different mechanism of tunneling compared to the
3 simple models described by previous authors like
4 Simmons.

5 Q. Okay. So as you said, Butler,
6 Exhibit 1044, presents a mathematical model for a
7 certain type of magnetic tunnel junction, correct?

8 A. Yeah, it's a computational model. It's
9 not purely analytical.

10 Q. Okay. And the -- Butler's particular
11 magnetic tunnel junction consists of iron(100),
12 MgO(100) and iron(100) sandwiches, correct?

13 A. Yes, that's right.

14 Q. And the iron(100) is a body-centered
15 cubic structure, correct?

16 A. Yes, that's right.

17 Q. And MgO(100) is also a body-centered
18 cubic structure?

19 A. No.

20 Q. MgO(100) is not a body-centered cubic
21 structure?

22 A. No. MgO is a face-centered cubic rock

1 salt structure.

2 Q. Okay. Okay. So in a body-centered
3 cubic structure, the (100) plane is the same as the
4 (001) plane, correct?

5 A. Yes.

6 Q. Now, Butler's computational model, as
7 you referred to it, recognized the existence of
8 certain block states in the iron electrodes,
9 correct?

10 A. Yes, that's right.

11 Q. And the block states in the iron
12 electrodes have certain symmetries, correct?

13 A. Well, by "certain symmetries," you can
14 distinguish block states with different symmetries.

15 Q. Okay. Okay. So Butler recognized the
16 existence of Delta 1, Delta 5, Delta 2 and Delta 2
17 prime symmetries in iron(100), correct?

18 A. Well, he recognized the existence of
19 different block states which were described with
20 these delta numbers, which designate the symmetry.

21 Q. Okay. Butler also recognized the
22 existence of certain evanescent states in the

1 magnesium oxide barrier, correct?

2 (Witness reviews document.)

3 A. Well, they're not exclusive
4 descriptions. Evanescent means it decays quickly.

5 Q. Right. But the evanescent states in
6 the magnesium oxide barrier have certain symmetries
7 as well, correct?

8 A. I think it may be more precise to say
9 that the different states, the Delta 5, Delta 2,
10 Delta 2 prime and so forth, propagate differently
11 in the MgO, leading to some evanescent character,
12 which means that some of those decay quickly.

13 Q. So, for example, if we look at page 6
14 of Butler, in the right-hand column, first full
15 paragraph, Butler says: (Reading)

16 Majority block states with
17 Delta 1 symmetry in the iron
18 electrodes decay as evanescent states
19 with Delta 1 symmetry and magnesium
20 oxide.

21 Correct?

22 A. You're looking -- I just want to find

1 that. You're looking at page 6?

2 Q. Page 6, right-hand column, first
3 sentence of the first full paragraph.

4 A. Okay. So what's the question?

5 Q. It says: (Reading)

6 Majority block states with
7 Delta 1 symmetry in the iron
8 electrodes decay as evanescent states
9 with Delta 1 symmetry in magnesium
10 oxide.

11 Did I read that correctly?

12 A. That's what it says.

13 Q. Okay. And in that, Butler is
14 recognizing that the evanescent states in the
15 magnesium oxide also have symmetry, correct?

16 A. It's more precise to say that the
17 Delta 1 states which are propagating in the
18 metallic iron become evanescent when they enter the
19 MgO, with the result that they decay in the MgO.

20 Q. Okay. But it's also accurate to say
21 that their symmetry is preserved in the evanescent
22 state, correct?

1 A. Well, "evanescent" just means it decays
2 quickly. So Butler's model is based on the
3 preservation of the symmetry of these various block
4 states as they transition through the iron MgO
5 iron(100) sandwich.

6 Q. Okay. So although the symmetry is
7 preserved as the electrons decay through the
8 magnesium oxide barrier, the decay rates for the
9 different symmetries are different in magnesium
10 oxide, correct?

11 A. Well, the decay rates for not just the
12 different symmetries, but for the majority and
13 minority electrons decay differently.

14 Q. Okay. If we go back to the
15 introduction or the abstract. Or sorry, the
16 introduction, actually, first paragraph and second
17 sentence here in the introduction. And this is
18 Butler describing sort of the history of magnetic
19 tunnel junctions. He says: (Reading)

20 Most of the interest for
21 applications currently centers on
22 systems with amorphous aluminum oxide

1 tunneling barriers because of the
2 relative ease of growing adherent
3 aluminum oxide without pinholes.

4 Did I read that correctly?

5 A. That's what he wrote.

6 Q. He goes on to say: (Reading)

7 Unfortunately, these systems
8 are difficult to characterize and
9 model because of the noncrystalline
10 nature of the oxide and the lack of
11 any known epitaxial relationship
12 between the oxide and the
13 ferromagnetic electrodes.

14 Did I read that correctly?

15 A. Yes.

16 Q. So the prevalent alumina barriers were
17 noncrystalline, correct?

18 A. The ones he's discussing in this
19 paragraph, it says: (Reading)

20 Most of the interest for
21 applications currently centers on
22 systems with amorphous aluminum oxide

1 tunneling barriers.

2 So those are the ones he's discussing,
3 the amorphous ones.

4 Q. And what he also says is for those
5 amorphous aluminum oxide barriers, there is no
6 known epitaxial relationship between the alumina
7 barriers and the iron electrodes, correct?

8 A. Well, he describes the lack of any
9 known epitaxial relationship, although he's not
10 citing, but that's what it says.

11 Q. Okay. In an amorphous alumina barrier,
12 the electron symmetry in the electrodes does not
13 affect the tunneling of the electrons through the
14 amorphous alumina, correct?

15 A. I don't know that there is no
16 relationship. Certainly that scenario is not
17 addressed by Butler because it is a scenario that
18 can't be addressed using the kind of techniques
19 that Butler is applying to these crystalline
20 structures.

21 Q. Well, in general, in an amorphous
22 alumina barrier, electrons are transmitted through

1 the barrier without regard to their symmetry,
2 correct?

3 A. I don't have an opinion about that
4 because I haven't reviewed that specific
5 literature.

6 The electrons will have a range of wave
7 vectors related to their symmetry, and those are
8 actually traveling in different directions, which
9 can affect how they interact with the barrier. So
10 I think the answer to that question is rather
11 complex and it's not something I've considered.

12 Q. Okay. Take a look at Exhibit 1057,
13 which is Dieny textbook.

14 A. Okay. I have that.

15 Q. Okay take a look at page 16, which is
16 PDF page 35, and Section 1.2.4.1. You see where it
17 references incoherent tunneling through an
18 amorphous alumina barrier?

19 A. Yes.

20 Q. Toward the bottom of that paragraph,
21 about four lines up from the bottom, it refers to
22 Jullière's model. Do you see that?

1 A. Yes, it refers to Jullière's model.

2 Q. It says: (Reading)

3 Jullière's model, previously
4 introduced, assumes equal tunneling
5 probabilities independent of the
6 electrons block states in the
7 electrodes. This is true only if the
8 tunneling process is incoherent,
9 meaning that the coherency of the
10 block states is not conserved during
11 tunneling. In the case of an
12 amorphous barrier, there is no
13 crystallographic symmetry in the
14 barrier. Consequently, electron wave
15 functions from the injector, no matter
16 their symmetry, couple identically to
17 any tunneling evanescent states in the
18 barrier through which they will
19 propagate and decay.

20 Did I read that correctly?

21 A. Yes.

22 Q. So in incoherent tunneling, as occurs

1 in an amorphous barrier like alumina, the block
2 states of the electrons in the electrode are not
3 preserved as they go through the barrier, correct?

4 A. Jullière's model certainly assumes that
5 by having no dependence on block states.

6 Q. Okay. And Jullière's model is accurate
7 for an incoherent amorphous barrier like alumina,
8 correct?

9 A. Jullière's model is a very simple model
10 which doesn't consider the wave vectors or the
11 block states at all. So it's a simple
12 approximation which makes the assumption that
13 there's no -- let me go back. It makes the
14 assumption, as stated here, that all the electron
15 wave functions couple identical -- couple
16 identically to any evanescent states.

17 Q. Okay. And it turns out to be accurate
18 for alumina barriers, correct?

19 A. It's a successfully applied model to
20 alumina barriers.

21 Q. Okay. Let's go back to Butler and
22 let's look at Figure 7.

1 A. Okay.

2 Q. So Figure 7 shows the tunneling density
3 of states for assuming K parallel of 0 for the iron
4 MgO iron MTJ, correct?

5 A. Well, it shows four different panels
6 for different -- different, what should I say,
7 different majority and minority carriers and
8 parallel and antiparallel magnetization of the
9 electrodes.

10 Q. Okay. And so in the upper left-hand
11 corner, we can see the parallel majority density of
12 states, correct?

13 A. Upper left corner shows the density of
14 states for the majority carriers with parallel
15 alignment of the magnetization in the two
16 electrodes.

17 Q. You can see that there is a Delta 1
18 block state represented there in the upper
19 left-hand corner figure?

20 A. Yes.

21 Q. And it is the dominant electron flow
22 mechanism in the parallel majority state, correct?

1 A. It's got the largest density of states.

2 (Brief pause.)

3 THE VIDEOGRAPHER: Did we lose
4 somebody?

5 THE CERTIFIED STENOGRAPHER: I believe
6 so. Let's go --

7 THE VIDEOGRAPHER: It looks like we
8 lost Mr. Wilson. Okay. We are going off the
9 record. The time is 10:38.

10 (Discussion held off the record.)

11 THE VIDEOGRAPHER: We are going back on
12 the record. The time is 10:39.

13 MR. WILSON: Okay. Sorry about that.

14 BY MR. WILSON:

15 Q. All right. Now, we were looking at
16 Butler's Figure 7. And if we look at the upper
17 right-hand corner, Butler Figure 7 shows the
18 parallel configuration in the minority density of
19 states, correct?

20 A. The top -- the top right, the minority
21 density of states for the parallel configuration.
22 That's what we're looking at?

1 Q. Yes. And you can see that in the
2 minority density of states in the parallel
3 configuration, there is no Delta 1 represented,
4 correct?

5 A. That's right. It's not on this --
6 shown up on this plot.

7 Q. So Butler determined that in the iron
8 MgO iron MTJ, the iron electrodes have Delta 1
9 spin-up states, but no Delta 1 minority states,
10 correct?

11 (Witness reviews document.)

12 A. Well, he's plotted that density of
13 states in Figure 3.

14 Q. So are you saying that Figure 3 shows
15 that or are you not sure?

16 A. Well, Figure 3 shows the density of
17 states for the iron near the MgO interface,
18 although it's not labeled with the symmetry of the
19 states. I would have to reread this to answer your
20 question precisely about what the population of
21 Delta 1 symmetry states are for minority electrons.

22 Q. So take a look at page 5 of Butler.

1 Do you see Section B in the right-hand
2 column, "Effective symmetry at K parallel equals
3 zero"?

4 A. Yes.

5 Q. In the second paragraph, the third
6 sentence -- well, fourth sentence -- actually, four
7 lines down from the top. It says "in the majority
8 channel."

9 Do you see that?

10 A. Yeah, I see that.

11 Q. Butler says: (Reading)

12 In the majority channel, there
13 is a Delta 1 state, a doubly
14 degenerate Delta 5 state and a Delta 2
15 prime state. The minority channel has
16 four states with the same symmetries
17 as the states of the majority channel
18 with the crucial exception that the
19 majority Delta 1 state is replaced by
20 a Delta 2 minority state.

21 Did I read that correctly?

22 A. That's what it says.

1 Q. Butler recognized that there was a
2 Delta 1 majority state but not a Delta 1 minority
3 state, correct?

4 A. He says the Delta 1 state in the
5 majority channel is replaced by a Delta 2 state in
6 the minority channel.

7 Q. In other words, there is not a Delta 1
8 minority state, correct?

9 A. Well, he doesn't exactly say that. He
10 says it's replaced by a Delta 2 state.

11 Q. Okay. A person of ordinary skill in
12 the art reading Butler would understand there is a
13 Delta 1 majority state and there is no Delta 1
14 minority state, correct?

15 A. I imagine they would infer that from
16 the statement.

17 Q. Okay. Now, if we go back to page 1 of
18 Butler, again in the introduction, the second
19 paragraph under the introduction, Butler says:
20 (Reading)

21 Recently, Heinrich, et al.,
22 have grown iron(100) MgO(100)

1 iron(100) magnetic tunnel junctions by
2 depositing MgO epitaxially onto iron
3 whiskers and then depositing another
4 iron electrode epitaxially on top of
5 the MgO.

6 Did I read that correctly?

7 A. That's what it says.

8 Q. And if you look at Footnote 5, you can
9 see that the Heinrich paper in the Applied Physics
10 Letter at the end there is actually to be
11 published?

12 A. Well, Footnote 5 cites two references.

13 Q. Right. So the first one is the Physics
14 of Low Dimensions, published in 2000?

15 A. Right.

16 Q. And the second one is a paper in
17 Applied Physics Letters to be published, correct,
18 yes?

19 A. Yes.

20 Q. Okay. So attributing the 2000 date to
21 this, are you aware of anyone making a magnesium
22 oxide magnetic tunnel junction before the year

1 2000?

2 A. Am I aware of a MgO tunnel junction
3 before 2000? I haven't looked at that question.

4 Q. Okay. Heinrich is Exhibit 1043.

5 A. Do you mean Wulfhekel, the one in the
6 Applied Physics Letters?

7 Q. So, actually, this is the first one.
8 Well, sorry, it's not either of those, actually.
9 It is just an -- what appears to be an extract of
10 the same thing. But if you look at Exhibit 1043.

11 A. 1043?

12 Q. Yes.

13 You can see, it's entitled
14 "Single-crystal tunnel junctions." And the first
15 sentence says: (Reading)

16 We have grown single-crystal
17 epitaxial magnetotunnel junctions
18 using iron whisker substrates,
19 MgO(001) oxide spacers and iron nickel
20 gold(001) top electrodes.

21 Do you see that?

22 A. Yes.

1 Q. Okay. And if you look at the bottom,
2 this is dated 2000 from IEEE, correct?

3 A. That's what it says.

4 Q. Okay. So if you look down on the lower
5 right, do you see where it says "in conclusion,"
6 five lines up from the bottom?

7 A. Yes.

8 Q. It says: (Reading)

9 In conclusion, we have shown
10 that we have grown highly perfect
11 crystalline epitaxial MTJ structures
12 using MgO dielectric layers. We have
13 demonstrated that a conducting tip of
14 AFM system can be used to study
15 ballistic tunneling, allowing one to
16 investigate local tunneling
17 characteristics with the lateral
18 resolution of 2-by-2 square
19 nanometers. A small fraction of the
20 scanned area showed defects in MgO
21 layers. However, the spikes do not
22 dominate the total tunneling current.

1 Did I read that correctly?

2 A. Yes, you did.

3 Q. Okay. So Heinrich reported the
4 successful fabrication of an MTJ with an MgO
5 barrier layer in 2000, correct?

6 A. He has an iron substrate, an MgO layer,
7 and then an iron layer. And he measures tunneling
8 characteristics using AFM, actually conductive AFM.
9 So he is measuring tunneling in that structure.

10 Q. And you're not aware of anyone
11 successfully fabricating a magnetic tunnel junction
12 with magnesium oxide before Heinrich in 2000?

13 A. I haven't looked into earlier
14 literature.

15 Q. Okay. And you see that one of the
16 authors with Heinrich is Wulfhekel?

17 A. Yes.

18 Q. Okay. Let's take a look at
19 Exhibit 1047, which is Wulfhekel.

20 A. Yes.

21 Q. You've reviewed Wulfhekel, correct?

22 A. I've reviewed it.

1 Q. Okay. And you can see that this was
2 published in January 2001?

3 A. Yes.

4 Q. And you can also see that Heinrich is a
5 coauthor?

6 A. He is the last author.

7 Q. Okay. Now, if you take a look in the
8 left-hand column on the first page, about midway
9 through, do you see the reference to Keavney?

10 (Witness reviews document.)

11 Q. Do you see that?

12 A. I'm just reading through. I see
13 Keavney, et al.

14 Q. Okay. Wulfhekel and Heinrich, among
15 others, reported that: (Reading)

16 Keavney, et al., prepared
17 crystalline epitaxial iron MgO
18 iron(001) trilayers using MgO(001)
19 substrates. Unfortunately, pinholes
20 due to rough bottom iron layer
21 resulted in shorts in the junction.

22 Did I read that correctly?

1 A. That's what it says.

2 Q. Okay. Exhibit 1047 goes on to say:

3 (Reading)

4 To allow studies of intrinsic
5 tunneling in crystalline and flat iron
6 MgO iron junctions, we have grown iron
7 MgO iron(100) junctions by
8 molecular-beam epitaxy or pulsed-laser
9 deposition of MgO and iron on polished
10 single-crystal iron(100) substrates
11 and iron whiskers and have
12 characterized the quality of the MgO
13 barrier locally.

14 Did I read that correctly?

15 A. That's what they wrote.

16 Q. Okay. So the earlier attempt at
17 growing an iron MgO iron MTJ by Keavney, et al.,
18 failed, correct?

19 A. I haven't reviewed Keavney, et al. Is
20 that one of the exhibits in this case?

21 Q. I don't think so.

22 A. Well, I don't know what Keavney, et al.

1 did. Wulfhekel states that their measurement
2 failed, but I don't have any further opinions about
3 Keavney.

4 Q. Okay. Let's take a look at
5 Exhibit 1051, which is Meyerheim.

6 A. Okay. I have that.

7 Q. Now, you reviewed Exhibit 1051,
8 correct?

9 A. Yes, I have.

10 Q. Okay. You can see that Meyerheim was
11 published in August 2001?

12 A. Right.

13 Q. Okay. And if you look on the first
14 page of the actual article, lower left-hand column,
15 about one, two -- seven, eight lines up from the
16 bottom, "as a consequence of this situation."

17 Do you see that?

18 A. I see that sentence.

19 Q. It says: (Reading)

20 As a consequence of this
21 situation, single crystalline oxide
22 barriers appear to be primary

1 candidates for the preparation of TMR
2 junctions, since they offer the
3 opportunity to control their
4 structural and physical properties in
5 a more reproducible way.

6 Did I read that correctly?

7 A. Yes.

8 Q. Now, if we go up to the top right-hand
9 column, about midway through that first paragraph,
10 do you see "although first attempts"?

11 A. Right.

12 Q. It says: (Reading)

13 Although first attempts to
14 prepare a crystalline iron MgO
15 iron(001) junction using a MgO(001)
16 crystal were not successful because of
17 pinholes leading to an Ohmic contact,
18 recent experiments depositing MgO by
19 electron beam deposition on a
20 iron(001) whisker were able to
21 demonstrate ballistic tunneling at
22 room temperature, although due to

1 equipment limitations, the TMR effect
2 could not be measured.

3 Did I read that correctly?

4 A. Yes.

5 Q. And you can see cite 12 is to Keavney?

6 A. I see in the reference list 12 is a
7 Keavney paper.

8 Q. And cite 13 is to Wulfhekel, correct?

9 A. It's a Wulfhekel paper.

10 Q. Okay. So several papers report
11 Keavney's unsuccessful attempt to fabricate an MgO
12 magnetic tunnel junction, correct?

13 A. Well, you've shown me two citations to
14 Keavney, but I haven't looked at Keavney itself.

15 Q. Okay. And several papers by Wulfhekel,
16 Heinrich and others report the successful
17 fabrication of an MgO magnetic tunnel junction
18 around the year 2000, correct?

19 A. Well, many of these people are from the
20 same group, producing several papers about the same
21 system, which in this case is a single-crystal iron
22 whisker or polished single crystal on which they

1 have deposited MgO and then iron and measured that.

2 So that's what these papers are about.

3 Q. Okay. But it was a successful
4 fabrication of a magnesium oxide magnetic tunnel
5 junction around the year 2000, correct?

6 A. It was a fabrication of magnesium oxide
7 and iron on top of a single crystal of iron and a
8 measurement of tunneling magnetoresistance.

9 Q. Okay. And as you sit here today,
10 you're not aware of a fabrication of a working
11 magnesium oxide magnetic tunnel junction prior to
12 2000, correct?

13 A. As I said, that's not a question I've
14 looked into.

15 Q. Okay. So let's take a look at
16 Slonczewski, Exhibit 2041.

17 Now, Slonczewski presents a
18 computational model for magnetic tunnel junctions,
19 correct?

20 A. Well, this one, I believe, is an
21 analytical model.

22 Q. Okay. Slonczewski presents an

1 analytical model for magnetic tunnel junctions,
2 correct?

3 A. Yes. It's a model that describes
4 transmission coefficients between the two
5 electrodes on either side of a barrier.

6 Q. And Slonczewski's model is a simplistic
7 model, correct?

8 A. It's not simplistic compared to
9 Jullière, for example. It certainly contains
10 approximations. But "simplistic" is something of a
11 value judgment here.

12 Q. Okay. Slonczewski's model does not
13 assume iron electrodes, correct?

14 A. It doesn't specify a particular
15 magnetic composition.

16 Q. Okay. And it doesn't specify a
17 particular crystalline arrangement of the
18 electrodes, correct?

19 A. No, it just treats them as S electron
20 conductors. S, the letter S, S electron
21 conductors.

22 Q. So Slonczewski does not recognize that

1 the Delta 1 conduction band is only present for
2 majority electrons in an iron electrode, correct?

3 A. He doesn't talk about those block
4 states.

5 Q. And Slonczewski did not address a
6 magnesium oxide barrier specifically, correct?

7 A. His model is just a rectangular
8 barrier.

9 Q. And he did not assume that the
10 rectangular barrier was crystalline, correct?

11 A. I don't recall him discussing the
12 composition of the barrier.

13 Q. Okay. And Slonczewski did not assume
14 that block state symmetry would be preserved
15 through the barrier, correct?

16 A. Well, Slonczewski doesn't discuss block
17 states. His model isn't based on block states, so
18 he doesn't comment on whether their symmetry would
19 be preserved or any of those kinds of factors.

20 Q. Okay. He doesn't take into account any
21 distinct preservation of different block states as
22 they travel through the barrier as would occur in

1 magnesium oxide, correct?

2 A. His model isn't formulated in terms of
3 block states, so he doesn't have anything to say
4 about block states.

5 Q. So as far as what Slonczewski considers
6 about the barrier, Slonczewski considers the
7 characteristics of the barrier, but only the
8 barrier's height and thickness, correct?

9 A. His model treats the barriers, a
10 rectangular barrier, with a certain thickness and a
11 certain height.

12 Q. Now, Slonczewski's paper, Exhibit 2041,
13 was published in 1989, correct?

14 A. Yes.

15 Q. And you're not aware of any successful
16 magnesium oxide MTJs in 1989, correct?

17 A. As I've said, I haven't looked into the
18 question of the prior MgO tunnel barriers or tunnel
19 junctions.

20 Q. Okay. Let's take a look at
21 Slonczewski, Exhibit 2041, as page 6998, which is
22 the fourth page.

1 A. Okay.

2 Q. You see equation 3.6?

3 A. I do.

4 Q. So Slonczewski equation 3.6 reports
5 tunneling conductance G for a ferromagnetic
6 barrier -- Sorry, let me strike that.

7 Slonczewski equation 3.6 reports
8 tunneling conductance G for a ferromagnet barrier
9 ferromagnet structure, correct?

10 A. Well, the paper is about conductance
11 through that structure, ferromagnet barrier
12 ferromagnet.

13 Q. Okay. And that's what equation 3.6 is
14 intended to capture, correct?

15 A. I'd have to reread it to remind myself
16 what that specific equation is about. It's
17 certainly showing a conductance.

18 Q. Okay. Do you understand the
19 significance of the term at the end of
20 equation 3.6, E to the minus 2 kappa D ?

21 A. Significance in what sense?

22 Q. Do you understand what that term

1 represents?

2 A. Well, it's an attenuation. D is a
3 distance and kappa is a decay. It represents the
4 decay of the -- of the electrons, if you like, the
5 transport of the electrons.

6 Q. Okay. Let's go back to Dieny,
7 Exhibit 1057.

8 A. Okay.

9 Q. Take a look at page 14, PDF page 33.
10 Do you see heading 1.2.3, "The Slonczewski Model"?

11 A. Yes.

12 Q. Okay. Under heading 1.2.3.1, "The
13 Model," you see it says: (Reading)

14 In Slonczewski model, several
15 assumptions are made, similar to those
16 of Jullière's model.

17 Do you see that?

18 A. Yes.

19 Q. So if we go down, about the middle of
20 that paragraph on that page, do you see, "finally"?

21 A. Okay.

22 Q. So below there, do you see the equation

1 that's presented there for kappa?

2 A. Yes, he gives an equation for kappa as
3 a function of E.

4 Q. Okay. And assuming that K parallel
5 equals -- or does not equal 0, correct?

6 A. Well, that's in the sentence.

7 Q. Okay. And kappa, as you just
8 explained, is the decay coefficient, correct?

9 A. It's a decay coefficient. It's labeled
10 here as such.

11 Q. Okay. Now, if we go back up to that
12 sentence "finally," it says: (Reading)

13 The model assumes that only
14 electrons propagating perpendicular to
15 the layers, that is K is approximately
16 equal to K perpendicular and K
17 parallel is approximately 0, can
18 efficiently tunnel through the
19 barrier.

20 Did I read that correctly?

21 A. That's what it says.

22 Q. Okay. So in Slonczewski's model,

1 K parallel is assumed to be 0 and only
2 perpendicular -- electrons tunneling perpendicular
3 to the barrier are considered, correct?

4 A. Well, that's one of the assumptions in
5 Slonczewski's model to make it tractable to
6 analysis.

7 Q. Okay. And "K" refers to the electron
8 wave vector, correct?

9 A. Typically.

10 Q. Okay. Okay. Do you agree with Dieny's
11 characterization of the model in Slonczewski?

12 A. Well, Dieny has a whole section on this
13 model. Are you asking me if I agree with all of
14 it?

15 Q. I'm asking if you agree with the parts
16 that we've just discussed.

17 A. I haven't analyzed whether that Dieny
18 says is -- about Slonczewski's model is correct, so
19 I don't know if I can answer that simply.

20 Q. Well, do you have any reason to
21 disagree with what Dieny says about Slonczewski's
22 model?

1 A. Well, Dieny is only, at least in the
2 part you've asked me to look at, Dieny is only
3 describing Slonczewski's model, and the
4 understanding of that is, as far as I can tell,
5 correct.

6 Q. Okay. Let's take a look at
7 Exhibit 2037, which is Saito or Saito. I'm not
8 sure how you pronounce it.

9 A. Saito.

10 Q. Saito.

11 You're familiar with Saito,
12 Exhibit 2037, correct?

13 A. Yes.

14 Q. Now, Saito, like Slonczewski, does not
15 describe distinct block states in iron
16 ferromagnetic electrodes, correct?

17 A. Well, Saito uses Slonczewski's model
18 with all of its approximations.

19 Q. Okay. So Saito would be subject to the
20 same limitations as Slonczewski, correct?

21 A. Well, Saito is using Slonczewski's
22 model. Slonczewski's model is based on free

1 electron metals and a rectangular barrier, not on
2 block states in the barrier.

3 Q. Okay. So it would not recognize any
4 distinct decay rates for different block states in,
5 for example, a magnesium oxide barrier, correct?

6 A. Well, Saito is about alumina barriers,
7 so I don't see how it can be discussing MgO
8 barriers.

9 Q. Okay.

10 A. At least it's describing experimental
11 data on alumina barriers.

12 Q. Okay.

13 MR. WILSON: We've been going for a
14 little over an hour. I'm happy to keep going
15 or we can take a quick break.

16 THE WITNESS: Can I just finish my
17 comment on Saito and then I'm happy to take a
18 break.

19 BY MR. WILSON:

20 Q. Sure, sure.

21 A. So Saito's paper makes tunnel barriers
22 out of alumina with different height and uses

1 Slonczewski's model or compares his results to
2 Slonczewski's model. So his assumptions are the
3 same as Slonczewski's. But he compares TMR with
4 barrier height for these alumina junctions.

5 Q. Okay. Is that it?

6 A. Yes.

7 Q. Okay.

8 THE VIDEOGRAPHER: Let's go ahead and
9 go off the record. Right, sir, ready to hop
10 off?

11 MR. WILSON: Yes.

12 THE VIDEOGRAPHER: Just making sure.

13 We are going off the record. The time
14 is 11:19.

15 (Recess taken.)

16 THE VIDEOGRAPHER: We are going back on
17 the record. The time is 11:29.

18 BY MR. WILSON:

19 Q. Dr. Ross, let's turn back to Butler,
20 Exhibit 1044.

21 A. Okay.

22 Q. Now, if we take a look at the first

1 page of Butler, right-hand column, first full
2 paragraph. You see the first sentence there says:
3 (Reading)

4 Most previous theories of
5 tunneling conductance and
6 magnetoconductance have emphasized the
7 density of states of the electrodes.
8 The tunneling matrix elements are
9 almost always neglected or treated as
10 inert factors.

11 Now, the tunneling matrix -- first, did
12 I read that correctly?

13 A. Yes.

14 Q. Okay. The tunneling matrix Butler
15 refers to is the insulator, correct?

16 A. Well, the tunneling matrix elements
17 represent how one would describe the conductivity
18 of that tunnel barrier. So it's not the barrier
19 itself, it's the elements of the matrix which
20 describe how it conducts current.

21 Q. Butler goes on to say in the next
22 sentence: (Reading)

1 One of our conclusions is that
2 this approach is completely inadequate
3 for understanding tunneling.

4 Did I read that correctly?

5 A. Yes.

6 Q. Now, Slonczewski was one of the models
7 that Butler is addressing, correct?

8 A. He doesn't cite any specific models in
9 that comment about most previous theories of
10 tunneling conductance.

11 Q. But Slonczewski treats the tunneling
12 matrix as an inert factor, correct?

13 A. I don't know if Slonczewski uses the
14 term "tunneling matrix elements."

15 Q. Well, as we previously discussed,
16 Slonczewski assumes that there is a rectangular
17 barrier of no particular composition, correct?

18 A. Correct.

19 Q. So the particular distinguishing
20 factors of magnesium oxide as a tunneling barrier
21 are not considered or taken into account at all in
22 Slonczewski's model, correct?

1 A. Slonczewski's model is a general model
2 which considers a rectangular barrier.

3 Q. So the answer to my question is "yes"?

4 A. The answer is that Slonczewski doesn't
5 refer to specific materials.

6 Q. Okay. Slonczewski treats the
7 characteristics of the barrier as inert factors,
8 correct?

9 A. I would say Slonczewski treats the
10 barrier as a rectangular barrier. "Inert factors"
11 is a bit difficult to know what Butler means
12 exactly by that, so I can't comment on what he
13 meant by that particular statement.

14 Q. You would agree that for a magnetic
15 tunnel junction with a magnesium oxide (001)
16 barrier layer, one must account for the properties
17 of the barrier layer in order to -- in order to
18 adequately understand its tunneling properties,
19 correct?

20 A. I would say that you can model tunnel
21 behavior by a variety of different models, and it
22 depends what you're trying to accomplish as to how

1 you analyze your data.

2 Q. Okay. The next sentence, Butler says:

3 (Reading)

4 The nature of the states, both

5 in the electrodes and in the barrier

6 layer, are extremely important in

7 determining the tunneling conductance.

8 Did I read that correctly?

9 A. Yes.

10 Q. And we agreed that Slonczewski ignores

11 the nature of the states in the barrier layer,

12 correct?

13 A. Slonczewski treats the barrier as a

14 rectangular barrier, and he describes the electrons

15 in the -- electrodes as based on an exchange

16 split-free electron model. I don't know if he

17 had -- I don't recall what he said about the nature

18 of the electrons in the barrier. I believe he

19 mentioned the directions of propagation.

20 Q. But he does not discuss or apply any

21 distinct decay rates for electrons with different

22 symmetries in the barrier layer, correct?

1 A. Well, I've mentioned before, he doesn't
2 use the same approach as Butler to analyze
3 tunneling. His assumptions are based on a free
4 electron model and a rectangular barrier, which is
5 different from what Butler did.

6 Q. And it's different in the respect that
7 it does not take into account distinct decay rates
8 for different electron symmetries in the magnesium
9 oxide barrier layer, correct?

10 A. It doesn't describe the electrons in
11 terms of block waves with specific symmetries.

12 Q. And in so doing, it also doesn't
13 account for the distinct decay rates of the
14 different block symmetries in a magnesium oxide
15 barrier, correct?

16 A. Well, as I've said, it doesn't treat
17 the electrons in that manner.

18 Q. Now, let's take a look deeper in Butler
19 at equation 9, which is on page 7.

20 Now, if you take a look at equation 9
21 on page 7 of Butler, and I want you to compare
22 equation 9 to the equation for kappa as a function

1 of E on page 14 of Dieny. And my question is, are
2 those the same equation for kappa?

3 A. I'd really have to look at these papers
4 in detail to look at that. Some of the terms are
5 labeled differently, and this isn't something I
6 considered in my declaration.

7 Q. Okay. So you don't have any opinion on
8 whether equation 9 in Butler is the same as the
9 equation for kappa in Section 1.2.3.1 of Dieny,
10 correct?

11 A. That's not a question I've been asked
12 to consider.

13 Q. And as a result, you have no opinion on
14 it, correct?

15 A. Well, at this point, I have no opinion
16 on it.

17 Q. Now, if we look just above equation 9
18 there in Butler, you can see Butler refers to the
19 theory for tunneling through a simple barrier.

20 Do you see that?

21 A. Yes.

22 Q. And that's what he's attributing

1 equation 9 to, correct?

2 A. Well, I don't know. It's referring to
3 Footnote 20, which is not a paper I've looked into.

4 Q. Okay. Well, Butler says, according to
5 the theory for tunneling through a simple barrier,
6 the transmission should vary with K parallel as E
7 to the negative $2D\kappa$, where D is the thickness
8 of the barrier and κ is given by equation 9,
9 correct?

10 A. Well, that's what it says in Butler,
11 but I don't have an opinion about this particular
12 equation.

13 Q. Okay. Now, if we go up one paragraph
14 above equation 9. Do you see the sentence at the
15 beginning of Section C, it's -- where Butler says:
16 (Reading)

17 It is generally believed that
18 the simple barrier model is
19 appropriate for describing the
20 tunneling of electrons through
21 insulating barriers.

22 Do you see that?

1 A. Yes, I see that.

2 Q. Butler says: (Reading)

3 In the preceding section, we
4 showed, contrary to that model, that
5 states with different symmetry decay
6 at different rates as they tunnel
7 through the barrier. In this section,
8 we address the variation of the
9 tunneling current with k parallel and
10 show that the barrier model fails for
11 this aspect of tunneling as well.

12 Did I read that correctly?

13 A. Yes.

14 Q. So Butler is explaining why the simple
15 barrier model fails for magnesium oxide, correct?

16 A. Well, he's making a statement about
17 what he believes. I haven't assessed that
18 statement myself.

19 Q. Okay. But he does make that statement,
20 correct?

21 A. Well, he makes the statements which are
22 stated in his paper.

1 Q. Okay. And if we look at Figure 9 in
2 the upper right-hand column, Butler shows majority
3 transmission probability as a function of K
4 parallel using both the simple barrier model and
5 his own computational model, correct?

6 A. Well, he's plotting transmission
7 probability of majority electrons under certain
8 conditions in his model.

9 Q. Right. And in Figure 9, he's comparing
10 his model to the simple barrier model, correct?

11 A. Well, there's data labeled "simple
12 barrier model."

13 Q. Okay. And there's quite a divergence
14 between the results from the simple barrier models
15 and his results, Butler's results, correct?

16 A. Well, there's certainly a difference.

17 Q. In fact, his results show an
18 oscillation that's not reflected at all in the
19 simple barrier, correct?

20 A. Yes, he has an oscillatory behavior.

21 MR. WILSON: Okay. We don't have any
22 further questions. We'll pass the witness.

1 MR. HRYCYSZYN: Why don't we take a
2 short break here and we'll get -- we'll see
3 if we have any follow-up questions.

4 MR. WILSON: Okay.

5 MR. HRYCYSZYN: Okay. Thanks.

6 THE VIDEOGRAPHER: Let's go off the
7 record. The time is 11:45.

8 (Recess taken.)

9 THE VIDEOGRAPHER: We are going back on
10 the record. The time is 11:54.

11 MR. HRYCYSZYN: IP Bridge has no
12 redirect questions.

13 MR. WILSON: Okay. I think we're done.

14 THE VIDEOGRAPHER: If there's no
15 further questions, this concludes the
16 deposition. The time is 11:54. Thanks.

17 (Signature reserved.)

18 (Deposition concluded at 11:54 a.m. EDT)

19 - - -

20

21

22

1 CERTIFICATE OF NOTARY PUBLIC

2

3 I, Amy A. Brauser, RPR RMR CRR, the officer
4 before whom the foregoing deposition was taken, do
5 hereby certify that the witness was duly sworn by me
6 prior to the taking of the foregoing deposition; that
7 the testimony of said witness was taken by me to the
8 best of my ability and thereafter reduced to
9 typewriting under my direction; that I am neither
10 counsel for, related to, nor employed by any of the
11 parties to the action in which this deposition was
12 taken, and further that I am not a relative or
13 employee of any attorney or counsel employed by the
14 parties thereto, nor financially or otherwise
15 interested in the outcome of the action.

16 This is the 25th day of September, 2025.

17

18



19

20

Amy A. Brauser, RPR RMR CRR
Notary Public
for the Commonwealth of Virginia

21 Notary Registration No.: 7675529

22 My Commission Expires: January 31, 2028

1 Case: Western Digital vs Godo Kaisha IP Bridge 1

2 Witness Name: Caroline A. Ross, Ph.D.

3 Deposition Date: 09/19/2025

4

5

6 Please be advised that the transcript in the above

7 referenced matter is now complete and ready for signature.

8 The deponent may come to this office to sign the transcript,

9 a copy may be purchased for the witness to review and sign,

10 or the deponent and/or counsel may waive the option of

11 signing. Please advise us of the option selected.

12 Please forward the errata sheet and the original signed

13 signature page to counsel noticing the deposition, noting the

14 applicable time period allowed for such by the governing

15 Rules of Procedure. If you have any questions, please do

16 not hesitate to call our office at (202)-232-0646.

17

18 Sincerely,

19 Digital Evidence Group

20 Copyright 2025 Digital Evidence Group

21 Copying is forbidden, including electronically, absent

22 express written consent.

2

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

5 Case: Western Digital vs Godo Kaisha IP Bridge 1

6 Witness Name: Caroline A. Ross, Ph.D.

7 Deposition Date: 09/19/2025

8 I do hereby acknowledge that I have read
9 and examined the foregoing pages
10 of the transcript of my deposition and that:
11 (Check appropriate box):

12 () The same is a true, correct and
13 complete transcription of the answers given by
14 me to the questions therein recorded.

15 () Except for the changes noted in the
16 attached Errata Sheet, the same is a true,
17 correct and complete transcription of the
18 answers given by me to the questions therein
19 recorded.

20 _____
DATE

WITNESS SIGNATURE

21

22 _____
DATE

NOTARY

3

1 Errata Sheet

2 NAME OF CASE: Western Digital vs Godo Kaisha IP Bridge 1

3 DATE OF DEPOSITION: 09/19/2025

4 NAME OF WITNESS: Caroline A. Ross, Ph.D.

5 Reason Codes: 1. To clarify the record.

6 2. To conform to the facts.

7 3. To correct transcription errors.

8 Page _____ Line _____ Reason _____

9 From _____ to _____

10 Page _____ Line _____ Reason _____

11 From _____ to _____

12 Page _____ Line _____ Reason _____

13 From _____ to _____

14 Page _____ Line _____ Reason _____

15 From _____ to _____

16 Page _____ Line _____ Reason _____

17 From _____ to _____

18 Page _____ Line _____ Reason _____

19 From _____ to _____

20

21

22

CAROLINE A. ROSS, PH.D.

(		1017 21:10	11:29 80:17	2	
		31:16	11:45 90:7		
(001)	47:4	1028 32:13,	11:54 90:10,	2	15:13
	83:15	14	16, 18		21:17
(100)	47:3	1031 20:20	12 15:13		23:1, 8, 18
		21:2, 22	69:5, 6		24:4 31:2
	0	22:8 37:10	125 30:18,		38:8 47:16
			22 31:1		48:9, 10
0	38:19	104 10:10	12th 8:9		59:14, 20
	56:3 76:5,	1043 62:4,	13 15:13		60:5, 10
	17 77:1	10, 11	69:8		74:20 87:7
		1044 19:18	139 30:19	2-by-2	63:18
	1	20:8 45:6,	14 75:9	20	87:3
		11, 14, 18	86:1	2000	61:14,
1	5:3 24:15	46:6 80:20	1494 8:2		20 62:1, 3
	25:17, 21	1047 64:19	9:8		63:2 64:5,
	26:11	66:2	16 53:15		12 69:18
	27:3, 7	1051 67:5, 7	167 9:21		70:5, 12
	34:6 37:7,	1057 53:12	10:5, 7	2001	65:2
	12, 16, 17,	75:7	11:9 12:8		67:11
	18 38:7	106 8:6, 7	14:15	2005	15:11
	39:5 47:16	107 8:13	15:14	2006	15:11
	48:17, 19	10:06 44:22	1794 25:18	2015	18:2, 9
	49:7, 9, 17	10:16 44:19	1795 23:9	2025	5:7
	56:17	45:3	1796 22:13		8:9
	58:3, 8, 9,	10:38 57:9	1963 27:10	2037	78:7,
	21 59:13,	10:39 57:12	1975 27:14		12
	19 60:2, 4,	11 8:17	1989 73:13,	2039	29:19
	7, 13, 17	11, 968, 909	16		30:1, 2, 6,
	72:1	6:12	19th 5:7		12
1.2.3	75:10	110 8:14		2041	19:1,
1.2.3.1		11:19 80:14			2, 5, 13
	75:12 86:9				70:16
1.2.4.1					73:12, 21
	53:16				
10	23:21				

2053 8:2		31:16 32:7	adequately
9:4, 6, 15	6	33:4, 14	83:18
15:21			
16:5, 8, 18	6 15:13	9:02 5:14	adherent
21:6 30:15	48:13		51:2
	49:1, 2	A	adjacent
24 22:17, 22			11:5, 22
23:2, 4, 7,	6998 73:21	a.m. 90:18	13:4 14:6
17 31:16			
	7	abstract	affect 52:13
296 10:10		50:15	53:9
11:17 15:8	7 8:17	accomplish	AFM 63:14
	21:11	83:22	64:8
3	55:22 56:2	account	agree 15:10
	57:16, 17	72:20	22:22 24:9
3 31:16	85:19, 21	82:21	28:1 44:3
58:13, 14,		83:16	77:10, 13,
16	8	85:7, 13	15 83:14
3.6 74:2, 4,		accurate	agreed 27:17
7, 13, 20	8 17:13	49:20	84:10
30 16:20	18:2, 4	55:6, 17	
33 75:9	21:17 23:6	accurately	ahead 80:8
35 53:16	24:4, 8	7:8	alignment
39 21:12			56:15
	9	actual 42:7	allowed
4	9 85:19, 20,	67:14	28:14
	22 86:8, 17	additional	allowing
4 15:13	87:1, 8, 14	30:16	63:15
	89:1, 9	address 72:5	alumina
5	909 6:15	88:8	51:16
	15:21	addressed	52:6, 11,
5 47:16	16:2, 5, 9,	34:22	14, 22
48:9 58:22	22 21:10	35:5, 21	53:18
59:14	22:12	39:14	55:1, 7, 18,
61:8, 12	23:1, 6, 8,	52:17, 18	20 79:6,
	18 24:3,	addressing	11, 22 80:4
	10, 15, 19	82:7	
	25:2, 9, 11		

aluminum	antiparallel	40:15	5:13
50:22	56:8		
51:3, 22	APL 10:12	approximately	assume 7:3
52:5	11:18	16:17	71:13
amenable	12:12, 16	76:15, 17	72:9, 13
36:21	13:2, 21	approximates	assumed
amorphous	14:22	39:22	26:21 77:1
13:8, 15	15:11, 17	approximating	assumes 54:4
14:13	appears 23:6	35:18	55:4 76:13
50:22	62:9	approximation	82:16
51:22	appendix	35:10 41:2	assuming
52:3, 5, 11,	8:12, 20	55:12	56:3 76:4
14, 21	9:1 23:22	approximations	assumption
53:18	31:2	36:16 41:4	55:12, 14
54:12	applications	43:2 71:10	assumptions
55:1, 7	50:21	78:18	75:15 77:4
Amy 5:12	51:21	area 20:13	80:2 85:3
analysis	applied	63:20	attempt
25:1 40:2	25:15	Armond 5:17	66:16
77:6	55:19	arrangement	69:11
analytical	61:9, 17	71:17	attempts
46:9 70:21	62:6	art 24:11,	68:10, 13
71:1	apply 84:20	19, 21 25:4	attenuation
analytically	applying	39:12	75:2
26:7 40:3	43:4, 20	43:12, 14	attributes
analyze	52:19	60:12	24:4
25:14 26:6	approach	article	attributing
84:1 85:2	82:2 85:2	67:14	61:20
analyzed	approaches	articulated	86:22
36:21	32:21	22:10	August 67:11
77:17	approximate	aspect 88:11	author 20:12
Anne 6:1	36:19	assessed	65:6
7:12	approximated	88:17	authors 46:3
answers 11:1	39:19	association	64:16

average 36:2	36:1, 2, 4,	43:5, 7	79:6, 8, 11,
38:16 39:3	8, 14, 17, 22	44:1, 7	21 87:21
aware 18:21	37:5, 13	48:1, 6	based 10:2
19:1, 10,	39:17, 18	50:8	50:2 72:17
17, 19	40:5, 11	52:11, 22	78:22
20:12	72:1	53:1, 9, 18	84:15 85:3
61:21 62:2	bands 28:20,	54:12, 14,	bases 41:13
64:10	21 29:7	18 55:1, 3,	beam 68:19
70:10	bar 38:13	7 64:5	beginning
73:15	barrier	66:13 71:5	87:15
	10:13 13:5	72:6, 8, 10,	behalf 7:14,
B	14:6 17:1,	12, 15, 22	17
	5, 9 23:15	73:6, 7, 10	behavior
back 8:16	26:2	74:6, 8, 11	45:21
20:16	27:19, 20	76:19 77:3	83:21
23:19	29:15	79:1, 2, 5	89:20
31:15	31:6, 13, 20	80:4 81:18	believed
34:9, 16	32:8, 17, 20	82:17, 20	87:17
44:18 45:2	33:3, 7, 8,	83:2, 7, 10,	believes
50:14	12, 13, 16	16, 17	41:22
55:13, 21	34:1, 2, 11,	84:5, 11,	88:17
57:11	12, 18, 20,	13, 14, 18,	bending 37:1
60:17 75:6	21 35:1, 4,	22 85:4, 9,	beta 23:21
76:11	5, 10, 15,	15 86:19	bit 83:11
80:16, 19	16, 20, 21	87:5, 8, 18	block 47:8,
90:9	36:9, 10	88:7, 10, 15	11, 14, 19
ballistic	37:18, 20	89:4, 10,	48:16 49:6
63:15	38:2, 15,	12, 14, 19	50:3 54:6,
68:21	16, 22	barrier's	10 55:1, 5,
band 28:2,	39:3, 4, 7,	73:8	11 56:18
3, 4, 5, 11,	8, 14, 16, 22	barriers	72:3, 14,
14, 19	40:1, 4, 14,	32:17 34:8	16, 17, 21
29:1, 2, 4,	15, 18, 19	51:1, 16	73:3, 4
5, 7, 8, 14	41:2, 8, 11,	52:1, 5, 7	78:15
31:8, 19, 22	13, 17	55:18, 20	
34:14	42:8, 10,	67:22	
35:8, 18	18, 19	73:9, 18	

79:2, 4	broadly 21:4	26:7 42:10	change 35:19
85:11, 14	25:15	43:5	changed 12:4
body-centered	30:13	calculated	channel
46:14, 17,	Butler	32:20	59:8, 12,
20 47:2	19:17, 19,	calculating	15, 17
boron 10:12,	21 20:5	33:13	60:5, 6
17 11:6,	45:6, 9, 14,	call 28:21	character
12, 14, 22	15, 18 46:5	called 28:10	48:11
12:6, 11, 20	47:15, 21	candidates	characteristic
13:7, 9, 14,	48:14, 15	68:1	s 17:8, 12,
15, 16	49:13	capital	18 18:7
14:12	50:18	23:5, 20	63:17 64:8
15:18	52:17, 19	capture	73:7 83:7
bottom 31:8,	55:21	74:14	characterizati
21 35:7, 18	57:17	Caroline 5:4	on 77:11
36:1, 2, 3,	58:7, 22	6:1 7:12	characterize
8, 14, 16	59:11	carriers	51:8
37:5 38:13	60:1, 12,	29:1 56:7,	characterized
39:16, 18	18, 19	14	28:12
40:10	80:19	case 12:19	66:12
53:20, 21	81:1, 14, 21	19:2, 6, 8	characterizes
63:1, 6	82:7 83:11	20:5, 9	29:9
65:20	84:2 85:2,	21:2, 7	check 34:16
67:16	5, 18, 21	43:19	circumstance
brackets	86:8, 18	54:11	21:20
37:22	87:4, 10, 15	66:20	citations
Brauser 5:12	88:2, 14	69:21	18:20
break 44:10	89:2	cases 41:20	69:13
79:15, 18	Butler's	centers	cite 69:5, 8
90:2	20:8 46:10	50:21	82:8
Bridge 5:6,	47:6 50:2	51:21	cited 8:18
21 7:14,	57:16	certified	18:16
17, 20	89:15	6:2 57:5	20:2, 18
10:21	c		25:9 30:14
16:15, 16	calculate		
90:11			

cites 61:12	column	composition	conducting
citing	21:11, 17	71:15	63:13
19:12, 15,	23:6 24:4,	72:12	conduction
21 52:10	8, 15 31:16	82:17	28:2, 5, 11,
claim 12:13	38:9 48:14	computational	19, 21
13:22	49:2 59:2	46:8 47:6	29:1, 5, 14
15:15	65:8 67:14	70:18 89:5	31:8, 22
claims 11:9,	68:9 81:1		34:14
19 12:8	89:2	computer	35:7, 18
14:15	comment	22:2	36:1, 2, 3,
15:13, 17	72:18	concept	8, 14, 16
17:1	79:17 82:9	27:19	37:5, 13
clarification	83:12	33:2, 5, 22	39:17, 18
6:22 7:3	commenting	34:22	40:5, 11
clear 11:8	11:18	35:5, 20	42:3, 5
close 31:21	common 24:22	39:13	44:3, 4
coauthor	29:17	40:11, 13,	72:1
65:5	compare	14, 19, 21	conductive
coauthored	85:21	41:17	64:8
17:14	compared	conclude	conductivity
cobalt	46:2 71:8	43:16	28:17 29:2
10:12, 17	compares	concluded	33:18
11:6, 12,	80:1, 3	90:18	42:13
14, 22	comparing	concludes	81:17
12:6, 11, 20	89:9	90:15	conductors
13:6, 8, 14,	compensated	conclusion	71:20, 21
15 14:12	7:19	63:5, 9	conducts
15:18	complete	conclusions	81:20
coefficient	9:2, 6	82:1	conference
76:8, 9	completely	conditions	5:9
coefficients	82:2	42:9 89:8	confident
71:4	complex	conductance	16:4
coherency	36:19	74:5, 8, 10,	configuration
54:9	53:11	17 81:5	57:18, 21
		82:10 84:7	58:3

consequence	41:10	19 40:12,	86:10, 14
67:16, 20		21 41:18	87:1, 9
conserved	contrary	42:1, 11, 19	88:15, 20
54:10	88:4	44:2 45:6,	89:5, 10,
	control 68:3	16 46:7,	15, 19
consideration	corner 22:14	12, 15	corrected
12:16	23:10	47:4, 9, 12,	9:18 10:7
13:21	56:11, 13,	17 48:1, 7,	
considerations	19 57:17	21 49:15,	corrections
11:20		22 50:10	15:20 16:1
considered	correct 6:18	51:17	correctly
8:13, 18, 22	7:14, 15	52:7, 14	31:10 32:5
9:3 24:20	8:10, 11, 20	53:2 55:3,	49:11
25:8 53:11	9:8, 9	8, 18 56:4,	51:4, 14
77:3 82:21	11:15 12:9	12, 22	54:20
86:6	13:13	57:19	59:21 61:6
	14:1, 15	58:4, 10	64:1 65:22
considers	15:14 16:5	60:3, 8, 14	66:14 68:6
33:6 39:21	17:2 18:2	61:17 63:2	69:3 76:20
73:5, 6	19:6, 14, 18	64:5, 21	81:12 82:4
83:2	20:9, 21	66:18 67:8	84:8 88:12
	21:3, 7, 18	69:8, 12, 18	
consists	24:5, 11	70:5, 12, 19	counsel 5:15
46:11	25:12	71:2, 7, 13,	10:21
constitute	26:11, 15,	18 72:2, 6,	couple 54:16
11:13	19, 22	10, 15	55:15
construct	27:4, 10,	73:1, 8, 13,	
39:8	13, 16, 21	16 74:9, 14	court 5:12
	28:2, 7, 11,	76:5, 8	crucial
construction	19 29:5, 16	77:3, 8, 18	59:18
14:19	30:12, 15	78:5, 12,	crystal 32:3
consultation	31:13	16, 20 79:5	68:16
10:21	32:9, 12, 18	81:15	69:22 70:7
contact	33:4, 14	82:7, 12,	crystalline
68:17	34:1, 15	17, 18, 22	52:19
	35:8 36:4,	83:8, 19	63:11
content 20:9	17 37:7, 19	84:12, 22	65:17 66:5
continuous	38:2, 17, 22	85:9, 15	67:21
	39:1, 4, 8,		

68:14	16, 18, 21,	defects	14, 19, 20
71:17	22 44:6	63:20	60:2, 4, 5,
72:10	79:11 84:1	define 34:12	7, 10, 13
crystallized	89:11	35:14	72:1
10:11, 15,	date 5:7	defined	demonstrate
18 11:4, 5,	61:20	23:5, 22	68:21
11, 13, 14	dated 8:9	27:20	demonstrated
12:1, 7, 8,	63:2	29:15 31:6	63:13
12, 13, 21,	day 11:3	33:13 34:3	density
22 13:4, 6,	decay 48:12,	36:10	56:2, 11, 13
10, 16	18 49:8, 19	38:15 40:8	57:1, 18, 21
14:5, 7, 14,	50:7, 8, 11,	defines	58:2, 12, 16
20 15:1, 3,	13 54:19	26:16 32:7	81:7
5, 16, 18	75:3, 4	34:10	dependence
crystallograph	76:8, 9	41:13	55:5
ic 54:13	79:4 84:21	defining	depends
cubic 46:15,	85:7, 13	33:3, 16	36:11 43:1
18, 20, 22	88:5	40:6	83:22
47:3	decays 48:4	definition	deposited
current	50:1	23:11, 13,	70:1
17:17 18:7	decision 9:1	16, 20 29:3	depositing
23:14	10:20	31:12	61:2, 3
41:21 42:7	declaration	34:17, 19	68:18
43:6 63:22	8:2, 3, 17,	37:3	deposition
81:20 88:9	19 9:14, 21	definitions	5:4, 8 6:8
curve 40:17,	10:5, 7, 14	38:4	9:11 10:6
18	16:2, 15, 18	degenerate	66:9 68:19
curves 26:8	17:13	59:14	90:16, 18
	18:10 21:6	delta 47:16,	describe
D	30:15 86:6	20 48:9,	26:4 78:15
data 17:9,	declarations	10, 17, 19	81:17, 20
22 20:17,	15:22	49:7, 9, 17	85:10
19 41:14	deeper 85:18	56:17	describes
42:13	defect 32:4	58:3, 8, 9,	12:12 13:5
43:6, 15,		21 59:13,	

25:13 52:8	35:1, 6, 21	discussing	8:18 9:13
71:3 84:14	36:7, 13	51:18 52:2	dominant
describing	37:4 39:14	72:11 79:7	41:21 42:7
24:12, 22	40:5 89:16	discussion	56:21
33:8 50:18	differently	21:12	dominate
78:3 79:10	22:20	57:10	63:22
87:19	48:10	dissertation	doubly 59:13
description	50:13 86:5	30:3, 8, 9	Douglas 5:17
15:2	difficult	distance	due 65:20
descriptions	44:6 51:8	35:11 75:3	68:22
48:4	83:11	distinct	duly 6:2
designate	Digital 5:5,	72:21	
47:20	11, 13, 18	78:15 79:4	
detail 86:4	Dimensions	84:21	E
determined	61:14	85:7, 13	
58:7	directed	distinguish	earlier 27:2
determining	17:1	39:6 47:14	45:15
84:7	directions	distinguishing	64:13
device 24:16	53:8 84:19	39:2 82:19	66:16
42:4	disagree	distribution	earliest
devices 42:2	40:22	41:5	17:10
dielectric	77:21	divergence	18:1, 3, 5
63:12	discontinuity	89:13	ease 51:2
Dieny 53:13	31:19	document	EDT 90:18
75:6	discovered	9:20 14:3	effect
77:12, 17,	27:16, 21	22:15	27:13, 16
21 78:1, 2	discovery	23:3, 12	69:1
86:1, 9	27:12	25:20	Effective
Dieny's	discuss	33:15	59:2
77:10	72:16	37:11	efficiently
difference	84:20	39:20 48:2	76:18
29:13 31:7	discussed	58:11	electrical
34:13	77:16	65:10	17:21
	82:15	documents	20:17

electrode	22 53:6	63:11	65:13, 16
26:1, 2	54:6 55:2	65:17	66:17, 19,
34:14	58:21 72:2	epitaxially	22
35:2, 7, 22	75:4, 5	61:2, 4	evanescent
36:14	76:14 77:2	epitaxy 66:8	47:22
38:7, 8	84:14, 18,	equal 54:4	48:4, 5, 11,
39:15 55:2	21 85:10,	76:5, 16	18 49:8,
61:4 72:2	17 87:20	equals 59:2	14, 18, 21
electrodes	89:7	76:5	50:1 54:17
26:21	elements	equates 40:4	55:16
27:1, 7	81:8, 16, 19	equation	evidence
47:8, 12	82:14	21:17	5:11, 13
48:18 49:8	embodiment	22:11, 12,	15:12
51:13	31:18	17, 22	exact 15:15
52:7, 12	emission	23:1, 2, 4,	EXAMINATION
54:7 56:9,	42:1, 6, 18	8, 17, 18, 21	6:4
16 58:8	43:4, 19	24:1, 4	examined 6:3
62:20	emphasized	42:14, 15	examples
71:5, 13, 18	81:6	43:5, 22	17:15
78:16 81:7	empty 29:8	74:2, 4, 7,	exception
84:5, 15	end 61:10	13, 16, 20	59:18
electron	74:19	75:22 76:2	exchange
41:10	energy 25:22	85:19, 20,	84:15
52:12	31:7 32:1	22 86:2, 8,	exchanged
54:14	enter 49:18	9, 17 87:1,	11:1
55:14	entire 11:6	8, 12, 14	exclude 13:3
56:21	12:20	equipment	27:7
68:19	entitled	69:1	exclusive
71:19, 20	62:13	error 10:19	48:3
77:7 79:1	epitaxial	11:7 14:5,	excuse 32:19
84:16	45:21	9, 10	exhibit 8:2
85:4, 8	51:11	established	9:4, 6, 15
electrons	52:6, 9	31:13	15:11, 21
28:13, 15	62:17	et al 60:21	
33:6, 11			
41:6 50:7,			
13 52:13,			

16:5, 8, 18	explained	face-centered	41:6
19:1, 2, 5,	76:8	46:22	ferromagnet
13, 18	explaining	fact 27:9	74:8, 9, 11,
20:8, 20	12:14	37:6 89:17	12
21:2, 6, 10,	88:14	factor 82:12	ferromagnetic
22 22:8	explicitly	factors	26:22
29:19	23:7	72:19	51:13 74:5
30:6, 12, 15	express 16:4	81:10	78:16
31:1, 16	expressed	82:20	field 24:10,
32:13, 14	9:4	83:7, 10	15, 19, 21
37:8, 10	expression	failed 66:18	25:4 42:17
45:6, 11,	26:3	67:2	43:19
14, 18 46:6	extent 15:7	fails 88:10,	figure
53:12	extract 44:7	15	25:17, 21
62:4, 10	62:9	Fair 24:3	26:11
64:19 66:2	extracted	familiar	27:3, 7
67:5, 7	17:9	18:11	34:6 37:7,
70:16	extremely	20:4, 8, 20	12, 16, 17,
73:12, 21	20:6 84:6	21:1 30:11	18 38:6
75:7 78:7,		41:18 45:5	39:5 55:22
12 80:20	F	78:11	56:2, 19
exhibits	fabricate	famous 20:6	57:16, 17
66:20	17:17	45:16, 19	58:13, 14,
existence	69:11	Fe(001) 32:2	16 89:1, 9
47:7, 16,	fabricated	feel 12:5	File 5:3
18, 22	17:7 18:6	Fermi 28:4,	filled 28:3
exists 12:21	fabricating	6, 8, 10, 13,	finally
expect 43:9	17:11	16 29:6, 14	75:20
44:5	64:11	31:9 32:1	76:12
experiment	fabrication	34:13	find 9:17,
32:18	17:20 64:4	35:2, 6, 22	19, 20 16:1
experimental	69:17	36:8, 13	22:2, 13
79:10	70:4, 6, 10	37:5, 14	29:22
experiments		39:15 40:6	48:22
68:18			finds 41:20

42:2	30:5	giving 14:21	36:9, 11
finish 79:16	full 7:11	gold(001)	38:2, 16, 21
firm 16:7	48:14 49:3	62:20	39:3, 7, 8,
fit 42:13,	81:1	good 6:6, 7	14, 16
15 43:16,	fully 7:7	44:8	40:1, 4, 14,
18 44:5, 8	11:4, 13	Greenfield	15, 18, 19
fits 40:18	29:7	5:21 7:17,	41:2, 14, 17
fitting	function	22 16:8, 12	42:10, 19
41:14	35:11	group 5:11,	43:5, 7
flat 37:2	40:7, 9	13 69:20	44:1, 7
66:5	41:10 76:3	growing 51:2	73:8, 11
flow 42:7	85:22 89:3	66:17	79:22 80:4
56:21	functions	grown 60:22	heights 17:9
follow-up	54:15	62:16	32:17, 20
90:3	55:15	63:10 66:6	Heinrich
Footnote	G	guys 44:11	60:21 61:9
61:8, 12	gap 29:4, 6	H	62:4 64:3,
87:3	general		12, 16
formed 10:13	25:21 26:3	Hang 25:19	65:4, 14
forming 9:4	29:10, 12	happy 44:10	69:16
formula	52:21 83:1	79:14, 17	held 5:8
21:17, 19	generalized	heading	57:10
24:6	23:15	38:10	highly 63:10
formulated	generally	75:10, 12	history
73:2	27:17	height 17:2,	50:18
fourth 59:6	87:17	5 27:19, 20	hold 43:22
73:22	generic	29:16	hop 80:9
fraction	26:19	31:6, 13, 20	hopping 33:7
63:19	give 15:17	32:8 33:3,	hour 44:10
free 78:22	42:18, 20	8, 12, 13, 17	79:14
85:3	43:6, 8, 10	34:1, 3, 5,	hours 16:20
front 8:3	44:1, 5	11, 13	Hrycyszyn
		35:1, 2, 6,	5:20 14:16
		15, 21	29:20 30:1

44:13, 18	54:8, 22	intended	IPR0224-01494
45:10	55:7	74:14	6:9
90:1, 5, 11	inconsistent	interact	IPR2014-01494
	10:18	53:9	5:6
I	incorrect	interest	iron 10:12,
ideal 32:2	42:19, 21	50:20	17 11:6,
idealized	43:7, 12	51:20	12, 14, 22
39:7	44:1	interface	12:6, 11, 20
identical	independent	29:13 31:9	13:7, 8, 14,
55:15	54:5	37:1, 3	15 14:12
identically	inert 81:10	58:17	15:18
54:16	82:12	intrinsic	45:21
55:16	83:7, 10	66:4	47:8, 11
identifies	infer 60:15	introduce	48:17
8:21	injector	5:15	49:7, 18
identify	54:15	introduced	50:4 52:7
8:17	insight	54:4	56:3, 4
IEEE 63:2	30:17	introduction	58:7, 8, 17
ignores	institution	50:15, 16,	61:2, 4
84:10	9:1	17 60:18,	62:18, 19
images 13:2	insulating	19	64:6, 7
imagine	26:1 87:21	investigate	65:17, 20
60:15	insulator	63:16	66:5, 6, 9,
important	26:10, 12,	involved	11, 17
84:6	18 28:22	17:4 20:12	68:14
inadequate	29:13, 15	involves	69:21
82:2	34:15 35:8	6:11	70:1, 7
include 23:7	36:4, 15	IP 5:5, 21	71:13 72:2
including	38:7 39:17	7:14, 17, 19	78:15
8:19	40:11	10:21	iron(001)
incoherent	81:15	16:15, 16	65:18
53:17	insulators	90:11	68:15, 20
	28:18, 20	IPR 8:2 9:8	iron(100)
	29:3, 9		46:11, 12,
			14 47:17
			50:5 60:22
			61:1 66:7,

10	24:13, 14	lateral	61:17 62:6
IV 17:8, 12	27:21	63:17	level 28:4,
26:8 32:22	50:19 61:1	law 16:7	6, 8, 10, 13,
40:17, 18	62:14, 17	lawyers	16 29:6, 14
	66:6, 7	16:12	31:9 34:13
J	68:2 70:18	layer 10:13	35:2, 6, 22
January 65:2	71:1 73:19	11:4, 6, 10,	36:9, 13
Jerry 5:20	80:4	14, 22	37:5, 14, 15
judgment	K	12:6, 20	39:15 40:6
71:11	kappa 74:20	13:5, 14, 16	41:6
Jullière	75:3 76:1,	14:12, 13	levels 25:22
27:14 71:9	2, 7 85:22	15:1, 2	37:2
Jullière's	86:2, 9	32:1, 2	lies 28:10
53:22	87:7, 8	64:5, 6, 7	limitation
54:1, 3	Keavney	65:20	10:16
55:4, 6, 9	65:9, 13, 16	83:16, 17	12:2, 8, 22
75:16	66:17, 19,	84:6, 11, 22	13:11 14:7
July 8:9	22 67:3	85:9	15:6
jump 30:19	69:5, 7, 14	layers 10:11	limitations
junction	Keavney's	12:11	69:1 78:20
17:6 18:6	69:11	63:12, 21	lines 38:12
20:14	kind 52:18	76:15	53:21 59:7
24:16 27:4	kinds 72:19	leading	63:6 67:15
46:7, 11		48:11	list 9:2
61:22 62:2	L	68:17	17:14 69:6
64:11	label 37:13	left 56:13	listed 18:1,
65:21	labeled 31:2	left-hand	3
68:15	58:18 76:9	23:10	literature
69:12, 17	86:5 89:11	56:10, 19	53:5 64:14
70:5, 11	lack 51:10	65:8 67:14	LLP 5:18
83:15	52:8	legal 5:11	local 63:16
junctions	largest 57:1	letter 61:10	locally
17:15, 21		71:20	66:13
18:9 20:1		Letters	

long 36:5	83:15	72:2 89:2,	means 11:11
looked 34:5	85:8, 14	7	37:1 48:4,
62:3 64:13	88:15	make 36:15	12 50:1
69:14	magnetic	77:5 88:19	83:11
70:14	17:6, 20	makes 55:12,	meant 83:13
73:17 87:3	18:6 19:22	13 79:21	measure
lose 57:3	20:14	88:21	17:17
lost 57:8	24:13, 16	making 61:21	measured
Low 61:14	27:3, 7, 21	80:12	17:7, 11
low-bias	46:1, 7, 11	88:16	18:6, 9
21:20 24:7	50:18	manner 85:17	20:18
low-voltage	61:1, 22	manufacturing	39:18 69:2
22:13	64:11	24:17	70:1
lower 22:14	69:12, 17	material	measurement
23:10 29:7	70:4, 11, 18	12:12	17:5 67:1
63:4 67:14	71:1, 15	15:3, 4	70:8
	83:14	26:11, 13,	measures
	magnetization	17, 19 28:8	64:7
	56:8, 15		
M	magnetoconduct	materials	measuring
made 14:4,	ance 81:6	8:13, 18, 21	37:13 64:9
9, 11 16:2	magnetoresista	9:3 27:6, 8	mechanical
18:9 32:17	nce 27:13,	83:5	41:9
45:20	16, 18 46:1	mathematical	mechanism
75:15	70:8	36:3 46:6	33:9, 10, 11
magnesium	magnetotunnel	matrix 81:8,	41:21 42:7
26:15	62:17	11, 14, 16,	43:17 44:4
48:1, 6, 19	Mahon 5:10	19 82:12,	46:2 56:22
49:9, 15	majority	14	medical 7:6
50:8, 9	48:16 49:6	matter 5:5	meet 12:7,
61:21	50:12	54:15	13, 21
64:12	56:7, 11,	maximum 34:5	mentioned
70:4, 6, 11	14, 22	meaning	27:2 84:19
72:6 73:1,	59:7, 12,	14:20 54:9	85:1
16 79:5	17, 19		
82:20	60:2, 5, 13		

mentioning	65:18	51:9 53:22	monolayers
37:14	68:15	54:1, 3	12:11 13:6
metal 28:11,	Mgo(100)	55:4, 6, 9,	14:5 15:3
12 29:11,	46:12, 17,	19 70:18,	morning 6:6,
12, 14	20 60:22	21 71:1, 3,	7, 18 9:11,
metallic	middle 75:19	6, 7, 12	12
49:18	midway 65:8	72:7, 17	MTJ 17:11,
metals 27:1	68:9	73:2, 9	17 56:4
28:1, 3, 6	minority	75:10, 13,	58:8 63:11
79:1	50:13 56:7	14, 16	64:4 66:17
method 24:17	57:18, 20	76:13, 22	MTJS 19:14
Meyerheim	58:2, 9, 21	77:5, 11,	73:16
67:5, 10	59:15, 20	13, 18, 22	
Mgo 10:13	60:2, 6, 8,	78:3, 17, 22	
11:5 12:1	14	80:1, 2	N
13:5 14:6	minus 74:20	82:22	
32:17	minutes	83:1, 20	nanometers
45:21	44:16, 17	84:16 85:4	63:19
46:22	Mitchell	87:18	nature 51:10
48:11	5:10	88:4, 10, 15	84:4, 11, 17
49:19 50:4	mobile 28:13	89:4, 5, 8,	needed 9:18
56:4 58:8,	model 18:15	10, 12	negative
17 61:2, 5	25:13, 15,	modeled 42:5	87:7
62:2	17 26:7	models	neglected
63:12, 20	27:3, 14	33:18, 20	81:9
64:4, 6	32:21 33:6	34:3, 7, 9,	nexus 11:19
65:17	35:9 36:3,	10, 18	nickel 62:19
66:6, 7, 9,	11, 20	36:12, 19	nonconducting
12, 17	39:21	40:16, 20	26:12, 19
68:14, 18	41:3, 8, 15	41:12	noncrystalline
69:11, 17	42:9	43:16 46:3	51:9, 17
70:1 73:18	43:18, 21	82:6, 8	noncrystallized 15:4
79:7	44:5, 7	83:21	nonobviousness
Mgo(001)	46:6, 8	89:14	15:12
31:22	47:6 50:2	molecular-beam	
62:19		66:8	

Notation	one's 41:14	64:12	17:14, 16
38:10	opinion	67:21	18:17, 20
notations	11:21	70:4, 6, 11	20:16
38:6	12:4, 14	72:6 73:1,	69:10, 15,
nuanced 37:3	13:1, 18	16 79:5	20 70:2
number 5:3, 6	14:21 15:7	82:20	86:3
6:12 41:3	24:18 53:3	83:15	parabolic
Numbered	86:7, 13, 15	85:9, 14	35:14
31:1	87:11	88:15	paragraph
numbers	opinions	P	8:17
47:20	9:4, 7	paid 7:21	10:10, 14
o	10:19	panels 56:5	11:17
	14:1, 2, 19	paper 10:12	14:2, 4
	16:4 67:2	11:18	15:8 17:13
oath 6:17	opportunity	12:13, 16	18:2, 4
Objection	68:3	13:2, 20, 21	48:15 49:3
14:16	order 11:13	14:22	50:16
objective	16:20	15:11, 17	51:19
15:12	83:17	18:1, 11	53:20 59:5
obtains	ordinary	19:2, 5, 13,	60:19 68:9
40:18	39:11	18, 20, 22	75:20 81:2
41:14	43:11	20:5, 8, 21	87:13
occupied	60:11	21:2, 5, 13,	parallel
28:15 29:8	oscillation	22 22:7	56:3, 8, 11,
occur 72:22	89:18	24:2, 10	14, 22
occurring	oscillatory	30:17	57:18, 21
43:20	89:20	32:11 34:4	58:2 59:2
occurs 54:22	oxide 26:15	38:3 41:18	76:4, 17
offer 68:2	48:1, 6, 20	61:9, 16	77:1 87:6
offering 9:7	49:10, 15	69:7, 9	88:9 89:4
14:18	50:8, 10, 22	73:12	parameter
Ohmic 68:17	51:3, 10,	74:10	23:4 40:17
	12, 22 52:5	79:21 87:3	parentheses
	61:22	88:22	31:19, 21
	62:19	papers	part 11:19
			21:5 24:1,

14 32:17	60:11	plot 58:6	prepare 9:10
78:2	pertinent	plotted	68:14
partially	25:10	58:12	prepared
28:3, 15	Petition	plotting	65:16
parts 77:15	8:22	89:6	preparing
partway 28:4	Petitioner	point 20:18	16:8, 15, 18
pass 89:22	5:18	86:15	21:6
Patent 6:11,	Ph.d. 6:1	polished	present
15 14:15	30:8	66:9 69:22	11:12
15:14, 21	phenomena	Poole-frenkel	40:17 72:1
16:5, 9, 22	24:22	33:18, 21	presented
21:10	25:15 26:4	40:16, 20	76:1
22:12	phenomenon	population	presents
23:1, 6, 8,	41:9	58:20	46:6
18 24:3,	phi 37:22	portion 12:6	70:17, 22
10, 15, 19	38:13, 19	14:13	preservation
25:2, 9, 11	phi(x) 37:21	possibility	50:3 72:21
31:16 32:7	phrases	13:3	preserved
33:4, 14	15:16	potential	49:21 50:7
patterning	physical	35:11	55:3
17:20	36:19, 20	preceding	72:14, 19
pause 22:4	41:4, 12	88:3	prevalent
57:2	68:4	precise 48:8	51:16
PDF 30:19	physically	49:16	previous
53:16 75:9	43:1, 3	precisely	46:3 81:4
people 25:14	Physics	58:20	82:9
69:19	61:9, 13, 17	predictions	previously
perfect 32:3	62:6	45:20	54:3 82:15
63:10	pinholes	preferred	primarily
perpendicular	51:3 65:19	31:18	32:21
76:14, 16	68:17	preparation	primary
77:2	plane 47:3, 4	68:1	67:22
person 39:11			prime 47:17
43:11, 14			

48:10	15:12	quick 79:15	62:15 63:8
59:15	28:17	quickly	65:12, 15
prior 18:9	publication	48:4, 12	66:3 67:19
19:8 70:11	20:11	50:2	68:12
73:18	publications		75:13
probabilities	18:15	R	76:12
54:5	published	RA 20:19	81:3, 22
probability	27:9	range 22:13	84:3 87:16
41:7 89:3,	61:11, 14,	53:6	88:2
7	17 65:2	rates 50:8,	ready 80:9
problem	67:11	11 79:4	real 39:22
25:11	73:13	84:21	reason 7:6, 9
proceeding	pulsed-laser	85:7, 13	77:20
18:22	66:8	88:6	recall 16:19
process 54:8	purely 46:9	rationale	17:8, 11, 22
producing	PYG381 42:4	14:10	18:8, 19
69:20	Q	reach 10:20	19:10, 12,
product	quality	read 9:12	15, 21
20:13	66:12	19:8 31:10	20:15, 18
pronounce	quantum 41:9	32:5 49:11	40:3 72:11
78:8	question	51:4, 14	84:17
propagate	6:20, 21	54:20	recent 68:18
48:10	7:2 25:6	59:21 61:6	Recently
54:19	49:4 53:10	64:1 65:22	60:21
propagating	58:20 62:3	66:14 68:6	recess 45:1
49:17	70:13	69:3 76:20	80:15 90:8
76:14	73:18 83:3	81:12 82:4	recited
propagation	86:1, 11	84:8 88:12	22:12
84:19	questions	reading	recognize
properties	10:2 11:1	31:5, 17	71:22 79:3
68:4	36:6 89:22	48:15 49:5	recognized
83:16, 18	90:3, 12, 15	50:19	47:7, 15,
provide		51:6, 19	18, 21 60:1
		54:2 59:11	recognizing
		60:12, 20	

49:14	referring	remains	reread 58:19
record 5:3,	25:17 38:2	13:14	74:15
16 44:22	87:2	14:13	reserved
45:3 57:9,	refers 53:21	remember	90:17
10,12	54:1 77:7	20:2	resistance
80:9,13,17	81:15	remembering	20:13
90:7,10	86:18	15:15	resolution
rectangle	reflected	remind 20:16	63:18
37:19 40:1	89:18	37:8 74:15	respect 85:6
rectangular	regard 53:1	remotely 5:8	respective
34:19,22	regime 24:8	replaced	34:3
35:4,13,17	region 15:4	59:19	result
38:21	regions 13:4	60:5,10	42:19,20,
39:4,7,21	related	report	21 43:10,
72:7,10	12:15 53:7	69:10,16	13 44:1
73:10 79:1	relates	reported	49:19
82:16	24:16	20:13,17	86:13
83:2,10	relation	64:3 65:15	resulted
84:14 85:4	11:17	reporter	65:21
redirect	relationship	5:12	results 80:1
90:12	23:14	reports	89:14,15,
refer 6:14	32:22	32:16,19	17
25:16 83:5	33:17	74:4,7	retained
reference	51:11	represent	7:16
18:11,22	52:6,9,16	81:17	reveals
33:9 40:10	relative	represented	14:22
65:9 69:6	51:2	56:18 58:3	review 22:22
referenced	relevant	represents	reviewed
8:19	36:9	75:1,3	8:22 9:14
references	relied 9:3	reproducible	19:4 20:7
53:17	remaining	68:5	21:5
61:12	13:9	required	30:14,16
referred		14:14	32:11,15
18:15			53:4
45:15 47:7			

64:21, 22		44:4	shape 33:7
66:19 67:7	<u>S</u>	Schottky's	shapes 34:8
reviewing	Saito 78:7,	42:14	35:13, 14
19:7	9, 10, 11,	science	short 90:2
reviews	14, 17, 19,	24:13	shorts 65:21
22:15	21 79:6, 17	scientifically	show 88:10
23:3, 12	Saito's	36:18	89:17
25:20	79:21	scientist	showed 63:20
33:15	salt 47:1	39:12	88:4
37:11	sandwich	scope 14:17	showing
39:20 48:2	50:5	secondary	74:17
58:11	sandwiches	11:19	shown 34:5
65:10	46:12	12:15	37:19 58:6
revised	satisfies	13:21	63:9 69:13
14:21	10:15	section	shows 13:2
right-hand	13:22	53:16 59:1	37:7 56:2,
22:14	satisfy 12:1	77:12 86:9	5, 13 57:17
48:14 49:2	13:10 14:6	87:15	58:14, 16
57:17 59:1	15:5	88:3, 7	89:2
68:8 81:1	scanned	semiconductors	side 41:11
89:2	63:20	29:9	71:5
Ririe 5:19	scenario	sense 74:21	sides 34:20
rock 46:22	42:12, 14	sentence	signature
Rodney 30:9	52:16, 17	31:4 49:3	8:7 90:17
room 68:22	schematic	50:17 59:6	significance
Ross 5:4	25:22	62:15	74:19, 21
6:1, 6 7:12	Schottky	67:18	similar
44:14 45:5	32:21	76:6, 12	75:15
80:19	33:6, 9, 10,	81:2, 22	Simmons
rough 65:20	18, 22	84:2 87:14	22:12, 14,
roughly	40:16, 21	September	17 23:1, 2,
16:20	41:4 42:1,	5:7	17, 20
running 8:14	3, 6, 13, 17	set 36:5	24:1, 4, 6,
	43:4, 19	42:8	

12, 14, 18,	32:3 67:21	71:6, 12	Spencer 5:19
20, 21	69:22 70:7	73:12	spend 16:18
25:8, 10,	single-crystal	76:22	spikes 63:21
13, 17	62:14, 16	77:5, 18, 21	spin-up 58:9
26:6, 16	66:10	78:3, 17,	split-free
27:6, 9	69:21	21, 22	84:16
33:21 34:4		80:1, 2, 3	square 63:18
37:7, 9, 12	sir 80:9	82:22 83:1	stack 25:22
38:1 39:2,	sit 7:8		35:12
6 40:4, 16,	16:3 70:9	small 63:19	stacks 45:21
21 42:9, 18	situation	smaller 32:2	stage 39:12
43:21 44:5	42:11, 17	solved 25:11	stand 14:3
46:4	67:16, 21	sort 50:18	start 26:3
Simmons'	situations	Soukup 30:9,	27:17
20:21	26:9	17 31:5	starting
21:2, 5, 13,	skill 39:11	32:9, 16	8:13 21:12
17, 19, 22	43:11, 14	33:2, 5, 8,	state 7:10
22:7, 11	60:11	12, 16 34:4	49:22
23:21 24:9	Slonczewski	41:17 42:2	56:18, 22
25:16, 21	18:11, 17,	43:15	59:13, 14,
26:10, 12,	22 70:16,	Soukup's	15, 19, 20
18, 21	17, 22	30:2 32:11	60:2, 3, 4,
27:1, 2, 19	71:22	41:17	5, 8, 10, 13,
39:21	72:5, 13, 16	spacers	14 72:14
42:15 43:5	73:5, 6, 21	62:19	stated 55:14
simple 36:20	74:4, 7	speaking	88:22
46:3 55:9,	75:10, 14	21:4	statement
11 86:19	77:11	specific	9:7 11:7
87:5, 18	78:14, 20	21:19 27:6	60:16
88:14	82:6, 11,	53:4 74:16	83:13
89:4, 10,	13, 16	82:8 83:5	88:16, 18,
11, 14, 19	83:4, 6, 9	85:11	19
simplistic	84:10, 13	specifically	
71:6, 8, 10	Slonczewski's	11:10	
simply 77:19	18:15	26:14 72:6	
single 8:1	19:1, 5, 13		

statements	64:9 74:9,	59:16	terms 35:11
88:21	11	84:22	40:6,9
states 28:14	structures	85:8,11,14	73:2 85:11
47:8,11,	52:20	symmetry	86:4
14,19,22	63:11	47:20	testified
48:5,9,16,	studies 66:4	48:17,19	6:3
18 49:6,8,	study 63:14	49:7,9,15,	testify 7:7
14,17 50:4	subject	21 50:3,6	testifying
54:6,10,17	78:19	52:12	7:13
55:2,5,11,	substrate	53:1,7	textbook
16 56:3,	64:6	54:13,16	53:13
12,14	substrates	58:18,21	theoretical
57:1,19,21	62:18	59:2	25:13
58:2,9,13,	65:19	72:14,18	theories
17,19,21	66:10	88:5	81:4 82:9
59:16,17	successful	system 63:14	theory 86:19
67:1 72:4,	64:4 68:16	69:21	87:5
17,21	69:16 70:3	systems	thickness
73:3,4	73:15	50:22	35:19
78:15	successfully	51:7,22	73:8,10
79:2,4	55:19		87:7
81:7 84:4,	64:11	T	thin 10:11
11 88:5	suggest 25:3	talk 41:16	11:3,22
stenographer	suggested	72:3	12:10
6:3 57:5	45:22	talking	thing 40:7
straight	sworn 6:2	10:11	62:10
30:20	symbol 37:21	techniques	thinking
strike 29:11	symbols	52:18	10:16,22
35:3 74:6	39:10	temperature	26:17
structural	symmetries	68:22	thought 9:17
68:4	47:12,13,	Ten 44:17	10:5
structure	14,17 48:6	term 23:21	time 5:14
13:2,9	50:9,12	74:19,22	7:20 16:17
36:20		82:14	
46:15,18,			
21 47:1,3			

22:21	traveling	83:15, 20	
44:22 45:3	53:8	88:6	U
57:9, 12	treat 85:16	tunneling	U.S. 6:11
80:13, 17	treated 81:9	20:21	understand
90:7, 10, 16	treats 71:19	24:12, 14,	6:8, 17, 21
tip 63:13	73:9 82:11	22 25:14	12:4, 18
TMR 68:1	83:6, 9	26:4 27:18	14:8, 9
69:1 80:3	84:13	33:1 41:8,	16:22
today 7:8,	triangular	21 42:5, 15	32:16
14, 20 8:1	35:13	46:2 51:1	60:12
70:9	trilayers	52:1, 13	74:18, 22
today's 6:8	65:18	53:17	83:18
top 21:16	true 54:7	54:4, 8, 11,	understanding
28:16 31:4	truthfully	17, 22 56:2	78:4 82:3
41:7 57:20	7:7	63:15, 16,	understood
59:7 61:4	tunnel 17:1,	22 64:7, 9	7:1, 4
62:20 68:8	5, 6, 14, 20	66:5 68:21	39:13
70:7	18:6, 9	70:8 74:5,	uniform
total 63:22	19:22	8 77:2	37:19
tractable	20:14	81:5, 8, 11,	unsuccessful
77:5	24:13, 14,	14, 16	69:11
transition	16 27:3,	82:3, 10,	
50:4	13, 15, 20,	11, 14, 20	upper 29:2, 8
transitioning	21 31:20	83:18 84:7	56:10, 13,
41:7	32:8 46:7,	85:3 86:19	18 57:16
transmission	11 50:19	87:5, 20	89:2
71:4 87:6	61:1, 22	88:9, 11	
89:3, 6	62:2, 14	turn 8:6	V
transmitted	64:11	80:19	
52:22	69:12, 17	turns 55:17	vacuum
transport	70:4, 11, 18	type 45:22	37:13, 14
75:5	71:1 73:18	46:7	valence
travel 72:22	76:18	Typically	28:21 29:4
	79:21	77:9	variation
	81:18		88:8

variety	15:9 22:6	
83:21	30:2, 4	Y
vary 87:6	44:9, 17, 20	year 61:22
vector 77:8	45:4, 13	69:18 70:5
vectors 53:7	57:8, 13, 14	yesterday
55:10	79:13, 19	9:21, 22
versus 5:5	80:11, 18	10:6 11:2
video 5:9	89:21	Yuasa 12:16
voltage	90:4, 13	14:12
17:17 18:7	Wolf 5:21	15:11 25:1
21:20	7:16, 21	Yuasa's
23:14 24:7	16:7, 12	10:12
43:6	words 42:16	11:18
	60:7	12:10
	work 16:11,	13:2, 20
W	14 19:14,	14:22 15:1
	22 40:7, 9	
wanted 11:2	worked 16:7	Z
wave 41:10	working	Zoom 5:8
53:6 54:14	34:17	
55:10, 15	70:10	
77:8	works 44:18	
waves 85:11	written	
ways 35:17	22:19 23:7	
Western 5:5,	wrong 13:13	
18	wrote 51:5	
whisker	66:15	
62:18	Wulfhekel	
68:20	62:5	
69:22	64:16, 19,	
whiskers	21 65:14	
61:3 66:11	67:1 69:8,	
Wilson 5:17,	9, 15	
18 6:5		