

In the Matter of:

*Western Digital Technologies, Inc. vs
Godo Kaisha IP Bridge 1*

Jeffrey Bokor

October 31, 2025

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

WESTERN DIGITAL TECHNOLOGIES,
INC.,

Petitioner,

vs.

GODO KAISHA IP BRIDGE 1,

Patent Owner.

Case No.
IPR2024-01494

REMOTE DEPOSITION OF
JEFFREY BOKOR, PH.D.
OCTOBER 31, 2025

Reported by:
Brooke Silvas, CSR 10988
Job No. 1423372

UNITED STATES PATENT AND TRADEMARK OFFICE
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WESTERN DIGITAL TECHNOLOGIES, INC.,)
)
Petitioner,)
)
vs.)
)
GODO KAISHA IP BRIDGE 1,)
)
Patent Owner.)
_____)

Case No.
IPR2024-01494

Deposition of JEFFREY BOKOR, PH.D.,
taken remotely via Zoom, commencing at
9:03 a.m., on Friday, October 31, 2025,
before Brooke Silvas, Certified Shorthand
Reporter No. 10988.

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2 (All appearances are via videoconference.)

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I N D E X

WITNESS: JEFFREY BOKOR, PH.D.

EXAMINATION BY

PAGE

ATTORNEY WICHMAN

5

E X H I B I T S

(None)

INSTRUCTION NOT TO ANSWER

(None)

INFORMATION TO BE SUPPLIED

(None)

REMOTE DEPOSITION; OCTOBER 31, 2025

9:03 A.M.

JEFFREY BOKOR, PH.D.,
having been duly administered an
oath remotely by the reporter, was examined
and testified as follows:

EXAMINATION

BY ATTORNEY WICHMAN:

Q Good morning, Dr. Bokor. Where are you
located today?

A Same place I was yesterday. Armond
Wilson office in Newport Beach.

Q I'm going to put a PDF in the chat. It's
entitled Paper Number 27. If you could download
that and let me know when you have it open,
please.

A I'm not seeing it in the chat yet.

Q Oh, sorry. Operator error.

A There. I'll put it on the desktop. That
will be better. Now, where -- where did it go?
Paper number 27. Okay. I have it open.

Q Okay. Do you see on the first page this
is a notice of deposition to you?

1 A I see that.

2 Q And this is in case number IPR2024-011494
3 [sic]; right?

4 A 01494. Yeah.

5 Q Okay. I'm going to call this case the
6 1494 case.

7 A Okay.

8 Q All right. And this concerns U.S. patent
9 number 11,968,909; correct?

10 A Correct.

11 Q And I'm going to call that patent the
12 '909 patent; okay?

13 A Sounds good.

14 Q All right. Do you have access to
15 exhibits in PDF for the 1494 case?

16 A I -- I do.

17 Q Okay. Can -- just to confirm that, can
18 you open Exhibit 1105 for the 1494 case.

19 A 1105. That's my declaration. Hang on.
20 What happened? Something went wrong. Sorry.

21 There. Okay. Okay. I have it.

22 Q And this -- you can confirm this is your
23 declaration in the 1494 case on the '909 patent?

24 A Correct.

25 Q Your reply declaration?

1 A My reply declaration.

2 Q Yes?

3 A Yes.

4 Q Okay. Thanks.

5 If you could turn to the last page. Let
6 me know when you're there.

7 A Okay.

8 Q That's your signature?

9 A That is my signature.

10 Q And you signed it on October 8th of 2025;
11 right?

12 A Correct.

13 Q And you signed it under penalty of
14 perjury?

15 A Correct.

16 Q So this declaration contains your
17 opinions offered in reply; is that right?

18 A Correct.

19 Q When did you start preparing this -- the
20 opinions in this declaration?

21 A The same answer as I had yesterday.
22 Shortly after I got the deposition from Dr. Ross,
23 which I think was fairly shortly after it was
24 taken. That's -- that's kind of the starting
25 point for when I really started work on this.

1 Q How much time did you spend preparing
2 this reply declaration?

3 A Yeah. I don't know exactly.

4 Q Was it more than ten hours?

5 A I would say that's a safe -- a safe thing
6 to say.

7 Q Was it more than 20 hours?

8 A Hard to say. I can't -- I can't answer
9 that. I can't answer that under oath with
10 certainty.

11 Q Can you say whether it was more than 50
12 hours?

13 A No. I'll say like I did yesterday, less
14 than a hundred. Somewhere between ten and a
15 hundred is the best I can do.

16 Q And -- and what did -- what are you --
17 what's your hourly rate for your engagement in
18 this matter?

19 A \$650 an hour.

20 Q So I mean you -- the work that you did in
21 preparing this reply is going to result in a bill
22 of \$6,500 and \$65,000, not counting time spent in
23 deposition today; right?

24 A That's fair.

25 Q And you don't know which end of the

1 spectrum it's on?

2 A Somewhere in there. That's the best I
3 can say. I don't have any better where -- I can't
4 testify to a number any more than that, any more
5 accurately than that.

6 Q what did you do to prepare for the
7 deposition in this case today?

8 A You know, the main focus was I -- I came
9 here to these offices on Tuesday and spent two
10 days preparing.

11 Q For this case in particular?

12 A Yes. Well, for the -- for the two cases,
13 right. We had one yesterday and we have this one
14 today. If you strictly call those two cases, I
15 spent the two days working on both cases.

16 Q Okay. Just to be precise, there are
17 three different cases here.

18 A Okay. Correct. That's right. But I
19 submitted one declaration, which we looked at
20 yesterday for both -- for two cases, for two
21 patents.

22 Q Okay. So that was --

23 A That was one -- that's what I meant when
24 I said two cases. Two declarations. I wrote
25 declarations that we were looking at yesterday and

1 today. And I was here for two days prior, earlier
2 this week, to prepare for the depositions that
3 we're doing -- that we did yesterday and today.

4 Q So within those two days, how much time
5 was devoted to this case?

6 A Ball -- I mean, ballpark, roughly half
7 and half. I spent one day on one declaration, the
8 other day on the other declaration. Occasionally,
9 you know, there would be some common elements. We
10 would go back and forth. But roughly speaking,
11 one day each.

12 Q Who did you speak to in preparing for
13 your deposition today?

14 A You know, the same attorneys.
15 Mr. Wilson, Ms. Arnold, Mr. Ririe, and to some
16 extent Ms. Armond.

17 Q Okay. So you -- if you could turn in
18 your declaration, Exhibit 1105, to paragraph 7.
19 Just let me know when you're there.

20 A Paragraph 7. Okay. I'm there.

21 Q All right. So you offered testimony that
22 a person of ordinary skill in the art would
23 understand Butler to teach that changing the
24 barrier height would change TMR in the
25 iron/magnesium oxide/iron magneto-tunnel junction;

1 right?

2 A A person of ordinary skill in the art
3 reading Butler in light of other prior art would
4 be motivated to expect a change in TMR with
5 barrier height.

6 Q And this is in support of your opinion
7 that a person of ordinary skill in the art would
8 have been motivated to modify the barrier height
9 in the magnesium oxide layer in Bowen's
10 magneto-tunnel junction in order to achieve a
11 barrier height of .33 electron volts; is that
12 right?

13 A You wound up landing on a different
14 question than I thought you would. So could you
15 please break it down? Just repeat it. Either
16 read it back.

17 Q It's your testimony that a person of
18 ordinary skill in the art would have been
19 motivated to modify the magnesium oxide layer in
20 Bowen's magneto-tunnel junction to achieve a
21 barrier height of .33 electron volts on the theory
22 that lowering the barrier height would result in
23 increased TMR; is that correct?

24 A So a person of ordinary skill in the art
25 would be motivated to lower the barrier height as

1 low as .3 electron volts in order to achieve a --
2 a change in TMR, yes.

3 Q And it's your testimony that a person of
4 ordinary skill in the art would have sought to
5 achieve a barrier height of .33 electron volts in
6 Bowen's magnesium oxide barrier layer by
7 introducing oxygen vacancies in the magnesium
8 oxide; correct?

9 A That's correct.

10 Q And so what I would like to know about
11 your testimony concerning Butler -- strike that.

12 So when you were offering testimony about
13 changing the barrier height in Butler, what you
14 mean is that the barrier height would be changed
15 by introducing oxygen vacancies; is that right?

16 A I think that's a fair statement.
17 That's -- that's the only -- that's the only
18 mechanism that we've seen from varying the barrier
19 height in any of the references that we've looked
20 at. So saying that by my opinion is directed to
21 lowering the barrier height by introducing oxygen
22 vacancy defects I think is -- is fair. I'm
23 hesitating because the claim is broader than that.
24 But in my opinion, I only considered changing the
25 barrier height using oxygen vacancy defects.

1 Q Okay. So I would like to understand how
2 those oxygen vacancies would be introduced in a
3 quantifiable manner. So let's start by asking how
4 many oxygen vacancies would a person of ordinary
5 skill in the art need to add to Bowen's magnesium
6 oxide barrier layer to achieve a barrier height
7 .33 electron volts.

8 A Well, if there's an answer to that -- and
9 I'm not sure there is. But if there is an answer
10 to that, I would refer to Soukup. So we could
11 open up and look at Soukup. Because I don't
12 recall specifically what degree of quantification
13 there was in Soukup about how many oxygen
14 vacancies you would get for a given barrier height
15 change.

16 Q Okay. Well, let me ask you this: How
17 many oxygen vacancies would a person of ordinary
18 skill in the art need to add to Nagahama's 001
19 textured magnesium oxide barrier layer to achieve
20 a barrier height of .33 electron volts?

21 A Same -- same answer. I don't know right
22 here as I -- off the top of my head sitting here.
23 I'm not even sure I gave an opinion at that level
24 of detail. If there is any information like that,
25 it's in -- it's in Soukup. There's nothing in my

1 declaration that gives that kind of information.

2 Q And so I would like to know physically
3 how these oxygen vacancies are going to manifest
4 themselves in the barrier layers. So let me ask
5 you, how would oxygen vacancies be distributed
6 within this modified Bowen magnesium oxide barrier
7 layer that are intended to achieve this .33
8 electron volt barrier height?

9 ATTORNEY WILSON: Objection. Scope.

10 THE WITNESS: Okay. So that one I can
11 answer. I did not offer an opinion on that.

12 BY ATTORNEY WICHMAN:

13 Q would the vacancies be introduced at the
14 interface with the ferromagnetic layer and the
15 magnesium oxide barrier layer?

16 A Again, I did not offer an opinion on
17 that.

18 Q what would a person of ordinary skill in
19 the art have -- strike that.

20 would a person of ordinary skill in the
21 art have sought to achieve oxygen vacancies at the
22 interface between a ferromagnetic layer and the
23 magnesium oxide barrier layer?

24 ATTORNEY WILSON: Objection. Scope.

25 THE WITNESS: I have not offered an

1 opinion on that. I don't have an opinion on that.

2 BY ATTORNEY WICHMAN:

3 Q would oxygen vacancies need to be
4 distributed throughout the bulk of the magnesium
5 oxide barrier layer?

6 ATTORNEY WILSON: Objection. Scope.

7 THE WITNESS: I don't think I have
8 offered an opinion on that. I don't have one as I
9 sit here today.

10 BY ATTORNEY WICHMAN:

11 Q would oxygen vacancies be clustered in
12 specific portions of the magnesium oxide barrier
13 layer?

14 ATTORNEY WILSON: Objection. Scope.

15 THE WITNESS: I have no opinion on that.

16 BY ATTORNEY WICHMAN:

17 Q would oxygen vacancies be clustered
18 together within the magnesium oxide barrier layer?

19 ATTORNEY WILSON: Objection. Scope.

20 THE WITNESS: I have no opinion on that.

21 And furthermore, let me add, as far as -- as far
22 as I'm aware, there's no teaching about that in
23 the patent either.

24 BY ATTORNEY WICHMAN:

25 Q what happens to a magnesium oxide lattice

1 at an oxygen vacancy?

2 ATTORNEY WILSON: Objection. Scope.

3 THE WITNESS: That's deeper -- a deeper
4 detail than I have analyzed. I don't have an
5 opinion.

6 BY ATTORNEY WICHMAN:

7 Q Does the lattice point of where the
8 oxygen is missing stay vacant within the magnesium
9 oxide material?

10 ATTORNEY WILSON: Objection. Scope.

11 THE WITNESS: Could you repeat that one,
12 please?

13 BY ATTORNEY WICHMAN:

14 Q We're talking about oxygen vacancies
15 within magnesium oxide; right?

16 A Right.

17 Q Okay. So at a vacancy defect, would that
18 point in the lattice remain vacant, where you
19 remove the oxygen out, would there be a gap in the
20 lattice?

21 ATTORNEY WILSON: Objection. Scope.

22 THE WITNESS: I understand the question.
23 That, I can answer. I believe a person of
24 ordinary skill in the art understands a vacancy to
25 be a vacancy. That's what a vacancy is. It is a

1 gap -- it is a place in the lattice where -- in a
2 perfect lattice, you would have an oxygen atom.
3 And a vacancy is a location in the lattice where
4 the oxygen is missing. And there's -- there's
5 nothing there. That's what a vacancy is.

6 BY ATTORNEY WICHMAN:

7 Q Okay. So in a -- in such a lattice where
8 there is an oxygen vacancy that remains vacant,
9 does the lattice deform in the region of the
10 vacancy --

11 ATTORNEY WILSON: Objection. Scope.

12 BY ATTORNEY WICHMAN:

13 Q -- as compared to the proper crystal
14 lattice?

15 ATTORNEY WILSON: Objection. Scope.

16 THE WITNESS: I certainly haven't offered
17 any opinion on that in either declaration.
18 There -- there may be literature on that, even
19 some literature I cited, but I don't recall the
20 details.

21 BY ATTORNEY WICHMAN:

22 Q Are you familiar with the idea of a
23 substitution -- a substitution defect?

24 A Yes.

25 ATTORNEY WILSON: Objection. Scope.

1 BY ATTORNEY WICHMAN:

2 Q Okay. So when there's an oxygen vacancy
3 in the magnesium oxide lattice, could the point
4 where the oxygen atom is missing be filled by a
5 different atom?

6 ATTORNEY WILSON: Objection. Scope.

7 THE WITNESS: It could be. But then it
8 would no longer be a vacancy.

9 BY ATTORNEY WICHMAN:

10 Q Okay. So when you are considering adding
11 oxygen vacancies to magnesium oxide in order to
12 achieve a .33 electron volt barrier height, you
13 are only considering a defect that is literally a
14 vacancy; that the oxygen atom is missing and
15 nothing is taking its place. Is that right?

16 ATTORNEY WILSON: Objection. Scope.

17 THE WITNESS: That sounded a little
18 tricky. Can you please -- I need to hear that
19 question again?

20 BY ATTORNEY WICHMAN:

21 Q I'll just read it back.

22 When you are considering adding oxygen
23 vacancies to magnesium oxide in order to achieve
24 a .33 electron volt barrier height, you are only
25 considering an oxygen vacancy defect that is

1 literally a vacancy, where the oxygen atom is
2 missing and nothing is taking that oxygen out of
3 its place; is that right?

4 ATTORNEY WILSON: Objection. Scope.

5 THE WITNESS: I did not consider that --
6 you know, that level of detail of the -- of the
7 atomic mechanisms involved. To the best of my
8 recollection, none of the literature that I cited
9 and reviewed and cited in preparing my
10 declarations addressed that question. So I don't
11 have an opinion on that.

12 BY ATTORNEY WICHMAN:

13 Q Okay. So if we could summarize this, in
14 forming your opinions on what Butler teaches, you
15 did not consider how Butler would have to account
16 for oxygen vacancies in his calculation, did you?

17 ATTORNEY WILSON: Objection. Scope.

18 THE WITNESS: Actually, I do have
19 something to offer on that. I -- the question of
20 how would oxygen vacancies play a role in Butler's
21 calculation, I do have some -- I do have some -- I
22 did not offer specific opinion on that in my -- in
23 either declaration. But in preparing for this
24 declaration, I did cite to a reference. I didn't
25 mention this point in my declaration. But I could

1 show you how in one of the references that I have
2 cited there's actually relevant information that a
3 person of ordinary skill in the art would consider
4 in order -- in the process of this consideration
5 that I've talked about for how the situation would
6 affect Butler's calculation.

7 BY ATTORNEY WICHMAN:

8 Q Do you have -- can you open Butler. It
9 is Exhibit 1044.

10 A Sure.

11 Okay. I've got Butler.

12 Q Okay. So Butler spin-dependent tunneling
13 conductance of iron/magnesium oxide/iron
14 sandwiches; right?

15 A Right.

16 Q Physical Review B, Volume 63.

17 A That's it.

18 Q Published in January of 2001. Right?

19 A Correct.

20 Q If you could open Exhibit 2056. And let
21 me know when you have that open.

22 A Okay. I have that.

23 Q All right. So this is from Google
24 Scholar, July 11th of 2025; right? Just look at
25 the header on the top.

1 A I see it.

2 Q July 11, 2025; right?

3 A Right.

4 Q And if you drop down, this is showing
5 that Butler's paper as of July 11th, 2025, had
6 been cited 2,921 times; right?

7 A That's what it says.

8 Q Do you have any reason to doubt the
9 citation number?

10 A Google Scholar is known to be not
11 strictly accurate. It does a good job. It
12 usually comes close, but you can't -- you can't --
13 in other words, there can be papers that don't
14 show up in a Google citation -- Google Scholar
15 citation list. There could be papers missing.
16 There are sometimes -- actually often there are
17 extra papers in there because the search algorithm
18 isn't perfect. So Google citation numbers are --
19 are pretty good. We all rely on them. We talked
20 about it in my first declaration, if I'm not
21 mistaken. Qualitatively I would believe that
22 number, but not precisely.

23 Q You agree that Butler is a famous paper;
24 right?

25 A Absolutely. I would call Butler a highly

1 cited paper. 2900, give or take 50 or a hundred,
2 is still a big number for a paper of -- of this
3 type on this topic in this literature. In some --
4 in some areas of literature, this is not a big
5 citation number. But in this field, for sure,
6 that's a highly cited paper. I think it is
7 reasonable to call it famous.

8 Q Okay. If you could go back to Butler
9 now, Exhibit 1044, page 1.

10 A I'm there.

11 Q PDF 1. Left-hand column. This is the
12 introduction.

13 A Yes.

14 Q Third column on the left-hand column in
15 this paper. Do you see that?

16 A I do.

17 Q First sentence. "In this paper we use
18 first-principle electronic structure techniques to
19 calculate the tunneling between iron 100
20 electrodes separated by MgO tunneling barriers."
21 Correct?

22 A Correct.

23 Q I want to focus on the next sentence.
24 "In order to calculate the electronic and magnetic
25 properties of iron/magnesium oxide/iron

1 sandwiches, it is necessary to have a reliable
2 physical model for the interface between iron 100
3 and magnesium oxide." Correct?

4 A Correct.

5 Q So Butler's -- Butler is focused on
6 developing an accurate reliable physical model of
7 the interface between an ideal iron 100 atomic
8 layer and an ideal 100 magnesium oxide atomic
9 layers; is that right?

10 A Butler says it is necessary to have a
11 reliable physical model for that.

12 Q Do you disagree with Butler on that
13 point?

14 A No. We could debate exactly what that
15 means, but that's what it says.

16 Q All right. And do you agree that that's
17 what he did; he created a reliable physical model
18 for the iron 100 and magnesium oxide 100
19 interface?

20 A He developed a -- he developed a reliable
21 physical model. Emphasize the word model.

22 Q Why is that important to you?

23 A In this -- in this art, people make
24 calculations all the time. And they -- they --
25 the term model is like a -- it's -- it's a -- it's

1 not necessarily what absolutely is -- is there.
2 You make a model. Okay. A model is -- it's a
3 little bit -- it's not quite accurate to call it a
4 guess. But a model is just a model. It's just,
5 okay, if the surface -- if the structure is this,
6 this is the best model that I can make based on
7 available information. And based on what I can
8 use to make a calculation given the tools that I
9 have. So a model -- a model is just a model.
10 It's like, you know, you -- as a child, you build
11 a model of a spaceship. It's a model. The model
12 in this context is not unlike that. You build a
13 model -- you don't build a rocket ship. You build
14 a model of the rocket ship. And then -- in this
15 case, you build a model of the atomic structure,
16 make -- make a calculation, and you have a model
17 calculation. Theorists do this all the time. It
18 is common. You do the best you can to develop a
19 theory for a real physical situation. You make
20 the best model you can. And then you look at the
21 consequences of the model. And then it's -- then
22 that's out there. That's the theoretical model.
23 That's a theoretical prediction. Theoretical
24 predictions are just predictions based on models.
25 The equations that he used in this calculation are

1 also a model of the physical world. The
2 Schrodinger equation, which is the underlying
3 quantum mechanical equation that underlies all of
4 the theory for electronic structure that Butler
5 did is a model. It's -- as physicists, it's our
6 best model for describing the physical world.
7 It's the best -- you know, we've come up with the
8 best that we can do. But it is just a model.
9 Someday somebody will do an experiment that will
10 give a result that violates that doesn't agree
11 with the results of a model and then we have to
12 change the model because we didn't fully
13 understand everything about the physical world
14 when we constructed that earlier model. That's
15 how physics progresses. You know, before we had
16 quantum mechanics, the model was classical
17 mechanics. $F = ma$. That was our model for
18 how particles would move around. It's a model.
19 Then quantum mechanics theory came along, and we
20 got a new model. But it's a model.

21 Q If you could turn to Butler Exhibit 1044,
22 page 2. It is PDF 2.

23 A I'm there.

24 Q You see there's a section 2 structure of
25 the iron magnesium oxide interface?

1 A I see that.

2 Q Okay. So here, Butler is describing how
3 he developed his reliable physical model of the
4 iron magnesium oxide interface; right?

5 A Yes, in this section, Butler is
6 describing how he arrives at -- at the model that
7 he uses. He talks about various models that have
8 been published in the literature. And what he's
9 motivating is to help a reader, a person of
10 ordinary skill, understand how he came up with his
11 model.

12 Q You agree that when Butler says it is
13 important to have a reliable physical model for
14 the interface, he was not focused on a reliable
15 model of the bulk magnesium oxide barrier. Do you
16 agree with that?

17 A No. He is interested in a reliable
18 physical model for the whole structure that he is
19 going to simulate.

20 Q The whole structure?

21 A Yeah.

22 Q So you're saying his -- his reliable
23 physical model is the lower ferromagnetic layer,
24 the magnesium oxide barrier layer, and then the
25 upper ferromagnetic layer of the magneto-tunnel

1 junction; is that right?

2 A Butler -- Butler tries to make as
3 reliable a physical model for the entire structure
4 as he can.

5 Q Okay. If you could look at --

6 A Idealized model. That's the point I want
7 to emphasize. His -- what he is doing is creating
8 a model that is -- is reliable but simple enough
9 that he can make the calculation. These
10 calculations are extremely complex and expensive
11 in the sense of how much compute time is required.
12 The amount of compute time scales typically in a
13 highly nonlinear way how fancy, how much detail
14 there is in the model. So a calculation like what
15 Butler is doing here, well known in the art, is a
16 compromise of trying to make as reliable a model
17 of the physical structure as he can, yet simple
18 enough that he can make the calculation that he
19 further describes in the rest of the paper. So
20 that's how this kind of theory is done. And
21 that's well known in the art. Everybody
22 understands that. That's -- that's how -- we
23 could pull up a bunch of other theoretical papers,
24 I'm sure, that are in the record here. That's
25 what theorists do.

1 Q Dr. Bokor, look at Figure 1 on page 2 of
2 Butler, Exhibit 1044.

3 A I see that.

4 Q It's in the top left column. Do you see
5 that?

6 A Yes.

7 Q Okay. You agree that Figure 1, you write
8 in the caption, it is showing the interface for an
9 iron 100 and magnesium oxide structure; correct?

10 ATTORNEY WILSON: Objection. Form.

11 THE WITNESS: Correct.

12 BY ATTORNEY WICHMAN:

13 Q It's a bunch of circles in this figure?

14 A Sure. I'll agree with that
15 characterization.

16 Q The larger circles are iron; correct?

17 A That's what it says in the caption.
18 Larger atoms are iron, yes.

19 Q Within each large circle is shown a
20 smaller dark circle; correct?

21 A Correct.

22 Q And those darker atoms are meant -- are
23 shown in a perspective as above the iron atoms;
24 correct?

25 A That's -- I'll agree with that.

1 Q It says darker atoms above iron atoms
2 represent oxygen; right?

3 A Right.

4 Q So you're looking -- so this viewpoint is
5 looking down at the interface. There's a layer of
6 magnesium oxide. And underneath it is a layer of
7 iron. Correct?

8 A It says that the darker atoms above the
9 atoms represent oxygen. I didn't catch in your
10 question which one you said was on top. I think
11 you might -- did you say that or did you say the
12 iron was underneath? I didn't -- I forget. If
13 you could repeat the question. Or I'll just
14 testify that what it says in the caption is that
15 the iron atoms are -- yeah. The atoms before the
16 iron are the oxygen. And the oxygen atoms are the
17 darker ones. They are above the iron atoms. The
18 iron atoms are underneath.

19 Q And every iron atom has an oxygen atom
20 above it; correct?

21 A In this -- in this picture, yes.

22 Q And then the smaller circles are -- the
23 small white atoms they are -- they represent
24 magnesium, right?

25 A Right.

1 Q Okay. So this picture is showing an
2 interface in which an ideal 100 iron atomic layer
3 is covered by an ideal magnesium oxide atomic
4 layer in which there is an oxygen atom above each
5 iron atom; correct?

6 A In this picture, that's correct.

7 Q Okay. And if we drop down to the first
8 paragraph underneath structure of iron magnesium
9 oxide interface, one, two, three -- there's -- the
10 third sentence says, "Low energy electron
11 diffraction (LEED) studies strongly suggest the
12 iron atom sit atop the oxygen atoms when atoms is
13 deposited onto a clean magnesium oxide 100
14 surface." Right?

15 A That's what it says. You read it
16 correctly.

17 Q So that's the same relationship that
18 there's an iron -- iron atom and an oxygen atom --
19 I'm sorry.

20 For the upper iron layer on top of
21 magnesium oxide, there's an iron atom above each
22 oxygen atom; correct?

23 A Correct.

24 Q And in the figure, it shows the -- you
25 can think of it as the lower ferromagnetic layer

1 in which there's an oxygen atom on top of each
2 iron atom; correct?

3 A I'm sorry. Could you -- that was a
4 little confusing. Could you just -- one more.

5 Q The sentence -- the sentence "low energy
6 electron diffraction" refers to iron atoms sit on
7 top of oxygen atoms; correct?

8 A That's what it says.

9 Q And the figure shows oxygen atoms on top
10 of iron atoms; correct?

11 A Oh, I see. I see the difference. Yeah.
12 So one puts the iron -- okay. So the text says
13 the iron atoms are on top of the oxygen atoms.
14 And the caption of the figure has the oxygen atoms
15 on top.

16 Q Either way, you agree that the interface
17 has an oxygen atom associated with each iron atom;
18 correct?

19 A An oxygen atom next to every iron atom,
20 yeah.

21 Q That's the interface of this model;
22 right?

23 A That is the interface.

24 Q There are no oxygen vacancies in this
25 model of an interface, are there?

1 A well, that is true. But I would also
2 point out that the calculation. We would have to
3 go down and look. And I don't recall and I
4 certainly haven't given any opinion on it. But
5 the nature of a calculation like this is to
6 actually calculate a very small structure. Not
7 unlike -- we would have to go and look. I think I
8 see on the right-hand column there is probably
9 some -- some of that. We would have to go and
10 look. But it calculates a small subset of the
11 structure. This -- again, because the cost of the
12 calculation, they can't do a calculation for a one
13 millimeter or a one micron or even a hundred
14 nanometer-size section of the interface. They
15 have to calculate a very small portion of the
16 interface. So that's important to keep in mind.
17 You know, as you're trying to compare a
18 calculation like this to a physical structure that
19 may have some imperfections in it, all kinds of
20 defects and so forth. So it is a model.
21 That's -- that's another sense in which this
22 calculation is a model. So they're calculating a
23 model of a very tiny interface and a very tiny
24 crystal. And then they use it to come up with
25 conclusions that are model -- that based on that

1 model. So I point out an important aspect of the
2 model here. If you're going to start talking
3 about interface defects and the like. It can't
4 capture an interface that's of the relevant
5 physical side in a device experiment because it
6 just can't calculate anything that big. So that
7 is part of the problem.

8 Q Dr. Bokor, do you agree that Butler in
9 his calculation did not model the effects of an
10 oxygen vacancy at an interface between an iron
11 ferromagnetic layer and a magnesium oxide barrier
12 layer?

13 A I haven't offered an opinion on that. I
14 would have to -- I would have to look, review the
15 whole article. No, I don't think -- I don't think
16 Butler did that. He didn't model vacancy defects.
17 That's fair.

18 Q So on page 2 -- staying on page 2 of
19 Exhibit 1044, Butler. Left-hand column, third
20 paragraph at the bottom, he says, our interest is
21 centered on a slightly different structure from
22 prior studies. Well, he doesn't say prior
23 studies. He says, "Our interest is centered on a
24 slightly different structure." And that means
25 compared to the prior studies he just described;

1 right?

2 A Right.

3 Q Okay. And -- but the difference is that
4 of -- in his model, it is only a few magnesium
5 oxide atom layers deposited onto an iron substrate
6 followed by a deposition of a relatively thick
7 iron top electrode; is that correct?

8 A You read it correctly.

9 Q But he kept the -- he retained this
10 aspect of the prior model that there is an oxygen
11 atom on top of every iron atom; correct?

12 A Yes, he did.

13 Q He did. Okay. So --

14 A But I think you should read the next --
15 we should take into account the next couple of
16 sentences. "Experimentally, seven atomic layers
17 of MgO can be grown pseudomorphically on the iron
18 100. For thicker MgO layers, misfit dislocations
19 form to partially relieve the 3 and a half percent
20 compressive in-plane strain that arises due to the
21 larger MgO lattice constant. Thus, the previous
22 studies were for an interface in which the iron
23 lattice was expanded in-plane, whereas it seems
24 more appropriate to model this system as having
25 interfaces in which the iron is at its equilibrium

1 lattice constant and the MgO layers are contracted
2 in-plane."

3 so he is model -- he is telling -- he is
4 trying to do his best to model this strain effect.

5 Q Dr. Bokor, what question are you
6 responding to?

7 A I'm responding to whether or not he took
8 into -- your question was did he take into account
9 defects. Right?

10 Q No.

11 A All right. Repeat the question, please.

12 Q Dr. Bokor, do you understand that in a
13 deposition, I ask you questions, and you respond
14 to my questions?

15 A I'm trying to do my best.

16 Q Dr. Bokor, I just ask you to listen to
17 the question that I'm asking you before you
18 answer. Will you agree to do that?

19 A Absolutely.

20 Q Okay. Let's talk about what Butler says
21 that he actually did. Okay?

22 A Yes.

23 Q Okay. On -- in Butler at page 2 in the
24 right-hand column at the top, the full paragraph,
25 he says that, "We therefore performed a series of

1 full potential LSDA-DFT calculations." Correct?

2 A Correct.

3 Q And this is density functional theorem, a
4 very sophisticated way of modeling the properties
5 of solid state materials; is that correct?

6 A It is.

7 Q And then he says, "In these calculations
8 the sandwich structure was modeled." And he's
9 going to tell us what the model was; right?

10 A That's right.

11 Q And he says that there's a 15
12 atom/supercell. Now a 15 atom/supercell is the
13 physical structure that he was modeling; correct?

14 A Yeah. That's what I was talking about a
15 minute ago that he can only model a relatively
16 small number of atoms. He is only modeling an
17 atom that basically has a dimension of 15 atoms.

18 Q It is not 15 atoms. It is 15 layers
19 actually. 15 atomic layers. Right?

20 A The dynamic of the structure is 15. It's
21 like a cube. Roughly. I mean, he's going to give
22 more details. A 15 atom/supercell is a supercell
23 that's got only 15 atoms in it. And in the next
24 sentence five iron layers.

25 Q Right. So there are -- so it is with

1 five 100 iron layers. Those are atomic layers of
2 iron; right?

3 A Yes.

4 Q And that's an ideal layer where the iron
5 atoms are disposed just as in Figure 1 that we
6 just looked at, isn't it?

7 A Right.

8 Q Okay. And then he alternates that with
9 five 100 magnesium oxide layers; right?

10 A Right. Let me clarify the answer -- my
11 answer to your previous question. You asked me if
12 is this -- if he shows -- if he gets five layers
13 like what's in Figure 1. There is only -- in
14 his -- in this structure he is describing, there
15 are five pure iron layers. Not five layers like
16 the ones shown in Figure 1 where you've got an
17 iron atom on top of every oxygen atom. He's got
18 five iron atoms and five MgO layers. And at the
19 interface, he's got a structure like what is shown
20 in Figure 1.

21 Q Right. Thank you.

22 So then Butler describes the in-plane
23 lattice constant was held equal to that calculated
24 for a DFT calculation of bcc iron; right?

25 A That's what it says.

1 Q And the lattice constant is the spacing
2 between the atoms in the atomic layer of iron; is
3 that right?

4 A Correct.

5 Q So property of bcc iron; is that right?

6 A Correct.

7 Q And then in his model, he allowed
8 relaxation of the atomic coordinates; right?

9 A In the direction perpendicular to the
10 layers. Not in the parallel direction. They're
11 held -- the in-plane lattice constant was held.
12 The atomic coordinates perpendicular to the layers
13 was allowed to relax.

14 Q As a result of that calculation, he
15 obtains a distance between each iron and oxygen
16 atom at the interface; is that right?

17 A That's what it says.

18 Q And that distance he reports as
19 2.169 angstroms; right?

20 A Correct.

21 Q He's using three significant digits to
22 report the distance in angstroms between the iron
23 and the oxygen; correct?

24 A He is.

25 Q So you will agree that Butler's

1 calculations are highly sensitive to the physical
2 placement of the atoms in his model; correct?

3 A That's a very broad statement. I
4 wouldn't agree with the statement as broad as you
5 said it.

6 Q You disagree that Butler's calculations
7 depend -- have a very high sensitivity to the
8 placement of atoms in his physical model?

9 A It depends. My understanding of a
10 calculation like this, he would -- I would expect
11 him to -- deeper down in the paper, where he is
12 reporting the results, he would indicate where the
13 results are very sensitive to some parameters and
14 not necessarily quite as sensitive to the other.
15 The fact that there are three significant digits
16 there is he gets -- he can get four significant
17 digits from a calculation. Experimentally, there
18 is no way that we can get anywhere near that
19 degree of accuracy. He is using -- he is showing
20 you that because that was a result of a
21 calculation he's got that much precision in his
22 calculation, so that's the number that he uses in
23 the calculation.

24 Q But he wouldn't report three digits --
25 significant digits if they didn't matter; right?

1 ATTORNEY WILSON: Objection. Form.

2 THE WITNESS: Again, it depends on what
3 you mean by matter. I think if the -- he doesn't
4 tell you how sensitive it is. Look what he says
5 in the next sentence, is that this value is
6 intermediate between one number that you get from
7 the previously cited theoretical calculation and
8 then experimental data, which, again, are actually
9 fixed to a data. So the number is intermediate
10 between two numbers that, you know, that -- and he
11 is choosing one in between. The implication there
12 is that at least within those bounds -- and he
13 doesn't cite it here and I don't know what they
14 are, what the difference between the two are. But
15 a person of ordinary -- a person of ordinary
16 skill -- now we're relying on an expert at the
17 level of Butler would understand this sentence to
18 say he picked this one number, but it is -- you
19 know, in between these two values, it could easily
20 be something else in between there. And the
21 implication is he doesn't think that that is going
22 to change the results much.

23 BY ATTORNEY WICHMAN:

24 Q On page 2, on the right-hand column,
25 there's a header III, Electronic and Magnetic

1 Structure. Do you see that?

2 A I do.

3 Q And so now here Butler is going to tell
4 us how he did his calculations of the electronic
5 structure --

6 A He is.

7 Q -- for this -- for this stack; right?

8 A Right.

9 Q And even -- he comes out and says, "To
10 determine the electronic structure within a
11 framework that could be used to determine the
12 transmission and reflection amplitudes of Bloch
13 waves in iron incident on the magnesium oxide
14 layer," he does a sophisticated calculation;
15 right?

16 A Right.

17 Q All right. And he -- to do that
18 calculation he tells us the physical model that he
19 uses; right?

20 A Right.

21 Q Four 100 layers of magnesium oxide.
22 Let's stop right there. Those 100 layers of
23 magnesium oxide is this model of an ideal 100
24 magnesium oxide atomic layer; correct?

25 A well, four layers.

1 Q well, each layer is an ideal 100
2 magnesium oxide atomic layer; right?

3 A That's fair.

4 Q Okay. And he uses four of them, as you
5 just said; right?

6 A Only four. Only four. That's important.
7 None of the -- none of the MgO barrier layers that
8 we have talked about that are studied and that are
9 reported in any of the experimental papers that we
10 have been talking about have an MgO barrier layer
11 that thin. They're typically -- even down to --
12 we would have to go and look what the thinnest one
13 was. Maybe a fraction of a nanometer. None of
14 them are as thin as four layers. Here is an
15 example where the calculation is making a model of
16 what the real experiment would have. Certainly
17 four layers is a lot less than the most of --
18 maybe there are one or two places where the
19 barrier got to be less than a nanometer thick, but
20 much less than a nanometer thick. Four layers is
21 way less than a nanometer thick. It is four times
22 a little less than three angstroms. Like 12 --
23 four times three angstroms.

24 Q Dr. Bokor, do you remember my question?

25 A Yeah. You were -- I'm just amplifying on

1 the result about four layers so that we understand
2 the context. Okay. It is about a nanometer
3 thick. All right. I take it back. Sorry. Four
4 layers. Actually, that's pretty good model.

5 Q So you agree that he modeled four layers?

6 A I agree that he modeled four layers. And
7 four layers in this case -- yeah. So I apologize.
8 I should be more careful. I have not reviewed
9 every line of this article in great detail in
10 preparing for this deposition. I -- I gave
11 opinions based on some of the summary conclusions.
12 So I should basically -- I should stop trying to
13 explain the details that you're trying to get into
14 on line by line going through this paper. Because
15 I didn't offer opinions on it in my declaration
16 and I haven't studied it sufficiently well to be
17 able to give you interpretations at this level of
18 detail. So with that background, we will stop and
19 we will see what your next question is.

20 Q These four 100 layers of magnesium oxide,
21 as we just said, are -- each -- each layer is an
22 ideal atomic layer of 100 magnesium oxide;
23 correct?

24 A Yeah. I'll agree with that.

25 Q There are no oxygen vacancies in any --

1 any of these four 100 layers of magnesium oxide in
2 Butler's model, are there?

3 A well, he doesn't -- he doesn't say that.
4 One could assume that there isn't.

5 Q These were embedded within an iron 100
6 lattice; is that right?

7 A Yes.

8 Q And then in his model, he gets to choose
9 the positioning of the atoms in the iron lattice,
10 right, because it's a model? Is that right?

11 A Yes.

12 Q And he chose --

13 A Go ahead.

14 Q -- an experimental lattice constant -- he
15 chose to use a value of an iron lattice constant
16 that had an experimental basis; correct?

17 A Because of the experimental iron lattice
18 constant, yes.

19 Q He gives that value as 2.866 angstroms;
20 right?

21 A He does.

22 Q So the experimental value was to a
23 precision of three significant digits; right?

24 ATTORNEY WILSON: Objection. Form.

25 THE WITNESS: That's what it's -- that's

1 what it says, yes.

2 BY ATTORNEY WICHMAN:

3 Q All right. Just how small is a
4 thousandth of an angstrom relative to an iron atom
5 dimension?

6 A It is very, very small. The size --
7 typical size of atoms is on the order of one
8 angstrom, plus or minus, you know, give or take.

9 Q So one thousandth of an angstrom is on
10 the order of one thousandth of dimensions of an
11 atom; is that right?

12 A That's right.

13 Q Okay. Then he tells us -- he got to
14 choose what distance he was going to impose
15 between an iron atom and an oxygen atom at the
16 interface between the iron atomic layer and the
17 magnesium oxide atomic layer; right?

18 A Well, he tells us that that distance was
19 taken. So to some extent, he was choosing.

20 Q That means in his model, that's the
21 distance that he set between the layers; right?

22 A I think that's the understanding, yes.

23 Q And then he chose a lattice constant for
24 magnesium oxide in plane and out of plane to just
25 be a square root of two -- a factor of a square

1 root of two larger than that of the iron lattice;
2 right?

3 A That's what it says.

4 Q Okay. So that's -- it is a very precise
5 physical arrangement of atoms that he is modeling;
6 correct?

7 A That's fair.

8 Q And there's no oxygen vacancies in this
9 model, are there?

10 A Evidently not.

11 Q He's representing atomic potentials using
12 this -- the very precise sphere radii for
13 magnesium and oxygen; correct?

14 A I can read the sentence. I'm not going
15 to be able to, you know, go deeply into
16 interpreting it for you. You're right, that's
17 what he says.

18 Q Okay. And then he even -- to make his
19 model even more faithful to physical reality, he
20 adds an empty sphere with a radius of
21 0.9476 angstroms in the interfacial iron layer
22 just below the magnesium atom to account for a
23 displacement in the magnesium atom; is that right?

24 or let me strike that -- so strike.

25 In this physical model that he is

1 creating, he wants to correctly account for the
2 volume of each layer; correct?

3 A Okay. I'm going to -- here is where I'm
4 going to basically draw a line and say you're
5 asking me to make a -- a detailed very
6 sophisticated interpretation of the details of
7 this calculation which I have not reviewed and
8 don't offer any opinions about.

9 Q So --

10 A My general opinion this is a paper that
11 had a big impact on the field as you just showed.
12 And I give -- I give opinions based on the bottom
13 line -- essentially the higher level conclusions
14 of the paper, without going into the gory details
15 of every little number that he put in his model
16 and in his calculation. And so now -- as you're
17 asking me to start and analyzing these three, four
18 significant digit numbers and interpreting them,
19 I'm going to have to say I can't give an opinion
20 on that. I haven't reviewed it. It isn't
21 anything that I have given any opinions on in any
22 of my declarations.

23 Q But you give opinions on the results of
24 this calculation; correct?

25 A I give opinions on how a person of

1 ordinary skill in the art would understand the
2 high level teachings of this reference.

3 Q And in giving those opinions, you didn't
4 take into account how the model was designed and
5 evaluated in order to arrive at the conclusions
6 that Butler gave in his paper; is that right?

7 A Not at the -- at the gory level of
8 detail. I'm not a theorist, as I -- I testified
9 before. I do not have the level of expertise
10 required to analyze and evaluate the gory details
11 of this paper. I trust in this paper that it's
12 well accepted by others who are those experts.
13 And I just go by the -- you know, the bottom line
14 conclusions to -- that would be relevant to an
15 experimentalist or person of ordinary skill in the
16 art trying to build a magnetic tunneling junction.

17 ATTORNEY WICHMAN: All right. We've been
18 going for an hour. Do you feel that you need a
19 break?

20 THE WITNESS: Yes. I do appreciate a
21 break every hour.

22 ATTORNEY WICHMAN: That's fine.

23 THE WITNESS: I don't want to guess your
24 age. I'm a little older. And it is good to have
25 a break once an hour to take care of business.

1 ATTORNEY WICHMAN: Five minutes enough?

2 THE WITNESS: Five minutes is about good
3 enough, yes.

4 ATTORNEY WICHMAN: All right. Let's --
5 it's four past now. well, let's come back at ten
6 past. Off the record.

7 THE WITNESS: Yeah.

8 (A recess was taken.)

9 ATTORNEY WICHMAN: On the record.

10 Q Dr. Bokor, other than our little
11 conversation here, did you speak with anybody
12 during the break?

13 A Not about the deposition.

14 Q Okay. If we go back to Butler -- well,
15 even before we start, do you agree that Butler's
16 model, his physical model that he is using to
17 calculate the electronic structure of the
18 iron/magnesium oxide/iron MTJ is highly sensitive
19 to the physical placement of the atoms in that
20 model?

21 A It's sensitive to the place -- so I'm not
22 an expert and I can't really testify what it means
23 by sensitive. How sensitive is it, to which
24 placement of which atoms. It's -- it certainly
25 depends on the placement of the atoms. The

1 sensitivity, I feel uncomfortable to testify about
2 this exactly how highly sensitive it is.

3 Q Do you agree that the electronic
4 structure of this device arises from the physical
5 placement of the atoms?

6 A As a general proposition, I would agree
7 with that.

8 Q Okay. So back to Butler. Exhibit 1044,
9 page 2. PDF 2. Right-hand column. The bottom.
10 Last line. And then continuing over to page 3.
11 Butler writes, "The electronic density of states
12 (DOS) is calculated for each layer and for the
13 majority and minority spin channels." Correct?

14 A You read it correctly.

15 Q All right. So Butler is using this
16 physical model to evaluate the density of states
17 for each layer; is that right?

18 A That's what it says.

19 Q And specifically, he is evaluating the
20 density of states for majority spin channel;
21 right?

22 A Well, majority and minority. Yes.

23 Q Right. Okay. He does it for both,
24 right.

25 And he found that the density of states

1 near the interface was quite different from the
2 bulk; is that right?

3 A That's what it says.

4 Q And the bulk means within the magnesium
5 oxide barrier layers; right?

6 well, strike that. The layers is
7 overloaded.

8 The magnesium oxide barrier layer is
9 modeled by these individual atomic layers of 100
10 magnesium oxide; right?

11 A Yes. That's my understanding.

12 Q Okay. And when Butler refers to the
13 bulk, he is referring to the atomic layers of 100
14 magnesium oxide; is that correct?

15 A Okay. I -- I think his description here
16 of bulk is relatively -- you know, it is not deep
17 down in the gory details, as I said. The bulk is
18 referring both to the MgO and the iron. Basically
19 what he means by the bulk is he is distinguishing
20 the bulk from the interface. So the interface is
21 the region right where the MgO and the iron meet.
22 We saw a picture of at an atomic level of detail
23 the interface. And the bulk are the levels away
24 from the interface.

25 Q Okay. So the Figure 1 that we were

1 discussing that's on Butler page 2,
2 that represents the interface between it shows
3 100 iron atomic layer with 100 magnesium oxide
4 layer on top; right?

5 A Correct.

6 Q Okay. All right. So you agree that the
7 density of states in the magnesium oxide at the
8 interface with the iron layer is important to
9 evaluating the tunneling current in the MgO?

10 A What I'm going to -- what I'm going to
11 say is that the paper has 12 pages of all kinds of
12 details. All these details are provided to help
13 an expert understand the details of the
14 calculation and how strongly they affect the
15 outcome or not. All I can say is that this
16 particular thing that you're pointing out, just
17 like everything else that described within the
18 bounds of the paper, are at least somewhat
19 relevant. Which ones are the most important and
20 the least important is -- that's where we get into
21 a gray area where I'm not comfortable giving
22 opinions on the -- you know, the degree of
23 importance or the degree of sensitivity of the
24 results on every little thing. So the bottom line
25 is I'm uncomfortable to answer your question

1 with -- with sworn testimony.

2 Q The figure below the section we've been
3 reading on page 3 of Butler, there's Figure 3 and
4 then on the right-hand column Figure 4; right?

5 A Right.

6 Q And Figure 3 is described as a density of
7 states for each atomic layer of iron 100 near an
8 interface with magnesium oxide; right? That's the
9 caption in Figure 3.

10 A Yes. Yes. I see that.

11 Q Okay. Figure 3 is actually labeled A and
12 B, but it is actually two plots; right?

13 A You mean there are two separate figures,
14 the top and the bottom. And you want to call
15 those A and B.

16 Q well, off -- okay. They are not labeled.
17 It's -- Figure 3 presents two plots stacked on top
18 of each other; correct?

19 A Correct.

20 Q And the top one, it says that it is
21 showing iron majority density of states near an
22 interface with magnesium oxide; is that right?

23 A Correct.

24 Q And the bottom one says it is showing
25 iron minority density of states near an interface

1 with magnesium oxide; right?

2 A Right.

3 Q And the plots, the squiggly lines in each
4 of these plots, that's showing you the -- the
5 results of the calculation that Butler did on his
6 model; right?

7 A Right.

8 Q And that result is for an ideal 100 iron
9 atomic layer covered by an ideal 100 magnesium
10 oxide layer. That's the interface he modeled;
11 right?

12 A well, that's the -- that's the precise
13 position of the interface, yes. But this plot is
14 showing modeling layers near that interface.

15 Q Okay. So --

16 A Junction at the interface.

17 Q Okay. Even if we account for every
18 atomic layer in Butler's model, it is still that
19 that model is still made of ideal 100 iron atomic
20 layers and ideal 100 magnesium oxide atomic
21 layers. Do you agree with that?

22 A well, ideal is a little -- is a little
23 loaded. we talked -- we looked at some of that
24 earlier, you know, where you could see he made
25 some -- he gave some description for what he means

1 by ideal. Right. So yes, within the confines of
2 the way he described those layers, they're --
3 they're ideal. They're -- that's the model.
4 There are some idealized layers. I'll agree with
5 that.

6 Q So you agree that the results shown here
7 in Figure 3 are calculations done without
8 accounting for an oxygen vacancy; correct?

9 A I'll agree to that.

10 Q And the same is true for Figure 4; is
11 that right?

12 A That is right.

13 Q So the difference between Figure 3 and
14 Figure 4 is that Figure 4 shows the density of
15 states for each of the atomic layers of magnesium
16 oxide near an interface with iron 100; right?

17 A Right.

18 Q So you can think of Figure 3 as the iron
19 side of the interface and Figure 4 as the
20 magnesium oxide side -- side of the interface;
21 right?

22 A I agree with that.

23 Q And none of these calculations accounted
24 for the idea of an oxygen vacancy of any kind or
25 number in the magnesium oxide; right?

1 A Yeah. He doesn't include -- I scrolled
2 through. He does not include oxygen vacancy
3 defects in his calculation.

4 Q Okay. So you agree that if a person of
5 ordinary skill in the art wanted to determine the
6 density of states for majority or minority spin
7 channels in an iron/magnesium oxide/iron sandwich
8 with oxygen vacancies in the magnesium oxide, they
9 would actually have to come up with a different
10 physical model than Butler used?

11 A Well, again, I'm not an expert in this.
12 How different it would have to be, what -- how
13 much they would have to change, I can't -- I can't
14 give an opinion on that. They would have to be
15 different.

16 Q And in fact --

17 A It might only be a little bit different.

18 Q There are all kinds of vacancies, each
19 would require a different model; correct?

20 A When you say require, what do you mean by
21 that?

22 Q Well, if we go back to Figure 1 of
23 Butler, page 2, you couldn't just pluck a single
24 oxygen atom out of the 100 magnesium oxide atomic
25 layer at the interface and say now you have

1 accounted for every possible oxygen vacancy, could
2 you?

3 A I don't -- I still don't understand the
4 question.

5 Q You could mod- -- if you were to modify
6 Butler's model, you could remove a single oxygen
7 atom from the magnesium oxide atomic layer at an
8 interface with iron; correct?

9 A In principle.

10 Q And if you did that, you would also have
11 to account for how the absence of the oxygen atom
12 would cause the magnesium oxide layer to deform;
13 correct?

14 A You know, you could make a model. You
15 could make a model accounting or not accounting
16 for it.

17 Q It is complicated?

18 A It is complicated.

19 Q And it gets even more complicated if you
20 think of multiple vacancies; correct?

21 A If the vacancies get to be -- in general,
22 it adds to the complication to have more than one
23 vacancy, sure.

24 Q And not just one vacancy at the
25 interface, but vacancies in the magnesium oxide

1 layers that are above the interface; correct?

2 A I think I missed the --

3 Q Okay. So --

4 A -- the meaning to the question.

5 Q -- it's not that you would just have to
6 decide how to model a single oxygen atom missing
7 in a magnesium oxide layer at the interface, but
8 you would have to also consider what if there were
9 multiple oxygen atoms missing at the interface;
10 correct?

11 A You would have to -- under -- what's
12 the -- what's the antecedent to that? You would
13 have to do that why, for what purpose?

14 Q To evaluate the effect of an oxygen
15 vacancy on the minority and majority spin density
16 of states -- spin channel density of states.

17 A So this is where -- so to answer that
18 question, I'll just tell you my understanding of
19 theoretical modeling. So here is -- here this
20 calculation doesn't include oxygen vacancy
21 defects. I agree with that. Now, if somebody
22 like Butler or one of his co-authors or somebody
23 else in this -- with this degree of sophistication
24 and theory said, I want to try to understand the
25 effect of defects, oxygen vacancy defects or other

1 kinds of defects, they would make a model. And
2 they might just put one oxygen vacancy defect in
3 there and not allow any relaxation and call that a
4 model. And they would come to some conclusions.
5 And then we would have to look at those
6 conclusions and see what they are. And then
7 somebody else might ask, well, you didn't take
8 into account the relaxation around the defect.
9 What effect does that have? well, maybe it is not
10 that important for the kind of properties that I'm
11 looking for. So people make models all the time
12 at different degrees of sophistication and try to
13 match the degree of sophistication of the model to
14 some result they're looking for. And they try to
15 get as close as they can. But people make
16 simplified models all the time. And, you know,
17 people in the art look at that, try to take some
18 guidance from it. They may take it with some
19 grain of salt, but they may take some guidance
20 from it and go forward. That's how -- that's how
21 experimental and theoretical physics works. It
22 goes back and forth. You make a simplified model.
23 People try to use it now, and they say, you're
24 missing this. Okay. I'll do my best to model
25 that. The experimentalists try to use that. They

1 may try to do the experiment. They may say, I
2 don't even think it is worth doing the experiment
3 because the calculation wasn't sophisticated or
4 not. They may or may not. That's a judgment call
5 of the experimentalist. So when you're saying
6 what would they have to do, well, they would do
7 the best they could. And then we have to -- you
8 know, as experimentalists or persons of ordinary
9 skill in the art, we have to make a decision how
10 believable this model is, how useful it is, and do
11 we want to go in the lab and take time and
12 resources to do an experiment based on the outcome
13 of that model calculation. There is no
14 black-and-white here is basically what I'm trying
15 to say.

16 Q So you could choose to model oxygen
17 vacancies just at the interface with the iron
18 layer if you wanted to; right?

19 A well, you said you. I couldn't.

20 Q why not?

21 A A theorist -- I don't know how to do
22 that. I'm not a theorist. I couldn't do that
23 calculation.

24 Q would a person of ordinary skill in the
25 art know how to make that calculation?

1 A As I have testified already, no. I think
2 this calculation -- and now if you start to add
3 additional features to the calculation, you want
4 to make a model even more complicated, then I even
5 more strongly would testify that a person of
6 ordinary skill in the art would not be able to
7 make the full detailed calculation.

8 Q And if you wanted -- if a -- if a person
9 of ordinary skill in the art wanted to come up
10 with a new model based on Butler that accounted
11 for oxygen vacancies not just at the interface but
12 in the bulk of the barrier layer, they would have
13 to introduce vacancies in other atomic layers for
14 the magnesium oxide; right?

15 A My opinion is that a person of ordinary
16 skill in the art would look at a calculation like
17 this one. And just because they don't -- and they
18 wouldn't necessarily have the capability to
19 understand every nuance of every little detail
20 that went in the calculation. And, you know,
21 whether they use the layer KKR technique or some
22 other technique to do the DFT and whether they
23 used LSDA or just LDA, all of these little bitty,
24 nitty-gritty details are beyond the scope of a
25 person of ordinary skill in the art. And whether

1 or not you have a vacancy or not would be beyond
2 their scope. However, people of ordinary skill in
3 the art all the time will look at a paper like
4 this, and they might think to themselves, well,
5 this is an ideal. I've got an experiment that
6 differs from this ideal in one way or another.
7 And based on the best understanding they have of
8 the paper, they might try to extrapolate and take
9 a guess, take an educated guess as to which way
10 the calculation might go if I varied -- if I could
11 vary it this way or that. I can't redo the
12 calculation. But I could take inspiration from
13 the calculation, think about how I would change
14 the experimental details, and get some guidance
15 as -- from the -- from the general trends shown in
16 the calculation, get some guidance to help me
17 make -- make decisions about what kind of
18 experiment -- how to do the experiment.

19 Q Dr. Bokor, did you find a single
20 publication that modified Butler's model or
21 introduced a new model based on Butler's approach
22 to evaluate minority and majority spin -- spin
23 channel density of states with oxygen vacancies in
24 the magnesium oxide?

25 A I did not find a calculation that had all

1 those features that you just mentioned. As you
2 pointed out, there are over 2,000 citations. I
3 didn't look at all of them. So I don't know if
4 there is a calculation like the one that you
5 described. I have seen calculations that are at
6 roughly a level of sophistication, DFT
7 calculations, that evaluate the density of states
8 in magnesium oxide in the presence of oxygen
9 vacancy defects. I cited that in this
10 declaration.

11 Q We will get to that. I want to know
12 specifically about the magnesium tunnel function
13 that Butler is evaluating, which is an
14 iron/magnesium oxide/iron sandwich. For that
15 device, you did not cite a single paper that
16 evaluates a model based on Butler's approach but
17 accounts for oxygen vacancies in the magnesium
18 oxide; is that right?

19 A I did not cite a paper that did that
20 calculation, no.

21 Q Are you aware of a paper that did that
22 calculation?

23 A If I was, I would almost certainly have
24 cited it.

25 Q So Butler was publishing --

1 A The answer is no, I'm not aware of a
2 paper like that.

3 Q So Butler was published in 2001; right?

4 A Right.

5 Q It's been cited 2900, plus/minus, times;
6 right?

7 A Right.

8 Q So in 24 years and nearly 3,000
9 publications, you couldn't find a single example
10 of anybody reporting this calculation of minority
11 or majority spin channel density of states when
12 there is an oxygen vacancy in the magnesium oxide;
13 is that right?

14 ATTORNEY WILSON: Objection. Form.

15 THE WITNESS: I did not cite such a
16 paper.

17 BY ATTORNEY WICHMAN:

18 Q And you couldn't find one, did you?

19 ATTORNEY WILSON: Objection. Form.

20 THE WITNESS: If I found one, I would
21 have cited it for sure.

22 BY ATTORNEY WICHMAN:

23 Q Okay. So you didn't cite it. If you had
24 found one, you would have cited it. And I'm
25 asking, did you find one?

1 A No.

2 Q No. Okay. But you looked?

3 ATTORNEY WILSON: Object to form.

4 THE WITNESS: I definitely did some
5 literature searching. It's hard to -- it's hard
6 to search 3,000 papers. Even with, you know, the
7 tools we've got available to us today.

8 BY ATTORNEY WICHMAN:

9 Q All right. Do you have your declaration
10 Exhibit 10 -- 1105 in front of you?

11 A One moment. Okay. I have it.

12 Q Can you go to paragraph 10. Paragraph
13 10.

14 A Yes.

15 Q So you write or you testify that "Butler
16 taught that a change in barrier height was
17 expected to affect majority and minority channel
18 tunneling." Correct?

19 A Correct.

20 Q Butler doesn't actually teach changing
21 barrier height at all, does he?

22 A He doesn't explicitly. But in my
23 opinion, a person of ordinary skill in the art
24 reading Butler would find that teaching in there.

25 Q Butler does not include barrier height as

1 a parameter in his model, does he?

2 A He shows -- okay. The narrow -- the
3 answer to your narrow question is no.

4 Q If we go down in paragraph 10 here, if
5 you drop down a couple sentences, the last
6 sentence on page 7, you wrote that -- you
7 testified that "density of states represents the
8 number of quantum states available for electrons
9 to occupy at a certain energy level and thus acts
10 as a proxy for electrical conduction at that
11 energy." Correct?

12 A That's what it says.

13 Q All right. The density of state, the
14 electrons that contribute to conduction are only
15 the ones that are at the Fermi energy level; isn't
16 that right?

17 A Yeah. This is -- at the end of the day,
18 if you measure electrical conduction, that relates
19 to the states at Fermi energy. But the density of
20 states provides information for electrical
21 conduction at other energies. And if the Fermi
22 energy would move to that location, then it would
23 tell you what to expect for electrical conduction
24 in that circumstance. That's the meaning of this
25 sentence.

1 Q Can you open Exhibit 1045.

2 A I have it.

3 Q Growth, structure, electronic and
4 magnetic properties of magnesium oxide/iron (001)
5 bilayers and iron/magnesium oxide/iron (001)
6 trilayers. Correct?

7 A That's the title.

8 Q A paper by Klaua and colleagues?

9 A Correct.

10 Q K-l-a-u-a. Right?

11 A Right.

12 Q Physical Review B, Volume 64?

13 A Correct.

14 Q And you're familiar with this paper;
15 right?

16 A Generally.

17 Q You cited this paper in your -- in your
18 declaration?

19 A I think so.

20 Q Okay. Left-hand column, page 1, under
21 introduction. Klaua states, "The electron
22 tunneling in such amorphous barriers is complex,"
23 referring to magneto-tunnel junctions with
24 amorphous aluminum oxide barriers; right?

25 A Correct.

1 Q The electron tunnel consists of random
2 hopping between oxide resonant states which are
3 created by a number of poorly understood defects;
4 correct?

5 A That's what it says.

6 Q All right. Oxygen vacancy in magnesium
7 oxide is a type of defect; correct?

8 A Yes.

9 Q All right. Klaua says that the lateral
10 component -- again, this is the aluminum oxide
11 barriers. "The lateral component of the electron
12 momentum k-parallel is randomized by scattering in
13 the barrier, such that the tunneling current is
14 not only determined by the intrinsic band
15 structure of the electrons and the oxide barrier
16 but is significantly affected by lattice disorder
17 in the barrier." Right?

18 A You read it correctly.

19 Q The tunneling current is significantly
20 affected by lattice disorder in the barrier;
21 right?

22 A That's what it says.

23 Q All right. And you agree that oxygen
24 vacancies and magnesium oxide are a type of
25 lattice disorder; correct?

1 A A type.

2 Q Okay. And if we go down now, he's going
3 to talk about Butler; right? If you go down to --
4 after reference note 2, do you see the sentence
5 that starts with "the recent theoretical
6 calculations"?

7 A Yes.

8 Q Okay. "The recent theoretical
9 calculations of an intrinsic electron tunneling
10 transport using fully spin-dependent electronic
11 band structure provides challenging predictions.
12 The tunneling conductance in iron/magnesium oxide/
13 iron 001 is governed by the majority spin
14 electrons." Right?

15 A You read it correctly.

16 Q That's Butler's result; right?

17 A That's Klaua's description of Butler's
18 result.

19 Q Right. And then Klaua said -- do you
20 agree that is Butler's result?

21 A I don't disagree with it.

22 Q Do you agree with it?

23 A I think that's a slight
24 oversimplification of Butler. But it's -- it is a
25 reasonable, you know, one-sentence description.

1 Q Okay. Klauda writes, "The tunneling
2 resistance for the parallel orientation of the
3 magnetic moments is estimated to be 100 times
4 smaller than that for the antiparallel orientation
5 of the magnetic moments due to the absence of
6 scattering in the barrier." Is that right?

7 A That's what it says.

8 Q All right. And Klauda cites reference 3;
9 correct?

10 A He does.

11 Q And if you turn to the last page, page 8,
12 PDF 8, you will see the references is reference 3.
13 It's Butler's paper, Exhibit 1044. Right?

14 A Right.

15 Q Okay. Back to page 1. "Tunneling
16 resistance for the parallel orientation," he is
17 talking about our -- what we call r-parallel;
18 right?

19 A Yeah.

20 Q Okay. And it is low, which means that
21 the conductance is high; right?

22 A Right.

23 Q And Butler says that is due to the
24 majority channel -- symmetry matching of the
25 majority channel spin. The majority spin channel

1 electrons. Right?

2 A well, I don't see symmetry matching in
3 this sentence.

4 Q Okay. Let's -- let's stay with this
5 sentence then. "The tunneling resistance for the
6 parallel orientation" means conduction in the
7 parallel state of magneto-tunnel junction; right?

8 A Right.

9 Q And that's what Butler refers to as the
10 majority spin channel?

11 A I think so, yeah.

12 Q Okay. And the reason that the resistance
13 is low, meaning that the conduction is high, is
14 due to the absence of scattering in the barrier;
15 correct?

16 A That's what it says.

17 Q Okay. So as compared to the prior art
18 aluminum oxide, there is an absence of scattering
19 in the iron/magnesium oxide/iron sandwiches;
20 right?

21 A By comparison, yes.

22 Q Right. And the problem with the aluminum
23 oxide is there is randomized scattering in the
24 barrier due to defects; correct?

25 A what it says here in the paper is that

1 the lateral component -- I'll just skip down.
2 well, "the lateral component of the electron
3 momentum k-parallel is randomized by scattering in
4 the barrier such that the tunneling current is not
5 only determined by the intrinsic band structure of
6 the electrons and the oxide barrier but
7 significantly affected by lattice disorder in the
8 barrier." That is not exactly the same thing as
9 defects.

10 Q Defects -- the oxygen vacancies are a --
11 in magnesium oxide would be a type of lattice
12 disorder?

13 A In the context here, my understanding of
14 this -- and I think the way a person -- a person
15 of ordinary skill would understand this is in
16 amorphous material, the amorphous aluminum oxide,
17 you have essentially no lattice order at all. The
18 material -- amorphous material is completely
19 disordered or essentially completely disordered.

20 Q Can I stop you there?

21 A Yes.

22 ATTORNEY WILSON: No. You can't. He
23 needs to finish his answer. You asked a question.
24 You can withdraw the question or he can finish his
25 answer.

1 BY ATTORNEY WICHMAN:

2 Q Did you want to finish your answer or do
3 you want to examine what you just said and then
4 come back and finish your answer?

5 A I'm going to finish my answer. The --
6 the lattice disorder referred to here is related
7 to the lattice disorder in an amorphous oxide.
8 And a single oxygen vacancy defect is not in the
9 same territory of lattice disorder that is being
10 referred to here. I wouldn't put those two in the
11 same bucket.

12 Q Okay. why are you focused on a single
13 oxygen vacancy defect?

14 A well, I think that is what you said.
15 oxygen vacancy defect.

16 Q Okay.

17 A You didn't say anything about the density
18 of the defects.

19 Q How many defects -- oxygen vacancy
20 defects would be needed for -- to -- for Bowen's
21 magneto-tunnel junction to achieve a .33 electron
22 volt barrier?

23 A I don't have a number for that. I
24 haven't given an opinion on it.

25 Q would it be more than one oxygen vacancy

1 defect?

2 A More than one in the entire crystal?

3 Yes.

4 Q Okay. So can we agree that we're talking
5 about a multiplicity of oxygen defects being
6 introduced into the oxygen barrier?

7 A We can talk about whatever you would like
8 to talk about. If that's what you want to talk
9 about, then I'm happy to do that. But you -- you
10 know, we need to be a little bit more specific.

11 Q Okay. So let's talk about something else
12 that you just said. You said there is no order in
13 an amorphous material, in an amorphous barrier
14 material.

15 A It is virtually completely disordered.
16 It is not that there is no order. There is almost
17 no order.

18 Q An amorphous material has no long-range
19 order; correct?

20 A It has essentially no -- no order at
21 almost all length scales except right down to the
22 single atom level. The average distance between
23 the atoms and an amorphous material has variation,
24 but it is roughly similar. And at all other light
25 scales, it is disorder. That's -- that's the

1 understanding a POSA has of an amorphous material.

2 Q And do you have any authority for that
3 statement?

4 A I haven't cited any. That's my
5 understanding. That's my opinion.

6 Q Okay.

7 A I don't -- I haven't cited any authority
8 on that and I don't have one right handy. But
9 that's my understanding. And I think it is the
10 understanding of a person of ordinary skill in the
11 art as we have defined it in this case.

12 Q And you have not formed an opinion about
13 the quantity of oxygen vacancy defects that
14 would -- a POSA would need to introduce to Bowen's
15 magnesium oxide barrier to achieve the .33
16 electron volt barrier; correct?

17 ATTORNEY WILSON: Objection. Form.

18 THE WITNESS: All right. In order to
19 answer that question, I would -- I would need to
20 refer to Soukup. I just want to check. Because I
21 don't recall exactly what Soukup says about the
22 density of defects. He may say something. So as
23 I sit here right now, I'm uncomfortable to make --
24 to answer that question. But it is within the
25 bounds of -- of what I can answer, but -- and I

1 would do that by referring to Soukup.

2 BY ATTORNEY WICHMAN:

3 Q would a POSA have understood that an
4 oxygen vacancy defect in the magnesium oxide
5 barrier would be a source of scattering for
6 tunneling electrodes -- electrons?

7 A That is a reasonable -- a reasonable
8 thing for a person of ordinary skill in the art to
9 consider.

10 Q And when you formed your opinion here in
11 your testimony that Butler taught a change in
12 barrier height was expected to affect majority and
13 minority channel tunneling, you did not consider
14 whether Butler -- that Butler did not account for
15 any scattering in the magnesium oxide, did you?

16 A I didn't offer any opinion on that in any
17 of my declarations. I won't say that I never
18 thought about it.

19 Q In forming your opinion, did you consider
20 the fact that Butler did not study or account for
21 scattering from defects in the barrier?

22 A In forming my opinion, I did consider it.
23 I didn't -- I didn't -- I didn't consider it as
24 the -- at the end of the day, the opinion I gave,
25 I felt it wasn't -- it didn't have -- it didn't

1 change my opinion.

2 Q would a POSA have understood that the
3 lateral component of electron momentum for current
4 tunneling through an MTJ would be randomized by
5 scattering in the barrier?

6 A There could be some effect like that.
7 How big it is is a question mark. And that's hard
8 to estimate.

9 Q I asked you if a POSA would have had that
10 understanding?

11 A A POSA would likely have had that
12 understanding.

13 Q Okay. Can you go back to Butler,
14 Exhibit 1044, page 1.

15 A Yeah.

16 Q Okay. I'm just trying to find my spot
17 here.

18 All right. So if you go to the end of
19 the abstract and count backwards -- one, two --
20 third sentence from the end.

21 A The abstract.

22 Q In the abstract, yeah. "In the majority
23 channel."

24 A I see that.

25 Q "In the majority channel the conductance

1 is primarily via Bloch electrons with small
2 transverse momentum." Correct?

3 A Correct.

4 Q And you agree that scattering would
5 change the Bloch electron momentum; correct?

6 A It could.

7 Q And you agree that Klaua says that it
8 does; correct?

9 A In an amorphous material, yes.

10 Q Does scattering -- you're saying that
11 scattering will change electron momentum in an
12 amorphous material, but it will not change
13 electron momentum in magnesium oxide? Is that
14 your testimony?

15 ATTORNEY WILSON: Objection. Form.

16 THE WITNESS: The issue is the
17 significance of the scattering. In an amorphous
18 material, there's a huge amount of scattering.
19 The material is completely disordered. In a
20 single crystal with a -- some sparse density of
21 defects, it's a much smaller effect. The amount
22 of -- the amount of transverse scattering is much,
23 much less than it is in an amorphous material.

24 BY ATTORNEY WICHMAN:

25 Q And what is the amount of transverse

1 scattering that would occur in Bowen's magnesium
2 oxide barrier layer when it is modified by adding
3 oxygen vacancy defects to achieve a .33 electron
4 volt barrier?

5 A I don't know.

6 Q And did you -- so because you don't know,
7 then you did not consider that when you evaluating
8 how changing a barrier -- barrier height in
9 Butler's results would affect -- in Butler's model
10 would affect Butler's results?

11 A No. That's not correct.

12 Q So tell me what I got wrong with that.

13 A The introduction of defects I agree can
14 lead -- could lead, would likely lead to some
15 amount of transverse scattering. The introduction
16 of the defects will also change the magnesium
17 oxide band structure, will also shift the Fermi
18 level so that the electrons tunneling through the
19 MgO are interacting with different density of
20 states than where the Fermi level is where Butler
21 put it. So as I have testified, it's a complex --
22 there's a lot of different factors that come into
23 play which would be known to a person of ordinary
24 skill. You look at Butler and you think, okay, if
25 there are some -- if -- first of all, if the Fermi

1 level shifts without defects, we're not talking
2 about that. We haven't gone there. So I won't
3 either. If you shift the Fermi level by
4 introducing oxygen defects, you could -- you
5 likely will introduce some degradation of the
6 k-parallel distribution, but you will gain or you
7 could potentially gain in terms of the -- at
8 parallel antiparallel resistances due to the band
9 structure effects. My testimony in this case from
10 day one has been a person of ordinary skill in the
11 art looking at Butler and being aware of
12 scattering as well -- since you add that to the
13 discussion right now. My understanding is a
14 person of ordinary skill in the art would look at
15 that and say, well, if I have some relatively, you
16 know -- it is not like the MgO goes completely
17 amorphous to shift the Fermi level. There's some
18 oxygen vacancy defects. They're at a relatively
19 moderate amount, such that we're not talking about
20 an amorphous material. So it's likely that if I
21 introduce enough oxygen vacancy defects to lower
22 the Fermi level, yeah, maybe I will get some
23 scattering, but that I will also -- that will
24 degrade the TMR. But I will also get a win --
25 potentially I would get a change in the TMR from

1 the band structure effects. And all I've said is
2 that a person of ordinary skill is unable to
3 predict with certainty how the TMR is going to
4 change when you vary the barrier height, including
5 by adding defects. It's not -- it's not easy for
6 a person -- to make that prediction. It is
7 unclear whether Butler could even make that
8 prediction, but he could make a try at it. Butler
9 is no longer with us. But people with the skill
10 of Butler. And a person of ordinary skill in the
11 art reading Butler would see that and say, hmm, it
12 looks like if you change the barrier height, the
13 band structure effects could change significantly,
14 unlike aluminum oxide. And so it's a good idea to
15 think about changing the barrier height to affect
16 the TMR. And there's at least a decent chance
17 that the TMR will go up. Worth a try. The fact
18 that there might be some influence of scattering
19 that would play a role in how much the TMR might
20 go up, that's another unknown factor. We don't
21 know how many -- what the density of defects would
22 be to get a certain lowering of the barrier
23 height. I can't predict that. I can't predict
24 what -- how much the band structure effect would
25 be by changing the energy of the electrons

1 tunneling through the MgO. So the benefit is
2 sufficiently compelling, as we know -- you know,
3 we've looked -- we have cited lots of -- lots of
4 information. You have cited a bunch of
5 information about, you know, how excited the
6 community is about increasing TMR. So if I'm an
7 experimentalist, I look at Butler, and I say,
8 well, it looks like varying the barrier height
9 could have a significant effect. It might go up.
10 It might go down. I can't really predict. Yeah.
11 Maybe some -- if I do it by putting oxygen
12 vacancies in there, that scattering might also
13 play a role. I can't predict that either. But
14 I've got -- I've got instructions in the art on
15 how to try to do this experiment. And it's got
16 enough potential payoff that I'm going to try it.
17 Or I say a person of ordinary skill in the art
18 looking at that could very well come to that
19 conclusion.

20 Q So in paragraph 10 of your reply
21 declaration, Exhibit 1105, you annotate Butler's
22 Figures 3 to 5; correct?

23 A 3 and 4.

24 ATTORNEY WILSON: Objection. Form.
25

1 BY ATTORNEY WICHMAN:

2 Q Correction. 3 and 4. Is that right?

3 A Right.

4 Q And you draw these red lines. These
5 vertical red line lines; is that right?

6 A Right. I drew those.

7 Q Okay. And you're saying that the red
8 line is there to indicate in this case an increase
9 in barrier height; is that right?

10 ATTORNEY WILSON: Objection. Form.

11 THE WITNESS: No. That's a decrease.

12 BY ATTORNEY WICHMAN:

13 Q That's a decrease in barrier height?

14 A Increasing the Fermi energy decreases the
15 barrier height.

16 Q So this is actually supposed to indicate
17 an increase in Fermi energy?

18 A The red line is the Fermi energy.

19 Q Okay. And what you're suggesting is that
20 at the point at which that Fermi energy -- or I'm
21 sorry. At the point at which the plotted density
22 of states intersects that red line representing an
23 increase in Fermi energy, you're suggesting that a
24 POSA would think aha there's a different density
25 of states, is that -- is that what you're saying?

1 A So far you've got the interpretation
2 about right.

3 Q But you agree that the squiggly lines in
4 each of these plots resulting from the
5 calculations that Butler made on his model don't
6 account for any oxygen vacancy defects, do they?

7 A No.

8 Q And they don't account for any what you
9 call band structure effects, do they?

10 A Oh, they do. These are all --

11 Q I'm sorry. They don't account for any
12 band structure effects resulting from introducing
13 oxygen vacancies, do they?

14 A No. That's true.

15 Q And they don't account for any scattering
16 from the introduction of oxygen vacancies; right?

17 A Yeah. Density of states -- as long as
18 the scattering was moderate. I mean, if we went
19 all the way to amorphous material, the density of
20 states would look different. But these don't
21 account for that.

22 Q And, in fact, you testified that a person
23 of ordinary skill in the art didn't even know how
24 many oxygen vacancies would have to be introduced
25 to Bowen's magnesium oxide layer; right?

1 A Well, that's true. However, not
2 quantitatively. But if we go to Soukup and we
3 look, you know, the material didn't become
4 amorphous. That would have shown up in the -- in
5 the experimental results. So at least
6 qualitatively a person of ordinary skill in the
7 art would not expect that even shifting the Fermi
8 level -- even shifting the barrier height all the
9 way down to .3 isn't going to turn the MgO into an
10 amorphous material. We can't estimate how high
11 the defect is or how much transverse scattering
12 that would result in. But it's reasonable for an
13 optimistic person of ordinary creativity to say,
14 hey, it might not be that bad. Let's try it.

15 Q And the person of ordinary skill in the
16 art would not even know whether the oxygen vacancy
17 defects that lowered the barrier height in Bowen's
18 modified magnesium oxide barrier layer would have
19 to be introduced at the interface with the
20 ferromagnetic layer; right?

21 A In order to -- for what purpose? You
22 mean to get that shift in the Fermi level?

23 Q Yeah.

24 A I'm not offering an opinion on that.

25 Q And the POSA would not know what the

1 effect would be on this calculation of minority or
2 majority spin density of states if oxygen
3 vacancies were present at the interface between
4 the ferromagnetic layer and the magnesium oxide
5 barrier layer; right?

6 A A person of ordinary skill in the art
7 would not know that from any of these
8 calculations. They could do an experiment to get
9 some information about it.

10 Q Did you do that experiment?

11 A I did not.

12 Q Okay. And, in fact, if they wanted -- if
13 the person of ordinary skill in the art wanted to
14 model this effect, they would have to come up with
15 an entirely new model; right?

16 A I disagree with entirely new.

17 Q Okay.

18 A First of all -- first of all, a person --
19 I have testified many times a person of ordinary
20 skill in the art would not have the capability to
21 make a calculation at this level of
22 sophistication. An expert like Butler -- one of
23 Butler's students or collaborators or colleagues
24 could make that calculation and exactly how -- how
25 much of this additional effects like where -- how

1 many oxygen vacancy defects where they are at the
2 interface or in the bulk, all those details, I
3 can't testify as to how much they would have to
4 change the model, how much they -- how many of
5 those effects they could include and still be able
6 to get a calculation that could converge on a
7 reasonable computer. I can't testify to any of
8 that.

9 ATTORNEY WICHMAN: Okay. Dr. Bokor, it
10 is close to an hour --

11 THE WITNESS: Yeah.

12 ATTORNEY WICHMAN: -- at this point. why
13 don't we take another break. I notice it is
14 11:00 your time. Just thinking ahead --

15 THE WITNESS: Yeah.

16 ATTORNEY WICHMAN: well, as we get close
17 to 12:00 your time we will figure out a lunch
18 break for you.

19 THE WITNESS: Yeah. I don't have a
20 strong feeling about when we have lunch. A
21 five-minute break now would be good. You want to
22 round it out to 11:15?

23 ATTORNEY WICHMAN: Sure. Let's do that.
24 We will come back at a quarter past.

25 THE WITNESS: Okay.

1 ATTORNEY WICHMAN: All right. off the
2 record.

3 (A recess was taken.)

4 ATTORNEY WICHMAN: On the record.

5 Q Dr. Bokor, during the break, did you
6 speak to anybody about the deposition?

7 A Nope.

8 Q Okay. We can go back to Butler,
9 Exhibit 1044, page 1, right-hand column, first
10 paragraph quickly.

11 A Give me a moment to get there.

12 Oh, wrong document. Butler, page 1.

13 Q Yep. Right-hand column.

14 A Right-hand column.

15 Q First full paragraph.

16 A All right.

17 Q Third sentence.

18 A One, two, three. One of --

19 Q Sorry. Fourth sentence. You're right.

20 "The nature of the states both in the electrodes
21 and the barrier layer are extremely important in
22 determining the tunneling conductance." Right?

23 A That's what it says.

24 Q It is talking about the density of states
25 of the majority spin, minority spin channels?

1 A well, I think the nature of the states is
2 broader than that.

3 Q what does it mean to you?

4 A Symmetries of the state, the dispersion,
5 the majority versus minority. There's a whole lot
6 of different factors that go into the nature of
7 the states besides density of states. What he
8 plots and relies on a lot to illustrate what is
9 going on are the density of states. But that's
10 not the only thing that he is talking about here.

11 Q Okay. would you agree that oxygen
12 vacancy defects in the magnesium oxide would
13 change the symmetry of the majority and minority
14 states?

15 A I don't think that's the effect that
16 Klaua is talking about. And even in applying that
17 to Butler, I don't think that's the nature of the
18 change that -- the way to think about the change
19 that would be introduced by oxygen vacancy
20 defects.

21 Q Do you agree that oxygen vacancy defects
22 would change the nature of the states in the
23 magnesium oxide barrier?

24 A In -- it would -- I mean, yes, in --
25 strictly speaking, yes, it would change the nature

1 of the states. I don't think that's the main
2 effect they would have on -- there is also the
3 scattering that we were just talking about. I
4 think that is more important in terms of the
5 effects that you're talking about.

6 Q If we drop down to the last sentence of
7 this paragraph, in Butler, "Interfacial resonance
8 states can also strongly influence tunneling
9 conductance."

10 A I see the statement.

11 Q Okay. Do you agree that oxygen vacancy
12 defects can change the interfacial residence
13 states?

14 A You know, I'm just not going to offer an
15 opinion on that. That goes beyond the level of
16 detail that I have considered in my analysis. And
17 I haven't given any opinions on that particular
18 question.

19 Q In forming your opinions on Butler, did
20 you consider whether the introduction of oxygen
21 vacancies in the magnesium oxide barrier would
22 affect interfacial residence states?

23 A Not specifically.

24 Q Tell me how you considered the effects of
25 oxygen vacancy defects, other than to say it would

1 change the Fermi level.

2 A I just said a lot about that. I will
3 repeat what I just said before the break. I did
4 consider that the introduction of some number of
5 oxygen vacancy defects in the MgO could lead to
6 scattering such that the increase in TMR that
7 comes from the majority and minority states could
8 be affected in a -- could be affected. So the --
9 if you look at Butler -- and we just talked about
10 this quite a bit. Emphasizing scattering.
11 Scattering effects will degrade the TMR. I think
12 a person of ordinary skill understands that.
13 Introducing oxygen defects could increase the
14 amount of scattering and act to reduce TMR. So I
15 did consider that. Without going into all of
16 these nitty-gritty details, what I understood was
17 introducing oxygen defects could lower the TMR.

18 Q Okay. In your reply declaration,
19 Exhibit 1105, if you could go to paragraph 11.
20 Are you there?

21 A Not yet. Okay.

22 Q All right. So you testified that "As can
23 readily be seen from Butler's Figures 3 and 4
24 (reproduced above)," in your paragraph 10, "moving
25 the level of the Fermi energy (see red

1 annotations) will have a significant impact on the
2 density of states of majority and minority
3 electrodes." Right?

4 A That's what it says.

5 Q But you just agreed that the density of
6 states shown in Figure 3 and Figure 4 do not in
7 any way account for the introduction of oxygen
8 vacancies in the magnesium oxide barrier, didn't
9 you?

10 A I said that.

11 Q So there really is no information to draw
12 from comparing density of states that are shown
13 with the Fermi energy that was derived from this
14 model with this vertical red line that you drew
15 because you only get that vertical red line by
16 introducing vacancies, which are not part of
17 Butler's calculation. Isn't that right?

18 A My consideration was that while there
19 could be some scattering introduced by the -- I
20 didn't take that into consideration in drawing the
21 red line, if that's your question.

22 Q well, I mean, you just agreed that
23 this -- let's just -- I'm going to call them very
24 technically the squiggly lines in Butler's Figures
25 3 and 4.

1 A Uh-huh.

2 Q Those squiggly lines that are the
3 calculation of density states in minority and
4 majority spin channels for iron near the interface
5 in Figure 3 and 4, magnesium oxide near the
6 interface in Figure 4, those squiggly lines
7 don't -- don't account for any oxygen vacancies in
8 the magnesium oxide, do they?

9 A Here, they do not. That's correct.

10 Q Okay. So you are suggesting just picking
11 a different Fermi energy out of the air and
12 comparing it to a calculation that doesn't account
13 for how you would get that Fermi energy; is that
14 right?

15 A I wouldn't say that it doesn't account
16 for it. I considered it a small effect that I
17 didn't think was -- that was small enough that it
18 wouldn't destroy the motivation to move that Fermi
19 level.

20 Q How did you arrive at the conclusion that
21 the effect of introducing oxygen vacancies in
22 magnesium oxide would only be small on the
23 calculation that Butler did for I'm going to say
24 ideal atomic layers of iron and magnesium oxide?

25 A well, I think it is highly likely if we

1 look at the range of oxygen defects that were
2 induced to move the Fermi level in Soukup, at --
3 he varies that, right. So the variation of the
4 barrier height depends on the density of defects.
5 Now, all we're talking about is lowering the
6 barrier height by some amount. We don't have to
7 lower the barrier height all the way to .3.
8 What's obvious is that you could lower the barrier
9 height down to whatever it was below -- less than
10 .5, I think. I think it is reasonable to expect
11 that the density -- that we're not talking about a
12 huge density of defects in order to do that. I
13 don't know that, but I think it is a reasonable
14 expectation. It is a reasonable guess by a person
15 of ordinary skill. I can't prove it. I don't
16 know that what that result would be. But I think
17 it is reasonable to expect that the degradation of
18 the effect I'm talking about that comes from
19 moving the Fermi level relative to the band
20 structure would overcome the degradation of TMR
21 that comes from the scattering. I don't think
22 that the defect density we're talking about is
23 likely to make -- well, I take it back. The
24 defect density will change the density of states
25 actually in the MgO. And I -- as I mentioned

1 before, I have a citation for that. So the --
2 the -- the defects wasn't considered by Butler.
3 But a person of ordinary skill in the art
4 understands that oxygen vacancy defects can indeed
5 have an influence on the band structure of the
6 MgO. And given that, at least there's a
7 reasonable chance that it will change the density
8 of states in the MgO in such a way as to increase
9 the TMR. I can't tell that from the data that I
10 have seen about change in density of states in the
11 MgO. But I think it's a strong enough indication
12 that it is reasonable to try. And maybe the
13 scattering effect would overwhelm the change in
14 TMR. I can't predict that. I don't think a
15 person of ordinary skill can predict it. But as I
16 have testified before, the potential benefit of
17 increasing TMR is so compelling that that -- and
18 this is not that difficult of an experiment to
19 try. It is worth trying.

20 Q Did you try it?

21 A You could have a -- it could have a huge
22 impact.

23 Q Did you try this experiment, Dr. Bokor?

24 A I did not.

25 Q If it is not that difficult to try, why

1 didn't you try?

2 A well --

3 ATTORNEY WILSON: Objection. Form.

4 THE WITNESS: I wasn't doing this kind of
5 work in 2004.

6 BY ATTORNEY WICHMAN:

7 Q In preparing your -- in preparing your
8 testimony, why didn't you just do it, tell us the
9 results?

10 A I don't have the capability of doing that
11 experiment myself.

12 Q Okay. You agree -- we talked about this
13 on Butler page 1, the bottom left, Butler states,
14 "It is necessary to have a reliable physical model
15 for the interface between iron 100 and magnesium
16 oxide." Right?

17 A I see that.

18 Q You agree that Butler creates a physical
19 model of this interface with an ideal 100 iron
20 atomic layer covered by an ideal 100 magnesium
21 oxide atomic layer; right?

22 A Right.

23 Q And he specifies the position of the
24 atoms in that model in exquisite detail, doesn't
25 he?

1 A Yeah.

2 Q I mean, to a thousandth of an angstrom;
3 correct?

4 A He gives numbers to a thousandth of an
5 angstrom, yes.

6 Q And he painstakingly specifies the
7 distance between each iron atom and each oxygen
8 atom in the magnesium oxide layer above the iron;
9 right?

10 A Right.

11 Q And you agree that removing an oxygen
12 from the magnesium oxide lattice will result in a
13 deformation of the magnesium oxide lattice;
14 correct?

15 A I did not agree to that.

16 Q You don't -- you disagree with that
17 statement?

18 A I -- well, it is a change in the lattice.
19 So there's an atom missing. Whether or not the
20 lattice relaxes around that point and how much, I
21 can't -- I can't testify to that. I thought
22 that's what you're asking me.

23 Q So you don't even know how much the
24 magnesium oxide lattice would have to -- would
25 change to accommodate a missing oxygen atom?

1 A Not as I sit here now, no.

2 Q Okay. Do you agree that modifying
3 Butler's model to account for a missing -- an
4 oxygen atom missing at the interface would require
5 changing the position of the atoms in the
6 magnesium oxide atomic layer at that interface?

7 A I can't answer that question. You know,
8 require is a qualitative decision. How -- you
9 know, as I've tried to testify -- I tried to
10 explain this multiple times. Theorists do the
11 best they can. If they're trying to take into
12 account an effect like magnesium -- like oxygen
13 vacancy defects in the MgO, there are various
14 levels of sophistication that they could use to
15 model that. They could just take an atom out and
16 not relax the adjacent atoms. They could try to
17 release the adjacent atoms. They could try to put
18 the defect in different locations. They could
19 change the density of the -- there's a lot of
20 different things that they can do. The more
21 sophisticated the model, generally speaking, the
22 more expensive it becomes. And theorists have to
23 contend with the cost of their modeling in the
24 sense that the cost increases the amount of
25 computer time. If I -- if I do a calculation and

1 it runs for a week and I get an answer, a theorist
2 will generally be more or less willing to do that.
3 But if -- if adding this additional sophistication
4 to the -- to the calculation means that now the
5 calculation to get the same -- the same result
6 that's relevant to the community, maybe it takes a
7 year of computer time, well that might be too
8 costly. They don't do that. So they will put as
9 much in as they can and see what -- what they can
10 come up with to provide guidance to the rest of
11 the community, particularly the experimentalists.
12 I will do a calculation that is as good as I can
13 do to help you decide what experiment you could do
14 or to help you decide what material to grow or to
15 help you decide what to do. So when you say
16 require, that's a -- that's a loaded word in this
17 context.

18 Q Is it fair to say that you don't know how
19 an oxygen vacancy at the interface between the --
20 between an iron and magnesium oxide atomic layers
21 would affect the results of Butler's calculations?

22 A I don't know with precision, no.

23 Q But you're willing to speculate that it
24 wouldn't matter that much?

25 A Yes. I'm willing to spec- -- I think a

1 person of ordinary skill in the art would -- some
2 persons of ordinary skill in the art -- you know,
3 there are optimists and there are pessimists. And
4 a reasonable person of ordinary skill in the art
5 with reasonable optimism would say, yeah, I don't
6 know how big of an effect the scattering would be.
7 And I don't know how big of an effect moving the
8 Fermi level would have on the -- you know, the --
9 the majority and the minority channel tunneling
10 density of states. I don't know how that is going
11 to go either. But it is reasonable to expect that
12 it very well might work out. This experiment --
13 unlike what I said, you know, theorists might have
14 to spend a -- take a year of super computer time
15 to do a calculation, given what I understand about
16 this experiment to introduce oxygen vacancy
17 defects to change barrier heights in an MgO tunnel
18 barrier like Bowen, I think that's doable. I
19 think that is within reasonable cost and it would
20 be well worth it to try because the payoff is
21 potentially so significant.

22 Q And you don't have an example of anybody
23 doing that in the prior art, do you?

24 A I do not. I would certainly have been
25 sharing that with you if I did.

1 Q Did you look for one?

2 A I did -- certainly I did some looking,
3 yes.

4 Q We're on paragraph 11. Go back to your
5 declaration, Exhibit 1105, paragraph 11.

6 A 11. Okay.

7 Q All right. Your next sentence, "Although
8 Butler's calculations would need to be repeated to
9 see what would happen to the density of states in
10 Figure 3 and 4 with a change in Fermi level."
11 That's your testimony, right?

12 A Right.

13 Q But if Butler's model doesn't include
14 oxygen vacancies, you couldn't repeat Butler's
15 calculation. You would have to change Butler's
16 model, wouldn't you?

17 A I'm not talking about that here.

18 Q What are you talking about?

19 A I'm talking about a more -- you know, a
20 calculation with less additional -- with less
21 changes. Just change where the Fermi level is.
22 In other words, change the barrier height. The
23 calculation has an assumption about barrier
24 height. He doesn't calculate the barrier height.
25 He uses a model value for the barrier height

1 actually. It is pretty high. If you look and see
2 where that Fermi level is. I think he has a
3 barrier height in there. It is cited somewhere in
4 Butler. We could look for it. He's got a pretty
5 high barrier height. That's an assumption that he
6 made in his calculation. The calculation could
7 readily be repeated with a different barrier
8 height and a different Fermi energy. Granted, not
9 taking into account the oxygen vacancies. Just
10 moving the Fermi level. That's what I'm talking
11 about here. That's a calculation that would be
12 straightforward to repeat, in my opinion, because
13 that's a simple -- single parameter that's in the
14 model that he could change. But I think the
15 effects on the density of states and ultimately
16 the TMR could well be significant. Very likely
17 would be significant. Maybe up, maybe down, as I
18 have testified before. But I think it is
19 highly -- I think a person of ordinary skill in
20 the art reading Butler would understand based on
21 what a person of ordinary skill could take away
22 from that paper and looking at Figures 3 and 4 and
23 others would say, hey, if you change the Fermi
24 level, there's a damn good chance that you're
25 going to be interacting with density states and a

1 different part of the band structure and that
2 likely changes the TMR. Very likely changes the
3 TMR. Likely enough that it is worth it to do the
4 experiment.

5 Q You said the calculation would be
6 straightforward to repeat. Did you repeat it?

7 A It would be straightforward for somebody
8 with the capability to make that calculation to
9 repeat. I can't repeat it. When I meant
10 straightforward, I meant that the co-authors who
11 did this calculation, they pick one number for the
12 Fermi level. Yeah. For the Fermi level. And if
13 all we were going to do was change the Fermi
14 level, I -- my opinion is that that's something
15 that they could do.

16 Q And you don't cite a single publication
17 reporting this calculation, do you?

18 A Correct.

19 Q And you looked but you couldn't find an
20 example of anybody doing this, could you?

21 A That's fair.

22 Q All right. If we stay with paragraph 11
23 of your declaration, now you say, "TMR directly
24 results from the difference in spin
25 polarizations." Right?

1 A Right.

2 Q "As shown in the following formula." And
3 then you label that Equation 1; right?

4 A Right.

5 Q And what you're doing is expressing TMR
6 ratio using Julliere's model; right?

7 A Yeah. That's a good point.

8 Q You agree that is Julliere's model?

9 A That comes from the Julliere's model.

10 Q If you could open Exhibit 1033.

11 A I have it.

12 Q So Julliere's model was published in
13 1975; right?

14 A Right.

15 Q It was long before Butler did his work in
16 2001; correct?

17 A Correct.

18 Q In Julliere's Model P1 and P2 are spin
19 polarizations of the ferromagnetic electrodes?

20 A Yes.

21 Q And the D terms refer to the density of
22 state at the electrodes at the Fermi level for
23 spin-up and spin-down bands; is that right?

24 A In my declaration or somewhere else?

25 Q In the model. I mean, you're quoting --

1 in your equation 1, you have P1 or P2 equals the
2 expression of D sub 1 or sub 2; right?

3 A Yeah. Right. So that -- that equation
4 doesn't come from Julliere. There is nothing in
5 Julliere with those density of states in it. It
6 does have the Ps, the P1 and the P2. They call
7 them P and P prime, I think. But the second
8 equation that I gave there -- I'm just reviewing
9 in Julliere. That's not from Julliere.

10 Q All right. Can you -- you cite
11 Exhibit 1050 at page 2427. Can you open
12 Exhibit 1050.

13 A Uh-huh. Okay.

14 Q PDF 2.

15 A Right.

16 Q Page 2427. Left-hand column. Bottom
17 line. "According to Julliere's simplified model,
18 reference 6, the TMR ratio is expressed as" the
19 equation that -- equation 1 that you put in your
20 declaration; correct?

21 A Right.

22 Q And Rp and Ra are tunnel resistances when
23 the magnetization of the two ferromagnetic
24 electrodes are aligned parallel and antiparallel,
25 respectively; right?

1 A Correct.

2 Q P1 and P2 are the spin polarizations of
3 the two electrodes; right?

4 A Right.

5 Q And then there are these D quantities.
6 And they're a little complicated because they are
7 sort of a compressed notation. But there's -- as
8 in your declaration, there's a D sub 1,
9 parenthesis, 2, with an up arrow; right?

10 A Right.

11 Q And what that's saying is for D1 or for
12 D2, the subscripts 1 and 2 are for the different
13 ferromagnetic electrodes; right?

14 A Right.

15 Q And the up arrow is -- refers to spin-up
16 or up-spin; right?

17 A Right.

18 Q And then there's a D sub 1, parenthesis,
19 2, with a down arrow; right?

20 A Right.

21 Q And the down arrow is referring to the
22 D value for a down-spin sub-band; right?

23 A Right.

24 Q And so in Exhibit 1050, it explains that
25 the D sub 1, parenthesis, 2, up arrow and D sub 1,

1 parenthesis, 2, down arrow are the density of
2 states of electrodes at the Fermi level for the
3 up-spin and down-spin sub-bands respectively;
4 right?

5 A Right.

6 Q You intended to cite that in your
7 declaration; right?

8 A I did.

9 Q And why did you cite Julliere's model in
10 paragraph 11 of your declaration?

11 A I'm sorry. In my declaration, I cited
12 Yuasa. I cite Exhibit 1050.

13 Q Okay. And we just looked at this.
14 Exhibit 1050 describes equation 1 as Julliere's
15 simplified model; correct?

16 A It does. Yuasa said that.

17 Q Do you disagree?

18 A well, you know, I hate to quibble with
19 Yuasa on this fine point. If you look at 1033,
20 which we just did, you don't find that second
21 equation with the density of states in it. That's
22 all I'm saying. Now, I don't know why we're
23 having this particular -- going down this
24 particular road. I cited Yuasa. Yuasa called it
25 the Julliere model. I have no opinion on why he

1 did that or whether he did it right or wrong. I
2 don't see the relevance here. I cited -- these
3 equations appear, you know, in a number of
4 references. They're well-known equations. I
5 cited them because -- well, I cited them. They
6 were in Yuasa. And they help in my discussion.

7 Q Okay. You agree that the D terms are
8 density of states of the electrodes in an MTJ?

9 A Okay.

10 Q Do you agree with that?

11 A I want to -- I want to qualify that.
12 Because this is -- this is something that I should
13 have made more clear when I wrote the declaration.
14 That equation for P1 and P2 is -- actually, Butler
15 criticizes that equation, if I'm not mistaken. Or
16 let's put it this way. Butler's theory is more
17 sophisticated. Let me just put it this way.
18 Butler's theory is more sophisticated than -- if
19 you just use that equation. Hold -- give me a
20 moment, and I'll point you to what I'm talking
21 about. Actually, it is in my declaration
22 somewhere. Hold on. Never mind. Let me just
23 make the statement. And then if you want to dig
24 deeper, we can. This is -- this is -- this
25 equation here is really relevant in the context of

1 Slonczewski or Julliere's model. And it's too
2 simple for Butler. It doesn't -- it doesn't -- on
3 its face it doesn't -- it doesn't perfectly
4 capture Butler. I think -- I'm not sure Butler
5 explicitly writes this. My interpretation of
6 Butler is this equation with the D s in it is
7 useful in Butler, with the modification that
8 what's used for the density of states is what
9 Butler calls the tunneling density of states. So
10 Butler is all about the influence of the -- the
11 tunneling states on the MgO on the -- on the TMR.
12 And that -- that equation with just -- just
13 depending only on the density of states in the two
14 electrodes doesn't take into account the effect of
15 that special nature of the MgO. Butler captures
16 that in a quantity that he calls the tunneling
17 density of states. And so that's -- for example,
18 in Figure 7 in Butler -- let me just take a look
19 at whether he also uses that. Yeah. In Butler
20 Figure 7, he's -- the label on the axis is density
21 of states. But in the caption, I'm talking about
22 Figure 7 on page 6 of Butler. PDF page 6.
23 Figure 7 shows what the caption identifies as
24 tunneling density of states. So with that
25 modification -- I should have clarified that in my

1 declaration. To get -- to get the TMR, you have
2 to take into account the tunneling in Butler. And
3 a good approximation -- I'm not sure if it is
4 perfect, but I think you get a lot closer to
5 calculating the TMR by using the P1s and 2s from
6 the tunneling density of states. This is -- you
7 know, this is really down into the -- a little bit
8 into the details. Not so deep that I don't think
9 I can talk about it. But anyway, that equation
10 should be understood in the context of Butler,
11 where those Ds are tunneling density of states.
12 Not just density of states in the electrodes.

13 Q Dr. Bokor, you cite Exhibit 1050 for this
14 Equation 1 in your declaration at paragraph 11.

15 A I do.

16 Q You didn't cite Butler for it, though,
17 did you?

18 A No. What I'm saying now is that was an
19 oversight when I wrote the declaration.

20 Q And so you're changing your testimony; is
21 this -- is that right?

22 A I'm correcting -- yes, I'm correcting my
23 testimony. I'm making a modification of my
24 testimony.

25 Q And you didn't cite any authority that

1 applies the understanding you just stated; meaning
2 TMR can be expressed as a ratio of tunneling
3 density of states as shown in your Equation 1, did
4 you?

5 A I'm saying that Butler is my support for
6 that.

7 Q Butler doesn't do it either, does he?

8 A He doesn't. But from the text, reading
9 Butler, and how he explains what the tunneling
10 density of states is, I believe a person of
11 ordinary skill would use this equation with the
12 tunneling density of states to get a good
13 representation of TMR ratio.

14 Q Okay. And --

15 A Butler goes into more detail than that.
16 And I don't argue that you would get an accurate
17 TMR ratio this way, but a lot more accurate than
18 the simple interpretation of D1 and 2 as density
19 of states in -- only in the electrodes. That's
20 the whole point of Butler.

21 Q And that testimony, that opinion that you
22 just offered for the first time now on your
23 surreply deposition is not supported by any
24 citation to authority other than your
25 interpretation now of Butler; is that right?

1 ATTORNEY WILSON: Objection. Form.

2 THE WITNESS: Strictly speaking, that's
3 true. It would have been a lot simpler. However,
4 this equation -- I don't use this equation to come
5 to the ultimate conclusions about whether or not
6 Butler teaches that changing the Fermi level would
7 change the TMR.

8 BY ATTORNEY WICHMAN:

9 Q Dr. Bokor, in your declaration, at
10 paragraph 11, you testify that "TMR directly
11 results from the difference in spin polarizations
12 of the two electrodes as shown in the following
13 equation," which we have discussed, and then say
14 thus. "Thus," meaning therefore it follows,
15 "changing the density of states of majority versus
16 minority electrons in either or both electrodes
17 unquestionably will change TMR." That's your
18 testimony; right?

19 A I stand by that statement. What I'm
20 testifying now is that to get an accurate
21 calculation of TMR, this -- this is too simple.
22 It will -- no doubt, changing the density of
23 states will change TMR. Butler is teaching a more
24 sophisticated analysis for the TMR where it
25 depends not just on the density of states in the

1 electrodes, but also on the electronic properties
2 of the barrier. And he goes in great detail to
3 explain that. So Butler doesn't use this equation
4 here to get his results. And it was an oversight
5 on my part to cite this equation. It doesn't
6 change the -- the conclusions that I come to at
7 all.

8 Q Dr. Bokor, are you just cherry-picking
9 equations from incompatible theories because you
10 think that looks persuasive in your declaration?
11 Is that what you're doing here?

12 A No.

13 ATTORNEY WILSON: Objection.
14 Argumentative.

15 THE WITNESS: I disagree with that
16 characterization. I disagree with that
17 characterization. I'm not cherry-picking. I'm
18 saying I put that simpler equation in there as an
19 oversight. It does not capture what Butler is
20 teaching. And I should have just left it out. It
21 doesn't change -- I didn't use it. I didn't -- it
22 doesn't change my conclusions. My conclusions are
23 based on a more -- a more -- a reading of Butler.
24 I base my conclusions on what Butler actually
25 teaches. This is a simplification. I shouldn't

1 have put it in there. I don't think -- it does
2 not directly influence my conclusions. The
3 statement is correct. Changing the density of
4 states of minority and majority does change TMR.
5 Butler teaches TMR is also influenced by this
6 tunneling effect. And he defines this new
7 quantity called tunneling of density of states,
8 which gives a much more -- which gives a much more
9 accurate characterization of what happens in the
10 case of the MgO barrier. So my conclusion is
11 based on a reading of Butler. And this equation
12 here doesn't influence my -- my -- my basic
13 conclusion. Changing the density of states will
14 unquestionably change TMR. And further, the
15 influence of the band structure of the barrier
16 will also change TMR. And how the electrons
17 transport through the barrier will also change
18 TMR.

19 BY ATTORNEY WICHMAN:

20 Q Dr. Bokor, do you agree that nothing in
21 Julliere's model describes tunnel matrix elements
22 for the barrier layer?

23 A I agree.

24 Q Do you agree that nothing in Julliere's
25 model describes the nature of states in the

1 barrier layer?

2 A That's correct.

3 Q Do you agree that nothing in Julliere's
4 model describes the symmetry of propagating
5 states?

6 A Correct.

7 Q Do you agree that nothing in Julliere's
8 model describes evanescent states of a barrier
9 material?

10 A I think that's right.

11 Q Do you agree that nothing in Julliere's
12 model describes the decay of evanescent states in
13 the barrier layer?

14 A Well, now I'm not so sure about that.
15 This particular Julliere reference, Exhibit 1033,
16 does not explicitly talk about the decay of the
17 wave function in the barrier and, you know, what
18 the overall tunneling probability is. It
19 certainly does talk about tunneling. He doesn't
20 explicitly talk about the decay. And he certainly
21 doesn't talk about how the decay would be
22 different for the two spin polarizations. I will
23 leave that as my answer.

24 Q Do you agree that nothing in Julliere's
25 model describes strong interference from multiple

1 states with complex wave vectors in the barrier?

2 A Sure.

3 Q Do you agree that nothing in Julliere's
4 model describes interfacial resonance states?

5 A I believe that's true.

6 Q Do you agree that nothing in Julliere's
7 model describes a barrier height?

8 A Well, he doesn't explicitly mention
9 barrier height. But he does explicitly talk about
10 the barrier and the distance. So the thickness of
11 the barrier. He doesn't explicitly talk about the
12 barrier height.

13 Q The barrier thickness and barrier height
14 are unrelated -- or different independent
15 properties; right?

16 A That's true.

17 Q All right. If you can go in your
18 deposition -- in your declaration, Exhibit 1105 to
19 paragraph 24.

20 A Okay. I'm there.

21 Q You testified that Butler explicitly
22 criticized earlier models of tunneling conductance
23 that failed to appreciate the crucial behavior as
24 completely inadequate. Right?

25 A Right.

1 Q And the crucial behavior is what you
2 described in the preceding paragraph 23; right?
3 That MTJs with -- of ferrous 001/MgO 001/ferrous
4 001 would exhibit a large magnetoresistance
5 because of, one, coupling of band structures in
6 the electrodes and evanescent states in the
7 magnesium oxide of compatible symmetries, and,
8 two, the difference in decay rates between these
9 different symmetries. Right?

10 A That's -- you correctly read paragraph
11 23.

12 Q Is that the crucial behavior that you're
13 referring to in paragraph 24?

14 A Well, only that I would further -- you
15 know, that statement I think is -- is further
16 based on the bullet points, which are quotes for
17 Butler in paragraph 24. That's all.

18 Q So by crucial behavior, you're referring
19 to the parts of Butler that you're quoting next,
20 is that what you're saying?

21 A Yes.

22 Q Okay. So in the first bullet point, you
23 quote Butler saying the tunneling matrix elements
24 are almost neglected or treated as inert factors
25 and that this approach is completely inadequate

1 for understanding tunneling in the 001 iron/MgO
2 001/iron 001 MTJs; right?

3 A Right.

4 Q Okay. And you agree that Julliere
5 doesn't -- Julliere's model doesn't account for
6 tunneling matrix elements; right?

7 A Yeah. Julliere's model comes under the
8 same umbrella of completely inadequate as
9 described by Butler.

10 Q Right. Okay. And then in the second
11 bullet here, paragraph 24, the relationship to the
12 symmetry of the slowly decaying evanescent states
13 in the barrier layer -- I'm sorry. "The symmetry
14 of the Bloch states at the Fermi energy and their
15 relationship to the symmetry of the slowly
16 decaying evanescent states in the barrier layer
17 are crucial to understanding tunneling
18 conductance." Right?

19 A Right.

20 Q That's from Butler?

21 A Butler.

22 Q And none of that is in Julliere's model;
23 right?

24 A Right.

25 Q Okay. And if you go to paragraph 30 --

1 A 30.

2 Q -- of your declaration.

3 A 30. okay. 30.

4 Q Now you're -- now you're -- you start by
5 talking about Sloczewski, but you say that,
6 "Butler recognized that a reliable physical
7 model" --

8 A Wait. I'm not up to you. You're in 30?

9 Q Second -- okay. Exhibit 1105, paragraph
10 30. Are you there?

11 A Yeah. Yeah.

12 Q Second sentence. "Butler, in
13 contrast" --

14 A Okay.

15 Q -- "recognized that a reliable physical
16 model of an MgO 001-based MTJ, including its
17 barrier layer, was necessary to truly understand
18 its behavior." Right?

19 A You read that correctly.

20 Q And Julliere's model does not -- is not a
21 reliable physical model of an MgO 001 MTJ,
22 including its barrier layer, is it?

23 A Correct.

24 Q Julliere's model doesn't account for
25 crystallinity or composition of the barrier, does

1 it?

2 A Correct.

3 Q There is no barrier layer in Julliere's
4 model, is there?

5 A I think there's a barrier layer.

6 Q There is no property of the barrier layer
7 in his expression for TMR, is there?

8 A I thought we were done with Julliere.

9 There's no -- I'm sorry. Please repeat
10 the question. Now I have Julliere up again.

11 Q Julliere's model -- Julliere's expression
12 for TMR does not account for a reliable physical
13 model of any barrier layer, does it?

14 A I think your sentence -- your statement
15 is, you know, generally reasonable. But I -- in
16 the interest of being as accurate as possible, he
17 does say some things about the barrier. He talks
18 about the tunneling is through a semiconductor.
19 He talks about, you know, to prevent shorting, we
20 have to make sure that we don't have pinholes. He
21 talks a little bit about the barrier. He does
22 mention barrier height. I think I might have
23 missed that previously. Barrier height deduced
24 from the G of V curved Figure 1 is in the order of
25 100 meV, milli-electronvolts. That is .1 volt.

1 Then he says, "Therefore, we can assume that
2 tunneling is through the semiconductor." So
3 Julliere does talk about the tunnel barrier at
4 least somewhat. It is not that he doesn't talk
5 about it or tell you anything about the properties
6 of the tunnel barrier.

7 Q Does Julliere's model, his mathematical
8 model of TMR, include the barrier height as a
9 parameter?

10 A Not explicitly, no.

11 Q Does Julliere's model, his mathematical
12 model for the value of TMR, account for any
13 property of the barrier?

14 A Well, only in the most gross sense that
15 it shouldn't have any pinholes. But I think in
16 the context you're asking about, the specific
17 electronic structure, no.

18 Q All right. And I think you testified,
19 you agree that Julliere's model is within this
20 category of completely inadequate for
21 understanding tunneling that Butler mentions at
22 page 1; right?

23 A Right.

24 Q Okay. And you still you cited as
25 explaining TMR in paragraph 11 of your

1 declaration?

2 A As I have testified, I agree that is in
3 error. It was not my intention to rely in any
4 way, shape, or form on Julliere's model. It was a
5 mistake to cite that equation. And I didn't use
6 that equation in coming up with any of my
7 conclusions. I cited that conclusion in error.

8 Q Okay. Why does the last sentence of your
9 testimony at paragraph 11 of your reply
10 declaration begin with the word "thus"?

11 ATTORNEY WILSON: Objection. Form.

12 THE WITNESS: Well, that's -- that is
13 interpreting the equation P1-2.

14 BY ATTORNEY WICHMAN:

15 Q So you are drawing conclusions from this
16 equation for TMR ratio in your paragraph 11?

17 A So the conclusion is -- is incomplete.
18 The conclusion, strictly speaking, is correct.
19 Changing the density of states of a majority
20 versus minority electrons in either or both
21 electrodes unquestionably will change TMR.
22 Butler -- I don't believe Butler would disagree
23 with that. However, it is inadequate. It doesn't
24 tell the full story. And I go on throughout the
25 rest of my declaration, you know, amplifying on

1 the correct -- the correct way to apply Butler
2 to -- to what would happen to TMR.

3 ATTORNEY WICHMAN: Okay. Dr. Bokor, it's
4 ten after the hour. I think this is a good time
5 for a break. Are you ready to take lunch now?

6 THE WITNESS: Yes. That's good for me.
7 That's good for me.

8 ATTORNEY WICHMAN: Is half an hour
9 sufficient? Or how about we go until a quarter to
10 the hour? So that gives you 46 minutes or 36
11 minutes.

12 THE WITNESS: It's a little tight.

13 ATTORNEY WICHMAN: All right. Do you
14 want -- when do you want to -- how much time do
15 you need?

16 THE WITNESS: How about 1:00. 50
17 minutes.

18 ATTORNEY WICHMAN: That's --

19 THE WITNESS: You want to go less?

20 ATTORNEY WICHMAN: Can we do a little
21 less? Because it's -- you know, my wife needs me
22 to help hand out --

23 THE WITNESS: You want to end early today
24 too. Good. Let's make it --

25 ATTORNEY WICHMAN: How about ten till.

1 THE WITNESS: -- 12:50.

2 ATTORNEY WICHMAN: Okay. We'll come back
3 at ten till. Off the record.

4 (A lunch recess was taken.)

5 ATTORNEY WICHMAN: All right. On the
6 record.

7 Q Dr. Bokor, during the break, did you
8 speak to anybody about the deposition?

9 A No.

10 Q Okay. In your declaration, Exhibit 1105,
11 please turn to paragraph 9.

12 A Okay.

13 Q In paragraph 9 you refer to Exhibit 1106
14 by first author Giordano, G-i-o-r-d-a-n-o; right?

15 A Right.

16 Q All right. Please open Exhibit 1106.
17 Do you have it open, Dr. Bokor?

18 A Yes. Now I do.

19 Q Okay. On page 1, of this article in the
20 abstract, Giordano explains that this was a study
21 of the role of surface oxygen vacancies on the
22 characteristics of palladium deposition on the
23 magnesium oxide 100 surface; correct?

24 A I see that.

25 Q So this isn't actually depositing

1 magnesium oxide on a material, it's taking a 100
2 magnesium oxide substrate and depositing palladium
3 on top of it; correct?

4 A That's fair.

5 Q And the study is focused on surface
6 oxygen vacancy -- the role of surface oxygen
7 vacancies; correct?

8 A That's what it is, yes.

9 Q A surface oxygen vacancy. On the surface
10 of the magnesium oxide, at some point there's an
11 oxygen missing; is that right?

12 A Okay. Yeah.

13 Q You agree?

14 A Yes.

15 Q All right. Page 5, it should be PDF 5,
16 left-hand column, first full paragraph, "The
17 presence of the vacancy." Do you see that?

18 A Uh-huh.

19 Q "The presence of the vacancy causes a
20 corrugation of the adsorbed palladium film."
21 Right?

22 A Right.

23 Q All right. So this is -- you refer to
24 this your deposition -- in your declaration as
25 studying the deposition of a monolayer of

1 palladium on magnesium oxide; right?

2 A Monolayer of palladium on magnesium
3 oxide, yes.

4 Q And monolayer means a single atomic
5 layer?

6 A Correct.

7 Q So this is a single atomic layer of
8 palladium deposited on magnesium oxide where the
9 surface of the magnesium oxide has oxygen
10 vacancies, plural; correct?

11 A Correct.

12 Q And this study shows that the presence of
13 the oxygen vacancies in the magnesium oxide
14 surface causes corrugation of the adsorbed
15 palladium film; right?

16 A Page 5, the presence of the vacancy
17 causes a corrugation of the adsorbed palladium
18 film.

19 Q What is -- the adsorbed palladium film,
20 that refers to the monolayer of palladium atoms
21 that, let's say, stick to the surface of the
22 magnesium oxide; is that right?

23 A Well, this paper deals with three
24 situations. A single palladium atom, a monolayer,
25 and then a bilayer of palladium. And there are

1 figures for each of those.

2 Q what does the word adsorbed mean when it
3 refers to an adsorbed palladium film?

4 A It means a palladium layer that has been
5 deposited and is stuck to the -- to the surface.

6 Q So even in this model, the oxygen vacancy
7 on the surface of the magnesium oxide is causing a
8 physical deformation of the structure. Is that a
9 fair statement?

10 A Okay. So, you know, I'm rereading this
11 paper. The detailed question that you're asking
12 me is not on the tip of -- you know, right at the
13 top of my head. I'm looking for where in the
14 paper it describes exactly what the -- what
15 happens of the position of the vacancy at
16 the distortion of the surface. I'm not finding it
17 easily. Since we are, you know, trying to be
18 efficient with time, if there's a part of this
19 paper that is talking about that you would like to
20 discuss, if you want to point me, that would save
21 some time. Otherwise, I'm looking for the
22 discussion about the question you're asking.

23 Q well, even if we just focus on the
24 palladium film, the sentence we just read states
25 that the oxygen vacancy on the surface of the

1 magnesium oxide causes that -- a corrugation of
2 that film?

3 A Of the palladium film.

4 Q Of the palladium film.

5 A Yes.

6 Q All right. So that's a physical
7 distortion of the palladium; right?

8 A In the palladium. I thought you were
9 asking in the MgO lattice. I see that in the
10 palladium. It causes a corrugation of the
11 palladium.

12 Q Okay. And if we drop down to the bottom
13 paragraph on the left-hand column of page 5, PDF
14 5, it says that "When an oxygen vacancy is
15 present, the palladium atoms within in the layer
16 become inequivalent, and the corresponding
17 palladium-projected density of states changes
18 considerably." Right?

19 A Right.

20 Q And this is just with the effect of a --
21 a surface -- a vacancy on the surface of the
22 magnesium oxide; is that right?

23 ATTORNEY WILSON: Objection. Form.

24 THE WITNESS: Right.

25

1 BY ATTORNEY WICHMAN:

2 Q And there is nothing in Giordano that
3 takes into consideration the effect of vacancy and
4 oxygen vacancy in -- in the magnesium oxide that
5 is not in the surface of the magnesium oxide, is
6 there?

7 A Well, the -- I'm not sure exactly how
8 well I understand your question. The paper
9 reports oxygen deficient MgO surface. Exactly
10 over what distance from the surface they are
11 integrating to get that DOS, I'm not seeing. And
12 I don't recall specifically. So it is near the
13 surface for sure. It's the density of states
14 would be modified near the surface. But how far
15 in it goes, I think I remember trying to figure
16 this out before from this paper. And it's -- it's
17 not coming back to me exactly what they say about
18 it.

19 Q Palladium is not a magnetic material, is
20 it, Dr. Bokor?

21 A Correct.

22 Q And there is no majority/minority spin
23 density of states in palladium, is there?

24 A That's -- that's fair.

25 Q You could not make a magneto-tunnel

1 junction using palladium electrodes, could you?

2 A True.

3 Q All right. In Giordano, there's no
4 density of states or a Bloch state with delta 1
5 symmetry, is there?

6 A No.

7 Q And there's no density of states for a
8 Bloch state with delta 5 symmetry, is there?

9 A Right.

10 Q There is no density of states for a Bloch
11 state with delta 2 symmetry, is there?

12 A Right.

13 Q And there's no density of states for the
14 evanescent decay of -- I'm sorry. There's no
15 calculation of the evanescent of decay of states
16 in the magnesium oxide, is there?

17 A From the metal, I don't think so. Like I
18 said, I was trying to find where it talks about
19 the wave function or density of states evolves
20 below the surface, but I'm not -- I'm not sure
21 they do. I'm not finding it. So I don't know the
22 answer to your question in detail.

23 Q Okay. So you agree that Butler did not
24 evaluate the effect of surface vacancies on
25 magnesium oxide when evaluating the iron/magnesium

1 oxide/iron sandwich density of states for majority
2 or minority spin channels; correct?

3 ATTORNEY WILSON: Objection. Form.

4 THE WITNESS: That much is correct.

5 BY ATTORNEY WICHMAN:

6 Q Okay. I would like to -- if we go back
7 to your declaration, paragraph 115.

8 A Paragraph 115.

9 Q Or I'm sorry. Yeah. Strike that.

10 Let's go back to your testimony here. It
11 is your opinion that the person of ordinary skill
12 in the art wanted to increase the TMR in a
13 magneto-tunnel junction; right?

14 A Absolutely.

15 Q And it is your opinion that the person of
16 ordinary skill in the art was interested in doing
17 this in magnesium oxide magneto-tunnel junctions
18 because of Butler and Mathon's theoretical work;
19 correct?

20 A Correct.

21 Q And specifically, that Butler and Mathon
22 predicted that magnesium oxide magneto-tunnel
23 junctions would provide significantly higher TMR
24 than the state of the art magneto-tunnel junctions
25 that used amorphous barriers; right?

1 A Yeah. I probably specifically mentioned
2 aluminum oxide, but generally yes.

3 Q So this is in your -- your reply
4 declaration, Exhibit 1105, paragraph 15. You
5 state that Butler and Mathon's papers in 2021 were
6 the first to predict these high TMRs in magnesium
7 oxide -- crystalline magnesium oxide MTJs; right?

8 A I think you're paraphrasing a little bit
9 but that's the intent, yes.

10 Q And then the next paragraph 16, it's the
11 predictions from Butler and Mathon "of an order of
12 magnitude increase the TMR represented a very
13 significant step forward from MTJs with amorphous
14 alumina barriers." Right?

15 A You read that correctly.

16 Q That's your testimony?

17 A Yes.

18 Q Okay. And you agree we just discussed
19 this you agree that Butler modeled magneto-tunnel
20 junctions that had ideal iron and magnesium oxide
21 atomic layers; correct?

22 A Okay. Yes, more or less.

23 Q And you agree that Butler modeled the
24 magneto-tunnel junctions that had ideal interfaces
25 between a 100 iron atomic layer and a 100

1 magnesium oxide atomic layer; correct?

2 A Ideal in the sense that there weren't any
3 imperfections or defects.

4 Q Okay. And Butler is -- you agree that
5 Butler is clear that the TMR predictions are
6 sensitive to the details of the interface between
7 the ferromagnetic electrode and the magnesium
8 oxide barrier; right?

9 A He does say that.

10 Q Okay. And if you look at Butler,
11 Exhibit 1044, at page 11, PDF 11, just let me know
12 when you're there.

13 A Page 11. I'm there.

14 Q Left column, the bottom paragraph. He
15 summarizes his results.

16 A Okay.

17 Q Correct?

18 A Yeah. The section called conclusions,
19 yeah.

20 Q All right. So he says that the "Results
21 that are particular to tunneling through epitaxial
22 insulators on iron 100 include," and then he lists
23 three results; right?

24 A Yes.

25 Q And the first is that "majority channel

1 tunneling is dominated by the transmission through
2 a delta 1 state at small values of transverse
3 crystal momentum." Right?

4 A You read that correctly.

5 Q His second conclusion is that "minority
6 channel tunneling is stronger and is strongly
7 enhanced for values of k-parallel near interfacial
8 resonance states." Right?

9 A That's what it says.

10 Q Okay. And then he says that that
11 conclusion, number two, that we just read, is
12 "tempered by the caveat that the interfacial
13 resonance states seem to be very sensitive to the
14 details of the interface." Right?

15 A Right.

16 Q So his results predicting high TMR are
17 very sensitive to the details of that interface
18 between the iron layer and the magnesium oxide
19 layer; correct?

20 A That's what he says.

21 Q And he drew those conclusions from
22 modeling an ideal interface between an idealized
23 interface between a 100 iron atomic layer and a
24 100 magnesium oxide atomic layer; right?

25 A Correct.

1 ATTORNEY WILSON: Objection. Form.

2 BY ATTORNEY WICHMAN:

3 Q All right. If you can look at Mathon,
4 Exhibit 1046. Just let me know when you have it.

5 A Okay. I have it.

6 Q So if you can go to page 4, which is
7 PDF 4.

8 A Okay.

9 Q All right. And the left-hand column,
10 bottom paragraph, that starts it is clear.

11 A Yeah.

12 Q Okay. Second sentence, "To observe such
13 a large R-TMR." Right?

14 A I see that.

15 Q All right. Large TMR -- large R-TMR is
16 referring to the TMR ratio; right?

17 A Right.

18 Q This is the prediction of large TMR in
19 the iron/magnesium oxide/iron MTJs?

20 A Okay.

21 Q Yes?

22 A Yes.

23 Q Okay. So "to observe such a large RTMR,
24 it is, therefore, essential that the
25 iron/magnesium oxide interface is perfect."

1 Right?

2 A That's what it says.

3 Q And then he says, "The behavior of RTMR
4 at small thicknesses of magnesium oxide is
5 determined by large peaks of special density (hot
6 spots) located outside the gamma point." Right?

7 A Okay.

8 Q "These are very sensitive, not only to
9 the interfacial roughness but also to the symmetry
10 of the junction." Right?

11 A That's what it says.

12 Q All right. So a POSA that was trying to
13 achieve the high TMRs that Butler and Mathon are
14 predicting for these iron/magnesium oxide/iron
15 MTJs would have done everything that they could to
16 make sure that the interfaces between the
17 ferromagnetic electrodes and the magnesium oxide
18 were perfect; correct?

19 A Fair to say they would do everything they
20 could.

21 Q Okay. If you could open Exhibit 1045.

22 A Klaua again.

23 Q Yeah.

24 A Okay.

25 Q well, actually you know what, let's set

1 that aside. We can skip that.

2 Let's talk about Bowen.

3 A Bowen. Okay.

4 Q Yeah. Exhibit 1026, if you could open
5 that.

6 A Okay. I have it.

7 Q All right. On Bowen, at page 1655,
8 PDF page 2.

9 A Right.

10 Q Let me find it here. In the left-hand
11 column second sentence, up to now most studies --
12 I'm sorry. Drop down. There -- do you see the
13 sentence that starts, "However, from a fundamental
14 point of view"?

15 A Okay.

16 Q The next sentence right after that.
17 "Most numerical calculations of spin-dependent
18 tunneling in TMR have been developed for single
19 crystal MTJs, such as a set of materials ending
20 with iron/MgO 100." Correct?

21 A Yes.

22 Q And next to iron MgO 100, there are two
23 endnotes 5 and 6; correct?

24 A Yes.

25 Q And if you go to Bowen page 1657, at

1 PDF 4, you will see that reference 5 is Butler;
2 right?

3 A Right.

4 Q which is Exhibit 1044?

5 A Yes.

6 Q Okay. And -- and in Bowen, reference 6
7 is Mathon, which is Exhibit 1046; right?

8 A Yeah. I think so.

9 Q Okay. So as we just discussed, the POSA
10 knew that Butler and Mathon's models required
11 accounting for the electronic structure of the
12 interface between the ferromagnetic electrode and
13 the barrier layer; right?

14 A That's right.

15 Q As you just agreed a person of ordinary
16 skill in the art would have done everything that
17 they could to make sure that that interface was
18 perfect?

19 A As best as they could.

20 Q Yep. If we go back to Bowen, page 1655,
21 PDF 2, left column, first full paragraph, right
22 below where we were just reading, it says all --
23 okay. "All of these studies," including Mathon
24 and Butler papers we just cited, "emphasized
25 that" --

1 A I'm not --

2 Q Okay.

3 A We were in 1655, bottom of the left
4 column.

5 Q well, not the bottom. The middle. That
6 sentence that says, "Most numerical calculations
7 of spin-dependent tunneling and TMR" --

8 A I'm with you now.

9 Q Okay. So "All" -- meaning all these
10 references, including Butler and Mathon --
11 "emphasize that a correct depiction of the
12 spin-dependent tunneling properties of epitaxial
13 MTJs must take into account the interplay of
14 electronic structure between metal and insulator."
15 Right?

16 A You paraphrased.

17 Q well, let's read the whole sentence
18 exactly as it is written. "All emphasize that a
19 correct depiction of the spin-dependent tunneling
20 properties of epitaxial MTJs must transcend the
21 simple potential barrier image and take into
22 account the interplay of electronic structure
23 between metal and insulator." Right?

24 A That's what it says.

25 Q And then if you go up to the top of this

1 page in the abstract, you see this is actually
2 what Bowen found. He found that the spin
3 polarization of tunneling electrons depends on the
4 actual electronic structure of the entire
5 electrode barrier system; right?

6 A Okay. Again, you paraphrased, but I'll
7 agree with your characterization of what it says.

8 Q Okay. And you agree that Bowen --
9 Bowen's group set out to test Butler and Mathon's
10 predictions of TMR in a single crystal epitaxial
11 MTJ; correct?

12 A Correct.

13 Q And that's the first line of the
14 abstract. "We present tunneling experiments on
15 Fe 001/MgO 20 angstroms/iron cobalt 001 single
16 crystal epitaxial junctions of high quality."
17 Correct?

18 A Correct.

19 Q And then if we go back into the text on
20 the same page, the left column, first full
21 paragraph, underneath we were reading, they say,
22 "A test of these models" -- meaning the models
23 including Butler and Mathon -- "can be performed
24 on single crystal epitaxially grown structures."
25 Right?

1 A I'm sorry. Again you lost me. Where are
2 you reading? Oh, I see.

3 Q "A test of these models can be performed
4 on single crystal epitaxially grown structures."
5 Right?

6 A I found it, yes.

7 Q That's what Bowen did. They fabricated a
8 single crystal epitaxially-grown structure; right?

9 A Right.

10 Q And, in fact, it is not just that they
11 epitaxially grew layers, but the entire device was
12 a single crystal; correct?

13 A Correct.

14 Q And you can see that on page 1655, on the
15 right-hand column, in the bottom paragraph,
16 starting with Figure 1A. If we drop down, he says
17 third sentence, "Further x-ray diffraction
18 symmetric and asymmetric scans confirm that the
19 whole structure is epitaxial with lattice
20 parameters close to bulk values." Right?

21 A Right.

22 Q And then on page 1657, which is PDF 4,
23 the right-hand column, first full paragraph,
24 second sentence, "As evidenced by Rheed,"
25 R-h-e-e-d --

1 A I'm sorry. I'm trying still to catch
2 you -- catch up to you. What page are you on?

3 Q Page 1657, which is PDF page 4.

4 A Okay.

5 Q Right-hand column.

6 A Right-hand column.

7 Q First full paragraph.

8 A "In conclusion."

9 Q 1657 of Bowen.

10 A The paragraph starting with "In
11 conclusion." And then you're going --

12 Q The paragraph starts with "In
13 conclusion." Next sentence.

14 A Okay. Now I'm with you.

15 Q "As evidenced by Rheed," R-h-e-e-d,
16 "x-ray diffraction and TEM analyses, optimized
17 growth conditions result in entirely epitaxial
18 samples of high crystalline quality with flat
19 sharp interfaces." Right?

20 A Right.

21 Q So this is Bowen telling us that not only
22 did they do everything they could to achieve a
23 perfect single crystal MTJ, but they actually got
24 pretty close; right?

25 A They got as close as they could.

1 Q Okay. And you agree that Bowen did
2 everything they could to achieve a perfect
3 interface between the iron ferromagnetic electrode
4 and the magnesium oxide barrier?

5 A I think that's fair. Yeah. I think
6 that's a fair conclusion. I think they tried as
7 hard as they could to make -- to make a sample as
8 close as they could get to what Bowen modeled.

9 Q Uh-huh. Okay. Now --

10 A They wanted -- they wanted to test
11 Bowen -- I mean Butler down to the last possible
12 detail.

13 Q Okay. So if we can turn to Exhibit 1027.
14 That's Nagahama; right?

15 A Nagahama. Okay. Yes. Okay.

16 Q So if you look at paragraph 14 on PDF
17 page 3?

18 A I'm there.

19 Q "It has been pointed out that a barrier
20 layer formed in magnesium oxide 001 single crystal
21 produces a giant tunnel magnetoresistive effect,"
22 citing Mathon, which is Exhibit 1046; right?

23 A Right.

24 Q So Nagahama was clearly aware of Mathon's
25 prediction; right?

1 A Clearly.

2 Q And at the end of paragraph 14, Nagahama
3 points out though that the problem is "a
4 single-crystal substrate is necessary to form an
5 element. This however makes it difficult to form
6 an element on a silicon LSI, and thus a challenge
7 for realizing a magneto-" -- "magnetic random
8 access memory." Right?

9 A "Has not yet overcome."

10 Q Overcome.

11 A Right.

12 Q So they recognize the theory relies on a
13 single crystal substrate, but that's a
14 manufacturing problem in the real world; right?

15 A Right.

16 Q Okay. At paragraph 73, on PDF 9 -- just
17 let me know when you're there.

18 A I'm there.

19 Q "Still another magnetoresistive element
20 was prepared which includes 001-highly-oriented
21 lower ferromagnetic electrode layer, a
22 001-highly-oriented magnesium oxide barrier layer,
23 and the 001-highly-oriented upper ferromagnetic
24 electrode layer." Correct?

25 A Correct.

1 Q All right. So you agree Nagahama was
2 also trying to make as high quality material
3 layers as he could for his MgO MTJs?

4 ATTORNEY WILSON: Objection. Form.

5 THE WITNESS: Well, as -- no. He wasn't
6 trying to make a structure as perfect as he could.
7 He was trying to make a -- a device as close as
8 perfect as he could get with other considerations
9 involving practical -- practical fabrication
10 issues. And, you know, manufacturing and making a
11 mass manufacturable product. So he wasn't trying
12 to make as perfect a structure as he could. He
13 was -- he was making a compromise and trying to
14 make a -- a structure as good as he could with an
15 additional consideration that he was trying to
16 make it on top of not a perfect high -- perfect
17 single-crystal substrate. So he knew he was
18 making a compromise. And he says, I'm going to
19 try this way. And he describes a way that he can
20 try to get a single-crystal -- as close to
21 single-crystal layers as he can. But he's
22 compromised. He didn't grow it on a single
23 crystal substrate.

24 BY ATTORNEY WICHMAN:

25 Q The -- Nagahama provides this magnesium

1 oxide double underlayer; correct?

2 A Correct.

3 Q And on top of that double underlayer, he
4 forms 001 iron ferromagnetic layers; right?

5 A Right.

6 Q Okay. That is a crystal iron
7 ferromagnetic layer; correct?

8 A It's -- it's crystalline, yes. But I
9 believe Nagahama and any one of ordinary skill
10 would understand that the highly oriented MgO seed
11 layer that he grew was not the same as a perfect
12 single crystal. There would be -- there would be
13 some imperfections there. So the iron 001, yes,
14 it is generally 001. But one would -- a person of
15 ordinary skill in the art would expect it would
16 be -- it wouldn't be perfect. Not as perfect as
17 Bowen's 001 iron grown on a perfect single-crystal
18 substrate.

19 Q Okay. The purpose of the magnesium oxide
20 underlayer in Nagahama -- well, strike that.

21 Nagahama provides the magnesium oxide
22 double underlayer so that the top surface of that
23 double underlayer provides a 100 template on which
24 to form a lower ferromagnetic electrode of 100
25 iron; correct?

1 A The MgO highly oriented MgO layer is what
2 we've been talking about as highly oriented,
3 poly-crystal-001-oriented layer. But it's not
4 identical to a perfect single crystal. It is
5 distinguished from a perfect single crystal. It
6 is highly oriented. It is darn good. It is
7 close. But there are departures. There are
8 differences between the layer that Nagahama grows
9 here and a perfect epitaxial crystalline 001 layer
10 grown, for example, in Bowen. So he's not making
11 a perfect single-crystalline MgO. He is making one
12 as good as he can get. But he is making a
13 compromise between the ideal -- at least what is
14 taught in Butler and Bowen, the ideal structure,
15 and taking into consideration other factors, I'm
16 going to compromise a little bit, try to do as
17 well as I can, while simultaneously satisfying
18 another consideration in terms of the features of
19 the device that he is trying to make.

20 Q Okay. You agree that once Nagahama has
21 formed the 100 iron ferromagnetic underlayer, that
22 he then grows 100 magnesium oxide on top of that
23 iron underlayer; correct?

24 A 001-highly-oriented materials. It's
25 not -- it's -- all -- all this is in the context

1 of, you know, the highly oriented MgO layer that's
2 nearly -- that's -- that has very good orientation
3 and crystallin properties. It's not a perfect
4 single crystal. And neither is the iron that you
5 grow on that MgO layer.

6 Q Okay. If you could look at paragraph 62
7 at bottom of PDF page 8.

8 A I see.

9 Q Okay. So this is reciting a method of
10 manufacturing for flat tunnel magnetoresistive
11 element; right?

12 A Right.

13 Q So I want to have -- step 3 is "deposit
14 magnesium oxide layer 212 by sputtering." Right?

15 A Right.

16 Q Then step 4 is "take out the object in
17 the air and transfer it to an MBE chamber."
18 Right?

19 A Right.

20 Q MBE, that's molecular beam epitaxy?

21 A Right.

22 Q So the MBE chamber is part of a device
23 for fabricating the layers, the films; right?

24 A Right.

25 Q All right. In the MBE chamber, he heats

1 the object and -- and removes absorbed water.

2 That's step 5; right?

3 A Right.

4 Q And then at step 6, he deposits the iron
5 layer 213 by sputtering; right?

6 A Right.

7 Q And then he anneals that step, the
8 uncapped iron layer 213; right?

9 A Right.

10 Q And he does that to planarize the system.
11 That's step 7; right?

12 A Right.

13 Q So you agree that Nagahama is being
14 careful to form a very clean and flat surface of
15 that 001 iron layer; right?

16 A He's being careful, but he's making a
17 compromise. He's growing -- step 1 is to clean
18 the silicon wafer substrate with oxide film. So
19 he is starting with a silicon wafer substrate with
20 an amorphous oxide surface. And he is using the
21 property of MgO growing on an amorphous surface to
22 form a highly oriented 100 film. But it is not a
23 perfect single-crystal film. It is highly
24 oriented but in-plane. There can be in-plane
25 variations, et cetera. We have seen that in a

1 number of other references in this record. So he
2 is trying to get as high quality surface as he can
3 subject to trying to satisfy another
4 consideration. And so he is compromising on the
5 perfection of the film that he's growing.

6 Q Okay. Dr. Bokor, you agree that Butler
7 and Mathon emphasized the importance of getting as
8 perfect as possible an interface between the iron
9 ferromagnetic layer and the magnesium oxide
10 barrier layer; right?

11 A As perfect as possible.

12 Q And you agree that Bowen set out to test
13 the predictions of Butler and Mathon; right?

14 A Right.

15 Q And you testified that you agree that
16 Bowen achieved as perfect as possible single
17 crystal device with iron magnesium oxide cobalt
18 iron magneto-tunnel junction; right?

19 A As perfect as possible. But even Bowen
20 and a person of ordinary skill in the art would
21 recognize that as hard as you try, you can never
22 get perfect.

23 Q Okay.

24 A There's going to be -- there's going to
25 be some disorder at that interface unavoidably.

1 How much, we don't know. Bowen didn't analyze for
2 that. But it is never perfect. So you try to do
3 as well as you can. And Bowen tried really hard
4 to get as well as he can. We don't know exactly
5 what level of defects he had, how much disorder he
6 might have had. I can tell you that no matter how
7 hard he tried, nobody ever gets to perfect. So
8 the -- that's the point I'm trying to make. You
9 never get to perfect. You try as good as you can.
10 And then like Butler -- sorry. Like Nagahama
11 here, he's -- he's compromising on perfection in
12 one way or another in order to satisfy his desire
13 to get this to grow on a silicon wafer.

14 Q Okay. So, Dr. Bokor, the reason for all
15 of this effort was because Butler and Mathon
16 predicted that with -- as perfect as possible
17 interface, you would achieve these high TMRs;
18 right?

19 A Right.

20 Q Okay. So if the person of ordinary skill
21 in the art knew that you wanted to get as perfect
22 as possible an interface to achieve high TMRs, why
23 would they ever screw that up by adding oxygen --
24 oxygen vacancy defects?

25 A For the same reason that Nagahama didn't

1 grow this device on a single-crystal substrate.
2 He had another consideration he was trying to
3 meet, a practical consideration. He wanted to try
4 to implement Butler's MTJ on a silicon wafer,
5 where it was well known you could not get perfect
6 single crystal iron or MgO. So he did his best to
7 overcome the amorphous silicon oxide surface by
8 using this trick that we talked a lot about
9 yesterday of growing MgO on an amorphous surface
10 that would create a highly oriented, high-quality
11 MgO crystal but not perfect. Similarly, a person
12 of ordinary skill looking at Butler, as I've said
13 many times, would be motivated to say, hey, I
14 might do even better if I could change the barrier
15 height. Now, if I do that using oxygen defects,
16 then that could be a compromise that might defeat
17 my goal. But I don't know how perfect I really
18 need. I don't know what the effect of scattering
19 from oxygen vacancy defects might be. And so
20 let's give it a try. Now, make -- let me make
21 another point. We've been talking all this time
22 about changing barrier height with oxygen vacancy
23 defects. And we have seen that there is art that
24 talks about changing barrier height using oxygen
25 vacancy defects. But we're talking about the

1 novelty of the claim in the '909 patent. The '909
2 patent doesn't specify how to lower the barrier
3 height in that claim. So any way of lowering the
4 barrier height would be covered by that claim. So
5 in terms of what would be obvious to a person of
6 ordinary skill, they might -- you know, it would
7 be obvious to lower the barrier height with
8 perhaps another way other than using oxygen
9 defects. So analyze -- you keep focusing on the
10 oxygen defects as maybe dissuading a person of
11 ordinary skill to try. A person of ordinary skill
12 might try lowering the barrier height other ways.
13 And I don't have a way to suggest that is
14 concrete. But barrier height can be varied in a
15 number of different ways. And so as far as from
16 an analysis of the claim, it's simply necessary --
17 it is simply adequate to lower the barrier height.
18 So I can't rule out that one could vary that
19 barrier height using a different technique. So
20 let me put it this way: Reading Butler, a person
21 of ordinary skill would be modified to lower the
22 barrier height and look for a way to do it.

23 Q So now your testimony is that a person of
24 ordinary skill in the art would be motivated to
25 lower barrier height, and they would modify Bowen

1 or Nagahama in whatever manner was needed to
2 achieve a lower barrier height by whatever
3 unidentified method you think they would have
4 found? Is that your testimony now?

5 A Yeah. For example, using a different
6 metal.

7 Q what do you mean by a different metal?

8 A A different ferromagnet. The barrier
9 height depends on the metal. You know, I don't
10 want to sit here and try to invent -- you know,
11 come up with other inventions that would meet the
12 limitations of the claim. I'm just saying persons
13 of ordinary skill in the art were aware that one
14 could vary the barrier height. Now, I cited other
15 references that vary barrier height with oxygen
16 defects. Those were some other claims in the
17 patent. I didn't cite any other references for
18 how to vary the barrier height otherwise. But
19 the -- I think that's possible. And therefore,
20 the claim is still obvious.

21 Q Dr. Bokor, in your reply declaration,
22 Exhibit 1105, I want you to tell me each paragraph
23 where you identify a mechanism for reducing the
24 barrier height in Bowen's magnesium oxide layer or
25 Nagahama's magnesium oxide layer.

1 A I did not specifically suggest any other
2 method in that.

3 Q If you open Exhibit 1024 in the 1494
4 case.

5 A Right.

6 Q Let's just start with Bowen. I want you
7 to tell me every paragraph where you describe the
8 POSA reducing the barrier height in Bowen's
9 magnesium oxide barrier that does not involve
10 adding oxygen vacancies.

11 A Okay. I don't have anything to --
12 specific to point to on that point.

13 Q In Exhibit 1024, this is your original
14 declaration in the 1494 case. Tell me every
15 paragraph where you describe the POSA reducing the
16 barrier height in Nagahama's magnesium oxide
17 barrier that does not involve adding oxygen
18 vacancies.

19 ATTORNEY WILSON: Objection. Form.

20 ATTORNEY WICHMAN: All right. Let me
21 strike that question because there was an
22 objection.

23 Q Dr. Bokor, you have Exhibit 1024 in front
24 of you?

25 A I do.

1 Q Tell me every paragraph in Exhibit 1024
2 where you describe the POSA reducing the barrier
3 height in Nagahama's magnesium oxide barrier that
4 does not involve adding oxygen vacancies.

5 A I don't have any.

6 ATTORNEY WICHMAN: Okay. Mr. Wilson,
7 I'll pass the witness.

8 ATTORNEY WILSON: Okay. Let's go off the
9 record for just let's say five minutes.

10 ATTORNEY WICHMAN: Off the record.

11 (A recess was taken.)

12 ATTORNEY WILSON: Okay. Let's go back on
13 the record.

14 We don't have any questions. We will
15 reserve the right to read and sign.

16 ATTORNEY WICHMAN: Okay. I think that
17 concludes the dep. Off the record.

18 (The proceedings concluded at 1:49 p.m.)

19 -000-

1
2
3
4 I have read the foregoing deposition
5 transcript and by signing hereafter, subject to any
6 changes I have made, approve same.

7
8 Dated: _____
9

10
11 _____
12 (Signature of Deponent)
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DEPOSITION OFFICER'S CERTIFICATE

STATE OF CALIFORNIA)
)
COUNTY OF RIVERSIDE) SS.

I, BROOKE SILVAS, a certified shorthand
reporter for the state of California, do hereby
certify:

That prior to being examined, the witness
named in the foregoing deposition solemnly stated to
testify to the truth, the whole truth, and nothing but
the truth;

That the said deposition was taken down by me
remotely in stenotype at the time and place therein
stated and thereafter reduced to typewriting under my
direction, and that the deposition transcript is a
true and correct record of the proceedings here held.

I further certify that I am not of counsel or
attorney for any of the parties hereto or in any way
interested in the event of this cause and that I am
not related to any of the parties thereto.

Dated: November 2, 2025

BROOKE SILVAS
CSR No. 10988

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COUNTY OF RIVERSIDE)

I, Brooke Silvas, hereby certify:

I am the deposition officer that
stenographically recorded the testimony in the
foregoing deposition.

written notice pursuant to Code of Civil
Procedure, Section 2025.520(a), having been sent, the
deponent took the following action within the allotted
period with respect to the transcript of the
deposition:

() In person, at the office of the
deposition officer, made the changes set forth on the
original of the transcript. (The parties attending
the deposition have been notified of said changes.)

() Approved the transcript by signing it.

() Refused to approve the transcript by
not signing it.

() By means of a signed letter, made the
changes and approved or refused to approve the
transcript as set forth therein. (Said letter has
been attached to the original transcript and copies

3 () Failed to approve the transcript within
4 the allotted time period.

5

6 Dated: November 2, 2025

Brooke Silvas

BROOKE SILVAS
CSR NO. 10988

	149:17	115	2.169
\$	10	131:7,8	38:19
	65:10,12,13 66:4	11:00	2.866
\$6,500	82:20 91:24	87:14	44:19
8:22	100	11:15	20
\$65,000	22:19 23:2,7,8,18	87:22	8:7 140:15
8:22	28:9 30:2,13 34:18	11th	2001
\$650	37:1,9 41:21,22,23	20:24 21:5	20:18 64:3 104:16
8:19	42:1 43:20,22 44:1,5	12	2004
	51:9,13 52:3 53:7	42:22 52:11	96:5
(	54:8,9,19,20 55:16	12:00	2021
	56:24 70:3 96:15,19,	87:17	132:5
(001)	20 120:25 124:23	12:50	2025
67:4,5	125:1 132:25 133:22	124:1	5:1 7:10 20:24 21:2,
	134:23,24 137:20,22	14	5
-	146:23,24 147:21,22	143:16 144:2	2056
	149:22	1494	20:20
-ooo-	1024	6:6,15,18,23 155:3,	212
156:19	155:3,13,23 156:1	14	148:14
	1026	15	213
0	137:4	36:11,12,17,18,19,	149:5,8
	1027	20,22,23 132:4	23
0.9476	143:13	16	117:2,11
46:21	1033	132:10	24
001	104:10 107:19	1655	64:8 116:19 117:13,
13:18 69:13 117:4	115:15	137:7 138:20 139:3	17 118:11
118:1,2 119:21	1044	141:14	2427
140:15 143:20	20:9 22:9 25:21 28:2	1657	105:11,16
146:4,13,14,17	33:19 50:8 70:13	137:25 141:22	27
147:9 149:15	77:14 88:9 133:11	142:3,9	5:16,23
001-based	138:4	1975	2900
119:16	1045	104:13	22:1 64:5
001-highly-oriented	67:1 136:21	1:00	2s
144:20,22,23 147:24	1046	123:16	110:5
001/ferrous	135:4 138:7 143:22	1:49	
117:3	1050	156:18	3
001/iron	105:11,12 106:24	1A	3
118:2	107:12,14 110:13	141:16	12:1 34:19 50:10
001/mgo	11		53:3,6,9,11,17 55:7,
117:3 140:15	21:2 91:19 101:4,5,6	2	13,18 70:8,12 82:22,
01494	103:22 107:10		23 83:2 85:9 91:23
6:4	110:14 112:10	2	92:6,25 93:5 94:7
	121:25 122:9,16	25:22,24 28:1 33:18	101:10 102:22
1	133:11,13	35:23 40:24 50:9	143:17 148:13
	11,968,909	52:1 56:23 69:4	3,000
1	6:9	105:2,14 106:9,12,	64:8 65:6
22:9,11 28:1,7 37:5,	1105	19,25 107:1 111:18	30
13,16,20 51:25	6:18,19 10:18 65:10	130:11 137:8 138:21	118:25 119:1,3,8,10
56:22 67:20 70:15	82:21 91:19 101:5	2,000	31
77:14 88:9,12 96:13	116:18 119:9 124:10	63:2	5:1
104:3 105:1,2,19	132:4 154:22	2,921	33
106:8,12,18,25	1106	21:6	11:11,21 12:5 13:7,
107:14 110:14 111:3	124:13,16		
120:24,25 121:22			
124:19 130:4 134:2			

20 14:7 18:12,24 73:21 75:15 79:3			
36 123:10	9	accurately 9:5	38:25 39:4 43:5,6,24 49:15 50:3,6 52:6
4	9 124:11,13 144:16	achieve 11:10,20 12:1,5 13:6,19 14:7,21 18:12,23 73:21 75:15 79:3 136:13 142:22 143:2 151:17,22 154:2	54:21 55:4,6,9,22 56:4 58:21 68:23 69:20,22 74:4 78:4,7 79:13 84:3 89:11,21 90:11 96:12,18 97:11,15 98:2 104:8 108:7,10 114:20,23, 24 115:3,7,11,24 116:3,6 118:4
4 53:4 55:10,14,19 82:23 83:2 91:23 92:6,25 93:5,6 101:10 102:22 135:6,7 138:1 141:22 142:3 148:16	9:03 5:2	achieved 150:16	121:19 122:2 125:13 130:23 132:18,19,23 133:4 140:7,8 143:1 145:1 147:20 149:13 150:6,12,15
46 123:10	A	act 91:14	agreed 92:5,22 138:15
5	A.M. 5:2	acts 66:9	aha 83:24
5 82:22 94:10 125:15 126:16 128:13,14 130:8 137:23 138:1 149:2	absence 57:11 70:5 71:14,18	actual 140:4	ahead 44:13 87:14
50 8:11 22:1 123:16	absolutely 21:25 24:1 35:19 131:14	add 13:5,18 15:21 61:2 80:12	air 93:11 148:17
6	absorbed 149:1	adding 18:10,22 79:2 81:5 99:3 151:23 155:10, 17 156:4	algorithm 21:17
6 105:18 109:22 137:23 138:6 149:4	abstract 77:19,21,22 124:20 140:1,14	additional 61:3 86:25 99:3 101:20 145:15	aligned 105:24
62 148:6	accepted 48:12	addressed 19:10	allowed 38:7,13
63 20:16	access 6:14 144:8	adds 46:20 57:22	alternates 37:8
64 67:12	accommodate 97:25	adequate 153:17	alumina 132:14
7	account 19:15 34:15 35:8 46:22 47:1 48:4 54:17 57:11 59:8 76:14,20 84:6,8,11, 15,21 92:7 93:7,12, 15 98:3,12 102:9 109:14 110:2 118:5 119:24 120:12 121:12 139:13,22	adjacent 98:16,17	aluminum 67:24 68:10 71:18, 22 72:16 81:14 132:2
7 10:18,20 66:6 109:18,20,22,23 149:11	accounted 55:23 57:1 61:10	administered 5:5	amorphous 67:22,24 72:16,18 73:7 74:13,18,23 75:1 78:9,12,17,23 80:17,20 84:19 85:4, 10 131:25 132:13 149:20,21 152:7,9
73 144:16	accounting 55:8 57:15 138:11	adsorbed 125:20 126:14,17,19 127:2,3	amount 27:12 78:18,21,22, 25 79:15 80:19 91:14 94:6 98:24
8	accounts 63:17	affected 68:16,20 72:7 91:8	amplifying 42:25 122:25
8 70:11,12 148:7	accuracy 39:19	age 48:24	amplitudes 41:12
8th 7:10	accurate 21:11 23:6 24:3 111:16,17 112:20 114:9 120:16	agree 21:23 23:16 25:10 26:12,16 28:7,14,25 31:16 33:8 35:18	

analyses 142:16	Arnold 10:15	42:2 43:22 45:16,17 46:11 51:9,13,22	80:11 143:24 154:13
analysis 90:16 112:24 153:16	arrangement 46:5	52:3 53:7 54:9,18, 19,20 55:15 56:24	axis 109:20
analyze 48:10 151:1 153:9	arrive 48:5 93:20	57:7 61:13 93:24 96:20,21 98:6 99:20	B
analyzed 16:4	arrives 26:6	126:4,7 132:21,25 133:1 134:23,24	back 10:10 11:16 18:21 22:8 43:3 49:5,14 50:8 56:22 59:22 70:15 73:4 77:13 87:24 88:8 94:23 101:4 124:2 129:17 131:6,10 138:20 140:19 156:12
analyzing 47:17	arrow 106:9,15,19,21,25 107:1	atoms 28:18,22,23 29:1,8, 9,15,16,17,18,23 30:12 31:6,7,9,10, 13,14 36:16,17,18, 23 37:5,18 38:2 39:2,8 44:9 45:7 46:5 49:19,24,25 50:5 58:9 74:23 96:24 98:5,16,17 126:20 128:15	background 43:18
angstrom 45:4,8,9 97:2,5	art 10:22 11:2,3,7,18,24 12:4 13:5,18 14:19, 21 16:24 20:3 23:23 27:15,21 48:1,16 56:5 59:17 60:9,25 61:6,9,16,25 62:3 65:23 71:17 75:11 76:8 80:11,14 81:11 82:14,17 84:23 85:7, 16 86:6,13,20 95:3 100:1,2,4,23 102:20 131:12,16,24 138:16 146:15 150:20 151:21 152:23 153:24 154:13	atop 30:12	backwards 77:19
angstroms 38:19,22 42:22,23 44:19 46:21	article 33:15 43:9 124:19	ATTORNEY 5:10 14:9,12,24 15:2,6,10,14,16,19, 24 16:2,6,10,13,21 17:6,11,12,15,21,25 18:1,6,9,16,20 19:4, 12,17 20:7 28:10,12 40:1,23 44:24 45:2 48:17,22 49:1,4,9 64:14,17,19,22 65:3, 8 72:22 73:1 75:17 76:2 78:15,24 82:24 83:1,10,12 87:9,12, 16,23 88:1,4 96:3,6 112:1,8 113:13 114:19 122:11,14 123:3,8,13,18,20,25 124:2,5 128:23 129:1 131:3,5 135:1, 2 145:4,24 155:19, 20 156:6,8,10,12,16	bad 85:14
angstroms/iron 140:15	aspect 33:1 34:10		Ball 10:6
anneals 149:7	assume 44:4 121:1		ballpark 10:6
annotate 82:21	assumption 101:23 102:5		band 68:14 69:11 72:5 79:17 80:8 81:1,13, 24 84:9,12 94:19 95:5 103:1 114:15 117:5
annotations 92:1	asymmetric 141:18		bands 104:23
antecedent 58:12	atom 17:2 18:4,5,14 19:1 29:19 30:4,5,12,18, 21,22 31:1,2,17,19 34:5,11 36:17 37:17 38:16 45:4,11,15 46:22,23 56:24 57:7, 11 58:6 74:22 97:7, 8,19,25 98:4,15 126:24		barrier 10:24 11:5,8,11,21, 22,25 12:5,6,13,14, 18,21,25 13:6,14,19, 20 14:4,6,8,15,23 15:5,12,18 18:12,24 26:15,24 33:11 42:7, 10,19 51:5,8 61:12 65:16,21,25 68:13, 15,17,20 70:6 71:14, 24 72:4,6,8 73:22 74:6,13 75:15,16 76:5,12,21 77:5 79:2,4,8 81:4,12,15, 22 82:8 83:9,13,15 85:8,17,18 86:5 88:21 89:23 90:21 92:8 94:4,6,7,8 100:17,18 101:22, 23,24,25 102:3,5,7
antiparallel 70:4 80:8 105:24	atom/supercell 36:12,22		
apologize 43:7	atomic 19:7 23:7,8 24:15 30:2,3 34:16 36:19 37:1 38:2,8,12 41:24		
applies 111:1		attorneys 10:14	
apply 123:1		author 124:14	
applying 89:16		authority 75:2,7 110:25 111:24	
approach 62:21 63:16 117:25		average 74:22	
approximation 110:3		aware 15:22 63:21 64:1	
area 52:21			
areas 22:4			
argue 111:16			
Argumentative 113:14			
arises 34:20 50:4			
Armond 5:13 10:16			

113:2 114:10,15,17, 22 115:1,8,13,17 116:1,7,9,10,11,12, 13 118:13,16 119:17,22,25 120:3, 5,6,13,17,21,22,23 121:3,6,8,13 133:8 138:13 139:21 140:5 143:4,19 144:22 150:10 152:14,22,24 153:2,4,7,12,14,17, 19,22,25 154:2,8,14, 15,18,24 155:8,9,16, 17 156:2,3 barriers 22:20 67:22,24 68:11 131:25 132:14 base 113:24 based 24:6,7,24 32:25 43:11 47:12 60:12 61:10 62:7,21 63:16 102:20 113:23 114:11 117:16 basic 114:12 basically 36:17 43:12 47:4 51:18 60:14 basis 44:16 bcc 37:24 38:5 Beach 5:14 beam 148:20 begin 122:10 behavior 116:23 117:1,12,18 119:18 136:3 believable 60:10 benefit 82:1 95:16 big 22:2,4 33:6 47:11 77:7 100:6,7 bilayer 126:25	bilayers 67:5 bill 8:21 bit 24:3 56:17 74:10 91:10 110:7 120:21 132:8 147:16 bitty 61:23 black-and-white 60:14 Bloch 41:12 78:1,5 118:14 130:4,8,10 Bokor 5:4,11 28:1 33:8 35:5,12,16 42:24 49:10 62:19 87:9 88:5 95:23 110:13 112:9 113:8 114:20 123:3 124:7,17 129:20 150:6 151:14 154:21 155:23 bottom 33:20 47:12 48:13 50:9 52:24 53:14,24 96:13 105:16 128:12 133:14 135:10 139:3,5 141:15 148:7 bounds 40:12 52:18 75:25 Bowen 14:6 100:18 137:2,3, 7,25 138:6,20 140:2, 8 141:7 142:9,21 143:1,8,11 147:10, 14 150:12,16,19 151:1,3 153:25 155:6 Bowen's 11:9,20 12:6 13:5 73:20 75:14 79:1 84:25 85:17 140:9 146:17 154:24 155:8 break 11:15 48:19,21,25 49:12 87:13,18,21 88:5 91:3 123:5 124:7 broad 39:3,4	broader 12:23 89:2 bucket 73:11 build 24:10,12,13,15 48:16 bulk 15:4 26:15 51:2,4, 13,16,17,19,20,23 61:12 87:2 141:20 bullet 117:16,22 118:11 bunch 27:23 28:13 82:4 business 48:25 Butler 10:23 11:3 12:11,13 19:14,15 20:8,11,12 21:23,25 22:8 23:5, 10,12 25:4,21 26:2, 5,12 27:2,15 28:2 33:8,16,19 35:20,23 37:22 40:17 41:3 48:6 49:14 50:8,11, 15 51:12 52:1 53:3 54:5 56:10,23 58:22 61:10 63:13,25 64:3 65:15,20,24,25 69:3, 24 70:23 71:9 76:11, 14,20 77:13 79:20, 24 80:11 81:7,8,10, 11 82:7 84:5 86:22 88:8,12 89:17 90:7, 19 91:9 93:23 95:2 96:13,18 102:4,20 104:15 108:14 109:2,4,6,7,9,10,15, 18,19,22 110:2,10, 16 111:5,7,9,15,20, 25 112:6,23 113:3, 19,23,24 114:5,11 116:21 117:17,19,23 118:9,20,21 119:6, 12 121:21 122:22 123:1 130:23 131:18,21 132:5,11, 19,23 133:4,5,10 136:13 138:1,10,24 139:10 140:9,23 143:11 147:14 150:6,13 151:10,15	152:12 153:20 Butler's 19:20 20:6 21:5 23:5 38:25 39:6 44:2 49:15 54:18 57:6 62:20,21 63:16 69:16,17,20 70:13 79:9,10 82:21 86:23 91:23 92:17,24 98:3 99:21 101:8,13,14, 15 108:16,18 152:4 C calculate 22:19,24 32:6,15 33:6 49:17 101:24 calculated 37:23 50:12 calculates 32:10 calculating 32:22 110:5 calculation 19:16,21 20:6 24:8, 16,17,25 27:9,14,18 32:2,5,12,18,22 33:9 37:24 38:14 39:10, 17,21,22,23 40:7 41:14,18 42:15 47:7, 16,24 52:14 54:5 56:3 58:20 60:3,13, 23,25 61:2,3,7,16,20 62:10,12,13,16,25 63:4,20,22 64:10 86:1,21,24 87:6 92:17 93:3,12,23 98:25 99:4,5,12 100:15 101:15,20,23 102:6,11 103:5,8,11, 17 112:21 130:15 calculations 23:24 27:10 36:1,7 39:1,6 41:4 55:7,23 63:5,7 69:6,9 84:5 86:8 99:21 101:8 137:17 139:6 call 6:5,11 9:14 21:25 22:7 24:3 53:14 59:3 60:4 70:17 84:9 92:23 105:6
--	---	---	--

called 107:24 114:7 133:18	12 79:16 80:25 81:4, 12,13 87:4 89:13,18, 22,25 90:12 91:1 94:24 95:7,10,13 97:18,25 98:19 100:17 101:10,15, 21,22 102:14,23 103:13 112:7,17,23 113:6,21,22 114:4, 14,16,17 122:21 152:14	66:24 citation 21:9,14,15,18 22:5 95:1 111:24 citations 63:2 cite 19:24 40:13 63:15, 19 64:15,23 103:16 105:10 107:6,9,12 110:16,25 113:5 122:5 154:17 cited 17:19 19:8,9 20:2 21:6 22:1,6 40:7 63:9,24 64:5,21,24 67:17 75:4,7 82:3,4 102:3 107:11,24 108:2,5 121:24 122:7 138:24 154:14 cites 70:8 citing 143:22 claim 12:23 153:1,3,4,16 154:12,20 claims 154:16 clarified 109:25 clarify 37:10 classical 25:16 clean 30:13 149:14,17 clear 108:13 133:5 135:10 close 21:12 59:15 87:10, 16 141:20 142:24,25 143:8 145:7,20 147:7 closer 110:4 clustered 15:11,17 co-authors 58:22 103:10 cobalt 140:15 150:17	collaborators 86:23 colleagues 67:8 86:23 column 22:11,14 28:4 32:8 33:19 35:24 40:24 50:9 53:4 67:20 88:9,13,14 105:16 125:16 128:13 133:14 135:9 137:11 138:21 139:4 140:20 141:15,23 142:5,6 comfortable 52:21 common 10:9 24:18 community 82:6 99:6,11 compare 32:17 compared 17:13 33:25 71:17 comparing 92:12 93:12 comparison 71:21 compatible 117:7 compelling 82:2 95:17 completely 72:18,19 74:15 78:19 80:16 116:24 117:25 118:8 121:20 complex 27:10 67:22 79:21 116:1 complicated 57:17,18,19 61:4 106:6 complication 57:22 component 68:10,11 72:1,2 77:3 composition 119:25 compressed 106:7 compressive 34:20
calls 109:9,16			
capability 61:18 86:20 96:10 103:8			
caption 28:8,17 29:14 31:14 53:9 109:21,23			
capture 33:4 109:4 113:19	changed 12:14		
captures 109:15	changing 10:23 12:13,24 65:20 79:8 81:15,25 98:5 110:20 112:6, 15,22 114:3,13 122:19 152:22,24		
care 48:25	channel 50:20 58:16 62:23 64:11 65:17 70:24, 25 71:10 76:13 77:23,25 100:9 133:25 134:6		
careful 43:8 149:14,16	channels 50:13 56:7 88:25 93:4 131:2		
case 6:2,5,6,15,18,23 9:7, 11 10:5 24:15 43:7 75:11 80:9 83:8 114:10 155:4,14	characteristics 124:22		
cases 9:12,14,15,17,20,24	characterization 28:15 113:16,17 114:9 140:7		
catch 29:9 142:1,2	chat 5:15,19		
category 121:20	check 75:20		
causing 127:7	cherry-picking 113:8,17		
caveat 134:12	child 24:10		
centered 33:21,23	choose 44:8 45:14 60:16		
certainty 8:10 81:3	choosing 40:11 45:19		
cetera 149:25	chose 44:12,15 45:23		
challenge 144:6	circle 28:19,20		
challenging 69:11	circles 28:13,16 29:22		
chamber 148:17,22,25	circumstance		
chance 81:16 95:7 102:24			
change 10:24 11:4 12:2 13:15 25:12 40:22 56:13 62:13 65:16 76:11 77:1 78:5,11,			

compromise 27:16 145:13,18 147:13,16 149:17 152:16 compromised 145:22 compromising 150:4 151:11 compute 27:11,12 computer 87:7 98:25 99:7 100:14 concerns 6:8 concluded 156:18 concludes 156:17 conclusion 82:19 93:20 114:10, 13 122:7,17,18 134:5,11 142:8,11, 13 143:6 conclusions 32:25 43:11 47:13 48:5,14 59:4,6 112:5 113:6,22,24 114:2 122:7,15 133:18 134:21 concrete 153:14 conditions 142:17 conductance 20:13 69:12 70:21 77:25 88:22 90:9 116:22 118:18 conduction 66:10,14,18,21,23 71:6,13 confines 55:1 confirm 6:17,22 141:18 confusing 31:4 consequences 24:21 considerably 128:18	consideration 20:4 92:18,20 129:3 145:15 147:15,18 150:4 152:2,3 considerations 145:8 considered 12:24 90:16,24 93:16 95:2 consists 68:1 constant 34:21 35:1 37:23 38:1,11 44:14,15,18 45:23 constructed 25:14 contend 98:23 context 24:12 43:2 72:13 99:17 108:25 110:10 121:16 147:25 continuing 50:10 contracted 35:1 contrast 119:13 contribute 66:14 converge 87:6 conversation 49:11 coordinates 38:8,12 correct 6:9,10,24 7:12,15,18 9:18 11:23 12:8,9 20:19 22:21,22 23:3, 4 28:9,11,16,20,21, 24 29:7,20 30:5,6, 22,23 31:2,7,10,18 34:7,11 36:1,2,5,13 38:4,6,20,23 39:2 41:24 43:23 44:16 46:6,13 47:2,24 50:13 51:14 52:5 53:18,19,23 55:8 56:19 57:8,13,20 58:1,10 65:18,19	66:11 67:6,9,13,25 68:4,7,25 70:9 71:15,24 74:19 75:16 78:2,3,5,8 79:11 82:22 93:9 97:3,14 103:18 104:16,17 105:20 106:1 107:15 114:3 115:2,6 119:23 120:2 122:18 123:1 124:23 125:3,7 126:6,10,11 129:21 131:2,4,19,20 132:21 133:1,17 134:19,25 136:18 137:20,23 139:11,19 140:11,12,17,18 141:12,13 144:24,25 146:1,2,7,25 147:23 correcting 110:22 Correction 83:2 correctly 30:16 34:8 47:1 50:14 68:18 69:15 117:10 119:19 132:15 134:4 corrugation 125:20 126:14,17 128:1,10 cost 32:11 98:23,24 100:19 costly 99:8 count 77:19 counting 8:22 couple 34:15 66:5 coupling 117:5 covered 30:3 54:9 96:20 153:4 create 152:10 created 23:17 68:3 creates 96:18	creating 27:7 47:1 creativity 85:13 criticized 116:22 criticizes 108:15 crucial 116:23 117:1,12,18 118:17 crystal 17:13 32:24 74:2 78:20 134:3 137:19 140:10,16,24 141:4, 8,12 142:23 143:20 144:13 145:23 146:6,12 147:4,5 148:4 150:17 152:6, 11 crystallin 147:9 148:3 crystalline 132:7 142:18 146:8 crystallinity 119:25 cube 36:21 current 52:9 68:13,19 72:4 77:3 curved 120:24 D D1 106:11 111:18 D2 106:12 damn 102:24 dark 28:20 darker 28:22 29:1,8,17 darn 147:6 data 40:8,9 95:9 day 10:7,8,11 66:17 76:24 80:10
--	--	---	---

days 9:10,15 10:1,4	16:17 17:23 18:13, 25 59:2,8 68:7 73:8, 13,15 74:1 76:4 85:11 94:22,24 98:18	24 95:7,10 98:19 100:10 101:9 102:15,25 104:21 105:5 107:1,21 108:8 109:8,9,13,17, 20,24 110:6,11,12 111:3,10,12,18 112:15,22,25 114:3, 7,13 122:19 128:17 129:13,23 130:4,7, 10,13,19 131:1 136:5	25:6 26:2,6 37:14 description 51:15 54:25 69:17, 25 designed 48:4 desire 151:12 desktop 5:21 destroy 93:18 detail 13:24 16:4 19:6 27:13 43:9,18 48:8 51:22 61:19 90:16 96:24 111:15 113:2 130:22 143:12 detailed 47:5 61:7 127:11 details 17:20 36:22 43:13 47:6,14 48:10 51:17 52:12,13 61:24 62:14 87:2 91:16 110:8 133:6 134:14, 17 determine 41:10,11 56:5 determined 68:14 72:5 136:5 determining 88:22 develop 24:18 developed 23:20 26:3 137:18 developing 23:6 device 33:5 50:4 63:15 141:11 145:7 147:19 148:22 150:17 152:1 devoted 10:5 DFT 37:24 61:22 63:6 difference 31:11 34:3 40:14 55:13 103:24 112:11 117:8
deals 126:23	defects 12:22,25 32:20 33:3, 16 35:9 56:3 58:21, 25 59:1 63:9 68:3 71:24 72:9,10 73:18, 19,20 74:5 75:13,22 76:21 78:21 79:3,13, 16 80:1,4,18,21 81:5,21 84:6 85:17 87:1 89:12,20,21 90:12,25 91:5,13,17 94:1,4,12 95:2,4 98:13 100:17 133:3 151:5,24 152:15,19, 23,25 153:9,10 154:16	dep 156:17 departures 147:7 depend 39:7 depending 109:13 depends 39:9 40:2 49:25 94:4 112:25 140:3 154:9 depiction 139:11,19 deposit 148:13 deposited 30:13 34:5 126:8 127:5 depositing 124:25 125:2 deposition 5:1,25 7:22 8:23 9:7 10:13 34:6 35:13 43:10 49:13 88:6 111:23 116:18 124:8,22 125:24,25 depositions 10:2 deposits 149:4 derived 92:13 describe 155:7,15 156:2 describes 27:19 37:22 107:14 114:21,25 115:4,8, 12,25 116:4,7 127:14 145:19 describing	
debate 23:14			
decay 115:12,16,20,21 117:8 130:14,15			
decaying 118:12,16			
decent 81:16			
decide 58:6 99:13,14,15			
decision 60:9 98:8			
decisions 62:17			
declaration 6:19,23,25 7:1,16,20 8:2 9:19 10:7,8,18 14:1 17:17 19:23,24, 25 21:20 43:15 63:10 65:9 67:18 82:21 91:18 101:5 103:23 104:24 105:20 106:8 107:7, 10,11 108:13,21 110:1,14,19 112:9 113:10 116:18 119:2 122:1,10,25 124:10 125:24 131:7 132:4 154:21 155:14			
declarations 9:24,25 19:10 47:22 76:17			
decrease 83:11,13			
decreases 83:14			
deduced 120:23			
deep 51:16 110:8			
deeper 16:3 39:11 108:24			
deeply 46:15			
defeat 152:16			
defect			

differences 147:8 differs 62:6 difficult 95:18,25 144:5 diffraction 30:11 31:6 141:17 142:16 dig 108:23 digit 47:18 digits 38:21 39:15,17,24, 25 44:23 dimension 36:17 45:5 dimensions 45:10 directed 12:20 direction 38:9,10 directly 103:23 112:10 114:2 disagree 23:12 39:6 69:21 86:16 97:16 107:17 113:15,16 122:22 discuss 127:20 discussed 112:13 132:18 138:9 discussing 52:1 discussion 80:13 108:6 127:22 dislocations 34:18 disorder 68:16,20,25 72:7,12 73:6,7,9 74:25 150:25 151:5 disordered 72:19 74:15 78:19 dispersion 89:4 displacement 46:23 disposed 37:5	dissuading 153:10 distance 38:15,18,22 45:14, 18,21 74:22 97:7 116:10 129:10 distinguished 147:5 distinguishing 51:19 distortion 127:16 128:7 distributed 14:5 15:4 distribution 80:6 doable 100:18 document 88:12 dominated 134:1 DOS 50:12 129:11 double 146:1,3,22,23 doubt 21:8 112:22 down-spin 106:22 107:3 download 5:16 draw 47:4 83:4 92:11 drawing 92:20 122:15 drew 83:6 92:14 134:21 drop 21:4 30:7 66:5 90:6 128:12 137:12 141:16 Ds 109:6 110:11 due 34:20 70:5,23 71:14, 24 80:8 duly 5:5 dynamic 36:20	E earlier 10:1 25:14 54:24 116:22 early 123:23 easily 40:19 127:17 easy 81:5 educated 62:9 effect 35:4 58:14,25 59:9 77:6 78:21 81:24 82:9 86:1,14 89:15 90:2 93:16,21 94:18 95:13 98:12 100:6,7 109:14 114:6 128:20 129:3 130:24 143:21 152:18 effects 33:9 80:9 81:1,13 84:9,12 86:25 87:5 90:5,24 91:11 102:15 efficient 127:18 effort 151:15 electrical 66:10,18,20,23 electrode 34:7 133:7 138:12 140:5 143:3 144:21, 24 146:24 electrodes 22:20 76:6 88:20 92:3 104:19,22 105:24 106:3,13 107:2 108:8 109:14 110:12 111:19 112:12,16 113:1 117:6 122:21 130:1 136:17 electron 11:11,21 12:1,5 13:7,20 14:8 18:12, 24 30:10 31:6 67:21 68:1,11 69:9 72:2 73:21 75:16 77:3	78:5,11,13 79:3 electronic 22:18,24 25:4 40:25 41:4,10 49:17 50:3, 11 67:3 69:10 113:1 121:17 138:11 139:14,22 140:4 electrons 66:8,14 68:15 69:14 71:1 72:6 76:6 78:1 79:18 81:25 112:16 114:16 122:20 140:3 element 144:5,6,19 148:11 elements 10:9 114:21 117:23 118:6 embedded 44:5 emphasize 23:21 27:7 139:11, 18 emphasized 138:24 150:7 Emphasizing 91:10 empty 46:20 end 8:25 66:17 76:24 77:18,20 123:23 144:2 ending 137:19 endnotes 137:23 energies 66:21 energy 30:10 31:5 66:9,11, 15,19,22 81:25 83:14,17,18,20,23 91:25 92:13 93:11, 13 102:8 118:14 engagement 8:17 enhanced 134:7 entire 27:3 74:2 140:4 141:11 entitled
---	--	--	---

5:16 epitaxial 133:21 139:12,20 140:10,16 141:19 142:17 147:9 epitaxially 140:24 141:4,11 epitaxially-grown 141:8 epitaxy 148:20 equal 37:23 equals 25:17 105:1 equation 25:2,3 104:3 105:1, 3,8,19 107:14,21 108:14,15,19,25 109:6,12 110:9,14 111:3,11 112:4,13 113:3,5,18 114:11 122:5,6,13,16 equations 24:25 108:3,4 113:9 equilibrium 34:25 error 5:20 122:3,7 essential 135:24 essentially 47:13 72:17,19 74:20 estimate 77:8 85:10 estimated 70:3 evaluate 48:10 50:16 58:14 62:22 63:7 130:24 evaluated 48:5 evaluates 63:16 evaluating 50:19 52:9 63:13 79:7 130:25 evanescent 115:8,12 117:6 118:12,16 130:14,15	evidenced 141:24 142:15 Evidently 46:10 evolves 130:19 EXAMINATION 5:9 examine 73:3 examined 5:6 excited 82:5 exhibit 6:18 10:18 20:9,20 22:9 25:21 28:2 33:19 50:8 65:10 67:1 70:13 77:14 82:21 88:9 91:19 101:5 104:10 105:11,12 106:24 107:12,14 110:13 115:15 116:18 117:4 119:9 124:10,13,16 132:4 133:11 135:4 136:21 137:4 138:4, 7 143:13,22 154:22 155:3,13,23 156:1 exhibits 6:15 expanded 34:23 expect 11:4 39:10 66:23 85:7 94:10,17 100:11 146:15 expectation 94:14 expected 65:17 76:12 expensive 27:10 98:22 experiment 25:9 33:5 42:16 60:1,2,12 62:5,18 82:15 86:8,10 95:18, 23 96:11 99:13 100:12,16 103:4 experimental 40:8 42:9 44:14,16, 17,22 59:21 62:14	85:5 experimentalist 48:15 60:5 82:7 experimentalists 59:25 60:8 99:11 Experimentally 34:16 39:17 experiments 140:14 expert 40:16 49:22 52:13 56:11 86:22 expertise 48:9 experts 48:12 explain 43:13 98:10 113:3 explaining 121:25 explains 106:24 111:9 124:20 explicitly 65:22 109:5 115:16, 20 116:8,9,11,21 121:10 expressed 105:18 111:2 expressing 104:5 expression 105:2 120:7,11 exquisite 96:24 extent 10:16 45:19 extra 21:17 extrapolate 62:8 extremely 27:10 88:21 F fabricated 141:7 fabricating 148:23 fabrication 145:9 face	109:3 fact 39:15 56:16 76:20 81:17 84:22 86:12 141:10 factor 45:25 81:20 factors 79:22 89:6 117:24 147:15 failed 116:23 fair 8:24 12:16,22 33:17 42:3 46:7 99:18 103:21 125:4 127:9 129:24 136:19 143:5,6 fairly 7:23 faithful 46:19 familiar 17:22 67:14 famous 21:23 22:7 fancy 27:13 Fe 140:15 features 61:3 63:1 147:18 feel 48:18 50:1 feeling 87:20 felt 76:25 Fermi 66:15,19,21 79:17, 20,25 80:3,17,22 83:14,17,18,20,23 85:7,22 91:1,25 92:13 93:11,13,18 94:2,19 100:8 101:10,21 102:2,8, 10,23 103:12,13 104:22 107:2 112:6 118:14 ferromagnet 154:8 ferromagnetic
---	--	--	--

14:14,22 26:23,25 30:25 33:11 85:20 86:4 104:19 105:23 106:13 133:7 136:17 138:12 143:3 144:21,23 146:4,7, 24 147:21 150:9 ferrous 117:3 field 22:5 47:11 figure 28:1,7,13 30:24 31:9,14 37:5,13,16, 20 51:25 53:2,3,4,6, 9,11,17 55:7,10,13, 14,18,19 56:22 87:17 92:6 93:5,6 101:10 109:18,20, 22,23 120:24 129:15 141:16 figures 53:13 82:22 91:23 92:24 102:22 127:1 filled 18:4 film 125:20 126:15,18,19 127:3,24 128:2,3,4 149:18,22,23 150:5 films 148:23 find 62:19,25 64:9,18,25 65:24 77:16 103:19 107:20 130:18 137:10 finding 127:16 130:21 fine 48:22 107:19 finish 72:23,24 73:2,4,5 first-principle 22:18 five-minute 87:21 fixed 40:9 flat 142:18 148:10 149:14	focus 9:8 22:23 127:23 focused 23:5 26:14 73:12 125:5 focusing 153:9 forget 29:12 form 28:10 34:19 40:1 44:24 64:14,19 65:3 75:17 78:15 82:24 83:10 96:3 112:1 122:4,11 128:23 131:3 135:1 144:4,5 145:4 146:24 149:14,22 155:19 formed 75:12 76:10 143:20 147:21 forming 19:14 76:19,22 90:19 forms 146:4 formula 104:2 forward 59:20 132:13 found 50:25 64:20,24 140:2 141:6 154:4 Fourth 88:19 fraction 42:13 framework 41:11 front 65:10 155:23 full 35:24 36:1 61:7 88:15 122:24 125:16 138:21 140:20 141:23 142:7 fully 25:12 69:10 function 63:12 115:17 130:19 functional 36:3	fundamental 137:13 G G-I-O-R-D-A-N-O 124:14 gain 80:6,7 gamma 136:6 gap 16:19 17:1 gave 13:23 43:10 48:6 54:25 76:24 105:8 general 47:10 50:6 57:21 62:15 generally 67:16 98:21 99:2 120:15 132:2 146:14 giant 143:21 Giordano 124:14,20 129:2 130:3 give 22:1 25:10 36:21 43:17 45:8 47:12,19, 23,25 56:14 88:11 108:19 152:20 giving 48:3 52:21 goal 152:17 good 5:11 6:13 21:11,19 43:4 48:24 49:2 81:14 87:21 99:12 102:24 104:7 110:3 111:12 123:4,6,7,24 145:14 147:6,12 148:2 151:9 Google 20:23 21:10,14,18 gory 47:14 48:7,10 51:17 governed 69:13 grain 59:19	Granted 102:8 gray 52:21 great 43:9 113:2 grew 141:11 146:11 gross 121:14 group 140:9 grow 99:14 145:22 148:5 151:13 152:1 growing 149:17,21 150:5 152:9 grown 34:17 140:24 141:4 146:17 147:10 grows 147:8,22 growth 67:3 142:17 guess 24:4 48:23 62:9 94:14 guidance 59:18,19 62:14,16 99:10 H half 10:6,7 34:19 123:8 hand 123:22 handy 75:8 Hang 6:19 happen 101:9 123:2 happened 6:20 happy 74:9 hard 8:8 65:5 77:7 143:7 150:21 151:3,7 hate 107:18
--	--	---	---

head 13:22 127:13 header 20:25 40:25 hear 18:18 heats 148:25 height 10:24 11:5,8,11,21, 22,25 12:5,13,14,19, 21,25 13:6,14,20 14:8 18:12,24 65:16, 21,25 76:12 79:8 81:4,12,15,23 82:8 83:9,13,15 85:8,17 94:4,6,7,9 101:22, 24,25 102:3,5,8 116:7,9,12,13 120:22,23 121:8 152:15,22,24 153:3, 4,7,12,14,17,19,22, 25 154:2,9,14,15,18, 24 155:8,16 156:3 heights 100:17 held 37:23 38:11 hesitating 12:23 hey 85:14 102:23 152:13 high 39:7 48:2 70:21 71:13 85:10 102:1,5 132:6 134:16 136:13 140:16 142:18 145:2,16 150:2 151:17,22 high-quality 152:10 higher 47:13 131:23 highly 21:25 22:6 27:13 39:1 49:18 50:2 93:25 102:19 146:10 147:1,2,6 148:1 149:22,23 152:10 hmm 81:11 Hold 108:19,22	hopping 68:2 hot 136:5 hour 8:19 48:18,21,25 87:10 123:4,8,10 hourly 8:17 hours 8:4,7,12 huge 78:18 94:12 95:21 hundred 8:14,15 22:1 32:13 I idea 17:22 55:24 81:14 ideal 23:7,8 30:2,3 37:4 41:23 42:1 43:22 54:8,9,19,20,22 55:1,3 62:5,6 93:24 96:19,20 132:20,24 133:2 134:22 147:13,14 idealized 27:6 55:4 134:22 identical 147:4 identifies 109:23 identify 154:23 III 40:25 illustrate 89:8 image 139:21 impact 47:11 92:1 95:22 imperfections 32:19 133:3 146:13 implement 152:4 implication 40:11,21 importance 52:23 150:7	important 23:22 26:13 32:16 33:1 42:6 52:8,19,20 59:10 88:21 90:4 impose 45:14 in-plane 34:20,23 35:2 37:22 38:11 149:24 inadequate 116:24 117:25 118:8 121:20 122:23 incident 41:13 include 56:1,2 58:20 65:25 87:5 101:13 121:8 133:22 includes 144:20 including 81:4 119:16,22 138:23 139:10 140:23 incompatible 113:9 incomplete 122:17 increase 83:8,17,23 91:6,13 95:8 131:12 132:12 increased 11:23 increases 98:24 increasing 82:6 83:14 95:17 independent 116:14 indication 95:11 individual 51:9 induced 94:2 inequivalent 128:16 inert 117:24 influence 81:18 90:8 95:5 109:10 114:2,12,15	influenced 114:5 information 13:24 14:1 20:2 24:7 66:20 82:4,5 86:9 92:11 inspiration 62:12 instructions 82:14 insulator 139:14,23 insulators 133:22 integrating 129:11 intended 14:7 107:6 intent 132:9 intention 122:3 interacting 79:19 102:25 interest 33:20,23 120:16 interested 26:17 131:16 interface 14:14,22 23:2,7,19 25:25 26:4,14 28:8 29:5 30:2,9 31:16, 21,23,25 32:14,16, 23 33:3,4,10 34:22 37:19 38:16 45:16 51:1,20,23,24 52:2,8 53:8,22,25 54:10,13, 14,16 55:16,19,20 56:25 57:8,25 58:1, 7,9 60:17 61:11 85:19 86:3 87:2 93:4,6 96:15,19 98:4,6 99:19 133:6 134:14,17,22,23 135:25 138:12,17 143:3 150:8,25 151:17,22 interfaces 34:25 132:24 136:16 142:19 interfacial 46:21 90:7,12,22
--	--	---	---

116:4 134:7,12 136:9 interference 115:25 intermediate 40:6,9 interplay 139:13,22 interpretation 47:6 84:1 109:5 111:18,25 interpretations 43:17 interpreting 46:16 47:18 122:13 intersects 83:22 intrinsic 68:14 69:9 72:5 introduce 61:13 75:14 80:5,21 100:16 introduced 13:2 14:13 62:21 74:6 84:24 85:19 89:19 92:19 introducing 12:7,15,21 80:4 84:12 91:13,17 92:16 93:21 introduction 22:12 67:21 79:13, 15 84:16 90:20 91:4 92:7 invent 154:10 inventions 154:11 involve 155:9,17 156:4 involved 19:7 involving 145:9 IPR2024-011494 6:2 iron 22:19 23:2,7,18 25:25 26:4 28:9,16, 18,23 29:1,7,12,15, 16,17,18,19 30:2,5, 8,12,18,20,21 31:2,	6,10,12,13,17,19 33:10 34:5,7,11,17, 22,25 36:24 37:1,2, 4,15,17,18,24 38:2, 5,15,22 41:13 44:5, 9,15,17 45:4,15,16 46:1,21 51:18,21 52:3,8 53:7,21,25 54:8,19 55:16,18 57:8 60:17 69:13 93:4,24 96:15,19 97:7,8 99:20 132:20, 25 133:22 134:18,23 137:22 143:3 146:4, 6,13,17,25 147:21, 23 148:4 149:4,8,15 150:8,17,18 152:6 iron/magnesium 10:25 20:13 22:25 49:18 56:7 63:14 67:5 69:12 71:19 130:25 135:19,25 136:14 iron/mgo 118:1 137:20 issue 78:16 issues 145:10 J January 20:18 JEFFREY 5:4 job 21:11 judgment 60:4 Julliere 105:4,5,9 107:25 115:15 118:4 120:8, 10 121:3 Julliere's 104:6,8,9,12,18 105:17 107:9,14 109:1 114:21,24 115:3,7,11,24 116:3, 6 118:5,7,22 119:20, 24 120:3,11 121:7, 11,19 122:4	July 20:24 21:2,5 junction 10:25 11:10,20 27:1 48:16 54:16 71:7 73:21 130:1 131:13 136:10 150:18 junctions 131:17,23,24 132:20,24 140:16 junctures 67:23 K K-L-A-U-A 67:10 k-parallel 68:12 72:3 80:6 134:7 kind 7:24 14:1 27:20 55:24 59:10 62:17 96:4 kinds 32:19 52:11 56:18 59:1 KKR 61:21 Klaua 67:8,21 68:9 69:19 70:1,8 78:7 89:16 136:22 Klaua's 69:17 knew 138:10 145:17 151:21 L lab 60:11 label 104:3 109:20 labeled 53:11,16 landing 11:13 large 28:19 117:4 135:13, 15,18,23 136:5	larger 28:16,18 34:21 46:1 lateral 68:9,11 72:1,2 77:3 lattice 15:25 16:7,18,20 17:1,2,3,7,9,14 18:3 34:21,23 35:1 37:23 38:1,11 44:6,9,14, 15,17 45:23 46:1 68:16,20,25 72:7,11, 17 73:6,7,9 97:12, 13,18,20,24 128:9 141:19 layer 11:9,19 12:6 13:6,19 14:7,14,15,22,23 15:5,13,18 23:8 26:23,24,25 29:5,6 30:2,4,20,25 33:11, 12 37:4 38:2 41:14, 24 42:1,2,10 43:21, 22 45:16,17 46:21 47:2 50:12,17 51:8 52:3,4,8 53:7 54:9, 10,18 56:25 57:7,12 58:7 60:18 61:12,21 79:2 84:25 85:18,20 86:4,5 88:21 96:20, 21 97:8 98:6 114:22 115:1,13 118:13,16 119:17,22 120:3,5,6, 13 126:5,7 127:4 128:15 132:25 133:1 134:18,19,23,24 138:13 143:20 144:21,22,24 146:7, 11 147:1,3,8,9 148:1,5,14 149:5,8, 15 150:9,10 154:24, 25 layers 14:4 23:9 34:5,16,18 35:1 36:18,19,24 37:1,9,12,15,18 38:10,12 41:21,22, 25 42:7,14,17,20 43:1,4,5,6,7,20 44:1 45:21 51:5,6,9,13 54:14,20,21 55:2,4, 15 58:1 61:13 93:24 99:20 132:21 141:11 145:3,21 146:4
---	---	---	---

148:23 LDA 61:23 lead 79:14 91:5 leave 115:23 LEED 30:11 left 28:4 96:13 113:20 133:14 138:21 139:3 140:20 left-hand 22:11,14 33:19 67:20 105:16 125:16 128:13 135:9 137:10 length 74:21 level 13:23 19:6 40:17 43:17 47:13 48:2,7,9 51:22 63:6 66:9,15 74:22 79:18,20 80:1, 3,17,22 85:8,22 86:21 90:15 91:1,25 93:19 94:2,19 100:8 101:10,21 102:2,10, 24 103:12,14 104:22 107:2 112:6 151:5 levels 51:23 98:14 light 11:3 74:24 limitations 154:12 lines 54:3 83:4,5 84:3 92:24 93:2,6 list 21:15 listen 35:16 lists 133:22 literally 18:13 19:1 literature 17:18,19 19:8 22:3,4 26:8 65:5 loaded 54:23 99:16	located 5:12 136:6 location 17:3 66:22 locations 98:18 long 84:17 104:15 long-range 74:18 longer 18:8 81:9 looked 9:19 12:19 37:6 54:23 65:2 82:3 103:19 107:13 lost 141:1 lot 42:17 79:22 89:5,8 91:2 98:19 110:4 111:17 112:3 152:8 lots 82:3 low 12:1 30:10 31:5 70:20 71:13 lower 11:25 26:23 30:25 80:21 91:17 94:7,8 144:21 146:24 153:2,7,17,21,25 154:2 lowered 85:17 lowering 11:22 12:21 81:22 94:5 153:3,12 LSDA 61:23 LSDA-DFT 36:1 LSI 144:6 lunch 87:17,20 123:5 124:4 M ma 25:17	made 54:19,24 84:5 102:6 108:13 magnesium 11:9,19 12:6,7 13:5, 19 14:6,15,23 15:4, 12,18,25 16:8,15 18:3,11,23 23:3,8,18 25:25 26:4,15,24 28:9 29:6,24 30:3,8, 13,21 33:11 34:4 37:9 41:13,21,23,24 42:2 43:20,22 44:1 45:17,24 46:13,22, 23 51:4,8,10,14 52:3,7 53:8,22 54:1, 9,20 55:15,20,25 56:8,24 57:7,12,25 58:7 61:14 62:24 63:8,12,17 64:12 67:4 68:6,24 72:11 75:15 76:4,15 78:13 79:1,16 84:25 85:18 86:4 89:12,23 90:21 92:8 93:5,8,22,24 96:15,20 97:8,12,13, 24 98:6,12 99:20 117:7 124:23 125:1, 2,10 126:1,2,8,9,13, 22 127:7 128:1,22 129:4,5 130:16,25 131:17,22 132:6,7, 20 133:1,7 134:18, 24 136:4,17 143:4, 20 144:22 145:25 146:19,21 147:22 148:14 150:9,17 154:24,25 155:9,16 156:3 magnetic 22:24 40:25 48:16 67:4 70:3,5 129:19 144:7 magnetization 105:23 magneto- 144:7 magneto-tunnel 10:25 11:10,20 26:25 67:23 71:7 73:21 129:25 131:13,17,22,24 132:19,24 150:18	magnetoresistance 117:4 magnetoresistive 143:21 144:19 148:10 magnitude 132:12 main 9:8 90:1 majority 50:13,20,22 53:21 56:6 58:15 62:22 64:11 65:17 69:13 70:24,25 71:10 76:12 77:22,25 86:2 88:25 89:5,13 91:7 92:2 93:4 100:9 112:15 114:4 122:19 131:1 133:25 majority/minority 129:22 make 23:23 24:2,6,8,16,19 27:2,9,16,18 46:18 47:5 57:14,15 59:1, 11,15,22 60:9,25 61:4,7 62:17 75:23 81:6,7,8 86:21,24 94:23 103:8 108:23 120:20 123:24 129:25 136:16 138:17 143:7 145:2, 6,7,12,14,16 147:19 151:8 152:20 makes 144:5 making 42:15 110:23 145:10,13,18 147:10,11,12 149:16 manifest 14:3 manner 13:3 154:1 manufacturable 145:11 manufacturing 144:14 145:10 148:10 mark 77:7 mass 145:11
--	---	--	---

match 59:13	meet 51:21 152:3 154:11	minutes 49:1,2 123:10,11,17 156:9	54:10 132:19,23 143:8
matching 70:24 71:2	memory 144:8	misfit 34:18	modeling 36:4,13,16 46:5 54:14 58:19 98:23 134:22
material 16:9 72:16,18 74:13, 14,18,23 75:1 78:9, 12,18,19,23 80:20 84:19 85:3,10 99:14 115:9 125:1 129:19 145:2	mention 19:25 116:8 120:22	missed 58:2 120:23	models 24:24 26:7 59:11,16 116:22 138:10 140:22 141:3
materials 36:5 137:19 147:24	mentioned 63:1 94:25 132:1	missing 16:8 17:4 18:4,14 19:2 21:15 58:6,9 59:24 97:19,25 98:3, 4 125:11	moderate 80:19 84:18
mathematical 121:7,11	mentions 121:21	mistake 122:5	modification 109:7,25 110:23
Mathon 131:21 132:11 135:3 136:13 138:7,23 139:10 140:23 143:22 150:7,13 151:15	metal 130:17 139:14,23 154:6,7,9	mistaken 21:21 108:15	modified 14:6 62:20 79:2 85:18 129:14 153:21
Mathon's 131:18 132:5 138:10 140:9 143:24	method 148:9 154:3 155:2	mod- 57:5	modify 11:8,19 57:5 153:25
matrix 114:21 117:23 118:6	mev 120:25	model 23:2,6,11,17,21,25 24:2,4,6,9,11,13,14, 15,16,20,21,22 25:1, 5,6,8,11,12,14,16, 17,18,20 26:3,6,11, 13,15,18,23 27:3,6, 8,14,16 31:21,25 32:20,22,23,25 33:1, 2,9,16 34:4,10,24 35:3,4 36:9,15 38:7 39:2,8 41:18,23 42:15 43:4 44:2,8,10 45:20 46:9,19,25 47:15 48:4 49:16,20 50:16 54:6,18,19 55:3 56:10,19 57:6, 14,15 58:6 59:1,4, 13,22,24 60:10,13, 16 61:4,10 62:20,21 63:16 66:1 79:9 84:5 86:14,15 87:4 92:14 96:14,19,24 98:3,15, 21 101:13,16,25 102:14 104:6,8,9,12, 18,25 105:17 107:9, 15,25 109:1 114:21, 25 115:4,8,12,25 116:4,7 118:5,7,22 119:7,16,20,21,24 120:4,11,13 121:7,8, 11,12,19 122:4 127:6	modifying 98:2
matter 8:18 39:25 40:3 99:24 151:6	Mgo 22:20 34:17,18,21 35:1 37:18 42:7,10 51:18,21 52:9 79:19 80:16 82:1 85:9 91:5 94:25 95:6,8,11 98:13 100:17 109:11,15 114:10 119:16,21 128:9 129:9 137:22 145:3 146:10 147:1,11 148:1,5 149:21 152:6,9,11	moment 65:11 88:11 108:20	moments 70:3,5
MBE 148:17,20,22,25	micron 32:13	momentum 68:12 72:3 77:3 78:2,5,11,13 134:3	monolayer 125:25 126:2,4,20, 24
meaning 58:4 66:24 71:13 111:1 112:14 139:9 140:22	middle 139:5	morning 5:11	motivated 11:4,8,19,25 152:13 153:24
means 23:15 33:24 45:20 49:22 51:4,19 54:25 70:20 71:6 99:4 126:4 127:4	milli-electronvolts 120:25	motivating 26:9	motivation 93:18
meant 9:23 28:22 103:9,10	millimeter 32:13	move 25:18 66:22 93:18 94:2	moving 91:24 94:19 100:7 102:10
measure 66:18	mind 32:16 108:22	modeled 36:8 43:5,6 51:9	MTJ 49:18 77:4 108:8 119:16,21 140:11 142:23 152:4
mechanical 25:3	minority 50:13,22 53:25 56:6 58:15 62:22 64:10 65:17 76:13 86:1 88:25 89:5,13 91:7 92:2 93:3 100:9 112:16 114:4 122:20 131:2 134:5		
mechanics 25:16,17,19	minus 45:8		
mechanism 12:18 154:23	minute 36:15		
mechanisms 19:7			

MTJS 117:3 118:2 132:7, 13 135:19 136:15 137:19 139:13,20 145:3 multiple 57:20 58:9 98:10 115:25 multiplicity 74:5 N Nagahama 143:14,15,24 144:2 145:1,25 146:9,20, 21 147:8,20 149:13 151:10,25 154:1 Nagahama's 13:18 154:25 155:16 156:3 nanometer 42:13,19,20,21 43:2 nanometer-size 32:14 narrow 66:2,3 nature 32:5 88:20 89:1,6, 17,22,25 109:15 114:25 necessarily 24:1 39:14 61:18 needed 73:20 154:1 neglected 117:24 Newport 5:14 nitty-gritty 61:24 91:16 nonlinear 27:13 notation 106:7 note 69:4 notice 5:25 87:13 novelty 153:1 nuance 61:19	number 5:16,23 6:2,9 9:4 21:9,22 22:2,5 36:16 39:22 40:6,9,18 47:15 55:25 66:8 68:3 73:23 91:4 103:11 108:3 134:11 150:1 153:15 numbers 21:18 40:10 47:18 97:4 numerical 137:17 139:6 O oath 5:6 8:9 object 65:3 148:16 149:1 objection 14:9,24 15:6,14,19 16:2,10,21 17:11,15, 25 18:6,16 19:4,17 28:10 40:1 44:24 64:14,19 75:17 78:15 82:24 83:10 96:3 112:1 113:13 122:11 128:23 131:3 135:1 145:4 155:19, 22 observe 135:12,23 obtains 38:15 obvious 94:8 153:5,7 154:20 Occasionally 10:8 occupy 66:9 occur 79:1 October 5:1 7:10 offer 14:11,16 19:19,22 43:15 47:8 76:16 90:14 offered 7:17 10:21 14:25 15:8 17:16 33:13 111:22	offering 12:12 85:24 office 5:14 offices 9:9 older 48:24 one-sentence 69:25 open 5:17,23 6:18 13:11 20:8,20,21 67:1 104:10 105:11 124:16,17 136:21 137:4 155:3 Operator 5:20 opinion 11:6 12:20,24 13:23 14:11,16 15:1,8,15, 20 16:5 17:17 19:11, 22 32:4 33:13 47:10, 19 56:14 61:15 65:23 73:24 75:5,12 76:10,16,19,22,24 77:1 85:24 90:15 102:12 103:14 107:25 111:21 131:11,15 opinions 7:17,20 19:14 43:11, 15 47:8,12,21,23,25 48:3 52:22 90:17,19 optimism 100:5 optimistic 85:13 optimists 100:3 optimized 142:16 order 11:10 12:1 18:11,23 20:4 22:24 45:7,10 48:5 72:17 74:12,16, 17,19,20 75:18 85:21 94:12 120:24 132:11 151:12 ordinary 10:22 11:2,7,18,24 12:4 13:4,17 14:18, 20 16:24 20:3 26:10	40:15 48:1,15 56:5 60:8,24 61:6,9,15,25 62:2 65:23 72:15 75:10 76:8 79:23 80:10,14 81:2,10 82:17 84:23 85:6,13, 15 86:6,13,19 91:12 94:15 95:3,15 100:1, 2,4 102:19,21 111:11 131:11,16 138:15 146:9,15 150:20 151:20 152:12 153:6,11,21, 24 154:13 orientation 70:2,4,16 71:6 148:2 oriented 146:10 147:1,2,6 148:1 149:22,24 152:10 original 155:13 outcome 52:15 60:12 overcome 94:20 144:9,10 152:7 overloaded 51:7 oversight 110:19 113:4,19 oversimplification 69:24 overwhelm 95:13 oxide 11:9,19 12:6,8 13:6, 19 14:6,15,23 15:5, 12,18,25 16:9,15 18:3,11,23 23:3,8,18 25:25 26:4,15,24 28:9 29:6 30:3,9,13, 21 33:11 34:5 37:9 41:13,21,23,24 42:2 43:20,22 44:1 45:17, 24 51:5,8,10,14 52:3,7 53:8,22 54:1, 10,20 55:16,20,25 56:8,24 57:7,12,25 58:7 61:14 62:24 63:8,18 64:12 67:24 68:2,7,10,15,24 69:12 71:18,23 72:6,
--	---	---	--

11,16 73:7 75:15 76:4,15 78:13 79:2, 17 81:14 84:25 85:18 86:4 89:12,23 90:21 92:8 93:5,8, 22,24 96:16,21 97:8, 12,13,24 98:6 99:20 117:7 124:23 125:1, 2,10 126:1,3,8,9,13, 22 127:7 128:1,22 129:4,5 130:16,25 131:17,22 132:2,7, 20 133:1,8 134:18, 24 135:25 136:4,17 143:4,20 144:22 146:1,19,21 147:22 148:14 149:18,20 150:9,17 152:7 154:24,25 155:9,16 156:3 oxide/iron 10:25 20:13 22:25 49:18 56:7 63:14 67:4,5 71:19 131:1 135:19 136:14 oxygen 12:7,15,21,25 13:2, 4,13,17 14:3,5,21 15:3,11,17 16:1,8, 14,19 17:2,4,8 18:2, 4,11,14,22,25 19:1, 2,16,20 29:2,9,16,19 30:4,12,18,22 31:1, 7,9,13,14,17,19,24 33:10 34:10 37:17 38:15,23 43:25 45:15 46:8,13 55:8, 24 56:2,8,24 57:1,6, 11 58:6,9,14,20,25 59:2 60:16 61:11 62:23 63:8,17 64:12 68:6,23 72:10 73:8, 13,15,19,25 74:5,6 75:13 76:4 79:3 80:4,18,21 82:11 84:6,13,16,24 85:16 86:2 87:1 89:11,19, 21 90:11,20,25 91:5, 13,17 92:7 93:7,21 94:1 95:4 97:7,11,25 98:4,12 99:19 100:16 101:14 102:9 124:21 125:6,9,11	126:9,13 127:6,25 128:14 129:4,9 151:23,24 152:15, 19,22,24 153:8,10 154:15 155:10,17 156:4 P p.m. 156:18 P1 104:18 105:1,6 106:2 108:14 P1-2 122:13 P1s 110:5 P2 104:18 105:1,6 106:2 108:14 pages 52:11 painstakingly 97:6 palladium 124:22 125:2,20 126:1,2,8,15,17,19, 20,24,25 127:3,4,24 128:3,4,7,8,10,11,15 129:19,23 130:1 palladium-projected 128:17 paper 5:16,23 21:5,23 22:1,2,6,15,17 27:19 39:11 43:14 47:10, 14 48:6,11 52:11,18 62:3,8 63:15,19,21 64:2,16 67:8,14,17 70:13 71:25 102:22 126:23 127:11,14,19 129:8,16 papers 21:13,15,17 27:23 42:9 65:6 132:5 138:24 paragraph 10:18,20 30:8 33:20 35:24 65:12 66:4 82:20 88:10,15 90:7 91:19,24 101:4,5 103:22 107:10	110:14 112:10 116:19 117:2,10,13, 17 118:11,25 119:9 121:25 122:9,16 124:11,13 125:16 128:13 131:7,8 132:4,10 133:14 135:10 138:21 140:21 141:15,23 142:7,10,12 143:16 144:2,16 148:6 154:22 155:7,15 156:1 parallel 38:10 70:2,16 71:6,7 80:8 105:24 parameter 66:1 102:13 121:9 parameters 39:13 141:20 paraphrased 139:16 140:6 paraphrasing 132:8 parenthesis 106:9,18,25 107:1 part 33:7 92:16 103:1 113:5 127:18 148:22 partially 34:19 particles 25:18 parts 117:19 pass 156:7 passion 127:15 past 49:5,6 87:24 patent 6:8,11,12,23 15:23 153:1,2 154:17 patents 9:21 payoff 82:16 100:20 PDF 5:15 6:15 22:11 25:22 50:9 70:12 105:14 109:22	125:15 128:13 133:11 135:7 137:8 138:1,21 141:22 142:3 143:16 144:16 148:7 peaks 136:5 penalty 7:13 people 23:23 59:11,15,17, 23 62:2 81:9 percent 34:19 perfect 17:2 21:18 110:4 135:25 136:18 138:18 142:23 143:2 145:6,8,12,16 146:11,16,17 147:4, 5,9,11 148:3 149:23 150:8,11,16,19,22 151:2,7,9,16,21 152:5,11,17 perfection 150:5 151:11 perfectly 109:3 performed 35:25 140:23 141:3 perjury 7:14 perpendicular 38:9,12 person 10:22 11:2,7,17,24 12:3 13:4,17 14:18, 20 16:23 20:3 26:9 40:15 47:25 48:15 56:4 60:24 61:5,8, 15,25 65:23 72:14 75:10 76:8 79:23 80:10,14 81:2,6,10 82:17 84:22 85:6,13, 15 86:6,13,18,19 91:12 94:14 95:3,15 100:1,4 102:19,21 111:10 131:11,15 138:15 146:14 150:20 151:20 152:11 153:5,10,11, 20,23
---	---	--	---

persons 60:8 100:2 154:12	plot 54:13	44:9	previous 34:21 37:11
perspective 28:23	plots 53:12,17 54:3,4 84:4	potential 36:1 82:16 95:16	previously 40:7 120:23
persuasive 113:10	89:8	139:21	primarily 78:1
pessimists 100:3	plotted 83:21	potentially 80:7,25 100:21	prime 105:7
PH.D. 5:4	pluck 56:23	potentials 46:11	principle 57:9
physical 20:16 23:2,6,11,17, 21 24:19 25:1,6,13 26:3,13,18,23 27:3, 17 32:18 33:5 36:13 39:1,8 41:18 46:5, 19,25 49:16,19 50:4, 16 56:10 67:12 96:14,18 119:6,15, 21 120:12 127:8 128:6	plural 126:10	practical 145:9 152:3	prior 10:1 11:3 33:22,25 34:10 71:17 100:23
physically 14:2	plus/minus 64:5	preceding 117:2	probability 115:18
physicists 25:5	point 7:25 16:7,18 18:3 19:25 23:13 27:6 32:2 33:1 83:20,21 87:12 97:20 104:7 107:19 108:20 111:20 117:22 125:10 127:20 136:6 137:14 151:8 152:21 155:12	precise 9:16 46:4,12 54:12	problem 33:7 71:22 144:3,14
physics 25:15 59:21	pointed 63:2 143:19	precisely 21:22	proceedings 156:18
pick 103:11	pointing 52:16	precision 39:21 44:23 99:22	process 20:4
picked 40:18	points 117:16 144:3	predict 81:3,23 82:10,13 95:14,15 132:6	produces 143:21
picking 93:10	polarization 140:3	predicted 131:22 151:16	product 145:11
picture 29:21 30:1,6 51:22	polarizations 103:25 104:19 106:2 112:11 115:22	predicting 134:16 136:14	progresses 25:15
pinholes 120:20 121:15	poly-crystal-001- oriented 147:3	prediction 24:23 81:6,8 135:18 143:25	propagating 115:4
place 5:13 17:1 18:15 19:3 49:21	poorly 68:3	predictions 24:24 69:11 132:11 133:5 140:10 150:13	proper 17:13
placement 39:2,8 49:19,24,25 50:5	portion 32:15	prepare 9:6 10:2	properties 22:25 36:4 59:10 67:4 113:1 116:15 121:5 139:12,20 148:3
places 42:18	portions 15:12	prepared 144:20	property 38:5 120:6 121:13 149:21
planarize 149:10	POSA 75:1,14 76:3 77:2,9, 11 83:24 85:25 136:12 138:9 155:8, 15 156:2	preparing 7:19 8:1,21 9:10 10:12 19:9,23 43:10 96:7	proposition 50:6
plane 45:24	position 54:13 96:23 98:5 127:15	presence 63:8 125:17,19 126:12,16	prove 94:15
play 19:20 79:23 81:19 82:13	positioning	present 86:3 128:15 140:14	provide 99:10 131:23
		presents 53:17	provided 52:12
		pretty 21:19 43:4 102:1,4 142:24	proxy 66:10
		prevent 120:19	Ps 105:6

pseudomorphically 34:17	question 11:14 16:22 18:19	read 11:16 18:21 30:15	10,13,17
publication 62:20 103:16	19:10,19 29:10,13	34:8,14 46:14 50:14	red 83:4,5,7,18,22 91:25
publications 64:9	35:5,8,11,17 37:11	68:18 69:15 117:10	92:14,15,21
published 20:18 26:8 64:3	42:24 43:19 52:25	119:19 127:24	redo 62:11
104:12	57:4 58:4,18 66:3	132:15 134:4,11	reduce 91:14
publishing 63:25	72:23,24 75:19,24	139:17 156:15	reducing 154:23 155:8,15
pull 27:23	77:7 90:18 92:21	reader 26:9	156:2
pure 37:15	98:7 120:10 127:11,	readily 91:23 102:7	refer 13:10 75:20 104:21
purpose 58:13 85:21 146:19	22 129:8 130:22	reading 11:3 53:3 65:24	124:13 125:23
put 5:15,21 47:15 59:2	155:21	81:11 102:20 111:8	reference 19:24 48:2 69:4
73:10 79:21 98:17	questions 35:13,14 156:14	113:23 114:11	70:8,12 105:18
99:8 105:19 108:16,	quibble 107:18	138:22 140:21 141:2	115:15 138:1,6
17 113:18 114:1	quickly 88:10	153:20	references 12:19 20:1 70:12
153:20	quote 117:23	ready 123:5	108:4 139:10 150:1
puts 31:12	quotes 117:16	real 24:19 42:16 144:14	154:15,17
putting 82:11	quoting 104:25 117:19	reality 46:19	referred 73:6,10
		realizing 144:7	referring 51:13,18 67:23 76:1
	R	reason 21:8 71:12 151:14,	106:21 117:13,18
	R-H-E-E-D 141:25 142:15	25	135:16
	r-parallel 70:17	reasonable 22:7 69:25 76:7	refers 31:6 51:12 71:9
qualify 108:11	R-TMR 135:13,15	85:12 87:7 94:10,13,	106:15 126:20 127:3
qualitative 98:8	Ra 105:22	14,17 95:7,12 100:4,	reflection 41:12
qualitatively 21:21 85:6	radii 46:12	5,11,19 120:15	region 17:9 51:21
quality 140:16 142:18 145:2	radius 46:20	recall 13:12 17:19 32:3	related 73:6
150:2	random 68:1 144:7	75:21 129:12	relates 66:18
quantifiable 13:3	randomized 68:12 71:23 72:3	recent 69:5,8	relationship 30:17 118:11,15
quantification 13:12	77:4	recess 49:8 88:3 124:4	relative 45:4 94:19
quantitatively 85:2	range 94:1	156:11	relax 38:13 98:16
quantities 106:5	rate 8:17	reciting 148:9	relaxation 38:8 59:3,8
quantity 75:13 109:16 114:7	rates 117:8	recognize 144:12 150:21	relaxes 97:20
quantum 25:3,16,19 66:8	ratio 104:6 105:18 111:2,	recognized 119:6,15	release 98:17
quarter 87:24 123:9	13,17 122:16 135:16	recollection 19:8	
		record 27:24 49:6,9 88:2,4	
		124:3,6 150:1 156:9,	

relevance 108:2 relevant 20:2 33:4 48:14 52:19 99:6 108:25 reliable 23:1,6,11,17,20 26:3,13,14,17,22 27:3,8,16 96:14 119:6,15,21 120:12 relies 89:8 144:12 relieve 34:19 rely 21:19 122:3 relying 40:16 remain 16:18 remains 17:8 remember 42:24 129:15 REMOTE 5:1 remotely 5:6 remove 16:19 57:6 removes 149:1 removing 97:11 repeat 11:15 16:11 29:13 35:11 91:3 101:14 102:12 103:6,9 120:9 repeated 101:8 102:7 reply 6:25 7:1,17 8:2,21 82:20 91:18 122:9 132:3 154:21 report 38:22 39:24 reported 42:9 reporter 5:6	reporting 39:12 64:10 103:17 reports 38:18 129:9 represent 29:2,9,23 representation 111:13 represented 132:12 representing 46:11 83:22 represents 52:2 66:7 reproduced 91:24 require 56:19,20 98:4,8 99:16 required 27:11 48:10 138:10 rereading 127:10 reserve 156:15 residence 90:12,22 resistance 70:2,16 71:5,12 resistances 80:8 105:22 resonance 90:7 116:4 134:8,13 resonant 68:2 resources 60:12 respond 35:13 responding 35:6,7 rest 27:19 99:10 122:25 result 8:21 11:22 25:10 38:14 39:20 43:1 54:8 59:14 69:16,18, 20 85:12 94:16 97:12 99:5 142:17 resulting 84:4,12	results 25:11 39:12,13 40:22 47:23 52:24 54:5 55:6 79:9,10 85:5 96:9 99:21 103:24 112:11 113:4 133:15,20,23 134:16 retained 34:9 review 20:16 33:14 67:12 reviewed 19:9 43:8 47:7,20 reviewing 105:8 Rheed 141:24 142:15 right-hand 32:8 35:24 40:24 50:9 53:4 88:9,13,14 141:15,23 142:5,6 Ririe 10:15 road 107:24 rocket 24:13,14 role 19:20 81:19 82:13 124:21 125:6 root 45:25 46:1 Ross 7:22 roughly 10:6,10 36:21 63:6 74:24 roughness 136:9 round 87:22 Rp 105:22 RTMR 135:23 136:3 rule 153:18 runs 99:1	S safe 8:5 salt 59:19 sample 143:7 samples 142:18 sandwich 36:8 56:7 63:14 131:1 sandwiches 20:14 23:1 71:19 satisfy 150:3 151:12 satisfying 147:17 save 127:20 scales 27:12 74:21,25 scans 141:18 scattering 68:12 70:6 71:14,18, 23 72:3 76:5,15,21 77:5 78:4,10,11,17, 18,22 79:1,15 80:12, 23 81:18 82:12 84:15,18 85:11 90:3 91:6,10,11,14 92:19 94:21 95:13 100:6 152:18 Scholar 20:24 21:10,14 Schrodinger 25:2 scope 14:9,24 15:6,14,19 16:2,10,21 17:11,15, 25 18:6,16 19:4,17 61:24 62:2 screw 151:23 scrolled 56:1 search 21:17 65:6 searching 65:5
--	--	--	---

section 25:24 26:5 32:14 53:2 133:18	shorting 120:19	simpler 112:3 113:18	86:6,13,20 91:12 94:15 95:3,15 100:1, 2,4 102:19,21 111:11 131:11,16 138:16 146:9,15 150:20 151:20 152:12 153:6,11,21, 24 154:13
seed 146:10	shortly 7:22,23	simplification 113:25	skip 72:1 137:1
semiconductor 120:18 121:2	show 20:1 21:14	simplified 59:16,22 105:17 107:15	slight 69:23
sense 27:11 32:21 98:24 121:14 133:2	showed 47:11	simply 153:16,17	slightly 33:21,24
sensitive 39:1,13,14 40:4 49:18,21,23 50:2 133:6 134:13,17 136:8	showing 21:4 28:8 30:1 39:19 53:21,24 54:4,14	simulate 26:19	Sloczewski 119:5
sensitivity 39:7 50:1 52:23	shown 28:19,23 37:16,19 55:6 62:15 85:4 92:6,12 104:2 111:3 112:12	simultaneously 147:17	Slonczewski 109:1
sentence 22:17,23 30:10 31:5 36:24 40:5,17 46:14 66:6,25 69:4 71:3,5 77:20 88:17,19 90:6 101:7 119:12 120:14 122:8 127:24 135:12 137:11,13,16 139:6, 17 141:17,24 142:13	shows 30:24 31:9 37:12 52:2 55:14 66:2 109:23 126:12	single 56:23 57:6 58:6 62:19 63:15 64:9 73:8,12 74:22 78:20 102:13 103:16 126:4,7,24 137:18 140:10,15,24 141:4, 8,12 142:23 143:20 144:13 145:22 146:12 147:4,5 148:4 150:16 152:6	slowly 118:12,15
sentences 34:16 66:5	sic 6:3	single-crystal 144:4 145:17,20,21 146:17 149:23 152:1	small 29:23 32:6,10,15 36:16 45:3,6 78:1 93:16,17,22 134:2 136:4
separate 53:13	side 33:5 55:19,20	single-crystallin 147:11	smaller 28:20 29:22 70:4 78:21
separated 22:20	sign 156:15	sit 15:9 30:12 31:6 75:23 98:1 154:10	solid 36:5
series 35:25	signature 7:8,9	site 110:13	Someday 25:9
set 45:21 136:25 137:19 140:9 150:12	signed 7:10,13	sitting 13:22	sophisticated 36:4 41:14 47:6 60:3 98:21 108:17,18 112:24
shape 122:4	significance 78:17	situation 20:5 24:19	sophistication 58:23 59:12,13 63:6 86:22 98:14 99:3
sharing 100:25	significant 38:21 39:15,16,25 44:23 47:18 82:9 92:1 100:21 102:16, 17 132:13	situations 126:24	sort 106:7
sharp 142:19	significantly 68:16,19 72:7 81:13 131:23	size 45:6,7	sought 12:4 14:21
shift 79:17 80:3,17 85:22	silicon 144:6 149:18,19 151:13 152:4,7	skill 10:22 11:2,7,18,24 12:4 13:5,18 14:18, 20 16:24 20:3 26:10 40:16 48:1,15 56:5 60:9,24 61:6,9,16,25 62:2 65:23 72:15 75:10 76:8 79:24 80:10,14 81:2,9,10 82:17 84:23 85:6,15	Soukup 13:10,11,13,25 75:20,21 76:1 85:2 94:2
shifting 85:7,8	similar 74:24		sounded 18:17
shifts 80:1	Similarly 152:11		Sounds 6:13
ship 24:13,14	simple 27:8,17 102:13 109:2 111:18 112:21 139:21		source

76:5 spaceship 24:11 spacing 38:1 sparse 78:20 speak 10:12 49:11 88:6 124:8 speaking 10:10 89:25 98:21 112:2 122:18 spec- 99:25 special 109:15 136:5 specific 15:12 19:22 74:10 121:16 155:12 specifically 13:12 50:19 63:12 90:23 129:12 131:21 132:1 155:1 specifies 96:23 97:6 spectrum 9:1 speculate 99:23 spend 8:1 100:14 spent 8:22 9:9,15 10:7 sphere 46:12,20 spin 50:13,20 56:6 58:15, 16 62:22 64:11 69:13 70:25 71:10 86:2 88:25 93:4 103:24 104:18 106:2 112:11 115:22 129:22 131:2 140:2 spin-dependent 20:12 69:10 137:17 139:7,12,19 spin-down 104:23 spin-up 104:23 106:15	spot 77:16 spots 136:6 sputtering 148:14 149:5 square 45:25 squiggly 54:3 84:3 92:24 93:2,6 stack 41:7 stacked 53:17 stand 112:19 start 7:19 13:3 33:2 47:17 49:15 61:2 119:4 155:6 started 7:25 starting 7:24 141:16 142:10 149:19 starts 69:5 135:10 137:13 142:12 state 36:5 66:13 71:7 89:4 104:22 130:4,8,11 131:24 132:5 134:2 stated 111:1 statement 12:16 39:3,4 75:3 90:10 97:17 108:23 112:19 114:3 117:15 120:14 127:9 states 50:11,16,20,25 52:7 53:7,21,25 55:15 56:6 58:16 62:23 63:7 64:11 66:7,8, 19,20 67:21 68:2 79:20 83:22,25 84:17,20 86:2 88:20, 24 89:1,7,9,14,22 90:1,8,13,22 91:7 92:2,6,12 93:3 94:24 95:8,10 96:13	100:10 101:9 102:15,25 105:5 107:2,21 108:8 109:8,9,11,13,17,21, 24 110:6,11,12 111:3,10,12,19 112:15,23,25 114:4, 7,13,25 115:5,8,12 116:1,4 117:6 118:12,14,16 122:19 127:24 128:17 129:13,23 130:4,7, 10,13,15,19 131:1 134:8,13 stay 16:8 71:4 103:22 staying 33:18 step 132:13 148:13,16 149:2,4,7,11,17 stick 126:21 stop 41:22 43:12,18 72:20 story 122:24 straightforward 102:12 103:6,7,10 strain 34:20 35:4 strictly 9:14 21:11 89:25 112:2 122:18 strike 12:11 14:19 46:24 51:6 131:9 146:20 155:21 strong 87:20 95:11 115:25 stronger 134:6 strongly 30:11 52:14 61:5 90:8 134:6 structure 22:18 24:5,15 25:4, 24 26:18,20 27:3,17 28:9 30:8 32:6,11,18 33:21,24 36:8,13,20 37:14,19 41:1,5,10 49:17 50:4 67:3	68:15 69:11 72:5 79:17 80:9 81:1,13, 24 84:9,12 94:20 95:5 103:1 114:15 121:17 127:8 138:11 139:14,22 140:4 141:8,19 145:6,12, 14 147:14 structures 117:5 140:24 141:4 stuck 127:5 students 86:23 studied 42:8 43:16 studies 30:11 33:22,23,25 34:22 137:11 138:23 study 76:20 124:20 125:5 126:12 studying 125:25 sub-band 106:22 sub-bands 107:3 subject 150:3 submitted 9:19 subscripts 106:12 subset 32:10 substitution 17:23 substrate 34:5 125:2 144:4,13 145:17,23 146:18 149:18,19 152:1 sufficient 123:9 sufficiently 43:16 82:2 suggest 30:11 153:13 155:1 suggesting 83:19,23 93:10 summarize 19:13
--	--	--	---

summarizes 133:15 summary 43:11 super 100:14 supercell 36:22 support 11:6 111:5 supported 111:23 supposed 83:16 surface 24:5 30:14 124:21, 23 125:5,6,9 126:9, 14,21 127:5,7,16,25 128:21 129:5,9,10, 13,14 130:20,24 146:22 149:14,20,21 150:2 152:7,9 surreply 111:23 sworn 53:1 symmetric 141:18 symmetries 89:4 117:7,9 symmetry 70:24 71:2 89:13 115:4 118:12,13,15 130:5,8,11 136:9 system 34:24 140:5 149:10 T takes 99:6 129:3 taking 18:15 19:2 102:9 125:1 147:15 talk 35:20 69:3 74:7,8,11 110:9 115:16,19,20, 21 116:9,11 121:3,4 137:2 talked 20:5 21:19 42:8 54:23 91:9 96:12 152:8	talking 16:14 33:2 36:14 42:10 70:17 74:4 80:1,19 88:24 89:10, 16 90:3,5 94:5,11, 18,22 101:17,18,19 102:10 108:20 109:21 119:5 127:19 147:2 152:21,25 talks 26:7 120:17,19,21 130:18 152:24 taught 65:16 76:11 147:14 teach 10:23 65:20 teaches 19:14 112:6 113:25 114:5 teaching 15:22 65:24 112:23 113:20 teachings 48:2 technically 92:24 technique 61:21,22 153:19 techniques 22:18 telling 35:3 142:21 tells 41:18 45:13,18 TEM 142:16 tempered 134:12 template 146:23 ten 8:4,14 49:5 123:4,25 124:3 term 23:25 terms 80:7 90:4 104:21 108:7 147:18 153:5 territory 73:9 test 140:9,22 141:3	143:10 150:12 testified 5:7 48:8 61:1 66:7 79:21 84:22 86:19 91:22 95:16 102:18 116:21 121:18 122:2 150:15 testify 9:4 29:14 49:22 50:1 61:5 65:15 87:3,7 97:21 98:9 112:10 testifying 112:20 testimony 10:21 11:17 12:3,11, 12 53:1 76:11 78:14 80:9 96:8 101:11 110:20,23,24 111:21 112:18 122:9 131:10 132:16 153:23 154:4 text 31:12 111:8 140:19 textured 13:19 theorem 36:3 theoretical 24:22,23 27:23 40:7 58:19 59:21 69:5,8 131:18 theories 113:9 theorist 48:8 60:21,22 99:1 theorists 24:17 27:25 98:10, 22 100:13 theory 11:21 24:19 25:4,19 27:20 58:24 108:16, 18 144:12 thick 34:6 42:19,20,21 43:3 thicker 34:18 thickness 116:10,13 thicknesses 136:4 thin 42:11,14	thing 8:5 52:16,24 72:8 76:8 89:10 things 98:20 120:17 thinking 87:14 thinnest 42:12 thought 11:14 76:18 97:21 120:8 128:8 thousandth 45:4,9,10 97:2,4 tight 123:12 till 123:25 124:3 time 8:1,22 10:4 23:24 24:17 27:11,12 59:11,16 60:11 62:3 87:14,17 98:25 99:7 100:14 111:22 123:4,14 127:18,21 152:21 times 21:6 42:21,23 64:5 70:3 86:19 98:10 152:13 tiny 32:23 tip 127:12 title 67:7 TMR 10:24 11:4,23 12:2 80:24,25 81:3,16,17, 19 82:6 91:6,11,14, 17 94:20 95:9,14,17 102:16 103:2,3,23 104:5 105:18 109:11 110:1,5 111:2,13,17 112:7,10,17,21,23, 24 114:4,5,14,16,18 120:7,12 121:8,12, 25 122:16,21 123:2 131:12,23 132:12 133:5 134:16 135:15,16,18 137:18 139:7 140:10
---	---	---	---

TMRS 132:6 136:13 151:17,22	121:3,6 143:21 148:10	underlayer 146:1,3,20,22,23 147:21,23	23 19:16,20 31:24 43:25 46:8 56:8,18 57:20,21,25 60:17 61:11,13 62:23 63:17 68:24 72:10 82:12 84:13,16,24 86:3 90:21 92:8,16 93:7,21 101:14 102:9 124:21 125:7 126:10,13 130:24 155:10,18 156:4
today 5:12 8:23 9:7,14 10:1,3,13 15:9 65:7 123:23	tunneling 20:12 22:19,20 48:16 52:9 65:18 67:22 68:13,19 69:9, 12 70:1,15 71:5 72:4 76:6,13 77:4 79:18 82:1 88:22 90:8 100:9 109:9,11,16, 24 110:2,6,11 111:2, 9,12 114:6,7 115:18, 19 116:22 117:23 118:1,6,17 120:18 121:2,21 133:21 134:1,6 137:18 139:7,12,19 140:3, 14	underlies 25:3	vacancy 12:22,25 16:1,17,24, 25 17:3,5,8,10 18:2, 8,14,25 19:1 33:10, 16 55:8,24 56:2 57:1,23,24 58:15,20, 25 59:2 62:1 63:9 64:12 68:6 73:8,13, 15,19,25 75:13 76:4 79:3 80:18,21 84:6 85:16 87:1 89:12,19, 21 90:11,25 91:5 95:4 98:13 99:19 100:16 125:6,9,17, 19 126:16 127:6,15, 25 128:14,21 129:3, 4 151:24 152:19,22, 25
tools 24:8 65:7	turn 7:5 10:17 25:21 70:11 85:9 124:11 143:13	underneath 29:6,12,18 30:8 140:21	vacant 16:8,18 17:8
top 13:22 20:25 28:4 29:10 30:20 31:1,7, 9,13,15 34:7,11 35:24 37:17 52:4 53:14,17,20 125:3 127:13 139:25 145:16 146:3,22 147:22	typical 45:7	understand 10:23 13:1 16:22 25:13 26:10 35:12 40:17 43:1 48:1 52:13 57:3 58:24 61:19 72:15 100:15 102:20 119:17 129:8 146:10	values 40:19 134:2,7 141:20
topic 22:3	typically 27:12 42:11	understanding 39:9 45:22 51:11 58:18 62:7 72:13 75:1,5,9,10 77:10,12 80:13 111:1 118:1, 17 121:21	variation 74:23 94:3
transcend 139:20	typical 45:7	understands 16:24 27:22 91:12 95:4	variations 149:25
transfer 148:17	U	understood 68:3 76:3 77:2 91:16 110:10	varied 62:10 153:14
transmission 41:12 134:1	U.S. 6:8	unidentified 154:3	varies 94:3
transport 69:10 114:17	Uh-huh 93:1 105:13 125:18 143:9	unknown 81:20	vary 62:11 81:4 153:18 154:14,15,18
transverse 78:2,22,25 79:15 85:11 134:2	ultimate 112:5	unlike 24:12 32:7 81:14 100:13	varying 12:18 82:8
treated 117:24	ultimately 102:15	unquestionably 112:17 114:14 122:21	vectors 116:1
trends 62:15	umbrella 118:8	unrelated 116:14	versus 89:5 112:15 122:20
trick 152:8	unable 81:2	up-spin 106:16 107:3	vertical 83:5 92:14,15
tricky 18:18	unavoidably 150:25	upper 26:25 30:20 144:23	
trilayers 67:6	uncapped 149:8	V	
true 32:1 55:10 84:14 85:1 112:3 116:5,16 130:2	unclear 81:7	vacancies 12:7,15 13:2,4,14,17 14:3,5,13,21 15:3, 11,17 16:14 18:11,	
trust 48:11	uncomfortable 50:1 52:25 75:23		
Tuesday 9:9			
tunnel 63:12 68:1 100:17 105:22 114:21			

view 137:14	123:3,8,13,18,20,25 124:2,5 129:1 131:5	9:24 66:6 108:13 110:19	
viewpoint 29:4	135:2 145:24 155:20 156:6,10,16	X	
violates 25:10	wife 123:21	x-ray 141:17 142:16	
virtually 74:15	Wilson 5:14 10:15 14:9,24 15:6,14,19 16:2,10, 21 17:11,15,25 18:6, 16 19:4,17 28:10 40:1 44:24 64:14,19 65:3 72:22 75:17 78:15 82:24 83:10 96:3 112:1 113:13 122:11 128:23 131:3 135:1 145:4 155:19 156:6,8,12	Y	
volt 14:8 18:12,24 73:22 75:16 79:4 120:25		year 99:7 100:14	
volts 11:11,21 12:1,5 13:7,20		years 64:8	
volume 20:16 47:2 67:12		yesterday 5:13 7:21 8:13 9:13, 20,25 10:3 152:9	
W		Yuasa 107:12,16,19,24 108:6	
wafer 149:18,19 151:13 152:4	win 80:24		
Wait 119:8	withdraw 72:24		
wanted 56:5 60:18 61:8,9 86:12,13 131:12 143:10 151:21 152:3	word 23:21 99:16 122:10 127:2		
water 149:1	words 21:13 101:22		
wave 115:17 116:1 130:19	work 7:25 8:20 96:5 100:12 104:15 131:18		
waves 41:13	working 9:15		
ways 153:12,15	works 59:21		
week 10:2 99:1	world 25:1,6,13 144:14		
well-known 108:4	worth 60:2 81:17 95:19 100:20 103:3		
white 29:23	wound 11:13		
WICHMAN 5:10 14:12 15:2,10, 16,24 16:6,13 17:6, 12,21 18:1,9,20 19:12 20:7 28:12 40:23 45:2 48:17,22 49:1,4,9 64:17,22 65:8 73:1 76:2 78:24 83:1,12 87:9,12,16, 23 88:1,4 96:6 112:8 114:19 122:14	write 28:7 65:15		
	writes 50:11 70:1 109:5		
	written 139:18		
	wrong 6:20 79:12 88:12 108:1		
	wrote		