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.	)	Case No. IPR2024-01494
GODO KAISHA IP BRIDGE 1,	)	
Patent Owner.	)	

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

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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.

APPEARANCES OF COUNSEL:

(All appearances are via videoconference.)

For Petitioner Western Digital Technologies, Inc.:

ARMOND WILSON LLP
BY: DOUGLAS R. WILSON, ESQ.
SPENCER RIRIE, ESQ.
4685 MacArthur Court, Suite 390
Newport Beach, California 92660
949-386-1341
doug.wilson@armondwilson.com
spencer.ririe@armondwilson.com

For Patent Owner Godo Kaisha IP Bridge 1:

WOLF, GREENFIELD & SACKS, P.C.
BY: ADAM WICHMAN, ESQ.
600 Atlantic Avenue, 23rd Floor
Boston, Massachusetts 02210
617-646-8000
adam.wichman@wolfgreenfield.com

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?

A I see that.
Q And this is in case number IPR2024-011494 [sic]; right?
A 01494. Yeah.
Q Okay. I'm going to call this case the 1494 case.
A Okay.
Q All right. And this concerns U.S. patent number 11,968,909; correct?
A Correct.
Q And I'm going to call that patent the '909 patent; okay?
A Sounds good.
Q All right. Do you have access to exhibits in PDF for the 1494 case?
A I -- I do.
Q Okay. Can -- just to confirm that, can you open Exhibit 1105 for the 1494 case.
A 1105. That's my declaration. Hang on. What happened? Something went wrong. Sorry.
There. Okay. Okay. I have it.
Q And this -- you can confirm this is your declaration in the 1494 case on the '909 patent?
A Correct.
Q Your reply declaration?

A My reply declaration.
Q Yes?
A Yes.
Q Okay. Thanks.
If you could turn to the last page. Let me know when you're there.
A Okay.
Q That's your signature?
A That is my signature.
Q And you signed it on October 8th of 2025; right?
A Correct.
Q And you signed it under penalty of perjury?
A Correct.
Q So this declaration contains your opinions offered in reply; is that right?
A Correct.
Q When did you start preparing this -- the opinions in this declaration?
A The same answer as I had yesterday. Shortly after I got the deposition from Dr. Ross, which I think was fairly shortly after it was taken. That's -- that's kind of the starting point for when I really started work on this.

Q How much time did you spend preparing this reply declaration?
A Yeah. I don't know exactly.
Q Was it more than ten hours?
A I would say that's a safe -- a safe thing to say.
Q Was it more than 20 hours?
A Hard to say. I can't -- I can't answer that. I can't answer that under oath with certainty.
Q Can you say whether it was more than 50 hours?
A No. I'll say like I did yesterday, less than a hundred. Somewhere between ten and a hundred is the best I can do.
Q And -- and what did -- what are you -- what's your hourly rate for your engagement in this matter?
A $650 an hour.
Q So I mean you -- the work that you did in preparing this reply is going to result in a bill of $6,500 and $65,000, not counting time spent in deposition today; right?
A That's fair.
Q And you don't know which end of the

spectrum it's on?
A Somewhere in there. That's the best I can say. I don't have any better where -- I can't testify to a number any more than that, any more accurately than that.
Q What did you do to prepare for the deposition in this case today?
A You know, the main focus was I -- I came here to these offices on Tuesday and spent two days preparing.
Q For this case in particular?
A Yes. Well, for the -- for the two cases, right. We had one yesterday and we have this one today. If you strictly call those two cases, I spent the two days working on both cases.
Q Okay. Just to be precise, there are three different cases here.
A Okay. Correct. That's right. But I submitted one declaration, which we looked at yesterday for both -- for two cases, for two patents.
Q Okay. So that was --
A That was one -- that's what I meant when I said two cases. Two declarations. I wrote declarations that we were looking at yesterday and

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

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

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

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

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

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

A Paragraph 7. Okay. I'm there.

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

right?
A A person of ordinary skill in the art reading Butler in light of other prior art would be motivated to expect a change in TMR with barrier height.
Q And this is in support of your opinion that a person of ordinary skill in the art would have been motivated to modify the barrier height in the magnesium oxide layer in Bowen's magneto-tunnel junction in order to achieve a barrier height of .33 electron volts; is that right?
A You wound up landing on a different question than I thought you would. So could you please break it down? Just repeat it. Either read it back.
Q It's your testimony that a person of ordinary skill in the art would have been motivated to modify the magnesium oxide layer in Bowen's magneto-tunnel junction to achieve a barrier height of .33 electron volts on the theory that lowering the barrier height would result in increased TMR; is that correct?
A So a person of ordinary skill in the art would be motivated to lower the barrier height as

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

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

A That's correct.

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

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

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

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

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

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

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

declaration that gives that kind of information.
Q And so I would like to know physically how these oxygen vacancies are going to manifest themselves in the barrier layers. So let me ask you, how would oxygen vacancies be distributed within this modified Bowen magnesium oxide barrier layer that are intended to achieve this .33 electron volt barrier height?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: Okay. So that one I can answer. I did not offer an opinion on that.
BY ATTORNEY WICHMAN:
Q Would the vacancies be introduced at the interface with the ferromagnetic layer and the magnesium oxide barrier layer?
A Again, I did not offer an opinion on that.
Q What would a person of ordinary skill in the art have -- strike that.
Would a person of ordinary skill in the art have sought to achieve oxygen vacancies at the interface between a ferromagnetic layer and the magnesium oxide barrier layer?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: I have not offered an

opinion on that. I don't have an opinion on that.
BY ATTORNEY WICHMAN:
Q Would oxygen vacancies need to be distributed throughout the bulk of the magnesium oxide barrier layer?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: I don't think I have offered an opinion on that. I don't have one as I sit here today.
BY ATTORNEY WICHMAN:
Q Would oxygen vacancies be clustered in specific portions of the magnesium oxide barrier layer?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: I have no opinion on that.
BY ATTORNEY WICHMAN:
Q Would oxygen vacancies be clustered together within the magnesium oxide barrier layer?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: I have no opinion on that. And furthermore, let me add, as far as -- as far as I'm aware, there's no teaching about that in the patent either.
BY ATTORNEY WICHMAN:
Q What happens to a magnesium oxide lattice

at an oxygen vacancy?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: That's deeper -- a deeper detail than I have analyzed. I don't have an opinion.
BY ATTORNEY WICHMAN:
Q Does the lattice point of where the oxygen is missing stay vacant within the magnesium oxide material?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: Could you repeat that one, please?
BY ATTORNEY WICHMAN:
Q We're talking about oxygen vacancies within magnesium oxide; right?
A Right.
Q Okay. So at a vacancy defect, would that point in the lattice remain vacant, where you remove the oxygen out, would there be a gap in the lattice?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: I understand the question. That, I can answer. I believe a person of ordinary skill in the art understands a vacancy to be a vacancy. That's what a vacancy is. It is a

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

BY ATTORNEY WICHMAN:

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

ATTORNEY WILSON: Objection. Scope.

BY ATTORNEY WICHMAN:

Q -- as compared to the proper crystal lattice?

ATTORNEY WILSON: Objection. Scope.

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

BY ATTORNEY WICHMAN:

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

A Yes.

ATTORNEY WILSON: Objection. Scope.

BY ATTORNEY WICHMAN:
Q Okay. So when there's an oxygen vacancy in the magnesium oxide lattice, could the point where the oxygen atom is missing be filled by a different atom?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: It could be. But then it would no longer be a vacancy.
BY ATTORNEY WICHMAN:
Q Okay. So when you are considering adding oxygen vacancies to magnesium oxide in order to achieve a .33 electron volt barrier height, you are only considering a defect that is literally a vacancy; that the oxygen atom is missing and nothing is taking its place. Is that right?
ATTORNEY WILSON: Objection. Scope.
THE WITNESS: That sounded a little tricky. Can you please -- I need to hear that question again?
BY ATTORNEY WICHMAN:
Q I'll just read it back.
When you are considering adding oxygen vacancies to magnesium oxide in order to achieve a .33 electron volt barrier height, you are only considering an oxygen vacancy defect that is

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

ATTORNEY WILSON: Objection. Scope.

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

BY ATTORNEY WICHMAN:

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

ATTORNEY WILSON: Objection. Scope.

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

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

BY ATTORNEY WICHMAN:

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

A Sure.

Okay. I've got Butler.

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

A Right.

Q Physical Review B, Volume 63.

A That's it.

Q Published in January of 2001. Right?

A Correct.

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

A Okay. I have that.

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

A I see it.
Q July 11, 2025; right?
A Right.
Q And if you drop down, this is showing that Butler's paper as of July 11th, 2025, had been cited 2,921 times; right?
A That's what it says.
Q Do you have any reason to doubt the citation number?
A Google Scholar is known to be not strictly accurate. It does a good job. It usually comes close, but you can't -- you can't -- in other words, there can be papers that don't show up in a Google citation -- Google Scholar citation list. There could be papers missing. There are sometimes -- actually often there are extra papers in there because the search algorithm isn't perfect. So Google citation numbers are -- are pretty good. We all rely on them. We talked about it in my first declaration, if I'm not mistaken. Qualitatively I would believe that number, but not precisely.
Q You agree that Butler is a famous paper; right?
A Absolutely. I would call Butler a highly

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

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

A I'm there.

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

A Yes.

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

A I do.

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

A Correct.

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

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

A Correct.

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

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

Q Do you disagree with Butler on that point?

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

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

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

Q Why is that important to you?

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

not necessarily what absolutely is -- is there. You make a model. Okay. A model is -- it's a little bit -- it's not quite accurate to call it a guess. But a model is just a model. It's just, okay, if the surface -- if the structure is this, this is the best model that I can make based on available information. And based on what I can use to make a calculation given the tools that I have. So a model -- a model is just a model. It's like, you know, you -- as a child, you build a model of a spaceship. It's a model. The model in this context is not unlike that. You build a model -- you don't build a rocket ship. You build a model of the rocket ship. And then -- in this case, you build a model of the atomic structure, make -- make a calculation, and you have a model calculation. Theorists do this all the time. It is common. You do the best you can to develop a theory for a real physical situation. You make the best model you can. And then you look at the consequences of the model. And then it's -- then that's out there. That's the theoretical model. That's a theoretical prediction. Theoretical predictions are just predictions based on models. The equations that he used in this calculation are

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

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

A I'm there.

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

A I see that.
Q Okay. So here, Butler is describing how he developed his reliable physical model of the iron magnesium oxide interface; right?
A Yes, in this section, Butler is describing how he arrives at -- at the model that he uses. He talks about various models that have been published in the literature. And what he's motivating is to help a reader, a person of ordinary skill, understand how he came up with his model.
Q You agree that when Butler says it is important to have a reliable physical model for the interface, he was not focused on a reliable model of the bulk magnesium oxide barrier. Do you agree with that?
A No. He is interested in a reliable physical model for the whole structure that he is going to simulate.
Q The whole structure?
A Yeah.
Q So you're saying his -- his reliable physical model is the lower ferromagnetic layer, the magnesium oxide barrier layer, and then the upper ferromagnetic layer of the magneto-tunnel

junction; is that right?
A Butler -- Butler tries to make as reliable a physical model for the entire structure as he can.
Q Okay. If you could look at --
A Idealized model. That's the point I want to emphasize. His -- what he is doing is creating a model that is -- is reliable but simple enough that he can make the calculation. These calculations are extremely complex and expensive in the sense of how much compute time is required. The amount of compute time scales typically in a highly nonlinear way how fancy, how much detail there is in the model. So a calculation like what Butler is doing here, well known in the art, is a compromise of trying to make as reliable a model of the physical structure as he can, yet simple enough that he can make the calculation that he further describes in the rest of the paper. So that's how this kind of theory is done. And that's well known in the art. Everybody understands that. That's -- that's how -- we could pull up a bunch of other theoretical papers, I'm sure, that are in the record here. That's what theorists do.

Q Dr. Bokor, look at Figure 1 on page 2 of Butler, Exhibit 1044.
A I see that.
Q It's in the top left column. Do you see that?
A Yes.
Q Okay. You agree that Figure 1, you write in the caption, it is showing the interface for an iron 100 and magnesium oxide structure; correct?
ATTORNEY WILSON: Objection. Form.
THE WITNESS: Correct.
BY ATTORNEY WICHMAN:
Q It's a bunch of circles in this figure?
A Sure. I'll agree with that characterization.
Q The larger circles are iron; correct?
A That's what it says in the caption. Larger atoms are iron, yes.
Q Within each large circle is shown a smaller dark circle; correct?
A Correct.
Q And those darker atoms are meant -- are shown in a perspective as above the iron atoms; correct?
A That's -- I'll agree with that.

Q It says darker atoms above iron atoms represent oxygen; right?
A Right.
Q So you're looking -- so this viewpoint is looking down at the interface. There's a layer of magnesium oxide. And underneath it is a layer of iron. Correct?
A It says that the darker atoms above the atoms represent oxygen. I didn't catch in your question which one you said was on top. I think you might -- did you say that or did you say the iron was underneath? I didn't -- I forget. If you could repeat the question. Or I'll just testify that what it says in the caption is that the iron atoms are -- yeah. The atoms before the iron are the oxygen. And the oxygen atoms are the darker ones. They are above the iron atoms. The iron atoms are underneath.
Q And every iron atom has an oxygen atom above it; correct?
A In this -- in this picture, yes.
Q And then the smaller circles are -- the small white atoms they are -- they represent magnesium, right?
A Right.

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

A In this picture, that's correct.

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

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

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

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

A Correct.

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

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

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

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

A That's what it says.

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

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

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

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

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

A That is the interface.

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

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

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

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

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

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

right?
A Right.
Q Okay. And -- but the difference is that of -- in his model, it is only a few magnesium oxide atom layers deposited onto an iron substrate followed by a deposition of a relatively thick iron top electrode; is that correct?
A You read it correctly.
Q But he kept the -- he retained this aspect of the prior model that there is an oxygen atom on top of every iron atom; correct?
A Yes, he did.
Q He did. Okay. So --
A But I think you should read the next -- we should take into account the next couple of sentences. "Experimentally, seven atomic layers of MgO can be grown pseudomorphically on the iron 100. For thicker MgO layers, misfit dislocations form to partially relieve the 3 and a half percent compressive in-plane strain that arises due to the larger MgO lattice constant. Thus, the previous studies were for an interface in which the iron lattice was expanded in-plane, whereas it seems more appropriate to model this system as having interfaces in which the iron is at its equilibrium

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

So he is model -- he is telling -- he is trying to do his best to model this strain effect.

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

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

Q No.

A All right. Repeat the question, please.

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

A I'm trying to do my best.

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

A Absolutely.

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

A Yes.

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

full potential LSDA-DFT calculations." Correct?
A Correct.
Q And this is density functional theorem, a very sophisticated way of modeling the properties of solid state materials; is that correct?
A It is.
Q And then he says, "In these calculations the sandwich structure was modeled." And he's going to tell us what the model was; right?
A That's right.
Q And he says that there's a 15 atom/supercell. Now a 15 atom/supercell is the physical structure that he was modeling; correct?
A Yeah. That's what I was talking about a minute ago that he can only model a relatively small number of atoms. He is only modeling an atom that basically has a dimension of 15 atoms.
Q It is not 15 atoms. It is 15 layers actually. 15 atomic layers. Right?
A The dynamic of the structure is 15. It's like a cube. Roughly. I mean, he's going to give more details. A 15 atom/supercell is a supercell that's got only 15 atoms in it. And in the next sentence five iron layers.
Q Right. So there are -- so it is with

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

A Yes.

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

A Right.

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

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

Q Right. Thank you.

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

A That's what it says.

Q And the lattice constant is the spacing between the atoms in the atomic layer of iron; is that right?
A Correct.
Q So property of bcc iron; is that right?
A Correct.
Q And then in his model, he allowed relaxation of the atomic coordinates; right?
A In the direction perpendicular to the layers. Not in the parallel direction. They're held -- the in-plane lattice constant was held. The atomic coordinates perpendicular to the layers was allowed to relax.
Q As a result of that calculation, he obtains a distance between each iron and oxygen atom at the interface; is that right?
A That's what it says.
Q And that distance he reports as 2.169 angstroms; right?
A Correct.
Q He's using three significant digits to report the distance in angstroms between the iron and the oxygen; correct?
A He is.
Q So you will agree that Butler's

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

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

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

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

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

ATTORNEY WILSON: Objection. Form.

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

BY ATTORNEY WICHMAN:

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

Structure. Do you see that?
A I do.
Q And so now here Butler is going to tell us how he did his calculations of the electronic structure --
A He is.
Q -- for this -- for this stack; right?
A Right.
Q And even -- he comes out and says, "To determine the electronic structure within a framework that could be used to determine the transmission and reflection amplitudes of Bloch waves in iron incident on the magnesium oxide layer," he does a sophisticated calculation; right?
A Right.
Q All right. And he -- to do that calculation he tells us the physical model that he uses; right?
A Right.
Q Four 100 layers of magnesium oxide. Let's stop right there. Those 100 layers of magnesium oxide is this model of an ideal 100 magnesium oxide atomic layer; correct?
A Well, four layers.

Q Well, each layer is an ideal 100 magnesium oxide atomic layer; right?
A That's fair.
Q Okay. And he uses four of them, as you just said; right?
A Only four. Only four. That's important. None of the -- none of the MgO barrier layers that we have talked about that are studied and that are reported in any of the experimental papers that we have been talking about have an MgO barrier layer that thin. They're typically -- even down to -- we would have to go and look what the thinnest one was. Maybe a fraction of a nanometer. None of them are as thin as four layers. Here is an example where the calculation is making a model of what the real experiment would have. Certainly four layers is a lot less than the most of -- maybe there are one or two places where the barrier got to be less than a nanometer thick, but much less than a nanometer thick. Four layers is way less than a nanometer thick. It is four times a little less than three angstroms. Like 12 -- four times three angstroms.
Q Dr. Bokor, do you remember my question?
A Yeah. You were -- I'm just amplifying on

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

Q So you agree that he modeled four layers?

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

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

A Yeah. I'll agree with that.

Q There are no oxygen vacancies in any --

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

A Well, he doesn't -- he doesn't say that. One could assume that there isn't.

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

A Yes.

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

A Yes.

Q And he chose --

A Go ahead.

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

A Because of the experimental iron lattice constant, yes.

Q He gives that value as 2.866 angstroms; right?

A He does.

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

ATTORNEY WILSON: Objection. Form.

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

what it says, yes.
BY ATTORNEY WICHMAN:
Q All right. Just how small is a thousandth of an angstrom relative to an iron atom dimension?
A It is very, very small. The size -- typical size of atoms is on the order of one angstrom, plus or minus, you know, give or take.
Q So one thousandth of an angstrom is on the order of one thousandth of dimensions of an atom; is that right?
A That's right.
Q Okay. Then he tells us -- he got to choose what distance he was going to impose between an iron atom and an oxygen atom at the interface between the iron atomic layer and the magnesium oxide atomic layer; right?
A Well, he tells us that that distance was taken. So to some extent, he was choosing.
Q That means in his model, that's the distance that he set between the layers; right?
A I think that's the understanding, yes.
Q And then he chose a lattice constant for magnesium oxide in plane and out of plane to just be a square root of two -- a factor of a square

root of two larger than that of the iron lattice; right?
A That's what it says.
Q Okay. So that's -- it is a very precise physical arrangement of atoms that he is modeling; correct?
A That's fair.
Q And there's no oxygen vacancies in this model, are there?
A Evidently not.
Q He's representing atomic potentials using this -- the very precise sphere radii for magnesium and oxygen; correct?
A I can read the sentence. I'm not going to be able to, you know, go deeply into interpreting it for you. You're right, that's what he says.
Q Okay. And then he even -- to make his model even more faithful to physical reality, he adds an empty sphere with a radius of 0.9476 angstroms in the interfacial iron layer just below the magnesium atom to account for a displacement in the magnesium atom; is that right?
Or let me strike that -- so strike.
In this physical model that he is

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

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

Q So --

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

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

A I give opinions on how a person of

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

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

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

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

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

ATTORNEY WICHMAN: That's fine.

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

ATTORNEY WICHMAN: Five minutes enough?
THE WITNESS: Five minutes is about good enough, yes.
ATTORNEY WICHMAN: All right. Let's -- it's four past now. Well, let's come back at ten past. Off the record.
THE WITNESS: Yeah.
(A recess was taken.)
ATTORNEY WICHMAN: On the record.
Q Dr. Bokor, other than our little conversation here, did you speak with anybody during the break?
A Not about the deposition.
Q Okay. If we go back to Butler -- well, even before we start, do you agree that Butler's model, his physical model that he is using to calculate the electronic structure of the iron/magnesium oxide/iron MTJ is highly sensitive to the physical placement of the atoms in that model?
A It's sensitive to the place -- so I'm not an expert and I can't really testify what it means by sensitive. How sensitive is it, to which placement of which atoms. It's -- it certainly depends on the placement of the atoms. The

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

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

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

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

A You read it correctly.

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

A That's what it says.

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

A Well, majority and minority. Yes.

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

And he found that the density of states

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

A That's what it says.

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

Well, strike that. The layers is overloaded.

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

A Yes. That's my understanding.

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

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

Q Okay. So the Figure 1 that we were

discussing that's on Butler page 2,
that represents the interface between it shows
100 iron atomic layer with 100 magnesium oxide
layer on top; right?
A Correct.
Q Okay. All right. So you agree that the
density of states in the magnesium oxide at the
interface with the iron layer is important to
evaluating the tunneling current in the MgO?
A What I'm going to -- what I'm going to
say is that the paper has 12 pages of all kinds of
details. All these details are provided to help
an expert understand the details of the
calculation and how strongly they affect the
outcome or not. All I can say is that this
particular thing that you're pointing out, just
like everything else that described within the
bounds of the paper, are at least somewhat
relevant. Which ones are the most important and
the least important is -- that's where we get into
a gray area where I'm not comfortable giving
opinions on the -- you know, the degree of
importance or the degree of sensitivity of the
results on every little thing. So the bottom line
is I'm uncomfortable to answer your question

with -- with sworn testimony.
Q The figure below the section we've been reading on page 3 of Butler, there's Figure 3 and then on the right-hand column Figure 4; right?
A Right.
Q And Figure 3 is described as a density of states for each atomic layer of iron 100 near an interface with magnesium oxide; right? That's the caption in Figure 3.
A Yes. Yes. I see that.
Q Okay. Figure 3 is actually labeled A and B, but it is actually two plots; right?
A You mean there are two separate figures, the top and the bottom. And you want to call those A and B.
Q Well, off -- okay. They are not labeled. It's -- Figure 3 presents two plots stacked on top of each other; correct?
A Correct.
Q And the top one, it says that it is showing iron majority density of states near an interface with magnesium oxide; is that right?
A Correct.
Q And the bottom one says it is showing iron minority density of states near an interface

with magnesium oxide; right?
A Right.
Q And the plots, the squiggly lines in each of these plots, that's showing you the -- the results of the calculation that Butler did on his model; right?
A Right.
Q And that result is for an ideal 100 iron atomic layer covered by an ideal 100 magnesium oxide layer. That's the interface he modeled; right?
A Well, that's the -- that's the precise position of the interface, yes. But this plot is showing modeling layers near that interface.
Q Okay. So --
A Junction at the interface.
Q Okay. Even if we account for every atomic layer in Butler's model, it is still that that model is still made of ideal 100 iron atomic layers and ideal 100 magnesium oxide atomic layers. Do you agree with that?
A Well, ideal is a little -- is a little loaded. We talked -- we looked at some of that earlier, you know, where you could see he made some -- he gave some description for what he means

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

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

A I'll agree to that.

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

A That is right.

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

A Right.

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

A I agree with that.

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

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

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

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

Q And in fact --

A It might only be a little bit different.

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

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

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

accounted for every possible oxygen vacancy, could you?

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

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

A In principle.

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

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

Q It is complicated?

A It is complicated.

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

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

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

layers that are above the interface; correct?
A I think I missed the --
Q Okay. So --
A -- the meaning to the question.
Q -- it's not that you would just have to decide how to model a single oxygen atom missing in a magnesium oxide layer at the interface, but you would have to also consider what if there were multiple oxygen atoms missing at the interface; correct?
A You would have to -- under -- what's the -- what's the antecedent to that? You would have to do that why, for what purpose?
Q To evaluate the effect of an oxygen vacancy on the minority and majority spin density of states -- spin channel density of states.
A So this is where -- so to answer that question, I'll just tell you my understanding of theoretical modeling. So here is -- here this calculation doesn't include oxygen vacancy defects. I agree with that. Now, if somebody like Butler or one of his co-authors or somebody else in this -- with this degree of sophistication and theory said, I want to try to understand the effect of defects, oxygen vacancy defects or other

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

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

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

A Well, you said you. I couldn't.

Q Why not?

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

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

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

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

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

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

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

A I did not find a calculation that had all

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

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

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

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

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

Q So Butler was publishing --

A The answer is no, I'm not aware of a paper like that.
Q So Butler was published in 2001; right?
A Right.
Q It's been cited 2900, plus/minus, times; right?
A Right.
Q So in 24 years and nearly 3,000 publications, you couldn't find a single example of anybody reporting this calculation of minority or majority spin channel density of states when there is an oxygen vacancy in the magnesium oxide; is that right?
ATTORNEY WILSON: Objection. Form.
THE WITNESS: I did not cite such a paper.
BY ATTORNEY WICHMAN:
Q And you couldn't find one, did you?
ATTORNEY WILSON: Objection. Form.
THE WITNESS: If I found one, I would have cited it for sure.
BY ATTORNEY WICHMAN:
Q Okay. So you didn't cite it. If you had found one, you would have cited it. And I'm asking, did you find one?

A No.
Q No. Okay. But you looked?
ATTORNEY WILSON: Object to form.
THE WITNESS: I definitely did some literature searching. It's hard to -- it's hard to search 3,000 papers. Even with, you know, the tools we've got available to us today.
BY ATTORNEY WICHMAN:
Q All right. Do you have your declaration Exhibit 10 -- 1105 in front of you?
A One moment. Okay. I have it.
Q Can you go to paragraph 10. Paragraph 10.
A Yes.
Q So you write or you testify that "Butler taught that a change in barrier height was expected to affect majority and minority channel tunneling." Correct?
A Correct.
Q Butler doesn't actually teach changing barrier height at all, does he?
A He doesn't explicitly. But in my opinion, a person of ordinary skill in the art reading Butler would find that teaching in there.
Q Butler does not include barrier height as

a parameter in his model, does he?
A He shows -- okay. The narrow -- the answer to your narrow question is no.
Q If we go down in paragraph 10 here, if you drop down a couple sentences, the last sentence on page 7, you wrote that -- you testified that "density of states represents the number of quantum states available for electrons to occupy at a certain energy level and thus acts as a proxy for electrical conduction at that energy." Correct?
A That's what it says.
Q All right. The density of state, the electrons that contribute to conduction are only the ones that are at the Fermi energy level; isn't that right?
A Yeah. This is -- at the end of the day, if you measure electrical conduction, that relates to the states at Fermi energy. But the density of states provides information for electrical conduction at other energies. And if the Fermi energy would move to that location, then it would tell you what to expect for electrical conduction in that circumstance. That's the meaning of this sentence.

Q Can you open Exhibit 1045.
A I have it.
Q Growth, structure, electronic and magnetic properties of magnesium oxide/iron (001) bilayers and iron/magnesium oxide/iron (001) trilayers. Correct?
A That's the title.
Q A paper by Klaua and colleagues?
A Correct.
Q K-l-a-u-a. Right?
A Right.
Q Physical Review B, Volume 64?
A Correct.
Q And you're familiar with this paper; right?
A Generally.
Q You cited this paper in your -- in your declaration?
A I think so.
Q Okay. Left-hand column, page 1, under introduction. Klaua states, "The electron tunneling in such amorphous barriers is complex," referring to magneto-tunnel junctures with amorphous aluminum oxide barriers; right?
A Correct.

Q The electron tunnel consists of random hopping between oxide resonant states which are created by a number of poorly understood defects; correct?
A That's what it says.
Q All right. Oxygen vacancy in magnesium oxide is a type of defect; correct?
A Yes.
Q All right. Klaua says that the lateral component -- again, this is the aluminum oxide barriers. "The lateral component of the electron momentum k-parallel is randomized by scattering in the barrier, such that the tunneling current is not only determined by the intrinsic band structure of the electrons and the oxide barrier but is significantly affected by lattice disorder in the barrier." Right?
A You read it correctly.
Q The tunneling current is significantly affected by lattice disorder in the barrier; right?
A That's what it says.
Q All right. And you agree that oxygen vacancies and magnesium oxide are a type of lattice disorder; correct?

A A type.
Q Okay. And if we go down now, he's going to talk about Butler; right? If you go down to -- after reference note 2, do you see the sentence that starts with "the recent theoretical calculations"?
A Yes.
Q Okay. "The recent theoretical calculations of an intrinsic electron tunneling transport using fully spin-dependent electronic band structure provides challenging predictions. The tunneling conductance in iron/magnesium oxide/iron 001 is governed by the majority spin electrons." Right?
A You read it correctly.
Q That's Butler's result; right?
A That's Klaua's description of Butler's result.
Q Right. And then Klaua said -- do you agree that is Butler's result?
A I don't disagree with it.
Q Do you agree with it?
A I think that's a slight oversimplification of Butler. But it's -- it is a reasonable, you know, one-sentence description.

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

A That's what it says.

Q All right. And Klaua cites reference 3; correct?

A He does.

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

A Right.

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

A Yeah.

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

A Right.

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

electrons. Right?
A Well, I don't see symmetry matching in this sentence.
Q Okay. Let's -- let's stay with this sentence then. "The tunneling resistance for the parallel orientation" means conduction in the parallel state of magneto-tunnel junction; right?
A Right.
Q And that's what Butler refers to as the majority spin channel?
A I think so, yeah.
Q Okay. And the reason that the resistance is low, meaning that the conduction is high, is due to the absence of scattering in the barrier; correct?
A That's what it says.
Q Okay. So as compared to the prior art aluminum oxide, there is an absence of scattering in the iron/magnesium oxide/iron sandwiches; right?
A By comparison, yes.
Q Right. And the problem with the aluminum oxide is there is randomized scattering in the barrier due to defects; correct?
A What it says here in the paper is that

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

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

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

Q Can I stop you there?

A Yes.

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

BY ATTORNEY WICHMAN:
Q Did you want to finish your answer or do you want to examine what you just said and then come back and finish your answer?
A I'm going to finish my answer. The -- the lattice disorder referred to here is related to the lattice disorder in an amorphous oxide. And a single oxygen vacancy defect is not in the same territory of lattice disorder that is being referred to here. I wouldn't put those two in the same bucket.
Q Okay. Why are you focused on a single oxygen vacancy defect?
A Well, I think that is what you said. Oxygen vacancy defect.
Q Okay.
A You didn't say anything about the density of the defects.
Q How many defects -- oxygen vacancy defects would be needed for -- to -- for Bowen's magneto-tunnel junction to achieve a .33 electron volt barrier?
A I don't have a number for that. I haven't given an opinion on it.
Q Would it be more than one oxygen vacancy

defect?
A More than one in the entire crystal? Yes.
Q Okay. So can we agree that we're talking about a multiplicity of oxygen defects being introduced into the oxygen barrier?
A We can talk about whatever you would like to talk about. If that's what you want to talk about, then I'm happy to do that. But you -- you know, we need to be a little bit more specific.
Q Okay. So let's talk about something else that you just said. You said there is no order in an amorphous material, in an amorphous barrier material.
A It is virtually completely disordered. It is not that there is no order. There is almost no order.
Q An amorphous material has no long-range order; correct?
A It has essentially no -- no order at almost all length scales except right down to the single atom level. The average distance between the atoms and an amorphous material has variation, but it is roughly similar. And at all other light 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

would do that by referring to Soukup.
BY ATTORNEY WICHMAN:
Q Would a POSA have understood that an oxygen vacancy defect in the magnesium oxide barrier would be a source of scattering for tunneling electrodes -- electrons?
A That is a reasonable -- a reasonable thing for a person of ordinary skill in the art to consider.
Q And when you formed your opinion here in your testimony that Butler taught a change in barrier height was expected to affect majority and minority channel tunneling, you did not consider whether Butler -- that Butler did not account for any scattering in the magnesium oxide, did you?
A I didn't offer any opinion on that in any of my declarations. I won't say that I never thought about it.
Q In forming your opinion, did you consider the fact that Butler did not study or account for scattering from defects in the barrier?
A In forming my opinion, I did consider it. I didn't -- I didn't -- I didn't consider it as the -- at the end of the day, the opinion I gave, I felt it wasn't -- it didn't have -- it didn't

change my opinion.
Q Would a POSA have understood that the lateral component of electron momentum for current tunneling through an MTJ would be randomized by scattering in the barrier?
A There could be some effect like that. How big it is is a question mark. And that's hard to estimate.
Q I asked you if a POSA would have had that understanding?
A A POSA would likely have had that understanding.
Q Okay. Can you go back to Butler, Exhibit 1044, page 1.
A Yeah.
Q Okay. I'm just trying to find my spot here.
All right. So if you go to the end of the abstract and count backwards -- one, two -- third sentence from the end.
A The abstract.
Q In the abstract, yeah. "In the majority channel."
A I see that.
Q "In the majority channel the conductance

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

A Correct.

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

A It could.

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

A In an amorphous material, yes.

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

ATTORNEY WILSON: Objection. Form.

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

BY ATTORNEY WICHMAN:

Q And what is the amount of transverse

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

A I don't know.

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

A No. That's not correct.

Q So tell me what I got wrong with that.

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

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

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

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

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

A 3 and 4.

ATTORNEY WILSON: Objection. Form.

BY ATTORNEY WICHMAN:
Q Correction. 3 and 4. Is that right?
A Right.
Q And you draw these red lines. These vertical red line lines; is that right?
A Right. I drew those.
Q Okay. And you're saying that the red line is there to indicate in this case an increase in barrier height; is that right?
ATTORNEY WILSON: Objection. Form.
THE WITNESS: No. That's a decrease.
BY ATTORNEY WICHMAN:
Q That's a decrease in barrier height?
A Increasing the Fermi energy decreases the barrier height.
Q So this is actually supposed to indicate an increase in Fermi energy?
A The red line is the Fermi energy.
Q Okay. And what you're suggesting is that at the point at which that Fermi energy -- or I'm sorry. At the point at which the plotted density of states intersects that red line representing an increase in Fermi energy, you're suggesting that a POSA would think aha there's a different density of states, is that -- is that what you're saying?

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

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

A No.

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

A Oh, they do. These are all --

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

A No. That's true.

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

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

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

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

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

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

Q Yeah.

A I'm not offering an opinion on that.

Q And the POSA would not know what the

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

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

Q Did you do that experiment?

A I did not.

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

A I disagree with entirely new.

Q Okay.

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

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

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

THE WITNESS: Yeah.

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

THE WITNESS: Yeah.

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

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

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

THE WITNESS: Okay.

ATTORNEY WICHMAN: All right. Off the record.
(A recess was taken.)
ATTORNEY WICHMAN: On the record.
Q Dr. Bokor, during the break, did you speak to anybody about the deposition?
A Nope.
Q Okay. We can go back to Butler, Exhibit 1044, page 1, right-hand column, first paragraph quickly.
A Give me a moment to get there.
Oh, wrong document. Butler, page 1.
Q Yep. Right-hand column.
A Right-hand column.
Q First full paragraph.
A All right.
Q Third sentence.
A One, two, three. One of --
Q Sorry. Fourth sentence. You're right. "The nature of the states both in the electrodes and the barrier layer are extremely important in determining the tunneling conductance." Right?
A That's what it says.
Q It is talking about the density of states of the majority spin, minority spin channels?

A Well, I think the nature of the states is broader than that.
Q What does it mean to you?
A Symmetries of the state, the dispersion, the majority versus minority. There's a whole lot of different factors that go into the nature of the states besides density of states. What he plots and relies on a lot to illustrate what is going on are the density of states. But that's not the only thing that he is talking about here.
Q Okay. Would you agree that oxygen vacancy defects in the magnesium oxide would change the symmetry of the majority and minority states?
A I don't think that's the effect that Klaua is talking about. And even in applying that to Butler, I don't think that's the nature of the change that -- the way to think about the change that would be introduced by oxygen vacancy defects.
Q Do you agree that oxygen vacancy defects would change the nature of the states in the magnesium oxide barrier?
A In -- it would -- I mean, yes, in -- strictly speaking, yes, it would change the nature

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

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

A I see the statement.

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

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

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

A Not specifically.

Q Tell me how you considered the effects of 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

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

A That's what it says.

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

A I said that.

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

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

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

A Uh-huh.
Q Those squiggly lines that are the calculation of density states in minority and majority spin channels for iron near the interface in Figure 3 and 4, magnesium oxide near the interface in Figure 4, those squiggly lines don't -- don't account for any oxygen vacancies in the magnesium oxide, do they?
A Here, they do not. That's correct.
Q Okay. So you are suggesting just picking a different Fermi energy out of the air and comparing it to a calculation that doesn't account for how you would get that Fermi energy; is that right?
A I wouldn't say that it doesn't account for it. I considered it a small effect that I didn't think was -- that was small enough that it wouldn't destroy the motivation to move that Fermi level.
Q How did you arrive at the conclusion that the effect of introducing oxygen vacancies in magnesium oxide would only be small on the calculation that Butler did for I'm going to say ideal atomic layers of iron and magnesium oxide?
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

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

Q Did you try it?

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

Q Did you try this experiment, Dr. Bokor?

A I did not.

Q If it is not that difficult to try, why

didn't you try?
A Well --
ATTORNEY WILSON: Objection. Form.
THE WITNESS: I wasn't doing this kind of work in 2004.
BY ATTORNEY WICHMAN:
Q In preparing your -- in preparing your testimony, why didn't you just do it, tell us the results?
A I don't have the capability of doing that experiment myself.
Q Okay. You agree -- we talked about this on Butler page 1, the bottom left, Butler states, "It is necessary to have a reliable physical model for the interface between iron 100 and magnesium oxide." Right?
A I see that.
Q You agree that Butler creates a physical model of this interface with an ideal 100 iron atomic layer covered by an ideal 100 magnesium oxide atomic layer; right?
A Right.
Q And he specifies the position of the atoms in that model in exquisite detail, doesn't he?

A Yeah.
Q I mean, to a thousandth of an angstrom; correct?
A He gives numbers to a thousandth of an angstrom, yes.
Q And he painstakingly specifies the distance between each iron atom and each oxygen atom in the magnesium oxide layer above the iron; right?
A Right.
Q And you agree that removing an oxygen from the magnesium oxide lattice will result in a deformation of the magnesium oxide lattice; correct?
A I did not agree to that.
Q You don't -- you disagree with that statement?
A I -- well, it is a change in the lattice. So there's an atom missing. Whether or not the lattice relaxes around that point and how much, I can't -- I can't testify to that. I thought that's what you're asking me.
Q So you don't even know how much the magnesium oxide lattice would have to -- would change to accommodate a missing oxygen atom?

A Not as I sit here now, no.
Q Okay. Do you agree that modifying Butler's model to account for a missing -- an oxygen atom missing at the interface would require changing the position of the atoms in the magnesium oxide atomic layer at that interface?
A I can't answer that question. You know, require is a qualitative decision. How -- you know, as I've tried to testify -- I tried to explain this multiple times. Theorists do the best they can. If they're trying to take into account an effect like magnesium -- like oxygen vacancy defects in the MgO, there are various levels of sophistication that they could use to model that. They could just take an atom out and not relax the adjacent atoms. They could try to release the adjacent atoms. They could try to put the defect in different locations. They could change the density of the -- there's a lot of different things that they can do. The more sophisticated the model, generally speaking, the more expensive it becomes. And theorists have to contend with the cost of their modeling in the sense that the cost increases the amount of computer time. If I -- if I do a calculation and

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

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

A I don't know with precision, no.

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

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.

Q Did you look for one?
A I did -- certainly I did some looking, yes.
Q We're on paragraph 11. Go back to your declaration, Exhibit 1105, paragraph 11.
A 11. Okay.
Q All right. Your next sentence, "Although Butler's calculations would need to be repeated to see what would happen to the density of states in Figure 3 and 4 with a change in Fermi level." That's your testimony, right?
A Right.
Q But if Butler's model doesn't include oxygen vacancies, you couldn't repeat Butler's calculation. You would have to change Butler's model, wouldn't you?
A I'm not talking about that here.
Q What are you talking about?
A I'm talking about a more -- you know, a calculation with less additional -- with less changes. Just change where the Fermi level is. In other words, change the barrier height. The calculation has an assumption about barrier height. He doesn't calculate the barrier height. He uses a model value for the barrier height

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

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

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

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

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

A Correct.

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

A That's fair.

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

A Right.
Q "As shown in the following formula." And then you label that Equation 1; right?
A Right.
Q And what you're doing is expressing TMR ratio using Julliere's model; right?
A Yeah. That's a good point.
Q You agree that is Julliere's model?
A That comes from the Julliere's model.
Q If you could open Exhibit 1033.
A I have it.
Q So Julliere's model was published in 1975; right?
A Right.
Q It was long before Butler did his work in 2001; correct?
A Correct.
Q In Julliere's Model P1 and P2 are spin polarizations of the ferromagnetic electrodes?
A Yes.
Q And the D terms refer to the density of state at the electrodes at the Fermi level for spin-up and spin-down bands; is that right?
A In my declaration or somewhere else?
Q In the model. I mean, you're quoting --

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

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

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

A Uh-huh. Okay.

Q PDF 2.

A Right.

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

A Right.

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

A Correct.
Q P1 and P2 are the spin polarizations of the two electrodes; right?
A Right.
Q And then there are these D quantities. And they're a little complicated because they are sort of a compressed notation. But there's -- as in your declaration, there's a D sub 1, parenthesis, 2, with an up arrow; right?
A Right.
Q And what that's saying is for D1 or for D2, the subscripts 1 and 2 are for the different ferromagnetic electrodes; right?
A Right.
Q And the up arrow is -- refers to spin-up or up-spin; right?
A Right.
Q And then there's a D sub 1, parenthesis, 2, with a down arrow; right?
A Right.
Q And the down arrow is referring to the D value for a down-spin sub-band; right?
A Right.
Q And so in Exhibit 1050, it explains that the D sub 1, parenthesis, 2, up arrow and D sub 1,

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

A Right.

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

A I did.

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

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

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

A It does. Yuasa said that.

Q Do you disagree?

A Well, you know, I hate to quibble with Yuasa on this fine point. If you look at 1033, which we just did, you don't find that second equation with the density of states in it. That's all I'm saying. Now, I don't know why we're having this particular -- going down this particular road. I cited Yuasa. Yuasa called it 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

Slonczewski or Julliere's model. And it's too simple for Butler. It doesn't -- it doesn't -- on its face it doesn't -- it doesn't perfectly capture Butler. I think -- I'm not sure Butler explicitly writes this. My interpretation of Butler is this equation with the Ds in it is useful in Butler, with the modification that what's used for the density of states is what Butler calls the tunneling density of states. So Butler is all about the influence of the -- the tunneling states on the MgO on the -- on the TMR. And that -- that equation with just -- just depending only on the density of states in the two electrodes doesn't take into account the effect of that special nature of the MgO. Butler captures that in a quantity that he calls the tunneling density of states. And so that's -- for example, in Figure 7 in Butler -- let me just take a look at whether he also uses that. Yeah. In Butler Figure 7, he's -- the label on the axis is density of states. But in the caption, I'm talking about Figure 7 on page 6 of Butler. PDF page 6. Figure 7 shows what the caption identifies as tunneling density of states. So with that 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 site 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

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

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

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

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

Q Okay. And --

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

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

ATTORNEY WILSON: Objection. Form.
THE WITNESS: Strictly speaking, that's true. It would have been a lot simpler. However, this equation -- I don't use this equation to come to the ultimate conclusions about whether or not Butler teaches that changing the Fermi level would change the TMR.
BY ATTORNEY WICHMAN:
Q Dr. Bokor, in your declaration, at paragraph 11, you testify that "TMR directly results from the difference in spin polarizations of the two electrodes as shown in the following equation," which we have discussed, and then say thus. "Thus," meaning therefore it follows, "changing the density of states of majority versus minority electrons in either or both electrodes unquestionably will change TMR." That's your testimony; right?
A I stand by that statement. What I'm testifying now is that to get an accurate calculation of TMR, this -- this is too simple. It will -- no doubt, changing the density of states will change TMR. Butler is teaching a more sophisticated analysis for the TMR where it depends not just on the density of states in the

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

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

A No.

ATTORNEY WILSON: Objection. Argumentative.

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

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

BY ATTORNEY WICHMAN:

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

A I agree.

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

barrier layer?
A That's correct.
Q Do you agree that nothing in Julliere's model describes the symmetry of propagating states?
A Correct.
Q Do you agree that nothing in Julliere's model describes evanescent states of a barrier material?
A I think that's right.
Q Do you agree that nothing in Julliere's model describes the decay of evanescent states in the barrier layer?
A Well, now I'm not so sure about that. This particular Julliere reference, Exhibit 1033, does not explicitly talk about the decay of the wave function in the barrier and, you know, what the overall tunneling probability is. It certainly does talk about tunneling. He doesn't explicitly talk about the decay. And he certainly doesn't talk about how the decay would be different for the two spin polarizations. I will leave that as my answer.
Q Do you agree that nothing in Julliere's model describes strong interference from multiple

states with complex wave vectors in the barrier?
A Sure.
Q Do you agree that nothing in Julliere's model describes interfacial resonance states?
A I believe that's true.
Q Do you agree that nothing in Julliere's model describes a barrier height?
A Well, he doesn't explicitly mention barrier height. But he does explicitly talk about the barrier and the distance. So the thickness of the barrier. He doesn't explicitly talk about the barrier height.
Q The barrier thickness and barrier height are unrelated -- or different independent properties; right?
A That's true.
Q All right. If you can go in your deposition -- in your declaration, Exhibit 1105 to paragraph 24.
A Okay. I'm there.
Q You testified that Butler explicitly criticized earlier models of tunneling conductance that failed to appreciate the crucial behavior as completely inadequate. Right?
A Right.

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

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

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

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

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

A Yes.

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

for understanding tunneling in the 001 iron/MgO 001/iron 001 MTJs; right?
A Right.
Q Okay. And you agree that Julliere doesn't -- Julliere's model doesn't account for tunneling matrix elements; right?
A Yeah. Julliere's model comes under the same umbrella of completely inadequate as described by Butler.
Q Right. Okay. And then in the second bullet here, paragraph 24, the relationship to the symmetry of the slowly decaying evanescent states in the barrier layer -- I'm sorry. "The symmetry of the Bloch states at the Fermi energy and their relationship to the symmetry of the slowly decaying evanescent states in the barrier layer are crucial to understanding tunneling conductance." Right?
A Right.
Q That's from Butler?
A Butler.
Q And none of that is in Julliere's model; right?
A Right.
Q Okay. And if you go to paragraph 30 --

A 30.
Q -- of your declaration.
A 30. Okay. 30.
Q Now you're -- now you're -- you start by talking about Sloczewski, but you say that, "Butler recognized that a reliable physical model" --
A Wait. I'm not up to you. You're in 30?
Q Second -- okay. Exhibit 1105, paragraph 30. Are you there?
A Yeah. Yeah.
Q Second sentence. "Butler, in contrast" --
A Okay.
Q -- "recognized that a reliable physical model of an MgO 001-based MTJ, including its barrier layer, was necessary to truly understand its behavior." Right?
A You read that correctly.
Q And Julliere's model does not -- is not a reliable physical model of an MgO 001 MTJ, including its barrier layer, is it?
A Correct.
Q Julliere's model doesn't account for crystallinity or composition of the barrier, does

it?
A Correct.
Q There is no barrier layer in Julliere's model, is there?
A I think there's a barrier layer.
Q There is no property of the barrier layer in his expression for TMR, is there?
A I thought we were done with Julliere.
There's no -- I'm sorry. Please repeat the question. Now I have Julliere up again.
Q Julliere's model -- Julliere's expression for TMR does not account for a reliable physical model of any barrier layer, does it?
A I think your sentence -- your statement is, you know, generally reasonable. But I -- in the interest of being as accurate as possible, he does say some things about the barrier. He talks about the tunneling is through a semiconductor. He talks about, you know, to prevent shorting, we have to make sure that we don't have pinholes. He talks a little bit about the barrier. He does mention barrier height. I think I might have missed that previously. Barrier height deduced from the G of V curved Figure 1 is in the order of 100 meV, milli-electronvolts. That is .1 volt.

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

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

A Not explicitly, no.

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

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

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

A Right.

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

declaration?
A As I have testified, I agree that is in error. It was not my intention to rely in any way, shape, or form on Julliere's model. It was a mistake to cite that equation. And I didn't use that equation in coming up with any of my conclusions. I cited that conclusion in error.
Q Okay. Why does the last sentence of your testimony at paragraph 11 of your reply declaration begin with the word "thus"?
ATTORNEY WILSON: Objection. Form.
THE WITNESS: Well, that's -- that is interpreting the equation P1-2.
BY ATTORNEY WICHMAN:
Q So you are drawing conclusions from this equation for TMR ratio in your paragraph 11?
A So the conclusion is -- is incomplete. The conclusion, strictly speaking, is correct. Changing the density of states of a majority versus minority electrons in either or both electrodes unquestionably will change TMR. Butler -- I don't believe Butler would disagree with that. However, it is inadequate. It doesn't tell the full story. And I go on throughout the rest of my declaration, you know, amplifying on

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

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

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

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

THE WITNESS: It's a little tight.

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

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

ATTORNEY WICHMAN: That's --

THE WITNESS: You want to go less?

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

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

ATTORNEY WICHMAN: How about ten till.

THE WITNESS: -- 12:50.
ATTORNEY WICHMAN: Okay. We'll come back at ten till. Off the record.
(A lunch recess was taken.)
ATTORNEY WICHMAN: All right. On the record.
Q Dr. Bokor, during the break, did you speak to anybody about the deposition?
A No.
Q Okay. In your declaration, Exhibit 1105, please turn to paragraph 9.
A Okay.
Q In paragraph 9 you refer to Exhibit 1106 by first author Giordano, G-i-o-r-d-a-n-o; right?
A Right.
Q All right. Please open Exhibit 1106.
Do you have it open, Dr. Bokor?
A Yes. Now I do.
Q Okay. On page 1, of this article in the abstract, Giordano explains that this was a study of the role of surface oxygen vacancies on the characteristics of palladium deposition on the magnesium oxide 100 surface; correct?
A I see that.
Q So this isn't actually depositing

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

A That's fair.

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

A That's what it is, yes.

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

A Okay. Yeah.

Q You agree?

A Yes.

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

A Uh-huh.

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

A Right.

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

palladium on magnesium oxide; right?
A Monolayer of palladium on magnesium oxide, yes.
Q And monolayer means a single atomic layer?
A Correct.
Q So this is a single atomic layer of palladium deposited on magnesium oxide where the surface of the magnesium oxide has oxygen vacancies, plural; correct?
A Correct.
Q And this study shows that the presence of the oxygen vacancies in the magnesium oxide surface causes corrugation of the adsorbed palladium film; right?
A Page 5, the presence of the vacancy causes a corrugation of the adsorbed palladium film.
Q What is -- the adsorbed palladium film, that refers to the monolayer of palladium atoms that, let's say, stick to the surface of the magnesium oxide; is that right?
A Well, this paper deals with three situations. A single palladium atom, a monolayer, and then a bilayer of palladium. And there are

figures for each of those.
Q What does the word adsorbed mean when it refers to an adsorbed palladium film?
A It means a palladium layer that has been deposited and is stuck to the -- to the surface.
Q So even in this model, the oxygen vacancy on the surface of the magnesium oxide is causing a physical deformation of the structure. Is that a fair statement?
A Okay. So, you know, I'm rereading this paper. The detailed question that you're asking me is not on the tip of -- you know, right at the top of my head. I'm looking for where in the paper it describes exactly what the -- what happens of the passion position of the vacancy at the distortion of the surface. I'm not finding it easily. Since we are, you know, trying to be efficient with time, if there's a part of this paper that is talking about that you would like to discuss, if you want to point me, that would save some time. Otherwise, I'm looking for the discussion about the question you're asking.
Q Well, even if we just focus on the palladium film, the sentence we just read states that the oxygen vacancy on the surface of the

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

A Of the palladium film.

Q Of the palladium film.

A Yes.

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

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

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

A Right.

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

ATTORNEY WILSON: Objection. Form.

THE WITNESS: Right.

BY ATTORNEY WICHMAN:
Q And there is nothing in Giordano that takes into consideration the effect of vacancy and oxygen vacancy in -- in the magnesium oxide that is not in the surface of the magnesium oxide, is there?
A Well, the -- I'm not sure exactly how well I understand your question. The paper reports oxygen deficient MgO surface. Exactly over what distance from the surface they are integrating to get that DOS, I'm not seeing. And I don't recall specifically. So it is near the surface for sure. It's the density of states would be modified near the surface. But how far in it goes, I think I remember trying to figure this out before from this paper. And it's -- it's not coming back to me exactly what they say about it.
Q Palladium is not a magnetic material, is it, Dr. Bokor?
A Correct.
Q And there is no majority/minority spin density of states in palladium, is there?
A That's -- that's fair.
Q You could not make a magneto-tunnel

junction using palladium electrodes, could you?
A True.
Q All right. In Giordano, there's no density of states or a Bloch state with delta 1 symmetry, is there?
A No.
Q And there's no density of states for a Bloch state with delta 5 symmetry, is there?
A Right.
Q There is no density of states for a Bloch state with delta 2 symmetry, is there?
A Right.
Q And there's no density of states for the evanescent decay of -- I'm sorry. There's no calculation of the evanescent of decay of states in the magnesium oxide, is there?
A From the metal, I don't think so. Like I said, I was trying to find where it talks about the wave function or density of states evolves below the surface, but I'm not -- I'm not sure they do. I'm not finding it. So I don't know the answer to your question in detail.
Q Okay. So you agree that Butler did not evaluate the effect of surface vacancies on magnesium oxide when evaluating the iron/magnesium

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

ATTORNEY WILSON: Objection. Form.

THE WITNESS: That much is correct.

BY ATTORNEY WICHMAN:

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

A Paragraph 115.

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

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

A Absolutely.

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

A Correct.

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

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

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

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

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

A You read that correctly.

Q That's your testimony?

A Yes.

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

A Okay. Yes, more or less.

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

magnesium oxide atomic layer; correct?
A Ideal in the sense that there weren't any imperfections or defects.
Q Okay. And Butler is -- you agree that Butler is clear that the TMR predictions are sensitive to the details of the interface between the ferromagnetic electrode and the magnesium oxide barrier; right?
A He does say that.
Q Okay. And if you look at Butler, Exhibit 1044, at page 11, PDF 11, just let me know when you're there.
A Page 11. I'm there.
Q Left column, the bottom paragraph. He summarizes his results.
A Okay.
Q Correct?
A Yeah. The section called conclusions, yeah.
Q All right. So he says that the "Results that are particular to tunneling through epitaxial insulators on iron 100 include," and then he lists three results; right?
A Yes.
Q And the first is that "majority channel

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

A You read that correctly.

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

A That's what it says.

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

A Right.

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

A That's what he says.

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

A Correct.

ATTORNEY WILSON: Objection. Form.
BY ATTORNEY WICHMAN:
Q All right. If you can look at Mathon, Exhibit 1046. Just let me know when you have it.
A Okay. I have it.
Q So if you can go to page 4, which is PDF 4.
A Okay.
Q All right. And the left-hand column, bottom paragraph, that starts it is clear.
A Yeah.
Q Okay. Second sentence, "To observe such a large R-TMR." Right?
A I see that.
Q All right. Large TMR -- large R-TMR is referring to the TMR ratio; right?
A Right.
Q This is the prediction of large TMR in the iron/magnesium oxide/iron MTJs?
A Okay.
Q Yes?
A Yes.
Q Okay. So "to observe such a large RTMR, it is, therefore, essential that the iron/magnesium oxide interface is perfect."

Right?
A That's what it says.
Q And then he says, "The behavior of RTMR at small thicknesses of magnesium oxide is determined by large peaks of special density (hot spots) located outside the gamma point." Right?
A Okay.
Q "These are very sensitive, not only to the interfacial roughness but also to the symmetry of the junction." Right?
A That's what it says.
Q All right. So a POSA that was trying to achieve the high TMRs that Butler and Mathon are predicting for these iron/magnesium oxide/iron MTJs would have done everything that they could to make sure that the interfaces between the ferromagnetic electrodes and the magnesium oxide were perfect; correct?
A Fair to say they would do everything they could.
Q Okay. If you could open Exhibit 1045.
A Klaua again.
Q Yeah.
A Okay.
Q Well, actually you know what, let's set

that aside. We can skip that.
Let's talk about Bowen.
A Bowen. Okay.
Q Yeah. Exhibit 1026, if you could open that.
A Okay. I have it.
Q All right. On Bowen, at page 1655, PDF page 2.
A Right.
Q Let me find it here. In the left-hand column second sentence, up to now most studies -- I'm sorry. Drop down. There -- do you see the sentence that starts, "However, from a fundamental point of view"?
A Okay.
Q The next sentence right after that. "Most numerical calculations of spin-dependent tunneling in TMR have been developed for single crystal MTJs, such as a set of materials ending with iron/MgO 100." Correct?
A Yes.
Q And next to iron MgO 100, there are two endnotes 5 and 6; correct?
A Yes.
Q And if you go to Bowen page 1657, at

PDF 4, you will see that reference 5 is Butler; right?
A Right.
Q Which is Exhibit 1044?
A Yes.
Q Okay. And -- and in Bowen, reference 6 is Mathon, which is Exhibit 1046; right?
A Yeah. I think so.
Q Okay. So as we just discussed, the POSA knew that Butler and Mathon's models required accounting for the electronic structure of the interface between the ferromagnetic electrode and the barrier layer; right?
A That's right.
Q As you just agreed a person of ordinary skill in the art would have done everything that they could to make sure that that interface was perfect?
A As best as they could.
Q Yep. If we go back to Bowen, page 1655, PDF 2, left column, first full paragraph, right below where we were just reading, it says all -- okay. "All of these studies," including Mathon and Butler papers we just cited, "emphasized that" --

A I'm not --
Q Okay.
A We were in 1655, bottom of the left column.
Q Well, not the bottom. The middle. That sentence that says, "Most numerical calculations of spin-dependent tunneling and TMR" --
A I'm with you now.
Q Okay. So "All" -- meaning all these references, including Butler and Mathon -- "emphasize that a correct depiction of the spin-dependent tunneling properties of epitaxial MTJs must take into account the interplay of electronic structure between metal and insulator." Right?
A You paraphrased.
Q Well, let's read the whole sentence exactly as it is written. "All emphasize that a correct depiction of the spin-dependent tunneling properties of epitaxial MTJs must transcend the simple potential barrier image and take into account the interplay of electronic structure between metal and insulator." Right?
A That's what it says.
Q And then if you go up to the top of this

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

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

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

A Correct.

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

A Correct.

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

A I'm sorry. Again you lost me. Where are you reading? Oh, I see.
Q "A test of these models can be performed on single crystal epitaxially grown structures." Right?
A I found it, yes.
Q That's what Bowen did. They fabricated a single crystal epitaxially-grown structure; right?
A Right.
Q And, in fact, it is not just that they epitaxially grew layers, but the entire device was a single crystal; correct?
A Correct.
Q And you can see that on page 1655, on the right-hand column, in the bottom paragraph, starting with Figure 1A. If we drop down, he says third sentence, "Further x-ray diffraction symmetric and asymmetric scans confirm that the whole structure is epitaxial with lattice parameters close to bulk values." Right?
A Right.
Q And then on page 1657, which is PDF 4, the right-hand column, first full paragraph, second sentence, "As evidenced by Rheed," R-h-e-e-d --

A I'm sorry. I'm trying still to catch you -- catch up to you. What page are you on?
Q Page 1657, which is PDF page 4.
A Okay.
Q Right-hand column.
A Right-hand column.
Q First full paragraph.
A "In conclusion."
Q 1657 of Bowen.
A The paragraph starting with "In conclusion." And then you're going --
Q The paragraph starts with "In conclusion." Next sentence.
A Okay. Now I'm with you.
Q "As evidenced by Rheed," R-h-e-e-d, "x-ray diffraction and TEM analyses, optimized growth conditions result in entirely epitaxial samples of high crystalline quality with flat sharp interfaces." Right?
A Right.
Q So this is Bowen telling us that not only did they do everything they could to achieve a perfect single crystal MTJ, but they actually got pretty close; right?
A They got as close as they could.

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

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

Q Uh-huh. Okay. Now --

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

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

A Nagahama. Okay. Yes. Okay.

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

A I'm there.

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

A Right.

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

A Clearly.
Q And at the end of paragraph 14, Nagahama points out though that the problem is "a single-crystal substrate is necessary to form an element. This however makes it difficult to form an element on a silicon LSI, and thus a challenge for realizing a magneto-" -- "magnetic random access memory." Right?
A "Has not yet overcome."
Q Overcome.
A Right.
Q So they recognize the theory relies on a single crystal substrate, but that's a manufacturing problem in the real world; right?
A Right.
Q Okay. At paragraph 73, on PDF 9 -- just let me know when you're there.
A I'm there.
Q "Still another magnetoresistive element was prepared which includes 001-highly-oriented lower ferromagnetic electrode layer, a 001-highly-oriented magnesium oxide barrier layer, and the 001-highly-oriented upper ferromagnetic electrode layer." Correct?
A Correct.

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

ATTORNEY WILSON: Objection. Form.

THE WITNESS: Well, as -- no. He wasn't trying to make a structure as perfect as he could. He was trying to make a -- a device as close as perfect as he could get with other considerations involving practical -- practical fabrication issues. And, you know, manufacturing and making a mass manufacturable product. So he wasn't trying to make as perfect a structure as he could. He was -- he was making a compromise and trying to make a -- a structure as good as he could with an additional consideration that he was trying to make it on top of not a perfect high -- perfect single-crystal substrate. So he knew he was making a compromise. And he says, I'm going to try this way. And he describes a way that he can try to get a single-crystal -- as close to single-crystal layers as he can. But he's compromised. He didn't grow it on a single crystal substrate.

BY ATTORNEY WICHMAN:

Q The -- Nagahama provides this magnesium

oxide double underlayer; correct?
A Correct.
Q And on top of that double underlayer, he forms 001 iron ferromagnetic layers; right?
A Right.
Q Okay. That is a crystal iron ferromagnetic layer; correct?
A It's -- it's crystalline, yes. But I believe Nagahama and any one of ordinary skill would understand that the highly oriented MgO seed layer that he grew was not the same as a perfect single crystal. There would be -- there would be some imperfections there. So the iron 001, yes, it is generally 001. But one would -- a person of ordinary skill in the art would expect it would be -- it wouldn't be perfect. Not as perfect as Bowen's 001 iron grown on a perfect single-crystal substrate.
Q Okay. The purpose of the magnesium oxide underlayer in Nagahama -- well, strike that.
Nagahama provides the magnesium oxide double underlayer so that the top surface of that double underlayer provides a 100 template on which to form a lower ferromagnetic electrode of 100 iron; correct?

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

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

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

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

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

A I see.

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

A Right.

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

A Right.

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

A Right.

Q MBE, that's molecular beam epitaxy?

A Right.

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

A Right.

Q All right. In the MBE chamber, he heats

the object and -- and removes absorbed water. That's step 5; right?

A Right.

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

A Right.

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

A Right.

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

A Right.

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

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

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

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

A As perfect as possible.

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

A Right.

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

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

Q Okay.

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

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

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

A Right.

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

A For the same reason that Nagahama didn't

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

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

A Yeah. For example, using a different metal.

Q What do you mean by a different metal?

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

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

A I did not specifically suggest any other method in that.
Q If you open Exhibit 1024 in the 1494 case.
A Right.
Q Let's just start with Bowen. I want you to tell me every paragraph where you describe the POSA reducing the barrier height in Bowen's magnesium oxide barrier that does not involve adding oxygen vacancies.
A Okay. I don't have anything to -- specific to point to on that point.
Q In Exhibit 1024, this is your original declaration in the 1494 case. Tell me every paragraph where you describe the POSA reducing the barrier height in Nagahama's magnesium oxide barrier that does not involve adding oxygen vacancies.
ATTORNEY WILSON: Objection. Form.
ATTORNEY WICHMAN: All right. Let me strike that question because there was an objection.
Q Dr. Bokor, you have Exhibit 1024 in front of you?
A I do.

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

A I don't have any.

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

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

ATTORNEY WICHMAN: Off the record.

(A recess was taken.)

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

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

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

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

-oOo-

I have read the foregoing deposition transcript and by signing hereafter, subject to any changes I have made, approve same.

Dated: _____

_____
(Signature of Deponent)

DEPOSITION OFFICER'S CERTIFICATE

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) SS.
COUNTY OF RIVERSIDE)

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

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BROOKE SILVAS
CSR No. 10988

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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

thereof mailed to all parties attending the deposition.)

( ) Failed to approve the transcript within the allotted time period.

Dated: November 2, 2025

Brooke Silvas

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CSR NO. 10988

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