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

WESTERN DIGITAL TECHNOLOGIES, INC.,	)	
Petitioner,	)	
vs.	)	Case No.
	)	IPR2024-01493
GOOD KAISHA IP BRIDGE 1,	)	IPR2024-01447
Patent Owner.	)	

REMOTE DEPOSITION OF
JEFFREY BOKOR, PH.D.
JUNE 25, 2025

Reported by:
Brooke Silvas, CSR 10988
Job No. 1355530

MAGNA LEGAL SERVICES

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6 vs.) Case No.
) IPR2024-01493
7 GOOD KAISHA IP BRIDGE 1,) IPR2024-01447
)
8 Patent Owner.)
_____)
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13 Deposition of JEFFREY BOKOR, PH.D., taken
14 remotely via Zoom, commencing at 9:00 a.m., on
15 Wednesday, June 25, 2025, before Brooke Silvas,
16 Certified Shorthand Reporter No. 10988.
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1 I N D E X

2 WITNESS: JEFFREY BOKOR, PH.D.

3 EXAMINATION BY PAGE

4 ATTORNEY WICHMAN 5

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9 E X H I B I T S

10 (None)

11

12

13 INSTRUCTION NOT TO ANSWER

14 (None)

15

16

17 INFORMATION TO BE SUPPLIED

18 (None)

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21

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1 REMOTE DEPOSITION; JUNE 25, 2025
2 9:00 A.M.
3
4 JEFFREY BOKOR, PH.D.,
5 having been duly administered an
6 oath remotely by the reporter, was examined
7 and testified as follows:
8
9 EXAMINATION
10 BY ATTORNEY WICHMAN:
11 Q Good morning, Dr. Bokor.
12 A Good morning.
13 Q Where are you located today?
14 A Offices of Armond Wilson in Newport
15 Beach, California.
16 Q California?
17 A California.
18 Q Is there anybody in the conference room
19 with you?
20 A No.
21 Q Do you have a computer in front of you?
22 A I do.
23 Q Does the computer contain a folder with
24 PDFs that are labeled exhibits?
25 A Yes.

1 Q I just want to make sure that they are
2 the exhibits for today's deposition. Can you tell
3 me, do you have two exhibits marked number 1024?
4 A Okay. Let's see. I think the -- give me
5 a moment. The one directory just has one. But
6 there's -- yeah. There's an upper directory that
7 has two exhibits 1024. I have them both.
8 Q Can you tell me the file names of the
9 exhibits that start with 1024?
10 A One is called Bokor Declaration '134
11 patent. And the other one is called Bokor
12 Declaration '167 patent.
13 Q Do you see a document marked Paper Number
14 15 and another document marked Paper Number 16?
15 A I see those.
16 Q Can you open those two documents for me,
17 please.
18 Are they -- do you have them open?
19 A I do.
20 Q Have you seen either of these documents
21 before?
22 A Not that I recall.
23 Q All right. In the document title Paper
24 16, do you see this is a notice of deposition for
25 case number IPR2024-01447?

1 A Yes.
2 Q And this concerns US patent number
3 8,405,134?
4 A I see that.
5 Q And you understand if I refer to the '134
6 patent, I'm referring to this patent number
7 8,405,134; right?
8 A Yes.
9 Q Can you turn to the second page of that
10 document.
11 A Okay.
12 Q Do you see that this document indicates
13 that today we are taking your deposition in two
14 cases? One of which is IPR2024-10477 and the
15 other one of which is number IPR2024-01493.
16 A I see that.
17 Q Okay. Can you look at the document
18 marked Paper Number 15.
19 A Okay.
20 Q This is a notice of deposition in case
21 number IPR2024-01493; correct?
22 A I see that.
23 Q And this case concerns US patent number
24 10,680,167; correct?
25 A That's what it says, yes.

1 Q So you understand that if I refer to the
2 '167 patent, I'm referring to US patent number
3 10,680,167; correct?
4 A Yes.
5 Q If you look at the second page of this
6 document, do you see that this deposition notice
7 also concerns the same two cases, case number
8 ending 01447 and ending 01943; right?
9 A I see that.
10 Q Okay. So I just want it to be clear,
11 yesterday, the deposition was a single case.
12 Today's deposition involves two cases. And you
13 have a declaration that was offered separately in
14 the 1447 and the 1493 case; correct?
15 A I believe that's true, yes.
16 Q All right. So I'm just going to ask you
17 to be clear when we -- when you're answering
18 questions which document in particular, which
19 declaration you are referring to. So if I ask you
20 a question about your declaration in the case
21 about the '167 patent, I want to be sure that
22 you're looking at that declaration and not the
23 declaration for the other case. Okay?
24 A Yeah. I understand. I hope you will
25 help -- you will be helpful in that respect as

1 well. You know, point me to the correct one.
2 Q We will do our best.
3 So you're appearing today on behalf of
4 Western Digital; is that correct?
5 A Yes, sir.
6 Q And Western Digital retained you to offer
7 opinions in each of these cases; is that correct?
8 A Yes.
9 Q You were deposed yesterday in case number
10 IPR2024-10494; is that right?
11 A I'll take your word for the number.
12 Q Concerning the '909 patent?
13 A Concerning the '909 patent.
14 Q Do you understand that the same rules for
15 the deposition that applied yesterday continue to
16 apply today?
17 A Yes.
18 Q You understand I'm going to ask you
19 questions today?
20 A Yes.
21 Q Do you agree to wait until I finish
22 asking a question before you begin to answer?
23 A I will do my best.
24 Q Okay.
25 A Yes.

1 Q Do you understand that you need to answer
2 questions verbally so Ms. Silvas, the court
3 reporter, can transcribe the answer?
4 A Yes.
5 Q Do you agree to ask me to clarify the
6 question if you do not understand the question?
7 A Yes.
8 Q Do you understand that I may refer to
9 exhibits today?
10 A Yes.
11 Q And you have the ability to manipulate
12 PDF files on the computer in your conference room;
13 correct?
14 A Yes.
15 Q Okay. And you understand that the
16 exhibits we're going to try to work from the files
17 that are in the folder on your desktop that you
18 just identified; correct?
19 A Right.
20 Q You understand that counsel for Western
21 Digital may object to a question?
22 A Yes.
23 Q You understand that unless you are
24 instructed not to answer, you still need to answer
25 the question after Western Digital's counsel

1 completes his objection?
2 A Yes.
3 Q We will attempt to take hourly breaks as
4 we did yesterday. Okay?
5 A Yes.
6 Q You -- if you need to take a break, just
7 let me know. Okay?
8 A I will.
9 Q You agree that if we're in the middle of
10 a question and answer, you will answer the pending
11 question before we take a break?
12 A Agreed.
13 Q You understand that once this deposition
14 begins, as it has now, until I finish my
15 cross-examination, you are not permitted to
16 discuss any of the questions or answers with
17 counsel for Western Digital or anybody else;
18 correct?
19 A Yes.
20 Q And you understand that that rule applies
21 regardless of the breaks. So it includes breaks
22 for the bathroom, breaks for lunch, any break in
23 the questioning; correct?
24 A Yes.
25 Q Did you bring any materials with you to

1 this deposition?
2 A No.
3 Q Do you have any case materials on the
4 computer other than the exhibits we've discussed?
5 A Well, there's another directory on the
6 desktop that has -- that is dated with yesterday's
7 date. It looks like it's got essentially all of
8 the same documents in it. But I haven't carefully
9 compared to see if there is anything else.
10 Q Let's stay out of that folder for today.
11 A Sure.
12 Q Okay. Do you have any --
13 A I haven't --
14 Q Go ahead.
15 A I haven't finished the answer.
16 Q Go ahead.
17 A You asked me is there anything else on
18 this computer. I haven't -- you know, it's not my
19 computer. I haven't dug into the directory
20 structure to see what else might be on this
21 computer. The folders that we're talking about
22 are on the desktop. Yesterday's folder and
23 today's folder of deposition materials. That's
24 all I can see. I can't testify as to what else
25 might be on this computer.

1 Q Do you have any email or chat
2 applications open on the computer?
3 A I do not.
4 Q Do you agree not to open any email or
5 chat applications during the deposition?
6 A Agreed. I do have a web browser open
7 which was originally open probably yesterday for
8 Magna Legal Services. I assume we're not going to
9 use that again today.
10 Q Correct.
11 A I can --
12 Q Go ahead and close that browser, please.
13 A I will go ahead and close that window.
14 Okay.
15 Q Dr. Bokor, what did you do to prepare for
16 the deposition today?
17 A I read most of the documents. I read all
18 of the exhibits. I read all of the patents, file
19 histories. Those were in the -- those were in the
20 exhibit folder. Met with counsel on a number of
21 occasions. Read a lot of references. I read a
22 number of references that aren't in the exhibits.
23 Q All right. Is that your answer?
24 A I'm thinking if -- if I can think of
25 anything else. That's -- at the moment, those are

1 the main things that I did to prepare for this
2 deposition.
3 Q You said that you met with counsel. So
4 for the 01447 case on the '134 patent, what
5 counsel did you meet with?
6 A Let's see. I met with Mr. Wilson. I met
7 with Ms. Arnold. Right now, Josepher -- I'm
8 forgetting -- I'm forgetting his family name.
9 Mr. -- I did talk with -- I also met with
10 Ms. Armond. Li. Josepher Li, I think it is.
11 Q Anybody else?
12 A I'm thinking. Those are the ones that I
13 can recall.
14 Q And how much time have you -- did you
15 spend preparing for deposition on the '134 patent?
16 A Well, it would be very difficult for me
17 to separate that out because we've got the '167.
18 We're talking about those two today. And I worked
19 on preparing for the '909. That was kind of a
20 unified effort. I didn't -- I certainly didn't
21 keep track separately of my activities in
22 preparing for each of those separately.
23 Q In preparing for deposition on the '167
24 patent, did you meet with the same attorneys?
25 A Yes.

1 Q So how much time in total have you spent
2 preparing for deposition on the '134 and '167
3 patent?
4 A Yeah. I can't even separate that out
5 because my work on the '909 was integrated with
6 these other two. So as I said, it's hard for me
7 to separate out and say I spent this amount of
8 time on '134, this amount of time on '167, this
9 amount of time on '909. Further, as I answered
10 yesterday, I don't have an accurate recollection
11 of the total amount of time that I spent on all
12 three of those patents. We went back and forth
13 yesterday, and we ended up with an estimate of
14 roughly $50,000 in billing. And that is the same
15 answer I would give today, with respect to my
16 hours of preparation for these three patents
17 together.
18 Q What is your billing rate?
19 A 650 an hour.
20 Q So you spent more than 50 hours preparing
21 for depositions?
22 A Yeah. That sounds right. On that order.
23 But, as I said, this is a very rough estimate. In
24 the meantime, I did not take the time to go back
25 and review my invoices for you. So I can't give

1 any better estimate of the total number of hours
2 that I spent. So it's a very rough estimate.
3 Q If you go back to the beginning of the
4 case, starting with preparing your declaration for
5 this matter, how much time have you spent on cases
6 involving the '134 and '167 patent?
7 A As I just answered, I can't give you a
8 separate -- a separate -- so first of all, when
9 I'm -- what I'm telling you about the time I spent
10 preparing for the deposition, that was your first
11 question. Right?
12 Q My -- my question now is not just
13 preparing for the deposition.
14 A I understand.
15 Q The entire case.
16 A Right. I understand that. And my answer
17 that I gave yesterday and the answer that I just
18 gave, which we said was plus 50 hours, perhaps
19 more, is the total time that I've spent. Because
20 in my mind, the total amount of work that I've
21 been doing related to these patents in one way or
22 another is preparing for this deposition. This is
23 sort of the capstone effort on this case, for me,
24 anyway. And so from the beginning, in reviewing
25 all of the documents and reading the references

1 and meeting with counsel, ultimately, I consider
2 preparation for this deposition. I can't separate
3 out work that I did prior to beginning to prepare
4 for the deposition. I don't know where I would
5 draw that line.
6 Q When did you begin working on the -- the
7 '167 patent case?
8 A Well, I can give you an estimate of that.
9 Roughly. I signed the declaration that we just
10 mentioned September 27, 2024. Now, the -- when I
11 started working on writing that declaration and
12 doing the preparation and then writing the
13 declaration was, you know, several months before
14 that. I can't -- again, I can't give you an exact
15 date. Probably sometime in the winter of 2024. I
16 honestly don't recall if it was -- it would be
17 right around the beginning of 2024. It could have
18 been as late as March. I can't sit here and tell
19 you for sure that I didn't start working on it in
20 late 2023 actually. I can't recall for sure. So
21 that -- my best guess of when I started working on
22 the '167 case would have been early 2024, my
23 best -- that's my best guess.
24 Q And do you have the same answer if I
25 asked you when you started working on the case

1 involving the '134 patent?
2 A Yes.
3 Q Can you open Exhibit 1024, your
4 declaration concerning the '167 patent.
5 A Okay. Got it.
6 Q So I just want to make sure, on page 1,
7 this is concerning the '167 patent; right?
8 A Right.
9 Q Can you turn to paragraph 174. Let me
10 know when you're there, please. It is PDF page
11 91.
12 A Thank you. That's very helpful when you
13 cite the PDF. That makes it a little quicker to
14 find. Thank you. You did that most of the time
15 yesterday. And I appreciate if you -- that saves
16 time. But it's your time. So -- I'm at paragraph
17 174.
18 Q So here you begin paragraph 174, you
19 testify that polycrystalline magnesium oxide
20 barrier layers were well known; correct?
21 A Yes.
22 Q Then it continues onto the next page.
23 And I want to drop down halfway down to where it
24 says, "Further, one of skill knew polycrystalline
25 magnesium oxide was an available and useful

1 barrier layer, capable of achieving low barrier
2 heights and thus high TMRs." Correct?
3 A Correct.
4 Q All right. So it's your testimony that
5 in 2004, a person of ordinary skill in the art
6 would have had a reasonable expectation that the
7 TMR of a magnetic tunnel junction would change in
8 response to lowering the barrier height because it
9 was understood that TMR could change as a function
10 of barrier height, but that a POSA would not have
11 known whether TMR would increase or decrease in
12 response to lowering the barrier height. Is that
13 correct?
14 A That's correct.
15 Q And that -- is that your testimony as
16 regards a polycrystalline magnesium oxide barrier
17 layer as well?
18 A Yes.
19 Q Where in your testimony for your
20 declaration on the '167 patent do you cite any
21 teachings in the prior art that there was an
22 understanding that TMR would change as a function
23 of barrier height in a magnetic tunnel junction
24 that had a magnesium oxide barrier layer?
25 A First I point to Moodera. Well, for now,

1 I'll say one of two the -- there are two Moodera
2 papers in the set of exhibits. One of them -- at
3 least one of them mentioned the potential -- the
4 possibility that the magnetoresistance ratio could
5 depend on barrier height. And I pointed to that
6 yesterday. I understand this is a separate case.
7 If you like, I'm happy to go and try to identify
8 which of the two Moodera papers that was.
9 Q Yes.
10 A Okay. Then you will need to give me a
11 moment.
12 All right. Exhibit 1038. That's a paper
13 by Moodera and Kinder in the Journal of Applied
14 Physics, Volume 79, page 4724, 1996.
15 In this paper, page 4728, in the
16 right-hand column, the second full paragraph,
17 starting with the phrase, "The MR shows
18 surprisingly strong decrease." Farther down in
19 that paragraph, a little past the middle -- well,
20 let's start a little higher than that. I'll start
21 here on -- I think it is the twelfth line of that
22 paragraph, in the middle of that line. It starts,
23 "Many causes can contribute to the decrease in the
24 MR with bias. Among them, the bias dependence of
25 the barrier height, creation of magnons, density

1 of states effects in the FM, et cetera, may be
2 responsible for the decrease in delta R over R."
3 So this early paper, relatively early
4 paper in the field, from 1996, suggests to a
5 person -- a POSA that the delta R over R could
6 vary with barrier height. So that's -- that's one
7 thing that I point to that suggested to a POSA
8 that varying the barrier height could influence
9 the MR, magnetoresistance ratio.
10 Now, I'm trying to remember exactly how
11 your question was phrased. Maybe you could repeat
12 it so we can decide whether that's enough to stop
13 or whether I should continue in my explanation.
14 Q I'll come back in a second. Right now I
15 want to ask you about this page 4728.
16 A Okay.
17 Q So in your declaration on the '167
18 patent, where do you cite Moodera page 4728?
19 A Well, I searched through the declaration,
20 I don't -- well, hold on. Let me just check one
21 other thing. I don't see a specific reference in
22 that declaration to that particular page.
23 Q Can you open your declaration on the '134
24 patent, please. Do you have it open?
25 A I do.

1 Q Just to be sure it's the right file, on
2 page 1, it refers to the '134 patent; is that
3 right?
4 A Yes.
5 Q PDF page 1?
6 A Yes.
7 Q In this declaration on the '134 patent,
8 where do you cite Moodera Exhibit 1038, page 4728?
9 A I do not find a specific citation to that
10 page. But if you -- since you're -- there is
11 another Moodera paper. Since you're looking for
12 references. Give me a moment to review that
13 paper. I said the Moodera papers. And I picked
14 one of them. And I found that reference to
15 barrier height. Okay. I see you're interrupt --
16 you're -- well, I would like to look through the
17 other Moodera paper.
18 Q We'll get there. Right now, I just want
19 to ask questions about Exhibit 1038.
20 A Okay.
21 Q Just to be clear. In your declaration,
22 on the '134 patent, you cannot identify a citation
23 to Exhibit 1038, page 4728; is that right?
24 A I'm going to carefully double-check that.
25 I don't find a specific citation to that

1 page of that reference.
2 Q Can we go back to your declaration on the
3 '167 patent.
4 A Okay.
5 Q You need a way to keep these straight. I
6 think perhaps the best thing to do is when we talk
7 about the '167 patent, you close the file that is
8 the 14 -- '134 patent declaration. So can you
9 close that '134 patent declaration.
10 A Okay.
11 Q All right.
12 A I had a different way of doing it, but
13 I'll follow yours.
14 Q All right. So we'll get to the
15 declaration in a second.
16 In Moodera, Exhibit 1038, page 4728, that
17 you just pointed out --
18 A Right.
19 Q -- you point to Moodera's discussion that
20 TMR shows surprisingly strong decrease as the bias
21 increases; correct?
22 A That was -- yes, I see that.
23 Q So the relationship that Moodera is
24 describing here -- well, first -- strike that.
25 When the bias across an MTJ increases,

1 the effective barrier height decreases; is that
2 right?
3 A Exactly. As Moodera describes it, as the
4 effective barrier height decreases. Correct.
5 Q So the relationship that you pointed to
6 in Moodera is that as the effective barrier height
7 decreases, the TMR decreases; correct?
8 A That's what Moodera is talking about
9 here, yes.
10 Q Okay. So I'm going to ask again. Other
11 than Exhibit 1038, where in your testimony on the
12 '167 patent do you cite any teaching in the prior
13 art that there was an understanding that TMR would
14 change as a function of barrier height in a
15 magnetic tunnel junction with a magnesium oxide
16 barrier layer?
17 A My testimony -- there's a reference in
18 this case by Butler. And that is Exhibit 1044.
19 Butler is a complex paper, theoretical analysis of
20 magnetic tunnel junctions with magnesium oxide
21 barriers. It's my opinion that a person of
22 ordinary skill in the art reading Butler would
23 have a good reason to expect that the barrier --
24 sorry. That the magnet -- the MT -- the TMR, the
25 tunneling magnetoresistance or the MR --

1 throughout the body of literature that I've
2 studied in connection with this case, some
3 researchers use the term MR, magnetoresistance,
4 magnetoresistance ratio. Some researchers use the
5 term TMR for tunneling magnetoresistance ratio.
6 Most of the time those refer to the same thing.
7 Any time there is a magnetic tunnel barrier, some
8 researchers use TMR, others use MR to refer to the
9 same quantity. So I'll try to be consistent. But
10 since the different references use those different
11 terms, I just wanted to state at the outset to try
12 to clarify. MR can mean something different if
13 there is no tunnel barrier. So if we -- if we
14 start discussing another reference which doesn't
15 have a tunnel barrier but does discuss MR, I'll
16 try to clarify.
17 Okay. That said, it's my opinion that a
18 person of ordinary skill, a POSA reading Butler
19 would have a reasonable expectation that varying
20 the barrier height in a specific way, different
21 than the way that barrier height is being varied
22 in Moodera, would have a reasonable expectation
23 that the TMR would change.
24 Q So have you finished your answer?
25 A That's -- yeah. That's as far as I will

1 go. I will wait for your follow-ups. I could go
2 further. But in interest of keeping on track,
3 I'll stop there and see if you have a follow-up.
4 Q First, Butler Exhibit 1044 concerns pure
5 crystalline magnesium oxide as a barrier; correct?
6 ATTORNEY WILSON: Objection. Form.
7 THE WITNESS: Well, that's not precisely
8 correct.
9 BY ATTORNEY WICHMAN:
10 Q Tell me what is wrong with this statement
11 that Butler conducted a first principles
12 calculation of tunneling conductance and
13 magnetoconductance of epitaxial iron 100,
14 magnesium oxide 100, and iron 100 sandwiches.
15 A I think that's a different question than
16 the first question that you asked and the one that
17 I answered that it wasn't precisely correct. So
18 Butler on -- on page -- I guess it's page 2, on --
19 in the left-hand column, near the bottom, let's
20 look at the -- starting at the last paragraph on
21 the bottom there.
22 "Our interest is centered on a slightly
23 different structure, that of only a few MgO atomic
24 layers deposited onto an iron substrate followed
25 by deposition of a relatively thick iron top

1 electrode. Experimentally, seven atomic layers of
2 MgO can be grown pseudomorphically on iron (100).
3 For thicker MgO layers misfit form to partially
4 relieve the 3.5 percent compressive in-plane
5 strain that arises due to the larger MgO lattice
6 constant."
7 So that's referring to an MgO layer
8 that's not strictly single crystal. Now, if you
9 want to ask about the calculations that he does,
10 we can -- we can go into that. But the paper does
11 not exclusively center on single crystal MgO.
12 Q Dr. Bokor, the language that you just
13 read in Butler Exhibit 1044, at page 2, is
14 referring to previous studies; correct? You might
15 want to look at the next sentence where you
16 stopped reading.
17 A Yeah. It's referring to previous
18 studies.
19 Q And then in the next paragraph, first
20 full paragraph, right-hand column, page 2,
21 Exhibit 1044, Butler explains that he is
22 performing a series of full potential LSDA-DFT
23 calculations in which the sandwich structure was
24 modeled by a 15 atom/supercell with five (100)
25 iron layers alternating with five (100) magnesium

1 oxide layers; correct?
2 A Correct.
3 Q And 100 magnesium oxide layers are
4 crystalline; correct?
5 A I believe so.
6 Q And DFT, that's a density functional
7 theory even calculation?
8 A That's right.
9 Q Okay. So Butler's model concerns
10 crystalline magnesium oxide; correct?
11 A Correct.
12 Q And Butler does not attempt to calculate
13 anything involving polycrystalline magnesium
14 oxide, does he?
15 A I don't think so.
16 Q And Butler, Exhibit 1044, does not
17 provide any prediction of how TMR will change with
18 a change in barrier height of the magnesium oxide
19 layer, does he?
20 A He does not explicitly -- he doesn't
21 explicitly calculate that.
22 Q And, in fact, the one prediction that he
23 does make about the relationship between TMR and
24 the magnesium oxide barrier layer is that a large
25 magnetoresistance increases with the magnesium

1 oxide bare thickness; correct?
2 A Can you point me to the location of that
3 sentence or teaching?
4 Q So -- so please look at Exhibit 1044,
5 page 1, the abstract. The last sentence of the
6 abstract.
7 A I see that.
8 Q "We predict a large magnetoresistance
9 that increases with barrier thickness." Correct?
10 A Correct.
11 Q So Butler's prediction, based on his
12 theoretical analysis, is that increasing the
13 thickness, the crystalline magnesium oxide barrier
14 layer will increase TMR; correct?
15 A Okay. I would like -- you pointed to a
16 statement or a sentence in the abstract. And I
17 would like to refer to the part of the paper which
18 is being abstracted there for further detail
19 before answering.
20 Okay. Thank you for the moment there.
21 Let's just have you repeat the question.
22 Q Butler's prediction based on his
23 theoretical analysis is that increasing the
24 crystalline magnesium oxide barrier layer
25 thickness will increase the device TMR; correct?

1 A Correct. He goes into some considerable
2 detail to amplify on that finding, which is --
3 those details are what help a POSA to understand
4 the conclusion that I mentioned about barrier
5 height.
6 Q So point me to where in Butler's paper he
7 discusses the effect of a change in barrier height
8 TMR.
9 A All right. There's several places. So
10 I'll -- I'll go through them one by one. First,
11 on page 1, near the bottom of the first column, a
12 few lines up from the bottom. Actually, let me
13 start with the whole paragraph. The whole
14 paragraph is relevant here.
15 So I'm talking about the paragraph, at
16 the bottom of the right column on page 1, starting
17 with "Because of the different character of the
18 states going on." Let me read that again.
19 "Because of the different character of
20 the states at the Fermi energy in the majority and
21 minority channels, the dominant tunneling
22 mechanisms are quite different. In the majority
23 channel, the conductance is primarily via Bloch
24 electrons with small transverse momentum. One
25 particular state with delta 1 symmetry is able to

1 effectively couple from the iron into the MgO and
2 also out of the MgO into the iron electrode on the
3 other side. In the minority channel the
4 conductance is primarily through interface
5 resonance state, especially for thinner layers.
6 As the barrier becomes thicker, the majority
7 channel conductance for parallel moment alignment
8 dominants the conductance because of the slow
9 decay of the delta 1 state in the MgO. This leads
10 to a large magnetoresistance that increases with
11 barrier thickness."
12 Now, I have other segments that I want to
13 go through. So I'll -- I'll stop here and point
14 to where I believe a person of ordinary skill in
15 the art reading that paragraph would have a
16 reasonable expectation that varying the barrier
17 height would vary the TMR.
18 Notice the sentence "in the minority
19 channel, the conductance is primarily through
20 interface resonance states, especially for thinner
21 layers." To a person of ordinary skill in the
22 art, that communicates that these -- when there's
23 resonance states, they're likely to be relatively
24 narrowly distributed in energy. That's what the
25 word resonance generally conveys to a person of

1 ordinary skill in the art. So what a POSA would
2 understand in reading this is if the energy with
3 which the electrons are enter -- if the spins are
4 entering the MgO, the minority channel conductance
5 would very likely vary significantly with energy
6 because they would be interacting differently with
7 those narrow -- with those -- I don't want to
8 editorialize -- with those interface resonance
9 states. So a person of ordinary skill in the art
10 looking at this would easily go the next step and
11 understand that if the location of the Fermi level
12 for the metal, for the iron, ferromagnet were to
13 be in a different position relative to the MgO
14 band structure, the minority channel conductance
15 is likely to vary much more strongly than the
16 majority channel.
17 That's pretty -- I think that is pretty
18 strong evidence right there for my opinion. But
19 there's more statements that support this within
20 the reference. I'm happy to continue.
21 Q Well, let me ask you about this first.
22 Where is it your testimony that the particular
23 state with delta 1 symmetry, that is effect --
24 able to effectively couple from iron into the
25 magnesium oxide and also out of the magnesium

1 oxide into the iron electrode on the other side
2 determines antiparallel resistance?
3 A No. That's the parallel resistance.
4 Q So it is your testimony that this
5 coupling is a function of symmetry explains
6 parallel resistance in an MTJ with crystalline --
7 iron crystalline magnesium oxide and crystalline
8 iron; is that right?
9 A I would say it this way: The -- it's the
10 state with delta 1 symmetry which dominates the
11 parallel resistance. And I should have read the
12 rest of that paragraph because it related to your
13 question about the thickness. As -- so this is
14 amplifying on my answer to your previous question
15 about barrier thickness and how the person of
16 ordinary skill would go from there to
17 understanding dependence on barrier height.
18 In this -- so I think I have answered
19 your first question. But I want to -- I want to
20 add, as the barrier -- near the bottom of this
21 paragraph on page 1, as the barrier becomes
22 thicker, the majority channel conductance for
23 parallel moment alignment dominates the
24 conductance because of the slow decay of the
25 delta 1 state in MgO. This leads to a large

1 magnetoresistance that increases with barrier
2 thickness.
3 So what Butler is saying here is that
4 there is this wide -- this relatively wide-open
5 channel for the majority spins because of the
6 delta 1 state. So that gives a boost to the
7 majority spin conductance. But the minority spin
8 conductance doesn't get that benefit. And, in
9 fact, its conductance is primarily through
10 interface resonance states that will decay much
11 more quickly with thickness. That's the reason
12 for the increase of TMR with thickness. And I
13 hope I've also answered the second question you
14 asked about this delta 1 symmetry.
15 Q What's the relationship between delta 1
16 symmetry and barrier height in crystalline
17 magnesium oxide?
18 A There isn't a direct relationship between
19 delta 1 symmetry and barrier height. The way that
20 I would explain this is that as the barrier height
21 varies, the energy, as I've said already before,
22 the energy with which the electrons from the iron
23 enter into the band -- the band structure of the
24 MgO, as the barrier height changes, not the way
25 that Moodera talks about, the effective barrier

1 height, but when the barrier height as discussed,
2 for example, in Simmons -- we can go back and
3 revisit that. We talked about it yesterday. The
4 barrier height that is the energy difference
5 between the Fermi level in the iron ferromagnetic
6 electrode and the bottom of the conduction band of
7 the MgO, that's the barrier height that I'm
8 talking about. And a person of ordinary skill in
9 the art understanding that very well, that that is
10 the barrier height. As the barrier height varies,
11 the energy at which the electrons enter the MgO is
12 varying relative to the band structure of the MgO.
13 Now, elsewhere we can find support for my
14 claim that the state with delta 1 symmetry is
15 broad, extends broadly through the MgO gap. So as
16 the barrier height changes, the majority channel
17 conductance, particularly how that is influenced
18 by the state with delta 1 symmetry, will not vary
19 significantly. Certainly not as significantly as
20 the minority channel conductance. Those states
21 are -- are -- have different symmetry and
22 different energy dependence. So that's how the
23 delta 1 symmetry comes into play with regard to
24 the dependence of the conductance with barrier
25 height.

1 Q Dr. Bokor, how does the barrier height of
2 a crystalline magnesium oxide barrier layer affect
3 symmetry of the delta 1 bands in the crystalline
4 iron electrode -- ferromagnetic electrode on
5 either side of the magnesium oxide insulator?
6 A The barrier height does not affect the
7 intrinsic band structure of the MgO and it doesn't
8 affect the delta 1 symmetry. That's a property of
9 the MgO and not related directly to what is
10 happening at the interface between the MgO and the
11 ferromagnet electrode on the left.
12 Q Butler says that one particular state
13 with delta 1 symmetry is able to effectively
14 couple from the iron into the magnesium oxide and
15 out of the magnesium oxide into the other iron
16 electrode; right?
17 A Right.
18 Q How does changing the barrier height
19 alter the delta 1 symmetry?
20 ATTORNEY WILSON: Objection. Form.
21 THE WITNESS: It doesn't affect the
22 delta 1 symmetry of the band in the MgO. It
23 affects the energy of the state with delta 1
24 symmetry that plays the role in the majority
25 channel conductance.

1 BY ATTORNEY WICHMAN:
2 Q It's your testimony that a person of
3 ordinary skill in the art would not have known and
4 not have been able to calculate from Butler how a
5 change in magnesium oxide barrier height would
6 affect the TMR; is that right?
7 A That's right. In this -- in this portion
8 of the paper we're talking about -- and there are
9 others -- but nowhere in there is there enough
10 information for a person of ordinary skill to
11 calculate exactly how the minority channel
12 conductance will vary with energy. I think the
13 theory is there in this paper. But Butler didn't
14 calculate it and present any data. And it takes a
15 very sophisticated theoretical physicist to be
16 able to implement the model that Butler has done
17 in his paper. It could be done. The paper has to
18 disclose all the details of how the calculations
19 were done. But to reproduce Butler's
20 calculations, that would not be within the
21 capability of a person of ordinary skill in the
22 art as we have defined it. So that person
23 wouldn't be able to predict which way the TMR
24 would go with barrier height.
25 But this -- this section right here,

1 particular -- I think is particularly germane to
2 the issue, does communicate to a person of
3 ordinary skill in the art that as the barrier
4 height varies, the energy will vary, the energy
5 with which the minority channel electrons interact
6 with the MgO will vary, and will very likely
7 change since they are interface resonance states.
8 Q So it is your testimony that a person of
9 ordinary skill in the art reading Butler would
10 have had reason to believe that reducing the
11 barrier height in Bowen's magnesium oxide barrier
12 could have decreased TMR; is that right?
13 A It could have.
14 Q And what likelihood would a POSA have
15 given to that outcome?
16 A There's no -- there's no basis for a
17 person to be able to estimate that. So since --
18 at least from my perspective and what I would
19 expect from a person of ordinary skill in the art,
20 they wouldn't be able to determine whether it
21 would go up or down. So in a very rough sense,
22 the likelihood that it would go up or down is
23 equal. So 50 percent chance for either -- well,
24 actually I should -- I should modify that. No.
25 I'll stick with that. Either up or down -- very

1 likely to go either up or down. And about 50/50.
2 Q Would a person of ordinary skill in the
3 art in 2004 have had reason to believe based on
4 Butler that reducing the barrier height in Bowen's
5 magnesium oxide barrier layer would have left the
6 TMR unchanged?
7 A I guess -- let me put it this way: For a
8 given -- there could be -- I think a person of
9 ordinary skill trying to determine or guess --
10 using Butler to try to -- to try to estimate how
11 the TMR would vary with barrier height, I think
12 that the person of ordinary skill in the art would
13 expect the barrier height -- sorry -- the TMR to
14 vary with barrier height fairly strongly. Could
15 be up, could go -- could be down. Could go
16 through zero. So there is at least some
17 possibility that for two -- two specific barrier
18 heights, you could get the same TMR. It seems
19 rather unlikely in the general case.
20 So if you think of a plot -- we've seen
21 plots of TMR as a function of various parameters.
22 As the TMR varies, it might well -- there might
23 well be a location in that curve where the plot is
24 sort of, you know, at a minimum. And so for small
25 changes in barrier height, the change in TMR could

1 be very small. But in my opinion, this sentence
2 right here, talking about interface resonance
3 states, suggests to a person of ordinary skill
4 that in the general case, if you vary the barrier
5 height, you're going to see the TMR change. There
6 might be -- okay. I think -- I don't want to
7 repeat myself. So if you vary the T- -- if you
8 vary the barrier height enough, you're -- you're
9 very likely to see a TMR change. It could be for
10 small changes in barrier height. That particular
11 barrier height to change would be weak or maybe
12 even zero for a narrow range. That's what I
13 believe a person of ordinary skill in the art
14 would be most likely to expect from reading that
15 section in Butler, and others.
16 Q Dr. Bokor, if -- in 2004, if a POSA
17 considered varying the barrier height in Bowen's
18 magnesium oxide layer between a value of 0.10
19 electron volts and 0.90 electron volts, is there a
20 value of barrier height at which the POSA would
21 have expected the TMR to be zero?
22 A I can't predict that. I don't have the
23 answer to that question. I -- I think it's --
24 back up. I think a POSA reading Butler and
25 considering Bowen's structure, based on this

1 section of Butler and others, a POSA would
2 expect -- would not expect there to be a barrier
3 height where the TMR goes to zero, except maybe as
4 we discussed yesterday very low barrier height,
5 you know, down around 10 millivolts. There
6 probably is a zero TMR there. But as the energy
7 increases well above room temperature -- and, you
8 know, we talked yesterday about trying to quantify
9 where that -- where that boundary would be. I
10 would find that hard. But for sufficient -- you
11 know, for more than .1, I think, as the barrier
12 height would vary from .1 to .9, it seems to me a
13 POSA reading Butler would find it very unlikely
14 that the TMR would go to zero at some barrier
15 height within that range.
16 Q Dr. Bokor, is there a single publication
17 that you can identify that articulates this theory
18 or this understanding of Butler that based on this
19 paragraph you identify in Exhibit 1044, page 1,
20 bottom paragraph on the right-hand column, TMR
21 would be expected -- TMR in a magnesium oxide
22 crystalline barrier layer would be expected to
23 vary with barrier height?
24 A I haven't found a publication that
25 explicitly discusses that.

1 Q And you don't cite any publication
2 discussing that proposition in your declaration on
3 the '167 patent?
4 A Other than Butler.
5 Q I'm asking about a publication that
6 discusses the proposition that you have -- let me
7 strike that.
8 I'm talking about a paper that elaborates
9 and explains the relationship between TMR and
10 barrier height based on this statement in Butler
11 on the last paragraph, right column, page 1 of
12 Exhibit 1044.
13 A I -- as I -- as I just said, I think, I
14 can't point to a publication that writes out that
15 particular interpretation.
16 Q And you -- and you did not cite a
17 publication that writes out that interpretation in
18 your declaration on the '167 patent; right?
19 A I can't think of one. I didn't cite one.
20 So no, I did not cite one.
21 Q And you did not cite such a publication
22 in your declaration on the '134 patent, did you?
23 A No.
24 Q Two more things that I would like to
25 think about. Well, a couple more things.

1 ATTORNEY WILSON: So we've been going for
2 almost an hour and ten minutes. Is this a good
3 time for a break?
4 THE WITNESS: Yeah.
5 ATTORNEY WICHMAN: Five minutes. Can
6 people last five minutes?
7 THE WITNESS: I can hold on five minutes.
8 BY ATTORNEY WICHMAN:
9 Q I had asked you where in your declaration
10 on the '167 patent you cite any teaching in the
11 prior art that there was an understanding that TMR
12 would change as a function of barrier height in
13 the magnetic tunnel junction with a magnesium
14 oxide layer; correct?
15 A Did you ask me that today?
16 Q Well -- all right. Let me ask you now.
17 Other -- you -- where in your declaration do you
18 cite Butler for the proposition that a POSA would
19 have understood that TMR would change as a
20 function of barrier height in a magnetic tunnel
21 junction device with a magnesium oxide barrier
22 layer?
23 A And we're in the '167 declaration;
24 correct?
25 Q Correct.

1 A '134 is closed. So --
2 Okay. Well, let's see.
3 Okay. The part of my declaration where
4 this is -- where this is addressed is in
5 paragraph -- most -- most directly is in paragraph
6 68.
7 Q Anywhere else?
8 A Well, there's other places where this is
9 discussed, yes.
10 Q Are the other places where this is
11 discussed any different than your testimony in
12 paragraph 68?
13 A Not -- essentially they -- they are
14 saying the same thing. There's further support.
15 But the main -- the main point here is in
16 paragraph 68. That I think is the -- gives the
17 best indication of how a POSA would understand the
18 TMR to change with barrier height.
19 Q Paragraph 68 in your declaration, Exhibit
20 1024 on the '167 patent, does not even mention
21 barrier height, does it?
22 A Not explicitly.
23 Q You don't use the words barrier height,
24 do you?
25 A Not in this paragraph, not explicitly.

1 Q And you don't assert that a POSA would
2 have understood that TMR of a magnetic tunnel
3 junction with a magnesium oxide barrier change
4 with barrier height in paragraph 68 of your
5 declaration on the '167 patent, do you?
6 A It's my -- it's my testimony -- my
7 opinion that a POSA reading paragraph 68 would
8 readily come to an understanding. But it doesn't
9 say it explicitly in that paragraph.
10 Q Okay. I'm sorry. You says a POSA
11 reading paragraph 68 of your declaration?
12 A Well, a POSA -- sorry. Paragraph 68
13 describes the information on which a POSA could
14 rely to readily come to an expectation that the
15 TMR would depend on barrier height. It does not
16 explicitly draw that -- I haven't written that
17 explicitly in paragraph 68. But it's the basis on
18 which my opinion is that a change in TMR with
19 barrier height is obvious.
20 Q I'm sorry. Dr. Bokor, if you meant to
21 testify that a POSA would have believed based on
22 Butler that the TMR of the magnesium oxide barrier
23 layer of -- I'm sorry. Strike that.
24 If you meant to testify that in 2004, a
25 POSA would have had reason to believe that the TMR

1 of a magnetic tunnel junction with a crystal
2 magnesium oxide barrier layer would have changed
3 if the barrier height of that magnesium oxide
4 barrier layer were changed, why didn't you just
5 say that?
6 ATTORNEY WILSON: Objection. Form.
7 THE WITNESS: I can't answer that
8 question.
9 BY ATTORNEY WICHMAN:
10 Q Why not?
11 A I don't know the -- I don't know why I
12 put that in there. That's a good question. I
13 wish I had now. It didn't occur to me when I --
14 when I wrote this.
15 Q So in other words, that's not the
16 information that you were intending to convey in
17 paragraph 68 of your testimony?
18 A I wouldn't -- I'm not going to agree to
19 that.
20 Q Uh-huh.
21 A I just didn't explicitly write it out.
22 ATTORNEY WICHMAN: Okay. Counsel for
23 Western Digital has asked for a break. Why don't
24 we come back at half past the hour.
25 THE WITNESS: Okay.

1 ATTORNEY WICHMAN: Off the record.
2 (A recess was taken.)
3 ATTORNEY WICHMAN: On the record.
4 BY ATTORNEY WICHMAN:
5 Q Dr. Bokor, before the break, we are
6 discussing your declaration on the '167 patent.
7 Now I want to discuss your declaration on the '134
8 patent. Tell me when you have that open.
9 A I'm closing the '167. And where did it
10 go? We're looking for '134; right?
11 Q The declaration. Yes, do you have the
12 declaration on the '134 patent?
13 A I have it.
14 Q Tell me where in your declaration you
15 discuss this idea that Butler teaches or would
16 have taught to a person of ordinary skill in the
17 art that changing the barrier height of magnesium
18 oxide in a magnesium magnetic tunnel junction
19 would have altered TMR.
20 ATTORNEY WILSON: Objection. Relevance.
21 THE WITNESS: It's -- the same basic
22 explanation is in paragraph 68 of the '134
23 declaration. Regarding the thin MgO barrier
24 passing delta 1 electrons while largely blocking
25 other electrons having opposite spin, leading the

1 way to high TMRs.
2 BY ATTORNEY WICHMAN:
3 Q Okay. Sorry. Go ahead. Finish your
4 answer.
5 A Basically the same text that is in the
6 '167 declaration.
7 Q You could close this and open the
8 declaration on the '167 patent again. Just let me
9 know when it is open.
10 A Okay. I'm back on the '167 declaration.
11 Q Okay. In your declaration on the '167
12 patent, do you cite anything other than you say
13 Butler for the proposition that in 2004, a POSA
14 would have had reason to expect that a change in
15 the mag- -- in the barrier height of Bowen's
16 magnesium oxide barrier layer would have resulted
17 in a change in TMR?
18 A Well, I would just -- in answer to that,
19 I would simply point out that in the paragraph
20 that we've been discussing, for, I don't know, the
21 last hour or so, paragraph 68 actually refers not
22 exclusively to Butler, but it also refers to
23 Mathon and Klaua. It briefly references the Dieny
24 textbook. But I will leave that out since it is
25 not prior art. The proposition that you asked

1 about is disclosed in -- to a person of ordinary
2 skill in the art looking at Butler, Mathon, and
3 Klaua, as described in paragraph 68. That's my
4 basis.
5 Q Paragraph 68 does not say that reducing a
6 magnesium oxide tunnel barrier height would change
7 TMR at all, does it? Those words are not in your
8 paragraph 68, are they?
9 A Those words are not in there.
10 Q Tell me what is in Klaua Exhibit 1045 at
11 page 1 that teaches that a change in the barrier
12 height of a magnesium oxide barrier layer would
13 increase the TMR of an MTJ that used such a
14 barrier layer.
15 A Okay, well I reviewed this paper
16 relatively carefully, just to be sure. What --
17 what -- what bearing it has on the question. And
18 the quote in my declaration, paragraph 68 about
19 the tunneling resistance for the parallel
20 orientation is estimated to be a hundred times
21 smaller than the antiparallel orientation of the
22 magnetic moments due to the absence of scattering
23 in the barrier. That -- that simply supports the
24 analysis that we've been talking about, about --
25 this comes from -- this is consistent with Butler,

1 when he said it is estimated, that is referring
2 basically to Butler. That's where Klaua supports
3 this discussion, this proposition. That a person
4 of ordinary skill, based on what is taught in
5 Butler, supported by Klaua, would expect the TMR
6 to vary with barrier height.
7 Q Dr. Bokor, you agree that there's a
8 difference between a statement that high TMR can
9 be achieved in crystalline magnesium oxide
10 barriers because of differences in tunneling
11 resistance for parallel and antiparallel electrons
12 and a statement that changing barrier height will
13 change TMR?
14 A Those narrow statements are different.
15 Q And the language that you have quoted
16 here in paragraph 68 of your declaration on the
17 '167 patent, from Exhibit 1045 (Klaua) at page 1 a
18 statement about tunneling resistance in a
19 crystalline magnesium oxide barrier purely
20 based -- based on the orientation of the
21 electrons; right?
22 A The statement here just talks about the
23 orientation. I keep emphasizing that a POSA,
24 based on that teaching, would readily come to the
25 understanding about how that would vary with

1 barrier height. It's not explicitly stated in
2 this paragraph. It's not explicitly stated in
3 Klaua. It is my opinion that it is obvious to a
4 person of ordinary skill.
5 Q It is not actually stated at all in this
6 paragraph, is it?
7 A Not -- the -- dependence on barrier
8 height. It -- as we've -- as we've discussed
9 already several times, it's not explicitly stated
10 there. It's -- it's understood.
11 Q Did you write this declaration as
12 testimony to be provided to a person of ordinary
13 skill in the art?
14 ATTORNEY WILSON: Objection. Form.
15 THE WITNESS: The declaration is written
16 to give my opinion of what a person of ordinary
17 skill in the art would understand.
18 BY ATTORNEY WICHMAN:
19 Q And in paragraph 68 of your declaration,
20 you do not state that a person of ordinary skill
21 in the art would understand from Butler or Klaua
22 or Mathon that reducing the barrier height of a
23 crystalline magnesium oxide barrier layer would
24 change the TMR of a magnetic tunnel device
25 junction that used that mag- -- that magnesium

1 oxide barrier layer, do you?
2 A This paragraph does not explicitly state
3 the barrier height dependence.
4 Q In Exhibit 1046, page 1, please open that
5 and tell me when it's -- when you have it in front
6 of you.
7 A I have it.
8 Q You quote -- on page 1, you quote the
9 abstract of this Exhibit 1046, Mathon, where he
10 writes, "The calculated optimistic TMR ratio is in
11 excess of 1000 percent for a magnesium oxide
12 barrier of approximately 20 atomic planes and the
13 spin polarization of the tunneling current is
14 positive for all magnesium oxide thicknesses."
15 Correct?
16 A Correct.
17 Q And that is not a statement that reducing
18 the barrier height of a magnesium oxide barrier
19 would increase the TMR in this device that he is
20 describing, is it?
21 A Not explicitly.
22 Q And then you quote this Exhibit 1046,
23 page 1, to support the proposition that their
24 research established that a thin magnesium oxide
25 barrier passed delta 1 electrons while largely

1 blocking other electrons having opposition spin,
2 leading the way to high TMRs; correct?
3 A That's what the declaration says.
4 Q So that statement is about the mechanism
5 that Butler has hypothesized for why there's a
6 greater -- why high TMR can be observed in
7 crystalline magnesium oxide; correct?
8 A Correct.
9 Q And that is not a statement that a --
10 changing the barrier height of a crystalline
11 magnesium oxide barrier layer in a magnetic tunnel
12 junction would be expected to change the TMR, is
13 it?
14 A That's fair.
15 Q Okay. Is there anything else that you
16 cite in this declaration on the '167 patent for
17 the proposition that changing barrier height of a
18 magnesium oxide barrier level would be -- would
19 have been expected to change the TMR of the
20 magnetic tunnel junction that used that magnesium
21 oxide barrier layer?
22 A All right. So in my declaration, I don't
23 cite any other. However, since you brought up
24 Mathon -- you had asked me about Klaua. If
25 anywhere else in Klaua supports the opinion that I

1 was giving about Butler and about how the
2 dependence of the TMR varies on energy. You
3 didn't ask me that about Mathon. But I have taken
4 the opportunity to review Mathon. There's
5 additional support in Mathon to suggest to a
6 person of ordinary skill in the art that the TMR
7 ratio could vary significantly with energy.
8 Q And where is this cited in your
9 declaration?
10 A It's not cited in my declaration. I cite
11 to Mathon to support the statement that is in my
12 declaration. I could point to a cite -- I could
13 point to a -- an excerpt from Mathon that provides
14 further support. But it is not in my declaration.
15 Q Tell me where this is in Mathon, please.
16 A If you go to Mathon, page 4, the last
17 page. And you look on the left-hand column near
18 the bottom. Sixth line from the bottom starting
19 with "Our results."
20 "Our results show that when the on-site
21 potentials of one of the iron electrodes are
22 shifted slightly away from their nominal values,
23 the TMR ratio can be altered very significantly in
24 the preasymptotic regime."
25 Q Explain what that means, please.

1 A That's a -- again, is a suggestion that
2 for energies shifted away from the -- from the
3 nominal values of the calculation, the TMR ratio
4 can be altered very significantly. When the
5 on-site potentials of one of the iron electrodes
6 are shifted slightly away from their nominal
7 values, that provides additional support for my
8 proposition that a -- that shifting the energy at
9 which the electrons are tunneling through the MgO
10 would have a significant effect on TMR. Because
11 that -- that statement in Mathon makes the
12 suggestion -- the exclusive suggestion of the
13 energy dependence that I hadn't noticed before
14 just now. But I'm pointing that as additional
15 support for my overall opinion that I've been
16 expressing today and yesterday.
17 Q So, Dr. Bokor, you've been working on
18 this case since winter of last year. And this is
19 the first time that you've come up with this
20 opinion that this passage in Mathon, Exhibit 1046,
21 page 4, bottom left column, is evidence that a
22 person of ordinary skill in the art in 2004 would
23 have had reason to believe that changing the
24 barrier height of a magnesium oxide barrier layer
25 would alter TMR. Is that right?

1 A Correct.
2 Q In which direction would the TMR be
3 altered, based on this passage in Mathon?
4 A It just says very significantly. I --
5 I -- I would need more time to see if I could
6 figure out which direction.
7 Q In two sentences after -- sorry. Go
8 ahead.
9 A Go ahead.
10 Q Two sentences after the -- what you just
11 read, Mathon writes, "We therefore conclude that
12 the optimum magnesium oxide thickness for
13 observation of large TMR ratio is around ten
14 atomic planes of magnesium oxide." Right?
15 A It does say that.
16 Q It does not say, any -- there's no
17 conclusion offered about what the optimum barrier
18 height is for maximizing TMR, does it?
19 A No, it doesn't.
20 Q So Mathon didn't seem to think that a
21 relationship between barrier height and TMR was
22 important in maximizing TMR, did he?
23 A He didn't think to mention it or to
24 calculate it. That's true. That seems to be
25 true.

1 Q Okay. I think my question was, is there
2 anywhere else in your declaration where you offer
3 testimony or -- strike that.
4 Is there anything else that you cite in
5 your declaration to support the proposition that a
6 POSA would have had reason to expect that changing
7 the magnesium oxide barrier height would have
8 altered the TMR of a MTJ?
9 A I did answer that question. I can't
10 find -- I can't point to anything else in my
11 declaration.
12 Q Okay. Maybe we should move on to
13 something else.
14 A Fine with me.
15 Q Okay. Do you -- do you have your
16 declaration on the '167 patent open?
17 A Yeah. That's what I have open.
18 Q All right. If you could go to paragraph
19 70, please. PDF 45.
20 A I'm on it.
21 Q Okay. So here you say that you're
22 talking about polycrystalline magnesium oxide
23 barrier layers; right?
24 A Generally, yes.
25 Q Okay. In the fourth sentence of

1 paragraph 70, you write or you testify that the
2 structure of polycrystalline magnesium oxide made
3 it well suited to deposition on a variety of
4 substances, including amorphous layers. Is that
5 right?
6 A The word was surfaces, not substances.
7 Q Surfaces. So the structure of
8 polycrystalline magnesium oxide made it well
9 suited to deposition on a variety of surfaces,
10 including amorphous layers; is that right?
11 A That's right.
12 Q And you cite Exhibit 1036, a paper by
13 Wulff, page 148, for the proposition that
14 magnesium oxide grows the strong preferential
15 100 orientation regardless of the substrate
16 selection; correct?
17 A That's the quote from Wulff.
18 Q Okay. And so you say that that quote
19 from Wulff supports the proposition that you can
20 grow magnesium oxide on an amorphous substrate; is
21 that right?
22 A You can grow highly well-oriented MgO
23 polycrystalline films on an amorphous substrate.
24 Q Okay. Can you open Exhibit 1036. Just
25 let me know when you have it open.

1 A Okay. I have it.
2 Q If you could go to page 150, that should
3 be PDF page 3.
4 A Okay.
5 Q In the left-hand column, do you see a
6 header entitled experimental results and
7 discussion?
8 A I do.
9 Q Okay. So here Wulff is describing
10 growing three magnesium oxide film thicknesses on
11 flat float glass and different alumina substrates;
12 right?
13 A Right.
14 Q And the three thicknesses, he describes
15 them as .1, .5, and 1 micron; right?
16 A Right.
17 Q And .1 micron, that's 100 nanometers?
18 A Right.
19 Q .5 is 500 nanometers?
20 A Right.
21 Q One micron is 1,000 nanometers?
22 A Right.
23 Q So Wulff doesn't have any results and did
24 not investigate how magnesium oxide films would
25 grow at a thickness of two nanometers, did he?

1 A I don't see any data, any discussion in
2 Wulff other than for those thicknesses.
3 Q What does the behavior of a hundred
4 nanometer thick magnesium oxide film tell you
5 about how a two nanometer thick magnesium oxide
6 film would form on an amorphous substrate?
7 A I think it offers a strong indication
8 that growing a thinner film would very likely grow
9 in a -- how the oriented polycrystalline form.
10 Q Why?
11 A It's just the way that crystal films
12 grow. It's -- it's -- if the -- if the initial
13 layers were not highly oriented, it would be
14 harder for the subsequent layers to become highly
15 oriented. And furthermore, as -- it's an
16 indication. It's -- it strongly suggests is my
17 opinion.
18 Q So it's your testimony that the
19 orientation that a magnesium oxide film achieves
20 at a thickness of a hundred nanometers is not
21 responsive to different physics in the orientation
22 that a magnesium oxide film achieves at a
23 thickness of two nanometers?
24 ATTORNEY WILSON: Objection. Form.
25 THE WITNESS: There's a connection there.

1 It's -- it's -- the physics -- the physics -- it's
2 possible for there to be an evolution of the
3 physics. I would have to concede that.
4 BY ATTORNEY WICHMAN:
5 Q If you had a magnesium oxide thin film at
6 two nanometers thick, how many atomic layers is
7 that -- would that work out to be?
8 A Two nanometers? I don't have -- I don't
9 recall right at the top of my head the lattice
10 parameter for MgO. Between one and two angstroms
11 probably. So 15 to 20 atomic layers, something
12 like that.
13 Q So let's just assume for discussion that
14 it is 20 atomic layers. Is it your testimony that
15 the orientation that a magnesium oxide film would
16 achieve growing on an amorphous substrate would be
17 no different if the thin film had a thickness of
18 20 atomic layers or a thickness of a thousand
19 atomic layers?
20 A Okay. So you're asking me a question
21 about thin film growth, which I did not address in
22 my declaration. And I haven't made a thorough
23 analysis of that question in preparation for this
24 deposition or in this case. And so I don't feel
25 comfortable giving an opinion about what the --

1 the details of the thin film growth from 20
2 nanometers to a hundred nanometers would be like.
3 I would just simply say that the data from Wulff
4 for hundred nanometer films strongly suggests that
5 a POSA could try to grow a thinner film to get a
6 similar orientation, similar crystal graphic
7 orientation.
8 Q So when you offered this testimony in
9 paragraph 70 of your declaration in the '167
10 patent, you did not consider the difference in the
11 magnesium oxide film thickness that Wulff was
12 describing and the magnesium oxide film thickness
13 that is relevant to the MTJs that you were
14 discussing in your declaration; is that right?
15 A With respect to Wulff, I simply say
16 that -- where were we? The structure of
17 polycrystalline made it well suited to deposition
18 on a variety of surfaces, including amorphous
19 layers. Wulff doesn't explicitly address 20
20 nanometer thickness. I didn't explicitly mention
21 that. As I say, I think it is suggestive. Other
22 references do find highly oriented MgO thin films.
23 And I cite those in the declaration. But with
24 respect to Wulff, I didn't -- I didn't
25 particularly try to -- I didn't -- I didn't

1 mention thinking about thickness when I cited to
2 Wulff. Let me just leave it at that.
3 Q In Wulff, could you turn to page 148.
4 That's the first page, PDF.
5 A Okay.
6 Q In the abstract, second sentence, "The
7 deposits were made in electron-beam evaporator at
8 substrate temperatures between 25 Celsius and 190
9 Celsius." Right?
10 A Right.
11 Q Would you use electron-beam evaporation
12 to make a commercial magnetic tunnel junction?
13 A Well, I'm not an expert in high volume
14 manufacturing. I haven't given an opinion on that
15 in my declaration. I'm hesitant to give an
16 opinion on that.
17 Q Would you use -- would a POSA have used
18 electron beam -- strike that.
19 Would a person of ordinary skill in the
20 art have used electron-beam evaporation to make a
21 magnetic tunnel junction?
22 A Would a -- would a person of ordinary
23 skill use electron beam evaporation to make a
24 magnetic tunnel junction?
25 Q Yes.

1 A I don't -- I don't have an answer to that
2 question without going back and reviewing all of
3 the literature. Because I don't remember exactly
4 which deposition method was made in each of the
5 references on magnetic tunnel junctions that I
6 cited in my declaration. I would need time to
7 look at that to answer that question.
8 Q Have you ever made a magnetic tunnel
9 junction using electron-beam evaporation?
10 A I'm not a hundred percent sure about
11 that. I would have to go back and look at some of
12 those papers that we were talking about yesterday
13 to confirm. I can't answer that question as I sit
14 here right now without doing additional --
15 additional study.
16 Q Does electron-beam evaporation require
17 specialized equipment?
18 A Certainly.
19 Q What equipment would you use to do
20 electron-beam evaporation?
21 A It's a machine called an electron-beam
22 evaporator. That's the name of the machine.
23 Q Have you used one to make a MTJ?
24 A That's what I'm saying I don't remember.
25 As we discussed -- so I haven't personally -- as

1 we discussed yesterday, I didn't personally make
2 the MTJs that I studied as part of my research.
3 They were made by other collaborators. I can say
4 that we do have an electron-beam evaporator in the
5 clean room at Berkeley. And there were MTJs made
6 in the clean room at Berkeley. What I can't tell
7 you, because I wasn't the one who hands-on made
8 those devices, what tool was used to deposit the
9 MgO. Not as I sit here right now. I could figure
10 that out. But I don't recall. I don't have that
11 information handy.
12 Q Can you make a magnet- -- strike that.
13 Would a magnetic tunnel junction that had a
14 magnesium oxide barrier layer with a thickness of
15 a hundred nanometers work?
16 A Define work.
17 Q Would you have a detectable tunneling
18 current through it?
19 A A hundred nanometers? It would be
20 extremely small.
21 Q Have you ever made magnetic tunnel
22 junction that had a barrier thickness of a hundred
23 nanometers?
24 A Well, with the caveat, as I just
25 testified, that I didn't make them myself. But I

1 can say from -- I can say with confidence that any
2 of the studies that I participated in of magnetic
3 tunnel junctions have barriers thinner than a
4 hundred nanometers.
5 Q The barrier thickness for a magnetic
6 tunnel junction is on the order of one to ten
7 nanometers; is that right?
8 A That is correct.
9 Q And that's because the probability of
10 tunneling decreases -- through the barrier layer
11 decreases exponentially with the thickness of the
12 barrier layer; is that right?
13 A That's one of the reasons.
14 Q Tell me another reason.
15 A Well, you want high current. So
16 there's -- there's -- the total current that you
17 get plus the TMR, plus the ratio between the
18 parallel/antiparallel tunneling. Both of those
19 are thickness dependent.
20 Q In your declaration, paragraph 70,
21 concerning the '167 patent, you also cite
22 Exhibit 1040 (Yoon) for the proposition that the
23 structure of polycrystalline magnesium oxide made
24 it well suited to deposition on a variety of
25 surfaces, including amorphous layers; right?

1 A Right.
2 Q Can you open 1040.
3 A All right. I have it.
4 Q Go to page 2840. It should be PDF 2.
5 A Yes.
6 Q This is the page that you cite in your
7 declaration, paragraph 70. So tell me what it is
8 on this page that you're relying on to support
9 your testimony in paragraph 70.
10 A So I'm referring to several things.
11 First of all, Figure 1. Figure 1 shows X-ray
12 diffraction pattern of MgO thin films on Silicon
13 (111), Silicon (100), Gallium Arsenide (100), and
14 fused quartz substrates. These X-ray diffraction
15 patterns show a strong peak identified as 20 --
16 200, which is evidence for highly orient -- highly
17 100 oriented MgO films.
18 There's text at the bottom of the
19 right-hand column in the first line, it starts --
20 the first sentence on that line, "These results
21 suggest that the texturing of vapor deposited MgO
22 films is a nucleation-controlled process. Recent
23 study on in-plane textured (100) MgO films, which
24 were deposited on amorphous silicon nitride
25 substrates by ion beam assisted deposition, also

1 showed that the texturing process for MgO is a
2 nucleation process."
3 A person of ordinary skill reading that
4 would understand that highly textured (100) films
5 would also grow on silicon nitride.
6 Q Is there anything else on this page that
7 you're relying upon?
8 A That's the key -- that's the key
9 information that I'm referring to.
10 Q Dr. Bokor, have you seen this paper
11 before today?
12 A Of course.
13 Q When was the last time that you saw this
14 Exhibit 1040?
15 A Honestly, I can't remember precisely. It
16 was in -- it was within recent weeks.
17 Q So you just stated that you are relying
18 on this last sentence in the right column on
19 page 2840 which refers to a different study that
20 deposited magnesium oxide films on amorphous
21 silicon nitride; correct?
22 A You asked me what -- what was in this
23 paper that supported the conclusion in my
24 declaration. And I did cite to that, yes, just
25 now.

1 Q That's not -- I don't want to argue with
2 you. Let's look at your declaration. Paragraph
3 70. It's your declaration on the '167 patent.
4 A Okay.
5 Q The citation to Yoon page 2840 is at the
6 end of that paragraph 70. Do you see that?
7 A Yes.
8 Q And the parenthetical says "studying the
9 deposition of highly oriented" -- "(100)-oriented
10 magnesium oxide crystalline thin films on silicon,
11 gallium arsenide, and fused quartz substrates."
12 Right?
13 A Right.
14 Q So your declaration did not rely on the
15 silicon nitrate study that somebody else did that
16 Yoon refers to on page 2840, did it?
17 A Okay. Fair enough. It did not.
18 Q So when I asked you what you relied on,
19 are you actually now thinking through what you
20 would say now as opposed to what you said in your
21 declaration?
22 A I'll stand by what I said in my
23 declaration. As I was reviewing the reference
24 now, I noticed this other point. I didn't cite it
25 in my declaration. When I wrote the declaration,

1 that was quite a while ago. Likely I didn't cite
2 silicon nitrates. As you point out, that was done
3 by somebody else.
4 Q Can I ask you to turn to page 1040, page
5 2841. It should be PDF page 3.
6 A Okay.
7 Q Do you see in Figure 3 that there's --
8 there's two figures here showing magnesium oxide
9 on silicon and then magnesium oxide on gallium
10 arsenide?
11 A I see that.
12 Q And do you see that the legend or the
13 data shows a range of thicknesses?
14 A I see that.
15 Q And in Figure 3a, the range starts at
16 50 nanometers, goes up to 520 nanometers; is that
17 right?
18 A Right.
19 Q And for Figure 3B, the thickness range is
20 120 nanometers to 500 nanometers; is that right?
21 A Right.
22 Q So this study by Yoon provides no
23 evidence or analysis of what would happen with
24 magnesium oxide deposited on an amorphous
25 substrate and grown to a thickness of two

1 nanometers, does it?
2 A Not explicitly. That's right.
3 Q Did he study a thickness of two
4 nanometers?
5 A Well, he doesn't report any data for two
6 nanometers. That's what we can say from looking
7 at these figures.
8 Q There's no data on a thickness of two
9 nanometers?
10 A No.
11 Q There's no data on the thickness of three
12 nanometers?
13 A No.
14 Q There's no data on a thickness of
15 anything less than 10 nanometers?
16 A No data there, yes.
17 Q And there's no data on a thickness of
18 anything less than 50 nanometers, is there?
19 A Apparently not.
20 Q So what does the behavior of a
21 50-nanometer-thick magnesium oxide film on
22 crystalline silicon tell you about how a
23 two-nanometer-thick magnesium oxide film would
24 form on an amorphous substrate?
25 A It merely -- as I said, I can't as I sit

1 here right now give an opinion definitive opinion
2 on how the thick -- how this data would
3 extrapolate down to thinner layers. These papers
4 by Yoon and Wulff gave a person of ordinary skill
5 an indication that highly oriented 100 MgO can
6 grow on amorphous substrates. Granted, the
7 thicknesses were large. But it was -- already
8 that's a surprising result in some sense. That
9 you could get oriented MgO crystals an amorphous
10 substrate, such as amorphous float glass like
11 Wulff or fused quartz like Yoon. There's no
12 orientation -- there's no epitaxy from amorphous
13 substrates like that. It doesn't provide explicit
14 proof of what would happen for thinner films. But
15 it's -- it's -- it was an unusual and interesting
16 result that you could get even thick films to grow
17 in that orientation on amorphous substrates. So I
18 cite to these papers to indicate that a person of
19 ordinary skill would look at those results and
20 think, wow, okay, you can get -- you can get these
21 highly oriented films of MgO to grow on amorphous
22 substrates. Granted, it doesn't give me absolute
23 guarantee of what will happen on -- for thinner
24 layers. But without this data, you might not have
25 even thought to try because it's -- it's

1 surprising. Remember, Bowen grew epitaxial MgO on
2 single crystal iron and then got a single crystal
3 MgO. That's not -- not that surprising. The
4 lattice constant for MgO and the lattice constant
5 for iron have a -- have a relationship -- and this
6 was discussed in Bowen -- have a relationship that
7 suggests it would be -- it is not unexpected that
8 you could get single crystal MgO on that
9 substrate. I cite to these papers to show that it
10 was known in the art that you could get at least
11 highly oriented 100 polycrystalline MgO on a
12 amorphous substrate. Now, granted, the thickness
13 isn't as thin as we would like. So from this --
14 and as I said, I haven't gone back -- I haven't
15 studied in preparation for this proceeding what --
16 the detailed physics of the thin -- of what
17 happens in the initial growth of very thin films.
18 But there are other references that do grow very
19 thin MgO films that are highly oriented
20 polycrystalline in the record here. So this --
21 these papers simply give an indication of, hey,
22 it's worth a try. It's a likelihood of success of
23 growing thin film highly oriented MgO.
24 Q You said there's a -- there's a near
25 lattice match between crystalline iron 100 and

1 crystalline magnesium oxide 100 that Bowen
2 observed and used to form his MTJs; right?
3 A That's my recollection. I would have to
4 go back and double-check. But I think he
5 discusses that.
6 Q So you said it is not surprising that you
7 can achieve crystalline 001 magnesium oxide on
8 crystalline 001 iron; right?
9 A Right.
10 Q Is that because the iron, the crystalline
11 layer serves as a template on which you deposit
12 and grow the magnesium oxide layer?
13 A Right.
14 Q So by a template, it slots the magnesium
15 oxide into position in a 100 orientation; is that
16 right?
17 ATTORNEY WILSON: Objection. Form.
18 BY ATTORNEY WICHMAN:
19 Q Let me strike that question and ask it
20 this way: Explain to me how crystalline iron
21 provides a template for the formation of
22 crystalline magnesium oxide.
23 A I'm looking at Bowen. So Bowen, on the
24 first page, page 1655 -- so let's start from Bowen
25 in the left-hand column the first paragraph at the

1 bottom. It says, "Iron cobalt/MgO/iron epitaxial
2 structures were grown on gallium arsenide (001) in
3 a combined sputtering/laser ablation system with a
4 base pressure of 2 times 10 to the minus 9
5 millibar as described elsewhere. We use a MgO
6 buffer layer as an interdiffusion barrier with
7 good electrical isolation characteristics. This
8 prevents the incorporation of arsenic from the
9 substrate into the iron bottom electrode - an
10 important precaution since, in a subsequent step,
11 the MgO barrier is grown at 400 degrees C in order
12 to obtain good crystallinity. This MgO buffer
13 layer also offers an appropriate symmetry and
14 lattice match for the epitaxy of iron on top, with
15 the well-known orientation relation iron
16 (100)[001]//MgO(100)[110]. Iron 50 cobalt 50 and
17 iron layers were deposited from individual iron
18 and cobalt targets."
19 Okay. I think that's enough. So what
20 Bowen is teaching here is that there is an
21 appropriate lattice match for the epitaxy of iron
22 on top, which also applies for the subsequent
23 growth. So it's the lattice match that promotes
24 the crystallinity of the iron and the MgO layers.
25 Q So is that what you mean by template?

1 A That could be. Yes. That's one way to
2 describe it. Template gets used elsewhere in
3 other references in this context.
4 Q It is your testimony that Bowen's bottom
5 iron layer with the 001 orientation provides a
6 template for the epitaxial growth of the single
7 crystal magnesium oxide 001 layer on top of it?
8 A Yes.
9 Q Okay. So I'm asking you, can you explain
10 to me how that works?
11 ATTORNEY WILSON: Objection. Form.
12 THE WITNESS: Epitaxy is a process where
13 highly oriented crystalline layer is grown on
14 an -- another highly oriented crystalline layer
15 where the lattices of the two layers match and
16 align to each other due to favorable chemical
17 bonding between the atoms of the upper layer and
18 the atoms of the lower layer. So the chemical
19 bonds can continue to form a periodic crystalline
20 structure because the periods of the two layers
21 are comparable.
22 BY ATTORNEY WICHMAN:
23 Q And in that scenario, what happens if the
24 lattices do not match?
25 A If the lattices do not match, then you

1 don't get epitaxy.
2 Q Well, what happens?
3 A It depends. That can vary. It depends
4 on the details. So, for instance, if you have an
5 amorphous layer and you try to grow a crystalline
6 on it, there is no epitaxy, there is no
7 templating, and so it is surprising that you get
8 MgO to grow on an amorphous layer.
9 Q And what if you had a crystalline layer
10 where the lattice constant was different from the
11 material that you hoped to crystallize on top of
12 it?
13 A Well, that's a -- that's a very broad
14 question. It's -- it's -- it's a thick topic.
15 How you -- how crystal layers grow one on top of
16 each other when there is not commensurate lattice
17 constants, there's a -- there's a huge literature
18 on that. I have -- I'm somewhat familiar on it.
19 But I'm no expert. I'm no crystal grower. And so
20 the question of what happens in that scenario, I
21 can't really answer sitting here today. The
22 answer to that, I -- I'm sure -- I could prepare,
23 you know, a whole course on that, frankly.
24 That's -- that's a very active -- continues to be
25 a very active area of research, growth of crystals

1 on top of each other and how that -- how that
2 varies depending on the crystal structure of the
3 various constituents.
4 Q Just a few more questions. I think we're
5 a little past an hour. Just want to ask a few
6 more questions, and then we'll take a break.
7 And, Mr. Wilson, do you want to do lunch
8 early perhaps since we're coming up on noon?
9 ATTORNEY WILSON: Yeah.
10 BY ATTORNEY WICHMAN:
11 Q Okay. All right. Dr. Bokor, if you
12 could go back -- turn your attention back to Yoon.
13 This is Exhibit 1040.
14 A Okay.
15 Q On page 2839. This is the first page.
16 It should be PDF 1.
17 A Okay.
18 Q Do you see any abstract that Yoon states
19 that he grew the magnesium oxide film by an
20 aerosol-assisted chemical vapor deposition?
21 A I see that.
22 Q What is aerosol-assisted chemical vapor
23 deposition?
24 A Well, he describes the process on the
25 next page under the heading experimental

1 procedure. "MgO films were deposited by AACVD
2 technique" -- that stands for aerial-assisted
3 chemical vapor deposition -- "which is based on
4 the pyrolysis of an aerosol produced by
5 ultra-sonic nebulizer (sonicator frequency:
6 1.6 megahertz). The liquid source to be misted
7 was a magnesium ethoxide" -- it gives a chemical
8 formula -- "dissolved in 2-methoxyethanol."
9 That's essentially the description of the process.
10 Q And on the same page, Yoon describes
11 doing this deposition on substrates preheated to
12 temperatures of 300 to 450 degrees Celsius;
13 correct?
14 A Yes.
15 Q Is the 300 -- heating the substrate to
16 300 to 450 degrees Celsius considered placing the
17 substrate as -- at an elevated temperature?
18 A Fair.
19 Q Would you -- can you make a magnetic
20 tunnel junction using the aerosol-assisted
21 chemical vapor deposition?
22 A I don't know the answer to that.
23 Q Have you ever made a magnetic tunnel
24 junction using that technique?
25 A I'm pretty sure I have not.

1 Q Can this technique be used in the mass
2 production of a commercial MTJ?
3 A I can't answer that question. I don't
4 know.
5 ATTORNEY WICHMAN: Okay. Let's go off
6 the record.
7 (A lunch recess was taken.)
8 ATTORNEY WICHMAN: Should we go back on
9 the record?
10 ATTORNEY WILSON: Sure.
11 BY ATTORNEY WICHMAN:
12 Q Great. Dr. Bokor, during the break, did
13 you speak to anybody about the deposition?
14 A No.
15 Q During the break, did you consult any
16 written materials related to this deposition?
17 A I was looking over my declaration.
18 Q Which one?
19 A The one we've been talking about, the
20 '167.
21 Q Anything else?
22 A No.
23 Q If you could turn to your declaration on
24 the '167 patent?
25 A I'm there.

1 Q If you could turn to paragraph 61, which
2 is at PDF page 40. Let me know when you're there.
3 A Okay. I'm there.
4 Q Maybe take a moment to review that
5 paragraph.
6 A Okay.
7 Okay.
8 Q So your testimony is that annealing the
9 amorphous cobalt iron boron electrodes induced
10 formation of a crystalline structure matching an
11 adjoining crystalline layer. One of skill was
12 aware that cobalt iron boron would adopt the
13 crystalline structure of an adjoining layer; is
14 that right?
15 A That's what I said, yes.
16 Q And you cite in this paragraph four
17 different exhibits as support for that
18 proposition; right?
19 A It looks like.
20 Q So let's start with the first one. This
21 is Exhibit 1060, a paper by Jimbo, if you could
22 open that, please.
23 Do you have that document open,
24 Dr. Bokor?
25 A I'm getting it.

1 Okay.
2 Q So on the bottom right, in the right-hand
3 column on the bottom of page 308, which is PDF
4 page 1, under the header result and discussions,
5 Jimbo describes a glass silicon nitrate (10
6 nanometer), cobalt iron boron (10 nanometer), gold
7 (2 nanometer) tri-layer; is that right?
8 A Right.
9 Q And Jimbo annealed that structure; right?
10 A Yes.
11 Q And Jimbo describes an X-ray diffraction
12 pattern of this structure after annealing; is that
13 right?
14 A Right.
15 Q What kind of annealing is this that Jimbo
16 performed?
17 A Let's see. It looks like he annealed at
18 250 and then increased the temperature to 300.
19 Later on to 400. Is that -- was that your
20 question? What do you mean by what kind of
21 annealing?
22 Q Is there a difference between something
23 called an in situ anneal and a post-anneal?
24 A Are both of those used in this paper?
25 Q That's not my question, sir.

1 A Well, I need some context for the -- for
2 the use of those terms. Out of context, it's --
3 it's not -- I can't really answer. I need some
4 context.
5 Q In your declaration on the '167 patent,
6 at paragraph 61, you say that Jimbo deposited
7 cobalt iron boron by sputtering; right?
8 A Right.
9 Q And then performed annealing for an hour;
10 is that right?
11 A Okay. Yeah.
12 Q And are you -- when you give that
13 testimony, are you referring to this particular
14 stack of glass/silicon nitride, cobalt iron boron,
15 and gold?
16 A Yes.
17 Q And then you state that the cobalt iron
18 boron adopted the fcc(111) structure of the
19 adjoining Au fcc(111) top layer. Is that right?
20 A Yes.
21 Q And the basis of that testimony is on
22 page 308, right-hand column, bottom, where Jimbo
23 writes, "In X-ray diffraction patterns, two peaks
24 at 38 degrees and 44 degrees which correspond to
25 Au fcc(111) and in CoFe fcc(111), respectively,

1 are observed." Is that right?
2 A Are you waiting for me?
3 Q Yes.
4 A I thought I answered right. Yes.
5 Q So Au is the symbol for gold; right?
6 A Correct.
7 Q And CoFe is a nomenclature for cobalt
8 iron; right?
9 A Right.
10 Q So in this passage, Jimbo is referring to
11 a crystalline gold layer with an fcc(111)
12 orientation; right?
13 A Right.
14 Q And he is referring to a cobalt iron
15 crystalline layer with an fcc(111) orientation;
16 right?
17 A He's referring to the peak at 44 degrees
18 that corresponds to a cobalt iron fcc(111) peak.
19 Q But he doesn't identify a peak for a
20 cobalt iron boron crystalline, does he?
21 A I think he does.
22 Q Why?
23 A Well, if we look at Figure 1 -- first of
24 all, in the caption, it says XRD patterns for
25 glass/silicon nitride (10 nanometers) cobalt

1 iron boron (10 nanometers), gold (2 nanometers)
2 tri-layers after annealing at various
3 temperatures. Point number one.
4 Point number two, in the cap -- in the
5 inset above the figure, it shows the layer between
6 the gold and the silicon nitride is identified as
7 cobalt iron boron.
8 Now, the vertical dashed line in the plot
9 at 44 -- roughly 44 degrees is identified as
10 cobalt iron fcc(111). That is a known position
11 for a peak for that known material. And what this
12 figure is communicating is that the peak for the
13 cobalt iron boron layer is coinciding with the
14 cobalt iron fcc(111) peak. That is the lattice
15 constant for the layer in the sample matches the
16 lattice constant for cobalt iron 111. Because
17 that's the -- the peak is through the -- through
18 the relation for X-ray diffraction. The position
19 of the -- of a peak like this and angle depends
20 simply on the lattice constant of the crystal.
21 And the material composition is not directly
22 measured in X-ray diffraction. Just the lattice
23 constant. Many crystals can -- many different
24 crystals can have the same lattice constant.
25 Q Is it your testimony that in Figure 1 of

1 Jimbo, Exhibit 1060, at page 309, the X-ray
2 diffraction pattern at 44 degrees indicates
3 crystalline cobalt iron boron with an
4 orientation -- with an fcc structure and a 111
5 orientation?
6 A That's what I believe that the -- the
7 reference is communicating. That's my testimony,
8 yes.
9 Q Then why isn't this peak labeled cobalt
10 iron boron?
11 A Because Jimbo doesn't have -- didn't have
12 prior data for what the X-ray diffraction peak
13 from cobalt iron boron, where that would appear.
14 What Jimbo is communicating here is I -- I
15 annealed cobalt iron boron. He doesn't say
16 anything about, well, the boron went away, there's
17 no boron, anything like that. He annealed a
18 cobalt iron boron layer. And one of ordinary
19 skill in the art -- there's no suggestion
20 whatsoever in this paper anywhere that the layer
21 that got annealed changed its composition. What
22 Jimbo is communicating to person of ordinary skill
23 in this figure and in the entire paper, in my
24 opinion, is that when you anneal cobalt iron
25 boron, it crystalizes with a crystal structure

1 that is very close to the crystal structure that's
2 known for cobalt iron. Depending on the
3 conditions, how close it is to that peak actually
4 varies, as we will see later on in this paper.
5 Q Did a person of ordinary skill in the art
6 in 2004 understand that when a cobalt iron boron
7 layer is annealed, the boron diffuses away from an
8 interface and a thin crystalline of cobalt iron is
9 formed?
10 A What a person of ordinary skill knew
11 about that was that the -- from Parkin, that when
12 it was annealed, the boron could diffuse and lower
13 the boron concentration in the layer. And under
14 certain conditions, it might -- all the boron
15 might diffuse out. But it was unclear depending
16 on the conditions. Here, there's no discussion
17 about diffusion. Jimbo did not do any independent
18 experiments in this paper to determine anything
19 about the boron diffusion. This paper is dated
20 1997. So there certainly was nothing known about
21 boron diffusion that you mentioned back in 1997.
22 A person of ordinary skill looking at
23 this, I think, comes to the conclusion that I just
24 gave. And there is information in the literature
25 about boron diffusion. There may -- there may be

1 some boron diffusion. But it's -- it's not --
2 it's not determined in this experiment. One of
3 ordinary skill, I believe, would understand that
4 what was formed as a crystalline layer with a
5 similar crystal structure to cobalt iron and very
6 likely still has some amount of boron. Some
7 amount of boron.
8 Q Where does Jimbo say that the cobalt iron
9 boron layer after anneal adopted the crystalline
10 structure of an adjoining layer?
11 A Of an adjoining layer? Well, he says
12 that the cobalt -- the cobalt iron boron layer
13 formed an fcc(111) crystal structure. And he also
14 found from his experiment that the adjoining gold
15 layer also formed a fcc(111) crystal structure.
16 So the conclusion that the cobalt iron boron
17 adopted the fcc(111) structure of the adjoining
18 gold fcc(111) top layer is -- I mean, it's -- it's
19 just what the figure shows. It's just what --
20 it's just what Jimbo says. They both have
21 fcc(111) structure. Therefore, they have the same
22 structure.
23 Q Is it your testimony that Jimbo shows
24 that the annealed cobalt iron boron layer adopted
25 an fcc(111) structure because the adjoining layer

1 was gold in an fcc(111) layer?
2 A Well, Jimbo doesn't go into the -- you
3 know, the -- the dynamics of the growth process
4 at -- at a deep level to say what was the
5 mechanism. It's -- I think a person of ordinary
6 skill looking at that coincidence would say they
7 both formed that same crystal structure because of
8 the interaction between the layers that they -- it
9 is not a coincidence that they both formed
10 fcc(111) structure. There's some interaction
11 between the layers.
12 Q The lattice constant for gold fcc(111) is
13 .408 nanometers, isn't it?
14 A I don't know that number off the top of
15 my head. Is that in one of these references?
16 Q The lattice constant for iron in an fcc
17 crystal 111 is .357 nanometers, isn't it?
18 A I don't have that --
19 ATTORNEY WILSON: Objection to form.
20 THE WITNESS: -- right off the top of my
21 head. I would have to look it up.
22 BY ATTORNEY WICHMAN:
23 Q Okay. Are you aware that the cobalt in
24 an fcc structure is not stable at room
25 temperature?

1 ATTORNEY WILSON: Objection. Form.
2 THE WITNESS: I'm not aware of that right
3 as I sit here now.
4 BY ATTORNEY WICHMAN:
5 Q The lattice constant for cobalt in an fcc
6 structure is 0.354 nanometers; right?
7 ATTORNEY WILSON: Objection to form.
8 THE WITNESS: I don't have that
9 information right in front of me. I can't confirm
10 that.
11 BY ATTORNEY WICHMAN:
12 Q The lattice constant for cobalt iron
13 alloy in an fcc structure will be somewhere
14 between .354 nanometers and .357 nanometers, won't
15 it?
16 ATTORNEY WILSON: Objection. Form.
17 THE WITNESS: I can't confirm that
18 number.
19 BY ATTORNEY WICHMAN:
20 Q You just testified that when two
21 materials have X-ray diffraction patterns at
22 different angles, that they have different lattice
23 constants; right?
24 A That's true.
25 Q So looking at Figure 1 of Jimbo, at

1 page 309 of Exhibit 1060, you see there is a gold
2 fcc(111) diffraction pattern at 38 degrees and a
3 cobalt iron fcc(111) diffraction pattern at
4 44 degrees; right?
5 A Right.
6 Q By your own testimony, there's a lattice
7 mismatch between gold and iron cobalt when both
8 are fcc and 111; correct?
9 A True.
10 Q And you just testified before lunch that
11 when there's a lattice mismatch, one crystal is
12 not going to be a template for the layer above it;
13 right?
14 ATTORNEY WILSON: Objection. Form.
15 THE WITNESS: Well, I don't remember
16 exactly the wording. I said there would be a
17 lattice mismatch. So you wouldn't get epitaxy.
18 And I don't think Jimbo or a person of ordinary
19 skill in the art looking at this data would come
20 to a conclusion that the gold -- that the -- the
21 co- -- the gold or the cobalt iron boron have an
22 epitaxial relationship between them. When there
23 is a lattice mismatch between two crystals during
24 growth -- I think we saw this in one of the other
25 references we were looking at this morning. You

1 can get -- for very thin layers, you can still get
2 a pseudo-epitaxy where the lattice constant of one
3 layer is stretched to fit the other one. And up
4 for a certain thickness, it's under strain, but it
5 can still be aligned. And then once the layer
6 continue to grow, the -- the epitaxy can no
7 longer -- the epitaxy relationship can no longer
8 be strained. Dislocations are formed. That's
9 well known. That -- that amount of crystal growth
10 physics I feel very comfortable with. And we saw
11 it, I think, in the -- in one of the papers we
12 were looking at this morning. Up to a certain
13 layer thickness. And then you get dislocations.
14 So here, there's nothing terribly unusual
15 or surprising or wrong to say that the -- the
16 growth of one layer on the other came about
17 because of an interaction in some adoption of the
18 structure. The layers here are not perfectly
19 single crystal. I'm pretty sure that Jimbo
20 doesn't suggest that they are. They have those --
21 they are -- they are likely polycrystalline
22 with -- with these orientations. Just because the
23 lattice constant of the gold and cobalt iron are
24 not the same doesn't mean that during growth,
25 there wasn't some alignment or adoption of one

1 crystal structure by the underlying crystal.
2 BY ATTORNEY WICHMAN:
3 Q Dr. Bokor, a POSA would have known that
4 the stable structure of cobalt iron boron crystal
5 is fcc; right?
6 ATTORNEY WILSON: Objection. Form.
7 THE WITNESS: That I'm not so sure about.
8 BY ATTORNEY WICHMAN:
9 Q Open Exhibit 1057, please.
10 A 1057. Dieny. Okay.
11 Q Page 48, PDF page 67. You've seen this
12 page before?
13 A PDF 67, did you say?
14 Q Yes.
15 A Okay. I see where he says that the
16 stable structure of cobalt iron boron is fcc.
17 I've seen this before. I didn't remember that
18 particular statement.
19 Q In fact, you cite this page in paragraph
20 61 of your declaration on the '167 patent; right?
21 A I do.
22 Q So a POSA would have known that the
23 stable structure of cobalt iron boron crystal was
24 fcc; right?
25 ATTORNEY WILSON: Objection. Form.

1 THE WITNESS: Well, I regret having cited
2 Dieny. I cited it for, you know, just general
3 background information. It's -- it's published in
4 2017. So based on that, a POSA at the time may or
5 may not have known what the stable crystal
6 structure of cobalt iron boron is. I do not -- I
7 do not -- I do not rely on Dieny for my opinion
8 about what was known by a POSA. This was cited
9 as -- as supplementary information or let's say
10 additional background information.
11 BY ATTORNEY WICHMAN:
12 Q Did the physics of cobalt iron boron
13 change between the time that Jimbo wrote his paper
14 and the time that Dieny was published?
15 A No.
16 ATTORNEY WILSON: Objection. Relevance.
17 THE WITNESS: No.
18 BY ATTORNEY WICHMAN:
19 Q No. So you consider yourself a person of
20 ordinary skill in the art; right?
21 A Yes.
22 Q And you are offering your testimony from
23 the point of view of a person of ordinary skill in
24 the art in 2000; right?
25 A 2004; right?

1 Q You tell me.
2 A My understanding is that the relevant
3 date is 2004. But anyway, let's see, we're
4 talking about Jimbo; right? No. You're asking me
5 about -- when I talk about the -- what a person of
6 ordinary skill in the art would understand, I
7 always -- I'm always referring to that in the
8 context of as of the date of the patent.
9 Q So as of the date of the patent, a --
10 would a person of ordinary skill in the art have
11 known that the stable structure of fcc cobalt iron
12 boron -- I'm sorry. Strike that.
13 As of the date of the patent, would a
14 person of ordinary skill in the art have known
15 that the stable structure of crystalline cobalt
16 iron boron was fcc?
17 A And what I'm saying is that Dieny in his
18 book says that. His book is dated 2017. He cites
19 reference 34 for that. Reference 34 is a paper by
20 none other than Yuasa, dated 2005. So a person of
21 ordinary skill in 2004, at least as best as we can
22 determine from this particular reference, may or
23 may not have known that.
24 Q Well, you're the expert. What would the
25 POSA have known?

1 ATTORNEY WILSON: Objection. Form.
2 THE WITNESS: My -- the only thing that I
3 have to rely on in terms of what a POSA would know
4 on a given date was what -- well, what was in the
5 open literature as of that date. That's what I
6 primarily rely on. I understand legally there may
7 be other sources of information to a person of
8 ordinary skill in the art as of a given date. But
9 I don't think any of those are, as far as I'm
10 aware, relevant in this case. So my opinion about
11 what a person of ordinary skill in the art knew in
12 2004 is based simply on what was in the open
13 literature as of that date. This particular fact
14 that you are pointing to in Dieny illustrates why
15 Dieny was an unfortunate thing to refer to at all
16 in my declaration. And I regret that. But that's
17 the problem. Right. Here, this particular fact
18 about the crystal structure of cobalt iron boron
19 was based on a publication dated in 2005.
20 Now, there may be -- if there is earlier
21 literature on that point, I'm not aware of it.
22 Just going by what I have in front of me right
23 now, a person of ordinary skill in the art at the
24 time of the patent did not know that the stable
25 crystal structure of cobalt iron boron is fcc.

1 BY ATTORNEY WICHMAN:
2 Q You didn't bother to investigate that as
3 of 2004?
4 A I did not.
5 Q Why not?
6 A Well, it didn't seem at the time to be
7 central to the question of whether or not a cobalt
8 iron boron layer would crystallize in the bcc
9 structure. It does crystallize in the bcc
10 structure. Dieny says that. Although, now we
11 would have to look into what -- what reference he
12 cites. But that's -- that comes from Parkin,
13 which is prior art. Parkin found also that the
14 cobalt iron boron crystallized in a bcc 001
15 structure, next to MgO 001. That's what I was
16 focused on.
17 Q Let's talk about Jimbo and your paragraph
18 61. The proposition that your paragraph -- your
19 testimony asserts is that annealing the amorphous
20 cobalt iron boron would induce the formation of a
21 crystalline structure that matches an adjoining
22 crystalline layer. That's your testimony; right?
23 A The cobalt iron boron adopted the
24 fcc(111) structure of the adjoining gold fcc(111)
25 layer. That's my testimony.

1 Q I'm pointing to the first two sentences
2 of your paragraph 61.
3 A Oh. Okay.
4 Q You assert that amorphous -- annealing
5 the amorphous cobalt iron boron would induce the
6 formation of a crystalline structure that matches
7 an adjoining crystalline layer; correct?
8 A That's what I'm saying.
9 Q And I want to know the evidence that
10 supports that assertion. Right.
11 A Okay.
12 Q And the first evidence you cite is
13 Jimbo's result for his silicon nitride, cobalt
14 iron boron, gold stack tri-layer; correct?
15 A Correct.
16 Q And you conclude that because Jimbo found
17 after annealing there was an fcc(111) cobalt iron
18 pattern in the X-ray diffraction and an fcc(111)
19 peak in the X-ray diffraction pattern, that
20 therefore it must be true that the cobalt iron
21 boron adopted the crystalline structure of the
22 gold crystal layer; correct?
23 A Okay.
24 Q That's your testimony?
25 A Not exactly.

1 Q If --
2 A Let me --
3 Q I didn't -- I didn't ask you to explain.
4 I'm just asking if that's your testimony. Would a
5 person of ordinary skill --
6 ATTORNEY WILSON: If you ask the
7 question, you need to let him finish answering the
8 question.
9 ATTORNEY WICHMAN: He did answer my
10 question. And then he started a soliloquy. I
11 have another question.
12 ATTORNEY WILSON: Dr. Bokor, are you
13 finished answering the previous question?
14 THE WITNESS: I'm fine to continue. I
15 have a feeling we're -- I'm confident we will get
16 to the bottom of what my opinion is.
17 ATTORNEY WILSON: Okay.
18 THE WITNESS: If not, I'll -- I'll take
19 the opportunity to explain it more fully at -- at
20 a sensible point.
21 BY ATTORNEY WICHMAN:
22 Q You assert as support for the proposition
23 that annealing cobalt iron boron would induce the
24 crystalline structure that adopts the crystalline
25 structure of an adjoining layer, the result in

1 Jimbo that annealing a silicon nitride cobalt iron
2 boron gold tri-layer resulted in a cobalt iron
3 fcc(111) peak in a gold fcc(111) peak; is that
4 right?
5 A Right.
6 Q And in evaluating whether there was a
7 causal relationship between the crystalline
8 structure found in the cobalt iron peak and the
9 crystalline structure found in the gold peak,
10 would a person of ordinary skill in the art have
11 considered it relevant to know what the stable
12 crystalline structure of cobalt iron boron was?
13 A That seems like it would be of interest,
14 yes.
15 Q And you have testified that you didn't
16 bother to check what a person of ordinary skill in
17 the art would have known about the stable
18 crystalline structure of cobalt iron boron as of
19 2004; is that right?
20 A I don't recall doing that, correct.
21 Q You don't recall the testimony or you
22 don't recall checking?
23 A I don't recall checking.
24 Q Okay. And why didn't you?
25 ATTORNEY WILSON: Objection. Form.

1 THE WITNESS: I'm not sure I can answer
2 that question. I felt -- I was investigating
3 whether or not it would have been obvious to a
4 person of ordinary skill in the art that a cobalt
5 iron boron layer would crystallize adjacent to MgO
6 and form a bcc(100) structure. And this result
7 gave a -- a strong indication that cobalt iron
8 boron would adopt the crystal structure of the
9 layer underneath. This was evidence of that
10 sufficient so that a person of ordinary skill in
11 the art would have a reasonable chance of success
12 in getting a cobalt iron boron crystallization
13 next to the MgO. And to me, this gave sufficient
14 evidence to suggest to a person of ordinary skill
15 that if they have a cobalt iron boron amorphous
16 layer next to MgO, it would crystallize with bcc
17 100.
18 Now, the fact that this is a somewhat
19 different situation with 111 gold is relevant, but
20 not dispositive. It's a suggestion. So one of
21 skill was aware that cobalt iron boron would adopt
22 a 111 fcc structure next to gold 111. And one
23 would be looking for a crystallized cobalt iron
24 boron structure next to the MgO in an MTJ.
25 So looking at Jimbo, they would be

1 motivated to crystallize the cobalt iron boron to
2 get an improved TMR. Because crystalline
3 ferromagnet was known to improve the TMR. So
4 that's why. You asked me why. I went through
5 my -- my thought process in -- in this analysis.
6 BY ATTORNEY WICHMAN:
7 Q Dr. Bokor, I'm not talking about
8 magnesium oxide. I'm not talking about bcc cobalt
9 iron boron. I'm solely talking about your
10 assertion that amorphous cobalt iron boron when
11 annealed will be induced to form a crystalline
12 structure matching an adjoining crystalline layer.
13 Okay?
14 A You asked me why I didn't investigate in
15 detail what the equilibrium structure of cobalt
16 iron boron is. That's the question I answered.
17 That was not -- I did not interpret that question
18 to be limited as narrowly as you just suggested.
19 Q Let's start some new questions. I want
20 to investigate the evidence for your testimony and
21 your opinion that a POSA in 2004 would have
22 believed that annealing amorphous cobalt iron
23 boron would induce it to form a crystalline
24 structure matching an adjoining crystalline layer.
25 Okay?

1 A Okay.
2 Q The first piece of evidence that you
3 adduce in support of this proposition is
4 Exhibit 1060 Jimbo, page 308; correct?
5 A Correct.
6 Q And in your testimony at paragraph 61,
7 you discuss Jimbo's result when he annealed a
8 tri-layer of silicon nitride, cobalt iron boron,
9 and gold; correct?
10 A Correct.
11 Q And you assert that the fact that Jimbo
12 observed as a result a cobalt iron fcc(111) signal
13 and a gold fcc(111) signal in his X-ray
14 diffraction patterns, that that means the cobalt
15 iron boron adopted the crystal structure of the
16 gold layer; correct?
17 A Right.
18 Q So you're asserting a causal
19 relationship; is that correct?
20 A Well, that is -- that is the statement in
21 my declaration, yes.
22 Q And I'm asking you -- I asked you whether
23 a person of ordinary skill in the art in 2004
24 reading Jimbo would have thought it would have
25 been important to know what the stable crystalline

1 structure of cobalt iron boron was before drawing
2 a conclusion that there was a causal relationship
3 between the resulting crystalline structure of the
4 annealed cobalt iron boron and gold layers in
5 Jimbo?
6 A It would be relevant.
7 Q And while you admit that it would have
8 been relevant, you also admit that you did not
9 bother to check whether a POSA would have known
10 what that stable crystalline structure of cobalt
11 iron boron was; correct?
12 A Well, I did not -- I did not investigate
13 that. That's fair to say.
14 Q If a POSA knew in 2004 that the stable
15 crystalline structure of cobalt iron boron was
16 fcc, why would the POSA have not concluded that
17 what Jimbo was showing would have occurred even in
18 the absence of the gold layer?
19 ATTORNEY WILSON: Objection. Form.
20 THE WITNESS: Well, a POSA -- if a POSA
21 knew that the stable crystal structure of cobalt
22 iron boron is fcc, then it's still -- let me put
23 it this way: The answer -- the answer to that
24 question is if you look at Jimbo, the X-ray
25 diffraction pattern from Jimbo, okay, if on your

1 hypothesis that one way to understand the
2 formation of cobalt iron boron in the fcc(111)
3 structure is that that was simply the stable
4 crystal structure of the cobalt iron boron,
5 then -- and there was no connection between --
6 there was -- there was no -- there was no
7 interaction. There was no interaction between the
8 gold and the cobalt iron boron. And the cobalt
9 iron boron just took its natural fcc structure,
10 then this X-ray diffraction pattern would be
11 different. X-ray diffraction measures the lattice
12 constant of a material, of a crystal, along the
13 direction -- along a particular direction. So
14 what this X-ray diffraction pattern tells a POSA
15 is that regardless of the -- so let's just make no
16 assumptions about the causality, to start with.
17 What this X-ray diffraction pattern does
18 tell a POSA is that the 111 plane, the orientation
19 of the -- of the -- both crystals are parallel.
20 So it's not just that the gold is 111 fcc and the
21 cobalt iron is 111 fcc. The planes -- the planes
22 of each of those crystals are parallel. That's
23 what that X-ray diffraction pattern shows.
24 If the cobalt iron boron just
25 crystallized with no templating or interaction at

1 all with the gold, it would form a polycrystalline
2 structure, with polycrystals oriented randomly.
3 And we would not get that X-ray diffraction
4 pattern. Similar for the gold. That is a
5 crystal -- that's an X-ray diffraction pattern for
6 a highly oriented crystal. It could be
7 polycrystalline, but it would have to be highly
8 oriented.
9 So the orientation of the cobalt iron
10 lines up with the orientation of the gold,
11 regardless of what the equilibrium lattice
12 structures were. So this X-ray diffraction
13 pattern in any event indicates an interaction
14 between those two layers during the growth.
15 Otherwise, there wouldn't be any relationship
16 between the -- those 111 crystal planes.
17 BY ATTORNEY WICHMAN:
18 Q You referred to templating. And you had
19 explained that templating is a crystalline
20 structure of a layer providing a way to organize
21 the crystalline structure of the layer above it.
22 A Uh-huh.
23 Q Is that right?
24 A Yes.
25 Q All right. Well, in Jimbo, the gold

1 layer was on top of the cobalt iron boron; right?
2 A Yeah.
3 Q So did the cobalt iron boron provide a
4 template for gold?
5 A I think the reasonable -- both -- let's
6 see. Hold on a second here.
7 The evidence for the causality is
8 given -- I got that from the text on page 308 of
9 Jimbo, right-hand column. We've been talking
10 about near the bottom. Notice he says, "The
11 intensity of gold fcc(111) peak increases rapidly
12 after annealing. The peak of cobalt iron fcc(111)
13 appears first after annealing at 250 and becomes
14 still higher at 300." That I would concede is not
15 dispositive. But it strongly suggests that the
16 cobalt -- the cobalt iron boron is following the
17 fcc(111) structure from the gold, since he is
18 suggesting that the gold fcc(111) forms earlier.
19 Q Dr. Bokor, if annealing cobalt iron boron
20 in its natural -- natural state, it would have
21 wanted to form fcc anyway, how can you conclude
22 that annealing it next to gold means that it took
23 on the structure of gold?
24 ATTORNEY WILSON: Objection. Form.
25 THE WITNESS: I just explained that.

1 It's because the -- there's a -- there is a strong
2 connection between the two crystal structures.
3 They're aligned to one another. So at a minimum,
4 a POSA looking at that would understand that
5 there's a connection. There's a reason -- they
6 aligned parallel to one another. That's not --
7 that's not just a random -- that's not consistent
8 with random crystallization of the two layers.
9 The fact that the plane -- the 111 planes of the
10 two crystals are aligned in the same plane, namely
11 the surface plane of the -- of the structure
12 indicates that there's a strong interaction and
13 that one or the other of these layers provided the
14 templating. It could be -- that there is kind of
15 a simultaneous interaction. They just lined up to
16 each other. But the statement that Jimbo makes
17 that I just read, it suggests strongly that the
18 nucleation started with the gold and that the
19 cobalt iron boron with a peak of -- that lined --
20 that aligns to cobalt iron fcc(111) followed.
21 Now, I'll -- I'll concede that the
22 statement here in Jimbo may not be dispositive,
23 but it strongly suggests that it was the gold that
24 templated the cobalt iron boron. And that is what
25 I relied on when I wrote the declaration.

1 BY ATTORNEY WICHMAN:
2 Q Is it your testimony that the behavior of
3 two crystal structures at an interface where there
4 is a lattice mismatch is a complicated field?
5 A I did testify -- I did testify to that,
6 yes.
7 Q So how can you be so confident in your
8 conclusion here that the gold layer is templating
9 a cobalt iron boron layer?
10 ATTORNEY WILSON: Objection. Form.
11 THE WITNESS: It's -- it's just the
12 most -- let's just call it Occam's razor. Now,
13 you know, it's possible that with an incredibly
14 detailed analysis and a long series of
15 experiments, we might be able to unravel whether
16 the situation is more complicated than the simple
17 observation that the gold -- the fcc gold and the
18 fcc cobalt iron boron adopted the same planar
19 structure was not understandable in terms of a
20 relatively simple interaction between the layers.
21 But the first -- a person of ordinary skill would
22 adopt -- would initially at least adopt the
23 simplest picture. That seems to be consistent
24 with all of the data that we have.
25 And, again, my -- the context for my

1 analysis here is relevant to that discussion.
2 That's relevant to the -- in the context. Right.
3 So what I was doing was looking in the literature
4 for what a person of ordinary skill in the art
5 might know about crystallization of cobalt iron
6 boron when it's next to another layer. And here,
7 it does -- the evidence is -- you know, like I
8 say, it may not be absolutely ironclad, but
9 it's -- it seems like the simple understanding
10 that a POSA would get from reading this paper is
11 that if you had amorphous cobalt iron boron and
12 anneal it, it's very likely -- in fact, quite
13 likely, to adopt the crystal structure to match
14 the crystal structure of the layer underneath.
15 Worth a try.
16 BY ATTORNEY WICHMAN:
17 Q The layer underneath. So the layer
18 underneath in Jimbo's stack was amorphous silicon
19 nitride layer; right?
20 A The adjacent layer. That's important.
21 Because in the formation of MTJs, we have cobalt
22 iron boron on both sides of the MgO. So I want to
23 be careful. It's my opinion that the -- this
24 templating issue is not -- is not sensitive to
25 gravity. So whichever side -- when there are two

1 layers next to each other, heated up and annealed,
2 the interaction can -- is not -- I don't expect --
3 I don't think a POSA expected the interaction to
4 depend on which layer is on top necessarily. You
5 could flip them over and get the same result. In
6 fact, if you put the -- when you put these samples
7 in a chamber to anneal them, the -- the wafer
8 could be facing in either direction.
9 Q In Exhibit 1057 at page 48, if we can go
10 back to that.
11 A 1057. Which one is that?
12 Dieny. Okay. Okay. Yeah. Page 48.
13 Q So right after it says that the stable
14 structure of cobalt iron boron is not bcc but fcc,
15 it says this clearly indicates that the magnesium
16 oxide (001) layer acts as a template for
17 crystalizing the amorphous cobalt iron boron
18 layers because of the good lattice match between
19 magnesium oxide (001) and bcc cobalt iron boron
20 (001). Right?
21 A Right.
22 Q But there was no good lattice match in
23 Jimbo between cobalt iron fcc(111) and gold
24 fcc(111), was there?
25 ATTORNEY WILSON: Objection. Form.

1 THE WITNESS: There's no good lattice
2 match. That's correct.
3 BY ATTORNEY WICHMAN:
4 Q So the reason that Exhibit 1057
5 identifies amorphous cobalt iron boron to take on
6 the bcc(011) structure of an adjacent MgO(001)
7 layer is not present in Jimbo, is it?
8 ATTORNEY WILSON: Objection. Form.
9 THE WITNESS: I disagree. There's no
10 lattice match. And it would be -- it would be
11 incorrect to call the process in Jimbo solid phase
12 epitaxy. But there is clearly an interaction
13 between the layers, the gold and the cobalt iron
14 boron. So a person of ordinary skill looking at
15 Jimbo would be motivated. And under your
16 scenario, if the person of ordinary skill knew
17 the -- that there's a lattice match between
18 MgO(001) and cobalt iron (001), that would simply
19 be further motivation for them to try to put those
20 two layers together and get a crystallization. So
21 the Jimbo result gives you a pointer. It says --
22 there's -- yeah. The cobalt iron boron -- the
23 amorphous cobalt iron boron when it crystalizes
24 next to another crystal will adopt -- will somehow
25 be at least influenced or oriented. The cobalt

1 iron boron in the Jimbo is oriented, although not
2 epitaxial because the last mismatch is too big.
3 But it did -- it did adopt some features of the
4 adjacent crystal structure. So if you then
5 know -- if a POSA knew -- happened to know the
6 lattice constant of bcc, cobalt iron boron, it
7 would just be additional motivation to crystalize
8 a cobalt iron boron layer that was crystallized on
9 MgO or one that was deposited and in which MgO was
10 subsequently deposited. It would be good -- a
11 good reason to expect that you would get the
12 crystalline orientation to obtain the increase in
13 TMR that comes from Butler. Or -- or Bowen.
14 Bowen showed already that -- well, Bowen was just
15 testing Butler. So let's just stick with Butler.
16 Having -- having -- having the layers be aligned
17 would help the delta 1 spin polarized state. Help
18 the -- help the magnetic tunneling be influenced
19 by that -- by this whole band structure process
20 we've been talking about. Sometimes I call it
21 Butler physics. The spin polarized delta 1 Bloch
22 state to exhibit that giant TMR effect, one of
23 ordinary skill in the art at the time would --
24 would be looking for that, was aware that that
25 would be a -- a mechanism to try to achieve -- to

1 try to use to get high TMR.
2 BY ATTORNEY WICHMAN:
3 Q Dr. Bokor, I asked you about Jimbo. Do
4 you recall that?
5 A I understand. I have given my answer
6 about Jimbo.
7 Q In Jimbo, the tri-layer silicon nitride,
8 the cobalt iron boron was 10 nanometers thick;
9 right?
10 A In Jimbo cobalt iron boron was 10
11 nanometers thick, yes.
12 Q The gold layer was 2 nanometers thick; is
13 that right?
14 A That's right.
15 Q When you anneal a thin layer of thin
16 film, do thinner layers crystallize faster than
17 thick layers?
18 A There's no simple answer to that, I don't
19 think. It depends on the melting temperatures of
20 the two layers. It depends on the thickness. It
21 depends on the different crystals. I don't think
22 there's a simple answer to that.
23 Q You referred to nucleation before.
24 A Here, Jimbo says that the gold seems to
25 crystallize first.

1 Q He says the intensity at peak increases
2 rapidly after annealing at 300.
3 A Right.
4 Q And the peak in the cobalt iron appears
5 after annealing at 250 and then grows.
6 A Right.
7 Q You referred to nucleation. What is
8 nucleation?
9 A Well, when we're talking about -- in the
10 context of, for example, an amorphous cobalt iron
11 boron layer crystallizing, generally there will be
12 locations where the crystallization starts. The
13 crystal -- for a crystal to form -- they don't
14 just sort of start from, like, liquid, and then
15 instantly the whole structure is a crystal. To
16 get an ordered crystal, the crystallization
17 generally is a dynamic process where it nucleates
18 somewhere, and then the crystal -- the additional
19 atoms come and add to the crystal structure in the
20 proper crystalline locations.
21 Q If the cobalt iron boron layer in this
22 Jimbo tri-layer started this nucleation process,
23 say in the center of the 10-nanometer film, and
24 grew at the same rate as the gold thin film
25 crystallization, what would be the X-ray

1 diffraction pattern have been at the point where a
2 two-nanometer-thick layer in the cobalt iron boron
3 had crystallized, but the rest of it remained
4 amorphous?
5 A Well, that's an awfully complicated
6 hypothetical that I'm not comfortable to answer.
7 But I will tell you, my understanding is that if
8 you have a layer that's amorphous -- it -- it is
9 much more likely to nucleate at a surface or an
10 interface than in the middle.
11 Q I'm trying to get a sense of what the
12 strength of the peak in the X-ray diffraction
13 pattern means.
14 A Oh.
15 Q So if the cobalt iron boron and the gold
16 had both started to nucleate at their mutual
17 interface at the same time in an fcc pattern and
18 they both grew the same thickness of a crystalline
19 structure, would the fact that the cobalt iron
20 boron was five times as thick mean that the X-ray
21 diffraction pattern or the cobalt iron boron would
22 be weaker even though the cobalt iron boron and
23 the gold had formed the same thickness of a
24 crystalline layer?
25 A I -- I really hesitate to speculate at

1 that level. That's a pretty -- it's a pretty --
2 that's a pretty hairy hypothetical really. Now
3 we're getting into that, you know -- you know, I
4 was -- I was taking some facts from the -- from
5 the experiment and saying it would make sense to
6 take the simplest -- the simplest explanation that
7 fits the data and assume that that is the most
8 likely. Now, here, it's not like you're proposing
9 what would be the simplest explanation, and I
10 could say that is the most likely. Now there's a
11 lot of complexities and a lot of moving parts in
12 that hypothetical of yours that I don't think I
13 can speculate about.
14 Q Is there a point in annealing, say, the
15 gold layer at which the intensity of the X-ray
16 diffraction peak stops growing?
17 A That's fair.
18 Q Why does it stop growing?
19 A Well, once the -- once the layer reaches
20 a final structure that is no longer changing, the
21 intensity of the peak no longer changes. So once
22 the whole layer is crystallized, then the -- then
23 the intensity of the peak stops changing. Now,
24 actually -- okay. So for this instance where the
25 gold is only two nanometers thick, that -- that's

1 a safe assumption, that the whole layer has
2 crystallized. In a thick layer, the peak
3 intensity could stop growing long before the full
4 layer was crystallized because the X-rays only
5 penetrate to a certain depth. But here, the
6 X-rays are penetrating through the whole film. So
7 that's not -- that's not a relevant consideration.
8 So the answer is yes, once the gold has fully
9 crystallized and is stable, the peak stops
10 growing.
11 Q Would you expect -- would a POSA in 2004
12 have expected it to take longer for a
13 ten-nanometer-thick cobalt iron boron layer to
14 crystallize than it would have taken for a
15 two-nanometer gold layer to crystallize?
16 A Not necessarily. I don't feel
17 comfortable predicting that. Not at the ratio
18 between two and ten.
19 Q Why not?
20 A Because the dynamics of crystallization
21 are not necessarily, you know, that -- they're
22 complicated. The whole -- I can't -- I can't
23 answer that. It's just not possible for me to --
24 that one, I'm not comfortable to try to predict.
25 ATTORNEY WICHMAN: We've been going past

1 an hour. Why don't we take ten minutes here.
2 THE WITNESS: Good.
3 ATTORNEY WICHMAN: Be back at 37 past the
4 hour. Off the record.
5 (A recess was taken.)
6 ATTORNEY WICHMAN: On the record.
7 Q Dr. Bokor, could you open Exhibit 1061,
8 please.
9 A 1061. Cardoso.
10 Q That's right.
11 A Okay. I have it.
12 Q So in your declaration on the '167
13 patent, at paragraph 61, you cite Cardoso
14 Exhibit 1061, page 2273; right?
15 A Right.
16 Q You assert that Cardoso found that cobalt
17 iron boron started to crystallize with annealing
18 and found that cobalt iron films are not
19 amorphous. Is that right?
20 Dr. Bokor?
21 A I said yes. I apologize if you didn't
22 hear me. I'll try to speak up.
23 Q Are you citing Cardoso, Exhibit 1061, for
24 the proposition that annealing amorphous cobalt
25 iron boron will cause it to adopt the crystalline

1 structure of an adjoining layer?
2 A I'm not specifically making that
3 statement on the basis of Cardoso.
4 Q In Cardoso, Exhibit 1061, page 2273, you
5 say that Cardoso describes cobalt iron boron base
6 junctions that comprise cobalt iron boron aluminum
7 oxide cobalt iron boron; right?
8 A 2273.
9 Q The same page you were just looking at.
10 A Are you quoting or just interpreting?
11 Where is that statement? I just want to be with
12 you.
13 Q If you look on 2273, left-hand column,
14 fourth line, referring to in region B clean. I'm
15 sorry. Not there.
16 If you look at Figure 1b, cobalt iron
17 boron-based junctions.
18 A Okay. Wait. In the text. Okay. Hold
19 on. Figure. You're talking about the text in the
20 column where it says Figure 1b?
21 Q The label on top of Figure 1b.
22 A Oh, you want me to look at Figure 1b.
23 Okay. Figure 1b. Okay. So you were -- you were
24 describing what it shows in Figure 1b, not quoting
25 from text. That's what was confusing me. So

1 please repeat your question.
2 Q If you look at page 2273, left-hand
3 column, bottom paragraph, it says, "X-ray
4 measurements of bulk cobalt iron and cobalt iron
5 boron 200-angstrom thick films (Figure 3) confirm
6 that the cobalt iron boron films are not
7 amorphous." Do you see that?
8 A I do. Did you not hear me?
9 Q No. I can't hear you at all.
10 A Oh, I'm not sure what is the problem is.
11 Q When you speak up, we can hear you.
12 A Okay. I'll try to speak a little louder.
13 Normally -- rarely do I have people tell me that I
14 don't speak loud enough. I'll try to speak up.
15 Q So you agree this he -- this is the
16 sentence that you're citing. In fact, you're
17 quoting part of it in your declaration at
18 paragraph 61. Right?
19 A Yeah. Cobalt iron boron films are not
20 amorphous. That's from that sentence.
21 Q And she refers to the existence of a peak
22 at around 45.3 degrees, corresponding to a strong
23 texture enhancement upon annealing; correct?
24 A Yes.
25 Q And the intensity of the peak is much

1 longer for cobalt iron boron films than for cobalt
2 iron; correct?
3 A Correct.
4 Q And in Figure 3, there's data for cobalt
5 iron boron annealed and cobalt iron annealed. Is
6 that right?
7 A Right.
8 Q So they have different diffraction
9 patterns; is that right?
10 A Well, they're not identical. They have
11 similarities and they have differences.
12 Q On page 2273, in the left column, second
13 paragraph from the bottom, Cardoso refers to 111
14 texturing of cobalt iron boron layers; right?
15 A Yes. There was some 111 texturing.
16 Q And she says that that was unexpected;
17 right?
18 A Yes. Yes.
19 Q Yes. Okay. Do you see in Figure 1b, at
20 the top left of page 2273, there is a dark field
21 stem fixture of tunnel junction structures with
22 cobalt iron boron electrodes?
23 A Yes.
24 Q And that structure was annealed to
25 280 degrees Celsius; right?

1 A Right.
2 Q And the structure is cobalt iron boron,
3 aluminum oxide, cobalt iron boron; right?
4 A Right.
5 Q Is it your understanding that Cardoso is
6 referring to the cobalt iron boron films in that
7 structure when she is referring to 111 texturing?
8 A I think there's -- there's some
9 difference there. Figure 3, the statement is with
10 respect to Figure 3. Figure 3, in the caption,
11 describes a simpler structure than in Figure 1.
12 In Figure 3, we just have silicon, silicon
13 dioxide, cobalt iron, or cobalt iron boron. So I
14 don't think that's coming from the structure in
15 Figure 1B.
16 Q Figure 3 concerns a cobalt iron film that
17 is 200 angstroms thick; right?
18 A Right.
19 Q The reference to 111 texturing refers to
20 a cobalt iron film that is 40 angstroms thick;
21 correct?
22 ATTORNEY WILSON: Objection to form.
23 THE WITNESS: That's correct.
24 BY ATTORNEY WICHMAN:
25 Q On the previous page, 2272, on the top

1 right, under experimental details, do you see a
2 reference to the tunnel junction described in this
3 paper?
4 A Yes. Yes.
5 Q And under -- after MnIr 90/X, it says
6 X 40; right?
7 A Right.
8 Q And then underneath it, it says X can be
9 cobalt iron or cobalt iron boron; right?
10 A Right.
11 Q Is the 40 -- does that mean 40 angstroms
12 thick?
13 A I think so.
14 Q So that corresponds to the tunnel
15 junction shown in Figure 1b; right?
16 ATTORNEY WILSON: Objection. Form.
17 THE WITNESS: Right. Figure 1 -- I
18 believe Figure 1 is showing results from the
19 structures that are described in the top of the
20 column on the right-hand side. Can you hear me
21 now?
22 BY ATTORNEY WICHMAN:
23 Q Yes. And so that cobalt iron boron layer
24 in Figure 1b is the one that is 40 angstroms
25 thick; right?

1 A Well, that seems like a reasonable
2 position. It's -- I have to say it seems a little
3 ambiguous which -- no. That is probably it.
4 There is also -- in that stack, there's another
5 layer called Y, which also could be cobalt iron
6 boron. But that's 30. So I think you're -- I
7 think I agree with you, that the -- the result
8 that she is quoting here in 2273 is the -- is most
9 likely the film -- the 40 angstrom X film in the
10 stack.
11 Q And that layer is adjacent to aluminum
12 oxide; right?
13 A It is, right.
14 Q And aluminum oxide is amorphous?
15 A Correct.
16 Q And nonetheless, Cardoso observed after
17 annealing the cobalt iron boron film had some 111
18 texturing; right?
19 A Right. Some. Uh-huh.
20 Q Is that consistent with the stable
21 crystal structure of cobalt iron boron being fcc?
22 A That's consistent, yes.
23 Q If you could go back to your declaration,
24 paragraph 61, on -- where it bleeds over on to
25 PDF page 41, you start to discuss Parkin. Is that

1 correct?
2 A Yes.
3 Q And in the very language that you quote,
4 Parkin is discussing cobalt iron boron storage
5 layer 175 that is deposited adjacent to a
6 magnesium oxide tunnel barrier 121 prime; right?
7 A 120 prime.
8 Q Yes. 120 prime.
9 So can you open Parkin. It is Exhibit
10 1062.
11 A I have it.
12 Q So I just want to make sure that I
13 understand, in Parkin, Figure 3a describes the
14 stack of this device; right?
15 A Right.
16 I'm going to ask you to give me a moment.
17 I'm going to open up another window for Parkin so
18 I can have the figure on my screen simultaneous
19 with the text. Is that okay with you?
20 Q Of course.
21 A Good. Okay.
22 Q So the device layer, there's a layer 119.
23 That's a ferromagnetic layer.
24 A 119. Yes.
25 Q There's a layer 120 prime. That's a

1 magnesium oxide layer.
2 A Right.
3 Q There's a layer 175. That is the
4 amorphous crystalline -- I'm sorry -- the
5 amorphous cobalt iron boron storage layer;
6 correct?
7 A Correct.
8 Q Layer 119 is crystalline; is that
9 correct?
10 A I'm going to have to review that.
11 Q Can I point your attention to column 13,
12 line 10.
13 A Thank you. Okay.
14 Q Parkin Exhibit 1062, column 13, line 10
15 says, "The layer 1115 is preferably formed from a
16 bcc alloy formed from one or more of cobalt and
17 iron." Correct?
18 A Correct.
19 Q And layer 115 comprised of one or more
20 bcc cobalt iron alloys in the 100 orientation and
21 the MTJ 200 displays high TMR; right?
22 That's at columns lines 23 to 25. Is
23 that right?
24 A I'm reading it.
25 I see that.

1 Q And if you go back to Figure 3a, layer
2 115 is actually the top -- it actually refers to
3 having two components, 118 and 119; right?
4 A Yes.
5 Q So that's the ferromagnetic layer in this
6 stack, on the bottom of the MTJ; right?
7 A Yes.
8 Q Then tunnel barrier 120 prime is formed
9 on top of the lower ferromagnetic electrode;
10 right?
11 A Right.
12 Q And that magnesium oxide tunnel barrier
13 120 prime is highly textured with a 100
14 orientation; correct?
15 A That is correct. I'm not looking at the
16 section in the text that says that, but I remember
17 that well.
18 Q Column 18, lines 49 to 50. Right?
19 A Column 18. Highly textured tunnel
20 barriers, yeah.
21 Q Okay. And then this amorphous cobalt
22 iron boron is deposited on top of the highly
23 textured magnesium oxide layer 120 prime to form
24 storage layer 175; right?
25 A Right.

1 Q And then it is annealed; correct?
2 A Right. Let's just -- can you point me to
3 the text? I would like to follow along with
4 the --
5 Q Well, I would like to focus on column 18,
6 lines 51 to 62. So, in fact, this line 51 to 59,
7 you quote at the bottom of your testimony here at
8 paragraph 61; right?
9 A Right.
10 Q The storage layer 175 adjacent to the
11 magnesium oxide tunnel barrier 120 prime is
12 crystallized and is, moreover, textured in the
13 same orientation as the crystalline magnesium
14 oxide tunnel barrier; correct?
15 A Yes.
16 Q Parkin says the simple cubic crystalline
17 MgO layer thus provides a template for the
18 formation of a thin crystalline ferromagnetic
19 layer which has the bcc structure of cobalt iron
20 and is oriented in the same 100 direction as the
21 MgO layer; right?
22 A Right.
23 Q So Parkin is describing what happens when
24 you deposit amorphous cobalt iron boron on top of
25 highly textured magnesium oxide; right?

1 A Right.
2 Q And Parkin also points out that
3 nevertheless, the bulk of the storage layer 175
4 remains amorphous; correct?
5 A Correct.
6 Q And that provides --
7 Okay. Now, if we go back to lines --
8 All right. Does -- is it your
9 understanding that this bcc structure cobalt iron
10 crust or layer within storage layer 175 is formed
11 after an anneal step?
12 A Yes, that's my understanding.
13 Q Okay. So there's a portion of layer 175
14 forms a cobalt -- a bcc structure of cobalt iron,
15 but the bulk of storage layer 175 remains
16 amorphous; is that right?
17 ATTORNEY WILSON: Objection. Form.
18 THE WITNESS: That's what he reports.
19 Yes.
20 BY ATTORNEY WICHMAN:
21 Q Okay. So I want to distinguish between
22 the idea of -- well, how does this support the
23 proposition that annealing amorphous cobalt iron
24 boron electrodes induces formation of a
25 crystalline structure matching an adjoining

1 crystalline layer?
2 ATTORNEY WILSON: Objection. Form.
3 THE WITNESS: It seems -- I'm not sure
4 what the issue is. The -- there's a highly
5 textured 100 MgO tunnel barrier. Then there's a
6 cobalt iron boron layer on top. After annealing,
7 there's a formation of a thin ferromagnetic layer
8 which has the bcc structure of cobalt iron and is
9 oriented in the same 100 direction. Same bcc
10 structure of cobalt iron. The composition of that
11 layer is discussed elsewhere. So I'm not sure if
12 you're asking about that. But the -- this thin
13 crystalline ferromagnetic layer is on top of the
14 MgO and has the matching bcc(100) structure.
15 BY ATTORNEY WICHMAN:
16 Q Does Parkin -- sorry. Go ahead.
17 A That seems -- that seems to meet the
18 description that you gave. What am I missing?
19 Q This is your testimony. It's not my
20 testimony.
21 A Well, you said -- you asked me how does
22 it demonstrate -- repeat the proposition, your
23 question. What does this evidence demonstrate?
24 Let me make sure --
25 Q Does Parkin describe what would have

1 happened if he had deposited an amorphous cobalt
2 iron boron layer followed by depositing magnesium
3 oxide then annealed that composition?
4 A Oh. Doing it the other -- the other way.
5 Q Right.
6 A So it's -- it's a couple of steps there.
7 So when you have cobalt iron boron next to the
8 MgO, where it is layer 175 on top, the cobalt iron
9 boron crystallizes at least in a thin layer.
10 Okay. So now you're asking me, well, what if the
11 cobalt iron boron is underneath and you put MgO on
12 top? Is that the question?
13 Well, first of all, we had a lot of
14 discussion a little earlier about whether or not
15 when you deposit MgO an amorphous layer whether it
16 forms that bcc 100. Based on Jimbo and -- Jimbo
17 and Yoon. You pointed out that the -- those
18 layers were very thick. So how would a person of
19 ordinary skill in the art know what will happen?
20 Well, I said they would be strongly motivated to
21 think that it might. And Parkin's paper I think
22 gives pretty strong evidence that the MgO when
23 deposited on cobalt -- amorphous cobalt iron boron
24 also forms 100 bcc. At least it does when it is
25 being annealed.

1 Now, if the cobalt iron boron is
2 underneath, I believe a person of ordinary skill
3 in the art would have every reason to expect this
4 thin crystallization layer that happened in the
5 other combination would also happen. I said
6 before, I think that what counts in these systems
7 is the interface. And which -- whichever side is
8 on the interface you're on I don't think is --
9 is -- I think either way, one of ordinary skill
10 would expect that to -- that same thing to happen.
11 Q You said Parkin's paper I think gives
12 pretty strong --
13 A Parkin's patent.
14 Q 1062?
15 A Right.
16 Q You agree that Parkin does not describe
17 what happens if you put down an amorphous cobalt
18 iron boron layer, then deposit magnesium oxide in
19 the thickness -- he says 22 angstroms -- and then
20 anneal. Right?
21 A Well, I'm not sure I agree with that.
22 Give me a moment.
23 So your question is does Parkin disclose
24 what happens if an MgO layer is deposited on top
25 of cobalt iron boron? Right?

1 Q Well, I'll just reread my question.
2 You agree that Parkin, Exhibit 1062, does
3 not describe what happens if you put down an
4 amorphous cobalt iron boron layer, then deposit
5 magnesium oxide, to a thickness of 22 angstroms,
6 and then anneal; right?
7 A So I don't agree that Parkin has --
8 doesn't -- doesn't describe that.
9 Q Where does he describe it?
10 A Well, in the whole discussion
11 regarding -- around Figure 11.
12 Q Can you point me to a column and line?
13 A Sure. So let's start in column 22. I
14 think we can skip over most of this, down to line
15 56. "The storage magnetic electrode 510 is formed
16 on the underlayer of 512 by deposition of a layer
17 515 comprising an amorphous ferromagnetic alloy.
18 The electrode may be formed from a wide variety of
19 amorphous ferromagnetic materials but particularly
20 the family of 3d transition metal ferromagnetic
21 alloys combines with glass forming elements. In
22 Figure 11 a layer of 515 of cobalt iron boron is
23 deposited which is 60 angstroms thick. The
24 composition of the layer as determined by RBS. An
25 interface layer 520 of crystalline cobalt iron

1 alloy may also be used."
2 To a person of ordinary skill, that means
3 it may not be used.
4 Subsequently, down in column 23, it says,
5 "An MgO barrier 540 is then formed according to
6 the methods described," et cetera, et cetera.
7 So here, my understanding is that Parkin
8 is describing cobalt iron boron storage electrode
9 510 formed from amorphous ferromagnetic materials.
10 And among those listed, cobalt iron boron, I think
11 is included. Particularly the family of 3d
12 transition metal ferromagnetic alloys combined
13 with glass forming elements, such as boron,
14 Hafnium, et cetera.
15 Then he deposits layer 515 of cobalt iron
16 boron. The interface layer 520 may also be used.
17 That means it may also not be used. So if there's
18 no interface layer of crystalline cobalt iron --
19 of cobalt iron, then there's cobalt iron boron.
20 And then the MgO tunnel barrier 540 is formed. So
21 that's -- that's a disclosure of forming an MgO on
22 top of amorphous cobalt iron boron.
23 Q And where does Parkin describe the
24 crystalline structure of the magnesium oxide
25 barrier layer 540?

1 A Well, he points to a number of other
2 documents. MgO tunnel barrier 540 is then formed
3 according to the methods described in. And then
4 there's a patent application. MgO tunnel barriers
5 and methods of formation. And then another Parkin
6 titled MgO tunnel barriers and methods of
7 formation. And he gives some details. First the
8 layer of magnesium is formed. Followed by 27
9 angstroms MgO which is formed by deposition of
10 magnesium in an argon-oxygen plasma containing
11 3 percent oxygen. Finally the MTJ device is
12 completed by forming the reference magnetic
13 electrode 560 and a capping layer 590. The
14 reference electrode 560 is in an exchange biased
15 ferromagnetic layer, et cetera, et cetera.
16 Now, at the end of the day, this forms an
17 MTJ that -- that -- that shows high TMR. One of
18 ordinary skill would certainly understand that
19 that MgO layer is crystallized.
20 Q What -- what is the crystal form of that
21 MgO layer 540?
22 A It's -- it's the 100 oriented MgO bcc.
23 Q Is it polycrystalline?
24 A Almost certainly.
25 Q Is it crystalline?

1 A It's probably -- it must be
2 polycrystalline. There's no epitaxy there. So
3 it's the well-known deposition of MgO that, like
4 in Jimbo, formed 100 bcc. One of ordinary skill
5 would fully expect that even though this layer is
6 thin, it's 100 textured. I can point to other --
7 let me -- give me a moment. Just, for example,
8 column 24, line 24. "While the preferred
9 embodiments of the current invention apply to
10 structures with 100 texturing for the highest
11 possible TMR or spin polarization values." This
12 is one of the preferred embodiments. It goes --
13 it gets high TMR following the well-known
14 prescription by now that you can get very high TMR
15 with textured 100 MgO tunnel barriers and a
16 suitable ferromagnet. One of ordinary skill would
17 certainly expect and understand that that tunnel
18 barrier in Figure 11 is 100 textured MgO. Even if
19 he doesn't -- I might be missing it. Maybe he
20 doesn't say that explicitly, but that's clearly
21 the message to one of ordinary skill. I could
22 look for more support for that. But this
23 statement that I just read, it should seem to me
24 to be sufficient.
25 Q Dr. Bokor, where in your declaration on

1 the '167 patent do you refer to Figure 11 of
2 Exhibit 1062?
3 A Well, I just checked to be sure. I don't
4 explicitly refer to Figure 11 in my declaration.
5 But the questions that you were just asking me
6 where I refer to Figure 11, you asked me whether
7 there was any disclosure in Parkin. So I don't --
8 I don't refer to that in my declaration, but I was
9 responding to your questions about whether or not
10 Parkin discloses growing MgO on top of an
11 amorphous layer.
12 Q Where in your declaration on the '167
13 patent do you refer to column 22 of Parkin Exhibit
14 1062?
15 ATTORNEY WILSON: Objection. Relevance.
16 THE WITNESS: I just looked. I don't
17 think I do.
18 BY ATTORNEY WICHMAN:
19 Q And in your declaration on the '134
20 patent, where do you refer to Figure 11 of
21 Exhibit 1062?
22 ATTORNEY WILSON: Objection. Relevance.
23 THE WITNESS: I'm pretty sure it's not
24 there either.
25

1 BY ATTORNEY WICHMAN:
2 Q Can you check?
3 A Okay. Is that a hint? Okay. I'll
4 check. Let me open it up. I've got to go up
5 here. Let me make sure that I close the other
6 one.
7 Okay. And we're talking about Parkin
8 1062. So just to make sure that looking for the
9 right thing. You're asking in my declaration if I
10 refer to anything from Exhibit 1062 Parkin in
11 column 22? Is that your question?
12 Q No. My question is where in your
13 declaration on the '134 patent do you refer to
14 Figure 11 of Parkin Exhibit 1062?
15 A Okay. Close enough.
16 Well, I've got to say I looked relatively
17 hard and didn't find it. Do I? Do you know of a
18 place that I do refer to Figure 11 in my
19 declaration that I seem to be missing?
20 Q If you could close that declaration, and
21 let's go back to the declaration on the '167
22 patent.
23 A Okay. All right. I'm back to '167.
24 Q Paragraph 108 at PDF page 63.
25 A All right. I'm there. Paragraph 108.

1 I'm right there.
2 Q Okay. So I just want to understand, you
3 do not offer an opinion whether Claim 2 would have
4 been obvious over Bowen in view of Sunai or Parkin
5 and Soukup; is that right?
6 A Claim 2. Give me a moment. I want to
7 just double-check the patent just to be double
8 sure.
9 This is the 167. Claim 2. I do not
10 offer an opinion on Claim 2.
11 Q Why don't we look at paragraph 107 in
12 your declaration on the '167 patent. Do you see
13 it?
14 A Yes.
15 Q You state that in your opinion Claims 1,
16 3, 5, 7 through 11, and 14 to 15 are obvious over
17 the two grounds presented in this declaration.
18 A Correct.
19 Q So is it correct you have no -- you do
20 not offer an opinion whether claim 4 would have
21 been obvious over either ground in the
22 declaration?
23 A Correct.
24 Q And you do not offer an opinion whether
25 Claim 6 would have been obvious over either ground

1 in the declaration?
2 A Correct.
3 Q And you do not offer an opinion whether
4 Claim 12 would have been obvious over either
5 ground in the petition?
6 A Correct.
7 Q You do not offer an opinion whether
8 Claim 13 would have been obvious over either
9 ground in the petition?
10 A Correct.
11 Q Why not?
12 A I wasn't asked to.
13 Q You weren't asked to. Okay. So you were
14 only asked to form an opinion concerning Claims 1,
15 3, 5, 7 through 11, and 14 and 15; is that right?
16 A Correct.
17 Q If we could talk about Ground 1, starting
18 at paragraph 108. I just want to understand,
19 what -- what are these combinations that you are
20 discussing? How many combinations are in this
21 ground?
22 A Well, one ground is Bowen in view of
23 Sunai or Parkin. You could call that two grounds
24 if -- if you want. It's -- there's two
25 combinations; Bowen and Sunai or Bowen and Parkin.

1 Claim 7, 8 and 14, that ground is Bowen
2 in view of Sunai or Parkin, optionally Soukup. So
3 that's perhaps three grounds. I mean, it depends
4 on how you want to count. But I give -- I give
5 analysis for Bowen in view of Sunai, Bowen in view
6 of Parkin. Claim 7, 8 and 14, I give an analysis
7 Bowen in view of Sunai or Parkin and then bring in
8 Soukup. I figured to both.
9 Q So I just want to understand what, in
10 fact, this combination is. So let's talk about
11 Bowen in view of Sunai. What is that combination?
12 ATTORNEY WILSON: Objection to form.
13 THE WITNESS: I'm not sure I understand
14 the question. Can you clarify?
15 BY ATTORNEY WICHMAN:
16 Q What are the teachings in Bowen that you
17 modify with the teachings in Sunai?
18 A Oh.
19 ATTORNEY WILSON: Objection to form.
20 THE WITNESS: Well, there's -- there's a
21 whole declaration. There's a lot of territory in
22 there. I'm sure you don't want me to read through
23 it all. Can you narrow --
24 BY ATTORNEY WICHMAN:
25 Q Put it this way: If I wanted to

1 determine how you had modified Bowen with the
2 teachings in Sunai, where would I find that
3 information? Would I need to go claim by claim?
4 Or limitation by limitation?
5 A Well, sure. I mean, that's the only --
6 I'm trying to do a careful analysis of each claim,
7 limitation by limitation. I think that --
8 maybe -- I think that the way that the -- let me
9 answer it this way. If I'm understanding what
10 you're getting at --
11 I'm just going through the table of
12 contents here to see if that helps.
13 Claim 1, I offer -- under section 12,
14 Claim 1, I give obviousness over Bowen in view of
15 Sunai or Parkin. And I go through all of the
16 elements of Claim 1. So in each one of those
17 elements, I think I discussed the combination for
18 Bowen and Sunai or Parkin. Each time.
19 Q Okay.
20 A Right. And then in Claim 3, same thing.
21 And so forth. Is that -- is that responsive to
22 your question?
23 Q We'll go on. In paragraph 109 through
24 119, you discuss the preamble of Claim 1, a method
25 of manufacturing a magnetic tunnel junction

1 device; right?
2 A Correct.
3 Q So is it your testimony that Bowen by
4 itself teaches a method of manufacturing of
5 magnetic tunnel junction that meets this preamble?
6 A In this section, I do mention other
7 references for some support. Like Nagahama,
8 Wollschlager, Klaua. I do mention for support
9 some additional details to fill out the picture,
10 so to speak Boubeta. So it's primarily Bowen.
11 Let me pick an example. Like in paragraph 115,
12 Bowen taught that Boubeta provided additional and
13 further details on how Bowen's epitaxial MTJ
14 structures were grown. So in these paragraphs
15 that you just mentioned, you'll -- you'll find
16 some -- some paragraphs that have that character.
17 Q So is it your testimony that Bowen's
18 method of manufacturing includes the teaching of
19 Boubeta Exhibit 1084?
20 A So in this example, I do -- let me just
21 double-check here something.
22 I think that's right. So what I'm saying
23 in paragraph 115, page 57, Bowen taught that --
24 taught that Boubeta provided additional details.
25 And Bowen, on page 1657, cites 1084, which is

1 Boubeta. So if you're asking, well, does Bowen
2 alone teach all of that via the site to Boubeta?
3 I provide some of that information from Boubeta
4 that Bowen cites to just for support, to provide
5 some additional explanation to help whoever is
6 reading this declaration -- primarily the PTAB, I
7 guess, and you and the patent owner and so
8 forth -- what -- what Boubeta adds that I thought
9 was significant. That's one example. I could
10 look through and look at other citations to see
11 if -- comfirm of they're of that similar character
12 or not. Off the top of my head, I don't want to
13 say without reviewing.
14 ATTORNEY WICHMAN: Let's go off the
15 record. It's been an hour.
16 (A recess was taken.)
17 ATTORNEY WICHMAN: On the record.
18 Q Dr. Bokor, could you open Exhibit 1084,
19 please.
20 Do you have it open?
21 A Not yet. Boubeta. Okay. I have it.
22 Q You cite this exhibit in paragraph 115 of
23 your declaration on the '167 patent; right?
24 A I'm sorry. What was the paragraph number
25 that you're citing to in the declaration.

1 Q 115.
2 A 115. Yes.
3 Q In the abstract on page 223, Boubeta is
4 describing insulator on metal epitaxy is also
5 confirmed as MgO layers are found to epitaxially
6 grow on previously deposited iron/MgO/gallium
7 arsenide thin films. Right?
8 A Right.
9 Q It means that they grew by magnesium
10 oxide layers by epitaxy on the iron thin film;
11 right?
12 A Right.
13 Q And they state that iron magnesium oxide
14 superlattices can be fabricated on semiconductor
15 substrates by appropriate selection of growth
16 conditions; right?
17 A Right.
18 Q What's a superlattice?
19 A A superlattice -- let's see here. Isn't
20 there a picture?
21 I know what a superlattice is, but I want
22 to find where it is mentioned in this paper so you
23 have the context. It doesn't say much.
24 Okay. So in general, person of ordinary
25 skill would understand that a superlattice is a --

1 a periodic thin film structure with at least two
2 different layers such as -- okay. I'm looking in
3 page 224 of Boubeta. Left-hand column. First
4 full paragraph. It says, "Up to date, there are
5 very few papers dealing with the epitaxy of
6 metal/insulator superlattices." And then it
7 mentions a few combinations, like silver, nickel
8 oxide, or ti-silver MgO. And a superlattice is
9 where that layer pair -- for example, silver and
10 nickel oxide -- are grown as alternating layers.
11 A layer of silver, a layer of nickel oxide,
12 silver, nickel oxide. To form a periodic
13 structure of layers. Superlattices are generally
14 layered. Usually epitaxial. That's what a
15 superlattice is. He's now referring -- the next
16 sentence down, "Nevertheless, several results are
17 already known on the MgO/gallium arsenide
18 epitaxy."
19 Skipping down a little farther to the end
20 of the paragraph. "Very few works have reported
21 on the epitaxy of MgO on iron 001 or of iron MgO
22 iron tri-layered structures." So the iron MgO
23 iron tri-layer structure is kind of a -- sort of
24 the first stage of a superlattice. It is just a
25 superlattice, which is ABA. Normally a

1 superlattice would be layers like ABABAB. I think
2 Bowen -- by the way, you know Bowen is the same
3 group. Right. Like in Bowen, Figure 1, you can
4 see what's essentially a superlattice there in B.
5 You can see he's got an image of an iron MgO 001
6 multilayer. And you can see there, there are
7 alternating light and dark layers. They're not
8 all the same thickness. Usually a superlattice
9 has all the layers the same thickness.
10 But I think that is what Boubeta is kind
11 of pointing at. He -- they're growing
12 iron/MgO/iron. And this shows that super -- MgO
13 superlattices can be fabricated. So that's what I
14 think he means in the abstract.
15 Q So Bowen describes an iron/MgO/iron
16 cobalt tri-layer grown epitaxially on magnesium
17 oxide buffered gallium arsenide; right?
18 A Right.
19 Q And Bowen has very specific steps for
20 achieving that tri-layer; right?
21 A Fair.
22 Q So the bottom iron electrode is deposited
23 at room temperature onto the MgO buffer layer;
24 right?
25 A Yes. So he says RT, for room

1 temperature, plus annealing at 400C for the iron
2 bottom electrode.
3 Q So Bowen Exhibit 1026, at page 1655, his
4 step for depositing the bottom electrode, first
5 there's a room temperature deposition of iron.
6 Then there is annealing at 400 Celsius. Correct?
7 A Hold on. I don't think that's quite
8 right. Let's see if there is a picture. My
9 understanding of Bowen is a little different than
10 that. Let me just get you support. I can see how
11 it is a little confusing.
12 So if you look on page 1655, as you -- as
13 you pointed to, you see in the last paragraph on
14 the left-hand column, "Iron cobalt/MgO/iron
15 epitaxial structures were grown on a gallium
16 arsenide 001 in a combined sputtering/laser
17 ablation system with a base pressure of 2 times 10
18 to the minus 9 as described elsewhere. We use an
19 MgO buffer layer as an interdiffusion barrier with
20 good electrical insulation characteristics. This
21 prevents the incorporation of arsenic from the
22 substrate into the iron bottom electrode - an
23 important precaution since, in a subsequent step,
24 the MgO barrier" -- a separate layer -- "is grown
25 at 400 C in order to obtain good crystalline."

1 So subsequently he doesn't talk so much
2 about it. But what he's saying here, you don't
3 want to put iron directly on gallium arsenide
4 because that would -- especially the iron bottom
5 electrode. Because then you would get -- isn't
6 there some statement about it somewhere? Then the
7 issue is that you would start to get a chemical
8 reaction between the iron and the arsenic in the
9 gallium arsenide. And I thought for sure there
10 was some mention of that in here. But maybe
11 that's not -- maybe that's not essential to go
12 into.
13 My understanding of Bowen is that he
14 starts with gallium arsenide, grows a MgO buffer
15 layer on top to serve -- to isolate the rest of
16 the structure from the gallium arsenide, which is
17 a highly reactive material. Then he grows the
18 iron on top of that MgO buffer layer. So he says
19 the MgO buffer layer also offers an appropriate
20 symmetry and lattice match for the epitaxy of iron
21 on top. Right. So that MgO buffer layer is under
22 the iron. With the well-known orientation,
23 et cetera. Right. So that's -- so that's the
24 structure.
25 Q The MgO buffer layer provides a lattice

1 match for the iron bottom electrode that is
2 deposited on top; is that right?
3 A Correct. This MgO buffer layer also
4 offers an appropriate symmetry and lattice match
5 for the epitaxy of iron on top.
6 Q The iron bottom electrode is deposited at
7 room temperature on the MgO buffer layer; correct?
8 A So let me read this again. It's the
9 few -- a few lines farther down. I'm on the
10 right-hand column. Page 1655.
11 "Optimal deposition temperatures" --
12 that's towards the bottom of the first paragraph.
13 "Optimal deposition temperatures were 400 degrees
14 C for the MgO. RT" -- room temperature -- "for
15 the iron cobalt top electrode and RT plus
16 annealing at 400C for the iron bottom electrode."
17 So the iron bottom electrode is deposited at room
18 temperature, but then annealed at 400C.
19 Q So the answer to my question is yes?
20 A Yes. I just wanted to get out there the
21 annealing step right after.
22 Q I want to talk about that next.
23 A Okay.
24 Q So the iron has been deposited at room
25 temperature; correct?

1 A Correct.
2 Q Then the stack is annealed at 400
3 Celsius; right?
4 A Right.
5 Q So the only thing that is being annealed
6 are the layers that have already been set down;
7 right?
8 A That's right.
9 Q Is this called an in situ anneal?
10 A It has to be. Does -- can you point --
11 does it say the words in situ somewhere? Or
12 you're asking if that is effectively what's going
13 on?
14 Q I'm asking whether a person of ordinary
15 skill in the art would have understood that this
16 is describing an in situ anneal?
17 A I think that's right.
18 Q So -- go ahead. Are you -- were you
19 going to say something?
20 A No. That -- that -- I'm done.
21 Q Okay. So is it accurate to say that an
22 in situ anneal is an annealing step that takes
23 place within the reaction chamber of where the
24 device is being grown?
25 A Correct.

1 Q And the annealing is at 400 degrees
2 Celsius; right?
3 A Yes. So it states annealing at
4 400 degrees C for the Fe bottom electrode. After
5 the -- then the MgO barrier is deposited. I don't
6 know if you're asking any questions about that
7 yet.
8 Q No. Please listen to my question. I'm
9 just asking about the iron bottom electrode.
10 A Okay.
11 Q All right. And Bowen is very clear that
12 this particular two steps, the low temperature and
13 subsequent annealing process, leads to an optimum
14 iron electrode in terms of crystallinity,
15 continuity and interface sharpness; right?
16 A Yes.
17 Q So Bowen thought it was important that
18 these two steps be done as he has described;
19 right?
20 A Presumably.
21 Q The next step is he grew magnesium oxide
22 at 400 degrees Celsius on top of the iron bottom
23 electrode; right?
24 A Right.
25 Q Okay. Now if we can go back to Exhibit

1084.

A Okay.

Q At page 228.

A All right.

Q There is a header on the top left column that says "Epitaxial iron/magnesium oxide multilayered structures." Right?

A Right.

Q It says that the next step in the fabrication of an iron/magnesium oxide multilayered structure was the epitaxy of magnesium oxide on iron; right?

A Right.

Q And that's what Bowen is doing. Bowen is providing epitaxy of magnesium oxide on this bottom iron electrode?

A Correct.

Q And in the right-hand column of Exhibit 1084, page 228, at the top, Boubeta describes depositing 20 angstrom magnesium oxide layer by laser ablation at 400 degrees Celsius on an iron thin film; right?

A Right.

Q And 20 angstroms is two nanometers?

A Right.

1 Q And that's the same thing that Bowen does
2 when he deposits his magnesium oxide barrier layer
3 on the bottom iron electrode at 400 degrees
4 Celsius; right?
5 A Right. Bowen deposits various
6 thicknesses of MgO layers, but it's the same
7 process otherwise.
8 Q So on the right-hand side of page 228 of
9 Exhibit 1084, the bottom paragraph halfway down,
10 Boubeta says, "In this case, iron films were grown
11 at room temperature and annealed at 400 Celsius
12 while magnesium oxide layers were grown at 400
13 Celsius." Correct?
14 A Right.
15 Q And that's the same thing Bowen describes
16 doing for the iron bottom electrode and then the
17 magnesium oxide barrier layer; correct?
18 A Yes.
19 Q Boubeta explains on Exhibit 1084, page
20 228, on the right-hand column at the top paragraph
21 that the absolute lattice -- I'm sorry. The
22 lattice mismatch between magnesium oxide and iron
23 is of 3.8 percent upon a 45-degree rotation of the
24 magnesium oxide lattice with respect to the iron,
25 which is the equivalent of well-known behavior

1 observed for iron/magnesium oxide 001; right?
2 A Right.
3 Q He says this implies that the magnesium
4 oxide iron interface has a much higher degree of
5 crystalline coherency as compared with the
6 magnesium oxide gallium arsenide interface, and
7 therefore, the crystalline quality of the
8 magnesium oxide is higher when grown on iron than
9 when grown on gallium arsenide; right?
10 A Right.
11 Q So it is important to the process in
12 Boubeta that there be a lattice match between the
13 iron bottom layer and the magnesium oxide layer
14 that is grown on top; right?
15 A Right.
16 Q And that's true of Bowen as well; right?
17 A Right.
18 Q All right. Page 229 of Boubeta,
19 Exhibit 1084, the iron growth temperatures -- let
20 me point you to exactly where it is.
21 A Please.
22 Q He says, on the left-hand column, second
23 paragraph, to show the dramatic influence that
24 iron growth temperature can have on the continuity
25 of an iron MgO multilayered structure, they made

1 another test sample; correct?
2 A Yes.
3 Q And this time, they kept the growth
4 temperature at 400 Celsius during the entire
5 deposition process?
6 A Yes.
7 Q And this resulted in a different -- that
8 was a temperature at which the iron morphology
9 exhibits a strong dendritic character. Is that
10 right?
11 A That's what it says.
12 Q He says that -- what is strong dendritic
13 character?
14 Well, let me strike that. I'll ask you a
15 different question.
16 What would a POSA have understood Boubeta
17 to mean when he says that the iron growth
18 temperature can have a dramatic influence on the
19 continuity of the iron magnesium oxide
20 multilayered structure?
21 A Well, he's comparing essentially the
22 structure from Figure 4b, cross-section -- it's on
23 the previous page 228. The figure in the middle.
24 So he is -- Boubeta is growing multilayers as
25 well, like Bowen did. And here, B is a

1 cross-sectional TEM image. I'm reading from the
2 caption of Figure 4, 4b. Of an iron MgO
3 multilayer with gradually decreasing MgO
4 thickness. The iron layers are 80 angstroms
5 thick, grown at room temperature and annealed at
6 400C. MgO layers 80, 60, 40, and 20 angstroms
7 thick were grown at 200 -- at 400C. And he is
8 comparing that to Figure 5.
9 Page 229, right-hand side, fourth line
10 down, "In Figure 5, we show two XTEM" --
11 cross-sectional TEM, transmission electron
12 microscope -- "images for this structure where
13 again dark and bright contrast regions correspond
14 to iron and MgO, respectively. Big single
15 crystalline iron islands are formed with very flat
16 surfaces parallel to the substrate plane and the
17 in-plane sizes between 130 and 30 nanometers.
18 Some other islands sides also correspond to
19 crystallographic iron planes, as indicated in
20 Figure 5b. On the other hand, MgO layers are
21 observed to cover the empty spaces left by the
22 iron islands."
23 Okay. So what he is saying is -- he's
24 comparing this -- the growth where the growth
25 temperature was kept at 400C during the entire

1 deposition. You get Figure 5. But if you grow
2 iron at room temperature and then anneal, you get
3 Figure 4b. 4b, you get a nice continuous flat
4 uniform thickness layers. Whereas what you have
5 in Figure 5b, I think that's what he's
6 characterizing as dendritic. Much more -- there's
7 order in there, but it is a much more different
8 type of order compared to what we got in the
9 Figure 4b.
10 Q On this page 229, in Exhibit 1084, the
11 bottom right, under Conclusions, Boubeta says
12 that -- there's a second step. Epitaxy of
13 magnesium oxide thin films on the previously
14 deposited iron layers is also demonstrated,
15 opening new directions for the fabrication of
16 fully epitaxial metal/insulator heterostructures
17 on semiconductor substrates; right?
18 A Right.
19 Q And that's what Bowen did; right?
20 A Bowen grew a fully epitaxial
21 metal/insulator structure.
22 Q And then he says, "To confirm this
23 assertion, two iron magnesium oxide multilayered
24 epitaxial heterostructures have been fabricated
25 following different thermal procedures." Right?

1 A Right.
2 Q And he says, "These structures can
3 exhibit continuous and flat interfaces if
4 appropriate growth conditions are selected." Is
5 that right?
6 A Right.
7 Q So is a growth condition -- strike that.
8 When Bowen describes depositing iron at
9 room temperature on 001 MgO buffer layer and then
10 annealing at 400 Celsius, is that -- are those
11 growth conditions?
12 A Yes.
13 Q Are they each a growth condition?
14 A You could say that. I mean, you know,
15 you could say that each -- each -- each step in
16 the growth has certain conditions. Growth
17 condition. Some literature would just describe
18 the entire -- would characterize the entire
19 process as growth conditions. It's not very
20 distinctive.
21 Q Okay. When Boubeta -- go ahead.
22 A It could be the whole process. In some
23 context, you might characterize the growth
24 condition for a single layer.
25 Q When Boubeta refers to appropriate growth

1 conditions, does that mean iron films grown at
2 room temperature and annealed at 400 Celsius while
3 magnesium oxide layers were grown at 400 Celsius?
4 A That would seem to be the implication of
5 what he is saying here.
6 Q So that is an appropriate growth
7 condition?
8 A For this -- for this particular system,
9 yes.
10 Q And this is what results in structures
11 that exhibit continuous and flat interfaces?
12 A Right.
13 Q And in Bowen, was it important to have
14 continuous and flat interfaces between each layer
15 of the magnetotunnel junction?
16 A Sure.
17 Q So would a person of ordinary skill in
18 the art understood that if the growth conditions
19 were changed, you could not be assured of
20 achieving continuous and flat interfaces in
21 Bowen's magnetic tunnel junction?
22 A Perhaps, yeah. In general.
23 Q Why -- why are you uncertain?
24 A Well, here, it does show a particular set
25 of growth conditions that would lead to continuous

1 sharp interfaces and uniform thickness. What was
2 the quote that you were using? Sorry. I lost it.
3 Hold on. Hold on.
4 Q Page 1655 of Exhibit 1026, right-hand
5 column, last sentence of the first paragraph.
6 A I'm sorry. 1026. Now we're back to
7 Bowen. Okay. Right. Sorry. I was looking at
8 Boubeta. What was your cite in Bowen? 1026.
9 Which page?
10 Q Page 1655, PDF page 2, right-hand column.
11 First paragraph, last sentence.
12 A Continuous and good quality MgO films
13 with sharp interfaces? That's what you're
14 referring to? Right?
15 Q Well, that's what you were referring to.
16 A Yeah. I'm just trying to make sure that
17 I'm talking about the same language as you.
18 Okay. So Boubeta and Bowen describe a
19 set of growth conditions that leads to continuous
20 and good crystal quality MgO films with sharp
21 interfaces, all the way down to the thinnest oxide
22 layer. And iron MgO indicative of the
23 crystallinity and high quality of the structure.
24 So one set of growth conditions is
25 provided here to get that -- to achieve that goal.

1 That doesn't mean these are the only possible --
2 what I was trying to say, this doesn't mean that
3 this is the only possible growth conditions. This
4 is one set of growth conditions that was found to
5 be effective for achieving this particular
6 structure. It doesn't say that there's no other
7 possible set of growth conditions you might come
8 up with to get similarly good results. That's the
9 point that I wanted to make here.
10 Q Okay. So in Bowen, after the magnesium
11 oxide has been grown at 400 Celsius on top of the
12 crystalline iron bottom electrode, Bowen provides
13 a room temperature deposition of iron cobalt for
14 the top electrode; right?
15 A Right.
16 Q And he finds that that room temperature
17 deposition achieves a crystalline iron cobalt 001
18 top electrode; right?
19 It's right there in the diffraction
20 pattern on Figure 1a on page 1656.
21 A Okay.
22 Q Do you agree?
23 A Yeah.
24 Q Okay. You agree that the only anneal
25 step in Bowen's process is when he anneals the

1 bottom iron electrode after the room temperature
2 deposition; correct?
3 A Are you saying he didn't anneal the iron
4 cobalt?
5 Q Yes.
6 A Oh. Let me check that.
7 That's -- that's somewhat surprising. I
8 didn't catch that before when I read this paper
9 many times. You're right, he doesn't specify a
10 second anneal step for the iron cobalt top
11 electrode.
12 Q So the only annealing that Bowen
13 describes doing is at 400 Celsius after depositing
14 the bottom iron electrode at room temperature?
15 A That seems to be what he is saying here.
16 I -- I have a problem with that. It doesn't sound
17 plausible to me. I agree with you; he doesn't
18 specifically say that the top iron electrode is
19 annealed. But in these -- you know, if you look
20 at Figure 1, the multilayer structure, he has to
21 be continuing to increase the temperature to
22 deposit those subsequent MgO layers. So the iron
23 is getting annealed.
24 Q Well --
25 A And so that part puzzles me. But I

1 can't -- I can't dispute what you're saying, that
2 it apparently doesn't say the upper iron cobalt
3 layer was annealed.
4 Q I just want to be clear. You're pointing
5 to the superlattice in Figure 1b, which is a
6 cross-section TEM image of an iron magnesium oxide
7 001 multilayer with gradually decreasing magnesium
8 oxide layer thickness; right?
9 A That's right. It's a different -- it's a
10 different structure. Yes. It's surprising to me
11 that that -- that that iron cobalt layer on top
12 was not also annealed. I don't know if that's
13 an -- whether that's an oversight or if it's
14 definite. I'm looking at Boubeta just to see if
15 that gives us any further insight. All right.
16 Let's -- let's move along and see where that goes.
17 Q You agree that if a device is annealed,
18 every layer in the stack is subject to that
19 annealing; correct?
20 A That's right.
21 ATTORNEY WILSON: Objection to form.
22 BY ATTORNEY WICHMAN:
23 Q So in this situation, if there were --
24 what would you -- what would a POSA have
25 understood a post-anneal to describe in a

1 situation where someone said we will anneal the
2 tri-layer stack?
3 A Just what -- I'm not sure how to expand
4 on what you just said. It seems quite
5 self-evident.
6 Q So in a post-anneal, would the device be
7 removed from the reaction chamber?
8 A Not -- it could go either way. That
9 wouldn't -- that wouldn't necessarily require
10 taking the device out and annealing it separately.
11 It would perhaps suggest that, but I don't think
12 it's not definitive. You could do post-anneal in
13 the growth chamber too. More than likely. What's
14 the context here? Was there a post-anneal
15 specified in one of these or somewhere else in
16 the -- in the -- my declaration or in the patent?
17 Q I just want to understand the distinction
18 in the art between a post-anneal and an in-situ
19 anneal.
20 A Yeah. I think to a person of ordinary
21 skill, if you say post-anneal -- if you say
22 post-anneal, most likely it is -- it is taking
23 the -- the sample out of the growth chamber and
24 then annealing it in a separate apparatus. But I
25 would have to see the context to know for sure.

1 Because I think it is also not impossible or
2 not -- it's also possible that the post-anneal was
3 done after the -- all the layers were done. And
4 then we did a final post-anneal in situ. That's
5 possible. I would have to look at the context to
6 see if I could be sure one way or the other.
7 Q I want to talk specifically about Bowen
8 now.
9 A Okay.
10 Q When Bowen epitaxially grows his single
11 crystal magnesium oxide layer at 400 Celsius on
12 the crystalline iron bottom electrode, he already
13 achieves a near perfect single crystal magnesium
14 oxide 001; right?
15 A Right.
16 Q What would be the point of annealing that
17 stack after he has grown a nearly perfect
18 magnesium oxide 001 layer?
19 A Well, the post-anneal would occur after
20 the growth of the next -- of the entire structure.
21 So after he deposits the iron cobalt top layer, a
22 post-anneal -- this is what -- this is what I've
23 been puzzling about. It -- I would have expected
24 that he does another anneal to anneal that top
25 iron cobalt layer. That would be the purpose of

1 the post-anneal. Does he -- does he --
2 Q I'm sorry. Go ahead.
3 A Does he -- does he specify a post-anneal?
4 I didn't see that. I was looking for it.
5 Q I thought you just agreed that he does
6 not?
7 A Yeah. Well, you brought it up, so that's
8 why I was wondering.
9 Q Okay.
10 A A post-anneal would be -- I would expect
11 a post-anneal for this structure. But that
12 doesn't specify it in Bowen.
13 Q Can -- can a crystal layer be annealed --
14 what happens if you anneal a crystal layer too
15 long?
16 ATTORNEY WILSON: Objection. Form.
17 THE WITNESS: Well, the definition of too
18 long would depend on what you were concerned about
19 happening. So if you anneal a structure too long,
20 something bad happens. But exactly what depends
21 on the context. A number of things could go wrong
22 if you anneal for an extended length of time.
23 BY ATTORNEY WICHMAN:
24 Q Can you give me two examples?
25 A Two examples. I don't think I can give

1 examples out of context. You know, in a
2 particular situation for a particular set of
3 growth conditions, for a particular set of
4 materials, an anneal that went too long could have
5 all sorts of possible -- you know, the -- there
6 could be delamination. There could -- it depends
7 on what the atmosphere was for the anneal,
8 whether -- you know, eventually you would get some
9 diffusion of some gas through the structure that
10 would cause some damage. There are all kinds of
11 ways that things could go wrong. Just saying too
12 long doesn't specify what's the consequent bad
13 effect of the long anneal. And out of context,
14 I -- I am -- I'm not willing to speculate on what
15 kind of bad things could happen in general.
16 Q So in Bowen's device now, if we modified
17 Bowen's process, its fabrication method, and
18 instead of depositing iron at room temperature for
19 the bottom electrode, we deposited cobalt iron
20 boron for the bottom electrode, what would happen
21 when you then annealed that layer at 400 Celsius?
22 ATTORNEY WILSON: Objection. Form.
23 THE WITNESS: Right off the top of my
24 head, I can't answer that question. We would -- I
25 would have to go look through -- I don't -- if

1 you -- if you are aware of a -- somewhere in all
2 of the literature where somebody did that, we
3 could -- I would be happy to look at that. But I
4 can't -- I'm unwilling to speculate just off the
5 top of my head what would happen. You're talking
6 about a cobalt iron boron layer with nothing else
7 on top of it. Is that right?
8 BY ATTORNEY WICHMAN:
9 Q Yes.
10 A Yeah. I don't know -- I don't know
11 what -- what -- what that might -- what might
12 happen in that situation. I can't speculate.
13 Q And what would a person of ordinary skill
14 in the art in 2004 have expected to have if in
15 Bowen's process they deposited amorphous cobalt
16 iron boron at room temperature on that magnesium
17 oxide buffer layer and then annealed at 400
18 Celsius?
19 ATTORNEY WILSON: Objection. Form.
20 THE WITNESS: I want to make sure that I
21 got the scenario. You're saying that you deposit
22 cobalt iron boron on MgO?
23 BY ATTORNEY WICHMAN:
24 Q I'm saying that we follow Bowen's
25 fabrication process exactly as we just discussed.

1 And when we reach the step when he deposits the
2 iron bottom electrode at room temperature, we
3 modify that to deposit cobalt iron boron at room
4 temperature, and then take the next step in
5 Bowen's process of annealing at 400 Celsius.
6 ATTORNEY WILSON: Objection. Form.
7 Relevance.
8 THE WITNESS: I don't recall anywhere
9 right off the top of my head as I sit here any
10 references that describe a process like that. And
11 I think it's -- I -- I'm unwilling to try to
12 predict. An uncapped cobalt iron boron layer that
13 would be annealed -- yeah, that -- I want to read
14 through the references to see if anybody did that.
15 Off the top of my head, I don't recall such a
16 situation. I'm not saying it's not anywhere in
17 the references. I just don't recall that. And
18 without having something to refer to, I -- I'm not
19 willing to speculate.
20 BY ATTORNEY WICHMAN:
21 Q In paragraph 125 of your declaration, on
22 the '167 patent, you state it would have been
23 obvious to replace Bowen's iron layer with
24 amorphous cobalt iron boron layer, as taught by
25 Sunai, including to improve TMR in lower Hf and

1 Hc. Do you see that?
2 A Say again what paragraph you're on.
3 Q 125.
4 A Yeah. So I don't necessarily suggest
5 here in paragraph 125 to follow Bowen's conditions
6 precisely. Where you would deposit the cobalt
7 iron boron layer and then anneal it before
8 depositing something else on top. Especially the
9 magnesium oxide. I think that's what Parkin did,
10 or taught. So it would have been obvious to
11 replace Bowen's iron layer, but with a modified
12 set of growth conditions. Because I -- you know,
13 I'm concerned to predict what would happen to
14 cobalt iron boron if it is annealed just either in
15 vacuum or -- certainly not in the air. In vacuum
16 with nothing on top. I think it would be more
17 obvious to deposit the MgO layer first.
18 Q Dr. Bokor, where -- in your declaration
19 on the '167 patent, where do you describe
20 modifying Bowen to avoid the anneal step after the
21 room temperature deposition of the bottom
22 electrode?
23 A So I don't have explicit discussion of
24 that. Again, in the context of the art, for
25 example, Sunai -- not Sunai, sorry. Cardoso.

1 Cardoso deposits all the layers and then anneals.
2 I believe. And I think a person of ordinary skill
3 starting to work with CoFeB, cobalt iron boron,
4 would have natural reticence to anneal that
5 without a layer on top. And Cardoso would also
6 give a person of ordinary skill that -- that idea,
7 that suggestion.
8 Q And where do you suggest that teaching
9 from Cardoso in your declaration on the '167
10 patent in Ground 1?
11 A We have to put together different
12 elements. I do point out in my declaration in
13 '167 declaration, paragraph 59, the end of that
14 paragraph, I say Cardoso fabricated cobalt iron
15 boron electrodes and found higher TMRs,
16 particularly after annealing. And if you look in
17 Cardoso, the anneal is done after the structure is
18 complete. So a person of ordinary skill trying to
19 modify Bowen to incorporate cobalt iron boron
20 would be aware of Cardoso, who did the anneal when
21 the -- both cobalt iron boron layers had
22 additional layers on top to prevent any -- any
23 negative effects to the free cobalt iron boron
24 surface during an anneal. That's what I'm --
25 that's what I'm saying. I think a person of

1 ordinary skill would have that concern. Do I
2 explicitly call that out in my discussion of
3 Bowen? I don't.
4 Q Dr. Bokor, do you remember when we
5 started this latest session, I asked you where
6 would a person look to identify what teachings in
7 Bowen you are modifying with Sunai or Parkin to
8 achieve the combination that you are asserting to
9 render these claims invalid? Do you remember
10 that?
11 A You asked me where I would modify Bowen
12 in light of Sunai.
13 Q No. If I were trying to understand what
14 this combination was, how the teachings in Bowen
15 were modified with the teachings in Sunai or the
16 teachings in Parkin, where would I find that
17 information. And you said we would go limitation
18 by limitation.
19 A Yes.
20 Q Okay. So now I'm -- your combination is
21 not Bowen in view of Sunai and further in view of
22 Cardoso; right?
23 ATTORNEY WILSON: Objection. Form.
24 Relevance.
25 THE WITNESS: I didn't --

1 BY ATTORNEY WICHMAN:
2 Q I mean that is just not the combination
3 in Ground 1 does not identify Cardoso as part of
4 the combination; right?
5 ATTORNEY WILSON: Objection. Form.
6 Relevance.
7 THE WITNESS: Okay. Hold on.
8 I'm a little -- I'm not quite sure what
9 you're referring to. In my declaration, for
10 example, talking about Claim 1a, paragraph 120,
11 Bowen in view of Sunai or Parkin, now, in this
12 section where I'm talking about Bowen in view of
13 Sunai -- paragraph 125 -- further down. Paragraph
14 127. Sunai explained that cobalt iron boron was a
15 superior material compared to iron or cobalt to
16 iron. For example, Sunai taught that cobalt iron
17 boron electrodes improved the TMR of an MTJ
18 compared to cobalt iron. Exhibit 1030 Sunai,
19 paragraph 27 to 28. Discussing improved TMR
20 resulting from adding boron to cobalt iron. See
21 also Exhibit 1061 Cardoso, at abstract. Cobalt
22 iron base junctions RA equal 500 micron squared
23 have lower TMR, 35 and larger Hf and Hc compared
24 to cobalt iron boron-based junctions. Cobalt iron
25 was also known to increase TMR related to iron,

1 referring to Moodera.
2 So I'm pointing to Cardoso in my -- in
3 this combination of Bowen with Sunai. Now, I
4 didn't point specifically to the issue that you're
5 raising about whether you -- when exactly you
6 anneal the cobalt iron boron when you substitute
7 it for the iron in Bowen. But I point to Cardoso.
8 And a person of ordinary skill would be aware of
9 Cardoso and that aspect, that Cardoso annealed the
10 structure with all of the cobalt iron boron buried
11 beneath other layers. So I didn't explicitly -- I
12 didn't -- I didn't anticipate a need to explicitly
13 talk about this issue that you're bringing up.
14 But it's inherent in my discussion about this
15 combination because I point the person of -- I
16 point to Cardoso, the abstract, as what -- as what
17 a person of ordinary skill in the art would be
18 aware of. And so I think a person of ordinary
19 skill in the art would read Cardoso and understand
20 probably not a good idea to anneal the first
21 ferromagnetic of cobalt iron boron itself before
22 you put the MgO on and put the next cobalt iron
23 boron layer if you're going to do both.
24 That -- that I think is something that a
25 person of ordinary skill in the art looking at

1 Cardoso would -- would take, take on and fold into
2 the practice of this technology.
3 BY ATTORNEY WICHMAN:
4 Q So in your declaration on the '167
5 patent, at paragraph 127, that is under a section
6 for limitation 1a which recites forming a first
7 cobalt iron boron layer that is amorphous. Is
8 that right?
9 A Well, yes. I picked that -- yes. I
10 picked that as an example where in making the
11 combination I point to Cardoso.
12 Q And in paragraph 127, you cite the
13 abstract in Cardoso to support the proposition
14 that Sunai explained that cobalt iron boron was a
15 superior material compared to iron or cobalt iron
16 electrodes; is that right?
17 A Right.
18 Q And it's your testimony today that
19 paragraph 127 means that you would have modified
20 the teachings in Bowen to alter his in-situ anneal
21 at 400 Celsius of the bottom electrode? Is that
22 your testimony?
23 A That's just one -- there's a better
24 place. I was looking for an example where I
25 pointed to Cardoso in the context of Claim 1. But

1 in terms of -- let's get a little more specific
2 here. I think it's Bowen in view of Parkin where
3 we get a better view of that. One moment. I just
4 want to be in the right place. Yeah. Okay. So
5 for this -- for this particular issue, we should
6 really be looking at Claim 1D. Right. Annealing
7 the first and second cobalt iron boron layers and
8 the MgO layer. That's -- that's the right -- I
9 think to address the issue that you're bringing
10 up, when do you anneal the cobalt iron boron,
11 it's -- it's discussed in -- better -- better
12 addressed in this -- starting in Claim 1 -- in
13 paragraph 149 on page 74 of the declaration.
14 Annealing the first and second cobalt iron boron
15 layers. Bowen, in view of Sunai or Parkin. I
16 cite to Cardoso again here. As well as Jimbo.
17 Right.
18 So Cardoso, if I go down to paragraph
19 154, where it spills over to page 76, Cardoso
20 taught annealing its cobalt iron boron tunnel
21 junction structure, including both upper and lower
22 cobalt iron boron electrodes and barrier layer.
23 Paragraph 155, it was obvious and a
24 skilled artisan would have been motivated to
25 anneal the cobalt iron boron and MgO barrier

1 layers to improve TMR and crystallize the layers.
2 So this is talking about Bowen, in view
3 of Sunai and Parkin. Sunai and Parkin's teachings
4 modified Bowen more significantly than simply
5 substituting the cobalt iron boron instead of the
6 iron and then doing an anneal. So Bowen teaches
7 doing -- depositing the iron and doing an anneal
8 before depositing the MgO. Bowen in view of Sunai
9 and Parkin involves a different set of steps.
10 Q Paragraph 156 of your declaration on the
11 '167 patent, this is under your mapping to
12 Limitation 1D.
13 A Right.
14 Q Correct?
15 A Right.
16 Q You rely on Bowen's annealing step for
17 the iron electrode. And you state, quoting Bowen,
18 that this optimized growth condition results in
19 entirely epitaxial samples of high crystalline
20 quality with flat, sharp interfaces resulting in
21 27 percent TMR at 300 Kelvin, which increases to
22 60 percent at 30 Kelvin. Correct?
23 A Right.
24 Q So now it's your testimony that the
25 combination of Bowen in view of Sunai or Bowen in

1 view of Parkin does not include this anneal step
2 in Bowen?
3 A It's not the identical anneal process in
4 Bowen. The last sentence of that paragraph says
5 it was understood that annealing was beneficial
6 and led to higher TMRs. A person of ordinary
7 skill after studying Sunai and Parkin, as well as
8 Cardoso, would use that to modify Bowen. Bowen
9 teaches that annealing is important. Annealing is
10 important. But Sunai and Parkin, particularly
11 Parkin here, teach that a different set of -- a
12 different set of conditions, but include an
13 anneal.
14 So Bowen teaches crystalline ferromagnet,
15 crystalline tunnel barrier, crystalline
16 ferromagnet. Substitution of cobalt iron boron
17 for Bowen's iron require a different set of
18 process conditions, which a person of ordinary
19 skill would get by studying in particular Parkin
20 but Cardoso. And I do reference Cardoso here. So
21 it doesn't mean that you follow Bowen -- okay.
22 I'm going to stop. That's my -- that's -- that's
23 my answer to your question.
24 Q So I'll ask you again, where in your
25 declaration on the '167 patent do you testify that

1 the combination of Bowen in view of Sunai or Bowen
2 in view of Parkin modifies Bowen to remove the
3 step of annealing the bottom electrode after a
4 room temperature deposition?
5 ATTORNEY WILSON: Objection. Asked and
6 answered.
7 THE WITNESS: I -- I don't have language
8 that -- as explicit as you're mentioning. I think
9 that that -- I'm saying that. That is inherent in
10 the combinations that I lay out in -- in my
11 declaration.
12 BY ATTORNEY WICHMAN:
13 Q Tell me what you mean by the word
14 inherent.
15 A The teaching of Parkin teaches a set of
16 anneals to do. What I'm saying is a person of
17 ordinary skill looking at Bowen understands that
18 an anneal is important. Substituting the material
19 of the ferromagnet -- of the ferromagnetic
20 electrode in the stack, a person of ordinary skill
21 in the art would well understand that the
22 annealing sequence might -- might vary. I'm
23 saying that's inherent in the general knowledge of
24 a person of ordinary skill in the art, without me
25 pointing to a reference. A person of ordinary

1 skill in the art would understand that when you
2 vary the materials in a -- any multilayer stack,
3 modifying the annealing conditions is -- is
4 obvious. That's just part of the general
5 knowledge of a person of ordinary skill. After --
6 with that knowledge and the reading of Parkin, a
7 person of ordinary skill in the art would have
8 enough information to understand how to modify
9 Bowen in view of Parkin to have cobalt iron boron
10 layers that are crystallized by annealing in the
11 stack.
12 Q Just a few more questions and then let's
13 take a break.
14 In paragraph 125 of your declaration on
15 the '167 patent -- tell me when you're there.
16 A 125. I'm there.
17 Q The first sentence reads, "It would have
18 been obvious to replace Bowen's iron layer with an
19 amorphous cobalt iron boron layer, as taught by
20 Sunai, including to improve TMR and lower Hf and
21 Hc." Is that right?
22 A Right.
23 Q Sunai achieved a maximum TMR of below
24 25 percent; isn't that right?
25 A I would have to pull up Sunai. I don't

1 recall that directly. But let's --
2 Q It's Exhibit 1030, Figure 3.
3 Third-to-last page.
4 A I've got it pulled up. I've got Sunai.
5 What paragraph?
6 Q Figure 3, third-to-last page. Top right.
7 A Okay. 20 -- slightly less than
8 25 percent.
9 Q And Bowen achieved TMRs of 27 percent at
10 300 Kelvin and 60 percent at 30 Kelvin; correct?
11 A Correct.
12 Q So if a POSA wanted to improve the TMR of
13 an MTJ starting with Bowen, why would they look to
14 the teachings of Sunai, who achieved a worst TMR?
15 A Sorry. I'm looking carefully at Sunai.
16 Because I think there's another difference.
17 I believe that in Sunai, the data there
18 was for an aluminum oxide barrier. Whereas Bowen
19 has an MgO barrier. Sunai taught that cobalt iron
20 boron electrodes improve the TMR compared to
21 cobalt iron. Sunai's TMR was low because he was
22 using aluminum oxide. So combining Sunai with
23 Bowen, Bowen teaches to use magnesium oxide. So a
24 person of ordinary skill would take the cobalt
25 iron boron from Sunai and put it together with

1 an MgO barrier to get an improvement.
2 Q So you just said that Sunai taught that
3 cobalt iron boron electrodes improve the TMR
4 compared to cobalt iron; correct?
5 A Well, that was one statement in there.
6 Hold on. In paragraph 127 of my declaration, I
7 state that Sunai explained that cobalt iron boron
8 was a superior material compared to iron or cobalt
9 iron.
10 Q Where does Sunai describe cobalt iron
11 boron as superior to iron?
12 A Okay. I point to Moodera for that.
13 Sorry. Hold on. Okay. I'm having trouble
14 finding that. But let's stick with cobalt iron
15 boron is superior to cobalt iron.
16 Q In the combination, you are replacing
17 Bowen's iron bottom electrode with cobalt iron
18 boron; correct?
19 A Correct.
20 Q So why would it matter to a POSA what
21 Sunai had to say about a comparison between cobalt
22 iron boron and cobalt iron if the relevant
23 comparison was Sunai's cobalt iron boron to
24 Bowen's iron?
25 A So there's a discussion about this

1 general idea of substituting cobalt iron boron,
2 paragraph 129 in my declaration. "One of skill
3 would have been motivated to replace either or
4 both of Bowen's MTJ electrodes with a cobalt iron
5 boron layer. Changing up the ferromagnetic
6 materials of the electrodes had long been an area
7 of research to find improvements in TMR. Almost a
8 decade before the '167 patent, a 1995 paper by
9 Moodera taught forming FM/I/FM think film planar
10 tunnel junctions prepared in a high vacuum
11 evaporation system and trying different cobalt,
12 iron, and cobalt iron alloys for the top and
13 bottom electrodes."
14 And then there's a cite from Moodera.
15 "Cobalt, iron, and nickel iron and cobalt iron
16 alloys were tried in this study as both bottom and
17 top electrodes. The best results were obtained
18 with cobalt iron bottom electrode and cobalt or
19 nickel iron top electrode. With iron films as one
20 of the electrodes, for the thickness range of A1
21 used, the junctions were too low in resistance."
22 Moodera, page 3274. "Others in the
23 literature had already suggested using cobalt iron
24 boron in both top and bottom electrodes. Wang
25 found such a large increase of TMR by changing the

1 free layer to cobalt iron boron, it is natural to
2 replace the free and pinned layers to cobalt iron
3 boron to further increase the TMR value." Cite of
4 Wang, page 2270.
5 "Similarly, Hosomi explained that both
6 the ferromagnetic layers 5, 7 are made of a cobalt
7 iron boron to achieve improvement of the TMR
8 ratio. Experimenting with different ferromagnetic
9 layers to improve TMR and tunneling was widely
10 known and an obvious modification."
11 Okay. That's finish quoting.
12 There was -- this -- this paragraph is
13 pointing to a number of references that had -- had
14 shown advantages of using cobalt iron boron as the
15 ferromagnetic layer in a magnetic tunnel junction.
16 So a person of ordinary skill in the art, in light
17 of all of the art that I cited in this paragraph,
18 would have been motivated to substitute the
19 ferromagnetic electrodes in Bowen together with
20 the MgO barrier and to switch to cobalt iron
21 boron. That's what -- that's where it says this
22 in my declaration.
23 ATTORNEY WICHMAN: Off the record.
24 (A recess was taken.)
25 ATTORNEY WICHMAN: On the record, please.

1 Q Dr. Bokor, do you have Bowen in front of
2 you, Exhibit 1026?
3 A Yes.
4 Q On page 1655, the authors are listed;
5 correct?
6 A Yes.
7 Q So you see Boubeta, Cebollada, Briones,
8 Cornet. Those are all co-authors on this paper;
9 right?
10 A Right.
11 Q And they are also authors on Exhibit
12 1084, Boubeta; right?
13 A There's quite -- let's see. One, two,
14 three, four, five, six. They're not all --
15 they're not all the same. But a lot of them are
16 on both. Navarro doesn't seem to be on Bowen.
17 Cebollada, he's on both. Briones, he's on both.
18 Peiro and Cornet. There are quite a few authors
19 in common.
20 Q On Bowen, Exhibit 1026, page 1655, the
21 fourth named author is A. Fert; right?
22 A Yes.
23 Q Do you recognize that as Albert Fert?
24 A Yes.
25 Q In 2007, Albert Fert went on to --

1 received a Nobel prize in physics for the
2 discovery of giant magnetoresistance; is that
3 correct?
4 A To the best of my recollection. I'll
5 take your word for the date.
6 Q If you could look at Exhibit 1057, at
7 page 7, it is PDF page 26.
8 A 1057. Okay. Oh, back to Dieny. I think
9 I still have that up.
10 All right. What was the page again,
11 please?
12 Q Seven.
13 A Page 7.
14 Q Are you there?
15 A Not quite. There's a lot of pages of --
16 page 7. I'm there.
17 Q Section 1.1.3, Discovery of GMR and Early
18 GMR Developments. Did I read that correctly?
19 A I see that.
20 Q If you drop down in that first paragraph,
21 "GMR was actually discovered in magnetic metallic
22 multilayers." Correct?
23 A I see that.
24 Q "This discovery by Albert Fert in Orsay,
25 France, and Peter Grunberg in Julich, Germany, in

1988."

Do you see that?

A Yes.

Q Bottom of this paragraph, last sentence -- or second-to-the-last sentence. "This discovery of GMR is considered the starting point of spinelectronics or spintronics." Right?

A Right.

Q And you tell us that's your field, spintronics?

A I work in the field of spintronics. One of the -- one of the areas that I work in, yes.

Q Next sentence. "Almost immediately, GMR attracted enormous interest both from the point of view of fundamental physics and also for its possible applications, especially in the fields of data storage and magnetic field sensors." Correct?

A Right.

Q "Fert and Grunberg were awarded the Nobel Prize in Physics in 2007 for this discovery."

A Yes.

Q Do you have any reason to doubt the accuracy of this information --

A No.

1 Q -- in Exhibit 1057?
2 A No. That all sounds consistent with my
3 understanding.
4 Q And you recognize that A. Fert on the
5 Bowen paper, working in Orsay, France, is the
6 Albert Fert who later became a Nobel laureate in
7 physics; right?
8 A Right.
9 Q Do you agree that the authors on Bowen's
10 paper were persons of ordinary skill in the art?
11 A At least.
12 Q So this group of people, including a
13 future Nobel laureate in the field of spintronics,
14 if it was so obvious to improve the TMR of a
15 magnetotunnel junction by replacing the iron layer
16 with a cobalt iron boron amorphous layer, why
17 didn't they do it?
18 ATTORNEY WILSON: Objection. Form.
19 Relevance.
20 THE WITNESS: Well, your guess is as good
21 as mine, you know. People -- scientists follow
22 different paths for different reasons. They come
23 up with different ideas. I can't possibly answer
24 that question.
25

1 BY ATTORNEY WICHMAN:
2 Q So these people were working in the field
3 in 2001; right?
4 A Yes.
5 Q Were you?
6 A I was not active quite that early in
7 spintronics. Not -- not too long after that.
8 I -- I will tell you, around that time I started
9 paying attention and started reading the
10 literature in this field. I think this GMR
11 discovery in 1988, I might not have heard about it
12 right then. But I heard about it in the late -- I
13 was already aware of it certainly in the '90s
14 and reading papers. I remember when the MTJ
15 started to -- started to get literature on the
16 MTJ. I was paying attention. Right around the
17 early 2000s.
18 Q I would like to ask you about Ground 2 in
19 your declaration on the '167 patent. If you could
20 turn to paragraph 224.
21 A I'm there.
22 Q Okay. So this is Ground 2. Now, if you
23 drop down to paragraph 227, you write or you had
24 somebody write for you that "Nagahama taught or
25 suggested a method of manufacturing a magnetic

1 tunnel junction device." Right?
2 A Right.
3 Q And down in paragraph 230, your testimony
4 is that Nagahama describes certain manufacturing
5 methods; is that right?
6 A Right.
7 Q And at the end of paragraph 230, you say
8 that one of skill would have had -- would have a
9 reasonable expectation of success in applying the
10 manufacturing techniques described in Nagahama's
11 paragraphs 57 and 62 through his paragraphs 73 and
12 74 embodiment. Is that right?
13 A That's what it says.
14 Q I'm less concerned about what the
15 document says as about what your testimony is
16 identifying the method in your combinations of
17 Nagahama in view of Sunai and Nagahama in view of
18 Parkin. Is it your testimony that the method of
19 manufacture meeting limitation 1 preamble are the
20 methods articulated in Nagahama paragraph 57
21 through 62 to paragraphs 73 to 74?
22 A Okay. Well, to answer those questions,
23 I'm going to have to pull up Nagahama and review
24 it again.
25 Okay. I have reviewed Nagahama.

1 Those -- those paragraphs from Nagahama. So is
2 there a question pending? Could you repeat the
3 question?
4 Q Yes to both.
5 Is it your testimony that the method of
6 manufacture meeting limitation one preamble in
7 ground two are the methods of manufacture
8 articulated in Nagahama paragraph 57 to 62 and
9 continuing through paragraphs 73 to 74?
10 A So I'll just jump down to paragraph 233
11 in my declaration. The answer to your question is
12 yes. As with Bowen, Nagahama's disclosed
13 manufacturing methods are also akin or comparable
14 to those described in the '167 patent. As I
15 explained for Ground 1, in section 12.A.1 of this
16 declaration, the '167 patent disclosed routine and
17 conventional fabrication methods, including
18 deposition methods, such as evaporation or
19 sputtering, and explained that it should be
20 obvious that other deposition methods are also
21 possible. Citing to the '167 patent. The '167
22 patent's fabrication techniques were routine and
23 conventional.
24 Q Is it your testimony that Nagahama in
25 view of Sunai and Nagahama in view of Parkin

1 depend on the teachings of the '167 patent
2 manufacturing methods?
3 A No. That's not what I'm saying. I am
4 saying that the '167 patent specification
5 disclosed routine and conventional methods, and
6 explained it should be obvious that other
7 deposition methods are possible. So the '167
8 patent specification refers to prior art
9 fabrication methods that were known. That's what
10 I mean here. Nagahama's disclosed manufacturing
11 methods -- again, reading from 233 -- are also
12 akin or comparable to those described in the '167
13 patent.
14 Q Dr. Bokor, if you were asked or paid to
15 write down the fabrication process steps meeting
16 Claim 1 for the combination of Nagahama in view of
17 Sunai, what steps would you write down?
18 ATTORNEY WILSON: Objection. Form.
19 THE WITNESS: There's a lot of steps.
20 That would take some time to put together that
21 list. I can give you an outline of how I would go
22 about making that list. But it would take an
23 awful long time for me to sit down and piece
24 together a full process flow, if that's what
25 you're asking for.

1 BY ATTORNEY WICHMAN:
2 Q Okay. Well, let me ask you this: If the
3 combination begins with Nagahama --
4 A Right.
5 Q -- which steps in Nagahama does it begin
6 with?
7 A Well --
8 ATTORNEY WILSON: Objection. Form.
9 THE WITNESS: Paragraph 62 shows nine
10 steps. We would start there. Clean the silicon
11 wafer. I'm looking at paragraph 62 from Nagahama.
12 Clean the silicon wafer substrate with oxide film.
13 Remove the water -- two, remove the water absorbed
14 at the surface with argon reverse-sputtering
15 cleaning in a sputtering chamber. Three, deposit
16 the MgO 212 (10 nanometers) by sputtering. Four,
17 take out the object in the air and transfer it to
18 an MBE chamber.
19 BY ATTORNEY WICHMAN:
20 Q Okay. Can I ask why you skipped over
21 paragraph 57 concerning the -- that leads to the
22 magnesium oxide underlayer?
23 A I was trying to save a little time.
24 These steps are similar. The first three steps.
25 Paragraph 57 says clean the substrate, one.

1 Remove the water, two. Three, deposit MgO. Those
2 three steps from 57 are also there in 62. More or
3 less. Pretty similar.
4 Q Okay. So I'm trying to understand your
5 testimony at paragraph 230. You say the
6 manufacturing techniques described in Nagahama
7 paragraphs 57 and 62 to his paragraphs 73 to 74.
8 I mean, just which range of paragraphs in Nagahama
9 do you mean?
10 A Okay. Well, 57 is somewhat duplicative
11 of 62. I wrote it in there just to point out that
12 Nagahama had -- honestly, as I sit here right now,
13 I can't -- I can't explain why I put 57 in there
14 as well. There was probably a reason. But it is
15 getting late and I'm getting a little tired. So I
16 can't remember exactly why I put the duplicative
17 steps of 57. But I'm not sure how -- how critical
18 that is to the discussion here.
19 Now, you asked me about what other
20 paragraphs, I think, are -- what's the range of
21 paragraphs. So paragraph 57, let's call that a
22 little extra. It doesn't add anything to -- as
23 far as I can see right now. From 62 all the way
24 through where he describes an embodiment in 73 and
25 74, I think all the -- I think all those

1 paragraphs are worth considering. Some of them
2 are characterization steps. But there's
3 considerable amount of information there about --
4 that relates to the manufacturing process. So I
5 would say to understand the manufacturing
6 techniques in Nagahama, it's worthwhile to take
7 the steps of 62, take in view 63 up to 72.
8 Because there's some steps in there. 73 and 74 is
9 another magnetoresistive element. But many of the
10 steps in 63 to 72 I think are relevant.
11 So I would -- I would say, to be on the
12 safe side, one of skill would apply the
13 manufacturing techniques described into Nagahama's
14 62 all the way through 74. 57 being a repeat of
15 the first three steps from 62. You know, there's
16 a slight -- 57 allows for a different choice of
17 substrates. Otherwise, it's more or less the
18 same.
19 Q Can you look at Figure 12 in Nagahama.
20 A Okay.
21 Q Just let me know when you're there.
22 A I'm there.
23 Q All right. Do you see this -- there's a
24 layer 203, a layer 202, and a bracket that the two
25 together are layer 204. Do you see that?

1 A I see that.
2 Q Yes?
3 A I see that.
4 Q Okay. And this is -- layer 204 is
5 referred to in paragraph 59 as an underlayer
6 composed of the amorphous magnesium oxide layer
7 202 and the magnesium oxide 001 crystal layer 203
8 as described above; right?
9 A That was in -- you were reading from
10 which paragraph, please? What did you say? Which
11 paragraph were you reading that text from?
12 Q 59.
13 A 59. Thank you.
14 All right.
15 Q What's the role of the double underlayer
16 of magnesium oxide?
17 A It is to produce a flat surface. So
18 from -- in Figure 12, you see that 202 is on 201.
19 Let me just go back. Amorphous layer 202 and then
20 MgO crystal layer 203 to produce a flat surface at
21 the top of 203 for subsequent device fabrication.
22 Q If you look at Figure 15 at page 19 of
23 Nagahama.
24 A I see it.
25 Q Do you see the layers are labeled on the

1 right?
2 A I do.
3 Q So ascending from the bottom, it is
4 silicon, amorphous MgO, crystal MgO; right?
5 A Right.
6 Q Is that an example of the double layer of
7 magnesium oxide?
8 A Evidently.
9 Q And then on top of the crystal MgO,
10 there's crystal iron 001 texturing.
11 A Right.
12 Q So the role of the magnesium double
13 underlayer is also to provide a template on which
14 to grow crystalline iron underlayer; is that
15 right?
16 A Right.
17 Q And in paragraphs 67 and 69, for example,
18 Sunai continues to refer to the magnesium oxide
19 double underlayer; is that right?
20 A Right.
21 Q And even in paragraph 73, Sunai refers to
22 a highly -- a 001 highly oriented lower
23 ferromagnet electrode layer with other layers on
24 the magnesium oxide double underlayer of the
25 present invention; right?

1 A Right.
2 Q So Nagahama's process steps require
3 performing this double underlayer; right?
4 A Right.
5 Q Okay. Paragraph 74, since we're there,
6 in Nagahama, a large tunnel magnetoresistive
7 effect of more than 90 percent was produced. Is
8 that right?
9 A Yes.
10 Q And we saw before that Sunai achieved the
11 TMR of less than 24 percent; is that right?
12 A Right.
13 Q In your declaration, at paragraph 245,
14 you state that it would have been obvious to
15 replace Nagahama's lower ferromagnetic layer
16 within cobalt iron boron ferromagnetic layer as
17 taught by Sunai, including to improve TMR, as well
18 as lower Hf and Hc; is that right?
19 A Right.
20 Q So why would a POSA whose objective was
21 to increase the TMR of an MTJ have modified the
22 teachings of Nagahama which already achieved a
23 90 percent TMR with the teachings of Sunai, which
24 achieved an inferior TMR of less than 25 percent?
25 A As I said before -- as I said before the

1 break, I read a paragraph from my -- an earlier
2 paragraph in this declaration that provides a
3 variety of sources that indicated that cobalt iron
4 boron had potential for increasing TMR in a
5 variety of other devices that didn't have all of
6 the same properties, all the same features. So
7 substituting cobalt iron boron for cobalt iron or
8 iron in other devices had a beneficial effect.
9 And so a person of ordinary skill in the art
10 looking at Nagahama, as well as all that other
11 literature, would be motivated to try substituting
12 Nagahama's electrodes with cobalt iron boron.
13 Because cobalt iron boron had been shown by a
14 number of investigators to have favorable
15 properties.
16 Now, researchers are constantly, you
17 know, trying to improve -- a person of ordinary
18 skill in the art looking at Nagahama would say --
19 would not say, oh, 90 percent, done deal. I give
20 up. I'm not going to try anything to improve on
21 that. There's an army of researchers that are
22 trying to improve TMR. Even today. And so you're
23 going to try -- try all sorts of things, whatever
24 you can find in the literature that suggests there
25 might be an improvement to be made, you want to

1 try that. Even today, like I say, there's not --
2 frankly, we need -- we still need higher TMR. And
3 there are people who are still struggling to
4 figure out how to do that. And, you know, people
5 try all sorts of things. And you don't
6 necessarily accept what's in the literature that
7 seems to indicate you can't do any better. People
8 want to try. And, you know, Nagahama, he got
9 90 percent. But he didn't try cobalt iron boron.
10 Maybe in -- in this context, cobalt iron boron
11 could even give a better TMR than what Nagahama
12 got. That's not unreasonable.
13 Q In paragraph -- paragraph 245 of your
14 declaration, you refer to these parameters Hf and
15 Hc. What is Hf?
16 A Hf is a -- basically a parameter that
17 describes a coupling between the two ferromagnetic
18 layers in a junction -- tunnel junction.
19 Q And what is Hc?
20 A Hc is what is called a coercive field.
21 So that is the field it takes to make a -- a
22 magnetic structure that is magnetized in one
23 direction, reverse, and become magnetized in the
24 other direction. You can do that with a magnetic
25 field. Just take a magnetized layer, put it in a

1 magnetic field, point it the other way, and see --
2 see how much field it takes. I can show you this.
3 There's lots of -- let me see. I think it's --
4 let's look in Bowen. In Bowen, Figure 2. Now,
5 it's plotting TMR percent as a function of
6 magnetic field. The magnetic field, if you start
7 with a strong positive magnetic field, both layers
8 are magnetized in the same direction as the
9 applied field. As you lower the magnetic field
10 and then reverse it, the magnetization -- the --
11 as you lower the magnetic field, it then -- yeah.
12 This is a bad example because he explains why the
13 reversal field there is zero. That's a -- that's
14 a -- that's a bad example because it's a little
15 pathological. But similar --
16 Let's see. Let me find another one.
17 Yeah. We can look in the '167 patent.
18 Figure 6. Where those sharp transitions occur in
19 resistance with magnetic field are where you have
20 coercive -- where you have crossed the coercive
21 field. That's where the -- one of the magnetic
22 layers reverses, and so the resistance jumps.
23 Because you go from parallel to antiparallel.
24 Because one of the layers jumped. You go from
25 parallel to antiparallel. The resistance jumps

1 up. That's exactly what TMR is all about.
2 Q So why would a cobalt iron boron
3 ferromagnetic layer lower Hf into Hc?
4 A The physics of that, I don't have that
5 right on the top of my head right now. You know,
6 Hc depends on -- you know, very -- on details
7 of -- both the structure of the magnet thickness
8 and so forth, its dimensions, but also its
9 magnetic properties in a way that I don't have at
10 the top of my head to explain to you right now.
11 Why does cobalt -- why does cobalt iron boron have
12 a lower Hc? I don't have -- I don't have that
13 right in front of me. That would take me some
14 time to come up with an answer for that. It's
15 just -- you know, it -- people have measured it.
16 It commonly is observed. So that's a good
17 motivation -- there's a reason that both Hf and
18 Hc -- lower Hf and Hc are parameters of interest
19 in MTJs.
20 Q Why is it -- sorry. Go ahead.
21 A Much of the effort that we've seen in a
22 lot of this literature refers to that. And cobalt
23 iron boron was reported by a number of researchers
24 to have a lower Hf and Hc. I think Sunai is what
25 I'm referring to here. But --

1 Q And why is that desirable in an MTJ?
2 A That can lower -- the lower Hc is easier
3 to explain. The lower the Hr, the less -- let me
4 use a term a little loosely. The less force it
5 takes to switch the layer. So if you're
6 switching -- so interestingly, all the literature
7 that we're looking at, in connection with MTJs, is
8 exclusively devoted to the readout mechanism, the
9 magnetoresistance. That's how you electrically
10 detect what -- whether the -- if it's -- for
11 example, a magnetic memory, whether it is a one or
12 a zero. Binary bit is encoded by the state of the
13 magnetization. All of this literature we've been
14 looking at exclusively is devoted to the
15 technology for the reading out of the state.
16 Figuring out is it a zero or a one bit. It is
17 also used for magnetic recording heads.
18 Essentially we're interested in a similar thing.
19 The lower the Hc, the smaller -- so you can write
20 the magnetic memory element, switch it from up to
21 down, zero to one, by applying a magnetic field.
22 Early MRAM, early magnetic memory, used a magnetic
23 field produced by current flowing through a wire
24 on the surface of the chip. And that magnetic
25 field was used to switch the storage layer, the

1 free layer, from one direction to the other. The
2 magnet -- the magnitude of the magnetic field
3 needed to switch. The storage layer is Hc. The
4 lower the Hc is, the less current you need in the
5 wire that is going to write that magnetic bit one
6 or zero. That reduces the power consumed in that
7 magnetic memory. So that's why Hc is of interest.
8 Q If you could turn to Parkin, Exhibit
9 1062, column 18.
10 A Okay. One second here. 1062. Let's see
11 if I can bring this up quickly. Parkin. Where in
12 Parkin? Sorry.
13 Q Column 18.
14 A Column 18. Yeah.
15 Q Are you there?
16 A I'm there. I'm there.
17 Q Bottom of column 18, line 59. Are you
18 there?
19 A I'm there.
20 Q The bulk of a storage layer 175 remains
21 amorphous, providing considerable improvement in
22 the magnetic switching properties of the arrays of
23 MTJ devices. Do you see that?
24 A I do.
25 Q So is that referring to Hc or Hf being

1 lower?
2 A Sitting here right now, it's been a long
3 day. I'm a little -- I'm a little tired. And it
4 is not immediately coming to me. It's -- I don't
5 want to guess. That might be what he is referring
6 to. But right now, I can't definitively answer
7 that question.
8 Q When Parkin, in line 60, column 18,
9 refers to storage layer 175, that is the cobalt
10 iron boron layer that he has deposited; correct?
11 A Yes.
12 Q So regardless of whether the magnetic
13 switching properties he refers to are Hf or Hc,
14 the beneficial improvement is a function of that
15 storage layer 175 remaining amorphous; is that
16 correct?
17 A That's what he says here.
18 Q And would a POSA in 2004 have understood
19 that the benefit of lowering Hf or Hc by the use
20 of cobalt iron boron electrodes was a function of
21 that material remaining amorphous?
22 ATTORNEY WILSON: Objection. Form.
23 THE WITNESS: That's what Parkin is
24 teaching here. A person of ordinary skill in the
25 art reading this would understand that that is

1 what Parkin is saying.
2 ATTORNEY WICHMAN: All right. Let's go
3 off the record.
4 (Discussion held off the record.)
5 ATTORNEY WICHMAN: All right. Let's go
6 back on the record.
7 Mr. Wilson, I tender the witness.
8
9 EXAMINATION
10 BY ATTORNEY WILSON:
11 Q Dr. Bokor, I just have a few questions.
12 Since we're at Parkin, let's start with column 18
13 line 58.
14 A I'm there.
15 Q And so actually, let's start at line 55.
16 This passage says, "The simple cubic crystalline
17 MgO layer thus provides a template for the
18 formation of a thin crystalline ferromagnetic
19 layer which has the bcc structure of CoFe, or
20 cobalt iron, and is oriented in the same hundred
21 direction as the magnesium oxide layer." Did I
22 read that correctly?
23 A Yes.
24 Q Earlier today you were asked a question.
25 And a premise of that question was that the

1 crystalline layer that is formed as described in
2 this passage is a cobalt iron structure. Sorry.
3 Is a -- consists of cobalt iron. And you agreed
4 with that question. Is it your opinion that the
5 crystalline layer that forms consists solely of
6 cobalt and iron?
7 ATTORNEY WICHMAN: Objection. Misstates
8 the record. Leading. Form.
9 THE WITNESS: Okay. Well, if I -- if I
10 said that, I think I -- I thought I said a number
11 of times that in a number of references, including
12 this one, when it refers -- in many instances,
13 when it refers to a ferromagnetic layer which has
14 the bcc structure of cobalt iron, in a layer which
15 started out as cobalt iron boron, had the boron in
16 it, and then was formed as a thin crystalline
17 layer, it would be a cobalt iron boron layer which
18 has a bcc structure like cobalt iron. I made that
19 distinction I'm pretty sure in a number of
20 instances. If I missed that here, then I will
21 correct that. That's what -- that's how I believe
22 a person of ordinary skill would read this
23 sentence.
24 BY ATTORNEY WILSON:
25 Q Also this morning, you spent close to two

1 hours discussing paragraph 68 of your declaration.
2 And you were asked repeatedly if there was
3 anywhere else in your declaration where you
4 discussed the relationship between TMR and barrier
5 height. And you testified that there was not. Do
6 you recall that?
7 A I do.
8 Q Okay. I want you to take a look at PDF
9 page 102 of your '167 declaration.
10 A I have it.
11 Q Okay. Can you look at paragraph 198.
12 A I see it.
13 Q Okay. Do you see the second sentence
14 that begins, "As explained in section VII.E.3"?
15 A Yes.
16 Q Do you know if paragraph 68 is in section
17 VII.E.3 of this declaration?
18 A I would have to check. I don't know. I
19 think so. But I could double-check. Let me do
20 that. 68. E3. Yes.
21 Q So section VII.E.3, does it include
22 paragraph 68?
23 A Yes.
24 Q Okay. Now, back to page 102, paragraph
25 198.

1 A Sorry. One moment.
2 198. I'm back there.
3 Q Okay. So same sentence, "As explained in
4 section VII.E.3 of this declaration, Butler and
5 Mathon taught that magnesium oxide barriers would
6 achieve higher TMRs due to symmetry matching
7 between the MgO barrier and ferromagnetic
8 electrodes, facilitating tunneling of parallel
9 electrons across the barrier compared to
10 antiparallel tunneling." Did I read that
11 correctly?
12 A Yes.
13 Q Okay. Drop down to the next paragraph,
14 paragraph 199.
15 A Okay.
16 Q First sentence, "To increase TMR of a
17 magnesium oxide barrier, skilled artisans would
18 have been motivated to explore lower barrier
19 heights to facilitate tunneling of parallel
20 electrons." Did I read that correctly?
21 A You did.
22 Q Okay. In light of what you just read, is
23 there any correction that you would make to your
24 testimony this morning?
25 A Well, this paragraph does discuss the

1 effect of lowering barrier height on TMR. So I
2 failed to mention this one. It definitely -- in
3 the same context of paragraph 68, that the energy
4 of the tunneling electrons in MgO could have a
5 significant effect on the ratio of parallel to
6 antiparallel resistance. Here, it explicitly
7 talks about lowering the barrier height to do
8 that. So that's -- that's a good catch. That is
9 correct. That is where I connect barrier height
10 to this energy varying the energy of the electrons
11 tunneling through the MgO barrier.
12 ATTORNEY WILSON: Okay. I don't have any
13 further questions.
14
15 FURTHER EXAMINATION
16 BY ATTORNEY WICHMAN:
17 Q Dr. Bokor, is it your testimony that in
18 2004, a person of ordinary skill in the art would
19 have expected that reducing the barrier height of
20 an MgO barrier would increase TMR?
21 A It's my testimony in 2004 that a person
22 of ordinary skill in the art would have a
23 reasonable expectation that lowering the barrier
24 height could increase the TMR.
25 Q And what probability would that

1 reasonable expectation have taken?
2 A Something like 50 percent.
3 Q So when you write or when you testify in
4 paragraph 199 that to increase TMR of an MgO
5 barrier, skilled artisans would have been
6 motivated to explore lower barrier heights to
7 facilitate tunneling of parallel electrons, the
8 basis of that testimony is that a person of
9 ordinary skill in the art would have had a
10 50 percent expectation that the TMR might increase
11 if the barrier height decreased?
12 A I would say it the way it is written in
13 that text. Skilled artisans would have been
14 motivated to explore lower barrier heights to
15 facilitate tunneling of parallel electrons. That
16 means explore, experiment, try. So you would
17 explore lowering the barrier height to see what
18 effect it would have on tunneling of parallel
19 electrons. I think that's the motivation of a
20 person of ordinary skill. I'm not sure the person
21 of ordinary skill would sit back and start
22 calculating probabilities. They would just say
23 there's a good chance. And that's enough. For
24 me, if I'm trying to improve some parameter or
25 another in technology and I think that that -- if

1 I vary one parameter, that I can't guarantee that
2 I'm going to get the effect that I'm looking for,
3 but there's a darn good chance. I'm going to try
4 it. I'm going to explore it. I will do
5 experiments. And I say that -- I said myself.
6 But I would say from the perspective of a person
7 of ordinary skill in the art.
8 Q Is it your testimony that in 2004, a
9 person of ordinary skill in the art would have
10 believed there was a chance that reducing the MgO
11 barrier height would change TMR?
12 A Yes.
13 Q And is it your testimony that in 2004 a
14 person of ordinary skill in the art could not say
15 which direction the TMR would change with a
16 reduction of barrier height?
17 A Not with any certainty, no.
18 Q And is it your testimony that in 2004, a
19 person of ordinary skill in the art would have
20 also believed it likely that reducing the barrier
21 height of a magnesium oxide barrier would have had
22 no change on the TMR?
23 A I think a person -- we had a long
24 discussion about this this morning. I think a
25 person of ordinary skill in the art, if they have

1 the capability to change the barrier height over
2 some reasonable range would be -- would have a
3 very strong expectation that they would see some
4 change in the TMR, not just zero. There might be
5 one particular -- there might be a particular
6 barrier height that would give a result of zero.
7 But they -- they -- they would expect that if you
8 could vary that barrier height over a certain
9 range, you would see -- you would -- at least
10 somewhere you would see -- you would see -- you
11 would see changes in the TMR. You could -- you
12 know, the TMR could even change sign. So they
13 would be motivated to vary the barrier height and
14 would have a very high expectation that somewhere
15 you would be -- you would see a change in TMR with
16 a good chance that it would be in the --
17 increase -- in the increase direction. I can tell
18 you, I just know -- I know lots of people of
19 ordinary skill in the art in the scientific and
20 engineering community. And when there is a -- a
21 goal that there's a large community of people
22 trying to achieve, like raising TMR, speeding up
23 the speed of a transistor, improving the energy
24 efficiency of a laser, you name it, when there's a
25 very -- when there's a large economic incentive to

1 achieve a certain increase in performance of some
2 technology element, people of ordinary skill in
3 the art will try even if they think the likelihood
4 that it will be successful is much lower than
5 50 percent. If you can figure out how to get
6 higher density MRAM and get it successfully have
7 that technology embedded into high-performance
8 processors made by Nvidia, let's say, and I might
9 be able to get a 10 percent improvement in
10 density, but I don't know there's something that I
11 could try has a two percent possibility of
12 working, I'm going to try that. People will try
13 to get an achievement of improvement with a high
14 economic incentive, even with a low probability of
15 success. So if I think that there's a 50/50
16 chance I'm going to get the improvement that I'm
17 looking for, boy, oh, boy, I'm going to try that.
18 And every -- many -- most persons of ordinary
19 skill working in the field are going to do that.
20 Q So you testified that Bowen's -- the
21 authors, the collaborative group on Bowen, were
22 people of at least ordinary skill in the art;
23 correct?
24 A True.
25 Q And that group of authors in Bowen

1 included a future Nobel laureate in physics in
2 your field, spintronics, that concerns
3 magnetotunnel junctions; right?
4 A Right.
5 Q And those people in -- that worked on
6 Bowen would have been fully aware of all of the
7 market incentives that you just identified for
8 increasing TMR; right?
9 A Right.
10 Q And in Bowen, there is no evidence and no
11 discussion of how to improve TMR by reducing the
12 barrier height of the -- of the magnesium oxide
13 barrier layer, is there?
14 A No explicit discussion of that in Bowen.
15 That's true. That's correct.
16 Q And you keep saying no explicit
17 discussion. Was there any other discussion?
18 A As I said, Bowen -- Bowen is a paper
19 that's very -- very closely related to Butler.
20 The Bowen paper cites Butler. It -- that work
21 was -- I have no doubt. I don't -- I can't state
22 with certainty what motivates people. I didn't --
23 you know, I've met Fert, but I don't know him. I
24 met Briones. I know him a little bit. But they
25 knew about Butler. And so there's no explicit

1 discussion in Bowen, but I'm pretty sure that
2 those people understood Butler probably a lot
3 better than I do. But they -- they -- you know, I
4 will say this, I'm pretty sure that most of those
5 people on that paper, the authors on that paper
6 continued to pursue whatever various lines of
7 effort to try to improve TMR. That I -- that I
8 can pretty confidently predict. They may not --
9 they may have had other ideas that they thought
10 were more promising that they tried.
11 Q Do you have Bowen in front of you?
12 A I do.
13 Q So this is Exhibit 1026, at page 1657.
14 A Okay.
15 Q Top right column.
16 A Right.
17 Q They write, "More interestingly, in
18 future experiments, we will aim to confirm the
19 predicted relative increase of the TMR with
20 magnesium oxide barrier thickness." Right?
21 A Yes.
22 Q That was Butler's, in your words,
23 explicit prediction; correct?
24 A Right. Right.
25 Q And, in fact, that's the last sentence of

1 the abstract in Butler.
2 A Yeah.
3 Q Exhibit 1044, page 1. Right?
4 A Right.
5 Q So they clearly were testing an explicit
6 prediction of how to increase TMR, which was by
7 increasing the thickness of the magnesium oxide
8 barrier layer; right?
9 A Right.
10 Q They do not have anything to say about
11 increasing TMR by changing the barrier height of
12 the magnesium oxide barrier layer, do they?
13 A Nope. Not explicitly, no. They don't
14 say that.
15 Q And do they say it implicitly?
16 A No. They don't say it. They just don't
17 say it.
18 Q They don't say it.
19 A No.
20 Q And in paragraph 199 of your declaration
21 that we have been discussing, you only cite two
22 references, Bowen and Soukup; right?
23 A Yes.
24 Q And Soukup does not have anything to do
25 with magnetic tunnel junctions, does it?

1 A Not directly.
2 Q Soukup was published in 1970?
3 A That sounds right.
4 Q Tunneling magnetoresistance was
5 discovered in 1975 by Julliere --
6 A Uh-huh.
7 Q -- five years later; correct?
8 A Yeah.
9 Q Soukup fabricated metal insulator metal
10 emission tunnel diodes; correct?
11 A Right.
12 Q The thickness of the barrier layer in
13 those mission tunnel diodes was in excess of
14 50 nanometers, was it not?
15 ATTORNEY WILSON: Objection. Form.
16 THE WITNESS: That sounds right.
17 BY ATTORNEY WICHMAN:
18 Q The devices that Soukup fabricated had
19 gold electrodes; is that correct?
20 A Correct.
21 Q Sorry. What was your answer?
22 A Correct.
23 Q Correct. One moment. I have a copy of
24 Soukup here.
25 A I'm pulling it up too.

1 Q From yesterday's.
2 A You're right. Actually Soukup's film
3 thickness minimum was 60.
4 Q 60 nanometers?
5 A Yes.
6 Q That's the smallest. Now, even if
7 Soukup's electrodes were ferromagnetic rather than
8 gold, would his device have operated -- been
9 operable as a magnetic tunnel junction with a
10 60-nanometer-thick magnesium oxide barrier?
11 A I would say highly unlikely he would get
12 any TMR from that device.
13 Q And in reality, the electrodes were made
14 of gold; right?
15 A Right.
16 Q And gold is not normally ferromagnetic;
17 right?
18 A Right.
19 Q So Soukup was not making MTJs?
20 A Is that a question?
21 Q Yes. Correct?
22 A Correct.
23 Q And Soukup was not concerned with
24 parallel resistance through an MTJ; is that right?
25 A That's fair.

1 Q And Soukup was not concerned with
2 antiparallel resistance through an MTJ; is that
3 right?
4 A Not that I know.
5 Q Dr. Soukup may have developed other
6 interests, but in this paper --
7 A In this paper.
8 Q -- exhibit 1028, he was not concerned
9 with tunneling magnetoresistance, was he?
10 A I agree.
11 Q And he did not make any estimates of
12 tunnel magnetoresistance, did he?
13 A Not in this paper.
14 Q Because his paper had nothing to do with
15 tunnel magnetoresistance; correct?
16 A Not correctly.
17 Q And, in fact, Soukup concluded that the
18 majority of his observations were consistent with
19 Schottky emission current through his emission
20 tunnel diodes; isn't that right?
21 A Right.
22 Q So the majority transport mechanism was
23 not tunneling; is that right?
24 A That's true.
25 Q Okay. So Soukup could not have supported

1 the proposition that to increase TMR of an MgO
2 barrier, skilled artisans would have been
3 motivated to explore lower barrier heights to
4 facilitate tunneling of parallel electrodes;
5 correct?
6 A Soukup would not -- as best as I can -- I
7 don't think Soukup would have had the ability to
8 do that at that time, no.
9 Q And as we -- and Bowen did not address
10 the issue of how changing the barrier height of
11 his magnesium oxide might effect the TMR of his
12 MTJs, did it?
13 A It did not -- it did not mention that.
14 ATTORNEY WICHMAN: Okay. Mr. Wilson, do
15 you have questions?
16 ATTORNEY WILSON: I just have a few
17 questions.
18
19 FURTHER EXAMINATION
20
21 BY ATTORNEY WILSON:
22 Q Dr. Bokor, do you have Soukup in front of
23 you?
24 A I do.
25 Q Can you turn to page 3233.

1 A I'm there.
2 Q Take a look at Table 1 in the bottom
3 right.
4 A I see it.
5 Q Do you see the second column S?
6 A I do.
7 Q Okay. Do you see the footnote which says
8 S equal oxide thickness in angstroms?
9 A Now you got me. You're showing how tired
10 I am. Yes. These are angstroms, not nanometers.
11 Q Okay. So how many of Soukup's devices,
12 in fact, exceed 50 nanometers in barrier width?
13 A There are just two of them.
14 Q Are the rest below 50 nanometers?
15 A The rest are below 50 nanometers. Many
16 of them are below 10 nanometers.
17 ATTORNEY WILSON: Okay. I don't have any
18 further questions.
19
20 FURTHER EXAMINATION
21 BY ATTORNEY WICHMAN:
22 Q Well, I just have one question then.
23 Dr. Bokor, regardless of the thickness of any
24 device listed in Table 1, there is nothing in
25 Soukup's that indicates that he identified

1 tunneling as a current transport mechanism in any
2 of these devices; is that right?
3 A That's right. He -- he identified the
4 origin of the current he was measuring as due to
5 thermionic emission basically.
6 ATTORNEY WICHMAN: Thank you.
7 Mr. Wilson?
8 ATTORNEY WILSON: Nothing further.
9 ATTORNEY WICHMAN: I think that concludes
10 the deposition.
11 THE WITNESS: Thank you.
12 ATTORNEY WICHMAN: Off the record.
13 (The proceedings concluded at 5:41 p.m.)
14 -oOo-
15
16
17
18 I have read the foregoing deposition
19 transcript and by signing hereafter, subject to any
20 changes I have made, approve same.
21
22 Dated: _____
23
24
25 _____

1 DEPOSITION OFFICER'S CERTIFICATE

2

STATE OF CALIFORNIA)

3) SS.

COUNTY OF RIVERSIDE)

4

5 I, BROOKE SILVAS, a certified shorthand

6 reporter for the State of California, do hereby

7 certify:

8 That prior to being examined, the witness

9 named in the foregoing deposition solemnly stated to

10 testify to the truth, the whole truth, and nothing but

11 the truth;

12 That the said deposition was taken down by me

13 remotely in stenotype at the time and place therein

14 stated and thereafter reduced to typewriting under my

15 direction, and that the deposition transcript is a

16 true and correct record of the proceedings here held.

17 I further certify that I am not of counsel or

18 attorney for any of the parties hereto or in any way

19 interested in the event of this cause and that I am

20 not related to any of the parties thereto.

21

22 Dated: June 26, 2025

23

24 _____

BROOKE SILVAS

25 CSR No. 10988

RealLegal . Notary for E-Transcript

1 DEPOSITION OFFICER'S CERTIFICATE

2

3 STATE OF CALIFORNIA)

) SS.

4 COUNTY OF RIVERSIDE)

5

6 I, Brooke Silvas, hereby certify:

7 I am the deposition officer that

8 stenographically recorded the testimony in the

9 foregoing deposition.

10 Written notice pursuant to Code of Civil

11 Procedure, Section 2025.520(a), having been sent, the

12 deponent took the following action within the allotted

13 period with respect to the transcript of the

14 deposition:

15 ( ) In person, at the office of the

16 deposition officer, made the changes set forth on the

17 original of the transcript. (The parties attending

18 the deposition have been notified of said changes.)

19 ( ) Approved the transcript by signing it.

20 ( ) Refused to approve the transcript by

21 not signing it.

22 ( ) By means of a signed letter, made the

23 changes and approved or refused to approve the

24 transcript as set forth therein. (Said letter has

25 been attached to the original transcript and copies

1 thereof mailed to all parties attending the
2 deposition.)
3 ( ) Failed to approve the transcript within
4 the allotted time period.
5
6 Dated: June 26, 2025
7
8 _____
BROOKE SILVAS
9 CSR NO. 10988
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MAGNA
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