

In the Matter of:
Western Digital Technologies, Inc. vs
Godo Kaisha IP Bridge 1

Jeffrey Bokor, Ph.D.

June 24, 2025

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

WESTERN DIGITAL TECHNOLOGIES,
INC.,

Petitioner,

vs.

GODO KAISHA IP BRIDGE 1,

Patent Owner.

Case No.
IPR2024-01494

REMOTE DEPOSITION OF
JEFFREY BOKOR, PH.D.
JUNE 24, 2025

Reported by:
Brooke Silvas, CSR 10988
Job No. 1355529

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Deposition of JEFFREY BOKOR, PH.D., taken
remotely via Zoom, commencing at 9:09 a.m., on
Tuesday, June 24, 2025, before Brooke Silvas,
Certified Shorthand Reporter No. 10988.

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2 (All appearances are via videoconference.)

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24
25

I N D E X

WITNESS: JEFFREY BOKOR, PH.D.

EXAMINATION BY	PAGE
ATTORNEY WICHMAN	5

E X H I B I T S

DEPOSITION	DESCRIPTION	PAGE
3	The Japan Society of Applied Physics article Correlation between Barrier width, Barrier Height, and DC Bias Voltage Dependences on the Magnetoresistance Ratio in Ir-Mn Exchange Biased Single and Double Tunnel Junctions	193

INSTRUCTION NOT TO ANSWER

(None)

INFORMATION TO BE SUPPLIED

(None)

1 REMOTE DEPOSITION; JUNE 24, 2025

2 9:09 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. My name is Adam
12 Wichman. And I represent IP Bridge. Thank you
13 for making time for us today.

14 A Good morning.

15 Q Before we get too far, tell me, what is
16 your computer setup this morning?

17 A What is my setup? Can you be a little
18 more specific?

19 Q Are you able to manipulate documents?

20 A Yes. I'm set up on a computer. A Mac
21 computer. There's a directory. Where did it go?
22 There's a -- there was -- hold on. Let me find it
23 again. No. I had a window that showed all the
24 documents that I think you folks sent over.

25 But --

1 Q Can you pull -- can you keep that window
2 open?

3 A I'm trying to find it. We opened up Zoom
4 and there's AgileLaw.

5 ATTORNEY WILSON: It is on the desktop.
6 There's a folder on the desktop.

7 THE WITNESS: There we go. That folder
8 there. Okay. Good. I got it now. I've got
9 that.

10 BY ATTORNEY WICHMAN:

11 Q Great.

12 A It has, you know, something like a
13 hundred documents or so in there.

14 Q All right. Let's try to simplify things.
15 For the most part, we will try to work from that
16 file.

17 A Yeah.

18 Q I will identify exhibits by exhibit
19 number. And you should be able to find them by
20 the document name and the exhibit.

21 A Yes. That, I agree, is probably the
22 simplest way to go.

23 Q All right. So within that folder, can
24 you find a document entitled Paper Number 15.

25 A Yes.

1 Q Can you open that document?

2 A Okay. Patent Owner's Notice of
3 Deposition.

4 Q Okay. So you understand that you're
5 appearing for deposition today in case number
6 IPR2024-1494?

7 A That's what it says on this document.

8 Q I'm asking about your understanding, sir.

9 A well, I don't independently know the case
10 number, but I know that I'm here for a deposition
11 about the '909 patent today.

12 Q The '909 patent. So that is US patent
13 11,968,909; is that right?

14 A Yes.

15 Q Okay. And you just referred to it as the
16 '909 patent. Throughout the deposition today,
17 when I refer to the '909 patent, you understand
18 that I mean the patent that we just identified on
19 the -- on this deposition notice; right?

20 A Right.

21 Q Okay. You're appearing on behalf of
22 Western Digital; is that correct?

23 A Correct.

24 Q And they -- they retained you to offer
25 expert testimony; is that right?

1 A Via the Armond Wilson firm, yes.

2 Q Where are you located today?

3 A I'm at the offices of Armond Wilson in
4 Newport Beach, California.

5 Q And I see you're in a conference room.
6 Who else is in that conference room with you?

7 A Nobody.

8 Q Okay. Have you been deposed before?

9 A I have.

10 Q How many times?

11 A I couldn't give you an exact number but
12 it's somewhere probably between 20 and 30 times.

13 Q When was the last time that you were
14 deposed?

15 A Let me think about that for a minute.
16 It's been a little bit of a while. Probably --
17 between a year and two is my best guess.

18 Q Have you --

19 A I testified recently in an arbitration
20 hearing. Not exactly a deposition. Before that,
21 yeah, it must have been -- it could be as much as
22 two or three years ago.

23 Q Have you been deposed in a remote
24 deposition before, like we're doing right now?

25 A You know, I have done it. It was quite a

1 while ago. It was right in the peak of the
2 pandemic I did one like this. But it hasn't --
3 that's the last time. It was probably back in,
4 you know, 2020 or '21.

5 Q So you understand that during this
6 deposition, I will ask you questions; right?

7 A Sure.

8 Q And you agree that you will wait until I
9 finish asking my question before you start to
10 answer; right?

11 A I will do my level best.

12 Q well, we have a court reporter,
13 Ms. Silvas, here, who is getting down everything
14 that we say. So it will make her job much more
15 difficult if we speak over each other.

16 A Yes. I fully understand that. As I say,
17 I've been deposed many times. Even live, we try
18 to avoid talking over each other. So I
19 understand, and I will do -- I will do my level
20 best to follow that protocol.

21 Q You understand that when I -- when you
22 answer a question, you have to answer verbally so
23 that Ms. Silvas can transcribe the answer.
24 Correct?

25 A (Witness nods head.)

1 Yes.

2 Q Will you agree to ask me to clarify a
3 question if you did not understand the question?

4 A Of course.

5 Q Okay. Do you understand that during this
6 deposition, I'm going to refer to exhibits?

7 A Yes. Of course.

8 Q Okay. And we just -- we just clarified
9 that on the computer in front of you, you have a
10 folder with many, if not all, of the exhibits that
11 we will refer to today from this case; right?

12 A Right.

13 Q All right. Do you understand that
14 counsel for Western Digital might object to a
15 question that I ask during this deposition?

16 A Yes.

17 Q All right. Do you understand that unless
18 you are instructed not to answer, you still need
19 to answer my question after counsel finishes their
20 objection?

21 A Understood.

22 Q Okay. We will try to take regular breaks
23 during this deposition. Roughly on an hourly
24 basis. Okay?

25 A Yes. Let me just comment on that. I --

1 I have a senior bladder. And so I hope you will
2 indulge me if occasionally I might need a break
3 sooner than one hour.

4 Q well, I simply ask just tell me if you
5 need to take a break. Okay?

6 A I will.

7 Q I would like you to agree if we are in
8 the middle of a question and an answer, that you
9 finish your answer before we take a break. Is
10 that acceptable?

11 A Sure.

12 Q Okay. Do you understand that once, you
13 know, we begin this deposition, we have begun this
14 deposition, until I finish my cross-examination,
15 you are not permitted to discuss any of the
16 questions or your answers with lawyers for Western
17 Digital?

18 A Understood.

19 Q Okay. Do you understand that this --
20 this rule includes during any break in the
21 examination?

22 A Yes.

23 Q Okay. So if we break for lunch or to use
24 the bathroom, you're not permitted to discuss the
25 questions and answers with Western Digital's

1 counsel; right?

2 A Understood.

3 Q Okay. Do you agree not to discuss this
4 deposition with anyone while the examination is
5 ongoing?

6 A You mean other than Western Digital
7 counsel? Yes.

8 Q Anybody not involved in the deposition.

9 A I agree. Yes.

10 Q What screens do you have open on your
11 computer right now?

12 A Well, I have a setup with two displays.
13 You want to know what windows I've got? Is that
14 what you're asking? Or the screens themselves?

15 Q I want to know if you have a chat or an
16 email window open?

17 A No.

18 Q Okay. Do you have anything other than
19 the file folder, Adobe, and the AgileLaw, and Zoom
20 applications open?

21 A No. I do not.

22 Q Okay. Do you agree not to open any other
23 files or screens during the deposition other than
24 the exhibits that we're discussing?

25 A Agreed.

1 Q what did you do to prepare for your
2 deposition today?

3 A well, I reviewed quite a few documents.
4 And I met with counsel to prepare based on review
5 of documents.

6 Q when you say met with counsel, who did
7 you meet with?

8 A well, Doug Wilson and Monica Arnold
9 primarily. I briefly chatted with Michelle
10 Armond.

11 Q Anybody else?

12 A No.

13 Q How much time did you spend in
14 preparation?

15 A well, probably 20 or 30 hours. It's hard
16 for me to draw a line between the work that I've
17 been doing -- okay. Since I prepared my
18 declarations, I suppose all -- all the work that I
19 have done since then would be considered in
20 preparation for this deposition. So probably 40
21 hours or more.

22 Q How much time have you spent working on
23 this particular dispute involving the '909 patent?

24 A Oh, I don't have that number handy. It's
25 been over a year. I couldn't give you a number

1 for that. I would have to go back and review my
2 invoices.

3 Q But you invoiced your time on this; is
4 that right?

5 A Yes.

6 Q And have you been paid in excess of
7 \$50,000 for your time on this case so far?

8 A Probably not in excess of 50,000. It
9 could be close -- it could be close to that. I
10 don't remember for sure. To give a definitive
11 answer, I would have to go back and review the
12 invoices.

13 Q Can you give me a ballpark?

14 A That is the best ballpark that I can give
15 you. 50K, plus or minus.

16 Q Okay. Dr. Bokor, I wanted to go through
17 your CV for a little bit, if I could. And I
18 wanted to ask you about some of your work. In
19 particular, I'm interested in Paper 202 which is
20 on your CV, which is 1025.

21 A Okay. Give me a moment to open that,
22 please.

23 Q It is also PDF page 24.

24 A What number was that again, the number of
25 the document?

1 Q The document is Exhibit 1025.

2 A Oh, sorry. The number on my CV. The
3 number for my paper that you wanted to ask me
4 about.

5 Q 202.

6 A See that, I already spoke over you once.
7 I'm going to do my best to avoid doing that.

8 200 and --

9 Q Two.

10 A Two. Okay. Hisamoto. Yes.

11 Q So it is a paper entitled "FinFET - A
12 self-aligned double-gate MOSFET scalable 20
13 nanometers." Right?

14 A Right.

15 Q This paper is interesting. How many
16 times has this paper been cited?

17 A I don't know. We would have to look it
18 up on Google Scholar. It's a well-cited paper.

19 Q Would you be surprised to know it was
20 cited 2,459 times?

21 A No, I would not. It is a famous paper.

22 Q So this work that you did in this paper,
23 is that sponsored by DARPA?

24 A In part.

25 Q In your CV at page 7, you list among your

1 professional associations, services, and awards a
2 DARPA Most Significant Technical Accomplishment
3 Award for 2000; right?

4 A Page 7?

5 Q Page 7.

6 A That's right. In 2000.

7 Q DARPA, D-A-R-P-A, that's the Defense
8 Advanced Research Projects Association?

9 A Agency.

10 Q Agency. Agency. Yeah.

11 Was that DARPA award in 2000 related to
12 the work that you published in this paper on
13 FinFETs?

14 A Related to. We publish quite a few
15 papers. The award wasn't specific to one paper.
16 It was specific to the body of work.

17 Q Okay. What made that paper so
18 significant or that work so significant?

19 A Well, it was a significant breakthrough
20 in the technology used to scale CMOS transistors
21 for use in high-performance microprocessors and
22 other large-scale integrated circuits. And we --
23 we were the first to clearly demonstrate a new
24 technology called FinFET, which was pretty radical
25 at the time. At that time, CMOS transistors were

1 fabricated in a so-called planer process. And we
2 showed how to relatively efficiently
3 manufacture -- we showed a pathway to manufacture
4 a much more scalable transistor in which the
5 transistor body was no longer a flat plane on the
6 surface of the silicon wafer, but a fin protruding
7 out off the surface. And we showed how to make a
8 transistor out of a fin like that. which enabled
9 ultimately the semiconductor industry to extend
10 the scaling, the increase in the number of
11 transistors on a silicon chip dramatically. And,
12 in fact, it turned out indeed to have a huge
13 impact on the industry. Now, still today, every
14 integrated -- advanced leading edge integrated
15 circuit, like the chips in your phone, in your
16 computer, the chips that are in the data centers
17 that are doing all the enterprise computing today
18 all use transistors that are called FinFETs.

19 Q So when you say that the paper was a
20 significant breakthrough, it was a significant
21 breakthrough for all of the reasons that you just
22 listed?

23 A I think so, yes.

24 Q When you say it is a famous paper, is it
25 because of this significant breakthrough or

1 these -- I should say significant breakthroughs,
2 plural?

3 A well, one -- one way to answer that is it
4 is a famous paper because over 2400 people have
5 cited it. 2400, I think you said, subsequent
6 scientific publications cite that paper. So a lot
7 of people have read it, found it important enough
8 to do work that is inspired by it such that they
9 cite it as a reference in their paper. So that's
10 one reason that it is a famous paper. But it's --
11 since somewhere in the -- I forget exactly when
12 Intel started manufacturing FinFET-base chips.
13 That significantly increased the notoriety of that
14 paper. Since Intel, they were the first company
15 to start selling commercial chips using FinFETs.
16 It was quite -- quite a noteworthy milestone in
17 the industry. And we get a significant amount of
18 credit for having invented the technology.

19 Q So would you say that the -- the fact
20 that more than 2400 people have cited in work in
21 their own subsequent academic work is an
22 indication of the significance of the work in
23 your -- in your FinFET paper?

24 A Yeah. In the academic community,
25 citation counts are currency of impact. So if you

1 have -- and 2400 is a -- you know, there are
2 papers with tens of thousands of citations or
3 more. So it is not -- by far it is not among the
4 most famous papers ever. But within the
5 integrated circuit engineering community, 2400 is
6 a pretty good citation count.

7 Q Do you have any other papers that have
8 been cited that many times?

9 A I -- I don't think so. I would have to
10 check. I have some other pretty well-known
11 papers. But that is probably my most heavily
12 cited paper.

13 Q If you look at the paper you identified
14 as number 57, this was a paper with Desai. "MoS2
15 transistors with 1-nanometer gate lengths," 2016.

16 A Tell me the number.

17 Q 57.

18 A 57. okay.

19 Q It's the second from the bottom on page
20 12.

21 A I found it. Desai and a long list of
22 authors. "MoS2 transistors with 1-nanometer gate
23 lengths," in the Science magazine. I see it.

24 Q would you be surprised to know that that
25 has been cited 1,624 times?

1 A That would not surprise me.

2 Q Is this one -- is this one of your famous
3 papers? Go ahead.

4 A That is another famous paper.

5 Q Famous paper.

6 Is Science -- is Science considered a
7 high-impact journal?

8 A By many, yes.

9 Q So can you explain to me, what is this
10 idea of a high-impact journal?

11 A Let me try to give a short answer to
12 that. I think to try to make this simple, some
13 journals have -- you know, the number of
14 subscribers has one -- is one factor in the impact
15 factor for a journal. Journals -- in the -- in
16 the scientific publication space, different
17 journals have an identified impact factor, a
18 number. And to be honest with you, I'm not sure
19 all the elements that go into the calculation of
20 that impact factor. The number of subscribers to
21 the journal is one. But I think the citation rate
22 by other academic publications of papers in that
23 journal contribute to the impact factor of the
24 journal, the whole journal. So Science has a
25 high-impact factor because lots of people read

1 that, subscribe to that magazine. Lots of
2 people -- lots of scientific papers cite other
3 papers that were published in Science. So that
4 also makes it a high-impact journal. I don't know
5 how they calculate, you know, all those different
6 factors and roll them all into the impact factor.
7 But people pay attention to the impact factor of
8 journals in the scientific community.

9 Q Let me ask you, at one point you were the
10 Chairman of the Electrical Engineering and
11 Computer Sciences Department at Berkeley; right?

12 A That's correct.

13 Q Were you involved in hiring faculty?

14 A Yes.

15 Q Were you involved in recruiting faculty?

16 A Yes.

17 Q Were you involved in promotion decisions
18 for faculty?

19 A Yes.

20 Q Did publication records play a role in a
21 hiring decision?

22 A They play a role for sure.

23 Q Is it an important role?

24 A Yes.

25 Q And do publications play a role in

1 promotion decisions?

2 A They do.

3 Q Is it an important role?

4 A Yes.

5 Q And if a candidate had published in a
6 high-impact journal, how would that have affected
7 his candidacy for hiring?

8 A It would have a positive impact.

9 Q And if a candidate had been cited more
10 than a thousand times in a high-impact journal,
11 would that weigh in favor of promotion?

12 A That's fair to say.

13 Q How did you value these numbers of -- you
14 know, number of citations in a high-impact
15 journal?

16 A well, personally, I'm -- I weigh that a
17 little bit less heavily than many others.
18 Throughout my career, I've been involved in making
19 these kinds of evaluations. You can go back
20 through my CV and see other experience I have
21 where you could guess that I had a lot of say in
22 hiring and promotions. Typically those hiring and
23 promotion decisions are for people whose work is
24 close enough to mine that I can understand the
25 details. And so I like to put much more weight on

1 my own personal evaluation of the creativity, the
2 significance, and the impact of a given
3 scientist's publications rather than popularity,
4 which is really what citation count.

5 Q So would you value work that had led to
6 industry adoption and development of a new type of
7 device like you described happening for your
8 FinFET device?

9 A Yeah. I would give a lot of weight to
10 something like that. It would be modulated by the
11 creativity. Sometimes a really simple kind of
12 almost obvious advance can make a big impact in
13 industry. I don't say I discount that. But I
14 like to look for work that is, you know, really
15 inspired and creative and radical.

16 Q There's an article number 11 on your CV
17 here, if you look at the top of -- or the bottom
18 of page 8. Do you see the 2021 Nature article?

19 A I do.

20 Q Is this another one of your famous
21 articles?

22 A Another one. I don't know what the
23 citation count is, but it is probably up there
24 close to the other ones. That's a relatively
25 recent paper. It's gotten a lot of attention.

1 Q Is Nature considered a high-impact
2 journal?

3 A Yes.

4 Q Is Nature Materials considered a
5 high-impact journal?

6 A It is. Not quite. I mean, its impact
7 factor is high, but probably not as high as
8 Nature.

9 Q Within a technical field, are certain
10 journals regarded as leading publications?

11 A Yes.

12 Q Is the IEEE Transactions on Electron
13 Devices considered a leading journal on FinFET
14 design?

15 A Yes.

16 Q Is Nature Materials considered a leading
17 journal for magneto-resistive tunnel junction
18 design? Or magnetic -- let me restate that.

19 Is Nature Materials considered a leading
20 journal for magnetic tunnel junction design?

21 A It's one of them. Yes.

22 Q So yes?

23 A Yes. I said yes.

24 Q Okay. I want to ask you about your
25 experience with magnetic tunnel junction. When I

1 refer to a magnetic tunnel junction, is that
2 frequently treated -- strike that.

3 when somebody says an MTJ, you understand
4 that they're referring to a magnetic tunnel
5 junction in the context of the '909 patent?

6 A Yes.

7 Q Okay. So when I say MTJ, you will
8 understand that I'm referring to a magnetic tunnel
9 junction; right?

10 A Yes.

11 Q Okay. On your CV, at page 2, you list
12 current research interests that include
13 spintronics; is that right?

14 A Yep. Yes.

15 Q Is a magnetic tunnel junction a
16 spintronics device?

17 A I would say so.

18 Q Okay. You list classroom teaching,
19 graduate/undergraduate courses in semiconductor
20 physics; right?

21 A I do.

22 Q In those classes, do you teach
23 spintronics?

24 A Yes. I've taught -- I've taught about
25 spintronics in classes.

1 Q what classes have you taught spintronics?

2 A we have a graduate class in semiconductor
3 physics, semiconductor device physics. And I have
4 talked about spintronics in that class. I have
5 taught that class and I have talked about
6 spintronics in that class.

7 Q when did you first start teaching --
8 strike that.

9 And when you have taught spintronics in
10 this graduate class on semiconductor device
11 physics, have you taught MTJ design?

12 A I would have to say my best
13 recollection -- it's been a little while since I
14 taught that class. I probably didn't go into much
15 detail about MTJ design. I probably mentioned MTJ
16 as one of a class of non-volatile memories. I
17 can't recall as I sit here right now how deeply I
18 went into the details of the design of MTJs.

19 Q And have you taught courses in
20 semiconductor device fabrication?

21 A I have.

22 Q And in those courses on semiconductor
23 device fabrication, have you taught the
24 fabrication of an MTJ?

25 A That class -- again, it's been a couple

1 years since I taught that class. And I probably
2 mentioned MTJs. But I don't think I went into --
3 as best as I recall, I don't think I went into
4 much detail.

5 Q what?

6 A I have class -- I have class notes, you
7 know, for those lectures. I haven't looked at
8 them in a while. I could figure that out, but I
9 don't recall as I sit here right now.

10 Q And when you brought up MTJs in these
11 courses, what -- what materials did you teach
12 from?

13 A what materials did I teach from? In
14 those classes, if -- when I -- whatever I said
15 about MTJs, I didn't -- I probably didn't have,
16 you know, well, review these pages in this
17 textbook. I was probably -- I'm quite sure I was
18 just going by my own understanding that comes from
19 having read a lot of literature. I couldn't point
20 to a single particular one. Like I say, in both
21 in the semiconductor physics and fabrication
22 classes, I would have -- I probably would have
23 mentioned MTJs, said that they were a magnetic
24 memory device, non-volatile. And, you know, that
25 kind of general information. Not citing to some

1 details that would be useful for the student to go
2 back and read in some textbook or other document.

3 Q what -- what year did you first teach
4 anything about MTJs in your semiconductor device
5 physics classes?

6 A I honestly can't remember.

7 Q would it have been after 2010?

8 A It seems likely.

9 Q would it have been after 2015?

10 A Give me a moment. Most likely somewhere
11 around 2015, plus or minus. Like I said, I can't
12 tell you exactly. But 2015 or so looks like a
13 reasonable rough estimate of when I would have
14 first started talking about MTJs in classes.

15 Q when you were at Berkeley, did -- did the
16 department have regular graduate seminars?

17 A Sure.

18 Q Did you have invited speakers?

19 A We do.

20 Q Do you recall Shinji Yuasa being an
21 invited speaker in 2012?

22 A Not off the top of my head. It is quite
23 possible. I might have even been at that talk. I
24 can't remember for sure. 2012. That's a while
25 ago.

1 Q So you don't recall speaking to Dr. Yuasa
2 about MTJs in 2012?

3 A I don't have a specific recollection of
4 that. Does he?

5 Q Did you sponsor that lecture by
6 Dr. Yuasa?

7 A So there is a weekly graduate seminar --
8 actually, it is not limited to graduate students.
9 We have a weekly seminar on solid state devices
10 and technology. And for probably the entire time
11 that I've been at Berkeley or close to it, I've
12 been one of the faculty sponsors of that series.
13 So in one sense, if you ask would I have been a
14 sponsor of that talk, if he gave that talk at the
15 solid state devices and technology seminar, I
16 would have been a sponsor. Now, we have probably
17 ten faculty who are sponsors of that seminar. I
18 don't have a specific recollection if I was there
19 for that seminar. Whether I went to lunch with
20 him. Whether I met him or not. I can't remember
21 any of that. Sometimes I -- you know, most
22 speakers are invited by one or two of the faculty
23 sponsors. It's possible that I invited Huwasa. I
24 don't have a specific recollection of that one way
25 or another. But I couldn't rule it out either. I

1 might very well have done that. I -- I don't
2 think so, but it's possible.

3 Q Have you ever made a magnetic tunnel
4 junction?

5 A So I don't make devices myself with my
6 own hands. I haven't done -- I have in the early
7 days of my career. When I was -- before I joined
8 the faculty at Berkeley, I was an engineer at Bell
9 Laboratories where I had a lab. And I went in
10 that lab and I did my own experiments and
11 fabricated structures and devices. It's not an
12 absolute rule, but the vast majority of university
13 professors -- I'll just talk about what I know for
14 sure, electrical engineering -- I think this is
15 actually true in a much broader context. Faculty
16 generally advise graduate students who fabricate
17 devices and make measurements and go in the lab
18 and do things. And I advise them. So since I've
19 been at Berkeley, I don't think I have made any
20 devices since 1993.

21 Q When is the last time that you stepped
22 into a clean room?

23 A Oh, I go in the clean room. I can't tell
24 you exactly. Within the past few years, I've been
25 in the clean room. I have a private laboratory,

1 which is not a clean room, for fabricating devices
2 where measurements are made. And I -- I haven't
3 been in that lab since July 1 of 2004, which is
4 when I retired from the faculty and gave up my
5 lab. But before that, I would go in that lab
6 probably at least once a week. Sometimes -- every
7 day for periods.

8 Q Is it fair to say that your hands-on
9 bench work is more in characterizing solid state
10 devices than fabricating solid state devices?

11 A I worked on doing device fabrication when
12 I was at Bell Labs.

13 Q Okay. Sorry.

14 A My hands on -- my hands-on experience
15 covered both.

16 Q So with regard to MTJs, is your
17 experience more characterizing MTJs or fabricating
18 MTJs?

19 A So as I just said, whether it is
20 fabrication or characterization, I supervise
21 others --

22 Q Uh-huh.

23 A -- with hands-on work.

24 Q Can you tell me what is your experience
25 in designing MTJs?

1 A I have some experience in designing MTJs.
2 I can't say that I -- no, that wouldn't be true.
3 I have some experience in designing MTJs.
4 Supervising students who fabricated MTJs or
5 devices very -- very much like MTJs. I have some.
6 I don't know how to characterize how much.

7 Q On your CV then, Exhibit 1025, can you
8 point me to a project that was the first time that
9 you designed an MTJ in any capacity?

10 A Probably. It's a paper from 2016.

11 Q What paper is that?

12 A Number 56. First author, Hong.

13 Q Okay. Paper number 56 was published on
14 IEEE Transactions on Magnetics, volume PP in 2016;
15 right?

16 A That is probably a typo. That's -- there
17 should be a volume number there. I just noticed
18 that. I just noticed that typo.

19 Q So tell me, in the -- in the MTJ that was
20 involved in that work, was it a three-layer
21 device?

22 A Most likely. I don't remember the
23 details of the design as I sit here right now. I
24 would have to look up that paper. But yeah, it
25 would have been -- I don't recall. I'm going to

1 have to say I don't recall the design, whether we
2 had more than three layers, pinning layers and so
3 forth. I can't recall exactly what the design of
4 the MTJ was in that paper.

5 Q what materials did you use for the bottom
6 ferromagnetic electrode?

7 A I don't recall.

8 Q what material did you use for the barrier
9 layer?

10 A I don't recall.

11 Q Okay. How did you learn how to make an
12 MTJ?

13 A You can see I had a co-author there. The
14 last author there is Khizroev. He was -- he was
15 the key expert in design -- how to design it -- I
16 learned how that device was designed from him.

17 Q So before 2016, you yourself had not
18 designed an MTJ?

19 A I had not designed an MTJ that was --
20 that subsequently we fabricated and tested, that's
21 for sure.

22 Q Did you design an MTJ in any capacity
23 before 2016?

24 A So it kind of depends on what you mean by
25 design. You know, if I sat down and sketched on a

1 paper, on a sketch pad what an MTJ looked like, it
2 probably was before that. To do a design
3 sufficiently detailed to use to fabricate
4 something, probably not.

5 Q Have you ever designed or chosen the
6 process steps to fabricate an MTJ?

7 A In collaboration with others, yes.

8 Q And when you say in collaboration with
9 others, you're referring to working with
10 Dr. Khizroev in this 2016 work?

11 A At least. I think there were people
12 working together with him that participated as
13 well.

14 Q And in that capacity, did you ever
15 suggest using one material rather than another for
16 ferromagnetic electrode?

17 A I don't recall specifically in that
18 particular instance. But I think highly likely
19 that we talked about what would be the materials
20 available, who had -- who had what targets in
21 their sputter chamber and so forth. That
22 certainly would have been a discussion.

23 Q You list as one of your major research
24 accomplishments demonstration of a 7 nanometer
25 magnetic memory using scanned probe magnetic

1 tunnel junction readout in 2018. Is that right?

2 It's on page 3 of your CV.

3 A I see that.

4 Q Was this related to the work in 2016 with
5 Dr. Khizroev?

6 A I think it was a different -- I think
7 that was with Khizroev. But that is referring to
8 a different publication.

9 Q Is it referring to publication number 45?

10 A No.

11 Q Is there a publication associated with
12 that work from 2018?

13 A I think I'm referring to publication 41.
14 No. Wait a minute. That's not --

15 Q All right. Dr. Bokor, can I ask a
16 different question?

17 A I'm on the verge of answering this last
18 one, if you give me one moment.

19 So I think the paper -- the 2018 paper
20 that I'm mentioning there is number 41, which
21 doesn't include Khizroev. "Self-assembled
22 single-digit nanometer memory cells." If I recall
23 correctly, those were a form of MTJ devices.

24 Q Did the MTJ devices in that work have
25 three layers?

1 A I think so.

2 Q Do you recall what the layer of materials
3 were?

4 A I do not.

5 Q Do you recall who decided what materials
6 to use?

7 A well, that would have been a decision I
8 think all four co-authors participated in. I
9 think Dr. You was the lead on the fabrication.

10 Q So what was your role on that project?

11 A well, I was the -- I was the leader of
12 the project. One of the leaders of the project.
13 A collaborator. We met -- I can't remember whose
14 idea initially it was to do that project.
15 Probably Hong, the first author. And then we had
16 meetings to discuss the project, what -- what we
17 had the capability to do, what we would do, how it
18 progressed along, how the progress was going. I
19 participated in all of the discussions as the
20 project evolved and including analyzing the data
21 and writing the paper.

22 ATTORNEY WICHMAN: Okay. All right.
23 Dr. Bokor, why don't we take a five-minute break.
24 Is that enough time for people -- for you to use
25 the bathroom if you need to?

1 THE WITNESS: That will work for me.

2 ATTORNEY WICHMAN: All right.

3 THE REPORTER: That's fine.

4 ATTORNEY WICHMAN: Let's go off the
5 record for five minutes. Let's come back at five
6 past the hour.

7 (A recess was taken.)

8 ATTORNEY WICHMAN: Back on the record.

9 Q Dr. Bokor, go back to your 2000 FinFET
10 paper and transactions on electric devices. On
11 your CV, at page 6, you list a number of patents
12 that you have received. Do you see number 10?
13 You list a patent number 600413802.

14 Let me restate that.

15 On your CV, at page 6, number 10, US
16 patent number 6,413,802. Is that right?

17 A Yes, I have that. I see that.

18 Q Yeah. Is that patent related to the work
19 that you published in your IEEE Transactions on
20 Electron Devices paper in 2000?

21 A It is related in the sense that it does
22 claim FinFETs.

23 Q So this was one of your famous papers;
24 right?

25 A This is a patent. You're asking me about

1 the patent?

2 Q I'm asking you about the paper now. So
3 the paper, the 2000 paper in Transactions on
4 Electronic Devices, we talked about that. That is
5 one of your famous papers?

6 A I remember talking about that.

7 Q Yeah. And you said that Intel went and
8 commercialized FinFETs that you had developed and
9 described in that paper; is that right?

10 A Correct.

11 Q And you obtained a patent on that same
12 FinFET subject matter that you described in part
13 in that paper; correct?

14 A Correct.

15 Q Okay. Can you open Exhibit 1026, please.
16 Let me know when you have it.

17 A 1026. Bowen. Yes. I have it.

18 Q So you cite this paper in your
19 declaration in this case; right?

20 A Yes.

21 Q So we will call -- when I refer to Bowen,
22 I'm referring to this paper, Exhibit 1026. okay?

23 A Fine.

24 Q So Bowen fabricated an MTJ with three
25 crystal layers; right?

1 A Yes.

2 Q So the bottom layer was a crystalline
3 iron layer that was oriented in 001; is that
4 right?

5 A Yes.

6 Q And for a barrier layer, he grew a single
7 crystal magnesium oxide that was oriented in 001;
8 is that right?

9 A Yes.

10 Q And for the top ferromagnetic electrode,
11 he grew an iron cobalt layer; is that right?

12 A That's my understanding, yes.

13 Q Okay. And he grew this tri-layer device
14 epitaxially; is that right?

15 A That's what he says.

16 Q Do you have any reason to doubt him?

17 A No.

18 Q So Bowen characterized this device by
19 estimating a barrier height for the magnesium
20 oxide layer; is that right?

21 A That's my understanding, yes.

22 Q So if you look at Bowen page 1656, which
23 is PDF page 3, Bowen fit something called the
24 Simmons equation for tunneling current density; is
25 that right?

1 A We're on page 1 -- sorry. which page are
2 we on?

3 Q Page 1656.

4 A Uh-huh.

5 Q The left-hand column, first full
6 paragraph halfway down. Do you see the sentence
7 starting with "The temperature dependence of I(V)
8 curves?

9 A I see it now, yes.

10 Q Okay.

11 A Mentioned right there. Yes.

12 Q So Simmons' equations yield -- what he
13 writes is, "Simmons' equations yield by
14 approximately 1.1 electron volts for a barrier
15 thickness d in approximately 15 angstroms."

16 A That's what it says.

17 Q And phi is the representation of barrier
18 height in the Simmons model; is that right?

19 A That's my understanding, yes.

20 Q And here, Bowen is using phi to represent
21 barrier height; is that right?

22 A Yes.

23 Q Okay. So fitting -- he also says --
24 sorry. If we -- he did this fitting at a -- for a
25 bias of 10 millivolts; right?

1 It is the previous sentence. I'm sorry.
2 One -- okay. Let me start over.

3 If you look in Bowen at page 1656, in the
4 left-hand column, first full paragraph, the --
5 one, two, three -- fourth sentence down, it starts
6 with "As shown in Figure 2(a)."

7 A Right.

8 Q Do you see that?

9 A Yes.

10 Q "The resistance of our MTJ (at 10
11 millivolts) saturates below 50 K." Do you see
12 that?

13 A Yes.

14 Q would you call that -- is that a low
15 voltage -- a low bias voltage for the Simmons
16 model?

17 ATTORNEY WILSON: Objection. Form.

18 THE WITNESS: I would -- 10 millivolts,
19 that's fair to say that is a low voltage for an
20 MTJ.

21 BY ATTORNEY WICHMAN:

22 Q The 10 millivolts if you were using the
23 Simmons equation, you would use the low-voltage
24 equation; is that right?

25 A That sounds fair.

1 Q And you understand that that's what Bowen
2 did to obtain his estimate of 1.1 electron volts
3 for the barrier height?

4 ATTORNEY WILSON: Objection. Form.

5 THE WITNESS: Well, that's -- that's a
6 little bit of a confusion of the way I read what
7 it says here.

8 BY ATTORNEY WICHMAN:

9 Q Tell me how you read it.

10 A Where he says Simmons equations -- okay.
11 He -- if your question is did he use the
12 low-voltage limit of Simmons equations to arrive
13 at that barrier height, that -- that I would -- I
14 think is fair. The way he -- so he gives an
15 experimental barrier height of .9 eV, which is the
16 one that he got using the 50 millivolts on the
17 device. Sorry. The 10 millivolts on the device.
18 So maybe I could ask you to repeat that question.

19 Q Well, let's do it this way: You see
20 where he says -- Bowen says, "The temperature
21 dependence of I(V) curves places the barrier
22 height at Fe equals .9 electron volts"?

23 A I see that.

24 Q You understand that to mean that Bowen
25 applied a I(V) and he measured current through the

1 MTJ device at different temperatures?

2 A That would be my understanding of that
3 sentence.

4 Q And using that information, he estimates
5 the barrier height as .9 eV; is that right?

6 A Right.

7 Q And then he also fit the Simmons equation
8 to estimate barrier height; right?

9 A He used the Simmons equation to estimate
10 barrier height, yes.

11 Q And when he did that, the barrier height
12 estimate he determined was 1.1 electron volts;
13 right?

14 A Right.

15 Q Approximately.

16 Okay. So if you look at page 1657 of
17 Exhibit 1026, in the top right column. Do you see
18 that?

19 A 1657.

20 Q The last page, yeah.

21 A Okay.

22 Q All right. On the right-hand column
23 first full paragraph, it starts with "In
24 conclusion." Are you there?

25 A I'm there.

1 Q Okay. If you go down, do you see the
2 sentence that begins "Transport measurements
3 show"?

4 A I see that.

5 Q So he -- so Bowen says that "Transport
6 measurements show 27 percent TMR at 300 K which
7 increases to 60 percent at 30K." Is that right?

8 A Right.

9 Q Okay. So 300 K, that's 300 kelvin;
10 right?

11 A Yes.

12 Q It is approximately 80 degrees
13 Fahrenheit?

14 A Approximately what?

15 Q 80 degrees Fahrenheit?

16 A 300 K is 80 degrees Fahrenheit? I'll
17 take your word for that. I would have to do the
18 calculation.

19 Q 300 kelvin is room temperature; right?

20 A It is about room temperature. 80 sounds
21 a little high. I could calculate it. I'll take
22 your word for it. It sounds a little high for
23 300 K, but whatever.

24 Q And 30 kelvin is a cryogenic temperature;
25 right?

1 A Correct.

2 Q Approximately negative 405 degrees
3 Fahrenheit?

4 A Again, I'll take your word for that.

5 Q Liquid nitrogen at a standard atmosphere
6 it liquifies -- it condenses into liquid at 77
7 kelvin.

8 A Correct.

9 Q And liquid helium condenses into a liquid
10 standard atmosphere at a temperature of 4.2
11 kelvin; right?

12 A I do -- I'm aware of that, yes.

13 Q Okay. So 30 kelvin, where Bowen made his
14 measurements, is somewhere between liquid helium
15 and the boiling point of liquid nitrogen; right?

16 A That is correct.

17 Q It's cold.

18 A Fair enough.

19 Q Okay. So --

20 A I don't know what -- the Fahrenheit
21 temperature that that corresponds to without
22 making a separate calculation. I could do that
23 easily. But I -- you cited a temperature in
24 Fahrenheit. That doesn't instantly click for me.
25 But I don't doubt that you got the right number

1 there.

2 Q So Bowen is telling us that at room
3 temperatures, his MTJ had a TMR of 27 percent; is
4 that right?

5 A I believe that's basically the -- the
6 gist of what he is saying.

7 Q Okay. If Bowen had achieved a barrier
8 height of .85 electron volts, what would have been
9 the room temperature TMR?

10 A If Bowen had obtained a barrier height
11 of -- say that again, please.

12 Q If Bowen had achieved a barrier height of
13 .85 electron volts, what would have been the room
14 temperature TMR?

15 A So you're saying if the barrier height
16 was .05 ev less than the one he measured, you're
17 asking what he would have got for a -- for a TMR?

18 Q Yes.

19 A I can't answer that question. I don't
20 know. I didn't -- I don't know. I don't believe
21 he gives data on that in the paper.

22 Q Why -- why can't you answer the question?

23 A Because I don't think Bowen's paper tells
24 us.

25 Q What would a person of ordinary skill in

1 the art expected the TMR to be?

2 A I -- I don't know. Well -- wait. Let
3 me -- let me clarify that. I don't think a person
4 of ordinary skill in the art at the time of this
5 publication, 2001, would have been able to make
6 that calculation.

7 Q why not?

8 A The temperature dependence -- sorry.
9 The -- the theory for that -- there was no
10 reliable theory for that in the art, as far as I
11 understand, in that time.

12 Q And what about in 2004?

13 A I would say it was similar. Your
14 question is what TMR would they have expected, if
15 I recall correctly. Is that right?

16 Q Let me ask again. In 2004, if Bowen
17 had -- strike that.

18 If Bowen had achieved a barrier height of
19 0.85 electron volts for his MTJ, in 2004, what TMR
20 would a POSA, person of ordinary skill in the art,
21 have expected that device to provide?

22 A I think my -- my opinion in 2004, a POSA
23 would have -- the only way that a POSA could have
24 answered that question is doing the experiment.
25 Expecting on the basis of theory, my -- my

1 understanding of the state of the theory at that
2 time was a POSA would not have been able to
3 reliably make an estimate of what that should have
4 been.

5 Q why not?

6 A I just said, I don't think the theory was
7 sufficiently detailed and -- there wasn't adequate
8 theory that could reliably make that depiction as
9 far as I know at that time.

10 Q If Bowen had achieved a barrier height of
11 0.85 electron volts for his MTJ in 2004, would a
12 person of ordinary skill in the art have expected
13 the room temperature TMR to increase from
14 27 percent?

15 A A person of ordinary skill in the art at
16 that time would not have been able to make a
17 definitive determination of that. They would have
18 expected -- it is reasonable to expect that the
19 TMR would change. But I think that's the best
20 they could do at that time.

21 Q In 2004, which direction would a person
22 of ordinary skill in the art have expected the TMR
23 to change?

24 A I think it would have been uncertain at
25 that time.

1 Q why do you say that?

2 A There -- as far as I know, there wasn't
3 sufficient information in the -- in the --
4 sufficient published information in the literature
5 to definitively indicate one way or the other.

6 Q In order to make this determination, what
7 would a POSA have needed to know?

8 A They would have needed to know the detail
9 dependence of TMR on barrier height.

10 Q And that was not known in 2004?

11 A Not definitively.

12 Q Explain.

13 A A person of ordinary skill at that time I
14 believe would have had -- based on literature,
15 they would have had an expectation that the TMR
16 would depend on barrier height. But the -- the
17 way that -- the detail mathematical dependence of
18 barrier height on TMR was not definitively known
19 or how to calculate it in detail. It might have
20 been known how to calculate it, but it wasn't
21 published. So there were theorists at the time
22 who probably could have made that calculation, but
23 I'm not aware of any publication where they
24 explicitly gave that dependence. So a person of
25 ordinary skill in the art I don't think would have

1 been able to make that calculation.

2 Q So what would a person of ordinary skill
3 in the art in 2004 have expected the TMR of
4 Bowen's device would have increased if Bowen had
5 achieved a barrier height of .85 electron volts?

6 A I'm sorry. Please repeat one more time.

7 Q Okay. Let me break it up into little
8 pieces here.

9 In 2004, if Bowen had achieved a barrier
10 height of .85 electron volts, would a POSA have
11 expected the TMR of Bowen's device to have
12 increased from the 27 percent TMR that Bowen
13 observed at room temperature?

14 A It is my opinion that a POSA would not
15 have had sufficient information to definitively
16 decide what direction the TMR would have gone.

17 Q And would they have had an expectation on
18 which direction TMR would have changed even if
19 that expectation was not definitive?

20 A What I'm saying is I think a person of
21 ordinary skill in the art at the time would have
22 had a reasonable expectation that the TMR would
23 change. But it would be not -- they would not be
24 able to be certain which way it would go, whether
25 it would go up or it would go down. I think it

1 was understood that TMR could change as a function
2 of barrier height. But the details -- how it
3 depended on the details of the MTJ structure, how
4 it depended on a whole variety of parameters was
5 not fully understood.

6 Q What other --

7 A So that -- so that person of ordinary
8 skill wouldn't be able to have a definite
9 expectation one way or the other.

10 Q So a person of ordinary skill in the art
11 in 2004 could not have said that the TMR would
12 have increased or decreased; is that right?

13 A That's what I'm saying.

14 Q So a person of ordinary skill in the art
15 in 2004 could not state the TMR -- could not
16 exclude the possibility that the TMR would
17 decrease; is that right?

18 A That's right.

19 Q And a person of ordinary skill in the art
20 in 2004 could not say that TMR would have
21 increased; is that right?

22 A That's my opinion.

23 Q So your testimony is that a person of
24 ordinary skill in the art in 2004 would have
25 thought something would have changed for the TMR

1 value, but they wouldn't know if it would go up or
2 down?

3 A For Bowen's specific device?

4 Q Right.

5 A Right.

6 Q Okay. And you referred to the whole
7 variety of parameters that were not fully
8 understood. Tell me what some of those parameters
9 were that you have in mind?

10 A The composition of the layers, the band
11 structure of the layers, the thicknesses of the
12 layers, crystal structures of the layers. Even
13 with that, it was -- it was not -- it was not easy
14 to make that calculation. A person of ordinary
15 skill in the art in 2004, in my opinion, did not
16 have the capability to make a calculation to
17 determine which direction the TMR would go, even
18 if they knew all the details of the -- of the
19 structure of the MTJ. That's my -- that's my
20 opinion.

21 Q Let me ask in terms of a reasonable
22 expectation. Would have a POSA have a reasonable
23 expectation that the TMR of Bowen's device would
24 increase if Bowen had achieved a barrier height of
25 .85 electron volts?

1 A It would have had a reasonable
2 expectation.

3 Q why?

4 A Because there are only two choices. It
5 could have gone up. It could have gone down. And
6 so a person of ordinary skill in the art would
7 have a reasonable expectation that if their goal
8 was to increase the TMR, it would be worth a try
9 to lower the barrier height.

10 Q Is it your testimony that the person of
11 ordinary skill in the art would have a reasonable
12 expectation that the TMR would change?

13 A Yes.

14 Q Okay. Is it equally like -- would they
15 have had a reasonable expectation that it was just
16 as likely the TMR would go down as for the TMR to
17 go up?

18 A I think so.

19 Q You're not sure?

20 A I think so. I think they would have had
21 just -- to them, it would have -- it would have
22 been hard to determine -- they wouldn't have had
23 the capability to determine whether it would go up
24 or down. But since it has to either go up or go
25 down, it's reasonable -- it is a reasonable

1 expectation for it to go down. Now, just as --
2 just as likely to go up, but it is reasonable to
3 expect it to go down.

4 Q If Bowen had achieved a barrier height of
5 0.80 electron volts in his MTJ, would a POSA in
6 2004 have expected the TMR of Bowen's device would
7 increase?

8 A It is the same answer. No difference for
9 .8 compared to .85.

10 Q No difference in terms of what?

11 A My answer.

12 Q Your answer. Okay.

13 A They would have the same -- the
14 expectation that it might go up or it might go
15 down.

16 Q Equally likely to go up as to go down?

17 A A POSA at that time I think could not
18 have determined what the likelihood is in either
19 direction. So in that sense, it would be equally
20 likely.

21 Q If Bowen had achieved a barrier height of
22 .75 electron volts in his MTJ, would a POSA in
23 2004 have reasonably expected the TMR to increase
24 from the 27 percent room temperature TMR that
25 Bowen estimated?

1 A They would have -- I believe a POSA would
2 think it was reasonable for it to go down. Yes.

3 Q would the -- the POSA would have thought
4 it would be reasonable for the TMR to go down?

5 A Go up -- be careful. Be careful. You
6 question -- please repeat your initial question.

7 Q I'm sorry. Ms. Silvas, are you able to
8 repeat my last question.

9 (The record was read back as
10 requested.)

11 THE WITNESS: My answer to that question
12 is yes.

13 BY ATTORNEY WICHMAN:

14 Q why?

15 A Same answer as I gave before. It's
16 reasonable to expect that it would go -- the TMR
17 would go up. Because the TMR could only go up or
18 go down. And so it is reasonable to expect either
19 way. I think a person of ordinary skill at the
20 time would have a reasonable expectation that the
21 TMR would change with the barrier height. It was
22 not possible to predict with certainty or even
23 some degree of probability which way, as far as
24 I'm aware. So yes, the TMR is very, very likely
25 to change. But which way it will go was -- was

1 not possible for a TMR to determine that with
2 precision or with definitive. They couldn't
3 assign a probability, I don't think. It could
4 have gone up. It could have gone down.
5 Reasonable to expect it's going to go down. Let's
6 give it a try.

7 Q If Bowen had achieved a barrier height of
8 0.75 electron volts in his MTJ, in 2004, how much
9 would a POSA have expected the TMR of Bowen's
10 device to have changed?

11 A I don't think they could have made a -- a
12 determination of how much with any degree of
13 confidence. It was known that it would change.
14 But -- my understanding of the state of the theory
15 that was understood by a POSA at that time, they
16 didn't have a theory that was sufficiently
17 workable for a POSA to be able to make that
18 calculation.

19 Q So is your testimony that a person of
20 ordinary skill in the art in 2004 would have
21 expected the TMR of Bowen's device would change if
22 Bowen's barrier height changed, but that person of
23 ordinary skill in the art could not say which
24 direction the TMR would change and it could not
25 say how much the TMR would change?

1 A Not quantitatively, no.

2 Q Not quantitatively that that is your
3 opinion or not quantitatively that they --

4 A They wouldn't have quantitatively
5 determined how much, including the sign, up or
6 down.

7 Q Okay. If Bowen had achieved a barrier
8 height of 0.70 electron volts in his MTJ, would a
9 POSA in 2004 have expected that Bowen's TMR would
10 have increased from 27 percent at room
11 temperature?

12 A My opinion of the barrier height is the
13 same. They would have had a reasonable
14 expectation that the TMR could go up. It was
15 reasonable to expect that the TMR would go up. By
16 how much, I don't think anybody could calculate
17 that in 2004, including the theoretical experts.
18 But it was reasonable to expect that the TMR would
19 go up. It might go down. But it was reasonable
20 enough to go -- that it would go up, which would
21 have been the desire of a -- of many at the time.
22 Increasing TMR was a strong motivation for many in
23 the art. And it would have been reasonable to try
24 reducing the barrier height to increase the TMR.

25 Q So I just want to understand. You told

1 us that the person of ordinary skill in the art
2 could not expect that the change would be up or
3 down with any certainty. Is that right?

4 A Correct.

5 Q Okay. So when you say that it would have
6 been reasonable for the POSA to have expected the
7 TMR to increase, what you mean is something had to
8 change. And it was as likely to be -- that the
9 TMR went up as for the TMR to go down. Is that
10 your testimony?

11 A Roughly, yes.

12 Q well, explain it to me. If I'm not -- if
13 I'm not understanding your testimony correctly,
14 please -- please clarify.

15 A I think you're understanding my
16 testimony.

17 Q Okay. So what -- other than the fact
18 that the TMR had to change, what basis would a
19 person of ordinary skill in the art in 2004 have
20 had for expecting that the TMR would increase if
21 Bowen's barrier height were lowered?

22 A I just said they had reasonable -- reason
23 to expect that the TMR would change. It could go
24 up. It could go down. That's what they -- that's
25 what -- so because it would be of such

1 considerable value for the TMR to go up, a person
2 of ordinary skill would be motivated to do the
3 experiment and see. Bowen didn't do that. But a
4 person of ordinary skill, looking at Bowen, as
5 well as the rest of the literature at the time,
6 would have reason to expect that if you change the
7 barrier height, there's a good chance that you
8 will get an increased TMR.

9 Q And what literature would have given the
10 POSA that expectation?

11 A That the TMR would change?

12 Q You said TMR would increase.

13 A Well, okay. So I'll -- that will take me
14 some time to dig up.

15 Q Did you provide testimony on this issue
16 in your declaration?

17 A I'm pretty sure. So you'll have to give
18 me a little time to go through my declaration to
19 see where that's discussed. Okay?

20 Q I'm sorry. Dr. Bokor, are you looking
21 for this part of your declaration?

22 A Yeah.

23 Q Your testimony. Okay.

24 A Okay. So the way I -- the way I think
25 about that question is the following: If we go to

1 Exhibit 1038, that's a paper from Moodera.

2 Q 1038, you said?

3 A Yeah. And I'm looking at page 4728.

4 Q Give me a minute. So Exhibit 1038, page
5 4728. Where should I be looking?

6 A So Moodera says in -- if you go to the
7 first full paragraph in the right-hand column, it
8 starts with "The MR shows." And a little bit
9 farther down -- one, two, three, four, five, six,
10 seven, eight, nine, ten, eleven, twelve.

11 "Many causes can contribute to the
12 decrease in the MR with bias. Among them, the
13 bias dependence of the barrier height, creation of
14 magnons, density of states effects in the FM,
15 et cetera, may be responsible for the decrease in
16 $\Delta R / R$."

17 So this is telling the POSA at least in
18 some circumstance the $\Delta R / R$, the
19 magnetoresistance could depend on barrier height.
20 Now, in this experiment, he relies on the bias
21 dependence of the MR to make that suggestion.

22 Now, the way that Moodera is -- what he
23 is talking about is in varying the bias -- in
24 varying the barrier height with bias is one -- it
25 has to do with when you apply bias, the barrier

1 takes on a triangular shape so that the barrier
2 across the insulator, across the MgO, the barrier
3 is not flat. There's a variation of barrier. It
4 goes down as you go through the MgO. It takes on
5 a slope. So when you apply a bias, the average
6 barrier height through that barrier is reduced
7 because it is reduced by the bias, by some
8 considerable amount. So that could change the --
9 the MR because the electrons are tunneling through
10 the barrier with a lower barrier height. On the
11 average in the MgO.

12 Now, a person of -- a POSA would then
13 combine this teaching, that the barrier height in
14 that context -- change the barrier height in that
15 context could lower the MR. But then they would
16 be aware of Butler.

17 So let me pull up Butler. Butler,
18 Exhibit 1044.

19 Actually, one moment. Let me instead go
20 to my declaration, the 909 declaration. Paragraph
21 68. Let me know when --

22 Q Go ahead. I've got it right here.

23 A Paragraph 68 says that "MgO has the
24 special property that tunneling is governed by the
25 majority (parallel) spin electrons." That's a

1 citation to Klaua.

2 Then it goes on, "Research groups led by
3 Butler (Exhibit 1044) and Mathon (Exhibit 1046) in
4 2001 calculated optimistic TMR ratio is in excess
5 of 1000 percent for an MgO barrier. Mathon at the
6 Abstract; see also Butler at page 1, Figure 16."
7 And also it cites to the Dieny textbook. "Their
8 research established that a thin MgO barrier
9 passed delta-1 electrons while largely blocking
10 other electrons having opposite spin -- leading
11 the way to high TMRs." Let's just finish out
12 this paragraph. "As a 2001 paper by Klaua
13 explained, unlike amorphous for aluminum oxide
14 barriers, for crystalline MgO barriers: 'The
15 tunneling resistance for the parallel orientation
16 of the magnetic moments is estimated to be 100
17 times smaller than that for the antiparallel
18 orientation of the magnetic moments due to the
19 absence of scattering in the barrier.'"

20 So what I'm saying here is that it was
21 understood that MgO was a special -- had special
22 properties with regard to MR that depended on the
23 detailed band structure of the MgO. MgO barrier
24 selectively passed delta 1 electrons. Those are
25 polar -- those are electrons polarized --

1 polarized electrons are selectively passed in the
2 MgO while electrons have the opposite spin are
3 blocked.

4 Now, a person of ordinary skill would
5 understand that the details of the MgO band
6 structure are energy dependent. The bands have
7 dispersion. And depending on what energy we're
8 looking at, the bands can vary. And in
9 particular, one also understood from Butler that
10 the parallel orientation of the magnetic moments
11 having selectively being passed was -- was rather
12 general throughout the MgO barrier. But what a
13 person of ordinary skill in the art, other than
14 Butler or people in his group, would have had a
15 hard time understanding -- hard time predicting
16 what would happen to the blockage of the
17 antiparallel electrons as a function of energy
18 within the MgO.

19 So a person of ordinary skill
20 understanding as best they could with their skill
21 in the art, understanding Butler, would have a
22 reasonable expectation that if you vary the
23 barrier height, not by the way that Moodera did
24 it, by tilting the barrier through the MgO, but by
25 changing the position of the Fermi level of the

1 metal relative to the MgO band structure. That's
2 what, for example, barrier height means in
3 Simmons. So by varying the position of the Fermi
4 level relative to the MgO band structure, a person
5 of ordinary skill would have a reasonable
6 expectation that that blocking would be energy
7 dependent and could be more effective with a
8 change in barrier height.

9 And a person of ordinary skill would not
10 have the ability, in my opinion, to make the
11 detailed calculation to decide whether it will go
12 up or down. Maybe Butler could have done that.
13 But Butler had skill far beyond that of a POSA at
14 the time, in my opinion.

15 So that's my basis for saying that a POSA
16 would have a reasonable expectation for thinking
17 about change of barrier height from Moodera. And
18 then going and looking at Butler and saying what
19 happens in Butler if I change the barrier height
20 by moving the Fermi level relative to the MgO band
21 structure?

22 That's a long explanation. I apologize.
23 But it's -- that's -- that's my opinion of how a
24 POSA would have considered this at the time.

25 Q Let me ask a few questions.

1 A Are we close to a good time for a break?
2 Do you want to ask a couple questions or take a
3 break now?

4 Q Fair. Let's go for a few more minutes
5 and then take a break.

6 A Okay.

7 Q First, when a bias is applied across an
8 MTJ and the Fermi level on one side lowers, the
9 Fermi level in one ferromagnetic electrode lowers
10 relative to the other, in your description, that
11 will increase the barrier?

12 A No. That will decrease the barrier.

13 Q That will decrease the barrier.

14 A What Moodera is talking about that the
15 barrier decreases with bias is that the average
16 barrier through the MgO, it is now a function of
17 distance through the MgO. You've got a lower --
18 lower bias on the second electrode. So the
19 barrier -- let me back up. When there is zero
20 voltage across the barrier, the two Fermi levels
21 on either electrode are the same energy. And then
22 there is a barrier from the -- from either side to
23 get into the conduction band of the MgO. The
24 barrier on either side, if the materials are the
25 same, is the same. So for simplicity, let's just

1 assume that the Fermi magnet on either side is the
2 same. We can modify that if we have different
3 materials subsequently. So the barrier -- the
4 energy of the conduction band in the MgO then is
5 independent of distance. It's the same.

6 Now, once you apply a bias to lower the
7 Fermi level on, let's say, the -- the second
8 ferromagnet, the position of the Fermi level for
9 each of the ferromagnetic relative to the MgO band
10 structure is in the same place. Instead, what we
11 have is an electric field causing the conduction
12 bandage to vary its position with distance through
13 the barrier. What Moodera is talking about in
14 that case for an electron that tunnels from the
15 Fermi level of the first ferromagnetic passing
16 through the MgO, it is experiencing -- and it --
17 it goes through essentially the same energy.
18 We're talking about elastic transport. So the
19 average barrier height that that is experiencing
20 as it is tunneling through the MgO is dropping
21 because of that tilt. So that's what Moodera was
22 talking about. And it is reasonable that the --
23 the MR goes down in that situation.

24 But Butler, what I'm saying is that if
25 you move the Fermi level for the first

1 ferromagnetic electrode relative to the MgO band
2 structure, which is what happens when you vary the
3 barrier height by composition or chemical or
4 defects or the like, the barrier height changes
5 because the Fermi level of the metal is move -- is
6 in a different position relative to the MgO band
7 structure. Relative to the conduction bandage of
8 the MgO. So now the physics that Butler was
9 pointing out, that there's this blockage of the
10 antiparallel electrons it is reasonable for a
11 person of ordinary skill to expect that that
12 blocking would not be the same. And that the TMR
13 would change in that case.

14 Q All right. Let me ask you just a few
15 more questions here.

16 In Exhibit 1038, this is the Moodera
17 paper --

18 A Okay.

19 Q -- you referred to page 4728.

20 A Right.

21 Q And in the right-hand column, second full
22 paragraph, the sentence that says, "Many causes
23 can contribute to the decrease in the MR with
24 bias."

25 A Yes.

1 Q MR is the TMR, the tunnel
2 magnetoresistance ratio. Is that right? Or I'm
3 sorry. Yeah. The tunnel magnetoresistance ratio,
4 the TMR that we've been speaking about; right?

5 A Yes.

6 Q And Moodera is describing a situation
7 where you're saying that there's a bias dependence
8 of the barrier height; right?

9 A That's what Moodera says.

10 Q Right. And so Moodera is describing the
11 MR decreasing when the barrier height decreases.
12 Is that right?

13 A Importantly he calls it the effective
14 barrier height.

15 Q Why is that important?

16 A Well, I -- I made my best effort to
17 explain that in my long explanation earlier. But
18 if you would like, I'll try to do it again. The
19 effective barrier height, what I'm talking about
20 is how the barrier height -- how the position of
21 the conduction band relative to the Fermi level of
22 the first electrode is varying with distance from
23 the interface of the first electrode. And so the
24 effective -- the effective barrier height is
25 lowering with bias by that simple mechanism.

1 Q So does Moodera -- would Moodera have
2 suggested to a person of ordinary skill in the art
3 in 2004 that if Bowen had achieved a lower barrier
4 height, the TMR would have decreased?

5 A So -- so the lower -- if Bowen had
6 achieved a lower barrier height by having
7 engineered the interface between the lower
8 ferromagnetic electrode and the MgO, if he had
9 lowered the barrier height by, for example,
10 changing the defect density so that the Fermi
11 level of the first ferromagnetic electrode changed
12 its position at the interface relative to the
13 conduction band of the MgO. That is the
14 fundamental definition of barrier height in the
15 art. I could point you to in my declaration where
16 I explain that, if you would like. The
17 fundamental definition of barrier height in this
18 context is the difference in energy between the
19 Fermi level of the metal on one side of the
20 barrier and the conduction band of the insulator
21 on the other side of the barrier. That energy
22 difference was well known could be -- could change
23 for the general case of any insulator. And if the
24 barrier height was varied that way, that would be
25 different than what -- what Moodera was talking

1 about.

2 I cited to the Moodera simply to suggest
3 that a person of ordinary skill in the art at the
4 time would have the idea that you could vary the
5 MR. But looking at Butler, which was published
6 subsequent to Moodera, then a person of ordinary
7 skill would look at that and be able to expect,
8 without being able to make a quantitative
9 calculation, that there would be reason to expect
10 the MR could go either way and have at least a
11 50 percent chance of going up.

12 Q If you could look at Butler Exhibit 1044.

13 A Okay. Sorry.

14 Q Page 1.

15 A Page 1.

16 Q PDF 1.

17 A Got it.

18 Q Do you see the abstract there?

19 A I do.

20 Q Last sentence, "We predict a large
21 magnetoresistance that increases with barrier
22 thickness."

23 A Yes.

24 Q Right.

25 A Right.

1 Q So that's the actual thickness of the
2 barrier layer; right?

3 A Correct.

4 Q And in Bowen, that barrier layer
5 magnesium oxide was 20 angstroms; correct?

6 A Yes.

7 Q So what Butler is predicting is that if
8 that barrier level were thicker than 20 angstroms,
9 Bowen would have achieved a higher TMR; is that
10 right?

11 ATTORNEY WILSON: Objection. Form.

12 THE WITNESS: Yes. That's what that
13 sentence means.

14 BY ATTORNEY WICHMAN:

15 Q Bowen doesn't make -- doesn't describe
16 TMR changing with barrier height, though, does he?

17 A Bowen did not change the barrier height.
18 He measured it, but he didn't vary it.

19 Q I'm sorry. Butler. Butler. Let me ask
20 again.

21 A Please.

22 Q Butler's theory does not describe the
23 effect of changing barrier height on TMR, does it?

24 A Butler's paper doesn't explore that
25 particular scenario in the -- in the -- within the

1 confines of the paper. But my -- my opinion is
2 that a person of ordinary skill reading Butler
3 could understand that there should be an energy
4 dependence on the blockage of the antiparallel
5 electrons such that the MR could go up with
6 decreasing barrier height. At least had a good
7 chance.

8 Q would that person of ordinary skill in
9 the art in 2004 reading Butler have thought it was
10 equally likely that TMR would increase as for it
11 to decrease if Bowen's barrier height had
12 decreased?

13 A I -- to be honest, I'm not completely
14 sure. Bowen -- sorry. Butler is a pretty
15 complicated paper. It's a very advanced level of
16 theory. And I think the answer to the question, I
17 think Bowen -- Butler's theory would have the
18 capability to make that estimate, whether the MR
19 would go up or go down. I consider myself to be a
20 person of ordinary skill. I've read through
21 Butler carefully. I have a hard time being able
22 to hand-wave my way one way or the other.

23 Now -- so by that -- by that standard, I
24 would have to answer I don't think a POSA would be
25 able to do that either.

1 Q Okay. Just a few more questions.
2 Because I know you had asked for a break.

3 But Butler's series is very specific to
4 crystalline iron, crystal magnesium oxide, and
5 crystalline iron sandwiches; right?

6 A Right.

7 Q And it's a first principles
8 calculation --

9 A It is.

10 Q -- of that device?

11 Okay. Why would a -- well, and Bowen
12 made crystalline iron, crystalline magnesium
13 oxide, and then crystalline iron cobalt for his
14 magnetic tunnel junction; right?

15 A Right.

16 Q Why would a person of ordinary skill in
17 the art in 2004 have thought that Moodera had
18 anything to say about how Bowen's device would
19 work?

20 A I think it is fair to say that a person
21 of ordinary skill in the art reading Moodera
22 would -- would have that same conclusion. It is
23 hard to -- it is hard to say what Moodera would
24 tell me about Bowen's device.

25 Q And Moodera was describing MTJs with

1 aluminum oxide barriers; right?

2 A Right. I'm saying that Moodera puts the
3 idea in the mind of a POSA to start thinking about
4 how the MR might depend on barrier height. It is
5 just a hint that, hey, think about how a --
6 changing the barrier height could influence the
7 MR. Now go read Butler and see if you can get any
8 hint there.

9 ATTORNEY WICHMAN: Okay. Why don't we
10 take a break. It's been an hour. Is ten minutes
11 sufficient? Would you prefer 15?

12 THE WITNESS: Ten will do.

13 ATTORNEY WICHMAN: Ten. Okay. So why
14 don't we come back on the record at 25 past the
15 hour.

16 THE WITNESS: Okay.

17 ATTORNEY WICHMAN: Okay. Thank you.
18 Ferromagnetic.

19 (A recess was taken.)

20 ATTORNEY WICHMAN: Okay. On the record.

21 Q Dr. Bokor, I want to bring your attention
22 back to Butler, Exhibit 1044, page 1. The
23 abstract. That last sentence, we talked about
24 that before the break. Right. The sentence says,
25 "we predict a large magnetoresistance that

1 increases barrier thickness." Right?

2 A Right.

3 Q Okay. In 2004, if a person of ordinary
4 skill in the art wanted to increase TMR in Bowen's
5 device, why wouldn't they have just increased the
6 thickness of the magnesium oxide barrier?

7 ATTORNEY WICHMAN: Objection. Form.

8 THE WITNESS: Well, there's lots of
9 reasons why that -- they might not want to do
10 that. The -- there are many things -- even if, as
11 Butler explains, the TMR could increase, many
12 other parameters of the MTJ device also decrease,
13 which may or may not be useful for whatever
14 application that POSA had in mind.

15 BY ATTORNEY WICHMAN:

16 Q So a person of ordinary skill in the art
17 in 2004 couldn't just focus on increasing TMR to
18 improve an MTJ device; is that right?

19 A Well, that's a pretty broad question.
20 Depend -- depending on the application that that
21 POSA had in mind, that's right.

22 Q What other considerations would have to
23 be factored into the decision of -- strike that.
24 What other things would a POSA have had
25 to balance against the idea of increasing TMR?

1 A Well, the most important one that comes
2 to mind is parameter in the art called RA, which
3 is basically the resistance -- the absolute
4 resistance, not the change in resistance, but the
5 absolute resistance of the junction. In many
6 applications, that's a very important parameter.
7 And that has to also meet certain specs depending
8 on the application. But there are many
9 applications that would increase the MR in a way
10 that was not advantageous for the particular
11 application. That's just one example that I can
12 think of right off the top of my head.

13 Q So RA is resistance area product of the
14 device?

15 A Correct.

16 Q Is that -- and tell me, why does RA
17 product matter to an MTJ design?

18 A Let me try to answer that as -- I've
19 already shown that I can go long. Let me try to
20 answer that briefly and succinctly.

21 In an electronic circuit in which the MTJ
22 is incorporated, voltages and currents are applied
23 to the MTJ. The change in resistance has to be
24 sensed by another circuit. And in particular in
25 MRAM, Magnetoresistive Random Access Memory, you

1 have lots of MTJs and very thin wires that would
2 connect them to other parts of the electronic
3 circuit. The resistance of the MTJ, it becomes a
4 very important relevant parameter to the
5 performance of the overall circuit.

6 Q Are there any other parameters that a
7 POSA would have had to take into account when
8 deciding how to build or how to -- let me strike
9 that.

10 what other parameters -- other than
11 resistance area product, what other parameters for
12 the MTJ device would a POSA have wanted to
13 consider when determining the trade-offs for
14 building that device?

15 ATTORNEY WILSON: Objection. Form.

16 THE WITNESS: Are we going to stick to
17 just varying the barrier thickness now? Do you
18 want me to give a full -- a full treatise on all
19 of the parameters that a POSA would need to take
20 into account in designing a MTJ? I will if you
21 want, but I have a feeling you don't want me to do
22 that.

23 BY ATTORNEY WICHMAN:

24 Q Let me ask, you agree that the designer
25 has to balance -- has to make tradeoffs for the

1 different performance characteristics of the MTJ;
2 right?

3 A That is exactly the job of a designer.

4 Q TMR is one performance metric for an MTJ;
5 right?

6 A One of -- one of a number, yes.

7 Q The resistance area product is a
8 parameter that characterizes an MTJ that has to be
9 taken into account in the design; is that right?

10 A Yes.

11 Q What -- tell me one or two other
12 important considerations that an MTJ designer
13 would want to account for when balancing against
14 the idea of maximizing TMR.

15 A Okay. I'll try to just narrow it down to
16 just a few. The size of the MTJ is a critical
17 parameter in many applications. The transverse
18 dimensions are critical. Some of the parameters
19 just have to do with fabrication. So you have
20 to -- you have to be able to fabricate the MTJ.
21 You have to be able to etch it. And etch --
22 almost every application today for MTJs, or even
23 in 2004, typically require the fabrication of very
24 small MTJs, very closely packed together. And
25 so what materials you use and what their

1 thicknesses are have a major impact on how small
2 you can make the device, how selectively you can
3 etch and stop etches on particular layers, how
4 close you can pack the MTJs. So that's another
5 consideration, what impact it has on the
6 fabrication.

7 Q Can I ask, does the manufacturability of
8 the MTJ play into the POSA's thinking?

9 A If the POSA is trying to design a product
10 that can be -- high volume manufacture,
11 absolutely.

12 Q So the fabrication process itself is an
13 important consideration; is that right?

14 A Yes.

15 Q Okay. I want to return to this -- this
16 idea of different barrier heights in Bowen. But
17 maybe we can try to speed it up. So I want to --
18 I've -- I think we got to .7. But if the -- if
19 Bowen had achieved a barrier height of .5 electron
20 volts in his MTJ in 2004, would a person of
21 ordinary skill in the art have had any reason to
22 believe that the TMR would decrease?

23 A My answer to this scenario where you
24 decrease the barrier to .5 eV don't change.
25 Compared to .7 eV. A person -- a POSA have a --

1 would have -- could have expected the MR to go up
2 or go down.

3 Now, let me just -- I'll stop there.
4 They could -- they could expect the barrier height
5 to go up or to go down based on, as I said, an
6 understanding of -- of Butler that I think a POSA
7 could get from reading it. would expect the MR to
8 change with barrier height, up or down. And
9 whether it is .7 or .5, the situation is the same.

10 Q Is the situation the same if Bowen would
11 have achieved a barrier height of .3 electron
12 volts?

13 A Not as far as I can tell, no.

14 Q It's not the same?

15 A It wouldn't --

16 Q Let me ask you that again. I think you
17 said would it have changed. Maybe I did.

18 Is the situation that you described the
19 same, meaning a person of ordinary skill in the
20 art in 2004 would not have been able to state
21 whether TMR would increase or decrease if Bowen
22 had achieved a barrier height of .3 electron
23 volts?

24 A That's my opinion, yes.

25 Q Okay. And then if Bowen had achieved a

1 barrier height of .1 electron volt, would the POSA
2 have expected the TMR to increase or decrease?

3 A I never considered barrier height that
4 small, so I'm reluctant to speculate about that.
5 You know, once things get that small, other
6 factors could come into play. I'm hesitant to
7 answer that question. I don't think -- I don't
8 think I can answer that question confidently.

9 Q what other factors would come into play?

10 A well, let me just put it this way: If
11 you break that -- if you bring that barrier height
12 to zero -- let me just start there -- now there's
13 no tunneling going on. And the transport through
14 the barrier now is -- undergoes different physics.
15 So as the barrier height gets smaller and smaller,
16 down into the range where the barrier height is
17 comparable to room temperature energy, things are
18 going to change. And I haven't considered what
19 that would mean for MR. But I think that the
20 scenario is different enough that I don't -- I
21 don't feel comfortable as I sit here right now to
22 predict what would happen.

23 Q And you referred to yourself. But the
24 question is about a person of ordinary skill in --

25 A Sorry. Please finish your question.

1 Q well, I'm just saying your answer is in
2 terms of what you would feel comfortable
3 predicting today. But I'm asking about what a
4 person of ordinary skill in the art would have
5 expected in 2004. Do you think they -- would they
6 have had the same expectation that you just
7 articulated for yourself?

8 A what I'm saying is I haven't considered
9 how a POSA would think about that scenario. I
10 can't predict what a POSA would expect because I
11 haven't thought about that. And I shared with you
12 some of the reasons why I -- it's different enough
13 that I haven't had -- that I couldn't feel
14 confident projecting even what a POSA would think
15 in that scenario.

16 Q Let's think about the barrier height in
17 Bowen's device on a spectrum from .1 electron
18 volts to .9 electron volts. Have you got that?

19 A Yes.

20 Q Is there any barrier height in that range
21 at which a person of ordinary skill in the art in
22 2004 would have expected the TMR to fall to zero?

23 A Bowen's device we're talking about;
24 right?

25 Q Yes.

1 A As I sit here right now, I can't think of
2 a scenario where a POSA might expect the MR to
3 drop to zero with barrier height in that energy
4 range. I'm -- yeah. I don't -- I don't -- as I
5 sit here right now, I can't think of any
6 literature that addressed that question that I
7 have reviewed. Based on the literature that we've
8 been talking about so far, I don't -- I don't see
9 anything that would indicate to a POSA that the MR
10 would drop to zero with a hypothetical barrier
11 height for Bowen's device in that range from .1 to
12 .8, I think is your range, or .7 or whatever.

13 Q .9.

14 A .9. That -- yeah. The issue is as you
15 go to very low barrier height like .1, I just -- I
16 can't think of any scenario off -- as I sit here
17 right now.

18 Q Can you open Exhibit 1031.

19 Just let me know when you have it.

20 A That's Simmons. Yes. I have it.

21 Q This is Simmons paper on a Generalized
22 Formula for the Electric Tunnel Effect between
23 Similar Electrodes Separated by a Thin Insulating
24 Film; right?

25 A Right.

1 Q Published in 1963?

2 A 1963. Yes.

3 Q And that was before magnetic tunneling
4 resistance had been discovered; right?

5 A I think that's right.

6 Q When was tunneling magnetoresistance
7 discovered?

8 A That's a good question. I don't have an
9 answer for that right off the top of my head.

10 Q Was it Julliere's paper in 1975?

11 A I can't state with certainty whether that
12 was the first. But Julliere's paper does talk
13 about MTJs.

14 Q Okay. In Simmons, can you go to page
15 1794. That is PDF 3.

16 A Okay.

17 Q I'm sorry. Yeah. In the top -- on the
18 right-hand column, top paragraph, do you see where
19 it says, "The electronic current can flow through
20 the insulating region between two electrodes"?

21 A I see that.

22 Q He identifies two currents. He calls
23 them "a" and "b." Is that right?

24 Two -- let me strike that.

25 That identifies two scenarios; right?

1 A A and B.

2 Q Yes. And the first one is that "The
3 electrons in the electrodes have enough thermal
4 energy to surmount the potential barrier and flow
5 in the conduction band." Is that right?

6 A That's right.

7 Q Is that known as thermionic emission?

8 A That's fair to say, yes.

9 Q And does that effect increase as the
10 barrier height decreases?

11 A It does.

12 Q Okay. And the second scenario that he
13 describes, B, is that, "The barrier is thin enough
14 to permit penetration by the electric tunnel
15 effect." Right?

16 A That's what it says.

17 Q That's tunneling current; right?

18 A Right.

19 Q Okay. At what barrier height would a
20 person of ordinary skill in the art have expected
21 thermionic emission at a room temperature of
22 300 Kelvin to have become a significant portion of
23 the current through Bowen's MTJ?

24 A I'm not prepared to answer that question
25 just as I sit here. It would require a little bit

1 of calculation, which I haven't done.

2 Q would a POSA have expected thermionic
3 emission to be significant in Bowen's MTJ if it
4 had a barrier height of .33 electron volts?

5 A I can't answer that question.

6 Q what would you need to know to answer
7 that question?

8 A well, I would have to do some
9 calculations to calculate -- to try to compare the
10 thermotic current to the tunneling current. That
11 would depend on -- yeah. Off the top of my head,
12 I don't have the -- you know, I don't have numbers
13 for that in my head that I could do that
14 calculation in my head. I didn't do it in
15 preparing for this deposition. So I don't know
16 the answer to that as I sit here. I could
17 probably come up with it, given -- given some
18 time.

19 Q Is this a current effect that is a
20 reason -- okay. Strike that.

21 Are thermotic emission currents a reason
22 that a POSA would want to -- let me strike that.

23 would a POSA have been concerned that
24 lowering the barrier height in Bowen's MTJ far
25 enough would have resulted in a significant

1 fraction of the current through the MTJ being
2 attributed to thermionic emission?

3 A would have a POSA have been concerned
4 about that?

5 Q Yes.

6 A I think that's a consideration that a
7 POSA should consider.

8 Q So would this have been a reason to avoid
9 lowering the barrier height in Bowen's MTJ?

10 A well, in the general case, I would have
11 to say yes. I've already said if the barrier
12 height went to zero, then there would be no
13 tunneling left. It would only be thermionic. So
14 certainly that is a consideration that a POSA
15 would need to take into account. And I'm -- I'm
16 not willing to go as far as how -- how low the
17 barrier height has to be before that becomes a
18 significant consideration that a POSA would have
19 to take into account.

20 Q All right. would a POSA have expected
21 that a barrier height of .33 electron volts in
22 Bowen's device would have increased the thermionic
23 emission current through the device?

24 A would a person -- would a POSA have
25 been -- repeat the question.

1 Q Okay. If Bowen's device had achieved a
2 barrier height of .33 electron volts, would a POSA
3 have expected that this device with the .33
4 electron volts would have had more thermionic
5 emission current than the device that Bowen
6 actually built?

7 ATTORNEY WILSON: Objection. Form.

8 THE WITNESS: I believe that a POSA would
9 be aware that the thermionic emission current
10 would increase as the barrier height decreases.
11 Now, at .33, would they have -- they would know
12 that the thermionic -- thermionic emission current
13 would increase compared to .9. How significant
14 that would be in their considerations is -- I
15 can't say.

16 BY ATTORNEY WICHMAN:

17 Q If a POSA had wanted to achieve a barrier
18 height of .33 electron volts in Bowen's device,
19 how would they have done it?

20 A well, that as I explain in my
21 declaration, one way is to follow the teachings of
22 Soukup, which involves fabricating on a barrier
23 with some concentration of vacancy -- oxygen
24 vacancies.

25 Q How many oxygen vacancy defects would a

1 POSA have added to Bowen's barrier layer to
2 achieve barrier height of .33 electron volts?

3 ATTORNEY WILSON: Objection. Form.

4 THE WITNESS: That information is not
5 available. That -- that's not strictly -- it's
6 uncertain. It's uncertain what -- what -- what
7 concentration of vacancies would be needed to get
8 to that barrier height.

9 BY ATTORNEY WICHMAN:

10 Q So just quickly, you referred to Soukup.
11 So when Soukup made its metal -- his metal
12 insulator metal tunnel diodes, he had three -- he
13 had panel devices where he increased the
14 atmospheric pressure of oxygen in the chamber;
15 right?

16 A Right.

17 Q And by increasing the oxygen pressure in
18 the chamber, he theorized that there would be
19 fewer oxygen vacancy defects; correct?

20 A Correct.

21 Q He calls that a more stoichiometric
22 material; right?

23 A Yes.

24 Q And by more stoichiometric, he means the
25 ratio of magnesium to oxygen in his insulator was

1 closer to a ratio of one to one; right?

2 A Right.

3 Q So tell me where Soukup describes the
4 opposite, introducing oxygen vacancy defects
5 rather than removing them.

6 A He assumes there is a certain
7 concentration of defects to start with that he can
8 decrease. But he doesn't give a -- a prescription
9 for increasing them.

10 Q But your testimony is that to achieve
11 a .33 electron volt barrier height in Bowen's
12 device, the POSA would have introduced oxygen
13 vacancies to Bowen's magnesium oxide layer; right?

14 A Well, let's bring up -- let me review
15 Soukup, if that would be --

16 Q Exhibit 1028. Soukup.

17 A Actually, what I'm going to do before I
18 go to Soukup is take -- take a moment to review my
19 declaration for any discussion of that.

20 All right. I've done some review on my
21 declaration and can -- and I'm prepared to address
22 this issue. It would help if you would repeat the
23 question, if you would.

24 Q So the question that -- there were two
25 questions. I'm not sure which one you're

1 responding to here. I wanted you to tell me where
2 Soukup describes oxygen defects rather than
3 removing them.

4 A I -- okay. I lost Soukup. Okay. Okay.
5 I do not see that Soukup gave a prescription for
6 increasing the oxygen defects.

7 Q So if a POSA in 2004 were to increase
8 oxygen vacancies in Bowen's magnesium oxide layer,
9 how would they have done it?

10 A well, there are a number of ways I think
11 they could have done that. They could have used
12 deposition parameters for the MgO to try to
13 increase the oxygen vacancy defects. There are a
14 variety of ways to deposit MgO that were known in
15 the art at the time. Some people would evaporate
16 magnesium and then oxidize it. Some people would
17 sputter MgO targets to deposit an MgO film. There
18 is -- let's see if Soukup talked about this.
19 There is -- I would have to look. There
20 certainly -- wait a minute. yeah. So Soukup
21 was -- Soukup was evaporating MgO. Let me read
22 that again.

23 Q Can I ask you a question?

24 A I'm sorry?

25 Q Can I interrupt with a question?

1 A well, give me a moment. I'm close to
2 what I was looking for. Yeah. Soukup used a --
3 just as he evaporated MgO.

4 Now go ahead and ask your question.

5 Q Okay. Do you have your declaration in
6 front of you, Exhibit 1024?

7 A Yes.

8 Q All right.

9 A I have to pull that up because now I have
10 quite a few windows. Okay.

11 Q Paragraph 173, it is at PDF page 93.
12 I'm sorry. Paragraph 172.

13 A 172.

14 Q Same page. Do you see that?

15 A Yes.

16 Q It says that, "A skilled artisan would
17 have had a reasonable expectation of success in
18 applying Soukup's teachings to Bowen to achieve a
19 tunnel barrier height in the range of .1 to .85
20 electron volts"; right?

21 A Right.

22 Q What are the teachings in Soukup that a
23 POSA would apply to Bowen to achieve let's just
24 say a tunnel barrier height of .33 electron volts?

25 A well, Soukup taught fabricating a MgO

1 barrier using evaporation. I think that's -- I
2 have to go back and look at how Bowen did it. But
3 anyway, that was Soukup's teaching for how to form
4 the MgO barrier.

5 Bowen -- Bowen is just a little bit
6 vague. Bowen seems to say that the structures
7 were grown in a combined sputtering laser ablation
8 system. So my -- it doesn't say whether they use
9 laser ablation or sputtering to deposit the MgO.
10 But I think a POSA would expect that they used
11 sputtering. And Bowen gives a -- gives a
12 temperature for that. And Soukup used a different
13 process.

14 Q So Bowen grew his single-crystal
15 magnesium oxide barrier layer at 400 degree
16 Celsius through this sputtering laser ablation;
17 correct?

18 A Correct. Page 1665 in Bowen.

19 Q So that's -- Bowen did epitaxial growth
20 of a single-crystal magnesium oxide layer; right?

21 A Correct.

22 Q Okay. So --

23 A On a -- on a single-crystal ferromagnet.

24 Q Right.

25 So what would a POSA have changed in

1 Bowen to achieve a .33 electron volt barrier
2 height in the magnesium oxide?

3 A well, a POSA would be motivated to
4 experiment using evaporation and varying the
5 temperature in order to try to get a barrier
6 height like Soukup did.

7 Q So Bowen's growing this epitaxial layer
8 of magnesium oxide in a chamber?

9 A Right.

10 Q And it is at high vacuum?

11 A Presumably. Yeah. It says what the
12 vacuum level was.

13 Q what was the vacuum level?

14 A Base pressure of two times 10 to the
15 minus 9 millibar.

16 Q So that was even a higher vacuum than
17 what Soukup used; right?

18 A well, let's go back to Soukup just to --
19 well, Soukup's chamber reached a pressure of 6
20 times 10 minus 11 torr. I think that is actually
21 not too far from Bowen's. Bowen had 2 times 10
22 minus 9 millibars. There's about a factor of a
23 hundred between millibars and torr. So it's
24 similar.

25 Q So Bowen was growing under vacuum

1 conditions that were already similar to what
2 Soukup used. Is that what you're saying?

3 A I think that's fair to say.

4 Q So why would changing the temperature
5 result in an increase in oxygen vacancies in
6 Bowen's magnesium oxide layer?

7 A Well, Bowen was using a different process
8 to deposit the MgO. He was doing sputtering.

9 Q Uh-huh.

10 A And Soukup was doing evaporation.

11 Q So it is your testimony that the -- go
12 ahead. Sorry.

13 A Evaporation can easily have produced the
14 higher concentration of defects.

15 Q Okay. Can you just tell me, where in
16 your declaration do you say that Bowen would be
17 modified to use evaporation to deposit the
18 magnesium oxide?

19 A I'm at my declaration. Can you please
20 repeat the question?

21 Q Where in your declaration do you say that
22 the POSA would have modified Bowen to deposit his
23 magnesium oxide using evaporation?

24 A What I say in my declaration is -- for
25 example, paragraph 172, on page 82 [sic] -- let me

1 know when you're ready.

2 Q I'm ready. I'm right there.

3 A "A skilled artisan also would have had a
4 reasonable expectation of success in applying
5 Soukup's teaching to Bowen to achieve a tunnel
6 barrier height in the range of .1 to .85."

7 Soukup's teachings encompass the Soukup
8 method for doing the deposition. So I think my
9 declaration says what you asked. Teaches -- to
10 take the Soukup teachings and apply them to Bowen.

11 Q Right. But my question is, what are
12 those teachings? So you're saying that the
13 teachings are to use evaporation to deposit the
14 magnesium oxide?

15 A Well, among others. The teachings are
16 the teachings of Soukup. One of them is to use
17 evaporation. The other has to do with
18 temperatures and so forth. So I'm just -- I'm
19 just saying it -- okay. So that's my answer.
20 It -- I don't explicitly call out the use of
21 evaporation in my declaration. I just say
22 Soukup's teachings in general.

23 Q Did Soukup achieve single crystal
24 magnesium oxide oriented in a .001 plane?

25 A Soukup doesn't explicitly say.

1 Q Soukup actually never says when the
2 magnesium oxide is crystalline or not; right?

3 A Soukup does not.

4 Q So is it fair to say that your testimony
5 is a person of ordinary skill in the art would
6 have modified Bowen by growing -- by depositing
7 magnesium oxide the same way that Soukup did?

8 A Well, not exactly. I think a person of
9 ordinary skill could do it -- could experiment to
10 find ways to combine the teachings of Bowen and
11 Soukup in a suitable way. So, for example,
12 varying the substrate temperature during the
13 evaporation and so forth.

14 Q I'm just trying to understand what the
15 combination is that you -- that you -- I'm trying
16 to understand what the modifications to Bowen are
17 that, in your opinion, would have rendered claims
18 obvious. So that combination is in paragraph 172,
19 that the POSA would have applied Soukup's
20 teachings to Bowen. Can you be any more specific
21 than the POSA would have experimented?

22 ATTORNEY WILSON: Objection. Form.

23 THE WITNESS: Well, Soukup did the
24 deposition with the evaporation at the substrate
25 at room temperature, as near as I can figure out.

1 Bowen taught to do the deposition at 400 C and
2 then anneal at 400 C. So the POSA could have
3 tried to combine those two, either to increase the
4 substrate temperature during the MgO deposition by
5 evaporation or annealing. That's one such example
6 of making a combination of the two that the POSA
7 would experiment with.

8 BY ATTORNEY WICHMAN:

9 Q So I just want to be clear about Bowen.
10 Bowen deposits iron at room temperature and then
11 does in situ anneal at 400 Celsius to crystallize
12 the iron bottom layer; correct?

13 A Right.

14 Q Bowen does not anneal the magnesium oxide
15 layer; right?

16 A well, okay. Bowen deposits at
17 400 degrees.

18 Q For epitaxial growth of a single-crystal
19 magnesium oxide; right?

20 A well, to achieve -- ultimately Bowen
21 achieves a single-crystal magnesium oxide.

22 Q Okay. When you say the POSA could have
23 tried to combine those two, where Soukup deposits
24 magnesium oxide with evaporation at room
25 temperature and Bowen rose magnesium oxide at

1 400 Celsius, what's -- what is the variation that
2 they would try? Are you saying that the POSA
3 would have changed Bowen to deposit magnesium
4 oxide at room temperature?

5 A well, that's one option. The other
6 option is to evaporate magnesium oxide with the
7 substrate temperature, high substrate temperature.
8 That's another combination.

9 Q But that's not what Soukup teaches;
10 right?

11 A Soukup evaporated MgO to deposit it.

12 Q At room temperature?

13 A At room temperature.

14 Q Okay.

15 A Bowen deposited at a high substrate
16 temperature. So a reasonable combination would be
17 to evaporate using the high substrate temperature,
18 for example.

19 Q Are you done?

20 A Yeah.

21 ATTORNEY WICHMAN: Okay. All right. I
22 believe it is 12:20 your time. We haven't
23 discussed lunch. I think -- is 30 minutes
24 sufficient for lunch or do you want 45?

25 ATTORNEY WILSON: I think 30 is

1 sufficient.

2 ATTORNEY WICHMAN: why don't we go off
3 the record and come back on at 10 minutes before
4 the hour.

5 ATTORNEY WILSON: Okay. Thank you.

6 (A lunch recess was taken.)

7 ATTORNEY WICHMAN: Let's go on the
8 record.

9 Q Dr. Bokor, during the break, did you
10 speak to anybody about this deposition?

11 A No.

12 Q Did you consult any written materials
13 related to this deposition during the break?

14 A No.

15 Q Before the break, you -- your testimony
16 was that a reasonable combination for Bowen to use
17 the teachings in Soukup would to be evaporate
18 magnesium oxide using Bowen's high substrate
19 temperature, meaning the 400 degrees Celsius
20 temperature; right?

21 A I suggested that as an example of where a
22 POSA could start doing experimentation.

23 Q And what evidence can you cite that that
24 approach would have increased oxygen vacancies in
25 Bowen's magnesium oxide layer?

1 A Only -- well, the results of Soukup. So
2 Soukup got that low barrier height. And there was
3 evidence in Soukup that that related to oxygen
4 vacancy defects.

5 Q So as we discussed in Soukup, Soukup
6 evaporated magnesium oxide at room temperature --
7 he actually had a gold electrode; right?

8 A That's right.

9 Q What evidence do you have or can you cite
10 that evaporating magnesium oxide in Bowen's
11 reaction chamber onto the crystalline iron
12 electrode at 400 Celsius would have resulted in an
13 increase in oxygen vacancies?

14 A I think that a person of ordinary skill
15 in the art looking at Bowen in view of Soukup
16 would have the -- a grasp of a variety of
17 deposition fabrication technologies that would be
18 routine to explore in order to work towards a --
19 an MgO layer with a high -- with vacancy defects
20 that was single crystal using what were at the
21 time routine experimental methods.

22 Q So you don't have any evidence -- a POSA
23 would not have had any evidence that using
24 Soukup's method of evaporating magnesium oxide in
25 Bowen's method of fabricating an MTJ would

1 actually have increased the oxygen vacancies in
2 Bowen's magnesium oxide layer; is that right?

3 A A person -- a POSA reading Soukup learned
4 how to deposit an MgO layer with a barrier height
5 of .33, which was attributed to a high
6 concentration of Bowen of oxygen vacancies. What
7 I'm saying is that such a POSA then looking at
8 Bowen for the structure of an MTJ would have found
9 it routine to -- by routine experimentation how to
10 combine the deposition methods of Soukup with the
11 teachings of Bowen about forming an MTJ to get an
12 MTJ which had those properties. Which had the
13 properties of high defect density and low barrier
14 height. That's what I'm saying.

15 Q So your testimony is that the person of
16 ordinary skill in the art would have had to
17 experiment in order to -- strike that.

18 So your testimony is that a person of
19 ordinary skill in the art would have had to
20 perform experiments on modifying Bowen's method to
21 achieve an increase in oxygen vacancies in Bowen's
22 magnesium oxide; is that right?

23 A What I'm saying is that a skilled artisan
24 would have had a reasonable expectation of success
25 in applying Soukup's teachings to Bowen to achieve

1 a tunnel barrier height in the range .1 to .85.
2 Period.

3 Q I'm asking if there's any evidence that
4 would have shown the POSA how to do that without
5 experimentation?

6 A I think it is reasonable to project that
7 a POSA would have using routine methods done some
8 experimentation to get to the result. So yeah,
9 there would be some -- there would be some -- some
10 amount of experimentation.

11 Q So you -- you cannot identify a document
12 that would have taught a POSA how to do this, to
13 achieve or -- to achieve an increase in oxygen
14 vacancies in Bowen's magnesium oxide layer
15 resulting in a barrier height of .33 electrodes;
16 is that right?

17 ATTORNEY WILSON: Objection. Form.

18 THE WITNESS: Other than what I've
19 already testified, Soukup in light of Bowen.

20 BY ATTORNEY WICHMAN:

21 Q So if -- other than Soukup, there's no
22 document that you can point to that would have
23 taught a POSA how to modify Bowen to increase the
24 oxygen vacancies so as to achieve a barrier height
25 of .33 electron volts; is that right?

1 A I don't think I have cited any additional
2 documents beyond what I just said and what's in my
3 declaration.

4 Q Okay. And you cannot identify a document
5 that would have taught a POSA that reducing
6 barrier height in Bowen's device would have
7 increased TMR; right?

8 A Well, we spoke about that at some length
9 this morning. That's -- that's -- that's my
10 testimony that I gave you this morning. I have
11 nothing to add to that.

12 Q We discussed Butler; right?

13 A We did.

14 Q And you said that a POSA could not have
15 drawn a conclusion as to which direction the TMR
16 would have changed based on Butler; right?

17 A I did say that.

18 Q Okay. I'm asking whether there's any
19 other document that would have taught a POSA that
20 reducing the barrier height in Bowen's MTJ would
21 have increased TMR?

22 A I -- I don't have any other documents
23 that I cite in my declaration that -- to that
24 effect. That's -- that's my line of
25 understanding.

1 Q Can you open the patent. This is 1017.

2 A 1017.

3 Q The '909 patent.

4 A Oh, 1017. Sorry. Okay.

5 Q All right. Can you go to Figure 8(A).

6 That's at PDF page 13.

7 A Okay.

8 Q So this is a cartoon of the three layers
9 of an MTJ; right?

10 A Right.

11 Q So there's a bottom ferromagnetic
12 electrode, there's a tunnel barrier, and there's a
13 top ferromagnetic electrode; right?

14 A Yes.

15 Q And in figure 8(A), the figure shows
16 arrows in the top and bottom ferromagnetic
17 electrode pointing to the same direction, in this
18 case to the right of the page; right?

19 A Yes.

20 Q And this represents the MTJ being in a --
21 what we would call a parallel state; is that
22 right?

23 A I believe so.

24 Q So when an MTJ is in this parallel state,
25 the resistance to current through the device -- so

1 through the electrodes and the tunnel barrier --
2 is called a parallel resistance; is that right?

3 A That's right.

4 Q And in the figure below, Figure 8(B),
5 this shows the same three layers, but this time
6 the arrows in the top and the bottom ferromagnetic
7 layers point in the opposite directions; right?

8 A Right.

9 Q And so this represents the magnetic
10 tunnel function being in an antiparallel state?

11 A Yes.

12 Q And when an MTJ is in this antiparallel
13 state, the resistance to current through the
14 device, through both electrodes and the barrier,
15 is called the antiparallel systems; right?

16 A Right.

17 Q And then the next page, in Figure 9(B),
18 this shows a unit cell of magnetic random access
19 memory; right?

20 A Yes.

21 Q And this is an example of where current
22 through the MTJ would experience antiparallel
23 resistance; correct?

24 A Correct.

25 Q If you could go to column 5, line 10.

1 This is at PDF 19.

2 A Line 10. I'm there.

3 Q So from lines 10 to 16, the patent is
4 describing the magnetoresistance ratio of an MTJ
5 device; right?

6 A Right.

7 Q And this is what we've been calling the
8 tunnel magnetoresistance or TMR?

9 A Right.

10 Q And here, the abbreviations are R_p and
11 R_{ap} for parallel resistance and antiparallel
12 resistance; correct?

13 A That's fair to say.

14 Q So it actually says that R_p and R_{ap}
15 indicate the tunnel junction resistance in the
16 cases of parallel in antiparallel magnetization
17 alignments, respectively, of the two electrodes;
18 right?

19 A That's what it says.

20 Q And that's what we just walked through
21 with Figures 8(A) and 8(B); correct?

22 A Yes.

23 Q All right. If you could go to your
24 declaration at -- this is Exhibit 1024, at
25 paragraph 36, which is at PDF page 29.

1 A So paragraph 36. Is that what you're --

2 Q Paragraph 36. So here you define tunnel
3 magnetoresistance as TMR; correct?

4 A Yes.

5 Q And as we just discussed, this is what
6 the patent calls magnetoresistance ration or MR
7 ratio; right?

8 A Yes.

9 Q In the next paragraph 37, you recite this
10 equation for TMR; correct?

11 A Correct.

12 Q And this is the same equation that we
13 just looked at in the patent, Exhibit 1015,
14 column 5, lines 10 to 16; right?

15 A Bear with me. What happened? Okay. I
16 guess my Acrobat window can only hold so many open
17 documents at once. So just give me a moment.

18 Okay. So you -- you're pointing me back
19 to the patent.

20 Q Exhibit 1019 [sic], column 5, line 10, at
21 PDF page 19.

22 ATTORNEY WILSON: Objection. Form.

23 THE WITNESS: 1017 is the patent, isn't
24 it?

25

1 BY ATTORNEY WICHMAN:

2 Q Correct. Exhibit 1017, column 5, lines
3 10 to 16, which is PDF page 19.

4 A Sorry. There was just a -- okay. So I'm
5 on the patent.

6 Q You agree that the equation in the
7 patent, at column 5, between lines 10 and 16, is
8 the same equation that you used to define TMR in
9 paragraph 37 of your declaration; correct?

10 A I'm sorry. I'm just having a little bit
11 of a hiccup with my setup here. If you will just
12 bear with me. I don't know why this is happening.

13 There's my declaration and there's the
14 patent.

15 Okay. So the equations that we were just
16 looking at in my declaration on page 19 for the
17 TMR. And we're comparing that to the equation in
18 the patent for ΔR over R_P . That's what
19 you're pointing me to; correct?

20 Q That's right. You agree it's the same
21 equation; right?

22 A Same equation, yes.

23 Q Okay. Dr. Bokor, when an MTJ is in an
24 antiparallel state, would a lower barrier height
25 also reduce the antiparallel resistance?

1 A In general, it would be expected to do
2 that, yes.

3 Q Paragraph 45 of your declaration -- this
4 is at PDF page 32.

5 A Okay.

6 Q So in paragraph 45, you state that "MTJs
7 operate based on tunneling." Correct?

8 A Correct.

9 Q So in your declaration, at paragraph 45,
10 you do not allege that lowering a barrier height
11 in an MTJ will reduce the parallel resistance by
12 more than it reduces the antiparallel resistance;
13 correct?

14 A Not in that paragraph.

15 Q In paragraph 46 of your declaration, you
16 discuss Simmons paper, Exhibit 1031; correct?

17 A Correct.

18 Q And at the bottom of page 22, at the
19 bottom of this paragraph, you -- you provide a
20 modified and annotated version of Simmons'
21 Figure 1; is that right?

22 A Yes.

23 Q So if you could go ahead and open up
24 Simmons -- this is Exhibit 1031, at page 1794.
25 That's PDF page 3.

1 A Okay. I've got Simmons open. Remind me
2 what page you want to go to again, please.

3 Q 1794. It is PDF page 3.

4 A Yes.

5 Q I just want to talk about Figure 1 in the
6 top left column.

7 A Okay.

8 Q Are you there?

9 A I'm there.

10 Q All right. I want to compare Figure 1 in
11 Simmons to this figure in paragraph 46 of your
12 declaration. okay?

13 A Okay.

14 Q So you changed some things. So in
15 Simmons, there's a label electrode -- electrode 1
16 and another label electrode 2. And in your
17 declaration, you changed that to ferromagnetic
18 electrode; right?

19 A Right.

20 Q But Simmons doesn't talk about
21 ferromagnetic electrodes, does it?

22 A That's correct.

23 Q You changed -- where Simmons wrote
24 insulator, you changed that to MgO barrier; right?

25 A Right.

1 Q Simmons is just talking generally about
2 metal insulator metal devices. Simmons is not
3 talking about magnesium oxide barriers, is it?

4 A That's correct.

5 Q And in Simmons, there's a label 5X, that
6 in the -- in your figure, you change that to
7 tunnel barrier height; is that right?

8 A Right.

9 Q And then you left out some things from
10 Simmons' figure; is that right?

11 A There are some things that are not in my
12 figure that are in Simmons Figure 1. That is fair
13 to say.

14 Q Simmons labels Figure 1 "General barrier
15 in insulating film between two metal electrodes."
16 Right?

17 A Right.

18 Q You left that out of your declaration?

19 A I didn't put that in my declaration,
20 that's correct.

21 Q Okay. And Simmons never talks about
22 magnetoresistance, does it?

23 A It does not.

24 Q And Simmons, like we talked about before,
25 was published in 1963; right?

1 A Right.

2 Q And tunneling magnetoresistance wasn't
3 discovered until 1975?

4 A I took your word for that. I don't
5 dispute it.

6 Q Do you know?

7 A I don't. Off the top of my head, I don't
8 know when TMR, tunnel magnetoresistance, was
9 first --

10 Q Sorry. Can you open Exhibit 1057.

11 A Got it.

12 Q All right. If you could go to page 42,
13 which is at PDF 61.

14 A Okay.

15 Q First full paragraph starts, "The TMR
16 effect was first discovered in 1975 by Julliere."
17 right?

18 A That's what it says.

19 Q Do you have any reason to doubt that?

20 A No.

21 Q And you have no independent knowledge of
22 any different discovery date of TMR?

23 A I do not.

24 Q This was 12 years after Simmons published
25 its paper?

1 A Right.

2 Q And Simmons never talks about parallel
3 resistance in an MTJ, does it?

4 A Obviously not. He didn't know about it.

5 Q Right. And Simmons doesn't talk about
6 antiparallel resistance in an MTJ; right?

7 A It does not.

8 Q So in paragraph 46 of your declaration,
9 you do not allege that lowering a barrier height
10 in an MTJ will reduce parallel resistance by more
11 than it reduces antiparallel resistance; correct?

12 A You asked about paragraph -- paragraph
13 46; right?

14 Q 46.

15 A Okay. That's correct.

16 Q Paragraph 47 of your declaration, you
17 discuss Simmons' paper; correct?

18 A Briefly.

19 Q So in paragraph 47 of your declaration,
20 you do not allege that lowering a barrier height
21 in an MTJ will reduce parallel resistance by more
22 than it reduces antiparallel resistance; correct?

23 A Correct.

24 Q Paragraph 48 of your declaration, you
25 discuss tunnel barrier height; is that right?

1 A Yes.

2 Q And in paragraph 48 of your declaration,
3 you do not allege that lowering a barrier height
4 in an MTJ will reduce parallel resistance by more
5 than it reduces antiparallel resistance; correct?

6 A Correct. Not in that paragraph.

7 Q Is there a paragraph where you do allege
8 that relationship?

9 A well, that conclusion has to come from
10 considering some -- several elements of the
11 declaration. I'm not sure it explicitly says that
12 just in so many words. But it's in there.

13 Q where?

14 A well, let's start with paragraph 68. We
15 discussed this, I think, this morning. "MgO has
16 the special property that tunneling is governed by
17 the majority (parallel) spin electrons."

18 And I'll just cut to the last part of the
19 paragraph.

20 "As a 2001 paper by Klaua explained,
21 unlike amorphous aluminum oxide barrier, for
22 crystalline MgO barriers: 'The tunneling
23 resistance for the parallel orientation of the
24 magnetic moments is estimated to be 100 times
25 smaller than that for the antiparallel orientation

1 of the magnetic moments due to the absence of
2 scattering in the barrier.'"

3 one of ordinary skill would understand
4 that lowering the barrier height would further
5 lower the tunneling resistance for the parallel
6 orientation. And as I testified this morning, the
7 teaching that I refer to in paragraph 68, that the
8 parallel orientation is estimated -- the
9 resistance is estimated to be a hundred times
10 smaller than that for the antiparallel
11 orientation.

12 So what this is saying to one of ordinary
13 skill is that the transport of the moments through
14 the MgO barrier is due to the band structure that
15 the person of ordinary skill would understand that
16 from Mathon and Butler. The tunneling resistance
17 is a hundred times smaller and is different for
18 the parallel and the antiparallel. It's a
19 different mechanism.

20 So my opinion is that a person of
21 ordinary skill looking at this and understanding
22 the basic properties of tunneling would understand
23 that lowering the barrier by -- would thereby
24 change the energy at which the spins or the
25 electrons are entering the barrier relative to the

1 band structure. And thus, the amount -- that
2 factor of a hundred that's referred to in the
3 paragraph 68, as the tunnel barrier is reduced,
4 that factor -- it is reasonable to expect that
5 that factor will change. That's what we talked
6 about at some length this morning. And as the
7 tunnel barrier is reduced, that changes the energy
8 alignments of the ferromagnetic electrode and the
9 MgO.

10 And so a person of ordinary skill would
11 understand that from reading Butler and have a
12 reasonable expectation that the effect on the
13 change of tunneling rate for the parallel and
14 antiparallel electrons would be different.

15 So the conclusion that we're talking
16 about here, a person of ordinary skill could come
17 to that conclusion by that line of reasoning based
18 on what a person of ordinary skill in the art
19 understood at the time.

20 Q Dr. Bokor, this morning you told me that
21 the person of ordinary skill in the art reading
22 Butler could not draw any conclusion as to which
23 direction TMR would go based on a change in
24 barrier height; right?

25 A That's fair to say.

1 Q Okay. Maybe we should go back to your
2 equation for TMR, in paragraph 37, at PDF -- at
3 PDF 30.

4 A Okay.

5 Q So TMR is defined as the ratio of the
6 quantity antiparallel resistance minus parallel
7 resistance divided by the parallel resistance;
8 correct?

9 A Correct.

10 Q So we could regard that as TMR is the
11 ratio of antiparallel resistance to parallel
12 resistance minus one; correct?

13 A Say it again, please.

14 Q We could rewrite this equation as TMR is
15 equal to the ratio of antiparallel resistance to
16 parallel resistance quantity minus one; correct?

17 A Okay.

18 Q The TMR will only increase if the ratio
19 of antiparallel resistance to parallel resistance
20 increases; correct?

21 A The ratio of antiparallel resistance to
22 parallel resistance has to increase. Right?

23 Q Right. Do you agree with that?

24 A I do.

25 Q Okay. So if the antiparallel resistance

1 and the parallel resistance changed by the same
2 amount proportionately, the TMR will not change;
3 right?

4 A That's fair.

5 Q So if you decrease both the antiparallel
6 and the parallel resistance by 10 percent, the TMR
7 would be unchanged?

8 A Fair.

9 Q If -- if we're talking about reducing the
10 resistances, the only way to increase TMR is if
11 the parallel resistance is decreased by
12 proportionately more than the antiparallel
13 resistance; correct?

14 A Correct.

15 Q All right. So if your testimony
16 concerning paragraph 68 of your declaration in
17 Butler is that a person of ordinary skill in the
18 art could not draw any conclusion as to which way
19 the TMR would change if the barrier height
20 changed, how can you say that the parallel
21 resistance would decrease by more than the
22 antiparallel resistance if the barrier height is
23 reduced?

24 A All right. Let's try this again. Give
25 me a moment. well, let me just bring up

1 paragraph -- paragraph 170 in my declaration. I
2 think it is PDF 92.

3 Q I'm there.

4 A why am I not surprised?

5 The statement here, which is similar to
6 the one we were just looking at, second sentence,
7 "As explained in Section VII.E.3 of this
8 Declaration, Butler and Mathon taught that MgO
9 barriers would achieve higher TMRs due to improved
10 symmetry matching between the MgO barrier and
11 ferromagnetic electrodes, facilitating tunneling
12 of parallel electrons across the barrier compared
13 to antiparallel tunneling."

14 I explicitly compare the parallel and
15 antiparallel there. what I've been trying to
16 explain for some time today is that the teaching
17 in Butler and Mathon, that a person of ordinary
18 skill would understand that if you vary the
19 barrier height -- and if -- let me -- let's --
20 let's go to -- I think it will help to go to
21 Figure 3 in Simmons -- so Simmons is Exhibit 1031.
22 And I'm referring to Figure 3 on page 1796.

23 okay?

24 Got you. So in A, what you see is that
25 what Simmons calls the barrier height, phi naught,

1 which we were looking at before. This is a
2 slightly simplified picture because -- compared to
3 Figure 1, but I think it is more helpful here.
4 The barrier height, as you can see there, in
5 Electrode 1, there's a horizontal line at the
6 bottom of the arrow for ϕ_{naught} . And I won't
7 bother to try to find where Simmons says this. I
8 think it is quite clear by now. A person of
9 ordinary skill would understand that horizontal
10 line at the bottom of the arrow for ϕ_{naught} is
11 the Fermi level for electrons in electrode 1. And
12 then the horizontal line at the top of that
13 ϕ_{naught} arrow represents the conduction band,
14 the bottom of the conduction band and the
15 insulator.

16 So the -- the barrier height is generally
17 understood by persons of ordinary skill to be
18 given by that diagram and that expression ϕ_{naught}
19 is equal to $E_{sub C}$, for the insulator,
20 minus $E_{sub F}$, for the electrode 1.

21 Now, notice that one of ordinary skill
22 also understands from Simmons and from the
23 literature on tunneling in textbooks that
24 electrons will tunnel through the barrier from --
25 predominantly from the top of the conduction band

1 in the metal, at that EF level, enter the
2 insulator at that energy, tunnel through and
3 emerge on the other side into electrode 2.

4 Now, if the barrier height ϕ naught
5 changes by doing something to that interface
6 between the barrier and the electrode 1 -- and
7 there's a variety of ways that that barrier height
8 could be changed, including defects -- then the
9 Fermi level in the electrode 1 would line up at a
10 different location within that band gap of the
11 insulator.

12 Butler -- now, if I go back to my --
13 where I was in my declaration, paragraph 170,
14 "Butler and Mathon taught that the MgO barrier
15 facilitates tunneling of parallel electrons across
16 the barrier compared to antiparallel tunneling."
17 And Butler and Mathon teach that the reason for
18 this is related to the -- what is called the band
19 structure of the MgO, which facilitates tunneling
20 of parallel electrons much more than the
21 antiparallel. And the ratio between the tunneling
22 of the parallel and antiparallel tunneling, that
23 ratio of R_p to R_{ap} that we were talking and that
24 you brought up, that ratio can be reasonably
25 expected to vary as the barrier height changes

1 because the electrons tunneling through that
2 barrier are interacting with the MgO energy bands
3 at a different location in the gap, where things
4 are different.

5 Now, I -- as I have said, I don't have
6 enough information to be able to simply predict
7 and I don't think a POSA had enough information
8 just by reading Butler or Butler and Mathon to be
9 able to confidently predict, project whether the
10 facilitated -- whether the -- the facilitation of
11 the parallel versus the antiparallel electrons
12 would go -- would be -- would go one way or the
13 other. That the antiparallel electrons would be
14 more effectively blocked or less effectively
15 blocked depending on what energy is going through
16 that barrier. But it is definitely reasonable to
17 expect that it would be different. That's the
18 basis for my opinion. That if you vary the
19 barrier height, you don't just change R_p and R_{ap}
20 proportionately, it is true that the tunneling
21 rate for both would go up, if you reduce the
22 barrier height. I can -- that is -- that I
23 would -- I think is clear.

24 But the amount which the tunnel
25 resistance changes as you vary the barrier height,

1 that ratio would also change. As the barrier
2 height goes down, the amount that the R_p and the
3 R_{ap} change is not necessarily simply by the same
4 proportion because of the -- of the sophisticated
5 or this complicated relationship of tunneling
6 through for -- for polarized spins to tunnel
7 through MgO which has this very special preference
8 for parallel versus antiparallel tunneling.
9 That's my basis for the opinion that R_p and R_{ap}
10 don't -- likely don't change by the same
11 proportion.

12 Q I want to make sure that you're done.

13 A Yes, I'm done.

14 Q Okay. Thank you.

15 So you referenced Simmons. But we just
16 agreed that Simmons doesn't describe antiparallel
17 or parallel resistances. It just describes
18 tunneling; right?

19 A Correct.

20 Q Okay. The question -- go ahead.

21 A Go ahead.

22 Q The question that I have is, where in
23 your declaration do you describe or assert that
24 reducing the barrier height in Bowen's magnesium
25 oxide barrier layer would increase the TMR? Not

1 just change it, but increase the TMR?

2 A I don't have a statement in my
3 declaration that goes beyond that presentation
4 that I just made. So I don't have an explicit
5 prediction that the TMR would go up as the barrier
6 height reduces. I -- I think it's reasonable to a
7 person of ordinary art would reasonably -- have a
8 reasonable expectation of success to lowering
9 the --

10 Q Success in what?

11 A In increasing the TMR. Reasonable
12 expectation. At least a 50 percent chance.
13 That's reasonable.

14 Q Okay. I'm -- I'm asking about what they
15 had a reason to believe would happen. I'm not
16 asking about a coin flip; it might go up, it might
17 go down. I'm asking specifically to identify any
18 evidence that would have taught a person of
19 ordinary skill in the art that decreasing the
20 barrier height in Bowen's magnesium oxide barrier
21 would have increased TMR.

22 A I don't have an explicit statement of
23 that. I've said it many times. I don't say that
24 it -- that a person would have -- would explicitly
25 know that it would specifically increase. I'm

1 saying they have a reasonable expectation that it
2 would increase. And I don't say that explicitly
3 in my declaration. I'm saying that that -- that's
4 my -- that's what I think a person of ordinary
5 skill in the art would understand based on the
6 presentation that I put in my declaration.

7 Q So if we could speak in terms of parallel
8 and antiparallel resistances, try to quantify this
9 that way. And we can stay with your paragraph 170
10 in your declaration. If Bowen reduced the barrier
11 height in his MTJ from, say, .9 electron volts to
12 .7 electron volts, how much would a POSA have
13 expected the parallel resistance to fall?

14 ATTORNEY WILSON: Objection. Form.

15 THE WITNESS: I can't -- I can't quantify
16 that. I do not have a basis for giving a number.

17 BY ATTORNEY WICHMAN:

18 Q And --

19 A And I don't think a POSA would have --
20 a priori would have a basis for predicting or
21 estimating what that reduction would be.

22 Q And if Bowen had reduced the barrier of
23 his magnesium oxide layer from .9 electron volts
24 to .7 electron volts, how much would the POSA have
25 expected the antiparallel resistance to fall?

1 A I don't -- same answer. I don't have a
2 way to quantify that. I don't think a POSA had
3 enough information to be able to estimate --
4 numerically estimate that quantity.

5 Q So a POSA would have been unable to form
6 an estimate of -- to -- of whether the
7 antiparallel resistance would fall by more than
8 the parallel resistance?

9 A That's another way to say the same thing
10 I've been saying all day.

11 Q And the POSA would not have had a way to
12 form an estimate of whether the antiparallel
13 resistance would fall by less than the parallel
14 resistance; is that right?

15 A Correct.

16 Q The POSA didn't know?

17 A A POSA did not have the resources to be
18 able to make a scientifically responsible estimate
19 of that.

20 Q Okay. So you pointed me to paragraph 68
21 and paragraph 170. Is there anywhere else in your
22 declaration where you discuss this issue?

23 A well, the issue depends. I mean, the
24 definition -- it depends on how -- where you draw
25 the boundaries for the issue.

1 Q Strike the question.

2 A I can argue that most of the declaration
3 addresses that issue.

4 Q Okay. Other than paragraph 68 and 170 in
5 your declaration, is there anywhere where you
6 address the question of how a POSA would have
7 expected TMR to change based on a reduction in
8 Bowen's barrier height?

9 A The points that are explicit in
10 paragraph 170 and -- what was it? 60?

11 Q 68.

12 A 68? okay.

13 I have a recollection -- I was looking
14 for it earlier, that there -- that there might be
15 some other place in the declaration that also
16 addresses this point -- looking at paragraph 68
17 again -- that the MgO barrier passes delta 1
18 electrons while largely blocking other electrons.
19 There might be something else that says something
20 very similar to that in the declaration. I can't
21 remember exactly where it is. Or even if -- I
22 have this sense that. You know, I would have to
23 look pretty hard to find it. There may or may not
24 be another place. But in any event, it is
25 essentially the same point. I don't have any

1 add-on to that, if that's what you're looking for.
2 The -- the opinion that I'm giving today that I
3 believe is based solidly on what's in -- and is
4 disclosed in my declaration is the one that we
5 have -- that I have repeated now multiple times.
6 The MgO barrier passes delta 1 electrons much more
7 efficiently -- much more strongly than the
8 electrons having the opposite spin. And that that
9 ratio between the R_p and the R_{ap} for electrons
10 tunneling through MgO is energy dependent.

11 One of ordinary skill in the art reading
12 Butler would have the reasonable interpretation
13 that that ratio should be energy dependent and
14 varying the barrier height is going to vary that
15 energy. That's -- that's the long and short of my
16 opinion. I -- I don't go farther than that in my
17 declaration or here today.

18 Q And -- well, based on that, it is also
19 your testimony that the person of ordinary skill
20 in the art would not have known how TMR would have
21 changed if barrier height were reduced in the MgO
22 barrier layer of Bowen; right?

23 A It would not have known quantitatively
24 how much the -- how much the TMR would change or
25 the sign.

1 Q And by sign, you mean they wouldn't have
2 known if it would have increased or decreased?

3 A Increased or decreased.

4 Q Okay. Can we go back to paragraph 49.
5 It's at PDF page 34.

6 A 49. We're back to Simmons. Okay. I'm
7 there.

8 Q So you just introduced a correction to
9 the Simmons formula for tunnel junction current
10 density in the low voltage range; right?

11 A That's in paragraph 49, yes.

12 Q And you actually provide the correction
13 in that paragraph; right?

14 A I did.

15 Q And this is a correction to Simmons
16 equation 25?

17 A Okay. If you want me to confirm the
18 equation number, I'll do that.

19 Q Yeah. It's Simmons page 1797 and PDF
20 page 6; right?

21 A Okay. So we're talking about Simmons
22 equation 25.

23 Q Right.

24 A Right. That is Simmons equation 25. The
25 one that is in my declaration is literally

1 photographically copied from Simmons equation 25.

2 Q Did you make that copy?

3 A Did I -- you mean was I the one who
4 captured --

5 Q Cut and paste?

6 A And dropped it in?

7 Q Yeah.

8 A I frankly don't remember.

9 Q Okay.

10 A Maybe not.

11 Q I just want to point out there are two
12 corrections in the corrective formula, right.
13 First, there was a factor of three halves that's
14 is removed from Simmons equation 25.

15 A Yeah.

16 Q Is that right?

17 A Yes.

18 Q And in Simmons equation 25, the barrier
19 height phi occurs twice. But Simmons left off --
20 for the first occurrence Simmons left off the
21 subscript zero; right?

22 A Correct.

23 Q And you fixed that. Or the corrected
24 version fixes that; right?

25 A Yeah. The corrected version comes from

1 the literature. And I give the reference. I
2 didn't -- I didn't come up with that all on my
3 own. That comes from the literature. And this is
4 my -- I believe this is widely accepted in the --

5 Q There's only one barrier height though in
6 this equation?

7 A Correct.

8 Q Okay.

9 A One barrier height.

10 Q So in this paragraph 49, you do not
11 allege that lowering a barrier height in an MTJ
12 will reduce parallel resistance by more than it
13 reduces antiparallel resistance; correct?

14 A Not in this paragraph. I agree. That
15 was your question, wasn't it?

16 Q Yes.

17 A Okay. We agree.

18 Q Go to paragraph -- go ahead.

19 A I was just going to say we're in
20 agreement.

21 Q Okay. Paragraph 169. This is PDF page
22 91 of your declaration.

23 A 169.

24 Q Okay.

25 A Okay. I'm at 169.

1 Q All right. In paragraph 169, you do not
2 allege that lowering a barrier height in an MTJ
3 will reduce the parallel resistance by more than
4 it reduces antiparallel resistance; correct?

5 A Okay. This is the paragraph that I was
6 thinking of when I said I think there is another
7 paragraph that addresses this. So let me be very
8 careful here. I just read this paragraph
9 carefully. Please ask your question one more
10 time.

11 Q In paragraph 169 of your declaration, you
12 do not allege that lowering a barrier height in an
13 MTJ will reduce parallel resistance by more than
14 it reduces antiparallel resistance; correct?

15 A That's correct. This paragraph just says
16 if you reduce the resistance for parallel compared
17 to antiparallel, that would increase the TMR.
18 That's what this paragraph says. And that's -- it
19 doesn't say what you just said. I agree with
20 that.

21 Q In paragraph 171, which --

22 A 171?

23 Q 171. Starts at the bottom of PDF 92.

24 A Okay.

25 Q In paragraph 171 of your declaration, you

1 do not allege that lowering a barrier height in an
2 MTJ will reduce the parallel resistance by more
3 than it reduces antiparallel resistance; correct?

4 A Correct.

5 Q Paragraph 172 of your declaration. This
6 is PDF page 93.

7 Okay. In paragraph 172, you do not
8 allege that lowering a barrier height in MTJ will
9 reduce parallel resistance by more than it reduces
10 antiparallel resistance; correct?

11 A Correct.

12 Q And in the next paragraph, 173, in your
13 declaration, you do not allege that lowering a
14 barrier height in an MTJ will reduce the parallel
15 resistance by more than it reduces antiparallel
16 resistance; correct?

17 A Correct.

18 ATTORNEY WICHMAN: Okay. why don't we
19 take a five-minute break here. Unless -- does
20 anybody need more time than that?

21 ATTORNEY WILSON: No.

22 ATTORNEY WICHMAN: All right. why don't
23 we come back -- well, it's 4:53 my time. why
24 don't we come back at the top of the hour.

25 ATTORNEY WILSON: Okay.

1 ATTORNEY WICHMAN: Off the record.

2 (A recess was taken.)

3 ATTORNEY WICHMAN: Back on the record.

4 Q If we could stay with paragraph 169 in
5 your declaration. Are you there?

6 A I am now.

7 Q Okay. So you referred to Soukup. The
8 abstract page 3232 and 3236 in this paragraph;
9 right?

10 A Right.

11 Q All right. So I don't know -- I don't
12 remember if we covered this or not. But Soukup
13 doesn't teach making MTJs at all; right?

14 A Right.

15 Q Soukup was published in 1970?

16 A Yeah. Yes.

17 Q And -- and it was before tunneling
18 magnetoresistance was discovered?

19 A Yes, as we established earlier.

20 Q And Soukup made thin film diodes; right?
21 Is that right?

22 A I'm just checking.

23 Yeah. Thin film emission diodes is what
24 he called them. Yes.

25 Q And Soukup used gold for his electrodes;

1 right?

2 A Correct.

3 Q Gold is not ferromagnetic, is it?

4 A It is not.

5 Q You cannot make an MTG with gold
6 electrodes -- an MTJ with gold electrodes; right?

7 A Not that I've ever heard of.

8 Q Would there be a tunneling
9 magnetoresistance effect between gold electrodes
10 separated by an insulator?

11 A Not under most common conditions, no.

12 Q All right. In this paragraph 169 in your
13 declaration, the second sentence you just recite
14 the TMR equation; right?

15 A Correct.

16 Q And you follow it with a cite to more
17 documents?

18 A Yes.

19 Q So let's come back to Moodera. But let's
20 start with Nagahama. Why did you cite Nagahama,
21 Exhibit 1027, paragraph 2?

22 A Referencing Nagahama paragraph 2 because
23 the same equation appears there.

24 Q So you just cite Nagahama because it
25 provides the equation for TMR at paragraph 2; is

1 that right?

2 A Yes.

3 Q Is there any other reason that you're
4 citing Nagahama?

5 A well, not there.

6 Q Okay. You cite the patent, the '909
7 patent, Exhibit 1017, at column 5, lines 8 to 16.
8 Encompasses lines 10 to 16 that we looked at
9 earlier; right?

10 A Yeah. That's -- that's where the patent
11 also provides that equation with text to help
12 identify the parameters, yes.

13 Q So you're citing the '909 patent just
14 because it cites the TMR equation; right?

15 A In this citation, yeah.

16 Q Okay. At -- in paragraph 169, you cite
17 Exhibit 1057.

18 A I do.

19 Q Page 13.

20 A Right.

21 Q It is PDF page 32. Can you pull that up?

22 A Sure. I had it, but I think I closed
23 that.

24 Q Are you there?

25 A Yes.

1 Q So equation 1.9 provides the equation for
2 the TMR equation. Strike that.

3 Equation 1.9 is the equation for TMR;
4 right?

5 A Correct.

6 Q Is this the reason you were citing
7 Exhibit 1057 in your paragraph 169?

8 A Yes.

9 Q Is there anything else on this page 13 of
10 Exhibit 1057 that you are relying on, other than
11 the equation for TMR, for your paragraph 169?

12 A Not for paragraph 169, no.

13 Q Okay. In your declaration, you refer to
14 this as a textbook, Dieny textbook.

15 A Yes.

16 Q Just out of curiosity, who -- did you
17 pick this textbook as a reference for your
18 declaration?

19 A I honestly -- I honestly do not recall.
20 Let's see. This declaration was completed
21 September of 2004 -- '24. I don't recall who
22 picked it. We did discuss it.

23 Q Have you used Exhibit 1057 in your work?

24 A You mean my general professional work,
25 career?

1 Q Yes.

2 A Yeah. This is a well-known textbook. I
3 happen to know the guy.

4 Q Have you taught courses using this
5 textbook?

6 A No, I haven't done that.

7 Q Is it actually a textbook? Is it used
8 for courses?

9 A well, I don't know that I can answer that
10 question definitively. I haven't used it in a
11 course. I don't know if it is used in anybody
12 else's course. It's -- I mean, if you want to
13 quibble over the attribution to it as a textbook,
14 we could debate that. I wouldn't push too hard on
15 that. It is a comprehensive book that could
16 certainly be used as a textbook. It's not the
17 only use for a book like this. It's got a lot of
18 paragraph -- it's got a lot par- -- sections
19 written by multiple authors, intending to be a
20 comprehensive sort of treatise. Is that a
21 textbook or not? I don't know. I'm not sure. Is
22 that relevant? I'm happy to -- I mean, if you
23 want --

24 Q I want to understand how you have used
25 this book, this reference?

1 A I use it as a reference source.

2 Q Okay.

3 A I have -- I have been -- as we discussed
4 before, I've been interested in -- in MRAM for
5 quite a -- quite some time, long before I started
6 publishing in it. And this is a very good
7 comprehensive text. It's relatively recent. So
8 it's got some, you know, some of the more recent
9 developments in there. So it's a good reference
10 that is relatively up to date. That's how --
11 that's my use for it.

12 Q All right. We can go back to paragraph
13 169 in your declaration. So of these citations to
14 Exhibit 1035 (Moodera), 1027 (Nagahama), the
15 patent, and 1057 (the textbook), it's your
16 testimony that the only reason that you're citing
17 Nagahama, the patent, and the textbook are for
18 they provide the equation for TMR; is that right?

19 A In this paragraph.

20 Q Right. In this paragraph.

21 A Right. Basically this equation is very
22 well known. Lots of people cite it. Everybody
23 agrees to it. That's kind of the point of this
24 paragraph.

25 Q All right. Can you open Exhibit 1035.

1 A I have it.

2 Q Okay. You cite the -- in paragraph 169
3 of your declaration, you cite Exhibit 1035 at page
4 3273. So let's look at Exhibit 1035, page 3273.
5 That's the first page.

6 A Okay.

7 Q So tell me why are you citing this
8 page 3273 of Exhibit 1035 in your declaration
9 paragraph 169.

10 A Okay. I think I know where you're going.
11 Same -- I cited for the same reason, to show that
12 this equation is well known. I'm anticipating
13 your next question. But I'll wait.

14 Q So you're citing equation -- you're
15 citing this for equation 1 on 3273 of Exhibit
16 1035; right?

17 A It is.

18 Q And this is a different formulation for
19 TMR; right?

20 A It is.

21 Q It's dividing through by the antiparallel
22 resistance rather than the parallel resistance;
23 right?

24 A Correct.

25 Q Was that a mistake to cite it or did you

1 intend to cite this representation?

2 A No. It's -- I only just relatively
3 recently -- I am aware of this discrepancy. I
4 relatively recently noticed it. And so it is --
5 it is a bit different than what is now the
6 conventional definition, which is the one in my
7 declaration. I recently noticed this discrepancy
8 and was wondering about it. You know, this is a
9 rather early paper. I mean, it is well past
10 discovery of the MTJ. So it is not that early.
11 But I don't know why Moodera put the equation that
12 way. It's a -- I'll call it a discrepancy. I
13 don't know why he defined it that way. It is not
14 the way that most researchers define it. Probably
15 shouldn't have cited it there. But there it is.
16 I noticed that it is -- it is not exactly the same
17 equation. So yes. It's not the same equation.

18 Q Is there any other reason that you're
19 citing page 3273 of Moodera in your paragraph 169?

20 A No. No.

21 Q Okay.

22 A My intention, as I said -- my intention
23 was to show this was a well accepted, well agreed
24 on formula for TMR. When I wrote this, it escaped
25 my attention that there was this discrepancy.

1 Q Do you agree that nothing in Exhibit 1035
2 (Moodera) states that lowering the barrier height
3 of a barrier layer will increase TMR?

4 A I -- nothing in here discloses that. I
5 agree with that.

6 Q Okay. And specifically now I want to
7 focus your attention on the top right column of
8 Moodera.

9 A Which page?

10 Q Fair. Page 3273.

11 A Top right column. Yes.

12 Q Okay. Do you see the sentence that says,
13 "Another theory of FM-FM tunneling has been
14 proposed by Slonczewski?

15 A Yes.

16 Q Okay. FM-FM tunnels means ferromagnetic
17 to ferromagnetic tunneling?

18 A Correct.

19 Q So he is talking about magnetoresistive
20 effects here; right?

21 A Right.

22 Q Okay. He is describing Slonczewski and
23 says, "This model analyzes the transmission of
24 charge and spin currents through a rectangular
25 barrier separating free-electron-like

1 ferromagnetic metals." Is that right?

2 A Yes.

3 Q Are you familiar with Slonczewski?

4 A Generally.

5 Q Okay.

6 A I've read it.

7 Q You didn't -- you didn't discuss
8 Slonczewski in your declaration, though, did you?

9 A No, I didn't.

10 Q Why not?

11 A It's similar to Butler. It's a very
12 advanced, dense theoretical paper. And I didn't
13 feel the need to cite it and get into it. And,
14 you know, other papers cite to it. Like this one.
15 So I didn't -- I didn't explicitly cite it in my
16 declaration. But I don't have any reason to -- I
17 don't have any disagreement with it.

18 Q I'm sorry.

19 A Any disagreement -- I didn't -- I didn't
20 leave it out because I have any problem with it.

21 Q The next sentence here, it says that,
22 "It" -- referring to Slonczewski's theory --
23 "predicts strong influence of tunnel height on the
24 orientation of the spins tunneling across the FM-I
25 interface, thereby affecting the spin polarization

1 and also the exchange coupling between the
2 ferromagnets, and was consistent with the low
3 values of ΔR divided by R seen previously."
4 Right?

5 A I see that.

6 Q Okay. FM-I, that refers to the
7 ferromagnetic insulator interface?

8 A Correct.

9 Q So that is the interface between Bowen's
10 device. That is the interface between, say, the
11 bottom iron electrode and the magnesium oxide
12 barrier layer; right?

13 A Right.

14 Q What does this mean, strong influence of
15 tunnel barrier height on the orientation of the
16 spins tunneling across the FM-I interface?

17 A It means that the -- it means what it
18 says.

19 Q Okay. So how does the barrier height
20 have a strong influence on the orientation of the
21 spins tunneling across the interface?

22 A How does that happen? Slonczewski -- as
23 I said, it's a dense theoretical paper.
24 Slonczewski explains that. I can't expand on it.
25 I haven't read Slonczewski in a while. I don't

1 have it in front of me. It is not in my
2 declaration. I'm hesitant to give further
3 opinions about Slonczewski. If you really want me
4 to discuss Slonczewski, then if you're willing to,
5 you know, give me -- give me the document, I'll be
6 happy to take a look at it and answer questions.

7 Q This is what I want to know. This
8 sentence here, "It predicts strong influence of
9 tunnel barrier height," through the end, do you
10 agree that this does not state that reducing
11 barrier height will increase TMR?

12 A That sentence does not say what you just
13 said. I agree.

14 Q Okay. So let's back up here. So this
15 whole passage then in Moodera, page 3273, the
16 right-hand column, top paragraph, from the
17 sentence "Another theory of FM-FM tunneling,"
18 through the end of that paragraph, it is your
19 opinion that that passage does not state that
20 decreasing the barrier height will increase TMR;
21 is that right?

22 A That sentence does not say that, what you
23 just said. I agree.

24 Q So it is three sentences then.

25 A The three sentences don't say whether the

1 orientations of spins go up -- get stronger or
2 weaker with tunnel barrier height. It doesn't say
3 the spin polarization gets stronger or weaker with
4 barrier height. It just says it is affecting the
5 spin polarization.

6 Q And a POSA reading this would have
7 understood that this does not predict which way
8 TMR would change with barrier?

9 A Not quite in so many words. It does say
10 that it was consistent with low values of delta R
11 over R seen previously. It does say that.

12 Q And what does that mean to you?

13 A It means that this is one possible way to
14 understand low values of delta R over R seen
15 previously. It doesn't -- it doesn't really -- it
16 doesn't say much more than that. It is not a
17 hundred percent clear. I don't take it as a
18 prediction that if you vary the barrier height in
19 the particular MTJ, whether -- whether you would
20 for sure get high or low values for delta R over
21 R. It is not a hundred percent crystal clear on
22 that.

23 Q So a person of ordinary skill in the art
24 familiar with this passage would not have
25 concluded that Moodera is describing TMR

1 increasing if barrier height is reduced; right?

2 A True. I do recall enough about
3 Slonczewski that Slonczewski does -- does not
4 consider the MgO barrier, which Butler does. So
5 that statement applies to a simple barrier like
6 aluminum oxide. And it doesn't -- you know, it
7 doesn't anticipate -- Butler was published well
8 after this. So this was the understanding based
9 on Slonczewski as of 1995.

10 Q So would a person of ordinary skill in
11 the art then have concluded since Moodera,
12 Exhibit 1035, and Slonczewski both concerned
13 aluminum oxide barriers, that they would not have
14 been relevant to forming predictions of TMR in
15 Bowen's magnesium oxide MTJ?

16 A I wouldn't say irrelevant, but they
17 wouldn't capture the subtleties that we've been
18 discussing for most of today.

19 Q Moodera and Slonczewski did not provide
20 the first principles analysis of crystal iron,
21 crystal magnesium oxide, crystal iron that Butler
22 did; right?

23 A Correct.

24 Q And Butler -- the Butler analysis is what
25 a POSA would have thought would have been relevant

1 to Bowen's MTJ; right?

2 A Right.

3 Q Okay. Can we look at paragraph 276 of
4 your declaration. That's at PDF page 135.

5 A 276 did you say?

6 Q Yes.

7 A Okay. I'm there.

8 Q You agree in paragraph 276 you do not
9 state that reducing the barrier height in
10 Nagahama's MTJ would increase TMR; right?

11 A Yeah. Consistent with other paragraphs
12 that we've looked at. Same -- same exact
13 situation.

14 Q And you agree that in paragraph 276, you
15 do not testify that reducing Nagahama's barrier
16 height would reduce the parallel resistance by
17 more than it would reduce the antiparallel
18 resistance; right?

19 A This paragraph, I do not say that. I
20 just say if lowering the barrier height for
21 parallel -- I just say lowering the resistance for
22 parallel spin electrons compared to antiparallel
23 would improve the TMR. I do say that.

24 Q In the next paragraph, 277, the second
25 sentence, you say that "Nagahama sought to

1 increase TMR by modifying properties of the MgO
2 barrier layer." Right?

3 A Right.

4 Q And you cite Nagahama, Exhibit 1027,
5 paragraphs 15 to 17; right?

6 A Right.

7 Q Can you open Exhibit 1027, please.

8 A Okay.

9 Q All right. So PDF 3, you find Nagahama
10 paragraph 15; right?

11 A Yes.

12 Q So Nagahama's first objective here was
13 varying the barrier layer thickness; correct?

14 A Correct.

15 Q So when Nagahama varies the barrier layer
16 thickness, that has nothing to do with changing
17 barrier height; right?

18 A Correct.

19 Q And in paragraph 16, Nagahama's second
20 objective was precisely controlling the barrier
21 layer thickness; right?

22 A Correct.

23 Q And the barrier layer thickness has
24 nothing to do with barrier height; right?

25 A well, those are two independent

1 parameters, yes.

2 Q And Nagahama's third objective was in
3 paragraph 17; right?

4 A Yes.

5 Q And in paragraph 17, Nagahama states that
6 a third objective was discovering a suitable
7 material and developing a technique for allowing
8 highly oriented crystals to grow evenly; right?

9 A That's what it says.

10 Q And developing a technique for allowing
11 highly oriented crystals evenly has nothing to do
12 with barrier height; right?

13 A Not directly, no.

14 Q And indirectly?

15 A Indirectly, if the element doesn't have a
16 highly oriented flat interface that's not affected
17 by the structure in roughness, that could affect
18 the effective barrier height indirectly.

19 Q So would -- go ahead. Sorry.

20 A We've seen that in other references.

21 Q Well, if Nagahama developed a technique
22 that allowed highly oriented crystals to grow
23 evenly, would that increase or decrease barrier?

24 A I hesitate to predict that. If -- if you
25 have a rough -- a rough film, a rough element

1 which is affected by the structure and roughness
2 of an amorphous or poly crystal underlayer, the
3 consequences are, at a minimum, you could have a
4 variable, not consistent barrier height. That
5 would be bad. Here, he's not referring to that
6 explicitly. But one of ordinary skill in the art
7 would understand that having a highly oriented
8 flat interface, not affected by roughness, would
9 have benefits conceive -- conceivably also in
10 terms of control of the barrier height.
11 Indirectly.

12 Q In your opinion, does Nagahama at
13 paragraphs 15 to 17 describe reducing a barrier
14 height?

15 A No.

16 Q So in your paragraph 277 in your
17 declaration, when you say that Nagahama sought to
18 increase TMR by modifying properties of the
19 magnesium oxide barrier layer, that does not
20 include reducing the barrier height; is that
21 right?

22 A All right. Please ask your question
23 again.

24 Q In paragraph 277 of your declaration,
25 when you say that Nagahama sought to increase TMR

1 by modifying properties of the magnesium oxide
2 barrier layer, that did not include reducing the
3 barrier height; correct?

4 A That's correct.

5 Q All right. In the next sentence you
6 assert, "It was understood to one of skill that
7 lowering the barrier height to increase tunneling
8 would have increased the TMR." Did I read that
9 correctly?

10 A Yes.

11 Q Okay. what is the evidence for that?

12 A Same evidence that we've been discussing.
13 would have had a reasonable expectation to
14 increase TMR is what it should say.

15 Q I thought your testimony was that the
16 person of ordinary skill in the art, the most they
17 could do is read Butler and conclude that TMR
18 would change, but would not have any reason or
19 expectation that the TMR would either increase or
20 decrease.

21 A well, we've been having a debate about
22 whether that is a reasonable expectation that it
23 would increase.

24 Q well --

25 A That's my perspective on it.

1 Q So this testimony here, what you're
2 saying is the POSA would have had a reasonable
3 expectation that lowering the barrier height would
4 increase TMR because the POSA knew that TMR had to
5 change and, look, it was either up or down, so
6 50/50, one of those would have increased TMR. Is
7 that -- is that your testimony?

8 A That's my testimony.

9 Q Okay. So the POSA -- just to be clear,
10 because it reads quite differently here. I want
11 to be clear that your testimony -- it is your
12 opinion that a POSA did not actually know that
13 reducing the barrier height would increase TMR?

14 A I do not have evidence for that.

15 Q You do not have evidence -- I'm sorry.
16 You do not have evidence that a POSA would have
17 known that reducing barrier height would increase
18 TMR; right?

19 A That's what I've been testifying.

20 ATTORNEY WICHMAN: Okay. Why don't we
21 take five minutes now, and then I want to turn to
22 some different topics, if we can.

23 ATTORNEY WILSON: Okay.

24 ATTORNEY WICHMAN: So could we be back in
25 five minutes. Thanks. Off the record.

1 ATTORNEY WILSON: Okay.

2 (A recess was taken.)

3 ATTORNEY WICHMAN: All right. On the
4 record.

5 Q I would like to talk about Dr. Soukup's
6 work. It's Exhibit 1028. If you could pull that
7 up.

8 A Okay. I have it.

9 Q Okay. If we go to -- if you can keep
10 that up and also go to your declaration at
11 paragraph 168. That's at PDF page 91.

12 Are you there?

13 A I'm there.

14 Q All right. It's your testimony that
15 Soukup taught that fewer oxygen vacancies in
16 magnesium oxide resulted in a higher barrier
17 height; is that right?

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

19 Q And we discussed this before. What
20 Soukup actually did was he -- for a panel of
21 devices, he increased the oxygen pressure in the
22 reaction chamber when he made the devices; right?

23 A Right.

24 Q And when he increased that oxygen
25 pressure, the expectation was that there would be

1 fewer oxygen vacancies in the material?

2 A Right.

3 Q And so this result about barrier height
4 is comparing the barrier heights that he estimated
5 from the devices that he made in this manner
6 varying the oxygen pressure; is that right?

7 A Right.

8 Q Okay. And you refer to Soukup at page
9 3232 in this paragraph 168.

10 A Yes.

11 Q Okay. And you -- the second sentence,
12 you say Soukup suggested there was a 'higher
13 barrier' question for the devices fabricated with
14 more oxygen present during the magnesium oxide
15 deposition which could mean more stoichiometric
16 oxide films. Right?

17 A Yes.

18 Q Okay. If you could -- in Soukup now, if
19 you could turn to page 3232, which is PDF page 5
20 of Exhibit 1028.

21 A I'm there.

22 Q So here in the bottom paragraph on the
23 left column of page 3232, Soukup describes this
24 experiment to determine the effect of
25 nonstoichiometry on the device characteristics;

1 right?

2 A Right.

3 Q And as we discussed before, Soukup does
4 not actually describe any step in which he removed
5 the oxygen from the reaction chamber; right?

6 A Not -- he explicitly adds oxygen. He
7 doesn't lower the oxygen below that of the base
8 pressure of his vacuum system.

9 Q In this paragraph on page 3232, he
10 describes two devices that he fabricated. One he
11 labeled PY-G-22(2). Correct?

12 A Right.

13 Q The other he labeled PY-G-25(3); correct?

14 A Correct.

15 Q And the first one, PY-G-22(2) was grown
16 in the presence of oxygen gas that was emitted to
17 the vacuum system to a pressure of 10 to the minus
18 8 torr; correct?

19 A That's right.

20 Q And a torr is a unit of pressure?

21 A Correct.

22 Q It is 1/760 of a standard atmosphere; is
23 that correct?

24 A Correct.

25 Q And the second device PY-G-25(3) was

1 grown in the presence of oxygen gas that was
2 emitted to the system to a pressure of 10 to the
3 minus 7 torr; right?

4 A Right.

5 Q And 10 to the minus 7 torr is a higher
6 pressure than 10 to the minus 8 torr; correct?

7 A Correct.

8 Q Ten times higher?

9 A Ten times higher.

10 Q All right. So device PY-G-25(3) was
11 grown under conditions where the oxygen pressure
12 was ten times higher than the oxygen pressure
13 under which device PY-G-22(2) was grown; right?

14 A Right.

15 Q And so higher oxygen pressure means there
16 was more oxygen present in the chamber during the
17 device fabrication; right?

18 A During the deposition of insulator, yes.

19 Q Okay. So the idea now is that if the
20 magnesium oxide layer was deposited in conditions
21 where the oxygen pressure was higher, then it
22 would be expected that the magnesium oxygen layer
23 would have fewer oxygen vacancies; right?

24 A That's the basic idea here, yes.

25 Q Okay. And so when Soukup refers to this

1 more stoichiometric oxide films, he means the
2 magnesium oxide layer had fewer oxygen vacancies;
3 right?

4 A Right.

5 Q And was that magnesium oxide layer was
6 more -- was closer to a uniform material that had
7 a ratio of one to one magnesium and oxygen; right?

8 A I'm not sure he meant -- I'm not sure he
9 talks about uniformity.

10 Q Okay. But do you -- do you agree -- go
11 ahead. Sorry.

12 A Is there a particular place that you can
13 point to where he discusses -- considers the
14 uniformity of the oxygen?

15 Q Let's forget the idea of uniformity.
16 Let's just say that more stoichiometric means that
17 the magnesium oxygen layer would have been a
18 material that was closer to having a ratio of one
19 to one magnesium and oxygen; right?

20 A That's what it means, yes.

21 Q Okay. So in your declaration, Exhibit
22 1024, at paragraph 168, you testified that "Soukup
23 found that a lower level of oxygen vacancy defects
24 may result in a higher barrier height. This
25 suggested a higher level of oxygen vacancy defects

1 lower the barrier height." Right?

2 A Right.

3 Q So on Soukup, page 3233, which is PDF
4 page 6, on the bottom right, there's a Table 1;
5 right?

6 A Right.

7 Q And Table 1 is titled "Summary of device
8 data"; correct?

9 A Correct.

10 Q And the left column, the first column is
11 device number; is that right?

12 A Correct.

13 Q And the second and third devices from the
14 bottom are this PY-G-22(2) and PY-G-25(3);
15 correct?

16 A Correct.

17 Q And those are the two devices that we
18 just discussed that were grown under different
19 oxygen pressures; right?

20 A Correct.

21 Q The rightmost column in Table 1 has a
22 letter -- has a header of P02, with a subscript
23 02. So that is the oxygen pressure; right?

24 A Right.

25 Q And if you drop down, the entry of oxygen

1 pressure associated with PY-G-22(2) is 10 to the
2 minus 8; right?

3 A Right.

4 Q And that's 10 to the minus 8 torr that we
5 just discussed for that device; right?

6 A Right.

7 Q And the next entry down, the oxygen
8 pressure is identified as 10 to the minus 7 for
9 device PY-G-25(3); correct?

10 A Correct.

11 Q And that's the 10 to the minus 7 torr
12 that we just discussed per this device I'll call
13 G-25?

14 A Right.

15 Q Okay. If you go back to the previous
16 page of Soukup, page 3232, on the bottom left
17 paragraph again, in the second-to-last sentence,
18 this is -- it states that "The zero-field
19 intercept of the Schottky plots is a function of
20 oxygen pressure with the lower intercept (higher
21 barrier?) present for the devices fabricated with
22 more oxygen present during MgO deposition, which
23 could mean more stoichiometric oxide films."
24 Right?

25 A That's what it says, yes.

1 Q And this is the sentence that you quote
2 the last half of it in your declaration at
3 paragraph 168; right?

4 I'm sorry. Did you agree that this is
5 the sentence that you're quoting?

6 A I just want to confirm and be sure.

7 Q Okay.

8 A Yes.

9 Q So you left out the part about the
10 zero-field intercept of the Schottky plots being
11 the source of the barrier height information;
12 right?

13 A In my declaration, in that paragraph, I
14 do.

15 Q Okay. So back to Dr. Soukup's paper,
16 page 3233, in Table 1, again, the fourth column
17 here has a header 5 sub 1; right?

18 A Right.

19 Q And footnote C explains that this is the
20 barrier obtained by the zero-intercept method in
21 electron volts; right?

22 A Right.

23 Q So this is the barrier height value that
24 Soukup determined by evaluating the zero-field
25 intercept of the Schottky plots; right?

1 A Fair. Yes.

2 Q This is the value that Soukup is
3 referring to on the previous page 3232 in that
4 sentence that you quote the last half; right?

5 A Right. From Figure 6.

6 Q Right. So just to summarize, when Soukup
7 is speculating that a higher barrier -- the
8 function of oxygen pressure with lower intercept
9 higher barrier could mean a more stoichiometric
10 oxide films, he is referring to the barrier height
11 determined by the zero-field intercept of the
12 Schottky plots that is reported in column 4 of
13 Table 1; right?

14 A Right.

15 Q All right. And then if you look at
16 Soukup, page 3231, which is PDF 4, he describes --
17 in the right-hand column, he describes the
18 zero-field intercept method; right?

19 A Basically. I would say that is
20 reasonable -- a reasonable description.

21 Q So in this second paragraph on page 3231,
22 Dr. Soukup describes an apparent barrier sub R
23 star; right?

24 A We're talking about in the right-hand
25 column on 3231?

1 Q Yeah. Below equation 5.

2 A Yeah. He -- that's correct.

3 Q Okay. Go ahead. Go ahead. Sorry.

4 A No. Phi R star, yes.

5 Q Okay. And Soukup says that the barriers
6 obtained in this manner range from .69 to .72
7 electron volts; right?

8 A Yes.

9 Q If you go back to page 3233, Table 1,
10 column 4, you see a range of barrier heights that
11 are from .69 to .72 electron volts; right?

12 A Right.

13 Q All right. So in Table 1, Soukup is
14 telling us that for device PY-G-22(2), the barrier
15 obtained by the zero-intercept method in electron
16 volts was .780 electron volts; right?

17 A Right.

18 Q And in Table 1, Soukup tells us that for
19 device PY-G-25(3), the barrier obtained by
20 zero-intercept method in electron volts was 0.823
21 electron volts; right?

22 A Right.

23 Q So this shows that the barrier obtained
24 by the zero-intercept method in electron volts
25 increased when the device was grown under a higher

1 oxygen pressure; right?

2 A Right.

3 Q And so this is the result that you're
4 relying on in your declaration at paragraph 168;
5 correct?

6 A Right.

7 Q So when you state in paragraph 168 that
8 Soukup found that a lower level of oxygen vacancy
9 defects may result in a higher barrier height, you
10 are relying on the zero-field intercept result in
11 Soukup; right?

12 A Right.

13 Q And when you state, "In sum, Soukup
14 taught that there was an inverse correlation
15 between oxygen vacancy defects and the barrier
16 height of the magnesium oxide layer," you are
17 relying on the zero-field intercept result in
18 Soukup; right?

19 A Correct.

20 Q Okay. And when you state, "In sum,
21 Soukup taught that there was an inverse
22 correlation between oxygen vacancy defects and the
23 barrier height of the magnesium oxide layer," you
24 were relying on Soukup's barrier height estimates
25 that were ascertained using this intercept method;

1 right?

2 A That's fair.

3 Q In Soukup Table 1 -- again, on page
4 3233 -- on the bottom right, there's a fifth
5 column that has a header Φ sub 2. Do you see
6 that?

7 A Yes.

8 Q And that barrier height is explained in
9 footnote D, like δ ; right?

10 A Right.

11 Q And so this barrier -- this entry, this
12 column reports barrier heights for each device
13 that are obtained from the slope of Arrhenius
14 plots in electron volts; right?

15 A Right.

16 Q And so the slope of an Arrhenius plot is
17 described at page 3232, the top left paragraph.
18 Right?

19 Let's do it step by step. So --

20 A Okay.

21 Q -- the first sentence of the top left
22 paragraph of 3232 says -- refers to the functional
23 dependence of I upon V indicates a Schottky
24 mechanism, which is very temperature dependent, so
25 that the I-V characteristics were measured at a

1 number of temperatures. Right?

2 A Right.

3 Q So V is the voltage that Soukup applied
4 to the device?

5 A Correct.

6 Q And I is the current that he measured to
7 characterize the device?

8 A Correct.

9 Q And he did this at different
10 temperatures; right?

11 A That's what he did, yes.

12 Q And he found that the I - V characteristics
13 are temperature dependent?

14 A Right.

15 Q So then he says, well, if a plot of the
16 zero-field intercept current I_{naught} obtained
17 from the figure that he has, Figure 4, was made on
18 a $\log I_{naught}$ over T squared versus 1 over T
19 plot, the result should be a straight line; right?

20 A Right.

21 Q And a plot of device characteristics 1
22 over T is known as an Arrhenius plot; right?

23 A You're not reading now. Now you're --

24 Q I'm just asking you -- I'm asking you
25 to -- what is an Arrhenius plot?

1 A Yes, that's correct. That's what he
2 means by an Arrhenius plot.

3 Q Then he goes on to say the slope of the
4 line on the Arrhenius plot will determine the
5 apparent barrier height $\phi_{\text{sub R}}$; right?

6 A Correct.

7 Q And then if you look now again on
8 page 3233, Table 1, fifth column, the values in
9 that fifth column are the slope of the line in
10 these Arrhenius plots that he made; right?

11 A Well, those numbers come from the slope.
12 The slope -- let's see. The slope involves ϕ_{R}
13 k volt constant. So he extracts.

14 Q He extracts.

15 Okay. Well, so back on page 3232, left
16 column, first paragraph, final sentence, he says,
17 with reference to Figure 5, the slope of the
18 straight line drawn in the figure gives a barrier
19 of .33 electron volts; right?

20 A Right.

21 Q And if you go back to page 3233, Table 1,
22 fifth column, you will see that the -- for
23 example, the top device, PY-G-11(1), the value in
24 column 5 is .33 electron volts; right?

25 A Right.

1 Q That is the value obtained of the
2 slope -- from the slope of the Arrhenius bolts?

3 A Yes.

4 Q Okay. So in Soukup Table 1 then, for
5 device PY-G-22(2), the barrier height obtained
6 from the slope of Arrhenius plots was 0.21
7 electron volts; right?

8 A That's what it says.

9 Q And then for device PY-G-25(3), the
10 barrier height obtained from the slope of
11 Arrhenius plots was 0.11 electron volts; right?

12 A Right.

13 Q So Table 1 is telling us that when the
14 oxygen pressure increased by a factor of 10, the
15 barrier height obtained from the slope of
16 Arrhenius plots decreased. Is that right?

17 A If we look at just Table 1, that's what
18 it shows. But Soukup amplifies on that, expands
19 on the discussion about that.

20 Q Are you saying that he found a different
21 barrier height for these last two devices that we
22 just discussed?

23 A He found that his numbers for the barrier
24 height for those devices was not reliable, was not
25 accurate.

1 Q And where does he say that?

2 A If we go to page 3234, the second full
3 paragraph on the right column, starting with
4 "According to Figure 5." "According to Figure 5,
5 the dependence of I upon temperature is not that
6 of a Schottky process. Figure 12 is a plot of $\log I$
7 over T squared versus $10^3/T$ for the
8 two devices fabricated with O_2 gas present during
9 oxide deposition and also for device PY-G-11(1).
10 It can be seen that these curves do not plot as
11 straight lines. From Figure 5 one gets" -- and
12 there's an equation there. If you want, I can
13 read it out. But I don't imagine we need that.
14 "Figure 5 one gets this equation and the curves in
15 Figure 12 should be straight lines. However, if
16 ϕ_R is a function of temperature" -- another
17 equation. "Thus, the slope of these plots would
18 not be proportional to the barrier height and
19 would not be a straight line."

20 So he hypothesizes that if $d\phi/dT$ where
21 T is temperature of ϕ_R is positive, if the
22 barrier increases with increasing temperature,
23 then $d\phi/dT$ divided by $1/T$ is negative
24 and the slope of $\log I$ over T squared versus $1/T$ plots
25 will give a number which is smaller than the

1 actual barrier, this was seen here.

2 So a person of ordinary skill reading
3 this would say -- would understand that Soukup
4 finds that the data for the two devices which are
5 the ones that you were pointing to from the table,
6 those devices G-22 and G-25, they don't -- they
7 don't follow the straight line in Figure 12.

8 Now, Soukup hypothesizes a barrier height
9 that depends on temperature to try to help explain
10 why they're not straight lines. But to one of
11 ordinary skill, a barrier height that is --
12 depends on temperature is -- is not generally
13 discussed or understood or talked about.
14 That's -- that's a hypothesis which is
15 somewhat spec- -- let's just say rather
16 speculative. And so that's what I mean when I say
17 that Soukup is -- is suspicious, doesn't -- is
18 basically telling one of ordinary skill that the
19 data for those two devices analyzed this way is
20 somewhat unreliable.

21 Q And he also says that for the third
22 device, PY-G-11(1); correct?

23 A Well, PY-G-11(1) does form a straight
24 line in Figure 12. The data fixes straight line
25 in Figure 12, unlike PY-G-22 and PY-G-25.

1 So I believe a person of ordinary skill
2 reading this paragraph starting according
3 Figure 5, the dependence of I is not that of a
4 Schottky process. Figure 12 is a plot of ϕ over
5 T^2 versus T^3/T for the two
6 devices with oxygen present. It can be seen that
7 these curves do not plot as straight lines. From
8 Figure 5 one gets that equation and the curves in
9 Figure 12 should be straight lines.

10 Q So it is your testimony --

11 A Let me -- hold on.

12 Q Sorry.

13 A Give me another moment to finish this.

14 Q Sure.

15 A So when he says it can be seen that these
16 curves do not plot as straight lines, I believe
17 that that is excluding the mention of PY-G-11 in
18 the previous sentence. So when he says it -- in
19 the sentence immediately after, where it says two
20 devices fabricated with O₂ gas present during
21 oxide deposition and also for device PY-G-11, it
22 can be seen that these curves do not plot as
23 straight lines, these curves are the ones for the
24 two devices fabricated with O₂ gas present. So he
25 is not -- he is not disparaging the data for that

1 device PY-G-11(1) as plot -- as plotting as a
2 straight line. It's just PY-G- and 25 that don't
3 seem to fit the theory.

4 So one of ordinary skill reading this
5 section would be led to have doubts about the
6 barrier height ϕR star extracted from this data
7 for those two devices. That's my basis for why I
8 say that Soukup expresses doubt about that data.

9 Q So for this entire panel, the barrier
10 height estimated by the zero-intercept method in
11 column 4 are quite different from the barrier
12 heights estimated by the -- or from the slope of
13 the Arrhenius plot in column 5; right?

14 A That is true.

15 Q Okay. So let's look at device PY-G-11,
16 on the top row.

17 A Okay.

18 Q The barrier height estimate from the
19 zero-intercept method is 0.714 electron volts;
20 right?

21 A Right.

22 Q And the barrier height estimate for
23 extracted from the slope of the Arrhenius plot is
24 0.33 electron volts; right?

25 A Correct.

1 Q which one is right?

2 A Good question.

3 Q They both can't be right, can they?

4 A That is true.

5 Q okay.

6 A Soukup discusses this. Right?

7 Q You tell me.

8 A I can tell you, Soukup discusses this.

9 Q Uh-huh.

10 A And I can go -- I can point you to that,
11 if that's -- if you're asking me to do that.

12 Q I -- I want to know which of these is the
13 POSA would have regarded as correct.

14 A So reading Soukup, the -- Soukup himself
15 says he's not sure which is correct. So a POSA
16 reading Soukup would have the same -- could only
17 have that same uncertainty. which one is correct?
18 Soukup isn't sure. And I'm -- you didn't ask, but
19 I'm going to cite it anyway. If you look at the
20 very last paragraph of the entire publication,
21 last sentence, "No direct evidence that this is
22 happening was obtained so no definite conclusions
23 as to the type of current flow mechanism present
24 in these devices can be made."

25 So a POSA reading this would, I believe,

1 have the following interpretation: The Schottky
2 emission fits a lot of the data. There's a great
3 deal of evidence that the Schottky emission is the
4 right -- is the -- is capturing what is actually
5 happening in these devices in terms of that
6 current. From several of the figures.

7 However, when he looks at the temperature
8 dependence and extracts barrier height that way
9 from the same model, he gets a different barrier
10 height. And he -- he has -- he's not sure
11 which -- which data is more reliable.

12 A POSA reading this paper I think can
13 come to the conclusion that the -- the Schottky
14 emission model seems to be correct. But there's
15 something wrong in his experiment where -- that
16 gave rise to this inconsistency. And Soukup
17 himself, it is clear from that sentence, he
18 doesn't know what went wrong either.

19 But a lot can be determined from the
20 data. There's a lot of good data here. The
21 Schottky emission model does seem to be correct.
22 But there is something wrong with his -- with one
23 of the datasets. And what -- where the problem
24 is, Soukup wasn't able to figure out, so neither
25 can a POSA. A POSA has trouble, has difficulty

1 deciding which of those two columns to rely on.

2 Q Okay. Sorry. You were on a roll.

3 A I'm -- I'm -- that -- that's -- that was
4 the complete -- that's the extent of my response
5 to your last question.

6 Q All right. You would agree that the
7 values of the barrier height that is estimated in
8 column 4 and column 5 of Table 1, those values are
9 not -- strike that.

10 The barrier height estimates obtained
11 from the slope of the Arrhenius plot as reported
12 in Figure 5 of Table 1 depend on the
13 zero-intercept of his IV measurements; correct?

14 A That's correct.

15 Q So these estimates are not independent,
16 are they?

17 A Not completely independent. But they're
18 not -- they're connected, but they're -- they also
19 have a separate part. The data in column 5 relies
20 on the variation of the temperature. So that's
21 what distinguishes the two.

22 Q Let's go back to page 3232. The way they
23 generate those plots is by plotting the zero-field
24 intercept current I_{naught} over different
25 temperatures; right?

1 A Right.

2 Q That's the same zero-field intercept
3 that's used to estimate the barrier height in
4 column 4 for each device; right?

5 A The zero-field intercept.

6 Q Right.

7 A More or less, yes.

8 Q So if there's a problem with the
9 zero-field intercept data, then there's also a
10 problem with the Arrhenius plot data?

11 A Well, that's one way -- that's one way to
12 look at it. It's not -- it's not definitive.
13 Soukup himself is unsure where -- where the
14 discrepancy comes from. He can't make a definite
15 conclusion. And I think a POSA reading this
16 paper, and especially that last sentence, where
17 Soukup is essentially admitting that it is hard to
18 make definite conclusions about these two
19 conflicting results. So a POSA is, as I said
20 before, is left unsure which -- which one of those
21 numbers to rely on.

22 Q But you state that a POSA would have
23 relied on the zero-field intercept numbers for the
24 proposition that increasing oxygen vacancies in
25 the magnesium oxide would reduce bare?

1 A Right.

2 Q So you are relying on the zero-field
3 intercept data for that proposition; right?

4 A True.

5 Q And then in your declaration, you just
6 rely on the different data to assert that Soukup
7 obtained a barrier height of 0.33 electron volts;
8 right?

9 A Right. There's a reason for that.

10 Q Tell me the reason.

11 A If we didn't have the problem for the two
12 devices that essentially were used -- the three
13 devices that were used to try to determine how the
14 barrier height varied with oxygen vacancies, it's
15 those three devices. The slope of the Arrhenius
16 plot data for those two devices is where we have
17 the greatest uncertainty. Where we have the
18 greatest -- we have -- we have data that doesn't
19 fit the model. All the -- everywhere else the
20 data pretty well fits, but in particular these two
21 devices when analyzed by the slope of the
22 Arrhenius plot give a dependence that doesn't seem
23 right. There's just something wrong with that
24 temperature dependent data. For those two --
25 sorry. For the oxygen-dependent data for those

1 two devices. So that's why I -- I think the data
2 for phi 1, for the oxygen vacancy effect, is more
3 reliable.

4 Q why do you limit your estimate of
5 reliability just to the oxygen vacancy effect?

6 A well, I don't. I'm saying when I'm
7 trying to consider the oxygen vacancy effect, the
8 data for the three devices measure -- obtained
9 from the zero-intercept method is more reliable
10 because he -- Soukup himself casts considerable
11 doubt on the two numbers for those devices that
12 were made with increased oxygen concentration
13 during deposition.

14 Q The -- the numbers for those devices that
15 are estimated based on the Arrhenius plot?

16 A Right.

17 Q Okay.

18 A He plots -- again, bringing your
19 attention to Figure 12. Those two devices -- this
20 is the Arrhenius plot data. Those two devices
21 don't have the right temperature dependence.
22 There's something going on in those devices. We
23 really can't tell what. What happened to those
24 devices. Analyzed this way. The analysis of
25 this -- of the barrier heights for these two

1 devices measured this way has some serious
2 discrepancies. That's why the -- that's why I say
3 the -- the data for these two devices analyzed
4 from the zero-intercept method seems more
5 reliable.

6 Q Okay. So before, I asked you about the
7 discrepancy between the numbers obtained from the
8 zero-intercept plot and the slope of the Arrhenius
9 plots or the barrier height estimates, and you
10 said there is something wrong with one of his
11 datasets. And where the problem is, Soukup was
12 not able to find out -- figure it out. And so
13 neither can a POSA. A POSA has trouble -- has
14 difficulty deciding which of these two columns to
15 rely on; right?

16 A Fair.

17 Q Okay. So why did you choose to rely on
18 the .33 electron volt barrier height value in your
19 testimony?

20 A Well, because it's at least -- a POSA
21 looking at this says, well, I can't really decide
22 for sure which one is right. But this paper at
23 least suggests a barrier height of .33 is at least
24 a possibility. It's not definitively determined
25 as .33. But you read that, and you say, well, it

1 might be .33. And here, it's not 50 -- I don't
2 think it is 50/50. I think it's -- well, there's
3 a definite number there. It was -- we got a
4 consistent value of .33 for a bunch of devices.
5 So there's a good chance that that -- that number
6 is correct. So a POSA --

7 Q Sorry.

8 A A POSA reading this paper, in my opinion,
9 would come away thinking, this paper teaches me
10 that if I -- if I do the -- if I grow the -- if I
11 grow the MgO the right way, there's a way of
12 growing the MgO that at least has a good chance of
13 giving me a barrier height as low as .33.

14 Q By a good chance, what -- can you
15 quantify that?

16 A I really can't quantify that.

17 Q A 50 percent chance?

18 A It might be 50. It might be better.
19 It's hard to say. I don't think it is quite the
20 same thing as -- as what we have for Butler and
21 the TMR effect. I think there's -- there's -- a
22 POSA looking -- very specific numbers. They're
23 consistent for a whole bunch of devices. It is
24 hard to say for sure, but there's a good chance
25 that the low barrier height might be right. I

1 can't -- I can't assign a probability to this one.

2 Q If the Arrhenius plot estimates depend on
3 the same data for the zero-intercept plot
4 estimates, how can they be more accurate?

5 A The problem is that I, Soukup, and I
6 think a POSA doesn't have a reliable way to
7 resolve that question. So you would look at this
8 and you would say you can get a barrier height as
9 low as .33. And that seems like a good thing to
10 try, as we discussed earlier, to improve TMR. So
11 I think a person -- a POSA has a good motivation
12 to try to repeat Soukup's technique to get a
13 higher TMR. It is a motivation to try.

14 Q I'm sorry. Did you just say to get a
15 higher TMR?

16 A Yeah. well, that -- we talked a lot
17 about that earlier today. So I'm extrapolating to
18 that. To get a lower barrier height, which might
19 lead to -- the motivation for a POSA to do that,
20 to try to get that low TMR -- low -- sorry -- to
21 get that low barrier height, this is a POSA who is
22 trying to get -- make a better MTJ. Right. We're
23 combining this with Bowen. So the motivation of
24 the POSA is, how can I improve the TMR? I have
25 some evidence that changing the barrier height has

1 a good chance of increasing the TMR. Let's not go
2 back and revisit that entire story. But my
3 opinion is that a person -- a POSA has a -- thinks
4 there's a reasonable chance of success. And here,
5 Soukup teaches that you have a reasonable chance
6 of getting a barrier height as low as .33. That's
7 a big effect. That's worth a try.

8 Q When you say that the data or the barrier
9 height estimates obtained by the Arrhenius plot
10 are consistent, how are they more consistent than
11 the zero-field intercept barrier height estimates
12 for the same?

13 A They're not. The zero barrier height
14 numbers are also pretty consistent for a large
15 number of devices.

16 Q So that can't be a reason for a POSA to
17 say that one of the results is more accurate than
18 the other or more likely accurate than the other?

19 A I don't think a POSA can really decide
20 for sure which one is more accurate. But this --
21 this low barrier height is so compelling and
22 tantalizing that I think a POSA would be highly
23 motivated to try to reproduce that.

24 You know, when you have -- as a
25 scientist, when you have an experiment, you do an

1 experiment, you measure a whole bunch of things
2 and you have this kind of inconsistency, what do
3 you do? Repeat the experiment. A POSA is highly
4 motivated to try to repeat this, to see if they
5 could get that .33 eV and see what effect it has
6 on the TMR. Highly motivated. That's my --
7 that's my opinion.

8 Q So why wouldn't a POSA have looked at
9 these results in Soukup and come to the conclusion
10 the data doesn't fit the model?

11 A There's too much about the data -- I
12 don't think a POSA reading this paper would
13 reasonably come to the conclusion and say I've got
14 to throw all of this out. The whole experiment is
15 junk. I ignore it completely. Because a lot of
16 the plots fit this pretty complicated model. So
17 it's not all wrong. It's -- a POSA looking at
18 this can't quite decide where there's some
19 discrepancy. Somewhere in this experiment,
20 something is not quite right. But so much of the
21 data is -- you know, if all of the data was
22 scattered everywhere and didn't follow any of
23 the -- you know, these -- you look at a figure
24 like Figure -- especially like Figure 4, Figure 3,
25 these are straight lines on a log plot over three

1 decades of data. Same thing for Figure 4. You
2 know, it's remarkable how good the fit is to that
3 straight line. So that -- and, you know, same
4 with Figure 6. So a POSA looking at this paper
5 would say, well, there's a lot of good data in
6 this paper. There's some kind of a -- something
7 wrong in the paper. But it's got enough -- enough
8 of it is consistent with this Schottky model to
9 suggest that these numbers are -- should be taken
10 seriously.

11 Q So if the data is consistent with the
12 Schottky model, doesn't that mean that the current
13 transport mechanism in devices was Schottky
14 emission?

15 A That -- it means that the dominant
16 current mechanism in these devices was Schottky
17 emission.

18 Q So just to summarize, you rely on the
19 zero-intercept barrier height estimates for the
20 effect of oxygen vacancies on barrier height, but
21 then you just choose to rely on the Arrhenius plot
22 estimate of .33 electron volts for your testimony
23 about the combination; is that right?

24 A I wouldn't -- I wouldn't put it that way.
25 No. I disagree with that characterization of my

1 testimony and my opinion.

2 Q What -- what is inaccurate about it?

3 A I don't discount the zero-intercept
4 method data.

5 Q Uh-huh.

6 A You get -- you get work -- you get
7 barrier heights there that are .7. That's not
8 nothing. That's less than the data, for example,
9 from Bowen. So I don't discount that data. What
10 I -- what I'm saying is a POSA would look at all
11 of this data and say there's enough here in this
12 experiment from -- there's enough in this
13 experiment, which dates way back to 1970, to
14 suggest that it is not all wrong. Barrier heights
15 as low as .7 are highly likely. Even possibly as
16 low as .3 -- .33. And so this seems to be
17 promising. I should try repeating this and see
18 what I get. Probably, you know, in something that
19 is closer to Bowen. I should try using -- I
20 should try incorporating this into an MTJ to see
21 what I get.

22 Q And in paragraph 169 of your declaration,
23 you rely on the barrier height from Soukup of 0.33
24 electron volts?

25 A I say a skilled artisan would have had a

1 motivation to take Soukup's teachings with a
2 barrier height of .33 and apply it to Bowen's MgO
3 barrier. What I said earlier that .33 eV barrier
4 is particularly compelling. So I read that paper.
5 And I say, wow, if I can get a barrier height as
6 low as .33, boy, let's try that. That -- that
7 should really -- that should really make a
8 difference.

9 Q A difference in what?

10 A That's the -- that's the -- that really
11 soups up the motivation to try.

12 Q would make a difference in what,
13 Dr. Bokor?

14 A To an MTJ.

15 Q What about the MTJ?

16 A Okay. We will go back to the same place
17 where we were all day. There's a -- there's a
18 strong suggestion from Bowen -- from Butler that
19 if you vary -- if you lower the barrier height,
20 you could get a significant effect on the TMR.
21 Soukup is teaching a way that potentially you
22 could really make a big change in the barrier
23 height. If there's a dependence on the barrier
24 height, if you could reduce the barrier height to
25 .33, you could really test that concept. That's

1 what I'm saying.

2 Q And if Bowen had achieved a barrier
3 height of 0.33 electron volts in his MTJ in 2004,
4 what would a POSA have believed would have been
5 the effect on TMR?

6 A A POSA would have believed the effect on
7 TMR should be significant. It has a good chance
8 of getting a higher TMR. And I want the higher
9 TMR so much that I'm willing to give -- give it a
10 good try.

11 Q what do you mean by good chance of a
12 higher TMR?

13 A I've been saying consistently, it is at
14 least 50 percent.

15 Q So it is also a good chance that it would
16 be a lower TMR; is that right?

17 A Yeah. Look, you do experiments.
18 Sometimes things work out. Sometimes they don't.
19 It's worth a try.

20 Q Uh-huh.

21 A It is a good idea to try this. My
22 understanding -- and I'm no -- I'm no attorney.
23 So my understanding is that a claim is obvious if
24 a person of ordinary skill in the art has a good
25 motivation to expect success. Good reason to try.

1 That's the -- that's the context here that I'm
2 giving this opinion.

3 Q And so your testimony is that a good
4 reason to try was there's a 50 percent chance that
5 TMR might go up?

6 A At least 50 percent chance, yes.

7 Q Okay. why would it be higher than
8 50 percent?

9 A I don't know. I don't have enough
10 information to say with certainty what the chance
11 the TMR would go up.

12 Q So I'm not -- I'm not asking about what
13 you know or -- and I'm not asking about certainty.
14 I'm asking about what a POSA would have had reason
15 to believe in 2004.

16 A That's what I keep saying. A POSA would
17 have a pretty good reason to believe that the TMR
18 would go up. How high is the chance? well,
19 it's -- maybe it is only 50 percent. I can't say
20 what it is. Objectively, that could be
21 determined. I mean, you know, there's -- there's
22 an objective answer to that. It will -- it will
23 either go up or go down. If somebody does the
24 experiment, they will find out. So there is --
25 like I said, if somebody like Butler might have

1 been able to repeat that calculation, change the
2 barrier height, and see what it gets. We don't
3 know what that would be. But I would say
4 there's -- you know, it's not -- it's not
5 unknowable.

6 Q Have you ever cited Soukup's paper?

7 A In any of my papers?

8 Q Yes.

9 A Not that I recall.

10 Q When is the first time that you saw or
11 read Soukup's paper?

12 A Probably in the context of this case.

13 Q Who found it?

14 A I don't -- I don't remember that. I did
15 a lot of -- I did a fair amount of literature
16 searching for this. I found some of the papers.
17 I can't remember who found Soukup. I mean, I
18 didn't do all the -- I was not solely responsible
19 for literature searching. So it could have been
20 somebody else. Somebody else. The attorneys.
21 Maybe even one of the attorneys who found it. I
22 don't know. I don't remember.

23 Q So you just testified that the POSA would
24 have wanted higher TMR so much that they -- you
25 said, I'm willing to give it a try. In other

1 words, try Soukup's magnesium oxide or barrier
2 layer; right?

3 A Right.

4 Q well, if that was such a compelling
5 motivation, why didn't Bowen do it?

6 A I can't -- I can't possibly answer that
7 question. Who knows if Bowen was aware of this
8 paper.

9 Q Uh-huh. What do you know about the
10 authors on the Bowen paper? Do you recognize any
11 of the names?

12 A Some of them.

13 Q Was Bowen a leading result in MTJs when
14 it was published in 2001?

15 A I can't answer that definitively. Look,
16 Albert Fert as a co-author was quite a well
17 known -- was quite well known, even back then. So
18 my guess is -- I didn't -- I didn't know about
19 this paper in 2001. I'm not sure when I became
20 aware of it. But it's not -- you know, it's
21 published in Applied Physics Letters. That's a
22 prominent journal. Reasonable impact factor.
23 Maybe not like Science or Nature. But lots of
24 people read APL. So this paper had some -- you
25 know, definitely had some impact.

1 Q Was this paper the first empirical test
2 of Butler's predictions?

3 A I can't say that for sure. I don't know
4 for sure.

5 Q Were they -- did they intend to test --
6 did they do this in order to test Butler's
7 predictions?

8 A Well, they cite Butler. So they were
9 influenced by Butler. I can't say whether they
10 were the first -- I can't say right as I sit here
11 now whether they were the first ones to try
12 crystalline MgO. Actually epitaxial single
13 crystal. The whole structure is single crystal.
14 To get to the closest to Butler's predictions, you
15 should do all single crystal.

16 Q Which is what they did?

17 A Which is what they did. So it is pretty
18 good chance that they were trying to explore, test
19 Butler's predictions. But I don't know. I don't
20 know these people personally, so I couldn't tell
21 you what they were thinking. It seems likely, but
22 it is pure speculation.

23 ATTORNEY WICHMAN: All right. We've been
24 going for an hour. Why don't we break for five
25 minutes. Let's go off the record.

1 (A recess was taken.)

2 (Deposition Exhibit 3 was marked for
3 identification by the court reporter.)

4 ATTORNEY WICHMAN: Okay. On the record.

5 Q Dr. Bokor, I put an exhibit in the chat
6 of the Zoom. It is marked Deposition Exhibit 3.
7 Are you able to open that document?

8 A Let me try here. Okay. I have it.

9 Q So you see that this is a paper in the
10 Japanese Journal of Applied Physics, Volume 39, in
11 the year 2000; right?

12 A I do.

13 Q It is entitled "Correlation between
14 Barrier Width, Barrier Height, and DC Bias Voltage
15 Dependences on the Magnetoresistance Ratio in
16 Ir-Mn Exchange Biased Single and Double Tunnel
17 Junctions." Right?

18 A That's the title. I see that.

19 Q And the last name of the first author is
20 Saito, S-A-I-T-O?

21 A Yeah. I would pronounce it Saito, but
22 yes.

23 Q Have you seen this paper before?

24 A I have to say it looks vaguely familiar.
25 But I didn't study it. It is not in the record of

1 the case.

2 Q It is not. So I will be asking you a
3 series of hypothetical questions about it.

4 A I have not looked at this paper recently.
5 If you like -- if you want to ask me questions
6 about it, I would ask for some time to read it.

7 Q well, let's just follow along with my
8 questions. And if you feel they're unfair, let me
9 know. okay?

10 A okay.

11 Q So first, just to point to the abstract
12 on page 1 of the PDF here, he is describing tunnel
13 junctions that have aluminum oxide barrier layers.
14 Right? Do you agree with that?

15 A That's what is disclosed in the abstract.

16 Q okay.

17 A Sometimes there's more in the -- there
18 might be other insulators discussed in the body of
19 the paper. But in the abstract, it only talks
20 about aluminum oxide. I can -- I can answer that.

21 Q Can you turn to the second page, the
22 marking on the document is L1036. It is PDF page
23 2.

24 A okay.

25 Q And I want to talk about the left-hand

1 column, the last paragraph in, and the Figure 1
2 underneath it.

3 A All right.

4 Q So first, if we talk about the words in
5 the paragraph, just for context, Saito says that
6 the Figure 1 shown here shows a barrier height
7 dependence on TMR ratio at two temperature
8 measurements in a single tunnel junction; correct?

9 A Okay.

10 Q And he says that the TMR ratio increased
11 with increasing barrier height; right?

12 A That's what it says.

13 Q That's what it says. And if you look at
14 Figure 1, he tells us that the dots are data taken
15 at 250 Kelvin and the squares are data taken at
16 3.7 Kelvin; right?

17 A Okay.

18 Q And the plot in Figure 1, the Y axis is
19 the TMR ratio in percentage and the X axis is
20 barrier height in electron volts; right?

21 A Okay.

22 Q And if you go back up to the paragraph,
23 he tells us that the solid line is a theoretical
24 calculation, resulting from using a free electron
25 model, assuming iron electrodes. That's what he

1 says; right?

2 A I'm sorry. Help me. Where are you
3 reading from now.

4 Q The paragraph just above the figure.

5 A Just above the figure. Okay.

6 Q Yeah. Third sentence.

7 A "The tunneling currents were calculated"?

8 Q No. "The solid line in Figure 1
9 represents the" --

10 A I missed -- that's the third one. I
11 apologize. I shouldn't have interrupted you.

12 Q Okay. So you see he's -- he states that
13 that solid line in Figure 1 is a calculation that
14 he made using a free electron model, assuming iron
15 electrodes; right?

16 A Well --

17 Q That's what he says; right?

18 A He didn't -- he points to another
19 reference, reference 11.

20 Q Okay. Yes.

21 A So I think he's pointing to a calculation
22 made in reference 11.

23 Q That is the calculation that he is
24 showing; right?

25 A The solid line in Figure 1 represents the

1 calculation result using the free electron model,
2 assuming iron electrodes, reference 11. So the
3 solid line seems to come from reference 11.

4 Q Right. And then he says that the
5 tunneling currents were calculated on the basis of
6 a particular equation; right?

7 A Right.

8 Q And then he says, "This suggests that the
9 result is roughly consistent with the free
10 electron model; that is, transmission coefficients
11 of up and down spin depend on the barrier height
12 for the STJs," and then cites reference 19.
13 Right?

14 A Right.

15 Q And if you look on page L1038, which is
16 PDF 4, reference 19 is Slonczewski's 1989 paper;
17 right?

18 A Yeah.

19 Q And that's the same Slonczewski paper
20 that Moodera cited in Exhibit 1035; right?

21 A Right.

22 Q All right. Now let's talk about this
23 Figure 1. I want you to assume this hypothetical.
24 Assume that this data is relevant to Bowen's
25 magnetic tunnel junction. Got that?

1 A well, I got it.

2 Q okay.

3 A It's a leap because it is aluminum oxide
4 barrier. But go ahead.

5 Q So if this data -- if -- okay. If a POSA
6 in 2004 thought that this model and calculation
7 shown in the solid line in Figure 1 was
8 descriptive of the behavior of Bowen's magnetic
9 tunnel junction, then the POSA would have
10 concluded that reducing the barrier height from .9
11 to .85 electron volts would have reduced TMR;
12 right?

13 ATTORNEY WILSON: Objection. Form.

14 THE WITNESS: The solid line does show
15 the TMR going down between .9. And what was your
16 other number? .7?

17 BY ATTORNEY WICHMAN:

18 Q .7. In any event, there's -- there's a
19 trough here, there's an inflection point in this
20 theoretical calculation; right?

21 A Uh-huh.

22 Q So in this calculation, TMR does not have
23 a linear dependence of barrier height, does it?

24 A That's what the plot in that figure
25 shows. I can confirm that.

1 Q Okay. So the theory is that the barrier
2 height -- starting from .9 electron volts and
3 reducing barrier height, the TMR is -- first, it's
4 going to fall; right?

5 ATTORNEY WILSON: Objection. Form.

6 THE WITNESS: I would just point out that
7 it goes back up.

8 BY ATTORNEY WICHMAN:

9 Q At low barrier heights, the theory says
10 TMR will then increase again.

11 A Yeah.

12 Q Okay. But the data doesn't increase as
13 you reduce barrier height, does it?

14 ATTORNEY WILSON: Objection. Form.

15 THE WITNESS: Well, you know, on its
16 face, the data can be seen. I haven't studied the
17 paper. I'm not comfortable making conclusions.
18 On its face, the data -- just looking at this
19 figure, the data is highly scattered. It does
20 generally the trend does have it going down. It
21 doesn't follow the theory though.

22 BY ATTORNEY WICHMAN:

23 Q So a POSA looking at this plot of data in
24 Figure 1, if the POSA believed that this was
25 representative of the behavior of Bowen's magnetic

1 tunnel junction, then the POSA would have
2 concluded that the best way to increase TMR would
3 be to increase barrier height; correct?

4 ATTORNEY WILSON: Objection. Form.

5 THE WITNESS: I can't -- just looking at
6 this figure, I can't -- I can't agree with that.
7 A POSA would get the idea that if I can reduce the
8 barrier height below .5, I would increase TMR.

9 BY ATTORNEY WICHMAN:

10 Q Just based on the data.

11 A Based on the data. Okay. Your
12 hypothetical, I -- I strongly object to your
13 hypothetical. You're suggesting that a POSA would
14 look at this and then try to imagine what would
15 happen in Bowen's. But as we spent the whole day
16 talking about, Bowen uses MgO. The whole point
17 about using MgO for a tunnel barrier is because it
18 has special properties, unique properties about
19 how the -- what happens to the TMR. And as I
20 suggested strongly many times today, the
21 dependence of how the TMR would vary with barrier
22 height according to Butler for MgO barriers
23 could -- is -- well, to put it simply, it's not
24 described by the -- either of the data or the
25 theory in this experiment for aluminum oxide

1 barrier. It's hardly -- it's hardly applicable.
2 So I complete -- I just reject your hypothetical.

3 Q You reject the idea that a POSA would
4 have thought this would be relevant to Bowen's
5 magnetic tunnel junction?

6 A Yes. I reject the hypothetical that the
7 POSA -- that a POSA would look at this paper and
8 have -- you know, I talked about how POSA would
9 have reasonable expectation to expect this or
10 that. I don't see how a POSA has a reasonable
11 expectation to accept any of this for the Bowen
12 MTJ.

13 Q Because --

14 A Especially the data.

15 Q Why is that?

16 A Yeah. Because it's for -- it's for an
17 aluminum oxide barrier. As you said. I mean, I
18 should -- I should hold up over there. I conceded
19 that the abstract talked about aluminum oxide. I
20 would like to take a little bit of time to see --
21 to understand what is going on in Figure 1, what
22 kind of devices and what was the barrier, if -- if
23 you will --

24 Q Well, I mean -- I don't mind taking the
25 time to do it. But, I mean, what if we just make

1 this a hypothetical. If -- if this data involves
2 aluminum oxide barrier, then your testimony is a
3 POSA would have regarded this as not relevant to
4 the behavior of Bowen's magnetic tunnel junction?

5 A That statement is way too broad.

6 Q Okay.

7 A I don't think that -- I mean, a POSA
8 would not rely on this data to speculate or
9 project or guess what would happen for an -- how
10 the TMR would depend on barrier height for an MgO
11 MTJ. This is a -- based on -- as you -- as you
12 pointed out, the theory here was -- they pointed
13 to Slonczewski.

14 Q Yes.

15 A A free electron model. It has nothing to
16 do with -- well, I won't say it has nothing to do
17 with. But it is missing a lot of the physics that
18 is in an MgO tunnel barrier, as Butler pointed
19 out. So I -- I hesitate to -- I haven't read the
20 paper. I hesitate to say a POSA would have no use
21 for this, anything in this paper. I won't say
22 that.

23 Q Okay.

24 A It's -- you know, for all I know, it's a
25 good paper. But for the dependence of the TMR on

1 the barrier height, I think a POSA would find
2 this -- maybe find this data interesting. But to
3 try to -- but then to use this as a basis for
4 thinking about how to modify Bowen, that -- that I
5 think is -- I don't think a person -- a POSA
6 looking at this would have a reasonable
7 expectation of success extrapolating from Figure 1
8 to Bowen.

9 Q And the reason for that is because this
10 is not purporting to describe the behavior of
11 magnesium oxide?

12 A Exactly. What makes Bowen special is the
13 M -- is the single crystal electrodes and the
14 single crystal MgO barrier. There's a major -- as
15 we discussed before, you know, it was a major
16 paper. I conceded that. It was done by credible
17 people in the field. And it made a significant
18 jump in the field by going to the MgO -- single
19 crystal MgO barrier. Whether it was the first
20 paper to test Butler's theory or not, I think it
21 was -- I think we came to an agreement that it was
22 a paper intended to test Bowen -- Butler. This
23 paper -- I don't see how this paper helps to
24 figure out what to expect for an MgO barrier.

25 Q Okay. If I could just ask you to look

1 back at Exhibit 1035. we talked about this.

2 A 1035. Moodera.

3 Q Moodera 1995. Page 3273. The right-hand
4 column. This language about another theory of
5 FM-FM tunnels has been proposed by Slonczewski.

6 A Right.

7 Q That's the same Slonczewski pre-electron
8 theory that Saito is describing in his Figure 1;
9 right?

10 A well, as we went through, it seems -- the
11 calculation seems to be based on Slonczewski's
12 theory.

13 Q Okay. So do you agree that this Moodera
14 paper, this discussion here, another theory of
15 FM-FM tunneling in Moodera has as little relevance
16 to the behavior of Bowen's magnesium oxide MTJs,
17 as you just explained for Saito's paper,
18 Deposition Exhibit 3?

19 A well, we have to be a little careful
20 about what -- what we're -- what relevance we're
21 talking about. Okay.

22 Q Uh-huh.

23 A If you're referring back to the
24 discussion we had earlier about this paper, what I
25 said was the take-away from this paper for a POSA

1 was simply that Moodera is bringing up the fact --
2 is bringing up the proposition that -- yeah.
3 Strong influence of tunnel barrier height on the
4 orientation of the spins. And what I said was
5 the -- I -- I pointed to this paper simply to say
6 that the -- that the paper suggested the concept
7 to a POSA that, hey, the TMR might depend -- is
8 likely to depend on barrier height. That's all.
9 That motivated the POSA to then, as we discussed
10 earlier, think about it -- how that might happen
11 in more detail. In particular, for an MgO
12 barrier, in light of Butler theory. So the
13 only -- the only relevance that I put forward for
14 when I cited this paper was just to give -- just
15 that hint.

16 Now, you point to another paper, this
17 Saito paper from 2000. And here is a subsequent
18 paper later on. But also -- the main point of the
19 paper is to suggest that MR ratio could depend on
20 barrier height. So in that light, yeah, here is
21 another paper that gives a POSA an indication, a
22 motivation, hey, let's think about how the MR
23 ratio would depend on barrier height and look at
24 Bowen.

25 Now, Slonczewski's theory, Saito's theory

1 here is not -- not quite on point to that. It
2 motivates -- it seems to me it motivates a POSA to
3 say let me figure out how barrier height would --
4 you know, would vary TMR in this more complicated
5 MgO crystal tunnel barrier described by Butler.
6 So this paper in my mind, the impact of this paper
7 on a POSA is similar to Moodera that says, hey,
8 see what happens -- see if barrier height can make
9 a difference.

10 Q But it is your testimony that a POSA
11 would not have looked at this prediction of a free
12 electron model and concluded -- or looked at the
13 data in Saito and concluded this suggests the best
14 way to increase TMR would be to increase the
15 barrier height of Bowen's MTJ?

16 A I think a POSA looking at this might say
17 this is one suggestion. But it's for a simplified
18 theory. Free electron theory. I'm looking at
19 Bowen. Bowen is a very interesting paper. It is
20 one of the earliest, if not one of the first
21 papers, to look at the crystal MgO to test Butler.
22 So maybe -- maybe the dependence of TMR on barrier
23 height is as simple as this. But there's good
24 reason to believe it would be more complicated in
25 light of Butler. So that's -- that's the way I

1 would characterize how a POSA would look at this
2 paper in light of Butler.

3 Q So if you were to read this paper in
4 light of Butler, would a POSA have thought it was
5 more likely than not that decreasing the barrier
6 height would decrease TMR? Would this tilt the
7 scales of the expectation in the direction of TMR
8 will fall if I reduce barrier height?

9 A No. Because it can go back up. The --
10 the place where that minimum occurs is -- you
11 know, is .5 eV for this free electron model. But
12 for MgO, with a complicated band structure, who
13 knows. Maybe it could -- maybe -- maybe the --
14 maybe for MgO, you would get a -- a curve like
15 this. It is sort of a parabolic curve. Where is
16 the minimum going to be? Maybe the minimum is
17 1 eV. And you would get a TMR that goes up as you
18 reduce the barrier height from 1 eV. It is
19 just -- it's just -- I can't say -- I don't see
20 how a POSA could make a conclusion one way or the
21 other. I don't see this changes the percentages
22 that we were talking about earlier about what a
23 POSA would think for MgO based on Butler.

24 Q So you're focusing on the theory, the
25 solid line. If you focus on the data, the data

1 does not have an increase in TMR, and the barrier
2 height falls below .5 eV; right?

3 A well, that's what this data shows for an
4 aluminum oxide barrier. That's true. But --

5 Q So for this data, in view of Butler,
6 would this have tilted the scale of probability so
7 that the POSA would have concluded it is more
8 likely than not that if I reduce Bowen's barrier
9 height, I will reduce the TMR?

10 A Okay. I'm going to fall back on not
11 having had the opportunity to study this paper in
12 detail, I'm not prepared to offer an opinion on
13 the influence on the probability of increasing TMR
14 by reducing barrier height for MgO based on this
15 paper. I can't give an opinion one way or the
16 other. I mean, I would need time to study the
17 paper. Probably read some of the references
18 before I could feel comfortable giving you a -- an
19 opinion on that.

20 ATTORNEY WICHMAN: Okay. Mr. Wilson,
21 I'll tender the witness.

22 ATTORNEY WILSON: We have no questions.

23 ATTORNEY WICHMAN: Very well. That
24 concludes our deposition. Off the record.

25 ATTORNEY WILSON: We reserve the right to

1 read and sign.

2 (The proceedings concluded at 4:23 p.m.)

3 -ooo-

4
5
6
7 I have read the foregoing deposition
8 transcript and by signing hereafter, subject to any
9 changes I have made, approve same.

10
11 Dated: _____

12
13
14 _____
15 (Signature of Deponent)
16
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25

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)
COUNTY OF RIVERSIDE) SS.

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

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

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

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

Dated: June 25, 2025

BROOKE SILVAS
CSR No. 10988

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I, Brooke Silvas, hereby certify:

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

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

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

() Approved the transcript by signing it.
() Refused to approve the transcript by
not signing it.

() By means of a signed letter, made the
changes and approved or refused to approve the
transcript as set forth therein. (Said letter has
been attached to the original transcript and copies

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CSR NO. 10988

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