

1 UNITED STATES PATENT AND TRADEMARK OFFICE

2
3 BEFORE THE PATENT TRIAL AND APPEAL BOARD

4
5 THE BOEING COMPANY,

6 Petitioner,

7 v.

8 THE REGENTS OF THE UNIVERSITY OF CALIFORNIA,

9 Patent Owner.

10
11 Case IPR2024-00761

12 U.S. Patent No. 7,487,684

13
14
15 Deposition of JUNLAN WANG, PH.D.

16 Conducted Virtually

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1 Deposition of JUNLAN WANG, PH.D., conducted
2 virtually.
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11 Pursuant to notice, before Judith E.
12 Bellinger, Registered Professional Reporter,
13 Certified Realtime Reporter, and Notary Public in
14 and for the State of Maryland.
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By Mr. Rachuba	5

E X H I B I T S

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P R O C E E D I N G S

JUNLAN WANG, PH.D.,

Being first duly sworn, was examined
and testified as follows:

EXAMINATION BY COUNSEL FOR THE PATENT OWNER
BY MR. RACHUBA:

Q Good morning, Dr. Wang.

A Good morning.

Q My name is Roman Rachuba. I represent
the patent owner in this IPR and I will be asking
you some questions during today's deposition.

Do you understand?

A Yes.

Q First of all, thank you for your time
today.

Have you ever been deposed before?

A No.

Q Okay. So I'll just give a little bit
of background of the procedure that we're going to
go through today.

I'll ask the questions, you will
answer. I ask that you, please, give a verbal

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1 answer rather than a nod or a uh-huh, just for
2 clarity of the record.

3 Do you understand?

4 A Yes, I do.

5 Q Okay. And, I'd also ask you, please,
6 just give me time for me to finish asking my
7 questions. Sometimes I pause in the middle of
8 sentences while I get my thoughts together.

9 So is that okay? Do you understand?

10 A Yes.

11 Q And, while we go on today, your counsel
12 may object to some of these questions, but you are
13 still required to answer the questions, unless
14 your counsel gives you an explicit instruction not
15 to answer.

16 Do you understand?

17 A Yes.

18 Q If at any point today any of my
19 questions are unclear or if you don't understand
20 them, please, just let me know and I will try to
21 ask another way or try to help you out in some
22 sort of understanding.

1 Do you understand?

2 A Yes.

3 Q Could you, please, state your full name
4 for the record.

5 A Junlan Wang.

6 Q Are you aware of any reason why you
7 cannot testify truthfully and accurately today?

8 A No.

9 MR. MATICH: Roman, before we keep
10 going, can we just put on the record who's
11 attending the deposition today?

12 MR. RACHUBA: Sure. So I'm asking the
13 questions. In the room with me here today is my
14 partner Dave Emery. And, also, on the call is
15 Dr. Gupta, the '684 patent inventor.

16 MR. MATICH: And here is me, Nick
17 Match, for the petitioner, The Boeing Company.
18 And with me is my colleague Casey Shomaker.

19 BY MR. RACHUBA:

20 Q Dr. Wang, I understand that you have
21 not been deposed before.

22 Have you ever served as an expert

1 witness in an IPR or litigation before?

2 A No.

3 Q Have you ever served as a consultant
4 for a litigation or IPR or intellectual property
5 dispute before?

6 A No.

7 Q Do you have an understanding of why you
8 are giving testimony in a deposition today?

9 A Yes.

10 Q What is that understanding?

11 A To give my technical opinion on whether
12 the claims in the patent has been disclosed by the
13 prior arts.

14 Q Okay. So you are a technical expert
15 witness for the petitioner, The Boeing Company,
16 correct?

17 A Yes.

18 Q In connection with that role, you
19 submitted an expert report along with the IPR
20 petition, correct?

21 A Yes.

22 Q Okay. So your testimony here today is

1 in connection with that report and testimony,
2 correct?

3 A Yes.

4 Q How did you come to be involved in the
5 case?

6 A I was approached by Nick and Casey.

7 Q Do you recall when that was?

8 A I don't recall the exact date. I think
9 it's early last year.

10 MR. MATICH: And I would caution the
11 witness not to disclose communications with
12 counsel.

13 Q When you say "early last year," do you
14 mean, roughly, springtime 2024?

15 MR. MATICH: Objection. Vague.

16 A I think so.

17 Q Okay. Are you being compensated for
18 your time in connection with your role as Boeing's
19 expert witness in this matter?

20 A Yes.

21 Q What is your compensation?

22 A It's based on my hourly contribution.

1 Q You're compensated by the hour?

2 A Could you, please, repeat that
3 question?

4 Q Sorry. Are you compensated by the
5 hour?

6 A Yes.

7 Q What is your hourly rate?

8 A \$450.

9 Q And, approximately, how many hours have
10 you spent working on this IPR?

11 A I don't recall exactly.

12 Q Can you give a general estimate?

13 A Sorry, I didn't keep that record. I
14 didn't think it was relevant. Yeah, I really
15 can't recall here.

16 Q Okay. Would you say, generally,
17 greater than or fewer hours than 150?

18 A I think it's fewer.

19 Q Okay. Did the petitioner, Boeing, give
20 you a specific assignment with respect to this
21 IPR?

22 MR. MATICH: Objection. Vague.

1 A Can you clarify?

2 MR. MATICH: Caution the witness not to
3 reveal communications with counsel.

4 Q Sure. I think you explained a little
5 bit earlier, but I guess what is your specific
6 purpose in your role as an expert in this IPR?

7 A So, to -- so my -- I was asked to look
8 at the patent. And then, based on my knowledge of
9 the prior art, to kind of come up with an opinion
10 whether it has been disclosed in that prior art.
11 And lots of prior art was my own dissertation.

12 Q Are you familiar with U.S.
13 Patent Number 7,487,684?

14 A You are referring to the patent that is
15 the discussion by Dr. Gupta, I guess?

16 Q Yes.

17 A Yes.

18 Q When did you first become aware of that
19 patent?

20 A When it was brought to me by -- by
21 Nick's office.

22 Q Did Boeing or their counsel provide

1 specific documents for you to review along with
2 the patent?

3 MR. MATICH: Objection. Privileged.
4 Instruct the witness not to answer.

5 MR. RACHUBA: Nick, this a yes-or-no
6 question of whether the documents were provided to
7 her. I don't see how that would involve any
8 privilege or work-product information.

9 MR. MATICH: Whether or not we provided
10 them or she discovered the documents discussed in
11 her declaration on her own, you're asking about
12 what we sent to her, explicitly.

13 If you want to ask what documents she
14 reviewed.

15 MR. RACHUBA: I disagree that
16 information is privileged, but I can come back to
17 it and ask it a different way.

18 Q Dr. Wang, do you have a general
19 understanding of what the '684 patent is about?

20 A Yes, I do.

21 Q What is that understanding?

22 A So, I think it has, of course, a number

1 of claims. But the most outstanding one from the
2 previous patent is a glass-modified element for
3 stress generation, stress propagation.

4 Q What do you mean, "most outstanding one
5 from the previous patent"?

6 A I understand there is another earlier
7 patent on this topic by Dr. Gupta, also on laser
8 spallation, so I understand that there was a
9 filing of this patent. So there was dispute about
10 whether this is repeating the previous one or it
11 should be approved. So the new -- the new
12 content, new aspect of this patent is the
13 glass-modified element that's going to modify the
14 waveform.

15 Q So, in your opinion, the addition of
16 the glass-modified waveform was not disclosed in
17 the previous patent?

18 MR. MATICH: Objection. Calls for
19 speculation. Misstates testimony.

20 MR. RACHUBA: Nick, I'm not sure what
21 the basis is for your objection, based on
22 speculation from expert witness. I don't believe

1 that's a proper objection.

2 MR. MATICH: Okay. Objection.

3 Misstates prior testimony.

4 MR. RACHUBA: Also, Nick, speaking
5 objections are not allowed in front of the PTAB.
6 If you could, please, limit your objection to form
7 or privilege or work product. I'd appreciate
8 that.

9 Q Dr. Wang, you can answer.

10 A Could you repeat the question?

11 Q Sure. So in your opinion, the addition
12 of glass-modified waveforms was not disclosed in
13 the previous patent?

14 A It's in the context of if you only
15 count the stress after generation, through the
16 propagation to test, the interface, then the
17 glass-modified element is new because that element
18 wasn't there in the previous element -- in the
19 previous patent. So this is a new element in the
20 whole setup.

21 Q What do you mean "if you only count the
22 stress after generation"?

1 A Otherwise, in the previous patent, the
2 waterglass is also doing similar function,
3 modified the stress wave generated.

4 Q So, your opinion in the previous
5 patent, to Gupta, the waterglass modified the
6 stress wave after generation?

7 A It modified the stress wave based on
8 comparison with other materials that was tested in
9 that patent.

10 Q Okay. And when you say "stress wave,"
11 are you referring to a tensile wave or compressive
12 wave or both?

13 A It can be either.

14 Q In the context of the previous patent
15 to Gupta, do you recall which waveform was
16 modified by the waterglass?

17 A It was modifying a compressive, like,
18 generated the stress that was a compressive.

19 Q And when you say modify, what do you
20 mean by "modify"?

21 A It means changes the waveform.

22 Q What does that mean?

1 A So these can be understood as either
2 changing the rise time or post-peak decay time.
3 So, basically, any deviation from generally stress
4 wave similar to the laser pulse.

5 Q Okay. I'm going to share an exhibit in
6 the chat. I'm going to put this in the chat.

7 And, Dr. Wang, let me know if you're
8 able to open the PDF that I share with you.

9 Let's go ahead and mark this as
10 Exhibit 1.

11 (Exhibit 1034 marked for identification
12 and attached to the transcript.)

13 MR. RACHUBA: For the record, Exhibit 1
14 is U.S. Patent Number 5,438,402.

15 A Can you show it on the screen?

16 MR. MATICH: Dr. Wang, you should be
17 able to download it from the chat, that way you
18 can control everything about it.

19 PLANET DEPOS TECHNICIAN: I can also
20 show it on the screen, if you guys need that, just
21 let me know.

22 MR. RACHUBA: Okay. I can, as well.

1 So let me -- let me go ahead and do that,
2 actually.

3 A Okay. Yeah, I opened it.

4 Q And do you see it on my screen as well?
5 You can use the one on the screen or you can use
6 the one that you opened, whatever is easier for
7 you.

8 A Okay. I opened. Yeah, you can just --

9 Q Okay. Do you recognize this document,
10 Dr. Wang?

11 A Yes.

12 Q Is this the previous Gupta patent that
13 we were just speaking about?

14 A Yes.

15 Q You can put that down for now.

16 Do you have any documents open on your
17 desk in front of you?

18 A No.

19 Q Do you have any programs or windows
20 opened on your computer, besides Zoom, right now?

21 A No.

22 Q Where are you located right now?

1 A Seattle, Washington.

2 Q Is this your home?

3 A No.

4 Q I guess, where in Seattle, Washington,
5 are you located?

6 A It's on -- it's in an office.

7 Q Your office or counsel's office?

8 A It's a University of Washington office.

9 Q Okay.

10 A On-campus office.

11 Q Okay. Are you represented, in this
12 case, by Boeing's counsel in your personal
13 capacity?

14 MR. MATICH: Objection. Calls for a
15 legal conclusion.

16 A Can you repeat that question?

17 Q Sure. Are you represented, in this
18 case, in your personal capacity, by Boeing's
19 counsel?

20 A No.

21 MR. MATICH: Same objection.

22 MR. RACHUBA: I'm going to share

1 another exhibit in the chat. One second.

2 Before we start on this exhibit.

3 Q Dr. Wang, I want to let you know that
4 at any time you want to take a break today,
5 please, just let me know and we can go take a
6 five-, ten-minute break off the record. At some
7 point, we can also take a lunch break for you, as
8 well.

9 A Sounds good. Thank you.

10 (Exhibit 1005 marked for identification
11 and attached to the transcript.)

12 Q Okay. So I just put in Exhibit 1005
13 from the IPR.

14 MR. RACHUBA: I guess, for the
15 clarification of this record, why don't we go
16 ahead and label that as Exhibit 1005. I think
17 later on, we'll renumber Exhibit 1 because I think
18 that is also an exhibit, but I don't recall, off
19 the top of my head right now, what that is.

20 Q So, Dr. Wang, please let me know when
21 you're able to open that up.

22 A Okay. Yeah, it's open.

1 Q Okay. Do you recognize this document?

2 A Yes.

3 Q And what is this document?

4 A It's my -- it's my Ph.D. dissertation.

5 MR. MATICH: And, Dr. Wang, you can
6 take whatever time you need to familiarize
7 yourself with the document before you provide any
8 testimony about it.

9 Q Yes, Dr. Wang, this is not a memory
10 test. So if at any time you want to further
11 review it, just let me know.

12 A Okay.

13 Q If you could, please, scroll to --
14 well, you can look at my screen or you can look at
15 the one in front of you. I'll share my screen
16 for --

17 A Okay. I'm looking at my PDF.

18 Q Actually, before you go to that page.
19 So this is your Ph.D. dissertation, correct?

20 A Yes.

21 Q What is this dissertation about?

22 A It's about the adhesion measurement by

1 laser-induced stress waves.

2 Q Can you repeat that again. I didn't
3 catch the first part of that.

4 Is it laser management?

5 A Thin-film adhesion measurement.

6 Q Thin-film adhesion measurement?

7 A By laser-generated stress waves.

8 Q Can you explain that in a little more
9 detail? I think I have a general understanding of
10 that concept, but --

11 A It's an experimental technique. So
12 it's an experimental technique to measure the
13 adhesion between a thin film and a substrate
14 interface using laser-generated stress wave.

15 Q Okay. Who was involved in your
16 dissertation?

17 A It's my Ph.D. dissertation. That means
18 I was the primary person or did everything. This
19 is a dissertation under the advisement of my two
20 advisors.

21 Q And who are your two advisors?

22 A Professor Nancy Sottos.

1 Q Can you spell that?

2 A Nancy, N-A-N-C-Y, Sottos, S-O-T-T-O-S.

3 Q And who is the other?

4 A Richard Weaver. R-I-C-H-A-R-D,
5 Richard. And the Weaver, W-E-A-V-E-R.

6 Q Was anyone else involved?

7 A Can you define the meaning by
8 "involved"?

9 Q Do you have a general understanding of
10 involved, just, like, from a layperson's
11 perspective?

12 A So, I conducted the research, wrote all
13 the papers, under the guidance of my advisors. I
14 also have a Ph.D. committee who, basically,
15 attended -- supervised the defense.

16 Q Okay. The Ph.D. committee is the same
17 as Sottos and Weaver, or is that a different
18 committee?

19 A The two of them are the chairs of the
20 committee. There are additional committee
21 members.

22 Q Okay. Who else was on the committee?

1 Do you recall?

2 A If we -- if you scroll down to page 6,
3 the VI, not the -- acknowledgment page.

4 Q Okay.

5 A I have, yeah, listed all the people
6 there.

7 Q And that's the people listed in the
8 third paragraph here?

9 A Yeah, Professor Philippe Geubelle,
10 Professor Scott White, and Professor Jimmy Hsia.

11 Q Okay. In the next paragraph, you
12 write -- well, let me back up.

13 Did you write this dissertation
14 yourself?

15 A Yes.

16 Q So the next paragraph you write "I want
17 to thank my labmates," there are one, two, three,
18 four labmates listed here.

19 What were these labmates' involvement
20 in your dissertation?

21 A It's a common practice in any Ph.D.
22 studies, within the group, you exchange ideas with

1 your labmates, you discuss research or -- not
2 research-related topics. So that's kind of
3 commonly -- yeah, everyday discussions.

4 Q Okay. Did they substantively
5 contribute to anything in your dissertation?

6 I didn't catch that. Was that a no?

7 A No.

8 Q And were these labmates, were these
9 graduate students?

10 A Yes. At that time.

11 Q Were any other graduate students
12 involved in your work?

13 A No.

14 Q If you could, please, turn to page 40
15 of the document -- sorry, page 60 of the document,
16 page number 43 at the bottom.

17 Let me know when you're there.

18 A Okay. Oh, sorry.

19 Q No problem. Yeah, you can just look at
20 the screen, if that's easier. Whatever you
21 prefer.

22 A Okay. Let's look at your screen.

1 Q All right.

2 A Okay.

3 Q The illustration shown in 3.1.

4 Do you see that?

5 A Figure 3.1, yes.

6 Q Can you explain to me what's going on
7 in this figure?

8 A Okay. So in this figure, this is the
9 experimental setup I used to do the measurement.
10 I'll start from a sample first. So, the right of
11 the sample or the left sample.

12 So you see the label sample there,
13 right?

14 Q Yes.

15 A So on the right-hand side is the ND
16 regulator. That's used to launch a high-power
17 pulse laser to the sample, to the back surface of
18 the sample. So the AR1 is a lens that's used to
19 focus the laser beam onto a desired spot.

20 Q Okay.

21 A So this is the stress-wave generation
22 mechanism.

1 Q Okay.

2 A Yeah. So once the stress wave is
3 generated and propagated, the left side of the
4 sample gets reflected into tensile; that's a
5 stress wave to cause spallation.

6 So the left-hand side of the sample is
7 called interferometry, or in specific, it's a
8 Michelson interferometry. That is used to measure
9 the transient surface displacement of the sample.
10 So that's the signal you get from the experiment.
11 So it's -- the sample is collected by the -- the
12 signal is collected by the photodiode, then send
13 it to an oscilloscope, then computer for further
14 analysis.

15 Yeah, so the graph of the elements, I
16 just -- the components of the uptake on
17 interferometry. For example, the argon ion laser,
18 so that's another laser, that's a wave laser
19 that's used for the signal collection.

20 AR2 is a focusing lens. That's used to
21 focus the argon ion laser onto the sample. And
22 the beam splitter, BS is a beam splitter. So

1 that, we are dividing the incoming beam from M1,
2 which is a mirror, into two beams. One goes to
3 the sample, then get back as agnostic beam. The
4 other goes to a stationary mirror, M2, then
5 reflected.

6 Q Okay. So only the YAG laser on the
7 right-hand side of the figure, that's what
8 generates the pulse that creates the stress wave?

9 A Yes.

10 Q What type of wave does that create?
11 Can you describe the -- I guess, can you describe
12 the generation of that wave?

13 A So, can we refer to another figure in
14 the paper so I can show you the mechanism?

15 Q Sure.

16 A If you scroll back. Okay. No, the
17 other direction. Scroll down. Yeah, this one.
18 Okay. Actually, combine these two. So this is
19 the sample configuration, the --

20 Q Let me, just for the record, so we're
21 clear, we're looking at Figure 3.2.

22 Okay. Sorry, Dr. Wang, please

1 continue.

2 A Actually, I want to refer to a
3 different figure.

4 Q Okay.

5 A Let me -- okay. Let's go to Figure 2.1
6 on page 7.

7 Q On page 7, you said?

8 A Yes, on the bottom. The 7 on the
9 bottom. Page 7.

10 Q Okay.

11 A Yeah, let's use this one for the
12 stress-wave generation.

13 So this one reverse the direction from
14 the previous figure we just discussed. So, now,
15 the laser is coming from the left.

16 Q Okay.

17 A So the sample consists of four layers
18 here, the substrate, in the middle, and then there
19 is a test film on the right-hand side. On the
20 backside of the substrate, there's an
21 energy-absorbing layer and a confining layer.

22 Q Okay.

1 A So when the laser pulse comes from an
2 Nd:YAG, they are focused by the focusing lens onto
3 the absorbing layer. The energy is absorbed by
4 the absorbing layer. So that part of the material
5 will expand quickly. And this is sudden thermal
6 expansion or evaporation, if the laser energy is
7 high enough to record generation of a compressive
8 stress wave at this point. Because the bonding is
9 confined by a transparent confining layer. So the
10 thermal expansion is limited. So that will
11 generate the compressive stress wave.

12 Q Okay. Is there a -- sorry, continue.
13 I didn't mean to cut you off.

14 A The compressive stress wave is
15 generated, will continue to propagate forward,
16 toward the right side -- right-hand side. Then
17 it's reflected from the free surface of the test
18 film and becomes a tensile wave. So if the net
19 loading of the interface is higher than the
20 strength of the interface, that will -- will lead
21 to spallation of the test film.

22 Q In addition to that compression wave,

1 is there another wave generated?

2 A So that's the primary -- yeah, the
3 compressive wave there.

4 Q Is that the only wave that's generated?

5 A In most cases.

6 Q Would there be a tensile wave that's
7 generated as well?

8 A Not at the -- the tensile wave comes
9 after reflection.

10 Q So there's no tensile wave generated
11 before reflection?

12 A Right.

13 Q With respect to that compressive wave
14 you were just talking about, what would the rise
15 time of that wave be?

16 A That depends on the various parameters
17 used in the experiment.

18 Q And in the parameters used in your
19 experiment, what would the rise time be?

20 A So it varies and it depends on the
21 laser pulse profile, whether it's a nanosecond
22 laser or picosecond laser. So it's typically

1 proportional to the rise time of the laser itself.

2 Q And what laser did you use in your
3 experiments?

4 A So, we used a nanosecond laser. So the
5 rise time is typically, you know, five to 10
6 nanoseconds as a generation. But that can evolve
7 as it propagates through the substrate.

8 So, typically, a few nanoseconds or up
9 to 20, 30 nanoseconds.

10 Q Looking back, again, at Figure 2.1. So
11 I understand that you said that the compressive
12 wave is generated in the substrate, right?

13 A It's -- I would say it's generated at
14 the absorbing layer.

15 Q Generated at the absorbing layer.

16 A Yeah, so on the backside of the
17 substrate. Where the absorbing layer is located.

18 Q Okay. Would there be another wave
19 going in the opposite direction, towards the
20 confining layer?

21 A Yes.

22 Q Would that be a compressive wave or a

1 tensile wave?

2 A So, it's compressive both ways, but
3 then it could be reflected into a tensile.

4 Q How would you define -- well, strike
5 that.

6 What do you mean by "compressive
7 waves"?

8 A It will compress the material.

9 Q What is a tensile wave?

10 A It stretches the material.

11 Q Okay. With respect to the compressive
12 wave that will be generated in the confining
13 layer, that you just talked about, what would the
14 rise time of that wave be?

15 A It's the same wave that's generated,
16 propagating to both directions.

17 Q So with the nanosecond laser that you
18 used in your experiments, it would be, roughly, 5
19 to 10 nanoseconds?

20 A Right.

21 Q This diagram -- sorry, this Figure 2.1,
22 that is representative of the setup used in your

1 experiment for the dissertation, correct?

2 A Only part of the dissertation.

3 Q What do you mean by that?

4 A Later on, I moved to expand the
5 technique to do a mix mode and a pure shear so the
6 setup is different.

7 Q Do you know where -- is that shown, is
8 that setup shown in your dissertation as well?

9 A Yes, let's go to chapter 3 or 4. Let's
10 go to chapter 3 first, let me see. Scroll down to
11 chapter 3.

12 Chapter 4. Let's go to chapter 4.

13 Q There we go. Okay.

14 A Yeah, so if we go to the next figure,
15 the first figure in chapter 4. Yeah. So, this is
16 the setup I used in the later part of the
17 dissertation.

18 Q Okay. You do not rely on this portion
19 of your dissertation, the mix-mode loading, in
20 your analysis, with respect to the '684 patent,
21 correct?

22 A Correct.

1 Q Okay.

2 A This is out of the scope for this
3 patent discussion.

4 Q Okay. Got it.

5 Okay. If we could turn to -- we looked
6 at that one already.

7 Actually, sorry.

8 I'm jumping around all over the place
9 right now.

10 So I know we had just looked at the
11 Figure 2.1 in chapter 2, and that was
12 representative of the experiments ran that were,
13 in your opinion, relevant to the '684 patent.

14 Is Figure 3.1, shown here, also
15 representative of those experiments?

16 A Yes.

17 Q Okay. I think we started to talk about
18 this Figure 3.2.

19 Can you explain to me what's going on
20 in 3.2?

21 A Yes.

22 Q Please go ahead.

1 A So, this is zoomed-in view of the
2 sample. So, again, we have the thickest piece
3 stands for the substrate. On the left side is the
4 test film. So the interface in between is the
5 interface we want to interrogate. That means we
6 need to generate a high enough stress to separate
7 it from the substrate.

8 The right-hand side, there's an energy
9 absorbing layer, that's to absorb the laser energy
10 for the stress generation. The confining layer is
11 confining the thermal expansion of that heated
12 volume.

13 So the substrate here, I studied two
14 different materials. One is silicon, with a
15 thickness from 400 to 3,000 micrometer. And a
16 fused silica, in the range of 1 to 6 millimeter in
17 thickness.

18 Q Okay.

19 MR. MATICH: Dr. Wang, just for the
20 benefit of the court reporter, can you spell the
21 substances you were referring to, silicon and
22 silica?

1 A Silicon. Silicon is, basically, the
2 element Si. So just for the silicon documented
3 material, silicon used there. And fused silica
4 is, basically, amorphous silica and, so, the
5 purest of form of silica.

6 Yes, this sometimes is also called
7 fused quartz, it's the high purity fused quartz.
8 So, interchangeably used with this one.

9 Q Thank you.

10 All right, let's go next to -- okay.
11 You see what I have on the screen now, this is
12 Figure 3.14 of your report?

13 A Yes.

14 Q Okay. Can you explain to me what's
15 going on in each of these four depictions?

16 A Yes. So this is a representative data
17 processing cycle for this technique. The
18 upper-left panel, that's the interferometric
19 signal you would obtain from the total detector.
20 So that's the interference from the Michelson
21 interferometer. So each fringe here, basically,
22 each complete fringe -- so this is the voltage

1 versus time collected on this plate of the
2 oscilloscope, and each fringe corresponds to a
3 displacement of the film surface of half of the
4 wavelengths of the light.

5 So each fringe, basically, is an
6 up/down, one sinusoidal for fringe corresponds to
7 half-lambda displacement. So you decomp root the
8 fringe data, you would get the theta of the
9 displacement at function time, in the upper-right
10 panel. That's the transient surface displacement
11 experienced by the film.

12 From that data, involving real
13 mechanics using (indiscernible) creations in this
14 thesis earlier, probably in the last page, you
15 would get the substrates stress as a function of
16 time. That is the bottom-left panel.

17 Then from there, using another
18 equation, described, probably, again, on the last
19 page, you would get an interface stress
20 experienced by the interface between the test film
21 and the substrate.

22 So, most critical is the tensile stress

1 in the interface stress profile that's responsible
2 for the spallation of the film.

3 Q So, the information shown in 3.14(a) is
4 actual experimental data obtained from the
5 oscilloscope, correct?

6 A Only the --

7 Q Interferometer, I'm sorry.

8 A Only the interferometer system is from
9 the oscilloscope. The other three are processed
10 from that data.

11 Q Okay. In the Figure 3.14(d), you said
12 the tensile stress is the most important, right?

13 A Right.

14 Q Which stress is shown as tensile, and
15 is there any other type of stress shown?

16 A So, the stress here, you see zero and
17 you see positive/negative.

18 Q Right.

19 A Negative stress is compressive stress.
20 Positive stress is tensile stress. So the first
21 part is the compressive stress. The stress above
22 zero, that's tensile stress.

1 Q Positive, tensile. Negative,
2 compressive.

3 Right?

4 A Right.

5 Q Okay.

6 A That's the definition of stress in
7 mechanics and materials.

8 Q Okay. Let's, next, go to Figure 3.15,
9 on the next page.

10 Do you see that up on the screen?

11 A Yes.

12 Q Can you, please, explain to me what's
13 going on here, in these each of these four
14 depictions?

15 A This is another set of signal obtained
16 from using fused silica as substrate. So the
17 previous was using silicon. So this is from fused
18 silica. So, again, the top left is the direct
19 signal from oscilloscope, the interferometer
20 signal, fringe data. And the top right is the
21 displacement. Bottom left is substrate stress.
22 Bottom right is interface stress.

1 Q And the same with Figure 1.4, where the
2 substrate was silicon, the experimental data was
3 obtained from the data shown in 3.15(a), and the
4 depiction shown in 3.15(b) through (d) were
5 derived from that data, correct?

6 A Correct.

7 Q Okay. And this figure, or the portion
8 of your experiments that were ran with fused
9 silica as the substrate, shown in -- depicted in
10 3.15, that is the portion of your experiment
11 dissertation that you are opining on with respect
12 to the '684 patent, correct?

13 A Correct.

14 Q Again, looking at 3.15(d), the positive
15 stress would be tensile, and the negative stress
16 would be compressive?

17 A Yes.

18 Q And same for the substrate stress in
19 15C?

20 A Yes.

21 Q Looking on the next page, I'm
22 highlighting the portion of this page here. And I

1 can read this into the record. I'm reading from a
2 portion on page 65 that goes on to, I think,
3 page 66. Your dissertation reads "An initial fall
4 time of a few nanoseconds has therefore been
5 reduced to nearly zero and occurs long before the
6 pulse arrived test film."

7 What does that sentence mean?

8 A It means -- it means, when you compare
9 the waveform of the substrate stress between, I
10 think the number is 3.14(c) and 3.15(c), you
11 compare the substrate stress profile. You look at
12 the post-peak decay time. So from nano -- few
13 nanoseconds dropped to less than 1 nanoseconds.
14 So it means the post-peak decay is compressed.

15 Can you go back to 3 point -- or was it
16 4.15.

17 Q This one?

18 A Yeah.

19 Q Yeah.

20 A So, I was discussing the last part of
21 the C panel.

22 Q Okay.

1 MR. MATICH: Just for the record,
2 Figure 3.15 is what's on the screen?

3 THE WITNESS: Oh, right. Correct.
4 3.15.

5 Q Okay. And are you talking about the --
6 sorry, you're talking about the initial fall time
7 of the compressive wave that is input into the
8 substrate; is that correct?

9 A Correct.

10 Q Where would the fall time of that wave
11 be depicted in any of these, 3.15(a) through (d),
12 drawings?

13 A The fall time is from the maximum
14 compressive stress to -- it's the last portion of
15 the stress there, after it reaches the maximum
16 compressive, coming back to zero. That's the
17 portion.

18 Q Okay. Why would that wave go beyond
19 zero in the substrate stress in 15C -- sorry,
20 15 -- yeah, 15C?

21 A So, that's -- that part, I did some
22 analysis. I don't recall the exact reason here.

1 But it's due to the rebound of the surface after
2 the shock.

3 Q So, looking at 15C, I'm going to zoom
4 in a little bit. So where the waveform crosses
5 the -- crosses the zero point in the y-axis, that
6 occurs after the wave is propagated through the
7 substrate, rebounded off the free surface of the
8 coating, and returned as a tensile wave?

9 Is that what your testimony is?

10 MR. MATICH: Objection.
11 Mischaracterizes testimony.

12 A Let me look at my...

13 Okay.

14 Q Okay.

15 A So in my thesis, page 65, I explain the
16 phenomenon.

17 Q Page 65?

18 A Page 65. The bottom page 65 explains
19 why it goes above a zero.

20 Q Okay. Can you either point me to where
21 you're referring or go ahead and explain, either
22 one?

1 A So, I could explain. So, this -- this
2 phenomenon was not very understood. Normally, you
3 would expect it draws back to zero. But in this
4 case, the thought was the positive stress is due
5 to the reflected tensile stress from the back
6 confining layer. Because due to the low stress,
7 that stress has a lower amplitude. It travels
8 faster. So, eventually, it catches up with the
9 compressive stress. So that's why the stress goes
10 above that.

11 So, I would point to -- you to those
12 lines on this -- yeah.

13 Q Are you referring to --

14 A The -- from, one, two -- counting from
15 the bottom, the seventh line.

16 Q So, I'm reading from your dissertation
17 at page --

18 A Yeah, let -- "The experimental picture
19 is complicated somewhat by the presence of a
20 tensile wave, reflected from the back of a
21 confining layer.

22 "The surface properties of that

1 confining layer are not well-controlled. Assuming
2 a plausible longitudinal wave speed in the
3 confining layer, the original compressive wave is
4 followed, about 30 seconds [sic] later, by a
5 tensile pulse."

6 So that's -- yeah. Again, this is not
7 as well understood as the first part in the fused
8 silica because the confining layer property is not
9 well-controlled, it's just a layer of waterglass.

10 Q Okay. Your dissertation reads, in the
11 last sentence on page 65, "Being tensile, it
12 propagates faster than the peak compressive stress
13 and faster than the low-stress tail of the main
14 pulse."

15 That "tensile" you're referring to,
16 that is the rebounded wave from the back of the
17 confined layer, correct?

18 A Correct.

19 Q So -- sorry, go ahead.

20 A This is, in part, based on the arrival
21 time. The other part is also postulation.

22 Q Okay.

1 A Yeah.

2 Q And the first full sentence on page 65
3 [sic] reads in "Figure 3.15, the shock is followed
4 by a regime in which the velocity has changed
5 time, indicating that the tensile pulse has
6 overtaken the compressive pulse."

7 So, looking back, again, to
8 Figure 3.15.

9 MR. MATICH: Roman, we're not seeing
10 that as the first full sentence on page 65. Can
11 you --

12 MR. RACHUBA: Sorry. First full
13 sentence on page 66. I'm highlighting it on my
14 screen right now for you.

15 MR. MATICH: Okay.

16 MR. RACHUBA: Do you see that, Nick?

17 MR. MATICH: Yes. I'm just reading it
18 for a second. Okay.

19 Q Okay. So looking, again, at 3.15(c),
20 following the compressive wave down from time zero
21 nanoseconds, up until 25 nanoseconds, we start to
22 see, well, I guess, roughly, looks like 27 or 28

1 nanoseconds. The compressive peak declines all
2 the way into a tensile peak of the same magnitude,
3 it appears, at, roughly, 30 nanoseconds, right?

4 A Roughly 30 seconds from the beginning?
5 Yes.

6 Q Okay. So, where, in 15c, does the
7 tensile wave overrun the compression wave? And by
8 "tensile wave," I'm referring to the rebounded
9 wave from the confining layer.

10 A The tensile wave is a wave above zero.

11 Q Okay.

12 A Of stress.

13 Q Where is the compressive stress
14 calculated in the substrate, where the data's
15 shown in 15c?

16 A What do you mean? Can you clarify?

17 Q Sure. So, 15c is a substrate stress,
18 right? So the substrate has some longitudinal
19 dimension.

20 Where, in the substrate, is that stress
21 calculated? From the end abutting the confining
22 layer? The end abutting the interface with the

1 film? Or somewhere in between?

2 A So the measurement is taken from the
3 surface of the film. So the calculated substrate
4 stress is closest -- is most closely representing
5 the substrate stress near the test film side.

6 Q How near?

7 A So we are showing the -- you can assume
8 this is the stress adjusting to the interface.
9 This is the substrate stress adjusting to the
10 interface.

11 Q Okay.

12 A It's all referred from surface stress.
13 It's based on the equation. The measurement is on
14 the very surface of the test film.

15 Q Okay. And the -- where is the stress
16 calculated for the interface stress?

17 A It's at the interface of the film and
18 the substrate.

19 Q Looking at 15c again, it appears that
20 the tension stress at, I think, 30 nanoseconds,
21 appears to be the same magnitude of the maximum
22 compressive stress at, roughly, 26 nanoseconds.

1 Is that understanding correct?

2 A In this exact figure, yes. But that
3 one varied. The tensile stress varied.

4 Q In the figure shown in 15c, looks like
5 the tensile wave overtakes the compressive wave, I
6 think, roughly -- where does that cross? Zero
7 axis. Probably between 28 and 29 nanoseconds,
8 right?

9 A Approximately, yes.

10 Q Okay. So, the tensile wave would reach
11 the interface before the compressive wave,
12 correct?

13 A No.

14 Q Why not?

15 A This signal is mirrored from the
16 surface. So the arrival time -- the timescale
17 shows the arrival time, so it's clearly shown in
18 the signals. So that tensile stress is below --
19 behind the compressive stress.

20 MR. MATICH: Roman, we've been going
21 for a little over an hour. I wouldn't mind taking
22 a break.

1 MR. RACHUBA: A couple more questions
2 on these figures and then take a break.

3 Q Dr. Wang, you had just testified that
4 the tensile wave overtakes the compressive wave
5 at, roughly, 28 or 29 nanoseconds, you said,
6 approximately.

7 So if that tensile wave overtakes the
8 compressive wave, how do you explain that the
9 compressive wave would reach the interface first?

10 Dr. Wang, are you able to answer the
11 question?

12 MR. MATICH: I believe she's reviewing
13 the document.

14 A I think so. Can you repeat your
15 question again?

16 Q Sure. So you had testified that the
17 tensile wave overtakes the compressive wave. So
18 if the tensile wave overtakes the compressive
19 wave, how do you explain that the compressive wave
20 can reach the interface first?

21 A So, in this case, it's almost
22 simultaneously. So the tensile wave follows, due

1 to the fast shock for time. So the two almost
2 immediately follow.

3 However, in my testing, this tensile
4 peak is not consistent. Really, it depends on the
5 stress peak amplitude and the -- when the stress
6 is too high, we often see the backside of the
7 confining layer actually coming off.

8 So you don't always get the same
9 tensile peak stress at the maximum. So even if a
10 small peak stress arrives early, it's that -- it's
11 literally not that stress that's causes
12 spallation.

13 Again, it's postulation.

14 MR. RACHUBA: Okay. I think now is a
15 good time to take a break. Let's take a 10-minute
16 break.

17 MR. MATICH: Sounds good.

18 MR. RACHUBA: Come back at 10 of.

19 THE WITNESS: Okay. Thank you.

20 MR. RACHUBA: Okay.

21 (Recess taken from 1:39 p.m. to
22 1:58 p.m.)

1 BY MR. RACHUBA:

2 Q Welcome back, Dr. Wang.

3 A You're welcome.

4 Q While we were on that break, did you
5 speak with either Nick or Casey?

6 A Yes.

7 Q What did you speak about?

8 A I told Nick to go to the men's bathroom
9 and Casey and I went to the women's bathroom.

10 Q Did you speak about your testimony at
11 all?

12 A No.

13 Q Going back to your dissertation -- hold
14 on one second.

15 Okay. Yes. Going back to your
16 dissertation. So this is Exhibit 1005, and I will
17 share my screen again.

18 Can you see that up there? I have a
19 sentence highlighted on page 65 of your
20 dissertation.

21 A Can you make it big? Why my screen --
22 the share screen so small?

1 Q Is that better?

2 A Are you sharing -- somehow the --

3 THE WITNESS: Casey, can you take a
4 look at why the share screening is only coming up
5 small.

6 MS. SHOMAKER: Let me see if I can --

7 THE WITNESS: Oh, okay.

8 A Yeah.

9 Q Okay. You see that there.

10 A Yes.

11 Q So page 65 of your dissertation reads
12 "The Experimental picture is complicated somewhat
13 by the presence of a tensile wave reflected from
14 the back of the confining layer. The surface
15 properties of that confining layer are not
16 well-controlled. Assuming a plausible
17 longitudinal wave speed in the confining layer,
18 the original compressive pulse is followed about
19 30 nanoseconds later by a tensile pulse of a
20 comparable magnitude."

21 Do you see that?

22 A Yes.

1 Q That last sentence, that talks about
2 tensile pulse of a comparable magnitude, is that
3 accurate?

4 A For that specific signal, it's
5 accurate. But it is not -- from what I recall,
6 that tensile peak stress is not consistent. For
7 some cases, it's comparable. Some cases, it's
8 going to be lower.

9 Q Can you point me to any data in your
10 report where the tensile stress was smaller or of
11 a non-comparable magnitude?

12 A So, okay. Let me see.
13 So that one -- so I refer you to
14 Figure 3.21.

15 Q 3.21.

16 MR. MATICH: What page are we on?

17 THE WITNESS: Page 78.

18 Q What am I looking at here on the --

19 A Figure 3.21(b).

20 Q Okay. What's going on in 3.21(b).

21 A So that tensile peak is much lower than
22 the compressive peak.

1 Q What is shown in 3.21(b)? What is that
2 depicting?

3 A So that's the substrate stress from
4 point -- half-micron-thick aluminum film, deposits
5 the 1500-micron-thick fused silica substrate.

6 So this is very -- there is still a
7 tensile peak, but that tensile peak is much lower
8 than the compressive peak.

9 Q What is shown in 3.21(a)?

10 A So that's the fringe signal.

11 Q What is the substrate made out of in
12 this experiment? Is this --

13 A Silicon.

14 Q Is this the same experiment that's
15 shown, experimental results shown in 3.145 --
16 sorry, 3.15 or is this a different experiment?

17 A This is a different experiment.

18 Q I see that the fringe record, the
19 3.21(a), goes from zero to 20 nanoseconds, but the
20 timescale in 3.21(b) only goes to 3 -- sorry, only
21 goes to 15 nanoseconds.

22 Why is that timescale different?

1 A So the signal after 15 nanoseconds is
2 no longer important.

3 Q Why is it no longer important?

4 A The stress is much lower. So for this
5 kind of measurement, if you go back to my earlier
6 fringe data, there's a lot of data, but you don't
7 need to -- at some point, you just have to stop
8 because the fringe slow down. That means the
9 stress there is much lower, is no longer
10 important. So there's no need to process them.

11 Q If you were to continue the timescale
12 out to 20 nanoseconds in 3.21(b), the waveform
13 would continue rising in tension, correct?

14 A It's not going to rise based on the
15 fringe spacing the fringe -- so the stress
16 amplitude is proportionate to the fringe -- the
17 fringe spacing. If the fringe is slowing down,
18 that means the stress is lower. So, the fringe
19 there is definitely showing attenuation there. So
20 the stress, up to that point, would be lower.

21 Q The tension, of course, would still
22 continue, though, correct?

1 A Tension will continue at a lower
2 stress.

3 Q Are there any other -- strike that.
4 In this experiment shown, how many
5 fringes are shown in 3.21(a)?

6 A You can count here. So, basically, you
7 assume it's a sinusoidal, so from one bottom to
8 another bottom, that's a fringe.

9 Q So it looks like there's two fringes
10 here?

11 A Right. In the middle of the second
12 fringe, that displacement turned direction. So
13 that's an indication of the shock. So after that,
14 the signal is less important.

15 Q I'm going to go back. Chapter 3 of
16 your dissertation discusses the experimental
17 results relative to your analysis on the '684
18 patent, correct?

19 A Correct. Both chapter 3 and chapter
20 4 -- chapter 2.

21 Q Right. Chapter 2, however, isn't
22 discussing experimental results that's discussing

1 experimental setup and theories, right?

2 A Yes. It discuss the theories for the
3 shock development in pure silicon.

4 Q Okay. So experimental data is present
5 in chapter 3.

6 Looking at the figures, again, at 3.15,
7 the tension wave is, roughly, the same magnitude
8 as compressive wave, right?

9 A For this one, comparable.

10 Q Okay. What about the tension wave in
11 3.16?

12 A So this is a group of data of substrate
13 stress as a function of time for different laser
14 fluence.

15 Q It looks to me, in each one of these,
16 that the tension stress is the same as compressive
17 stress, correct?

18 A For most cases, I would say. Some of
19 that, for example, the third, is data slightly --
20 is lower. The tensile is lower than the
21 compression.

22 Q Which one?

1 A The .112.

2 Q .112, that line.

3 A So the maximum compression is about .5.
4 The maximum tension is about .2 something. Yes.

5 Q A little over .2, right?

6 A A little bit over, yeah.

7 Q Okay. So for three of the four
8 examples shown in 3.16, the tension wave is of
9 comparable magnitude; would you agree?

10 A And the second one was slightly lower.
11 So, yeah, you -- I think it's okay to say that.

12 Q Okay. What about the example shown in
13 3.17?

14 A So this one has a lower tension than
15 compression.

16 Q And by "lower" --

17 A So, the maximum compression is about
18 .56-ish or .5. You can see the maximum tension is
19 about .3-ish.

20 Q Maybe a little more -- maybe a little
21 above .3?

22 A 3 point -- 0.35 is the estimate, yeah,

1 about, 35, versus 56, or 55. Yeah.

2 Q So in this one, though, the fringe
3 pattern is measuring on a timescale from zero
4 seconds to 50 nanoseconds, but the stress diagram
5 is only going to 30 nanoseconds. But we can see,
6 from 3.17a, that the final infringe, you're still
7 seeing a fringe interference pattern all the way
8 up to 50 nanoseconds, correct?

9 A That's correct, yeah. It's typical for
10 you to -- the motion will continue.

11 Q Okay.

12 A Yeah.

13 Q And if you were to extend the timescale
14 up to 50 nanoseconds in 3.17b, the tension would
15 also continue, correct?

16 A The tension continues at much lower
17 amplitude.

18 Q What is your basis for saying that?

19 A The spacing of the fringe signal. So
20 if you look at the fringe signal before the arrow
21 there, you see the fringe gets narrower and
22 narrower. So that's -- the fringe spacing becomes

1 smaller and smaller. That's where you see the
2 stress go higher and higher, you know, in the
3 compressive. So that's basically -- the stress is
4 proportionate to the fringe spacing, how fast the
5 fringe changing.

6 So, clearly, after the arrow pointing,
7 you can see the fringe is becoming wider and
8 wider. That's an indication of the stress going
9 down, stress going lower.

10 Q Does the fringe interference pattern
11 demonstrate a constant velocity in one direction
12 or a change in velocity?

13 A Change in velocity.

14 Q So, if the free end of the film would
15 be under continued tension stress, regardless if
16 the fringes get more narrow, the tension would
17 still -- could still go higher because it could be
18 moving in the same direction, correct?

19 A No.

20 Q The tension is after the fringe
21 spacing, though, correct?

22 A Can you repeat the question, please?

1 Q Sure. The tension -- so we have the
2 smallest narrow fringe band, it looks like,
3 roughly, 25 nanoseconds.

4 Would you agree?

5 A Yeah.

6 Q Okay. So at that point, looking at the
7 timescale on the stress, that looks to be,
8 roughly, the peak compressive stress, right?

9 A Right.

10 Q So we're seeing the most tensile stress
11 where the fringes are not so close together,
12 right?

13 A The most tensile stress is close to
14 that turning point. It's right next to the
15 turning point. After the turning point, it's
16 already slowing down.

17 Q Well, the peak tension looks to be --
18 we're still seeing large magnitude -- we're still
19 seeing fringe movement past 30 seconds, a full
20 size sort of wave after the 30-second mark. And
21 that's not included, at all, in the stress chart
22 in the bottom, right?

1 A Right. The motion is on, it still
2 continues. But it's slowing down.

3 Q But the peak tension is after the
4 turning point, correct?

5 A Yes.

6 Q So would tension fall after the turning
7 point? Sorry, what -- so why, in your opinion,
8 would the tension fall after the turning point?

9 A The loading is slowing down based on
10 the fringes. So when the fringe becomes wider,
11 that means the whole moving -- the whole motion is
12 slowing down. That means the tensile stress is
13 reducing.

14 So the stress is proportionate to
15 velocity.

16 Q But the stress is increasing after the
17 max velocity, right?

18 A So, the fastest changing point of the
19 fringe is the highest stress point.

20 Q Well, the fastest changing point in the
21 fringe appears to be, roughly, 25 nanoseconds,
22 right?

1 A That's a turning point.

2 Q That's a turning point?

3 A Right.

4 Q That appears to be the highest
5 compressive stress.

6 A Zero. The highest compressive stress
7 is right before that. A turning point, that's
8 where displacement is changing direction, that's
9 where the velocity is zero.

10 Q Right. But the peak tensile stress
11 shown is after the turning point, right?

12 A Right, right.

13 Q Okay. Let's look at 3.1a. It looks,
14 to me, like the maximum tensile force is
15 greater -- sorry. Maximum tension stress is
16 greater than the maximum compressive stress,
17 right, in this example?

18 A Yes. It appears so.

19 Q Looking at Figure 3.22, there's no
20 corresponding fringe pattern produced for these
21 sets of experiments, correct?

22 A There were fringe pattern, but this, I

1 was showing the substrate stress only.

2 Q I think we've already discussed 3.21,
3 right?

4 A Yes.

5 Q In 3.20, the fringe pattern goes to
6 40 nanoseconds, but the stress data is only
7 charted out 25 nanoseconds, correct?

8 A Correct.

9 Q And in 3.19, the fringe pattern goes to
10 40 nanoseconds, but the stress data only goes to,
11 roughly, a little past 30 nanoseconds?

12 A Correct.

13 Q Okay. Looking back, again, at 3.22, if
14 you were to extend that timescale out, the tension
15 would continue, correct?

16 A It might.

17 Q It might rise, right?

18 A No. I don't -- I don't think it's
19 going to rise. I think it's going to continue at
20 a lower stress. But I don't have the fringe data
21 here, so it's -- I cannot draw that comparison
22 until I see the fringe data. But some of this was

1 based on the earlier. For most of the data, I
2 processed so the fringe was slowing down. That's
3 why I stopped processing that signal.

4 Q Do you still have that fringe data?

5 A The research was 20 years ago, so,
6 after publication, honestly, I have changed
7 computers multiple times. I don't have -- so all
8 the data, unless it's in published or here, yeah,
9 I cannot retrieve those, no.

10 Q Okay. Would you agree that each of
11 those -- each of the data plots shown in 3.22 has
12 a tensile stress element shown?

13 A Yes.

14 Q Going back to 3.15, which is on
15 page 64.

16 So we had talked about how the stress
17 shown in 3.15(c) was calculated and derived from
18 the data shown in 3.15(a), correct?

19 A Mainly, roughly.

20 Q If we scroll to page 44 of your
21 dissertation, I'm looking at equation 3.4. Is
22 that the equation that you used to calculate the

1 stress in the substrate?

2 A Yes.

3 Q And is equation 3.5 the equation you
4 used to calculate the stress at the -- where the
5 substrate meets the coating layer?

6 A The interface, yes.

7 Q Yes. That was the word I was looking
8 for.

9 Let's take a look at 3.4 equation.

10 Can you explain to me what the ratios
11 and variables in this equation are?

12 A So U -- $\frac{dU}{dt}$ stands for the derivative
13 of U , with respect to T . Here, U is the surface
14 displacement of the film. T is time.

15 Within the processes, ρ C , ρ is
16 density, and C is longitudinal wave speed. This
17 is of the substrate, SUB stands for the substrate.
18 Then we have a one half -- next to one-half vector
19 and that's because when the wave reaches free
20 surface, it's reflected. So the U here is the
21 matter of the surface displacement.

22 And so, based on wave mechanics of the

1 displacement in a substrate, it's only one half of
2 that type of surface. So that's kind of a
3 standard equation you use in wave mechanics.

4 Q Do you recall what variable you used
5 for rho to density?

6 A I believe it's listed in my
7 dissertation somewhere. And so, rho and C, it
8 depends on the surface, right? If this is for
9 silicon substrate, you have silicon. If it's for
10 fused silica, you use that for fused silica.

11 We measure the C for fused silica
12 ourselves, in the lab, and we use the density from
13 the vendor, from the supplier where we bought the
14 substrate.

15 Q If you use the density of the substrate
16 as a variable, doesn't that presume that it's the
17 density of an infinitely long substrate of a
18 constant density?

19 A So, can you -- what do you mean? I
20 don't quite -- can you repeat your question,
21 please?

22 Q So --

1 A For most of the material, yes. It is
2 kind of (indiscernible) now, where it's
3 (indiscernible) substrate.

4 Q Hold on one second here.

5 So, do you recall where, in the
6 appendix, that rho is listed? You said
7 Appendix C, I believe. Sorry, my version of this
8 document is not word searchable.

9 A Right.

10 Q Sorry about that.

11 A I think it's about 2.2 somewhere,
12 and -- not in the appendix.

13 Q Oh, it's not in the appendix? It's
14 above?

15 A Let me think. Right. Cannot search
16 for keyword.

17 Q Okay. I'm looking at page 129. This
18 is the first page of Appendix B.

19 A Excuse me. Okay. Can we go back -- I
20 would like to answer the question just asked.

21 Q Okay. We'll come back to that one.

22 A Okay.

1 Q I want to get to this one first, if you
2 don't mind.

3 I'm looking at -- this is the first
4 page of Appendix B, page 129 of your dissertation.
5 And your dissertation reads "The substrate is
6 considered as a homogeneous, isotropic,
7 semi-infinite media."

8 What do you mean by that? Or what does
9 that mean?

10 A Homogeneous means uniform composition.
11 So, no significant changes from one place to the
12 other.

13 Isotropic means no direction of
14 dependence. So that's the rational to the Y
15 direction.

16 And semi-infinite, meaning, in this
17 case, comparing to the wavelengths of the stress
18 wave. So it's much bigger, longer, than the
19 wavelength for stress wave.

20 So we'll compare the stress wavelengths
21 versus the substrate. The stress wave is only a
22 small fraction of the substrate thickness. That's

1 what it meant. Do not need to consider the left
2 boundary there.

3 Q So for purposes of stress calculation,
4 in your dissertation, the substrate is,
5 essentially, of infinite length from the left-hand
6 side throughout the interface with the film,
7 right?

8 A Right. So you need -- so you don't
9 need to consider mark for reflections.

10 Q Okay. So looking back at that
11 equation, 3.4, where does this equation take into
12 account the distance to the interface?

13 A Do you mean distance from the left or
14 right?

15 Q Well, assuming, let's say, interface is
16 on the right and the pulse is generated from the
17 left.

18 So, I understand, from the left-hand
19 side, we, essentially, have an infinite length.
20 And from the right-hand side, where do we take
21 into account the distance from the interface?

22 A H. 3.5. The H there. That's a

1 thickness of the film.

2 Q Yes, but that stress is to calculate
3 the stress in the film. 3.4 is the equation used
4 to calculate the stress in the substrate.

5 A Right.

6 Q So, H is not included in 3.4, correct?

7 A No. Oh, correct.

8 Q So 3.4 does not take into account the
9 distance on the right-hand side from the
10 interface, correct?

11 A Correct.

12 Q Okay. So then, assuming we're not
13 taking into account the distance from the
14 interface, is my understanding correct in that the
15 stress would be calculated, essentially, with
16 respect to the wavelength of the laser, an
17 infinite distance from the left and an infinite
18 distance from the right?

19 A Right.

20 Q Okay. Let's go back to the depictions
21 shown in 3.15.

22 In your experiments that you

1 performed --

2 A Excuse me?

3 Q Sorry. Let me strike that question.

4 What is the maximum tension that can be
5 generated from the tension wave reflected off the
6 confining surface with respect to the interface
7 film?

8 A So, are you asking what's the
9 maximum -- sorry. Can you repeat that question
10 again?

11 Q What is the maximum stress that can be
12 generated in the substrate from the tension wave
13 that is reflected off the confining surface?

14 A That, at most, would be equal to the
15 generated stress right at the absorbing layer.

16 Q What is the maximum tension that can be
17 generated from the compressive wave that bounces
18 off the free end of the interface surface and
19 reflected back into the substrate?

20 A That would be the maximum compressive
21 stress.

22 Q Would that compressive stress be

1 attenuated by the tension wave that we discussed
2 earlier, that is immediately following the
3 compressive wave?

4 A What do you mean "attenuated by"?

5 Q Would the magnitude decrease?

6 A If two tensile stress in the same
7 place, they will enhance. If Y is positive, Y is
8 negative, they will cancel.

9 I guess that's depending on the arrival
10 time and the sign of the stress.

11 Q Looking at -- looking at 3.15(c) again.
12 Where is the front end of the compressive wave?

13 A The linear part -- the linear slope,
14 from zero to about 28. So the -- so a lot of the
15 common scales, zero is the front. So, then, the
16 rest come in behind.

17 Q Can you explain? I'm not sure I
18 followed that. Can you explain that again?

19 A So the front end means the section
20 before the maximum stress. So that's the -- from
21 zero to 25-ish nanoseconds. That's the front end.

22 Q Okay.

1 A The rising part.

2 Q Okay. Where is the front end of the
3 tensile waveform?

4 A So, it's not clearly shown here. But
5 that would be the tensile part of the stress.

6 Q Which direction, from left to right, is
7 the wave moving in 3.15(c)?

8 A So 3.15(c) is on the timescale. So,
9 zero is -- depending on the experimental setup, if
10 my film is on the right-hand side, the substrate
11 on the left-hand side, so zero is moving toward
12 the film. So that 25 nanoseconds is behind. It's
13 coming later.

14 Q What is the time difference between the
15 compression wave peak and the tension wave peak in
16 3.15(c).

17 A So, here, if I assume the tension wave
18 peak is around 30 nanoseconds, so that's a couple
19 of nanoseconds there. That's from the maximum
20 compression to the maximum tension.

21 Q What is the velocity of a compression
22 wave with fused silica?

1 A So in my work -- so that's a -- that's
2 the longitudinal speed. I listed in page -- so
3 the velocity is 5,940.

4 Q Where are you reading from?

5 A It's -- okay. It's on page 85, bottom,
6 85.

7 The paragraph below equation 4.3.

8 Q Oh, I see it.

9 What is the velocity of the tensile
10 wave?

11 A The same.

12 Q On page 65 -- on page 65 of your
13 dissertation, you state that the tensile wave
14 propagates faster than the compressive wave.

15 Which portion of your dissertation is
16 correct there?

17 A Okay. We're talking about just a
18 slight change of the wave speed, considering the
19 nonlinear effect.

20 So without the nonlinear effect,
21 compression tension would have the same. So
22 that's the zero -- almost like zero-stress speed.

1 And then with stress, that speed will change
2 slightly based on the nonlinear effect. But
3 that's where the -- so the weight matter, so,
4 that, you consider as a zero stress speed, the
5 594 -- 5,904.

6 So the compressive stress will reduce
7 that stress -- that speed slightly. The tensile
8 stress will increase that speed slightly due to
9 nonlinear effect.

10 Q Let me see if I understand this
11 correctly.

12 The compressive wave waveform is going
13 to impart a nonlinear effect in the -- in the
14 fused silica by applying stress to the substrate.
15 And that stress allows the tensile wave to travel
16 faster?

17 A Not the whole wave. I would say the
18 wave speed depends on stress, even for the same
19 waveform. So the zero stress traveled faster than
20 the maximum peak stress.

21 So that's how the shock is formed.

22 Q Okay. What would be the velocity of

1 the maximum peak compressive stress in the
2 substrate?

3 A There is an equation in my dissertation
4 that you can plug in to get based on the stress
5 level.

6 Q Do you recall where that is in your
7 report?

8 A I believe it's in chapter 2.

9 Q Oh, sorry. I meant dissertation. I
10 meant dissertation.

11 A Yeah, my dissertation, chapter 2.

12 Q Okay. What about the max peak tensile
13 stress? What would be the velocity of that?

14 A You can plug in the same -- into the
15 same equation, calculate based on the stress
16 level.

17 Q But the nonlinear effect would still
18 have an impact on that?

19 A I believe so. However, I do need to
20 double-check because the equation I cited used the
21 parameters from another reference, whose only
22 study was shock, study with compressive property.

1 So the phenomena should be the same,
2 but to the extent different, it might be slight
3 different.

4 Q Let's try to find those equations,
5 though. So I'm going to go through these
6 equations. Let me know when I find the right one.

7 A Go to page 24, start from there.

8 Q Okay.

9 A Continue. Next. Continue. Next one.
10 Let's see. Okay. Yeah. Equation 2.63. So, this
11 is the equation of the wave speed at the function
12 of stress.

13 Q Can you explain to me what's going on
14 here?

15 A In this equation, I used the theory to
16 derive the wave speed at the function of stress,
17 using the nonlinear velocity coefficient from
18 other -- another prior art.

19 Q And for the record, we're talking about
20 equation 2.63.

21 A The C here is the wave speed that we
22 are talking about.

1 Q Okay.

2 A Sigma is stress, and the C not is --
3 yeah. C not is the low-amplitude dilation of wave
4 speed. That's basically -- okay. That's a number
5 here. You can think of it as zero-stress speed.
6 That, in this case, it's a 5.9391.

7 Q Sorry, which one is zero-stress speed?

8 A C zero, C subzero.

9 Q Okay. So we're looking at the --

10 A The very last equation, 2.63, you only
11 need to look at the very last step.

12 Q So C zero is a zero-stress speed.

13 A Right. So that's the one I cited
14 earlier -- or showed you on page 84. But also
15 mentioned here, it is a slightly different 5.9391.

16 Q Okay. And then what was alpha again?

17 A Alpha and the beta are two coefficients
18 that, in the previous equation -- if you scroll
19 back by one page. One more page back. One more
20 page back. One more. Sorry. Here. Here.

21 That's equation 2.53.

22 Q Okay.

1 A So that's an equation there.

2 Q So, essentially, this is giving a
3 coefficient or a variable of stress in the
4 substrate?

5 A Right. This is a stress-strain
6 relationship for the substrate.

7 Q Okay. So --

8 MR. MATICH: Roman, before you proceed
9 to your next question. Just a technical point.
10 The laptop Dr. Wang is using is connected to the
11 open Wi-Fi here and we get kicked off every
12 three hours if you don't re-get on. So we're, I
13 think, approaching that point.

14 MR. RACHUBA: Okay.

15 MR. MATICH: If we drop, that's why.
16 But I think we're also approaching a potential
17 lunchtime as well.

18 MR. RACHUBA: Yes. If I can get one or
19 two more questions in before you get kicked off,
20 but, otherwise -- I guess now is a good time for
21 lunch. We can pick this back up after lunch.

22 MR. MATICH: You're welcome to keep

1 going. Just I'm not sure when it would kick us
2 off, and we can get back on fairly quickly. I was
3 just warning you, if we drop. That's fine.

4 MR. RACHUBA: Why don't we not risk it.
5 Why don't we -- let's go off the record and we'll
6 talk about lunch plans.

7 (Recess taken from 2:55 p.m. to
8 3:50 p.m.)

9 BY MR. RACHUBA:

10 Q Welcome back, Dr. Wang.

11 A Thank you.

12 Q During the break, did you speak with
13 your counsel regarding the substance of your
14 testimony?

15 A No.

16 Q Before we went on a break, we were
17 talking about the adhesion of the stress waves and
18 substrate.

19 Do you recall that?

20 A Yes.

21 Q I'm just going to pull back up and
22 share your dissertation again. And we can pick up

1 where we left off.

2 Can you see that on your screen?

3 A Yes.

4 Q Okay. So we were talking about
5 equation 2.63 before.

6 Do you recall that?

7 MR. MATICH: Roman, what page are we
8 on?

9 MR. RACHUBA: This is page 30 of the
10 dissertation, page 47 of the PDF document.

11 MR. MATICH: Thank you.

12 Q Okay. So, Dr. Wang, I think we got
13 distracted. So could you, please, explain to me
14 the last line of equation 2.63, that's showing on
15 your screen right now, what the variables are
16 again?

17 A Yes. So, the C_0 , C_{subzero} , is the
18 low-amplitude relocation of velocity, that's the
19 wave speed.

20 Q It's a lower-amplitude what? Sorry, I
21 didn't catch that last part.

22 A Low amplitude -- you can consider it as

1 a low-stress velocity.

2 Q Okay.

3 A Yeah.

4 Q And this equation is for the
5 compressive stress waveform, the tensile stress
6 waveform, or both?

7 A It's for the compressive.

8 Q Okay. What are the variables in the
9 ratio on the right-hand side of the equation?

10 A Beta and alpha are the coefficients in
11 the stress-strain relationship. That was in the
12 earlier equation --

13 Q Right.

14 A -- a few pages back. That's the beta
15 order, the second order, and coefficient.

16 Q Okay. And is -- does your dissertation
17 include a formula for the tensile stress waveform?

18 A No.

19 Q Does your dissertation disclose how to
20 calculate the tensile stress waveform?

21 A No. You mean for the wave speed?

22 Q Yes, wave speed, correct.

1 A No.

2 Q Are you aware if the stress-strain
3 relationship would have an impact on the speed of
4 the tensile waveform?

5 A Yes. Based on the literature, yes.

6 Q What literature?

7 A That was one of the prior art and,
8 also, cited in this chapter early on. If you --
9 that's -- if you scroll back, it's the Barker and
10 the Hollenbach paper and where -- yes, if you
11 scroll down. Scroll back a few lines.

12 Q Am I going the right direction or
13 should I go the opposite direction?

14 A That's the right direction.

15 Q Okay.

16 A A few pages back. The other direction,
17 sorry.

18 Q No problem.

19 A Further. Let me see. Okay. Should be
20 here. Okay. Here.

21 That's the reference 51, Barker and
22 Hollenbach, so, from those. Yeah, and both 50 and

1 51 mention this. But that equation was from 51.

2 Q So it reads here, Barker and Hollenbach
3 also fit the compressive wave data into a
4 fourth-order stress-strain.

5 Are you saying that that reference also
6 describes tensile stress?

7 A No. I think -- the equation that fits
8 only describes the compressive.

9 Q Okay. So your dissertation does not
10 discuss tensile --

11 A No.

12 Q -- wave speed?

13 A No.

14 Q I guess, to the extent it does, we
15 spoke about it earlier on page --

16 A Right.

17 Q -- 65 and 66, where the tensile wave
18 can overtake the compressive wave?

19 A Yeah. So to that extent, we were
20 mostly postulating based on the equation, assuming
21 the same equation applied to tensile. But there
22 is no formal quantitative relationship known at

1 that time.

2 Yeah, it's most assuming.

3 Q Okay. If that same -- if that same
4 equation would govern the tensile stress waveform
5 speed, how would it be possible for the tensile
6 stress waveform to overtake and catch up to the
7 compressive waveform?

8 A So, I think we -- if we go to the same
9 equation, you would see that. Go to the same
10 2.64, I think. 2.63.

11 So it's the same -- if this -- assume
12 this same equation hold. Let me see.

13 Can we go back? Can I look at the
14 value for beta?

15 Q Sure. That was --

16 A Okay. Here. Here. Yeah.

17 Q Did I pass it? Was it on that page?

18 A You passed it. Here. Okay. Let's go
19 back to the same equation again, 2.63.

20 So in this equation, this equation is
21 for the compressive stress.

22 Q Right.

1 A The beta is -- beta is a negative
2 number.

3 Q Okay.

4 A So with the larger amplitude of stress,
5 C would be lower.

6 Q Right.

7 A That's for compressive stress.

8 Q So, would -- sorry, go ahead.

9 A So that's where we see the low stress
10 travels faster, high stress travels slower.
11 That's how the shock is formed for this material.

12 Assuming the same equation hold, the
13 tensile stress will need a negative -- sigma is a
14 negative number. That means the higher the
15 stress, the higher the speed. That's why it's --
16 it would be fast -- you will get higher speed for
17 tensile than for the compressive, assuming this
18 equation still valid.

19 Q Okay. Let's move on. Let's go to
20 Figure 3.14 on page 63.

21 A Okay.

22 Q Looking at 3.14(c), what is the rise

1 time of the compressive wave?

2 A The rise time depends on how you define
3 it. If we go from zero to the maximum, that's
4 around 3.5 nanoseconds.

5 Q Okay. What would be another way to
6 define it?

7 A Sometimes people go from 10 percent of
8 the peak to 90 percent of the peak. Yes.

9 Q In this same figure, what would be the
10 rise time of the tensile wave?

11 A There's no tensile wave here.

12 Q Okay. Let's move to Figure 3.15, on
13 the next page, page 64 of your dissertation.

14 What is the rise time of the
15 compressive wave in 3.15(c)?

16 A Now it's about 26, 27 -- 26. Yeah,
17 27 nanoseconds.

18 Q And what would be the rise time of the
19 tensile wave?

20 A So, we don't have the complete profile;
21 however, if I -- if you go from zero stress to the
22 maximum tensile here, that's -- that's about

1 1 nanosecond, well, 2 nanoseconds. But, really,
2 there's no complete stress wave, so you really
3 don't see. You can't tell rise time.

4 Q Okay. Is there a rarefaction shock
5 shown in 3.15(c)?

6 A There's shock, but it's a rapid change
7 of stress. In this case, from the maximum of 0.6
8 to 0. So that's indication of a shock.

9 Q Is it clear, from experimental data,
10 what causes that change?

11 A That experimental data shows and also
12 clear, clearly indicate it's a shock.

13 Q What -- well, what do you mean by
14 "shock"?

15 A Shock is a rapid change of pressure or
16 a rapid change of stress.

17 Q Over what time? What do you mean by
18 "rapid"?

19 A Rapid, in this case, if you compare
20 3.15(c) and the 3.14(c), compare the post-peak
21 decay time.

22 Can we go back to the 3.14?

1 Q Sure.

2 A If you stop here. So the compressive
3 stress, after the peak, takes more than -- around
4 10 seconds to decay to zero, from three seconds to
5 13 seconds. So if you go back to 3.15(c), that
6 time is compressed to almost to 1 nanosecond. So
7 that's very rapid drop of stress in there. So
8 that's an indication of a shock.

9 Q Okay. And this is the case in 3.15(c)
10 because that tensile wave is overtaking the
11 compressive waveform, correct?

12 A That -- I would say that's responsible
13 for the tensile portion. Yeah, part of the
14 confusion could come from there.

15 Q Which part?

16 A So the tensile portion. Because of the
17 finite thickness of the waterglass, so the
18 reflective tensile could overtake -- could catch
19 up.

20 Q So, looking at the change in stress in
21 3.15(c), from, roughly, 26 nanoseconds to about
22 30 nanoseconds, what portion of that change in

1 stress is due from the tensile wave reflected from
2 the confining (indiscernible due to coughing)?

3 A So this is -- yeah, this part is not a
4 straightforward answer, I would say, so it's
5 probably a combination of both. My chapter 2
6 clearly, that theory clearly indicated. So even
7 without the tensile, how this shock would form.
8 So that's exactly what we see here for the
9 compressive portion.

10 Q So, chapter 2 discusses the theory --

11 A Yeah.

12 Q -- but chapter 3 is the experimental
13 results, right?

14 A Right.

15 Q Just so it's clear --

16 A If we go for some cases where the
17 tensile components is very small. If you go to --
18 can you scroll down?

19 Q Well, I want to focus on this one, just
20 for a sec. We can look at that one later.

21 This --

22 A So.

1 Q Sorry, continue.

2 A The shock, again, is the rapid drop of
3 stress from the maximum there to zero. The
4 tensile portion is more from the catching up from
5 the reflective.

6 Q Can you tell, from this experimental
7 data, what portion of that change in stress,
8 3.15(c), is due to the tensile wave and which is
9 due to the waveform of the compressive wave
10 itself?

11 MR. MATICH: And, Dr. Wang, if you need
12 to look at or point to another part of your
13 dissertation, you can do that.

14 THE WITNESS: Thank you.

15 A So I will refer you to Figure 8 here.

16 So Figure 8, you can clearly see -- so
17 the turning point is the arrow there. So before
18 that, that's the compressive. And after that,
19 that's the -- after that, that's the turning. So
20 before that --

21 Q Dr. Wang, that was not my question. My
22 question is looking at 3.15(c), not 3.15(a). In

1 3.15(c), we see a stress change from negative
2 .6 GPa, all the way up to .6 GPa.

3 Do you see that?

4 A Yes.

5 Q Okay. Can you tell from the data in
6 this experiment, in your dissertation, what
7 portion of that stress change is due to the
8 tensile wave and which is due to the shape of the
9 compressive wave?

10 A It's the stress below zero.

11 Q What is the stress below zero?

12 A Okay. So you see the vertical axis
13 that is from negative .6 to negative -- positive
14 .6, then you have zero in the middle?

15 So from the maximum, from negative 0.6
16 to zero stress, that portion is due to
17 compressive.

18 The very last portion, from zero,
19 continue to rise to about positive .6. That's due
20 to tensile.

21 Q No, I understand that the tensile wave
22 is causing the tensile stress above zero and that

1 the compressive wave is causing the compressive
2 stress below zero. But can you tell, from the
3 data reflected in 3.15, how the tensile wave
4 affected the change in stress in the substrate?

5 A Yes, it went from compressive to
6 tensile. That's how it changed.

7 I'm not sure how to --

8 Q Okay. You can -- maybe I didn't
9 express that question clearly enough.

10 Okay. Let me ask it this way: Why
11 does the slope of the stress, shown in 3.15(c),
12 change from a linear slope from, roughly, 4 -- 3
13 or 4 nanoseconds to, roughly, 26, 27 nanoseconds,
14 to a sharp vertical increase?

15 What is responsible for that change in
16 slope?

17 A That's how fast the stress is changing.

18 Q Why does the stress change that fast?

19 A That's how the material was responding
20 to the stress.

21 Q Do you have an understanding of why the
22 material responds to that stress in that way?

1 A It's based on the nonlinear property of
2 the material. So that's how the stress evolved.

3 So, one is the (indiscernible) material
4 property. The other, there could also be
5 detection limit of the instrument.

6 Q So it's not clear?

7 A Based to our best understanding. So
8 that's basically not to -- if it's -- if it's a
9 theoretically absolute shock. So the slope would
10 be infinite. However, the electronic system has a
11 detection limit, has a response time. So based on
12 the best performance of the equipment, so there is
13 a limited slope for the shock.

14 Theoretically, it should be sharp,
15 infinitely sharp.

16 Q Well, how do you account for the
17 tension wave of equal magnitude overtaking the
18 compression wave? Would that also not show an
19 infinite slope?

20 A So that could also contribute to the
21 non-infinite slope.

22 Q Can you tell, from this depiction in

1 3.15(c), how much the tension wave contributes to
2 that slope?

3 A No, I cannot tell exactly.

4 Q Would you agree that the time that it
5 takes, from the peak compressive stress in
6 3.15(c) -- Sorry. Strike that question.

7 Would you agree that the time for the
8 peak compressive stress in 3.15(c) to go to the
9 peak tensile stress is 2 nanoseconds?

10 A About.

11 Q And that is not zero, correct?

12 A It's not. We experimented with almost
13 zero, but you can never be absolute.

14 Q What was the sensitivity of the
15 instruments used to measure the displacement of
16 the free surface?

17 A Sensitivity? You mean for the response
18 time or -- so the instrument we used to have --
19 there are several PPs in length, it's the
20 oscilloscope that has a 20 gigahertz sample per
21 second sampling rate.

22 Q Okay.

1 A Then there's a detector that has a
2 response time of 200 picoseconds. So that will
3 slow down the -- that's kind of the sensitivity of
4 equipment.

5 Q One second, everyone.

6 A No problem.

7 MR. MATICH: How long have we been on
8 the record?

9 MR. RACHUBA: Are you asking for total
10 time?

11 MR. MATICH: Yes.

12 MR. RACHUBA: We can go off the record.
13 Let's go off the record, briefly, and have the
14 technician read the time in.

15 (Discussion held off the record.)

16 MR. RACHUBA: Let's go back on the
17 record.

18 PLANET DEPOS TECHNICIAN: Okay. Back
19 on the record at 1:18 -- excuse me, 4:18.

20 BY MR. RACHUBA:

21 Q So looking again, at 3.15(c), do you
22 agree that the stress drops from peak compression

1 to zero, along a certain slope?

2 A Excuse me? Can you repeat that
3 question?

4 Q Yes. So looking at 3.15(c), the slope
5 at which the stress goes from peak compression to
6 zero, that's at a certain slope, right?

7 A Yes.

8 Q Okay. And then, the slope from that
9 wave, that goes from zero to peak tension stress,
10 that is also at a certain slope, right?

11 A Right.

12 Q Would you agree, looking at this
13 3.15(c), that that slope is the same?

14 A The slope is changing. It's changing
15 the whole time, from the maximum compression to
16 tension.

17 Q What do you mean by that?

18 A It's the same sign, but not the same --
19 that's why you see a peak value. So that means
20 the slope is changing from zero to a peak, then
21 to -- so it's a changing slope still. Between the
22 maximum compression the maximum tension, they

1 reach maximum value.

2 Q Well, it looks, to me, like the
3 magnitude is changing from negative 6 GPa [sic] to
4 .6 GPa. But it looks, to me, like the slope is
5 the same. In other words, it looks to be a
6 straight line, from negative .6 to .6.

7 Would you agree?

8 A No. It looks linear. Looks like a
9 straight line. That means it looks the same
10 slope. But there is a slight variation there.
11 So, otherwise, it's going to be a straight line in
12 feet, but it's not. It's changing. There's a
13 slight change in that slope.

14 Q Okay. What do you mean by "slight
15 change"?

16 A So, Figure D, basically, correspond to
17 the time derivative of Figure C. So if the slope
18 is constant, you will see, from 26 to 30, a
19 horizontal straight section. But you see a peak
20 there, at about 29 nanosecond, so there is --
21 yeah, there is a slight change in the slope. It
22 appears linear because they compress the

1 timescale.

2 Q The data -- the un -- the data with the
3 uncompressed timescale, that is not included in
4 your dissertation, correct?

5 A So, when we see a compressed, we are
6 mostly comparing to either -- you can think of it
7 as 3.14 feet. So, first, if you go back to the
8 last page for different material, so the -- or we
9 are -- or we can compare with theoretical and
10 compressed. For the theoretically -- the
11 theoretical stress wave is a Gaussian stress wave,
12 similar to the laser pulse.

13 So if you -- you want to go --

14 Q Yeah, I'll bring that up in a second.
15 I'll go to the end of the report.

16 A Okay.

17 Q But I still want to -- I want to stick
18 with 3.15(c) for a little longer.

19 How much time does it take for the
20 stress on the substrate to concede, to go from max
21 compression to zero?

22 A That's about 1 nanosecond, from the

1 figure.

2 Q And how much time to go from zero,
3 after the stress has reached peak compression, to
4 peak tension stress?

5 A Okay. I don't have a cursor. I think
6 you have to draw a horizontal line there. It's
7 about -- both are nanosecond, that's small scale.

8 Q All right.

9 A Yeah, less than a nanosecond. Yeah.

10 So, again, there is not much
11 importance, I think, to dwell on this one because
12 this part is, really, the limitation of the
13 instrument, the experimental -- basically, how
14 fast the instrument can respond to that fast
15 signal.

16 Q Let's move on.

17 Okay. I pulled up Figure 3.16 now.
18 And I think we talked about it earlier, but just
19 to confirm. Each of these different waveforms
20 shown, caused by different lasers, have a tension
21 element, correct?

22 A Excuse me, can you repeat the question?

1 Q Sure. Each of these different -- each
2 of these different lines depicted in this graph
3 are from different lasers, correct?

4 A From a different energy.

5 Q Different energy?

6 A Yeah.

7 Q Okay.

8 A From the same laser, different energy
9 level.

10 Q And they all have a tension element,
11 correct?

12 A Yes. Correct.

13 Q Would you agree that the slopes of
14 these lines are all parallel?

15 A Appears. It appears. But, again,
16 it's -- at that really compressed timescale. If
17 you zoom in, there's always -- there would be some
18 changes. So, yeah, appears parallel, but I
19 wouldn't say absolute.

20 Q Okay. I mean, we're never going to
21 have a perfect absolute measurement, right?
22 There's always going to be --

1 A Right. It's really approaching the
2 limit of the instrument.

3 Q Okay. None of these lines are
4 vertical, though, right?

5 A Right.

6 Q So that means the change in stress is
7 not zero, right?

8 A I don't quite understand. Can you say
9 that again?

10 Q So, it takes some time for each of
11 these lines to change from peak compressive stress
12 towards a tension stress, right?

13 A Yes.

14 Q Does the tension portion in each of
15 these lines indicate that a tension wave outran
16 compressive wave?

17 A Yes. On the same postulation, yes.

18 Q Likewise, in 3.17b, the time that it
19 takes for the substrate stress to go from peak
20 compressive stress to tension stress is not zero,
21 correct?

22 A Correct. Approached there, but not

1 there.

2 Q And in 3.17b, when the stress changes
3 from a compressive stress to a tension stress,
4 does that mean the tension wave outran the
5 compressive wave?

6 A Assumably, yes.

7 Q Same question the 3.18b. The time for
8 the stress wave to go from peak compressive stress
9 to tension is not zero, correct?

10 A Yeah, correct.

11 Q And the tension element in that wave
12 means that the tension wave outran the compressive
13 wave, correct?

14 A Correct.

15 Q Can you explain to me what's going on
16 in Figure 3.19?

17 A So this is -- the top is the fringe
18 signal, bottom is substrate stress.

19 Can you show me the figure caption,
20 please?

21 Q Sure. Sorry.

22 A So this is a thinner fused silica

1 substrate.

2 Q You said a thinner fused silica
3 substrate?

4 A Yes.

5 Q Thinner compared to the experiment
6 shown --

7 A Yeah, previous with the 3 millimeter.
8 This one is 1.5 millimeter thick. Half of the
9 thickness.

10 Q Okay. What is the rise time -- well,
11 scratch that.

12 Is there a tension wave depicted in
13 3.19(b)?

14 A No.

15 Q Is there a compressive wave depicted in
16 3.19(b)?

17 A Yes.

18 Q Would you characterize -- scratch that.

19 Is there a shock shown in 3.19(b)?

20 A No.

21 Q Why is there no shock shown here?

22 A So the shock was not detected by the

1 experiments.

2 Q Do you have an understanding of why it
3 was not detected?

4 A I have some postulation there.

5 Q Well, based on the theories you
6 discussed in chapter 2, you would expect to see a
7 shock here, right?

8 A So, the shock depends on the starting
9 stress level. And, also, depends on evolution,
10 yeah.

11 Q Does it depend -- sorry. Go ahead.
12 Didn't mean to cut you off.

13 A Can you give me a time? I'm scrolling
14 down to the section I discuss this.

15 Q In chapter 2 or in here?

16 A Chapter 3. Let me find the page
17 number, I'll let you know.

18 Q Well, I want to keep this up from my
19 screen, but you can download the report on your
20 end. I don't want to make this a memory thing,
21 but I want to keep this figure up because I want
22 to keep asking questions about it.

1 Earlier, I shared --

2 A I need to look at another section of
3 the dissertation.

4 Q Okay.

5 A Can we -- okay. Can you slow down,
6 please. Okay. Can you show me the figure number
7 again? Which figure are we looking at?

8 Q We're looking at 3.19(b).

9 A 3.19, okay. Can we scroll down again.
10 Can we go back to -- can we scroll up.

11 Q Why don't we start at --

12 A Slow down. Let me -- yeah. Let me
13 see.

14 Q I think it might be addressed on
15 page 70. Let me --

16 A Yeah, let me see here. Sorry. Can you
17 give me the control?

18 Q I can't give you the control, but I can
19 give you the -- you should see -- let me stop
20 sharing.

21 If you go in the chat on Zoom, you
22 should see a copy of your report and you can

1 download and open that in your PDF browser.

2 PLANET DEPOS TECHNICIAN: I can also
3 assist, if needed.

4 MR. RACHUBA: I think that might be
5 helpful.

6 PLANET DEPOS TECHNICIAN: Sure. Would
7 you like me to start sharing the exhibit?

8 THE WITNESS: I have it open on my
9 screen, if you don't mind, now.

10 MR. RACHUBA: I'd rather you not share
11 it. I'd rather Dr. Wang just look at her copy.

12 PLANET DEPOS TECHNICIAN: Sure.

13 A Okay. Now, you can share screen and go
14 to page 70.

15 Q One second. Page 70?

16 A Yeah.

17 Q Okay. I'm here.

18 A The last paragraph, it discuss the why
19 we are not seeing the shock.

20 Q The last paragraph reads "For the
21 1500 micrometer thick fused-silica sample, no
22 fringe turning point was observed for the same

1 range of waterglass thickness (greater or equal to
2 8 micrometers) but significant damage occurred in
3 the test film. A typical interferometric signal
4 obtained for a 0.5 micrometer aluminum film
5 deposited on a 1500 micrometer fused-silica sample
6 with 8 micrometer thick waterglass at 80% of the
7 full YAG power is shown in Figure 3.19. Within 40
8 nanoseconds, 10 fringes developed corresponding to
9 a total displacement of 2.57 micrometers.
10 Significant film damage was also observed."

11 So how does that explain why no shock
12 is shown?

13 A So, basically, the film had a lot of
14 damage in this case. So no shock was detected.
15 So that means there are no clear -- we cannot rely
16 on this data to -- for clear conclusion.

17 So the whole section, actually, part of
18 my focus in this part is we were trying -- we're
19 trying to do parametric study so we can clearly --
20 we only draw concurrence when the shock is
21 basically shown on the data. But in this case,
22 due to the significant damage of the film, so the

1 shock wasn't shown -- wasn't detected.

2 Q Figure 3.19(b) depicts the stress in
3 the substrate, not the film. So why would damaged
4 film have any impact on the stress in the
5 substrate?

6 A So the -- this is experimental data.
7 So the substrate stress is calculated from the
8 data detected from the film's surface.

9 Q Right.

10 A If there is significant film damage,
11 then the -- you won't be able to continually --
12 continue to collect the data. So you don't get
13 the complete stress with signal using the data.

14 Q Why would you not? Why would a damaged
15 film affect what an interferometer measures?

16 A The interferometer, basically, relies
17 on shining a laser light onto the film --

18 Q Right.

19 A -- with the purpose to reflect the
20 light back to the photodetector.

21 So if the film is damaged, depending on
22 the damage level, if it's still flat and

1 reflective, if the light can still go back to the
2 photodetector, there is no problem.

3 But if the film failed extensively, the
4 light won't be able to be reflected back to the
5 detector, then you won't be able to catch reliable
6 data.

7 Q Okay.

8 A That's just --

9 Q Okay. But if we look at 3.19(a), we're
10 still able to see a complete fringe pattern with
11 no interruptions between the peaks. So if there
12 was damage on the film that was to interfere with
13 interferometer signal, you would see some
14 incomplete fringe data, correct?

15 A It depends -- this is -- based on my
16 experience, it depends on the nature of the film
17 failure. Sometimes we see fringes like that
18 because film is damaged but it continues to move.
19 You see a lot of continuous fringes. And other
20 time, you see a sudden drop of the signal. So you
21 suddenly lose the signal. So this could all
22 happen, depending on in what fashion the film

1 fails.

2 Q Well, I guess, regardless of the
3 reason, we can agree that Figure 3.19(b) does not
4 show a shock, correct?

5 A Correct.

6 Q Let's go to page 27 of your
7 dissertation. Sorry. Let's go to page 32 of your
8 dissertation.

9 Do you see that -- do you see the
10 figures on the screen, Figure 2.12, (a) through
11 (c)?

12 A Yes.

13 Q Okay. Can you explain to me what's
14 going on in each of these depictions?

15 A Yes. So this figure shows the
16 evolution of the Gaussian stress spalls in fused
17 silica as it travels through with time.

18 And so, Figure A shows a peak stress of
19 1 GPa, and Figure B, a peak stress of 2 GPa, and
20 Fig. 3 [sic] is peak stress of 3 GPa.

21 So that's, basically, what's generated
22 at absorbent layer. This is theoretical data,

1 based on the theory that initially damaged, due to
2 the stress, is a Gaussian stress of different
3 amplitude. The amplitude depends on the laser
4 energy.

5 So each of these shows how the stress
6 waveform evolved from zero time to a later time
7 and to show how the shock is developed.

8 If we take example of A. So, zero
9 time, T equals zero, that dotted line. That's an
10 initial Gaussian stress. The dotted line is a
11 Gaussian stress. Yeah, good. If you look at,
12 it's a symmetric rise time and fall time.

13 That's based on, theoretically, when it
14 was generated. If we have a Gaussian laser
15 spalls, you have a Gaussian stress spalls. So at
16 the zero time is symmetric. But then after it
17 travels 20 nanoseconds, so that's a solid line.
18 Based on that equation early on, 2.63, different
19 stress will travel with different speed. Lower
20 stress travels faster and the higher stress
21 travels slower. You can get -- you can see the
22 post peak, the fall time, now, has compressed. So

1 the rise time -- the leading edge is stretched so
2 the peak can move to the right of the dotted line.

3 So the leading edge is stretched. The
4 folding edge is compressed. So this will continue
5 to evolve if we just look at the falling edge. So
6 the peak will continue to travel slower, the slow
7 stress will continue to travel faster. By the
8 baseline, that's at the PE for 54 nanoseconds. So
9 after the stress, it will travel 54 nanoseconds in
10 the material. You see, now, the folding edge is
11 compressed almost to a straight line in the middle
12 there. So that's our shock. So now the low
13 stress caught up with the high stress.

14 Q The 54 nanoseconds, that's the
15 rarefaction shock?

16 A Right. That's the -- that's evidence
17 of the shock forming.

18 Q Okay. And so, looking at the timescale
19 at the 54-nanosecond waveform shown, it looks like
20 we go from peak compressive stress to zero
21 compressive stress in -- instantaneously, zero
22 nanoseconds, essentially, right?

1 A Almost. Yeah.

2 Q Let's go to -- I guess before we go off
3 that, in -- looking at that same waveform, 54
4 nanoseconds, what's the distance that that wave
5 would travel at 54 nanoseconds?

6 A Okay. You time that with the wave
7 speed. You get the distance of travel.

8 So, if we just take the standard wave
9 speed of around 5900 meter per second, you time
10 this -- time you get the distance.

11 Q What does the 5900 correspond to?

12 A Excuse me?

13 Q What is the 5900 coming from?

14 A That's the wave speed of fused silica.

15 Q Okay.

16 A We talked before twice. It's a rounded
17 number.

18 Q Okay. So if we're going 5900 -- strike
19 that.

20 Okay. Turn, now, to page 37 of your
21 dissertation, Figure 2.15.

22 Can you explain to me what's going on

1 here?

2 A This figure is showing the attenuation
3 of the stress as it travels through the substrate.
4 Figure A shows the attenuation factor. Figure B
5 shows the remaining peak stress.

6 Q What do you mean by remaining peak
7 stress?

8 A This is after the peak stress travels
9 through certain thickness of the substrate.

10 Q Oh. So this is, like, the tail end of
11 the stress wave?

12 A This is what you can detect at a
13 distance. For example, if you have fused silica
14 of 3 millimeter, after it travels through that
15 whole distance, what's the peak stress you can
16 detect.

17 Q Okay. Turn now to page 79 of your
18 dissertation, looking at Table 3.6.

19 A Okay.

20 Q What is shown here in 3.6?

21 A This is the interface strength of a
22 1.8-micron-thick aluminum film deposited on

1 3,000-micrometer-thick fused silica substrate,
2 measured by experiments.

3 Q What is interface stress on the last --
4 what's the difference between the interface stress
5 in the last column and the interface stress in the
6 column to the left on the last column on the
7 right?

8 A So, this is interface stress calculated
9 using two versions of the equation. One is for
10 using a thin-film assumption, the other is for
11 using a thick-film assumption.

12 Q What do you mean by that?

13 A So, this refers to -- we can -- we can
14 look at equation 2.46 and 2.47. If you can scroll
15 back, show me those equations, I can explain.

16 Q Here's 2.46 on page 19 of your
17 dissertation.

18 A Okay. Let me see. Okay. So this is
19 by using the -- okay. So this, by taking the
20 derivative -- let me see.

21 Can we see equation 2.47. Right.

22 Okay. So, the simply -- when the

1 film -- okay. Let's go to the Appendix B. Yeah,
2 go from there. That's the exact equation. And
3 this one is the simplified equation.

4 Okay. Okay. I need to look at the
5 paper again. Okay. I think it's okay. That's
6 good.

7 Q Hold on a second. It was on -- I
8 forgot the page number. This table, 3.6.

9 A 17, 18. Okay. Let's go to B17, B18
10 equation.

11 Q Okay.

12 A So, the two sets of equations, one is a
13 simplified equation. We use a lot in publication.
14 Assuming film thickness is small comparing to the
15 actual stress wavelength in the substrate. So the
16 other is the more exact equation that's modeled
17 here, for large film thickness. And then for --
18 so this also --

19 Q Okay. So, it's theoretically
20 calculated maximum interface stress, right?

21 A Right -- no, the equation is theory.
22 So you derive the equation using the

1 one-dimensional wave mechanics theory. One is the
2 accepted equation, taking account of the acoustic
3 mismatch between the film and the substrate
4 interface. And, also, taking account into the
5 superposition of the reflected tensile and
6 still-incoming, remaining compressive wave.

7 So that's the last column.

8 Q Okay.

9 A In the second-to-last column, this is
10 assuming the film thickness is so small, so the
11 tensile, the reflective tensile and the incoming
12 compressive can be approximated using a second
13 derivative of the surface displacement is now
14 equivalent to -- interface stress is proportionate
15 to the mass of the film times the second
16 derivative. So this was all derived in the
17 dissertation. It's just two versions of the
18 stress, comparing how much the simplified equation
19 would deviate from the exact equation.

20 Q Okay. So if you were to run the test
21 for the results shown in Table 3.6 using a
22 0.5-micrometer-thick aluminum film but kept all

1 other conditions the same, would you agree that
2 the interface stress would be less than 370 MPa?

3 A The stress, not the strength? Yes.
4 For the same laser, everything the same, just the
5 film thickness is different, yes.

6 Q If you look at the table shown in 3.22,
7 would you agree that none of these lines represent
8 a peak compressive stress going to a tensile
9 stress in zero seconds?

10 A Near zero, not exact zero. There is a
11 finite slope.

12 Q Is this because the tension wave would
13 overtake the compressive wave?

14 A Again, this is experimental data, so
15 it's very hard to capture absolute shock. So
16 that's a response time of the instrument and the
17 reason we talked earlier.

18 Q Okay.

19 MR. MATICH: Dr. Wang, do you need a
20 break?

21 THE WITNESS: Actually, yes. Can we
22 have a short break?

1 MR. RACHUBA: Sure. Yeah, we've been
2 going about an hour. Let's take a ten-minute
3 break.

4 THE WITNESS: Sounds good. Thank you.

5 MR. MATICH: How long have we been on
6 the record now?

7 (Recess taken from 5:02 p.m. to
8 5:16 p.m.)

9 MR. RACHUBA: Let's go back on the
10 record then.

11 BY MR. RACHUBA:

12 Q Welcome back, Dr. Wang.

13 A Thank you.

14 Q Did you speak with anyone regarding the
15 substance -- sorry, strike that.

16 Did you speak with anyone regarding the
17 substance of your testimony today during the
18 break?

19 A No.

20 Q Dr. Wang, I'm going to share your
21 dissertation again.

22 A Okay.

1 Q Hold on one second.

2 I have page 65 of your dissertation up
3 on my screen.

4 Do you see that?

5 A Yes.

6 Q About halfway down in the page, there's
7 a sentence that reads "The falling tail end of the
8 pulse has been compressed by the same amount. An
9 initial fall time of a few nanoseconds has,
10 therefore, been reduced to nearly zero and occurs
11 long before the pulse arrives in the test fall."

12 Do you see that?

13 A Yes.

14 Q Okay. What did you mean by that
15 sentence?

16 A That's what illustrated by the previous
17 figure, when we talk about the evolution of the
18 stress wave to form a shock. So it means the
19 post-decay time has significantly reduced from the
20 original rising time and the fall time, to a
21 near-zero decay, that's from the maximum
22 compression to the zero stress.

1 Q And a near-zero decay, would that be
2 longer -- a near-zero decay, would that be shorter
3 than 1 nanosecond?

4 A I wouldn't try to distinguish too much.
5 That's, basically, the tail we have been talking
6 about, that slope.

7 Q Right. I'm just trying to get --

8 A Yeah, so you can think about a
9 nanosecond or, yeah, a sub-nanosecond. There are
10 no -- I don't think it's -- there's significant
11 importance to talk about 1 second versus .5 or
12 1.5. Basically, significantly shorter than the
13 original decay time. And much longer than the
14 linear rep. The linear rep is now 20 to
15 30 nanoseconds. So the full time is only about a
16 second -- a nanosecond or less.

17 Q Let's go look at that 3.15 what that
18 sentence is discussing.

19 A It's discussing the time of the last
20 part, the rising part versus the linear ramp going
21 down to the left of the peak.

22 Q So we're talking about from max

1 compressive stress to max tensile stress?

2 A Right. So we're talking about that
3 part, near-zero decay. Actually -- yeah. So
4 that --

5 Q Are you talking -- sorry.

6 Are you talking about the time to go
7 from max compressive stress to zero or --

8 A Right.

9 Q -- compressive stress to max tensile
10 stress?

11 A I was mostly talking to reduce to zero.

12 Q Okay. And are you able to tell, from
13 this data, what causes that stress to go from max
14 compression to zero?

15 A You have to rely on the (indiscernible)
16 we analyzed earlier to understand this data. Just
17 from the data itself, nobody can tell. Basically,
18 that's just what's shown, what's collected from
19 experiments. However, based on prior art by
20 Barker and Hollenbach and by my theoretical work,
21 so we could understand this as due to the shock
22 value.

1 Q So you cannot confirm shock based on
2 experimental data alone, correct?

3 MR. MATICH: Objection.

4 A Yes. You can. But that's a shock. So
5 shock is here, clearly indicated by this data.

6 Q So given, in 3.15(c), that the tensile
7 wave overtakes the compressive wave, are you able
8 to tell, from experimental results, whether that
9 wave -- whether the compressive wave completely
10 dissipates before it enters the interface?

11 A So, fact that there is this linear ramp
12 and this full compressive stress wave is an
13 indication it is not completely dissipated. This
14 linear ramp is exactly what's predicted by the
15 reference when you have a compressive stress that
16 evolves into a shock. So the linear acceleration,
17 that's exactly what's shown here and predicted by
18 theory.

19 Q When you talk about linear ramp, what
20 are you referring to?

21 A The rising part of the stress, from
22 zero to 92.6 gigapascals, that portion. So that's

1 almost a linear ramp. That's predicted by theory.

2 Q Okay. But we agreed earlier that from
3 when the stress is at maximum compression and
4 negative .6, and we go to positive .6 GPa, that is
5 due to the overtaking by the tension wave from the
6 confining layer.

7 Now, given that the tensile wave
8 overtakes the compression wave, how are we able to
9 tell whether or not the compressive wave
10 dissipates before reaching the interface?

11 A So, I want to clarify. So the tensile
12 wave uptaking would only contribute to the
13 positive part, to contribute to the stress above
14 zero there.

15 Q What is your basis for that?

16 A So the turning point in the fringe,
17 that's at the stress at zero. And before that,
18 that was a compressive stress.

19 Q What is your basis -- if the tensile
20 stress is acting in the opposite direction of the
21 compressive stress, why would the tensile stress
22 only affect stress above zero? Would it not have

1 an effect on the compressive stress below zero?

2 A So, okay, for this question, it doesn't
3 matter. So what matters would be whether the
4 shock is there or not. And there is no --

5 Q Why do you say whether it matters?

6 A Again, it's a postulation. So the
7 reflected tensile, that's from the backside of the
8 confining layer. That one is less controlled as a
9 compressive, as a substrate.

10 You could say it's attributed to that,
11 but, clearly, that's about the shock.

12 Q So, let me see if I understand.

13 The shock can be caused by the tensile
14 wave overtaking the compressive wave, but it
15 doesn't matter so long as there's a shock?

16 A It could cause. But it doesn't need
17 it. The shock would evolve with certain distance
18 propagating with the compressive stress
19 propagating through the substrate.

20 Q That is one way. Your opinion that
21 it's one way for the shock to evolve. Another way
22 is the tensile stress wave to overtake the

1 compressive stress wave, correct?

2 A Not to -- let me -- it could
3 contribute.

4 Q What do you mean by "contribute"?

5 A So, the shock development doesn't need
6 the tensile, but the tensile overtake would
7 contribute to the development of shock, and that
8 would lead to the tensile portion of this stress
9 above zero.

10 Q Okay. What is the basis for your
11 position that the compression wave would result in
12 a shock without contribution from the tensile
13 wave?

14 A So that's, again, predicted by my
15 theoretical model. And, also, that was done by
16 looking the behavior here compared to what --
17 yeah.

18 Q So do you have any experimental results
19 that support your theoretical opinion that the
20 shock would develop without the overtaking tensile
21 wave?

22 A So the overtaking is a postulation.

1 That part, experimentally, there are no way to
2 kind of firmly confirm that. In some cases, the
3 backside confining layer is completely off. And
4 then for that, when the confining layer was off,
5 that means the wave cannot have been reflected.
6 So that's -- that happens a lot also. However,
7 for this work, our focus wasn't focused on that
8 because we were focusing on whether we have shock
9 or not. And so, we did a parametric study and
10 focused on one situation by optimizing all these
11 parameters to obtain this shock.

12 Q In your dissertation, is there any
13 experimental data where the confining layer was
14 not present?

15 A So, I didn't systematically track that.
16 Some situations were. When the laser parts were
17 low so the confining layer was there, but a lot of
18 cases, the confining layer was far off from the
19 sub -- on the back already. So, yeah, so that
20 wasn't part of the primary focus at that time. So
21 that wasn't a primary focus. So that's why I
22 cannot recall, just sitting here, which one is

1 which.

2 Q Why don't we go through the different
3 data in chapter 3 and see if we can find any
4 confining layer.

5 Would you agree that the only way to
6 determine whether the spike in the compressive
7 stress wave was due -- was not due to the tensile
8 wave would be if there's no confining layer?

9 A You can't have multiple waves. Either
10 the confining layer is off or the confining layer
11 is so thick then the tensile wouldn't catch up,
12 probably.

13 Q What is the basis for your position
14 that the confining layer being so thick that the
15 tensile wave would not catch up? Is that
16 disclosed in your paper that we're looking at?

17 A No. It was not a focus, so we,
18 basically, never paid a lot of attention to that.
19 It's my understanding, based on many, many years
20 of working this field. So if the confining layer
21 so thick the wave has to go back to catch up with
22 the front compressive wave, it takes time.

1 Q But that's not disclosed in your
2 dissertation, correct?

3 A I don't recall sitting here, yeah,
4 without going line by line.

5 Q Okay. So, earlier, we established that
6 chapter 3 is the only relative chapter with
7 experimental data.

8 Let's go through what is shown.

9 Actually, I think we talked about it --
10 we talked about the sample fabrication. And as
11 shown in Figure 3.2, a confining layer is the
12 waterglass layer that's between .4 and
13 30 micrometers thick.

14 You can take your time to scroll
15 through the version that you have of your
16 dissertation as well. But I'm not seeing, in
17 Section 3.2.3 of your report, a sample fabrication
18 method that does not include a confining layer.

19 Would you agree?

20 A Okay. To clarify, the sample
21 configuration, the confining layer is always
22 there. What I see is off, is when the laser

1 absorbs the energy, the thermal expansion, if it's
2 only thermal expansion, so that confining layer
3 will stay there. But sometimes the whole backside
4 is completely ablated off. That's when I say
5 there's no confining layer. At the fabrication
6 stage, confining layer is always there. It's
7 after the shock of the laser pulse.

8 Q Okay. But even -- okay. So in each of
9 your experimental data run, there was a confining
10 layer present, at least initially?

11 A Right.

12 Q Okay. So in a situation where you have
13 the confining layer completely ablated off, why
14 would you not still have a tension wave reflected
15 towards the substrate before complete ablation?

16 A It's just the instantaneous thermal
17 expansion evaporation, that process immediately
18 removes the backside.

19 Again, all this -- some of this is
20 postulation because we never had high-speed camera
21 to really capture that nanosecond event. It's
22 after the experiment, when you look at the back

1 surface, sometimes the waterglass is still there.

2 Sometimes the waterglass is gone.

3 Q So, whether a tension wave was not
4 formed is pure speculation, correct?

5 A Yes. Based on the -- yes.

6 Q Earlier, we were talking about the
7 speed of the rebounded tension wave on the
8 confining layer.

9 Would that rebounded tension wave be
10 modified in the fused silica substrate?

11 A So if we assume the same equation, same
12 conservative relationship, it's still varied for
13 the whole tensile wave, yes, it will be modified.

14 But I never modeled -- never paid close
15 enough attention to that.

16 Q But didn't we establish, earlier, that
17 the same equation wouldn't be applied because the
18 tension wave would overtake the compression wave?

19 A Again, that's my position --
20 speculation. I assumed that it applied, explains
21 why we have a tensile wave catching up. But I
22 never -- I never did refresh myself to study the

1 tensile behavior for the stress-strain
2 relationship for fused silica. Nor did I find any
3 reference, at that time, devoted to that behavior.

4 So people mostly studied shock
5 behavior, just the compressive behavior.

6 Q Okay. So if it's your postulation that
7 the tensile wave behaves differently than the
8 compressive wave, which allows the tensile wave to
9 overtake the compressive wave, wouldn't it
10 necessarily follow that the tensile wave would not
11 be modified?

12 A So, if you assume the same accretion
13 hold, again, it really depends on what kind of
14 sampling you take. If I postulate the same
15 behavior and the tension and the compression, the
16 same equation hold, then the tensile wave will
17 also be modified.

18 Q But that is contrary to your
19 postulation that the same equation did not apply,
20 correct?

21 A No. So, I -- my postulation is if we
22 are following the same behavior for tensile

1 stress, the same equation, the higher-stress
2 tensile will catch up with a lower stress. So the
3 same -- it will -- modify, basically, means if we
4 effect a waveform. So -- I would expect it
5 modifies, but I don't know the precise, how much
6 because there's no published data on the stress
7 wave relationship for the tensile part.

8 Q So, I understand that there's no --
9 nothing in the record, right now, regarding the
10 effects of the tensile waveform. But we spoke
11 earlier -- when we spoke earlier, it was your
12 testimony that --

13 A Oh, okay.

14 Q Can I go ahead?

15 A To clarify. So I -- when we spoke
16 earlier, I possibly say that we apply the same
17 equation. Same equation that tensile stress will
18 go faster. Higher stress go faster than lower
19 stress. So you would still modify the stress
20 wave. But instead of allowing acceleration follow
21 the peak at the end for the tensile, you will see
22 a peak at the beginning.

1 Q So almost like the opposite of what you
2 would expect to see with compression?

3 A Right. Right.

4 Q Dr. Wang, is shock a feature or a
5 property of a waveform? Sorry, I didn't mean to
6 ask like I was adding something on to the
7 sentence. That was the full of my thought.

8 Is the shock a feature or a property of
9 a waveform?

10 A I would say it's a feature in the
11 waveform. That's the sudden change of the
12 amplitude of stress.

13 Q So when we were looking at your
14 dissertation, though, let's say -- we spent a lot
15 of time on 3.15, I think that's the easiest to
16 explain things to myself at least. I'm going to
17 share that dissertation again.

18 Do you see it up on your screen,
19 page 64 of your dissertation?

20 A Yes.

21 Q So we're talking about 3.15(c), where
22 the shock, or what you characterize as the shock,

1 shown. This shock isn't necessarily part of one
2 waveform. We talked about this could be the
3 result of combining the compression wave and the
4 tensile wave, right?

5 A It could be. But it could also just
6 result from the compressive, itself.

7 Q Right.

8 A Yeah.

9 Q Okay. Okay. I understand. I'm just
10 trying to characterize whether shock is just a
11 difference in stress or part of a property of a
12 wave?

13 A It's the sudden change of stress.

14 Q Okay. So for purposes of your opinion
15 and testimony in this case, shock can mean either
16 a -- a waveform can have a shock property or a --
17 you can show shock on a stress-over-time plot,
18 right?

19 A So, shock is a special feature of
20 waveform. So, shock can be indicated by the
21 waveform when you have a sudden drop or sudden
22 increase of stress or pressure.

1 Q Okay. So I think we got sidetracked a
2 little bit earlier.

3 We were talking about with respect to
4 3.15, for the experimental data, two possibilities
5 of generating shock, one would be the tensile wave
6 overtaking the compression wave, and two would be
7 the properties of the compression wave itself,
8 right, as it passes through the fused silica?

9 A To clarify, only a tensile wave can top
10 a compression wave. It doesn't necessarily form
11 the shock, if the stress change is gradual. So
12 you have to have a sudden change. So that change
13 has to happen rapidly.

14 Q Right. Okay. I understand.

15 A Yeah.

16 Q So we have two possibilities to form
17 that shock, right, a rapid overtaking in change
18 due to the tensile waveform or something inherent
19 in the compression wave that's modified fused
20 silica?

21 A So I studied the more comprehensive on
22 the compressive part.

1 Q Okay.

2 A Yeah.

3 Q Are you aware of any data in your
4 dissertation that demonstrates a shock that is
5 solely due to compressive forces and no tensile
6 effect?

7 A So that's -- I would think -- so I had
8 a lot of data, I think, but just thinking.
9 Majority of the data did show a tensile portion.

10 Q Are you aware of any data that does not
11 show a tensile portion?

12 A I don't recall, sitting here. And I
13 think there were cases where either very small
14 tensile or close to no.

15 Q Sharing your dissertation again.

16 Back on page 64. Looking at 3.15,
17 Figure 3.15.

18 What is the amplitude of the substrate
19 stress in Figure 3.15(c) immediately after
20 generation of the compression wave after laser
21 impingement?

22 A That part is not available here. This

1 is a stress matter near the film surface. You can
2 only see -- this is after all the attenuation
3 that's what matter. We don't know -- you can't
4 know exactly what were the stress because you have
5 to take into account all the attenuation,
6 absorption, so, it should be much higher.

7 Q Okay. Let's look at 15D [sic].

8 Is there any preloading compressive
9 stress shown in 15D?

10 A Yes.

11 Q Where is that shown?

12 A That's -- that's a low stress between
13 zero and the 25-ish. So that's -- that's a low
14 compressive stress there.

15 Q Well, that stress looks like it
16 oscillates back and forth between tensile and
17 compressive, right? It's not purely compressive
18 stress?

19 A So that part, yeah. So, the wiggles is
20 due to experimental noise.

21 Q And the only significant stress that
22 the interface sees is the tensile stress; would

1 you agree?

2 A That's right.

3 Q What causes that tension spike in 15D?

4 A So that's when the whole interface will
5 go through the stress and based on the reflected
6 tensile stress and the incoming compressive
7 stress. So at some point, that stress reaches a
8 maximum that's indicated by this peak here.

9 Q So it's your opinion that the tensile
10 stress shown in 15D, that spike is caused by the
11 compressive waveform passing through the
12 substrate, rebounding off the free surface?

13 A Right.

14 Q What is the basis for your opinion?

15 A That's the wave practices, that's the
16 practice of stress waves when it reaches a free
17 surface. It will rebound.

18 Q Well, could that tensile stress also be
19 caused by the tensile waveform that we discussed
20 earlier, that's passing through the substrate
21 already?

22 A So if -- so in this case, based on this

1 data here, this tensile stress still corresponds
2 to the last portion of the compressive stress
3 data, to the slope of the last portion. We think
4 it's still caused by the reflected. Otherwise,
5 let me think.

6 Okay. No, it shouldn't be by the
7 reflected.

8 Q Please explain.

9 A So this is the practice of shock wave.
10 So once a shock is formed, it will maintain that
11 shock feature and, so, it wouldn't go -- so the
12 rising tail will stay behind the linear ramp, it
13 will just get stretched with distance. It will
14 not go further before the compressive ramp.

15 Q What do you mean by that? I don't
16 follow that.

17 A Okay. So, we could go back to chapter
18 2 somewhere. I explained the shock attenuation
19 and the continuous evolution of the shock wave
20 once it's formed.

21 Q But we established earlier that --

22 A So at that time, it will overtake, but

1 it will not go further past the compressive. And
2 so the shock, once it's formed, it will follow the
3 linear ramp, continue. It may become sharper, but
4 it won't go beyond that point. So it should still
5 be that reflected.

6 Q So you're saying before the stress wave
7 propagates through the interface, the tensile wave
8 will catch up to the compressive wave but it won't
9 pass it?

10 A No.

11 Q So they will actually be on top of each
12 other?

13 A Right. Once the shock is form.

14 Q Once the shock is formed. Okay.

15 So if we look at that in 15c, then,
16 that that shock has a tensile --

17 A The tensile is behind the compressive.

18 Q Well, that's not what's shown in 15c.
19 What we're seeing in 15c is that either the
20 tensile waveform has overtook and passed the
21 compression waveform, or what you just explained,
22 that the tensile waveform is overlapping.

1 A So that is a slope. Will at most be
2 vertical. It will never go the other direction.
3 So the tensile will not go before the compressive.
4 It will follow the compressive.

5 Q Okay. So but it is --

6 A So once the shock is formed, so that
7 shock will continue to evolve, continue to
8 stretch, and the lower amplitude, but it will
9 not -- the tensile will not go before the
10 compressive.

11 Q So the tensile would not go before the
12 leading edge of the compressive waveform, right?

13 A Right, right, correct.

14 Q But it would go -- it would still go
15 past the peak of the compression waveform, right?

16 A It will not go past the time. So that
17 tensile is behind the maximum compressive. So
18 when it catches up exactly, it can only drop to
19 zero or slow -- but it will not go -- the slope
20 will not go the other direction. The slope can
21 become infinitely shocked.

22 Q How do you know the tension waveform is

1 not past the peak compressive waveform?

2 A So that's based on my knowledge about
3 the shock property. Also by the theoretical work
4 early on. So once the shock wave is formed, the
5 shock -- for treating edge will stay there.

6 Q What is the shock velocity?

7 A Shock velocity is the speed before and
8 after. You will take the average of that.

9 Q Is the shock velocity slower than the
10 tension waveform speed?

11 A Slower? So, again, I think -- so the
12 shock velocity is modeled as the average before --
13 the velocity before and after. So the tensile
14 speed can catch up with the shock, but it will not
15 go over.

16 Q Can you explain, in your own words, why
17 the tension waveform will not overtake the shock?

18 Dr. Wang, may I ask you what program
19 you have open on the computer right now?

20 A It's my dissertation.

21 Q Okay.

22 A Yep. So my answer is based on the

1 experimental -- of the reasons we observed. We
2 never -- if the tensile stress overtakes that, I
3 would expect the slope will, first, become
4 infinitely sharp, then go to other direction. But
5 I never seen that.

6 Q Why would you expect the slope to be
7 infinitely sharp from the tension wave --

8 A One second. I would expect that
9 will -- honestly, I have never seen that behavior.
10 So that's based, you know -- okay.

11 Q Sorry, go ahead.

12 A I think when the substrate fringe, that
13 might happen. That's when you do not see the
14 shock, that's when you wouldn't detect a shock,
15 probably.

16 MR. RACHUBA: I think now is a good
17 time for a break. We've been going about an hour.
18 Let's go off the record. Let's take a ten-minute
19 break.

20 And then when I get back, we'll also
21 see how much time we've spent on the record.

22 PLANET DEPOS TECHNICIAN: Okay. Off

1 the record at 6:13 p.m.

2 (Recess taken from 6:13 p.m. to
3 6:28 p.m.)

4 PLANET DEPOS TECHNICIAN: All right.
5 Back on at 6:28 p.m.

6 BY MR. RACHUBA:

7 Q Dr. Wang, did you speak with anyone
8 regarding the substance of your testimony during
9 break?

10 A Excuse me?

11 Q Did you speak with anyone regarding the
12 substance of your testimony while we were on a
13 break?

14 A No, I didn't.

15 Q What is the speed of the front end of
16 the compressive waveform in the fused silica?

17 A The front end would be around that
18 standard speed of 5900, the number we talked
19 about, the C subzero.

20 Q Right. What would the speed of the
21 peak of the compressive waveform be in a fused
22 silica?

1 A So that's by decreasing. You plug in
2 the peak stress into that.

3 Q Slower than 5900?

4 A Slower than the front end, yeah.

5 Q What would be peak of a tensile
6 waveform -- strike that.

7 What would be the speed of the peak of
8 a tensile waveform fused silica?

9 A I don't know sitting here. I'm not
10 aware of a good, very established studied for the
11 tensile behavior.

12 Q Showing your dissertation again.

13 I'm on page 65 of your dissertation.

14 I'm looking about at the bottom of
15 page 65. I'm going to read a portion into the
16 record. "Assuming a plausible longitudinal wave
17 speed in the confining layer, the original
18 compressive pulse is followed, about
19 30 nanoseconds later, by tensile pulse of
20 comparable magnitude. Being tensile, it
21 propagates faster than the peak compressive stress
22 and faster than the low-stress tail of the main

1 pulse and eventually overtakes the compressive
2 pulse and linear dissipative mechanisms govern the
3 final thicknesses of the shock. In Figure 3.5 the
4 shock is followed by a regime in which the
5 velocity has changed sign, indicating the tensile
6 pulse has overtaken the compression pulse."

7 So going back up to Figure 3.15, do you
8 still agree with the portion of your dissertation
9 that I just read, that the peak of the tensile
10 waveform overtakes the peak of the compressive
11 waveform, as shown in Figure 3.15?

12 A Right. By assuming the same
13 relationship.

14 Q So you understand that to mean, as
15 depicted in 3.15, the peak of the tension waveform
16 reaches the interface before the peak of the
17 compression waveform?

18 A That seem to indicate so.

19 Q Okay. So, if we look at 15D.

20 PLANET DEPOS TECHNICIAN: Sorry to
21 interrupt. Dr. Wang, can you just please make
22 sure that your mouth is in the frame so that the

1 court reporter can read your lips, if necessary.

2 Thank you so much.

3 MR. MATICH: I think we may need to go
4 off the record for a second to relog into the
5 Wi-Fi.

6 MR. RACHUBA: Okay. All right. Let's
7 take, like, a two-minute break or so.

8 MR. MATICH: Yeah. I don't think we
9 need to go any more.

10 MR. RACHUBA: Okay. I'll just mute
11 myself and hang out until Dr. Wang gets back on.

12 PLANET DEPOS TECHNICIAN: We're off the
13 record at 6:33.

14 (Recess taken from 6:33 p.m. to
15 6:38 p.m.)

16 PLANET DEPOS TECHNICIAN: Back on at
17 6:38 p.m.

18 BY MR. RACHUBA:

19 Q So looking, again, at Figure 3.15d,
20 Dr. Wang. If the peak or the tension waveform --
21 strike that.

22 If the peak of the tension waveform

1 arrives at interface 4 of the compression
2 waveform, and we established, earlier, that the
3 compression waveform has the same magnitude as the
4 tensile waveform, wouldn't the tensile waveform be
5 responsible for the tensile stress shown at the
6 interface in 15D?

7 A It could. Depending on the magnitude.
8 But for this specific waveform, based on the time
9 sequence, so the peak stress came from the --
10 following the compressive. So it's possible.
11 If -- yeah, I would say both scenarios are
12 possible. So either you can reach a high tensile
13 when the stress catches up or the shock was
14 reflected.

15 So either way, you will reach a very
16 high tensile stress in the interface.

17 Q Is it possible to tell, from your
18 experimental data, whether the tensile stress
19 shown in the interface is from the tensile wave,
20 itself, or the reflected compression waves?

21 A I don't think so. So either way, there
22 is a very high tensile stress reached in the

1 interface.

2 Q I understand. And that tensile stress,
3 whatever the cause, that results in the film
4 separating at the interface?

5 A Right.

6 Q Going back down to Figure 3.19. I
7 believe it was your testimony earlier that there
8 was a film failure in this experiment, correct?

9 A I believe so. Can we go to 3.19?

10 Q Sorry. Do you not see that? What do
11 you see right now?

12 A Page 65.

13 Q Oh, sorry. Sharing the wrong screen.
14 Sorry about that.

15 Do you see 3.19 now?

16 A Yes.

17 Q So I believe it was your testimony,
18 earlier, that there was a failure in the film --

19 A Right.

20 Q -- correct?

21 If there was a failure in the film, did
22 you rerun the experiment?

1 A So we did -- we did a lot of
2 experiments. And because this kind of a failure
3 they bring -- so it's not clear, so we rerun. We
4 do rerun experiments.

5 Q You reran the experiment but chose to
6 put the version of the experiment with the failed
7 film in your dissertation; is that correct?

8 A This case happens a lot with thin fused
9 silica substrate. So we stayed, mostly, with a
10 thicker fused silica substrate when the shock is
11 clearly indicated. So we -- so instead of using
12 this kind of one, when it's hard to tell whether
13 there is shock or not because the signal is not
14 indicative enough.

15 Q Based on the theory discussed in
16 chapter 2 of your dissertation, would you expect
17 to see a shock at 1 NPa?

18 A So, we -- I do, I think we expect to
19 see a shock. So, this lack of shock in the stress
20 might be due to the film damage that comes in the
21 way of the signal connection.

22 Q What was the limit of your

1 instrumentation, in terms of the smallest time it
2 could resolve a fringe?

3 A I remember we used different detector.
4 The fastest, at that time, we used was
5 200 picoseconds in response time. Yeah, so
6 there's a -- that response time and the
7 oscilloscope is the 5 gigahertz, 20 gigs per
8 second sampling rate.

9 So you can take about 200 picoseconds
10 as a response time.

11 Q And 200 picoseconds is .2 nanoseconds,
12 correct?

13 A Correct.

14 Q So, a drop in peak stress to zero can
15 easily be measured within 0.2 nanoseconds, right?

16 A Ideally, yeah. However, I think for
17 old instrumentation. So the actually achievable
18 resolution or response time is always slower than
19 what's claimed by the spec sheet.

20 Q How much slower?

21 A It's a rule of thumb. You times that
22 by ten. So, ideally, it should, but that's a --

1 yeah, hard-to-achieve number, I would say.

2 Q I'm going to turn, now, to page 141 of
3 your dissertation. This is the very last
4 paragraph of your dissertation on -- 124 of your
5 dissertation, 141 of the PDF.

6 Last paragraph reads "In the current
7 research, the intrinsic interfacial strength for
8 aluminum/fused-silica substrate is determined for
9 both tensile and mixed-mode loading cases. Fused
10 silica is found to be an ideal substrate material
11 for launching high-amplitude shock waves (its
12 negative nonlinear elasticity being critical for
13 the development of decompression shock). By
14 inserting an extra layer of the desired substrate
15 material between the fused silica and the thin
16 film, the current technique can be used to test a
17 variety of substances and films, especially those
18 interest of in microelectronics industry, such as
19 polyimide, copper, aluminum, and polysilicon on
20 single-crystal silicon substrates."

21 Do you see that?

22 A Yes.

1 Q And this paragraph is under the heading
2 Future Work, Section 5.2 of your dissertation.

3 Do you see that?

4 A Yes.

5 Q So my question to you is, do you ever
6 perform this future work of inserting an extra
7 layer of the desired substrate material between
8 the fused silica and the thin film?

9 A Yes.

10 Q When?

11 A You saw my later work.

12 Q Do you have an approximate year?

13 A It's probably -- we did this multiple
14 times. So one is inserting fused silica in front
15 of silicon. We also did use fused silica in front
16 of tungsten. So we applied this multiple times.

17 If I recall right, it's a 2006 paper
18 for interfacial adhesion of zero-light coatings on
19 silicon substrate.

20 Q Why did you not perform that work
21 before 2006?

22 MR. MATICH: Objection.

1 Mischaracterizes testimony. Outside the scope.

2 MR. RACHUBA: You've got to keep these
3 speaking objections out. You can object to form.

4 MR. MATICH: Roman, Roman. Stop
5 interrupting me, please.

6 MR. RACHUBA: Nick, I'm telling you the
7 law before the PTAB, and speaking objections are
8 not allowed. I can identify you specific cases.

9 MR. MATICH: Roman, I barely object to
10 anything and you're the one that keeps talking.
11 If you hadn't interrupted me, I'd be done already.

12 MR. RACHUBA: It's not the fact that
13 you're interrupted -- well, it is the fact that
14 you're interrupting, but it's the fact that your
15 speaking objections are coaching the witness.

16 MR. MATICH: Roman, you're also
17 proceeding outside the scope of her declaration,
18 which the rule of the PTAB is your questions have
19 to be --

20 MR. RACHUBA: Nick, you can object to
21 form -- you can object to form or you can instruct
22 the witness not to answer on the basis of

1 privilege, in which case we would challenge that.

2 MR. MATICH: No. And you are not
3 allowed to ask questions that are outside the --

4 MR. RACHUBA: Fine. Let's go off the
5 record. Let's go off the record here.

6 PLANET DEPOS TECHNICIAN: Okay. Off
7 the record.

8 MR. RACHUBA: I don't know why I said
9 that. I want the conversation on the record. So
10 let's go back on the record.

11 PLANET DEPOS TECHNICIAN: On the
12 record.

13 MR. RACHUBA: So, Nick, I'm asking
14 questions that are -- I'm asking about a question
15 that's the language directly in Dr. Wang's
16 dissertation.

17 MR. MATICH: You're asking about work
18 that -- you're asking about work that she
19 performed later and isn't discussed in her
20 declaration. If you want to keep asking about
21 that, fine. I just want to lodge my objection.

22 MR. RACHUBA: That's fine. Lodge your

1 objection.

2 MR. MATICH: So, why don't you ask your
3 question again and we'll keep going.

4 MR. RACHUBA: Okay.

5 BY MR. RACHUBA:

6 Q So, Dr. Wang, we were discussing the
7 Future Work section of your dissertation. And if
8 I recall your testimony correctly, you testified
9 that you performed this described future work in
10 around 2006, correct?

11 MR. MATICH: Objection. Outside the
12 scope.

13 A I propose in the thesis and it's
14 tabulation of feasibility based on the work
15 already. So that's just something -- yeah, so I
16 did follow up later on, after experiments.

17 Q Why did you wait until 2006 to perform
18 this work?

19 MR. MATICH: Same objection.

20 A So, at the time, so for Ph.D., this
21 is -- this is science. You don't -- you can't do
22 everything you wanted to do. So at that point, my

1 advisors and the committee decided that was not
2 enough so -- to complete my Ph.D. degree. And so,
3 that future work demonstrated feasibility, but
4 it's out of the scope of the Ph.D. work. And I
5 had enough contributions already, in my Ph.D.
6 work, on this shock film development, and I
7 further expanded to mix mode and pure shear, which
8 was in later chapters in the dissertation. That's
9 another advancement contribution to the field.

10 So, at that time, that was the primary
11 focus at that time. So, yeah, so I decided to
12 finish the Ph.D., then move on. So some of the
13 work, we continued after I became a faculty
14 member.

15 Q Does your dissertation discuss the
16 feasibility of this future work, besides that
17 paragraph?

18 A So the feasibility already
19 demonstrated. So there were shock (indiscernible)
20 in fused silica. So it's just -- it's really
21 nothing more, it's just inserted into any
22 substrate material. So you form that shock, let

1 it continue to propagate, and utilize that to
2 delaminate the film. So it's just -- yeah, I
3 don't see any difficulty to follow up there.

4 Q So, in your opinion, the remainder of
5 your report demonstrates the feasibility of the
6 future work discussed in the last paragraph?

7 A Could you, please, say that again?

8 Q Sure. So, in your opinion, it is the
9 rest of your dissertation that provides evidence
10 of feasibility of your future work discussed?

11 A Right.

12 Q Okay. Are you aware of any other --

13 MR. MATICH: Roman, I want to note, for
14 the record, that Casey actually had to depart.

15 MR. RACHUBA: Okay. Dave Emery
16 actually left, too. I don't know -- his laptop is
17 still in this room, so I'm assuming he's going to
18 come back at some point, but he's been missing for
19 some time.

20 Q Are you aware of any other disclosures,
21 besides what's in your dissertation, that
22 discusses the feasibility of your future work

1 here?

2 MR. MATICH: Objection. Form.

3 A I guess Dr. Gupta's work in 1992 also
4 had a figure there he used in his research, if
5 that can serve as a feasibility.

6 Q Any other disclosures?

7 A These two will probably be the most --
8 the closest.

9 Q Okay. I'm going to share another
10 exhibit in the chat. This is Exhibit 1019 from
11 the current -- from exhibits currently on record
12 in this IPR.

13 MR. RACHUBA: Let's go ahead and use
14 that same exhibit number, 1019, for clarity.

15 (Exhibit 1019 marked for identification
16 and attached to the transcript.)

17 Q Dr. Wang, you can either open that up
18 or I can share it on my screen as well.

19 A Okay. I have it open now.

20 Q Do you recognize this document?

21 MR. MATICH: Just remind the witness
22 she can --

1 MR. RACHUBA: Yes.

2 Q Feel free, you can scroll.

3 MR. MATICH: Yes.

4 A Yes. So this is Dr. Gupta's work.

5 Q Have you read this work before?

6 A Yes.

7 Q Do you opine on it in your declaration,
8 in connection with this IPR?

9 A I don't think so. Because this -- this
10 is very similar to the content in the patent.
11 This is, yeah, almost the same as in the patent
12 for the background information.

13 Q Let's go to -- I'm on page 6 of
14 Exhibit 1019, looking at Figure 3(a) and 3(b).

15 Do you see those at the bottom of the
16 page?

17 A Yes.

18 Q Before I ask you about this, when did
19 you first read this reference?

20 A This is after I was asked to serve as
21 the patent expert on this. So that was in the
22 last year.

1 Q Okay. Do you have an understanding of
2 what's shown in Figure 3(a)?

3 A That's the interferometric signal.

4 Q What's depicted in this interferometer
5 signal?

6 A That's a fringe signal, right?
7 Can you zoom in to make it bigger,
8 please?

9 Q Sure. Sorry.

10 A Okay.

11 Q Is velocity shown in Figure 3(a)?

12 A Yes.

13 Q How so?

14 A What do you mean? So -- oh, velocity
15 is in (b), right?

16 Q Right. Okay.

17 MR. MATICH: Nick, can we zoom out? We
18 can't see all of the two figures.

19 MR. RACHUBA: Here. I'll try to --

20 Q In Figure 3(b), is there any reversal
21 in velocity?

22 A I can't tell.

1 Q Why can't you tell?

2 A Because the stress wave is very
3 compacted and the amplitude is very small, at some
4 point. So I don't -- I can't tell whether there
5 is a reversal there or not.

6 Q I'll stop sharing this for a second.

7 In your dissertation, as to the
8 substrate, you were using fused silica, right?

9 A Right.

10 Q What is fused silica?

11 A Fused silica is the purest form of
12 amorphous silicon. So it's an amorphous SiO₂,
13 silicon dioxide.

14 Q So since it's amorphous, it is not
15 crystalline, correct?

16 A Correct.

17 Q Do you know what the failure strength
18 of fused silica is in tension?

19 A I don't recall.

20 Q Is fused silica described as the
21 material that can be used as glass element, as
22 claimed in the '684 patent?

1 A Excuse me? Was that a question?

2 Q Yes. Is fused silica described as one
3 of the materials that can be used as the glass
4 elements, as claimed in the '684 patent?

5 A Can we look at the '684 patent again?

6 Q Sure. I think that was -- actually, I
7 don't think we put the '684 patent in the record
8 yet. So why don't we go ahead and do that. One
9 second.

10 (Exhibit 1001 marked for identification
11 and attached to the transcript.)

12 Q Okay. I placed in the record, marked
13 as Exhibit 1001, U.S. Patent Number 7,487,684.

14 Let me share that screen with you. Go
15 to the top.

16 Do you recognize this document?

17 A Yes.

18 Q What is it?

19 A That's the patent by Dr. Gupta that is
20 the discussion right now.

21 Q This is the patent that's the subject
22 of the IPR that you're offering an opinion in,

1 your expert opinion in, in this case, correct?

2 A Correct.

3 Q Okay. I am going to direct your
4 attention to column 3.

5 A Can you zoom in?

6 Q Yes.

7 A Thank you.

8 Q Column 3, lines 18 through 20. I'll
9 highlight that on the screen for you.

10 A Okay.

11 Q Does the '684 patent describe fused
12 silica as a material that can be used as the glass
13 element?

14 A I would consider fused silica as
15 similar material.

16 Q What's your basis for --

17 A So all these elements, the primary --
18 primary consist of silica, either in the amorphous
19 form or in the crystalline form.

20 So, fused silica is very -- in
21 composition, chemical composition, but very
22 similar to quartz. But the difference, quartz is

1 in the crystalline form, fused silica is in the
2 amorphous form.

3 And the rest, also, mostly glass
4 material, primarily consists of amorphous silica,
5 for example, soda lime borosilicate, all those.
6 So these all have similar composition.

7 Q Quartz is fully crystal, right?

8 A Right.

9 Q Is Pyrex fully crystal?

10 A I don't know, sitting here. I'm
11 thinking it's probably mostly amorphous.

12 Q But you do not know sitting here,
13 right?

14 A Right.

15 Q What about soda lime?

16 A Soda lime glass is usually amorphous.

17 Q Sorry. Did you say "usually
18 amorphous"?

19 A Yeah.

20 Q But --

21 A We can also search that, but, yeah.

22 Q But it can be fully crystalline?

1 A I have never used -- we use soda lime
2 glass in mostly amorphous form.

3 Q What about borosilicate? Is that
4 amorphous or crystalline?

5 A I think it's also usually amorphous.

6 PLANET DEPOS TECHNICIAN: Hey guys,
7 sorry to interrupt. It seems that the court
8 reporter did not have any sound.

9 MR. RACHUBA: For how long?

10 PLANET DEPOS TECHNICIAN: At 4:06. I
11 do have the backup audio, so she will have that.

12 I just wanted to make sure that she was
13 back in and had sound.

14 Judy, are you there?

15 Sorry to interrupt, guys.

16 It says that she is not currently in
17 the meeting.

18 Do we want to go off the record and
19 wait until she's back?

20 MR. RACHUBA: Yes. That's a good idea.

21 PLANET DEPOS TECHNICIAN: Well, it's
22 weird because, like, under the participants, it

1 says she's here, but I tried to message her, it
2 says she's not here.

3 I guess we'll just wait until -- I'll
4 go ahead and call her right now.

5 MR. RACHUBA: Okay. Let's go off the
6 record. I'll just mute myself, but I'll be in the
7 room.

8 PLANET DEPOS TECHNICIAN: Okay. Off
9 the record at 7:10.

10 (Recess taken from 7:10 p.m. to
11 7:23 p.m.)

12 PLANET DEPOS TECHNICIAN: Back on at
13 7:23 p.m.

14 BY MR. RACHUBA:

15 Q Welcome back, Dr. Wang, our impromptu
16 break.

17 A Thank you.

18 Q Do you have an understanding of what
19 the term "nonlinear" means, with respect to
20 material properties?

21 A Yes.

22 Q What is that understanding?

1 A So, in the context of the laser
2 spallation here, it typically means the
3 stress-strain relationship. So the stress is a
4 nonlinear function of the strength.

5 Q Does your dissertation discuss the
6 stress-strain relationship of fused silica in
7 comparison to other materials?

8 A That's that equation we cited, that's a
9 nonlinear equation of the stress-strain fused
10 silica. That's a nonlinear equation.

11 Q Yes. But did you discuss the nonlinear
12 equation of fused silica in comparison to other
13 materials or did you just discuss the nonlinearity
14 of fused silica?

15 A Just the fused silica.

16 Q I'm going the place in the chat --

17 MR. MATICH: Roman, before you do, is
18 the realtime up because it seems I've lost it.

19 (Discussion held off the record.)

20 BY MR. RACHUBA:

21 Q Dr. Wang, I'm placing another exhibit
22 in the chat. Let's call this -- this is

1 Exhibit 1003.

2 PLANET DEPOS TECHNICIAN: We went off
3 record. Would you like to go back on, I'm
4 assuming? We went off at 7:26, so we will be back
5 on at 7:27.

6 MR. RACHUBA: Before we do that, can we
7 get a time check how much time we've used on the
8 record so far?

9 PLANET DEPOS TECHNICIAN: Please stand
10 by.

11 (Exhibit 1003 marked for identification
12 and attached to the transcript.)

13 BY MR. RACHUBA:

14 Q Dr. Wang, I just shared in the chat
15 Exhibit 1003. This is the declaration that you've
16 submitted in connection with this IPR. Let me
17 know when you've opened that up. We'll also --

18 A Okay. It's open.

19 Q Okay. Do you recognize this document?

20 A That's my declaration. Yeah.

21 Q Your declaration in connection with the
22 IPR that we've been discussing?

1 A Yes.

2 Q And does this -- strike that.

3 Does your declaration discuss the
4 stress-strain properties of fused silica?

5 A So, my declaration mostly discussed
6 whether the claims have been disclosed by
7 referencing the prior art. I'm mentioning the
8 nonlinear elasticity of fused silica, yes.

9 I didn't go into details of the
10 stress-strain relationship, but that's, basically,
11 indicated in the nonlinear elasticity.

12 Let's go through it. I don't know that
13 I included the exact equation there because it's
14 already in my dissertation, in the other prior
15 art.

16 Let me see.

17 Q Okay. Yeah, please, let me know where
18 you discussed the nonlinearity of fused silica.
19 If you can find it in your version, let me know
20 and I can pull it up on my copy that I have worked
21 with.

22 A It's in paragraph 56. Or if we go to

1 page 22.

2 Q Okay.

3 A I mentioned using nonlinear elastic
4 substance, such as fused silica.

5 Q Does your declaration discuss any
6 quantifiable qualities of nonlinearity?

7 A So my declaration included the
8 references there, such as my dissertation. But I
9 didn't repeat the exact information, given the
10 length limit. But if needed, I could elaborate.

11 Q But your declaration did not elaborate,
12 correct?

13 A I would just refer to due to the
14 negative nonlinear elasticity of a substance like
15 fused silica, yes. Mostly just elaborated by word
16 but didn't include the exact equation.

17 Q And here, you're referencing
18 Exhibit 1016 abstracts.

19 A Exhibit 1014 to 1018.

20 Q Oh, 1014 to 1018?

21 A Right.

22 Q Okay. Let's go back to Exhibit 1001,

1 which is the '684 patent.

2 A Okay.

3 Q All right. Let's look at -- well,
4 while I'm trying to figure out where to look in
5 the patent, you mentioned earlier that you
6 discussed the nonlinearity of fused silica in your
7 dissertation, correct?

8 A Correct.

9 Q Did your -- did you quantitatively
10 measure any properties related to the nonlinearity
11 or did you use a listed supplied value?

12 A I used, for my -- that's in the
13 theoretical work. I referenced one of the prior
14 arts. So adopted their work, their values.

15 Q So you did not calculate any values
16 that qualified nonlinearity aspect of fused
17 silica, correct?

18 A So, I don't do the exact experiments.
19 I adopted their values. And when we faded any
20 experimental data, so the experimental data
21 aligned well with the prediction from their value.

22 Q Okay. Let's go to claim 1 of the '684

1 patent. This is on page -- second-to-last page,
2 page 20 of the PDF document.

3 A Page 20. Okay.

4 Q Okay. You -- do you see claim 1 there?

5 A Yes.

6 Q Okay. The last wherein clause of
7 claim 1 reads "Wherein the glass element is
8 configured to propagate and modify a stress wave
9 to the coating/substrate interface to generate
10 tensile stress between the substrate and the
11 coating."

12 Do you see that?

13 A Yes.

14 Q What is your understanding of that
15 claim element?

16 MR. MATICH: Objection. Form.

17 A So my understanding is exactly what's
18 stated here. So the glass element will -- it's
19 placed there to propagate the stress wave and
20 modify the stress wave. Therefore, tensile stress
21 will be generated as the substrate and the coating
22 interface.

1 Q Is it your understanding that the
2 stress wave, that's referred to in that wherein
3 clause, has to create a new tensile stress?

4 A What do you mean by "new"?

5 Q A stress not due to a different
6 waveform.

7 A So, this clause didn't say anything
8 how. It's, basically, you generate a stress wave
9 and it produces a tensile stress at a film
10 substrate interface.

11 Q What is your understanding of generated
12 tensile stress, as recited in claim 1?

13 A So, a tensile stress will go through
14 the interface.

15 Q What is your understanding of
16 "generate," in that context?

17 A Apply or resolve, or lead to, or
18 similar meaning.

19 Q Did you just look up the word
20 "generate" on an online dictionary?

21 A No. My -- sorry.

22 Q No, go ahead.

1 A Okay. My dissertation is about
2 laser-generated stress waves. There is no need
3 for me to look for it.

4 Q Okay. Do you have an understanding,
5 based on that wherein clause from the claim,
6 whether the tensile stress has to be generated
7 from a wave reflected off the free surface or
8 whether there can be another source?

9 A It doesn't say that. They didn't
10 specify.

11 Q Do you have an understanding, based on
12 your reading of the patent, generally?

13 A Again, it didn't -- they didn't -- I
14 didn't get that information, any specifics on that
15 information.

16 Q Okay.

17 A But the patent only claims tensile
18 stress at the interface.

19 Q Let me back up.

20 Did you read the '684 patent?

21 A Yes.

22 Q Did you read the prosecution history of

1 the '684 patent?

2 A Briefly.

3 Q What do you mean by "briefly"?

4 A It was -- a lot of legal terms.

5 Very -- very time-consuming. Very hard to

6 understand. So I tried to focus on the technical

7 part. Yeah, so, that's what I mean. Some of the

8 legal part very confusing and, yeah, so I didn't

9 spend a lot of time on that.

10 Q Okay. I understand you're not a

11 lawyer.

12 Are you listed as an inventor on any

13 U.S. or foreign patents?

14 A Some provisional, yeah.

15 Q Okay. Some provisional applications

16 but no issued patents?

17 A Don't think so. I didn't pursue a lot

18 on patents.

19 Q Okay. Prior to you reading the '684

20 patent, and excluding the provisional applications

21 that you were involved in, have you read any

22 patents before?

1 A Again, very briefly. Not the whole
2 patent.

3 Q I mean patents other than the '684
4 patent.

5 A Think so.

6 Q Do you understand that terms in a
7 patent claim are to be interpreted in light of the
8 specification and prosecution history?

9 A Can you explain?

10 Q Well, what is your understanding of my
11 question that I just asked?

12 A So, you mean the -- can you repeat the
13 question again? Sorry.

14 Q Sure. Do you understand that terms in
15 a patent claim are to be interpreted in light of
16 the specification and file history?

17 A Yes.

18 Q So taking into account the prosecution
19 history and specification of the '684 patent, is
20 it your understanding that the generated tensile
21 stress, in the last wherein clause of claim 1, has
22 to be generated from a reflected compressive --

1 strike compressive.

2 Reflected waveform from the free
3 surface of the interface, free surface of the
4 film?

5 A I don't think the patent specify that.
6 I think, from the file history, is mostly the
7 glass element would change the waveform as it
8 passes through the glass element. But in most
9 cases, I would say it is the reflective tensile
10 stress. But with this patent, I don't think it's
11 specified in the claim language.

12 Q Looking at claim 13. It's on the same
13 page.

14 A Claim 13. Okay.

15 Q The last element of claim 13 reads
16 "Separating the coating from the substrate as a
17 result of the stress-wave generated tensile
18 force."

19 Do you see that?

20 A Yes.

21 Q What is your -- do you have an
22 understanding of that claim element?

1 A Yes.

2 Q What is that understanding?

3 A This is very similar to that same last
4 line in claim 1. So, basically, just a matter
5 that will generate the tensile stress at the film
6 substrate interface to separate it.

7 Q Does claim 1 require separation?

8 A Let me see. Claim 1, more
9 specifically, referring to applying the tensile
10 stress at the interface. And claim 13, more
11 specifically, meaning the stress has to be high
12 enough to remove or to separate the film from the
13 substrate.

14 Q Okay.

15 A Yeah, there is some additional.

16 Q Okay. Let's go back to -- okay. I'm
17 going to put another exhibit in the chat. This is
18 Exhibit Number 1011.

19 (Exhibit 1011 marked for identification
20 and attached to the transcript.)

21 Q If you could go ahead and open that up,
22 Dr. Wang.

1 A Okay. It's downloading.

2 Yes, it's open.

3 MR. RACHUBA: One second. For the
4 record, if the court reporter could mark what I
5 initially shared as Exhibit 1 in this chat, the
6 '402 patent, as Exhibit 1034. That corresponds --
7 it is the same document as Exhibit 1034 in this
8 case.

9 PLANET DEPOS TECHNICIAN: Got it.

10 MR. RACHUBA: To keep the record clean,
11 if that's all right with you.

12 PLANET DEPOS TECHNICIAN: I was just
13 wondering about that one. So Exhibit 1034. Got
14 it.

15 MR. RACHUBA: Yes.

16 Q Okay. Dr. Wang, do you have
17 Exhibit 1011 open?

18 A Yes.

19 Q Do you recognize this document?

20 A Yes.

21 Q What is this document?

22 A This is Dr. Gupta's 1992 JMPS paper.

1 Q Does your declaration rely on this
2 document?

3 A Yes. In some sections.

4 Q Did you cite this document in your
5 dissertation that we discussed earlier?

6 A Yes, I think so.

7 Q Let's look at Figure 2A, on page 5 of
8 the document.

9 Do you see that? Figures 2A and 2B?

10 A Yes.

11 Q What is depicted in Figure 2A?

12 A 2A is the more kind of standard laser
13 spallation setup without the glass element.

14 2B is with the E13, the fused quartz.
15 Basically, that's the glass element in the '684
16 patent.

17 Q Well, it looks like Figure 2A and 2B
18 both have fused quartz. But it looks like there
19 is an additional element in Figure 2B.

20 A Yes.

21 Q So is that additional -- is there an
22 additional fused quartz element in Figure 2B?

1 A Yes.

2 Q How is the configuration shown in
3 Figure 2B different than the future work portion
4 you discuss in your dissertation?

5 A That's same idea.

6 Q Are there any differences?

7 A This is the same idea. 13 fused silica
8 or fused quartz, yes. I think you can consider
9 them as equivalent, or the same.

10 Q Are you aware whether the experimental
11 setup depicted in Figure 2B was tested by
12 Dr. Gupta?

13 A So it's included in the paper and that
14 paper went through review. I would think it's
15 tested. But the result in this paper was very
16 brief -- discussed very briefly.

17 Q Let's -- moving on to -- let me scroll
18 down to Figure 11. This is on page 17.

19 A The same exhibit?

20 Q Yes, same exhibit.

21 A Did you say Figure 11?

22 Q Yes, Figure 11, page 17.

1 A Which page? Which exhibit are we
2 looking at?

3 Q Sorry, still at Exhibit 1011. Let me
4 just share the screen, actually.

5 A Do you mean 157?

6 Q Yes, 157, page up here. I was looking
7 at the stamping at the bottom.

8 A Okay.

9 Q Okay. So Figure 11 here, do you have
10 an understanding of what's depicted?

11 A It says this is the effect of laser
12 fluence on the structure of the stress spalls with
13 gold as the laser energy absorbed them.

14 Q Is a shock depicted in these waveforms?

15 A I can't tell. I don't think this
16 experiment had enough resolution to depict the
17 shock.

18 Q What resolution would you need to be
19 able to identify whether a shock is present?

20 For reference --

21 A Can you -- can you tell me, did this
22 come from Figure 2B, using that of the Figure 2B,

1 or I need to read through?

2 Q Okay. Take your time and read through
3 it.

4 A Okay.

5 Q I'll stop sharing so you can look at
6 the version that you have.

7 Dr. Wang, are you able to provide an
8 answer?

9 A So this was -- this signal, I'm not
10 sure whether this signal -- I think that signal
11 was not using Figure 2B. It's a separate
12 experiment.

13 Q Well, the question just was, it wasn't
14 analyze what experiment this was from, it was
15 whether a shock was present in any of these
16 waveforms?

17 A I cannot tell by -- yeah.

18 Q Okay. Why don't we scroll to Figure 15
19 on page 164 of the copy document, 24 of the PDF.

20 A 24. Okay.

21 Figure 15?

22 Q Yes. Is a shock shown in any of the

1 waveforms depicted in Figure 15?

2 A Doesn't look like.

3 Q Okay. You can put that exhibit away.

4 Have you ever met Dr. Gupta, an
5 inventor of the '684 patent?

6 A No, I have not.

7 Q But you reviewed some of his work,
8 correct?

9 A I cited some of his work. I also
10 reviewed for this case, yes.

11 Q I understand.

12 Would you consider Dr. Gupta to be an
13 expert in laser spallation technology?

14 MR. MATICH: Objection. Outside the
15 scope.

16 A Yes, I do. There were a group of
17 experts who contributed to the advancement of this
18 technique to this field, yes, Dr. Gupta is one of
19 them.

20 Q I'm going to share, in the chat,
21 another exhibit. This is Number 1016.

22 (Exhibit 1016 marked for identification

1 and attached to the transcript.)

2 Q And Dr. Wang, you can go ahead and open
3 that up when you get a chance.

4 A Okay. Let me look here. Are we
5 looking -- oh, okay.

6 Q Scrolling to page 5 of the PDF, page
7 number 74 over in the bottom left of the journal.

8 A Okay.

9 Q What are we looking at here?

10 A Some -- that's my paper. One of my
11 papers.

12 What do you mean?

13 Q I was just making sure that we're
14 looking at the right one.

15 A Okay.

16 Q Does this paper discuss experiments
17 with the same setup that you used in your
18 dissertation?

19 A Yes.

20 Q At a high level, what, if any,
21 differences are described in this paper compared
22 to what's disclosed in the dissertation?

1 A It's one section of the dissertation.
2 It's -- yeah, it's part of the dissertation work.

3 Q Okay. So the dissertation is a more
4 comprehensive analysis than what's included in
5 here?

6 A Right.

7 Q But everything in this paper is
8 included in the dissertation?

9 A Think so. Most part, yes.

10 MR. RACHUBA: Okay. I have no further
11 questions. Thank you, Dr. Wang.

12 THE WITNESS: Thank you.

13 MR. RACHUBA: I'll pass the witness. I
14 don't think you're quite done yet.

15 MR. MATICH: Great. Can we take a
16 break?

17 MR. RACHUBA: Sure. Ten-minutes?
18 Five minutes?

19 MR. MATICH: I think five minutes.

20 MR. RACHUBA: Okay.

21 PLANET DEPOS TECHNICIAN: Okay. We are
22 off the record at 8:10 p.m.

1 (Recess taken from 8:10 p.m. to
2 8:11 p.m.)

3 PLANET DEPOS TECHNICIAN: Back on at
4 8:11 p.m.

5 MR. MATICH: No questions from
6 Petitioner.

7 MR. RACHUBA: Okay. Dr. Wang, thank
8 you for your time today. Thank you for your
9 professionalism. Appreciate the opportunity to
10 speak with you.

11 THE WITNESS: You're welcome. Thank
12 you.

13 MR. MATICH: Judy, do you have any --
14 are there any spellings or word clarifications you
15 need?

16 THE STENOGRAPHER: No, I will get them
17 off of the exhibits. Thank you.

18
19
20
21
22

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1 CERTIFICATE OF SHORTHAND REPORTER - NOTARY PUBLIC

2
3 I, Judith E. Bellinger, Certified Reporter
4 and Notary Public within and for the Commonwealth
5 of Virginia do hereby certify:

6 That JUNLAN WANG, PH.D., the
7 witness whose deposition is hereinbefore set
8 forth, was duly sworn by me before the
9 commencement of such deposition and that such
10 deposition was taken before me and is a true
11 record of the testimony given by such witness.

12 I further certify that the adverse party,
13 The Boeing Company, was represented by counsel at
14 the deposition.

15 I further certify that the deposition of
16 JUNLAN WANG, PH.D., occurred remotely
17 on Thursday, January 16, 2025, commencing at
18 12:13 p.m. EST.

19 I further certify the inspection, reading
20 and signing of said deposition was not discussed
21 on the record.

22 I further certify that I am not related to

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1 any of the parties to this action by blood or
2 marriage, I am not employed by or an attorney to
3 any of the parties to this action, and that I am
4 in no way interested, financially or otherwise, in
5 the outcome of this matter.

6
7 IN WITNESS WHEREOF, I have hereunto set my
8 hand this 21 day of January, 2025.

9
10 My commission expires: September 30, 2028

11
12 *Judith E. Ballinger*
13 _____

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