1 UNITED STATES PATENT AND TRADEMARK OFFICE
2 BEFORE THE PATENT TRIAL AND APPEAL BOARD
3
4 LG ENERGY SOLUTION, LTD.,
5
Petitioner,
6
v.
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8 MOLECULAR REBAR DESIGN, LLC,
9 Patent Owner.
10
Case IPR2024-01005 (US Patent No. 9,636,649)
11
Ref. 18768-0210IP7
12
VIDEOCONFERENCE DEPOSITION OF
13
DEBORAH D.L. CHUNG, Ph.D.
14
INDIVIDUALLY AND ON BEHALF OF
15
PATENT OWNER
16
JUNE 25, 2025
17
Page 1 - 162 9:04 a.m. to 2:29 p.m. EST
18
19
20 REPORTED BY:
Tamara L. Houston
21 CA CSR No. 7244, RPR, CCRR No. 140
Job Number J12853871
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23
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REMOTE VIDEOCONFERENCE DEPOSITION OF DEBORAH D.L. CHUNG, Ph.D., taken on behalf of the Petitioner, commencing from 9:04 a.m. to 2:29 p.m. EST, Wednesday, June 25, 2025, before Tamara L. Houston, CSR No. 7244, CCRR, RPR.

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DEBORAH CHUNG, Ph.D.

LG ENERGY SOLUTION, LTD. vs. MOLECULAR REBAR DESIGN, LLC

JUNE 25, 2025

Tamara L. Houston, CSR No. 7244, CRR No. 140, RPR

EXHIBIT	DESCRIPTION	PAGE
Exhibit 1	LGES 1100; two pages with two handwritten drawings	119

(Exhibit marked electronically.)

--o0o--

(Exhibit not attached)

WEDNESDAY, JUNE 25, 2025, 9:04 A.M.

--o0o-

COURT REPORTER: My name is Tamara Houston, California Certified Shorthand Reporter Number 7244.

--o0o--

Whereupon, DEBORAH D.L. CHUNG, PH.D., having been called as a witness was duly sworn to tell the truth, the whole truth, and nothing but the truth testified as follows:

--o0o--

EXAMINATION BY MR. RIFFE:

Q. Good morning. Could you please state your name for the record.

A. Deborah D.L. Chung.

Q. And could you please provide a business address for the record.

A. Yes. Department of Mechanical and Aerospace Engineering, University At Buffalo, the State University of New York, Bell Hall, Room 211, Buffalo, New York, 14260.

Q. And how long have you been with the University of Buffalo?

A. About 39 years.

Q. Could you please provide a home address for

the record as well?

A. 108 Rolling Meadow Lane, East Amherst, New York, 14051.

Q. And how long have you been at that address?

A. Amherst with an A.

Q. And how long have you been at that address?

A. Over 40 years. No, no. That's not -- that may be 35 years. I have to calculate it.

Q. Yeah. Just wanted to explain a little bit because we're on this Zoom platform for the deposition today.

I'll be asking a series of questions to you, as I've been doing so far this morning. I would ask that we try to -- you try to allow me to finish my question before you begin answering so the court reporter can take down our questions and answers appropriately.

At times I may be introducing exhibits. And in normal procedures, if we were sitting across from one another, I'd be able to hand those to the court reporter, and then she would then hand a copy of the exhibit to you. But in this instance, I may need to place a copy of the exhibit in the chat room or the chat feature of the Zoom and then ask you to download it from that chat room.

Are you familiar with that procedure on the videoconference platforms?

A. Yes. I don't see the chat box here yet.

Q. Okay. If you -- if you do -- if you do bring up the little ribbon bar at the bottom of the Zoom, you'll see a chat box.

A. I see that. I see it now.

Q. And if you click on that, it will open the side frame for you.

A. Okay. Got it.

MR. GLENN: Counsel, she has a -- she has a paper copy, I believe, of every document on -- on file in this proceeding.

MR. RIFFE: Okay. Okay.

MR. GLENN: So she may be -- she may do that and use the paper document, if that's okay.

MR. RIFFE: That's fine. That's fine.

BY MR. RIFFE:

Q. Dr. Chung, given that you have paper copies of the pleadings and the exhibits filed in this proceeding, are those paper copies that you have with you, do they have any markings of any kind whatsoever on them?

A. No.

Q. Those are all clean copies?

A. Yes.

Q. Okay. Do you have anything on your computer that would allow you to conduct a conversation with anyone during the deposition while you're testifying?
A. No.
Q. Such as a Skype feature or any other type of messaging feature?
A. No.
Q. Do you have any files on your computer that you can refer to today during your deposition?
A. Oh, yeah, definitely -- certainly files there. I -- I don't intend to refer to any of them, but --
Q. Okay.
A. Yeah.
Q. All right. So outside of the paper copies that you have with you present in the room, it sounds like you do not have any other files that you plan to review or refer to during the deposition today; is that correct?
A. Yes.
Q. Okay. Have you been deposed before Dr. Chung?
A. Yes.
Q. How many times?
A. I really can't remember because it's been many years. Could be five times.
Q. And what were those depositions related to, if

you recall?

A. Litigation, including those with the board and also injury cases, trade secret case.

Q. When was the last time you were deposed?

A. Maybe around three years ago.

Q. And was that a patent case or trade secret case?

A. Patent case.

Q. Do you recall what the patent case pertained to?

A. I -- I can't remember very well. It has to do with certain material. I can't remember.

Q. Have any of your prior cases for which you've provided deposition testimony been related to technology surrounding carbon nanotubes?

A. Prior what? I didn't hear that word.

Q. Your prior deposition testimony that you provided, have they been related to carbon nanotube technology?

A. I remember I think one case that has to do with carbon, you know, but whether carbon nanotube is specifically included, I cannot remember exactly.

Q. Do you recall the parties for whom you provided deposition testimony previously related to carbon?

A. It has to do with carbon battery electrode between the Japanese company and a Chinese company.

Q. Sitting here today, you don't recall who those Japanese or Chinese companies were?

A. I'm not positive about my memory.

Q. Okay.

A. More or less.

Q. Okay. Are any of those prior litigations for which you provided deposition testimony identified in your CV which is attached to your declaration that was submitted as Exhibit 2006 in this proceeding?

A. I don't think my CV lists my expert witness record.

Q. Do you know why you don't list your expert witness record in your CV?

A. I've never done that. In the academic world, you know, that expert witness work is kind of sideline. It's not our main line academic work. So I've never -- I've never done that.

Q. Okay. Have you testified at trial before in any of these prior cases?

A. Never.

Q. Only in deposition?

A. That's correct.

Q. And how many times have you been deposed in an

IPR or Inter Partes Review proceeding such as the one we're talking about today?

A. Maybe two times.

Q. And do you recall who you were represented in those IPR proceedings?

A. Oh, you mean the parties involved in the case, huh?

Q. That's correct.

A. I really don't remember.

Q. Okay. Do you recall if you were on the side of the petitioner or the patent owner in those prior IPR proceedings?

A. I'm sorry. Can't remember. I just remember the -- the firm's name. That's all I remember.

Q. Okay. And what -- what were those firms that you recall?

A. That was Foley.

Q. In both IPR proceedings?

A. No. One of them. In one of them was --

Q. Who was the other firm?

A. The other -- I cannot remember. It actually could be one or two. You know, I'm not positive that it's two, but at least one.

Q. And what was the technology in play in those IPR proceedings, if you recall?

A. Certain material, and I remember it's not carbon.

Q. And certainly not carbon nanotubes; is that correct?

A. Right.

Q. And did you testify live at the hearing in either of those IPR proceedings in the past?

A. Yes.

Q. So you provided deposition testimony in the IPRs as well as testifying live at the oral hearing; is that correct?

A. Live at what?

Q. The oral hearing or oral argument before the PTAB judges.

A. No, not before the judges. Just in the --

Q. Just the deposition? Okay. Let me just make sure that's clear.

So in the prior IPR proceedings, Inter Partes Review proceedings, you only provided deposition testimony; is that correct?

A. That's right. And obviously the declaration. Yes.

Q. Okay. Thank you.

I know you've been deposed before. It sounds like maybe three years ago. Let's just go over some of

the ground rules again to make sure we have an understanding between each other.

If you will, please provide verbal answers to my questions, no head nods or shake of the head so that Ms. Houston can properly record your testimony.

Is that okay?

A. Yes.

Q. And you understand that you've been given an oath to tell the truth as if it will be as if you were testifying in the court.

Do you understand that?

A. Yes.

Q. And you agree to do that today?

A. Yes.

Q. You're permitted to speak with your counsel during the breaks but not about the substance of your testimony.

Do you understand that?

A. Yes.

Q. And your attorney may make some limited objections during today's deposition, but do you understand that unless you're instructed and you choose not to answer, that you're obligated to answer my questions to the extent you're able to do so?

A. Yes.

Q. If you don't understand a question I ask, will you, please, let me know --

A. Yes.

Q. -- as you've done already this morning?

And if you don't ask me to clarify a question that I ask of you, is it fair for the judges to assume that you understood my question when reviewing the transcript of today's deposition?

A. Yes.

Q. Is there any reason you can't provide your best, most accurate testimony today?

A. No.

Q. Are there any medical conditions that would impact your ability to testify?

A. No.

Q. Was there anything else that would impact your ability to testify that I should be aware of?

A. No.

Q. And if any of this changes during the deposition, will you be sure to let us know?

A. Yes.

Q. As we discussed prior to the deposition starting with your attorney, if there are any technical issues with your connection or any of our connections, we'll try and go off the record to address those.

Is that understood as well?

A. Yes.

Q. In any of the prior litigations or IPR proceedings for which you've provided expert testimony, do you recall if any parts of your expert declaration or report were stricken by the Court for any reason?

A. No.

Q. Dr. Chung, what did you do to prepare for your deposition today?

A. There were various documents, and I listed them in my declaration. So I look -- look at those.

Q. And which particular documents are you referring to that you listed in your declaration? And in your declaration, specifically we're referring to Exhibit 2006; is that correct?

A. Oh, yes, 2006. This is my declaration, yes.

Q. Okay. And you mentioned that there were various documents that you listed in your declaration, so you looked at those in preparation for your deposition.

Can you let me know what those documents were?

A. Yes. They include the MRD-2007, 2008, 2009, 2010, 2011, 2012, and 2013.

In addition, I looked at the LGES 1004, 1001, 1008, 1007, 1003. I think that's about it.

Q. Okay. And just for the record, LGES 1004, that is the Sun prior art reference. If we can refer to that as the Sun reference today. Is that okay?

A. Okay.

Q. And that is U.S. Publication 2010/0197832; is that correct?

A. Yes.

Q. And Exhibit 1001 is -- or LGES 1001, that is the U.S. Patent Number 9,636,649 to Bosnyak, et al; is that correct?

A. Yes.

Q. Is it okay with you if we shorthand that to refer to that today as the '649 patent?

A. Yes.

Q. Okay. Exhibit LGES 1008 is the United States patent application publication to Narayan, et al., U.S. 2003/0213939; is that correct?

A. Can you repeat that?

Q. Yes. LGES 1008 is United States patent application publication to Narayan, et al., and that publication number is U.S. 2003/0213939. Is that correct?

A. Yes.

Q. And if we refer to the LGES 1008 today, can we shorthand refer to that as Narayan? Is that okay?

A. Yes.
Q. Okay. Thank you. LGES 1007 that you refer to, that is the Farrugia patent publication, U.S. Number 2010/0124713; is that correct?
A. Yes.
Q. And is it okay if we refer to that today in shorthand as Farrugia reference?
A. Yes.
Q. Thank you.
And then finally you mentioned LGES 1003. That was the declaration of Dr. Samuel Gido. Is that correct?
A. Yes.
Q. Thank you.
Are there any other documents that you reviewed other than the one that you just identified in preparing for your deposition today?
A. There's also MRD-2005. Did I mention?
Q. I don't believe so.
A. Also MRD-2008, MRD-2009. I could have mentioned that already.
Q. And 2008 and 2009 are listed on the exhibit list on page 4 of your declaration, correct?
A. Correct.
Q. All right. And what again is MRD-2005?

A. 2000 -- okay. That's the deposition of Samuel Gido on March 20th, 2025.

Q. Is that also listed as MRD-2011 in your exhibit list on page 4 of your declaration?

A. Yes.

Q. Okay. Dr. Chung, why did you list Exhibit No. MRD-2006, your declaration, in the exhibit list on page 4 of your declaration? Do you recall?

A. I guess it's just for the sake of completeness.

Q. Okay. Thank you.

In preparation for your deposition today, did you have an opportunity to meet with counsel for Molecular Rebar Design to prepare for your testimony?

MR. GLENN: Objection to the extent that question calls for attorney work product, that the witness may answer "yes" or "no" if she did or did not.

THE WITNESS: Yeah, I've never had any communication with Molecular Design, but certainly I have had communication with counsel.

BY MR. RIFFE:

Q. Okay. And in preparation for your deposition today, did you meet with counsel for MRD?

A. Yeah. I had Zoom meetings with counsel.

Q. Okay. And when did those take place?

A. Oh, yesterday.
Q. Okay. And was that with Mr. Glenn, who is present today?
A. Yes. Also with Mr. Zinda.
Q. How do you spell Mr. Zinda's last name?
A. Z-I-N-D-A, with the same law firm.
Q. Okay. And approximately how long was your meeting with Mr. Glenn and Mr. Zinda yesterday in preparation for your deposition today?
A. Could be four hours or so.
Q. And during that preparation, did you review the documents that you previously identified for me in preparation for your deposition?
A. More or less. We did not review, you know, everything that -- the main -- main documents that directly pertain to the declaration we kind of went through.
Q. Okay. Other than yesterday's Zoom meeting with Mr. Glenn and Mr. Zinda, did you have any other meetings with counsel for MRD in preparation for your deposition today?
A. Well, I had meeting to cover the kind of the general gist of deposition.
Q. And when did that take place?
A. That took place -- just looking at my

calendar. Okay. June 23rd.

(Court Reporter requested clarification.)

BY MR. RIFFE:

Q. Was that meeting on June 23rd also conducted by videoconference?

A. Yes.

Q. And approximately how long did that meeting last?

A. Probably around four hours.

Q. And during that meeting, did you discuss --

A. I'm sorry.

Q. No. Please, go ahead.

A. It was not four hours. Could be one to two hours.

Q. Okay. And, again, that -- that meeting was to discuss general topics related to depositions; is that correct?

A. Yes.

MR. GLENN: Objection to the extent the question calls for attorney work product, but I'll allow the witness to answer "yes" or "no."

THE WITNESS: Yeah. The discussion amounts to, you know --

MR. GLENN: Objection and instruct the witness not to answer if it includes attorney work product or

attorney communication.
BY MR. RIFFE:
Q. Do you recall the question, Dr. Chung?
A. Could you repeat the question?
Q. Sure. The question was: The meeting on June 23rd was to discuss, as I think you testified previously, general topics related to depositions in general, correct?
MR. GLENN: Same objection. But will allow the witness to answer "yes" or "no."
THE WITNESS: Yeah. It includes some --
MR. GLENN: And instruct the witness not to -- not to testify to attorney work product or attorney communication. She may confirm the general nature of the meeting, however.
THE WITNESS: Yes, I confirm that it was directed to prepare me so that I know what I'm supposed to do in that deposition.
BY MR. RIFFE:
Q. Okay. Thank you.
Outside of your meeting with counsel -- and let me back up.
When I refer to MRD today in shorthand version, is that acceptable to you that we're referring to the patent owner, Molecular Rebar Design, in this

proceeding?

A. Yes.

Q. Okay. Thank you. Just wanted to make sure that's clear for both of us.

Outside of your meeting with counsel -- the two meetings you had with counsel for MRD, did -- and your review of the documents in preparation for today's deposition, did you do anything else to prepare for your deposition today?

MR. GLENN: Objection. Ambiguous.

THE WITNESS: To tell the truth, I prayed.

BY MR. RIFFE:

Q. Well, we'll try not to have to inject that into today's deposition hopefully, but I appreciate that.

Okay. Did you have any meetings with any MRD employees in preparation for your deposition today?

A. No.

Q. And let me just be clear. Outside of the meeting that you had yesterday with Mr. Zinda and Mr. Glenn for approximately four hours, did you spend any time outside of that four hours reviewing documents in preparation for your deposition?

A. Yes.

MR. GLENN: Objection to the extent it calls

for attorney work product.
BY MR. RIFFE:
Q. And approximately how many hours did you spend reviewing those documents in preparation for your deposition outside of those four hours you spent with counsel yesterday?
A. Couple of hours.
Q. Okay. And do you recall the focus of that document review? Was that directly related to your declaration or something else?
MR. GLENN: Same objection.
THE WITNESS: It was centered at the declaration, yes.
BY MR. RIFFE:
Q. Do you know Mr. Clive Bosnyak of MRD?
A. No.
Q. Do you know Mr. Kurt Swogger of MRD?
A. No.
Q. And do you -- do you understand that they are the named inventors of the '649 patent we'll be discussing today?
A. Yes. I'm more familiar with the first name than the second name.
Q. Okay. All right. Have you ever -- I assume you've never met either Mr. Bosnyak or Mr. Swogger; is

that correct?

A. That's correct.

Q. And have you ever spoken to Mr. Bosnyak or Mr. Swogger before?

MR. GLENN: Objection. Asked and answered.

THE WITNESS: No.

BY MR. RIFFE:

Q. Have you had any discussions with any employee of MRD today?

MR. GLENN: Same objection.

BY MR. RIFFE:

Q. Strike that.

Have you had any other discussions with any other employee of MRD --

MR. GLENN: Same objection.

MR. RIFFE: What's the objection, Counsel?

MR. GLENN: It's been -- that's the third time it was asked.

MR. RIFFE: I'm not asking in the context of the deposition, Counsel. I'm now asking --

MR. GLENN: I apologize. I'll withdraw the objection.

MR. RIFFE: All right.

BY MR. RIFFE:

Q. Did you have any -- have you had any

discussions with any other employees of MRD prior to today?

A. No.

Q. Okay. And just to close this out, Dr. Chung, have you ever been an employee of MRD?

A. No.

Q. Has MRD ever sponsored any of your research?

A. No.

Q. And outside of this IPR -- these IPR proceedings, have you ever been paid by MRD for your services?

A. No.

Q. Are you being paid by MRD currently for your services with respect to these IPR proceedings?

MR. GLENN: Objection. Ambiguous.

THE WITNESS: I'm not directly paid by MRD.

BY MR. RIFFE:

Q. Okay. Are you paid by MRD's counsel for your services with respect to these IPR proceedings?

A. Not directly either. There's -- there's a company that refers experts, you know. That company pays me.

Q. Okay. And what's that company's name?

A. Yes. Rubin -- Rubin An- something. The Rubin An- --

Q. Could you spell that, to the best of your ability?

A. Rubin is R-U-B-I-N, Rubin. And then "An-," A-N something.

Q. And what is your hourly rate that you are charging for your services in these IPR proceedings?

A. 750.

Q. Do you know if this Rubin entity is adding any additional rate to your hourly rate of $750 in their hourly charge to MRD?

A. Yes, they do.

Q. Do you know how much that is?

A. I don't know.

Q. Does your hourly rate of $750 vary based on whether you're providing testimony versus other types of work?

A. No.

Q. It's a flat fee of $750; is that correct?

A. Yes.

Q. Do you recall --

A. Rubin Anders.

Q. Rubin Anders, A-N-D-E-R-S; is that correct?

A. Yes.

Q. Okay. Thank you.

Do you recall how much you have billed to date

for this IPR proceeding related to the '649 patent?
A. About $90,000.
Q. And do you recall how much in total --
A. I'm sorry. I should clarify that there are five patents involved, you know. So there's not just today's patent. And I deal with all five. That's why it adds up.
Q. Sure. And that was going to be my next question, so thank you for getting there.
So is it fair to say then that you have billed approximately $90,000 total for across all of the IPR proceedings for which you've been retained on behalf of MRD?
A. Yes.
Q. Thank you.
When were you first contacted to work on these IPR proceedings on behalf of MRD?
A. I can't remember, but maybe half a year ago. I really can't remember.
Q. And do you recall who contacted you first?
A. It was that company, Rubin Anders.
Q. Rubin Anders?
A. Yeah.
Q. And do you recall the reasons why you decided to take on this work on behalf of MRD in these IPR

proceedings?

A. Well, I think it's something that my expertise would help, be of value.

Q. And in the prior litigations and IPR proceedings that we discussed earlier today, were you retained for those proceedings through Rubin Anders as well?

A. No.

Q. Were you retained directly for purposes of those prior proceedings from either law firm or entity involved?

A. I recall that it was also through these -- such companies that refer experts, but it's not this particular company.

Q. Okay. So another third-party referral firm; is that correct?

A. Exactly.

Q. And I know -- I may draw an objection from counsel on this, but I'm trying to get a more specific question here.

With respect to the preparation of your declarations in this proceeding and/or the other proceedings, did you have any discussions with any employees of MRD for purposes of preparing your declaration?

A. No.
Q. Is it fair to say then that for purposes of preparing your declaration, those were prepared in conjunction with your work with counsel for MRD?
A. Yes.
Q. Do you know if anyone at MRD reviewed your draft declaration before it was filed in these proceedings?
A. I don't know.
Q. Dr. Chung, I realize after having had the opportunity to review your CV and some of your YouTube videos, in fact, that you've published, that you have a very accomplished career.
And so my colleagues who are on this call today recognize you've had a very accomplished career and even know your former colleague, Dr. Dresselhaus. I did, however, want to explore a few additional things regarding background with you, but I did want to make note of that in the first instance, a very distinguished career.
Now, in your declaration, which is, again, MRD-2006, you note that you published 36 peer review publications on carbon nanotube, carbon nanofiber, carbon black and graphite nanoplate, correct?
A. Yes. Yes. Also carbon filament, which is the

original term for carbon nanofiber. Yes.

Q. Okay. And that was one of my questions as well. You beat me to it again. So that's helpful.

And those 36 peer review publications appear on page 9 of your declaration, correct, in paragraph 16?

A. Yes. I hope it adds up to 36. I suppose it adds up to 36. Oh, yeah. Okay. All right.

Q. And then in your declaration at paragraph 17 on page 10, you specifically list several articles that you say, quote, "pertain to the processing, structure, properties, and applications of carbon nanotube and related materials," end quote, correct?

A. Yes.

Q. And several of those are listed continuing on over to page 13; is that right?

A. Yes.

Q. Are these references listed in your CV, and specifically are those references listed in your CV beginning at page 75 under the heading "Carbon" on page 75?

A. They should be. I'm sure they're listed in my CV. But -- but they are to be listed in the Carbon, but in this categorization in my CV might not be perfect, but that's --

Q. Okay. And so there's no reason to believe

that any of these articles that you've listed in your declaration would not be identified in your CV, correct?

A. That's right. Oh, yes. Oh, yes. Now I remember. For the CV, it -- I have listed "Carbon" as one category and "Cement-Matrix Composites" as another category, "Polymer-Matrix Composites" as another category. And these are the composites that can include carbon, you know. And that's why the -- the listed publications in my declaration I'm sure are not all in the category of carbon of my CV.

Q. I see. And why did you choose to list out the specific articles that begin on paragraph 17, page 10, and extend over to page 13 in your declaration? Why did you specify those particular articles in your declaration?

MR. GLENN: Objection to the extent the question calls for attorney work product.

THE WITNESS: I'm -- could you repeat, please?

BY MR. RIFFE:

Q. Sure. I want to understand why did you choose to list the specific articles you chose to identify on pages 10 through 13 in your declaration in paragraph 17.

MR. GLENN: Same objection.

THE WITNESS: Those publications pretty much directly related to carbon filament, carbon nanotube,

carbon black. You know, those are really the most relevant.

BY MR. RIFFE:

Q. Okay. Do any of the publications referenced in paragraph 16 listed in paragraph 17 of your declaration refer to or describe discrete carbon nanotubes?

MR. GLENN: Objection. Ambiguous.

THE WITNESS: Could you repeat, please?

BY MR. RIFFE:

Q. Yes. Do any of the publications referenced in paragraph 16 or listed in paragraph 17 of your declaration refer to or describe discrete carbon nanotubes?

MR. GLENN: Objection. Ambiguous.

THE WITNESS: I do not use such a term.

BY MR. RIFFE:

Q. What do you mean you do not use such a term?

A. That is, I don't have explicit mention of discrete carbon nanotubes.

Q. And why is that?

A. Well, part of that because I often use the term "carbon filaments." That's one of the reasons. Another reason is I recognize that carbon nanotubes or carbon filaments, whatever you call them, they -- they

come in an intertwined state, intertwined morphology. That's the norm, you know; and with that norm, it's not discrete.

Q. Have you -- have you used the phrase "discrete carbon filament" before in your prior writing?

A. No.

Q. Why not?

A. Again, because the material comes in an intertwined form, just not discrete.

Q. Are you aware of prior processes that attempted to de-agglomerate or exfoliate these agglomerated carbon filaments or nanotubes?

A. Well, because of this case, you know, I certainly know that. But when I was writing these papers, or publications, that -- I did not really -- I was aware of the discrete nanotubes.

Q. Were you aware of exfoliated nanotubes or nanofibers at the time of your writing? I apologize. I misspoke.

Were you aware of exfoliated nanotubes or carbon filaments when -- at the times of your prior writings?

MR. GLENN: Objection. Ambiguous.

THE WITNESS: Actually, I -- I did publish on exfoliated carbon filament. But it's not the same

meaning of the term "exfoliation" compared to what -- relevant to this particular case because I was exfoliating one carbon filament, not -- not a whole collection of carbon filaments, you know.

So I'm actually an expert in exfoliation of carbon materials. And by that term, I mean exfoliating a particular -- one particular filament, not a bunch of them.

BY MR. RIFFE:

Q. And so in your publications with respect to exfoliating carbon filament -- I just want to make sure I'm understanding -- you were exfoliating a single carbon filament at the time; is that correct?

A. Yes.

Q. And -- and it's your understanding that -- that single carbon filament could also be referred to as a single carbon nanotube in today's terminology; is that correct?

A. Yes.

MR. GLENN: Objection. Ambiguous.

THE WITNESS: I'm trying to remember. It's been so long ago. The exfoliations that I did, I did it on graphite, and I did it on carbon fiber. But I don't think I did it on carbon filament. My recollection is not perfect.

BY MR. RIFFE:

Q. Your -- to the best of your recollection, the exfoliation you did was on carbon fiber; is that correct?

A. Yes. Most of it was on graphite, actually. But also on carbon fiber.

Q. So when you said earlier that you were exfoliating a carbon -- a single carbon filament, is that incorrect?

MR. GLENN: Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Yeah. My -- yeah, I think it's incorrect because -- but based on my recollection at this point, I did not do the exfoliations of a single carbon filament.

BY MR. RIFFE:

Q. At the time of your prior articles on exfoliation of graphite, were you familiar with the concept of a single carbon filament or carbon nanofiber, which is now referred to as carbon nanotube?

MR. GLENN: Objection. Ambiguous and compound.

MR. RIFFE: And, Counsel, during these IPR proceedings, my understanding -- and I've been very careful in defending these -- not to use "vague and

ambiguous" as objections. I think they're called out as improper in the trial practice guide.

So I'm not sure if you're trying to coach Dr. Chung with those objections, but --

MR. GLENN: I'm simply --

MR. RIFFE: I'd ask that you adhere to the trial practice guide or else we're going to have to get in front of a judge this morning, which I despise to do, but --

MR. GLENN: Understood. I'm actually trying to do the opposite. I'll restrict my objection to form, if that --

MR. RIFFE: I think that would be better.

MR. GLENN: Understood.

MR. RIFFE: Okay. Thank you.

THE WITNESS: Yeah. Just if you could repeat --

BY MR. RIFFE:

Q. Sure. That's no problem.

So, Dr. Chung, I just want to unpack what you've said in the last ten minutes.

Initially you said that you were exfoliating a single carbon filament, but now you're saying that you -- based on your recollection, you weren't doing that. So I'm just trying to unpack what, if any,

familiarity you had with exfoliation of single carbon nanofibers or single carbon filaments in the past.

MR. GLENN: Objection. Form.

THE WITNESS: I -- I did not do that. That is the exfoliation of single carbon filament or single carbon nanotube. And I doubt if anybody has done that.

However, I have done activation of the carbon filament.

BY MR. RIFFE:

Q. And what do you mean by "activation of the carbon filament"?

A. Just like activated carbon, you know. You make it more porous. And just like activated carbon, the porosity serves to get the junk so they can clarify stuff.

(Court Reporter requested clarification.)

THE WITNESS: Activated carbon is well known for its intended porosity, and the pores are where the junk -- that is the impurities -- that you want to get rid of. The junk will reside. That's why -- that's how the activated carbon serves to purify fluid like air or water.

So in a similar vein, I activated carbon filament, and that -- that -- that was the very first time that anybody did activation of carbon filament.

BY MR. RIFFE:

Q. And the carbon filament that you were performing this activation of, was this an agglomerated part of carbon filament, or were they discrete or separated carbon filaments?

MR. GLENN: Objection. Form.

THE WITNESS: Not separated because the norm, as I said, is the intertwined morphology.

BY MR. RIFFE:

Q. So the activation that you were performing was on an intertwined morphology of the carbon filament; is that correct?

A. Yes.

Q. Prior to your work in these Inter Partes Review proceedings on behalf of MRD, had you heard of the phrase, quote, "discrete carbon nanotubes," end quote?

A. No.

Q. Had you heard of the phrase "exfoliated carbon nanotubes"?

A. I might have heard of that, but I also understood that it's not the exfoliations that the original term "exfoliations" is supposed to mean, you know. The original term of exfoliation of carbon nanotube would mean doing exfoliation on a single

nanotube, you know.

And I realize that that original meaning of exfoliation is not the meaning that pertains to the present case.

Q. And what's the meaning of exfoliation that pertains to the present case, in your opinion?

A. For the present case, there's no exfoliation for -- you know, each carbon nanotube. It's just untangling the collection of nanotubes so that they are not so intertwined.

Q. And at that point you would disagree if someone referred to those nonintertwined carbon nanotubes as exfoliated; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Could you clarify, please?

BY MR. RIFFE:

Q. Sure. At the point that the carbon nanotubes are not intertwined, you would disagree with someone of skill in the art that would refer to those nanotubes as exfoliated; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Well, it depends on what they mean by exfoliation, you know. Understanding that they don't mean the original meaning of exfoliation, then it's okay, you know. So I have to search their hearts

to see what they mean by exfoliation.
BY MR. RIFFE:
Q. So if -- if someone in this industry referred to exfoliated nanotubes as individually dispersed nanotubes, would you agree with that reference?
MR. GLENN: Objection. Form.
THE WITNESS: Not exactly. Individually disperse, that's more demanding than just untangling.
BY MR. RIFFE:
Q. So you would disagree with someone in the industry that referred to individually dispersed --
MR. RIFFE: And I'm saying dispersed here, Ms. Houston, with a P, as in Paul.
BY MR. RIFFE:
Q. You would disagree with someone in the industry that referred to individually dispersed carbon nanotubes as exfoliated, correct?
MR. GLENN: Objection. Mischaracterizes --
THE WITNESS: Oh, okay.
(Court Reporter requested clarification.)
MR. GLENN: Objection. Mischaracterizes the witness's testimony.
THE WITNESS: Okay. This entanglement leads to exfoliation, kind of pops up, you know, but that doesn't mean that they become individually dispersed,

you know. That is, if it's individually dispersed, it has to be exfoliated. But if it's exfoliated, it doesn't have to be individually dispersed. So the two scenarios are not identical.

MR. RIFFE: Okay. I'm going to strike that as nonresponsive.

BY MR. RIFFE:

Q. My question is: If someone in the industry refers to individually dispersed carbon nanotubes as exfoliated, would you agree or disagree with that person's definition?

A. I tend to agree with that. As I said already, if it's individually dispersed, it -- it's exfoliated.

Q. Okay. Thank you.

Let's back up just a minute, Dr. Chung. What -- what in general is a carbon nanotube? I've seen many, many references to this, but I just wanted to see what your understanding is.

A. Yes. A carbon nanotube is a form of carbon nanofiber. And its structure is such that it consists of one or more concentric cylinders. We call them walls, you know.

And it could be -- one wall, we call it single wall. Multiple walls, we call it multiwall nanotubes. So basically a tube -- also is a tubular structure. So

that's -- there's a hollow channel in the middle along the axis of the nanotube.

Q. And -- and I think I asked one of my colleagues this. My simple mind of thinking here, is that these carbon nanotubes are mono diameter; in other words, they have a single diameter; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Oh, no. Obviously between the single wall and multiwall, there can be a really big difference in the diameter. The more the number of walls, the more is the diameter, and the number of walls is a big barrier.

And so within the category of single wall, then the diameter has less variation. But within the category of multiwall nanotubes, then the variation in the diameter is very large.

BY MR. RIFFE:

Q. And that's helpful and maybe my question wasn't as good as I thought it was.

Take an instance where we have a single single-walled nanotube, somehow we managed to unagglomerate and we have a single single-wall nanotube.

Does that single nanotube have a consistent diameter?

A. Yeah. For the single wall, the variation in

diameter is much smaller than that of the multiwall, but it's still not -- not every single nanotube has exactly the same diameter. It's not as exact as that.

Q. Understood. But if we take the instance of this, if we're looking at one single nanotube, does that nanotube have the same diameter across its length?

A. I see what you mean. For a single -- a single-wall carbon nanotube along its length, ideally, the diameter is constant.

Q. Okay.

A. But it might not be ideal because there can be even functional groups sticking out, you know.

Q. Okay.

A. And even other defects like little nanoscale indentation, you know. So in reality, it might not be so constant.

Q. I see. Is it possible for a single single-walled nanotube to break apart and then reconfigure itself to another larger diameter single-walled nanotube such that you had sort of -- you ended up with a single-walled nanotube of a smaller diameter connected to a single-walled nanotube of a larger diameter?

A. Please clarify your question. Sounds complicated.

Q. Okay. Maybe I'll just strike that just as background. Okay.

We've -- we've said a lot of phraseology here this morning, and I just want to make sure I'm clear with you.

You say that a carbon nanotube is a type of carbon nanofiber; is that correct?

A. Yes.

Q. Okay. And that carbon nanofiber was originally known as carbon filament; is that correct?

A. Yes.

Q. So the progression has kind of been carbon filaments were types of carbon nanofibers, and now carbon nanofibers are now referred to as carbon nanotubes in certain instances; is that correct?

A. In certain instances, yes. The carbon nanotube is not the only type of carbon nanofiber, even today.

Q. What are the other types of carbon nanofiber besides carbon nanotubes?

A. Another type is also having the hollow tube in the middle, but then instead of concentric cylinders of carbon, it's got the carbon layers at an angle with respect to the axis of the -- of the tube, and such that the nanofiber is essentially a stack of ice cream cones.

It's like ice cream cones with the tip of each cone cut off in the stack of this, okay, and that -- that is the other type of carbon nanofiber.

Q. Does that have a specific name or label?

A. They call it fish bone morphology.

Q. Okay.

A. Ice cream cone, you know, like a fish bone.

Q. Okay. So they have a more sharper edge, if you will, than the carbon nanotubes; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Well, sharp edge sounds unclear in meaning to me. But the thing is, you know, because of the angle, the edge of the carbon layers would be more exposed, yeah.

BY MR. RIFFE:

Q. Okay. That's helpful.

What are some applications of carbon nanotubes?

A. Oh, there are numerous applications, both mechanical and electrical, you know. Concerning the mechanical side, the carbon nanotube within the tube is very strong in terms of bolstering an elastic modulus. And so it can be a very good reinforcement. Okay. That's the mechanical side.

The electrical side is that it's electrically

conducted, and it is -- the aspect ratio can be substantial because of the tiny diameter of the nanotube that is compared to, say, short carbon fiber. Okay?

By "fiber," I mean the conventional micron diameter fiber. Compared to short carbon fiber, the carbon nanotube tends to have larger aspect ratio, and the larger aspect ratio would enhance the chance of developing percolation. That is forming a continuous electrical network because of the touching of one nanotube with another nanotube.

And having longer aspect ratio makes it more likely to have these contact points, and these contact points are essential for percolation. That is for the entirety of the collection of nanotubes to provide a continuous electrically conductive path.

And so conductivity is another big application area of the nanotubes.

Q. Okay. That's very helpful. So you agree that then, I think based on what you just told me, that these carbon nanotubes are known for having a length that's significantly larger than their diameter which leads generally to them having a higher aspect ratio; is that right?

A. Yes.

Q. And -- and based on what you've told me --

just make sure my understanding is correct -- this high aspect ratio of the carbon nanotubes contribute their ability to form percolating networks within a matrix material; is that right?

A. Yes.

Q. And that's helpful -- in some instances crucial -- for achieving high conductivity; is that right?

A. Yes.

Q. What are the common types of carbon nanotubes in terms of -- I want to make that a little more precise. What are the common structures of carbon nanotubes? I think we've talked about some of them, but in your opinion, in your expertise, what are some of those common structures?

A. Well, the main is pertaining to the diameter, and that relates to the number of walls.

Another is the length. The length is limited; you know, very far from infinity. And so the length, the diameter, and its associated aspect ratio, those are -- from the point of view of the geometry, that's important characteristics.

But there are other characteristics such as the surface chemistry which relates to the functionalization, and that can -- the functionalization

provides the surface function loop to stick out from the trunk of the nanotube, and that's allowing the nanotube to interact with other species around and -- and the functionalization can greatly affect the behavior of the nanotube.

Q. In terms of the wall, carbon nanotubes are either single wall or multiwall; is that correct?

A. Yes. Multiwall, including double wall, triple wall, and so on, yes.

Q. Okay. And it seems to me like these single-wall or multiwall nanotubes can have almost an infinite number of geometrical configurations; in other words, they can be anywhere from very -- very straight carbon nanotubes, sort of wormy-looking carbon nanotubes, if you will, or even could they be formed into a doughnut shape in some instances?

A. I'm not sure what you mean by the doughnut shape. You mean the collection of nanotubes making a doughnut?

Q. I'm thinking of a single nanotube, if you will. So we have a single-walled nanotube that could be straight. It could be sort of wormy, if you will, looking -- if you look at it under a microscope.

Could a single-walled nanotube be formed into a doughnut; in other words, if you took the ends and

brought them around; is that a possibility?

A. Well, the nanotubes condense, right?

Q. Right.

A. And that's why, when you said "wormy," you know, it's condensed. And you can -- but, you know, you can bend it and have the two ends kind of almost meet or meet, but I don't mean joining, you know, just kind of closed like a doughnut. But I think the radius of curvature obviously cannot be too tiny; you know, tiny doughnut.

Q. Right. Right.

A. Too sharp a bend. So bendable, you know. There's a limit to how sharp a bend you can have it.

Q. So it's true then that if you bend the carbon nanotube too far, it will break; is that correct?

A. Yes.

Q. Under certain conditions. Okay.

Are single-walled nanotubes used in applications instead of multiwalled nanotubes, and vice versa, even?

A. Yeah. Because of the diameter difference, the single-wall and multiwall nanotubes tend to be different in their attractiveness for various applications.

Because of these tinier diameter of the single-wall nanotube, it -- if you have a long enough

single-wall carbon nanotube, the aspect ratio can be very large. That is, for the same length with the carbon -- a single-wall carbon nanotube would have a higher aspect ratio than a multiwall. Okay?

And the larger of the aspect ratio, the more is the chance of developing a percolative network, you know, electrically connected network through percolation.

And that means you would need a lesser amount, say by volume, of the nanotubes to achieve percolation. And that saves money and efficient to having other attractiveness such as the dispersion being not so viscous.

MR. GLENN: Counsel, we've been going about like an hour. I just don't know if you want a quick break. I'm fine. Just check in with the witness just for logistics purposes if you wanted a quick break somewhere.

BY MR. RIFFE:

Q. Dr. Chung, would you like to take a break?

A. Okay. Maybe just five minutes then.

MR. RIFFE: Okay. That's fine. We'll come back around 10:20.

(Recess: 10:15 a.m. to 10:25 a.m.)

BY MR. RIFFE:

Q. Dr. Chung, before the break, we were talking a little bit about single-walled nanotubes and multiwalled nanotubes and their application.

I next want to move to a different question. Are there uses of carbon nanotubes on their own, or are they always added in a mixture or dispersion with other elements?

MR. GLENN: Objection. Form.

THE WITNESS: Both. Both on their own and as part of the composite.

BY MR. RIFFE:

Q. Okay. What are some uses on their own that carbon nanotubes have?

A. It is for both mechanical and electrical. Because there are some situations where you want very tiny -- very microscale kind of devices, and you want reinforcement to be in a very tiny, tiny scale.

Now, composites can be big scale. But if you deal with a single nanotube, it can be really tiny scale, and in some micro devices, they might need that tiny scale. Whether mechanical or electrical, that tiny scale is beneficial for micro devices.

So it can be by itself or as a connection, yes.

Q. And in that instance where you say that you could have a single nanotube in a micro device for mechanical or electrical benefits, is that a single individual nanotube, or is it an agglomeration of nanotubes that are used in that sort of micro device application?

A. Like I said, if you want it to be a really, really micro device, then having a big agglomerate would not be suitable because you want it really, really tiny. So it depends on how tiny you want it. If you want it to be really, really tiny, you don't want a big agglomerate.

Q. Are you familiar with micro devices that use single carbon nanotubes in the past either for an electrical or mechanical application?

A. In the first instance, one can make electrical devices such as transistors. Okay. For a transistor, you need different electronic components on the different materials, the semi-conductive ones and metallic ones.

And single carbon nanotube can be rendered metallic or semi-conducting. So you can have an assembly of carbon nanotubes, the metallic ones and semi-conductive ones, and assemble that into a transistor. That's kind of the research direction

that's very active right now.

Q. And how do they go about separating those nanotubes to apply them in that single nanotube application?

A. It's -- it's tedious work. It's never easy. But there can be mechanical or electrical ways of doing that. I'm not an expert in the details of how they do it, but it can be done.

Q. Can you buy from a supplier -- strike that.

Can you specify from carbon nanotube suppliers that you want individualized single carbon nanotubes?

A. I don't think so.

Q. Is it your understanding that any commercially available carbon nanotubes would be shipped or present in an agglomerated fashion?

A. Yeah. Intertwined fashion, yes.

Q. How are these carbon nanotubes generally provided to a researcher or to another company? What form do they take? Do they take a powder form, an emulsion, or both?

A. Yeah, a solid form. You can call it powder. A solid form is the most common. But in the form of a dispersion, it's possible too. But most often it's in the solid form.

Q. But when you say "most often it's in the solid

form," it's an agglomeration, or it's a powder of collection of nanotubes?

A. I'm not sure what you mean by "powder."

Q. What do you mean when you say a solid form?

A. Not a solid liquid combination. It's just solid.

Q. We look at it under a microscope, it's an agglomeration of nanotubes in a solid form?

A. Yeah. But agglomeration would be a solid, you know.

Q. Right. Right.

A. So solid is not limited to agglomerate.

Q. But would those -- would that starting solid material have individualized nanotubes in it?

MR. GLENN: Objection. Form.

THE WITNESS: The -- it comes in intertwined morphology, you know. If you want it not intertwined, you have to --

BY MR. RIFFE:

Q. Process it?

A. -- process it yourself. I don't think you can buy something that's already, you know, individualized.

Q. Have you or your research teams performed research on the implementation of these individual carbon nanotubes in micro devices as you described

earlier?

A. No. I haven't done that.

Q. But are you aware of industry participants that use individualized carbon nanotubes in these micro device implementation?

MR. GLENN: Objection. Form.

THE WITNESS: I'm aware of such work in research, you know, in universities, but I'm not sure this industrial kind of work on that.

BY MR. RIFFE:

Q. And the work that you're aware of in the university setting, was your awareness before or after you became involved in work on these Inter Partes Review proceedings?

A. Before.

Q. How -- how much -- how much in the past were you aware or -- at what point in the past did you become aware of this work on the micro device implementation that you described today?

A. Well, it starts with me where the carbon nanotubes can be metallic or semi-conductive. That was the big discovery of Professor Dresselhaus, my mentor. And that is the -- that is the discovery which make possible of what I just said about micro devices involving metallic form of nanotube in semi-conductive

form.

So the start of the thinking, you might say, is the discovery made by Professor Dresselhaus.

Q. And, again, those are -- those were single individualized nanotubes at the time for use in those micro devices as you described earlier; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: They don't have to be single. Okay.

BY MR. RIFFE:

Q. Could they -- could they have been?

A. It depends on -- at the very beginning, I should say, the discovery, that -- that is actually theoretical. Okay? Depending on the detailed structure, which is called the chirality of the nanotube, it can end up metallic or semi-conductive, and that can -- as a theoretical prediction, and then it was verified experimentally.

But that -- that doesn't mean that you have to deal with a single nanotube. You can have a collection, which is all metallic or collection, which is all semi-conductive.

Q. Okay. And I -- that's what I just wanted to clarify because earlier I think in your testimony you said that there are uses in these micro devices where a

single carbon nanotube could provide the structural or electrical characteristic that you're looking for.

I just want to make sure that -- is it a single carbon nanotube that can provide that or an agglomeration of nanotubes? Which one were you referring to?

A. As I said, it can be a single having, say, semi-conductive behavior. It can be a collection such that all of the units in that collection are semi-conducted. You know, but if you have a collection, with some nanotubes being metallic and some being semi-conducted, then you have a mess.

Q. Do you agree that carbon nanotubes typically have lengths ranging from nanometers to centimeters?

A. Oh, not that long. Even in a micrometer range, it's considered to be long. A centimeter is a few orders of nanotube, longer than a micrometer.

Q. So would it be more correct to say that the lengths vary from nanometers to micrometers?

A. Yeah, that would be more realistic.

Q. And what diameter ranges does -- do carbon nanotubes have? Are those generally in the nanometer range?

A. Yes. Yes, but it -- it can -- by nanometer range, I don't mean one nanometer range. It can be 10

nanometer, even larger. But, yeah, it is nanometer scale, yeah.

Q. I earlier asked you if single-walled nanotubes have certain applications instead of multiwall nanotubes, and we kind of got into this next question, but I just wanted to make sure that I have a full record here.

Do agglomerated carbon nanotubes have different uses than discrete carbon nanotubes? And if so, what are some examples?

MR. GLENN: Objection. Form.

THE WITNESS: So, see, what you call agglomerated, I suppose you mean interconnected from the network. Okay? And that is widely used for composites or whatever components that need high electrical conductivity, because each individual nanotube cannot be very long. That -- you want the conductivity to be over a substantial distance, so you cannot achieve that with a single nanotube. The single one is too short.

So you need multiple nanotubes, and you need them to touch one another. That's what I mean by a continuous electrically connected network.

And that form is very widely used. The discrete form of the single individualized form is much less used, and -- and the utilization could be in terms

of mechanical or electrical, but in a way that is more microscopically directed. As a reinforcement or as an electrically conductive path, it's for a microscopic region, not over a big region.

BY MR. RIFFE:

Q. So are there applications, specific applications or examples that you could provide where that single individualized form is used? I know it's used less than the -- the interconnected, but are -- are there some specific examples that you're aware of where those discrete forms are used?

MR. GLENN: Objection. Form.

THE WITNESS: I have not read papers that -- that deal with that. But I see the feasibility of using that in those small situations, microscopic situations. But I -- I haven't read papers that specifically talk about that.

BY MR. RIFFE:

Q. That's fine.

So if nanotubes are being added to improve electrical conductivity, like you said, the interconnectivity, is it your view that those nanotubes cannot be discrete?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Yeah. As I said, for percolation, there has to be contact between one nanotube unit and another nanotube unit. And that connectivity results in a continuous conductive path, which is necessary.

And if you don't have this conductive network, you would -- let's say you have just a single one, then it's so short. You can still do it, but it's so short. And so between point A and point B, you can still connect electrically, but the distance between A and B has to be very small.

BY MR. RIFFE:

Q. And that's -- that's more along the microscopic scale that you were referencing earlier, I take it; is that correct?

A. Yes.

Q. Okay. And just to make sure I've got a clear record, you said for percolation there has to be contact between one nanotube unit and the other nanotube unit, and that connectivity results in the continuous conductive path, which is necessary, correct?

A. Yes.

Q. And with individualized or discrete carbon nanotubes, you just can't obtain that, maybe just for a microscopic distance, if you will?

MR. GLENN: Objection. Form. Mischaracterizes the witness's testimony.
BY MR. RIFFE:
Q. Is that right? Do you recall the question?
A. Can you clarify --
Q. I said with individualized or discrete carbon nanotubes, you can't obtain that except for in that -- in that example you provided in that very short microscopic distance; is that correct?
MR. GLENN: Same objections.
THE WITNESS: Yes. You want to electrically connect point A and B using a single nanotube. Then the distance between A and B has to be very small, yes.
BY MR. RIFFE:
Q. In your opinion, do discrete carbon nanotubes have any advantages over agglomerated or carbon nanotubes?
MR. GLENN: Objection. Form.
THE WITNESS: Yeah. If one doesn't want the electrical conductivity, then one doesn't need the percolated form. So under that situation, the discrete form may be attractive for some other reasons.
BY MR. RIFFE:
Q. What reasons?
A. As I said, you might have a situation where

you want to interconnect between -- electrically connect between point A and point B, and the point A and point B are very close to each other. And so that's a scenario where it's a very short distance, and the single one would suffice.

Q. Are there any other reasons that you would want to use those discrete individualized carbon nanotubes other than this situation where you have this very short distance to connect point A and B?

MR. GLENN: Objection. Form.

THE WITNESS: Yeah, you -- you can have -- I mention about electrical conduction -- electrical connection between A and B. They have to be very close together.

But another application is not electrical but mechanical. Okay? That is, you have an object, which is -- which is the A and B inside the object, you know, and A and B are very close -- and the distance is small between A and B. Okay? Then you can consider having a single one to provide the reinforcement, okay, over the distance from A to B.

BY MR. RIFFE:

Q. What types of applications are you referring to? Are you referring to semi-conductors? Are you referring to other types of micro devices?

A. It's the general situation. For semi-conductors, they don't care that much about mechanical. It's mostly electrical. Okay? But for a lot of other applications, such as battery electrodes, they care about mechanical, not just electrical. So it depends on the application whether they care about mechanical or not.

Q. And it's your opinion that a single carbon nanotube can provide reinforcement in those applications?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: It can provided that the -- the single nanotube is sufficiently bonded to that entity that it's supposed to reinforce.

BY MR. RIFFE:

Q. And in the context of battery electrodes where you say they're -- they care about mechanical properties, how does a single carbon nanotube provide such mechanical properties in those applications?

A. In a battery electrode, particularly a lithium ion battery, it involves intercalation during charging and de-intercalation during discharge. And in intercalation you have expansion because you're putting something in. In de-intercalation, you have

contraction.

And so you have dimensional change. And you have many cycles of charge, discharge, charge, discharge and so many cycles of expansion and contraction. And that can lead to fatigue, you know. And that can lead to mechanical degradation of the electrode, even fracture of the active particles.

And when the active particles are fractured, you lose both electrical and mechanical performance. Electrical performance goes back because you have a crack there within a particle, an actual particle. You have a crack within it, and so it's almost like a little open circuit within it, so it would make the electrical connectivity much worse, the electrical cracking that -- but the mechanical also that -- and you have a crack there.

But a battery electrode doesn't need high strength, but it cannot be too flimsy. So when the particles are cracked, it can be kind of flimsy.

Q. Why do the nanotubes have to be discrete to prevent these fractures that you just described?

MR. GLENN: Objection. Form.

THE WITNESS: Okay. These particles are not very big, and you want to make the particles have a lower tendency to crack. Okay. And so you need kind of

a mechanical bridge to cut -- to go across that particle to kind of constrain the particle in case it wants to crack.

And so for that constraining, for that one particle, you don't need a long length of the nanotube.

So even one could suffice provided that, as I said, that that one nanotube is sufficiently bonded to that particle.

If you have multiple nanotubes, it's possible; but then it -- they -- but what I mean is that it's not required. Okay?

BY MR. RIFFE:

Q. You would agree with me that in these -- in these applications in the electrodes you've been discussing this morning, discrete carbon nanotubes are not required to provide that structural characteristic, correct?

MR. GLENN: Objection. Form.

THE WITNESS: You want at least one nanotube to do this reinforcement between A and B, you know, within the particle. Okay. And you want to make sure that at least one is doing that, and so -- and if you have a bunch of that, not all of that may be physically connected or bonded to that particle, the active particle. Okay?

It has to be bonded to it. If you have an agglomerate and only the outer -- outer -- outermost unit of the nanotube is bonded to this particle, and the rest is not bonded, then the rest is not participating in the reinforcement. Any nanotube can participate in the reinforcement only if it's sufficiently bonded to that entity that is being reinforced.

So if you have a bundle, you might be wasting a large part of your bundle because a large part of the bundle might not be sufficiently bonded to the entity that you want to reinforce.

BY MR. RIFFE:

Q. You would agree with me, however, that you could use nondiscrete carbon nanotubes. It just may not be as efficient if you -- if you were to use a two or three, if you will, bundled nanotubes versus a single discrete individualized nanotube, correct?

MR. GLENN: Objection. Form.

THE WITNESS: Could you rephrase, please?

BY MR. RIFFE:

Q. Sure. You could certainly use a bundled set of nanotubes in this application, in the electrode application. It just may not be as efficient as using a single individualized nanotube as you've testified to earlier; is that correct?

A. There are other complications of using a bundle as opposed to a single because within the bundle you have empty space, right, between the adjacent units of the nanotube in the bundle. You have some empty space there.

And -- and other things can get into the empty space -- empty space like impurities from the environment. Even the binder itself can get -- get in. And it just complicates matter.

And in addition, when you have a bundle, the -- the single carbon nanotube that happens to be touching that entity to be reinforced is mechanically constrained on the other side by the rest of the bundle, you know. It's like baggage. The rest of the bundle is like a baggage for this single nanotube that is touching the entity to be reinforced.

So it's got that baggage at its back that would make a single nanotube not -- not so free in doing what it wants to do. So there can be various complications if one has a bundle.

Q. Dr. Chung, could you please explain to me how you prepared your declaration?

MR. GLENN: Objection to the extent the question calls for attorney work product.

THE WITNESS: Well, I reviewed those various

documents, as I mentioned to the board, and I look -- looked at the various concepts inside in the context of how I understand the subject is. I looked at those -- whether I agree with or not agree with some of the concepts presented by various documents, I try to formulate some -- some reasons.

Now, if I don't agree, I say why I don't agree so a lot of thinking -- a lot of thinking is involved in association with reviewing all those documents. And obviously I also have discussion with the counsel, and the counsel helps me in -- in putting my thoughts in a format which -- which is required for the declaration.

BY MR. RIFFE:

Q. Did you write the first draft of the declaration, or did your counsel provide you with the first draft?

MR. GLENN: Objection. Calls for attorney work product. We would instruct the witness not to answer.

(Witness instructed not to answer the question.)

BY MR. RIFFE:

Q. Are you going to follow the instruction not to answer?

A. Well, it's a joint effort.

Q. But did you write portions of the declaration and then the attorneys wrote other portions?

MR. GLENN: Same objection. Instruct the witness not to answer.

(Witness instructed not to answer the question.)

BY MR. RIFFE:

Q. Are you going to follow the instruction not to answer?

A. Yes.

MR. RIFFE: Counsel, you're not going to allow her to answer whether she wrote portions of the declaration or the attorneys wrote other portions; is that your standing objection?

MR. GLENN: It is.

BY MR. RIFFE:

Q. How much time in total did you spend drafting your declaration, Dr. Chung?

A. A lot.

Q. Do you recall how many hours?

A. It's a lot of hours. I told you how many -- how many dollars. Now you can divide by hourly rate and you know how many hours I spent pretty much.

Q. Right. So you spent 120 hours in total across the five IPRs, correct? You spent about -- you charged

about $90,000 at $750 an hour. That comes to about 120 hours if my calculator is correct.

Does that sound correct?

MR. GLENN: Objection. Form.

THE WITNESS: I don't -- I don't have my -- I can use my calculator if you want me to check your math.

Yeah, your math is right. 120 hours, and then you divide by five, right, because there are five patents. So that would be 24 hours. Something like that.

BY MR. RIFFE:

Q. You didn't spend 24 hours drafting this declaration, MRD-2006, correct?

MR. GLENN: Objection. Form.

THE WITNESS: If drafting means actually -- and I'll preface it, writing things, it's -- it's -- I consider declaration preparation, which is not just drafting. It's a lot of thinking involved.

BY MR. RIFFE:

Q. So is it fair to say that in total in reviewing documents, discussions with counsel for MRD and then drafting portions of your declaration, you spent approximately 24 hours on this IPR proceeding; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: More or less, roughly.
BY MR. RIFFE:
Q. Let me ask you this question: Did you actually type any portion of your declaration into a word processing software feature? Or did you rely on counsel to do the drafting?
MR. GLENN: Objection. Form.
THE WITNESS: I might have done part of that, and I might have also verbally told the counsel. I think I've done both.
BY MR. RIFFE:
Q. Did anyone help you form your opinions set forth in your declaration?
MR. GLENN: Objection. Form.
THE WITNESS: No other person. I discuss with counsel to a degree, but no -- the thoughts come from me alone.
BY MR. RIFFE:
Q. Are you aware of any errors in your declaration that you'd like to make note of on the record and correct at this time?
A. There might be a little bit of really nonessential errors that anybody can see it's not -- not really... so there's nothing really important enough to really go through.

Q. Maybe -- maybe that's your opinion, but I might disagree with you on that.

Did you note any errors that you specifically -- let me strike that.

Are there any errors in your declaration that you would like to note on the record at this time?

A. I've noticed a couple, but I did not jot them down. So I'm not sure if I can get those couple so quickly.

Q. Do you understand what the nature of those errors were? Were they typographical errors or substantive errors?

A. It's not substantive. It's just like missing a word or messing up with one word or something like that.

Q. Well, if we -- as part of the review of your declaration, if you -- if you come across that error, will you please let me know about that?

A. Sure.

Q. Okay. Thank you.

If you will, turn to page 67 of your declaration, and let me know when you're there.

A. Yes, I'm there.

Q. Is that your signature on page 67 of the declaration?

A. Yes.
Q. Did you insert your signature, or did Counsel?
A. I did.
Q. And did you sign the declaration on March 31st, 2025?
A. Yes.
Q. Are you aware of any changes that were made to your declaration after you signed it on March 31st, 2025?
A. No.
Q. Turn to Section 3 of your declaration. It begins on page 13.
A. Yes.
Q. And this is a legal standard. In paragraph 19 on page 13 you state: "I am not an attorney. For purposes of this declaration, I have been informed about certain aspects of the law that are relevant to my opinions, as set forth below."
Do you see that?
A. Yes.
Q. And then you go on to discuss patentability on page 14, prior art on page 19, inherency on page 20, person of ordinary skill in the art on page 20, and then claim construction on page 22. And that section ends on page 23, correct?

A. Yes.

Q. Okay. What's your understanding of the difference between whether prior art anticipates or renders obvious a claim?

A. Okay. Excuse me, I have to look.

Q. Sure.

A. "For a patent claim to be anticipated by the prior art, each and every element or requirement of the claim must be found expressly or inherently in a single prior art reference.

"Anticipation requires that the single prior art reference must disclose the elements of the claim arranged or combined in the same way as in the claim.

"A claimed invention is obvious if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art.

"Obviousness requires consideration of the following underlying factual inquiries:"

One: "Determining the scope and content of the prior art."

Two: "Ascertaining the differences between the claimed invention and the prior art."

Three: "Resolving the level of ordinary skill in the art."

Four: "Violating objective evidence or secondary considerations of nonobviousness such as experimental results, commercial success, long felt but unresolved need, failure of others, industry praise and unexpected results."

"A reference must be analogous art to the claimed invention in order to be properly considered for use in an obviousness inquiry."

"A reference is analogous art to the claimed invention if:"

Number one: "The reference is from the same field of endeavor as the claimed invention, even if it addresses a different problem."

Or, number two: "The reference is reasonably pertinent to the problem faced by the inventor even if it is not in the same field of endeavor as the claimed invention."

"Whether a reference is reasonably pertinent depends on how the problem faced by the inventor is reflected, either explicitly or implicitly, in this specification."

Q. And you were reading from photographs 22 to 27 of your declaration in that answer, correct?

A. Yes.

Q. Outside of what you just read, do you have an understanding of the difference between what is anticipation of a claim versus what is obviousness of a claim?

MR. GLENN: Objection. Calls for a legal conclusion.

THE WITNESS: I'm not understanding your question very well.

BY MR. RIFFE:

Q. Outside of the paragraph that you just read, do you have any other understanding of the differences between anticipation and obviousness of a claimed invention?

MR. GLENN: Same objection.

THE WITNESS: Well, I -- I could read more because what I read is not everything.

BY MR. RIFFE:

Q. Okay.

A. I could read more if you want.

Q. I'm not going to ask you to read into the record your declaration for certain. Okay.

Is it your understanding that each of the asserted grounds of unpatentability set forth in the petition filed in this IPR against the '649 patent are

based on the obviousness of the challenged claims?
A. Obviousness is -- is -- yes.
Q. Okay. Turn to page 20 of your declaration.
A. Yes.
Q. And will you explain why you included a section on inherency here?
A. It is good to --
(Videoconferencing interruption; Mr. Glenn dropped from Zoom.)
MR. RIFFE: Let's go off the record for a moment.
(Short pause in the proceedings.)
BY MR. RIFFE:
Q. At page 20 of your declaration, Dr. Chung, you included paragraphs 37 and 38 on the concepts of inherency. And I just wanted to note why you included this section on inherency here.
MR. GLENN: Objection to the extent the question calls for attorney work product.
THE WITNESS: If a prior art reference does not expressly set forth a particular claim element, the prior art may still disclose that element if it is inherent in its disclosure.
BY MR. RIFFE:
Q. Are you aware if Petitioner has relied on

inherency in the petition in this IPR proceeding?

MR. GLENN: Objection to the extent it calls for a legal conclusion.

You may answer, Dr. Chung, to the extent that you know.

THE WITNESS: I -- I believe that this -- this is relevant to the case.

BY MR. RIFFE:

Q. And what's that based on?

MR. GLENN: Objection to the extent it calls for attorney work product.

THE WITNESS: I haven't studied it in -- in the angle of inherency.

BY MR. RIFFE:

Q. Then why do you believe it's relevant to the case if you haven't studied it?

MR. GLENN: Same objection.

THE WITNESS: As I said, if a prior art reference does not expressly set forth a particular claimed element, the prior art may still disclose that element if it is inherent in its disclosure.

BY MR. RIFFE:

Q. Do you have any opinions set forth in your declaration, which is MRD-2006, with respect to whether a claim element is inherently disclosed in any of the

prior art references?

MR. GLENN: Object. Object. Calls for a legal conclusion.

THE WITNESS: Could you please repeat?

BY MR. RIFFE:

Q. Sure. Do you have any opinions set forth in your declaration, which is MRD-2006, with respect to whether a claim element is inherently disclosed, or not, in any of the prior art references?

MR. GLENN: Objection. Form. Objection. Calls for a legal conclusion.

THE WITNESS: In the declaration, other than this particular page, page 20, I did not use the inherent -- the discussion. But that doesn't imply that the inherency is irrelevant. I did not express -- explicitly address the inherency scenario -- inherency situation. I did not address that expressly.

BY MR. RIFFE:

Q. Okay. And that's what I wanted to just close out is that in your declaration you have not provided an opinion with respect to inherency of the challenged claims in view of the prior art, correct?

MR. GLENN: Objection. Form. Objection. Calls for a legal conclusion.

THE WITNESS: Yeah. As I said before, I did

not address the inherency explicitly.
BY MR. RIFFE:
Q. Okay. And in your declaration, you have not provided an opinion with respect to inherency, right?
MR. GLENN: Objection. Form. Objection. Calls for a legal conclusion.
THE WITNESS: Yeah. I offered a lot of opinions. And some of the opinions may be relevant to this inherency issue, so I wouldn't say that everything I mentioned in my declaration is irrelevant in the angle of inherency.
BY MR. RIFFE:
Q. Let's turn to Section 6 of your declaration that begins on page 25. And it's under the heading, "Claim Construction."
A. Yes.
Q. And do you recall writing any of the claim construction section that begins on page 25 and extends over to the top of page 28 in your declaration?
MR. GLENN: Objection to the extent it calls for attorney work product.
THE WITNESS: I certainly provided a lot of thoughts to -- to the counsel in -- in formulating what has been written in the declaration. I counterviewed it a lot.

BY MR. RIFFE:

Q. But my question was: Did you write any of the paragraphs 54 through 58?

MR. GLENN: Objection. Form. Objection to the extent it calls for attorney work product.

THE WITNESS: Well, this is a product of a lot of back-and-forth communication between myself and the -- and the counsel. And...

BY MR. RIFFE:

Q. Let me try this, make it a little more crystal clear, maybe.

Did you type any portion of paragraphs 54 through 58 in your declaration?

MR. GLENN: Objection. Form.

THE WITNESS: I -- I did not assemble the pieces of information through typing.

BY MR. RIFFE:

Q. Can you explain to me how you came up with the plain and ordinary meaning of the term "discrete carbon nanotubes" set forth in paragraph 54 of your declaration?

MR. GLENN: Objection to the extent it calls for attorney work product.

THE WITNESS: Yes. It is the plain and ordinary meaning of discrete carbon nanotubes; that is,

I call the nanotubes separate and distinct from other nanotubes not attached to other nanotubes.

BY MR. RIFFE:

Q. I'm sorry.

A. Yeah, and the face of the patent teaches this.

Q. Okay. Let me go back to my original question.

How did you come up with what you just read from paragraph 54, which was the first sentence, your proposed definition of discrete carbon nanotubes? How did you come up with what a POSITA would understand a plain and ordinary meaning of that phrase would be?

MR. GLENN: Objection. Form. Objection to the extent it calls for attorney work product.

THE WITNESS: Yeah. As I said, number one, it is the plain and ordinary meaning of discrete carbon nanotubes.

Number two, the face of the patent teaches this.

BY MR. RIFFE:

Q. Dr. Chung, with all due respect, my question is: How did you come up with this plain and ordinary meaning? You're just reading from your declaration. I'm asking you: How did you come up with this meaning?

MR. GLENN: Same objections.

THE WITNESS: Yeah. I came up with this by

looking and reviewing the various documents, even the dictionary.

BY MR. RIFFE:

Q. And what documents are you referring to?

A. The dictionary is Webster. Okay? And as I said, the specification teaches that an embodiment of the invention is a method for obtaining individually dispersed carbon nanotubes. So it's looking at all these specific kinds of information.

Q. Okay. Thank you.

In that second sentence that you just read, you say, "The face of the patent teaches this," and I know you have a copy, but for our court reporter, I dropped that into the chat, a copy of Exhibit 1001.

And, Dr. Chung, feel free to refer to your copy of Exhibit 1001, which again is the '649 patent.

And I would like for you to describe for me how the face of the patent, the '649 patent, teaches that a POSITA would understand that a plain and ordinary meaning of discrete carbon nanotubes are carbon nanotubes that are separate and distinct from other nanotubes; not attached to other nanotubes?

MR. GLENN: Objection. Form.

THE WITNESS: Okay. In Column 3 --

BY MR. RIFFE:

Q. I apologize to interrupt, Dr. Chung. I'm talking about -- let me make sure we're discussing the same thing.

When you said the face of the patent teaches this, were you referring to the front page of U.S. patent 9,636,649? Or what were you referring to as the face of the patent?

A. I'm referring to the -- how the patent shows itself.

Q. I don't understand that.

A. The face is not limited to the first page. Okay? The face is how the patent faces to the reader.

Q. Well, that's not what you said in your declaration. You said the face of the patent teaches this. You didn't say the patent teaches this. You said the face of the patent teaches this.

Under my understanding of face -- and I think most people in my industry -- the face of the patent is the first page.

Is that not what you were referring to when you said, "the face of the patent teaches this"?

MR. GLENN: Objection to form.

THE WITNESS: Yeah, that's not my understanding of the word "face."

BY MR. RIFFE:

Q. Your understanding of the word "face" is not only the front page of the patent but all subsequent pages of the patent?

A. Yes.

Q. So when you say someone's face of a person, you include their entire body? I'm just trying to make sure I understand what you're talking about.

MR. GLENN: Objection to form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: I don't think the analogy is very appropriate because the face and the body of the person are really -- they are both facing to the people that see, you know. So like the body -- the hand is page 1. The body is page 2. Both page 1 and page 2 can be seen by people.

BY MR. RIFFE:

Q. But when you're talking about the face of the patent, when I'm looking at a patent in paper form, I only see the first page. I don't see all of the subsequent pages. But under your construction of face of the patent, that includes the subsequent pages, correct?

A. Yes.

Q. Did you come up with this phrase, "face of the

patent," Dr. Chung, or did counsel?

MR. GLENN: Objection to the extent it calls for attorney work product.

THE WITNESS: I did not come up with this phrase, "the face."

BY MR. RIFFE:

Q. Counsel for MRD came up with it?

A. I never considered that to be a very significant word. I didn't look at that as a significant word.

Q. Okay. All right. So just to be clear, the face of the patent that you referred to in page 25, paragraph 54, includes the entirety of the patent, correct?

A. Yes.

Q. Okay. Thank you.

Now, at the bottom of paragraph 54, you state that, "The specification also teaches that the carbon nanotube fibers are exfoliated, which a POSITA would understand that exfoliation refers to the untangling of carbon nanotubes from one another allowing the CNTs to be separated from one another to become discrete."

That's what you wrote, correct?

A. Yes.

Q. Now, earlier when I asked if you agreed with

the phrase "exfoliated meaning individually dispersed nanotubes," you agreed with me on that.

Do you recall that?

MR. GLENN: Objection. Mischaracterizes the witness's testimony.

THE WITNESS: I did not agree to that. I said that the two are not the same thing. Exfoliation refers to untangling, but untangling doesn't mean no touching. Okay? And so discreteness means no touching. And, therefore, you need exfoliation in order to have discreteness. But exfol- -- this -- in other words, in order to be discrete, it has to be exfoliated. But to be exfoliated doesn't imply that it's discrete.

BY MR. RIFFE:

Q. So if someone in the industry -- and I believe this might have been my question. If someone in the industry refers to exfoliated as individually dispersed nanotubes, would you agree with them or not?

MR. GLENN: Objection. Form.

THE WITNESS: I would say that that's a sloppy kind of definition.

BY MR. RIFFE:

Q. Why -- why would you say "sloppy"?

A. As I said, exfoliation means untangling, doesn't mean no touching. And discrete means no

touching. And so the two cannot be equated.

Q. So what do you mean by "no touching"? When you say discrete necessarily means no touching, what do you mean by that?

A. As I mentioned before, discrete carbon nanotubes are carbon nanotubes that are separate and distinct from other nanotubes not attached to other nanotubes. So not attached is what I mean by not touching.

Q. So is attached equivalent to not touching in your parlance?

A. That is. Touching means contact, okay? And you have a point of one nanotube touching a point of another nanotube. And there is scientific origin for that contact. Could be due to the -- the bent nature of the nanotubes, which is geometry, so that it has to touch in there because it's not straight. Okay. And also can be due to some forces, like Van der Waals forces.

MR. GLENN: You should probably go ahead and spell that for the reporter.

THE WITNESS: Yeah, V-A-N D-E-R W-A-A-L-S. Van der Waals forces, and those forces can be particularly strong if you have functional groups sticking out from the trunk of the nanotubes. So -- so

that's what I mean by touching or attaching.
BY MR. RIFFE:
Q. So let me break this down because in your definition or what -- strike that.
In your construction of what the plain and ordinary meaning of discrete carbon nanotubes said -- and I'm looking at the top of page -- paragraph 54. You say there are, "carbon nanotubes that are separate and distinct from other nanotubes; not attached to other nanotubes."
There you don't use "touching." You don't say not touching to other nanotubes. You say "attached."
Is there a difference, in your opinion, between touching and attached in the context of carbon nanotubes?
MR. GLENN: Objection to form.
THE WITNESS: Attachment has to involve touching. And what I mean by that is really contact. Okay. Physical contact between one nanotube and another nanotube. Okay. The physical origin of that physical contact is another matter, as I mentioned before, the Van der Waals forces or whatnot. Okay?
But the point is you have contact, physical contact, between a certain point of one nanotube and a certain point of another nanotube. And that's the

meaning of the word "attach" here.

BY MR. RIFFE:

Q. You say, "The point is you have contact, physical contact, between a certain point of one nanotube and a certain point of another nanotube, and that's the meaning of the word 'attach' here."

Okay. What is touching then?

A. Touching is contact. Okay. That is the physical contact means touching.

Q. That's what you just told me attaching means.

A. Yeah.

Q. So does touching and attaching mean the same thing in your opinion?

MR. GLENN: Objection to form.

THE WITNESS: Touching is a little less precise than -- than attaching because touching may -- may -- may be a very loose type of touching. But attaching is a little more precise.

But it's -- you know, it's a matter of -- of the physical interaction. There is physical interaction involved whether it's touching or physical contact or attachment.

BY MR. RIFFE:

Q. Where is the line between touching and attachment? And then I'll give you an example, but I

want to hear from you first.

MR. GLENN: Objection to form.

THE WITNESS: Okay. Touching might have more reversibility than attaching. That is you touch and not touch. And it's reversible; touch and not touch. But the attaching might not have that high a degree of reversibility.

BY MR. RIFFE:

Q. So if I touch my colleague, Dr. In, on the shoulder, but then I proceed to give him a hug and I don't let go, is that touching an attachment, in your opinion, as an analogy?

MR. GLENN: Objection to form.

THE WITNESS: I -- I understand your analogy, but I don't think it's a very appropriate analogy.

BY MR. RIFFE:

Q. Let me put it in the context of carbon nanotubes then.

We have these little -- I call them worms. I know that's probably not technically precise. That's what they look like to me under a -- you know, we have these carbon nanotubes, and they crisscross and they touch at a point, but there aren't Van der Waals forces that attach to themselves.

Is that the difference, in your opinion,

between touching and attachments --

MR. GLENN: Objection to form.

BY MR. RIFFE:

Q. -- in the context of carbon nanotubes.

MR. GLENN: Same objection.

THE WITNESS: No. Really, the ultimate objective is whether that contact point is an electrical contact. Okay. That -- that is really what's relevant to the context of this whole -- whole discussion here. It's -- it's whether that physical contact is an electrical contact or not. Okay? And you can call it attaching; you can call it contact. You can also call it touch. But the acid test is whether it's a -- it's an electrical contact or not.

BY MR. RIFFE:

Q. And how does one determine between two carbon nanotubes if that touch/attachment is an electrical contact or not?

A. For instance, if there is a little bit of junk, okay, in the -- and that junk is -- let's say is insulating junk, okay? There's a little thin film of junk that's insulating between the -- the nanotube A and nanotube B at contact point. Then that contact would not be an electrical contact.

Q. What type of junk, for example, would that

include --

A. Say --

Q. -- based on your experience.

A. Yes. Say a polymer or resin, which is typically not conductive.

Q. Are carbon nanotubes ever wrapped in a polymer resin that would prevent them from being electrically conducted?

MR. GLENN: Objection to form.

THE WITNESS: Yeah. The wrapping of a single carbon nanotube by a polymer molecule, that -- that's known to exist, and the -- the wrapping -- the wrapping doesn't mean covering the surface of the nanotube hundred percent, you know. It's just like a ribbon wrapping around. And so possibly surface area of the nanotube is still kind of exposed.

BY MR. RIFFE:

Q. And if that -- I'm sorry. I didn't mean to cut you off?

A. Yeah, that's -- that's all I mean. You can have this wrapping, but that wrapping might not cover the entirety of the surface.

Q. So if I had a single carbon nanotube that -- just based on your most recent example, that was wrapped or insulated along a portion of its length and then a

portion of its length was not insulated or wrapped and it was contacting another carbon nanotube at the insulated half, if you will, and contacting another carbon nanotube at its noninsulated half, that single carbon nanotube, based on your -- your opinion, could be both discrete and nondiscrete; is that correct? Because a portion of the carbon nanotube has electrical contact, and a portion of the carbon nanotube does not have electrical contact --

MR. GLENN: Objection to form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Yeah, I don't think your logic is right, because as long as a nanotube is in contact -- I mean electrical contact with another nanotube, that nanotube is not discrete even though part of the nanotube might -- might be insulated and another part not insulated. As long as a part of it is making a contact, particularly an electrical contact, with another nanotube, then that makes this particular nanotube not discrete.

BY MR. RIFFE:

Q. I see. That's helpful. Thank you.

So you would agree with me, then, that based on what we just discussed, nonconducting filaments -- nonconducting nanotubes, if you will, or filament, those

can never be attached to each other, correct?

MR. GLENN: Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Yeah, I -- I -- my testimony in this whole thing deals with carbon nanotube, okay, which is conductive, and you're trying to branch it off to a nonconductive nanotube. I don't think that's really relevant.

BY MR. RIFFE:

Q. Well, I guess I assume, then, that if -- if a carbon nanotube is surrounded by an insulator or has this sort of junk, if you will, on its surface somewhere that prevents it from it making electrical contact, then that carbon nanotube is discrete, in your opinion, because it can -- it cannot make electrical contact in that instance, correct?

MR. GLENN: Objection. Objection. Form.

THE WITNESS: From a plain and ordinary meaning of discrete carbon nanotube, it doesn't require electrical contact. But from a point of view of our understanding of the relevant science for this particular patent, we understand that the impact of whether it's discrete or not discrete -- or not discrete on the electrical behavior relates to whether that touching or attaching or contact is an electrical

contact or not. Okay?

In that context, that's what's relevant; whether there's an electrical contact or not in impacting the electrical conductivity. But for the plain and ordinary meaning of "discrete," it doesn't require the electrical contact to be present.

BY MR. RIFFE:

Q. That seems contradictory in and of itself.

I mean, how does one of skill in the art determine if a carbon nanotube is discrete or not if you're saying electrical conductivity doesn't matter?

I mean, it has to matter, doesn't it?

MR. GLENN: Objection to form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: I never said electrical conductivity doesn't matter. In fact, I said the opposite.

In the context of this patent, electrical conductivity matters greatly because a lot of the prior art, maybe vast majority, all of it, use carbon nanotube for the purpose of electrical conductivity enhancement. Okay. So I never said that electrical conductivity is not important.

BY MR. RIFFE:

Q. Okay. And what -- what's your basis for this

electrical conductivity concept that you -- you're discussing this morning with respect to discrete carbon nanotubes?

MR. GLENN: Objection to form.

THE WITNESS: Could you clarify?

BY MR. RIFFE:

Q. Well, I'll strike the question. With respect to this patent, the '649 patent, where does the patent talk about electrical conductivity in the context of discrete carbon nanotubes?

MR. GLENN: Objection to form.

THE WITNESS: In -- in this particular patent, the discreteness is not specifically or in a singular manner directed at electrical conductivity. But the prior art that I've cited, they all point to the importance of percolation in forming a continuous conductive network so as to achieve good conductivity. Okay? And that is the distinction.

If you have a discrete carbon nanotube, you cannot have percolation. You cannot have that continuous electrically conducted network. But that network is precisely what the prior art is trying to exploit in order to achieve high conductivity.

So the contrast between the '649 patent and the prior art is really clear.

MR. GLENN: Counsel, we've been going for about another hour. So let's --

MR. RIFFE: We can take a break here. That's fine.

(Recess: 11:47 a.m. to 12:01 p.m.)

BY MR. RIFFE:

Q. Dr. Chung, welcome back.

Did you have any discussions with counsel regarding the substance of your testimony during the break?

A. No.

Q. Okay. So going back to our discussion of discrete, and I guess I'm harkening back to -- it's an earlier discussion where you introduced the concept of, for lack of a better word, junk that might be between the carbon nanotube and something else. So in your view, discrete means not touching, but not touching other nanotubes only.

In other words, the carbon nanotube can touch anything and still be discrete, but it just can't touch another nanotube; is that correct?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Yeah. For instance, the carbon nanotube can touch a lithium-ion active particle in the

battery, electrode. That touching is a good one. But that touching does not mean that the nanotube is not discrete with respect to the carbon nanotube itself. It -- it -- it is still discrete even though it touches that ion active particle.

BY MR. RIFFE:

Q. Okay. And so long as -- so long as one carbon nanotube is separate and distinct from other nanotubes; in other words, not attached to other nanotubes.

That's your -- that's your construction of what discrete carbon nanotubes means, right?

A. Yes.

Q. Okay. Now, you also mentioned you relied on the Webster dictionary, and I think you cite to that at the bottom of page 25 in paragraph 55, and that's MRD-2012, 4. And you have a parenthetical there that says, "define discrete to mean separate and distinct, not attached to others; unrelated."

And that, to me, you're relying primarily on the Webster dictionary for that plain and ordinary meaning, correct?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: I wouldn't say primarily because it's all these different sources of information put

together, as I mentioned, from the patent and so forth. And the dictionary meaning is consistent with the meaning we obtained from other sources. So it's just consistency rather than saying it's primarily coming from the dictionary.

BY MR. RIFFE:

Q. Other than the dictionary meaning that it's not touching, what other source other than the dictionary did you rely upon to say that discrete means not touching?

A. Okay.

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: The specification teaches that an "embodiment of the invention is a method for obtaining individually dispersed carbon nanotubes." And "The background discusses hampered utilization of CNTs because of the 'inability to reliably produce individualized carbon nanotubes.'"

Also, "The methodology of the specification uses the fact that carbon nanotube fibers can have oxidation species comprising of carboxylic acid or derivative carbonyl containing species and are essentially discrete individual fibers."

And there are more -- more examples of such

information that points to this concept of discreteness.
BY MR. RIFFE:
Q. But none of what you just read, Dr. Chung, respectfully, says anything about touching, correct?
MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.
THE WITNESS: Well, individualized carbon nanotubes -- they're individualized. That's consistent with the lack of touching, and also it mentions discrete individual fibers. And also the specification goes on to describe mixtures of master batches where the individually dispersed nanotubes are distributed, whether uniformly or nonuniformly.
And, also, the specification teaches that the carbon nanotube fibers are exfoliated. A POSITA would understand that exfoliation refers to the untangling of carbon nanotubes from one another, allowing the nanotubes to be separated from one another to become discrete.
BY MR. RIFFE:
Q. Individualized -- I think what you said, you said consistent -- individualized consistent with the lack of touching.
So you're drawing an analogy between individualized and not touching; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Individualized is the prerequisite for being discrete, just like exfoliation is a prerequisite for being discrete.

BY MR. RIFFE:

Q. Does something come after individualized before it can then -- the carbon nanotube can become discrete just like you testified as the intermediary step between exfoliating before it can become discrete?

MR. GLENN: Objection. Form.

THE WITNESS: Yeah, could you clarify, please?

BY MR. RIFFE:

Q. You said, "individualized is the prerequisite for being discrete."

If an individual -- individualize is a prerequisite, is there some intervening step that has to take place before the carbon nanotube can become discrete?

MR. GLENN: Objection. Form.

THE WITNESS: The term "individualized" means that the nanotubes cut into individuals, but that doesn't mean that these individuals are not touching one another at all. The same thing for exfoliations. It doesn't imply that the nanotubes are not touching at all.

And so it takes effort, yes, to make it truly discrete. And that is more what this patent '649 provides.

BY MR. RIFFE:

Q. So when you're saying -- when you point to the patent at Column 536 through 39 -- and you mentioned this earlier in your testimony -- you say, "they are essentially discrete individual fibers."

A. I'm sorry. Where are you reading from?

Q. In the paragraph 54 of your declaration, about middle of the page, it says, "The methodology of the specification uses the fact that 'carbon nanotube fibers can have oxidation species comprising of carboxylic acid or derivative carbonyl containing species and are essentially discrete individual fibers.'"

Do you see that?

A. Yes.

Q. Are you drawing a distinction there, then, at this point between individual and discrete fibers?

A. Okay. Let me take a look. Okay.

What you are reading is from -- from that patent, '649, Column 5, line 36 to 39. About the actual -- let me see.

Yeah, I thought the actual process used to achieve discrete carbon nanotubes is better to look at

the examples rather than this generalized statement in Column 5.

Q. You -- you -- I'm just reading what you cited in your declaration, and you pointed to -- when I asked you what other support outside of Webster's dictionary do you have for discrete carbon nanotubes not being attached to other nanotubes, and you pointed specifically me to this statement of discrete individual fibers at Column 5.

So what support do you have outside of Webster's dictionary that "discrete" means not attached to other nanotubes?

MR. GLENN: Objection. Mischaracterizes the witness's testimony.

BY MR. RIFFE:

Q. Do you understand my question, Dr. Chung?

A. Yes.

As I mentioned -- excuse me.

Yeah, the specification of '649 mentions about individually dispersed nanotubes that are distributed and also mentions about exfoliated nanotube fibers and the untangling, which is necessary for the discreteness.

So putting all these things together, all these specific information together, it paints a picture which is discreteness in the sense of not attached to

other nanotubes, and this understanding is consistent with what Webster dictionary says.

In addition, this understanding is consistent with the Petitioner's expert, Dr. Zhu's testimony. And he testified in relation to the meaning of discrete carbon nanotubes in the co-pending IPRs challenging together CNT related patents of the patent owner, and he mentioned that the discreteness would involve the nanotubes being fully isolated from each other in order to be discrete.

And so it's various information, including Dr. Zhu's testimony which points at the discreteness, meaning no attachment, fully isolated.

Q. Let me try to make it very simple.

You would agree with me that the phrase "not attached" is -- only appears in Webster's dictionary, correct?

MR. GLENN: Objection. Form.

THE WITNESS: The word is in the Webster dictionary, but the meaning behind this word is very well supported by all these other pieces of information, including Dr. Zhu's testimony.

BY MR. RIFFE:

Q. Dr. Chung, your counsel can ask you other questions during his redirect, but I'm asking you a very

specific question.

The phrase "not attached" only appears in Webster's dictionary, Exhibit MRD-2012 -- MRD-2012, correct?

MR. GLENN: Objection. Form.

THE WITNESS: Yes. The term "attached," indeed, is expressly mentioned only in the -- in that dictionary. But what we are after is not just one particular word but the meaning embodied in that word. I think the meaning --

BY MR. RIFFE:

Q. That's not my question. I'm going to strike your answer as nonresponsive.

Dr. Chung, I'm asking you this very specific question, and I want you to answer my question. Your counsel can redirect you at his will later on, but I want an answer to my question.

Do you understand me?

A. Yes.

Q. Okay. My question is: The phrase that appears in your definition of discrete that is, quote, not attached, end quote, that phrase only appears in Webster's dictionary, which is MRD-2012, correct?

MR. GLENN: Objection to form.

THE WITNESS: I would say the word "attached,"

not the phrase associated with the attached, but the word "attached," indeed, comes from the Webster dictionary.

BY MR. RIFFE:

Q. Look at the top of your declaration, page 26, where you cite to Webster's dictionary, and you have a quotation there defining discrete, correct?

A. Yes.

Q. It says -- it says, "Defining discrete to mean 'separate and distinct; not attached to others; unrelated.'"

Did I read that correctly?

A. Yes.

Q. The phrase "not attached" appears in that definition of discrete from Webster's dictionary, correct?

A. Yes.

Q. The phrase "not attached," the only support you have cited to for that phrase, quote, "not attached," end quote, is Webster's dictionary, correct?

MR. GLENN: Objection to form. Objection. Mischaracterize's the witness's testimony.

THE WITNESS: Could you rephrase, please?

BY MR. RIFFE:

Q. Yes.

The phrase, quote, "Not attached," end quote, only appears in Webster's dictionary, correct?

MR. GLENN: Objection to form.

THE WITNESS: Within the realm of exhibits that I cited, the term "not attached" is explicit. Perhaps only in the dictionary, but --

BY MR. RIFFE:

Q. Okay. Dr. Chung, does the phrase "not touching" appear in any of the exhibits that you rely upon for what you believe a person of ordinary skill in the art would understand discrete carbon nanotubes to mean?

A. The term "not touching" is -- is a term that I tried to use during this discussion just to make it, you know, easy to understand. Okay. A better term is physical contact, you know. So I don't want to make the "touching" word a very important word because I just use it just like you say touching another person, you know. I just use that word to -- to -- to explain things --

Q. Okay.

A. -- in an easy fashion. I don't mean to make it a technical term.

Q. Does physical contact equal attachment or attached?

MR. GLENN: Objection to form.

THE WITNESS: Yeah. Physical contact, yeah, A; physically contacting, B. So that which would be in the same -- same -- same -- same concept as attachment.
BY MR. RIFFE:
Q. So physical contact, the way you're using that phrase, is it the same degree of contact that we discussed earlier today between the phrases "touching" and "attachment"?
MR. GLENN: Objection. Form.
THE WITNESS: I -- could you rephrase, please?
BY MR. RIFFE:
Q. I'm trying to -- I'm trying to understand what the difference is between physical contact and touching now.
Or are you saying they are the same?
MR. GLENN: Objection to form.
THE WITNESS: Yeah. When A, physically touch -- physical contact, B, A has to touch B.
BY MR. RIFFE:
Q. Okay. So physically contacting is the same as touching in the discussion that we've had here today; is that correct?
A. That's -- yes.
Q. Okay. So going back to our earlier discussion, there is a degree of physical contact or

touch before you get to attachment; is that correct?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: In the context of the present definition of the word "discrete carbon nanotubes" or the word "discrete," the term "attachment" doesn't reflect the degree of -- of the -- of the contact that is -- it doesn't reflect that. It's just plain and ordinary meaning. Okay. It doesn't imply that the attachment, as mentioned in this definition, is different from physical contact. Whether it's a higher degree or a lower degree, it doesn't imply that.

BY MR. RIFFE:

Q. So if a carbon nanotube, in your opinion, is physically contacting another carbon nanotube, is it attached to that carbon nanotube?

A. In the context --

Q. Please go ahead.

A. Yes, in the context of this -- this technology being discussed, yes.

Q. And so physical contact, touching, attached, all the same thing to you with respect to carbon nanotubes; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Yes. But I have to make it

clear that A physically contacting B doesn't mean having something in between, you know.

BY MR. RIFFE:

Q. So if A and B are contacting one another but there's something in between them, they are not attached; is that correct?

MR. GLENN: Objection. Form.

THE WITNESS: Right, in this context.

BY MR. RIFFE:

Q. In this context.

A. In this context, the A is a carbon nanotube. B is another carbon nanotube, okay? So when A touches B, indeed, there is no intervening junk, or whatever you call it, between the A and the B.

Q. Okay. And those are attached pursuant to your definition of discrete, correct?

MR. GLENN: Objection to form.

THE WITNESS: Yes, that's what I said.

BY MR. RIFFE:

Q. Okay. And then if there's a carbon nanotube A and a carbon nanotube B but there's intervening junk and that junk could be an insulator or, you know, nonconductive material, then those are not discrete; is that correct?

MR. GLENN: Objection to form.

THE WITNESS: As I tried to explain before, in -- in the plain and ordinary meaning of discreteness, it doesn't specify whether that contact is -- the electrical contact or not an electrical contact, in that plain and ordinary meaning, it doesn't specify that.

But when we look at this -- this definition in the context of this very patent and associated prior art, then we realize that this attachment pertains to having an electrical contact between one nanotube and the other nanotube without having an insulator in between. Okay? In the context of this -- this patent, we realize that the attachment has to involve an electrical contact. But in the ordinary and plain meaning of the term "discrete," it doesn't narrow it down.

BY MR. RIFFE:

Q. But, Dr. Chung, when the PTAB judges are trying to determine if the prior art references render obvious this claim limitation of discrete carbon nanotubes and they're faced with your proposed definition of what discrete carbon nanotubes are, how do they then discern whether two carbon nanotubes are attached to each other?

Because you're saying on the one hand, plain and ordinary meaning doesn't require you to look at the

electrical conductivity; but then you go to say, well, in the context of this patent, it actually does require to determine. Whether two carbon nanotubes are attached, you have to look at their electrical conductivity.

But the board judges need to have a clear delineation between what you mean by this phrase not attached, and that's what I'm trying to get at. With all due respect, it seems like you're talking out of both sides of your mouth, but I'm trying to get a clear record for the judges so that they can make a determination.

So does your -- what a POSITA would understand "not attached" to mean, the question is: Does that require electrical conductivity or not between the two carbon nanotubes?

MR. GLENN: Objection to form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Okay. Let me explain. In order for nanotube A and nanotube B to be in electrical contact, they have to be extremely close to one another at the -- at that particular point. I don't mean junk now. I just mean not exactly contacting, just a tiny bit, say, 10 angstroms, you know, a tiny bit, a tiny little microscopic gap at the point of so-called

touching. Okay?

And if that is the case, it's not an electrical contact just because of that tiny microscopic gap there. Okay.

So that -- that's what I mean. If there's this tiny microscopic gap, then it's not an electrical contact, and that's not attachment because there's this tiny microscopic gap.

BY MR. RIFFE:

Q. What range of microscopic gaps can you have before you have attachment and you don't have attachment?

MR. GLENN: Objection. Form.

(Court Reporter requested clarification.)

THE WITNESS: Yeah. The question is, is the size of that gap. Okay. If the size of that gap is more than, let's say, 10 angstroms, then there's no electrical contact.

And 10 angstroms is a very small size, by the way. Very small size. Very small distance.

BY MR. RIFFE:

Q. Where does an electrical contact begin, at what distance between two carbon nanotubes?

A. It's not a clear-cut delineation because the electron wave function doesn't work like that. It's

just a wave function. It's a probability distribution from the electron wave, so -- but the ballpark is what I said.

Q. Okay. So the ballpark is 10 angstroms, and at -- if there are two carbon nanotubes at that 10 angstrom ballpark, those would not be attached; and, therefore, those would be discrete carbon nanotubes, in your opinion; is that correct?

MR. GLENN: Objection to form.

THE WITNESS: In the plain and ordinary definition, one would not read it as deeply as what I said, the plain and ordinary definition. Okay. But if at one point, one wants to dig deep into what's meant by the electrical contact, then what I mentioned about that -- the size of the little gap matters.

BY MR. RIFFE:

Q. If -- if I'm designing a microcircuit of some type and I'm looking at the '649 patent, for example, and I'm trying to avoid -- I'm doing my darnedest to avoid infringing Mr. Swogger's patent, and I'm trying to get -- make sure I don't have discrete carbon nanotubes in my device, where is the line?

If I'm designing my device to have a 10 angstrom gap between my carbon nanotubes, am I infringing -- do I have discrete carbon nanotubes or do

I not? I mean, part of the patent process is allowing people still in the art to try to avoid patents.

So where is the line that you draw based on your expertise for doing that?

MR. GLENN: Objection. Form.

THE WITNESS: I really need to explain a little better, okay, because the matter is not just electrical. It's mechanical as well, as I mentioned earlier. Okay?

BY MR. RIFFE:

Q. Okay.

A. This matter of electrical contact only pertains to the electrical side, but there's the other side, which is mechanical; and for that purpose, the electrical contact is -- is not pertinent. Okay. And that's why I kept saying, in the plain and ordinary definition, one should not limit it to the attachment being an electrical contact because we are not limited to the electrical side. There's also the mechanical side, which is totally different.

Q. Okay. So given that totality of electrical/mechanical and I'm trying to design a new circuit to not infringe on Mr. Swogger's patent, how do I know that my nanotubes are not going to be attached to each other based on your definition of discrete carbon

nanotubes? Your definition says they are separate and distinct; they are not attached.

Where is the line that I can design up to to ensure that my nanotubes are not attached to one another?

MR. GLENN: Objection. Form. Objection to the extent it calls for a legal conclusion.

THE WITNESS: In general, to show discreteness, the best way is microscopy. And you actually look at -- under the microscope to see if they are discrete or not, to see if there is this physical contact between the nanotubes or not.

BY MR. RIFFE:

Q. Okay. Based -- your definition that you set forth here of discrete, that applies to the -- all of the IPRs in context in this particular set of IPRs; is that correct?

In other words, you apply the same definition of discrete in this IPR as the other four; is that correct?

MR. GLENN: Objection to form.

THE WITNESS: Yes. Pretty much. Although the -- the language is not the same among the different patents.

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(Whereupon Exhibit 1101 was marked for identification.)

BY MR. RIFFE:

Q. Okay. So let's -- let me introduce an exhibit -- it will be labeled exhibit -- I'm going to put this one in the chat because, based on your most recent testimony about microscopy -- I've got a little schematic. It's not microscopy. You'll see that once we get to it, but I wanted to talk to you a little bit about this one. So let me put this in the chat. I'll send that.

Let me know once you're able to get that, Dr. Chung.

MR. RIFFE: And, James, if you'll let me know as well as, Tamara, if you've got it.

THE WITNESS: So I have to go to the chat?

BY MR. RIFFE:

Q. Yes, ma'am. You open that up, you should see it down there, Exhibit 1100.

A. No, it goes to -- I click it, and it goes to my documents in my computer. It wants to stay there when I click it.

Q. It might -- you may have to save it, and then you can open it from there. Sometimes this chat feature makes you do that, unfortunately.

MR. GLENN: Mine did the same thing.

MR. RIFFE: Yeah, I think it's a part of the Zoom feature.

THE WITNESS: Okay. So I --

MR. RIFFE: If you could save it to your desktop maybe and then you could erase it after this.

THE WITNESS: Okay.

MR. GLENN: To make sure that I'm looking at the right document, Mr. Riffe, it's two pages including two handwritten drawings, one on each page?

MR. RIFFE: Yes, two pages marked LGES 1100 at the bottom right.

MR. GLENN: Okay. Was this an exhibit to anything else, or is that just a number you --

MR. RIFFE: It's a new number.

MR. GLENN: Got it. Okay. I just wanted to make sure.

THE WITNESS: By clicking 1100, I see only one drawing. Am I supposed to see two drawings?

MR. GLENN: Yeah, two pages.

MR. RIFFE: If you scroll in the PDF.

And, Tamara, just to be clear. I do want to mark this as Exhibit 1.

(Exhibit 1 was marked for identification.)

THE WITNESS: I see it.
BY MR. RIFFE:
Q. Do you see it now? Okay. The best of intentions here.
So two-page document before you marked LGES 1100 bottom right corner.
Do you see that?
A. Yes.
Q. Okay. So are the nanotubes -- I'm looking at page 1 of LGES 1100, which is now marked also as Exhibit 1 to your deposition.
Are the nanotubes depicted in this drawing on page 1 of Exhibit 1100 -- are those discrete carbon nanotubes?
MR. GLENN: Objection to form.
THE WITNESS: Yes, those are discrete.
BY MR. RIFFE:
Q. Why?
A. Because they are not physically in contact. They are separate.
Q. Would you need to know how many angstroms apart the two carbon nanotubes depicted in -- on page 1 of Exhibit 1100 are in order to confirm that they are discrete carbon nanotubes?
MR. GLENN: Objection to form.

THE WITNESS: Well, as I said, that the quality of the electrical contact only pertains to electrical applications or applications that require the electrical contact. But, in general, you have mechanical as well as electrical performance requirements; and the quality of the electrical contact in general would not be of prime importance.

So in the general case -- well, if I look at this picture and there's no scale -- right now, there's no scale, right? If there's no scale, then I would interpret this as being discrete.

BY MR. RIFFE:

Q. If there were a scale, hypothetically, that showed that those two -- the closest point between those two carbon nanotubes was 10 angstroms as measured by a microscope, would those two carbon nanotubes be discrete in accordance with your definition of discrete carbon nanotubes?

MR. GLENN: Objection. Form.

THE WITNESS: Did you say it's more --

BY MR. RIFFE:

Q. I'm sorry. Let me repeat the question for you.

If there were a scale that showed that the two closest points between the two carbon nanotubes shown on

page 1 of Exhibit 1100, as measured by the microscope where it's 10 angstroms, would these two carbon nanotubes depicted here be discrete in accordance with your definition of discrete carbon nanotubes?

MR. GLENN: Objection. Form.

THE WITNESS: The -- even if it's -- see, when you come to that small a distance, then there could be electrical interaction between the two, but the mechanical interaction might be absent.

BY MR. RIFFE:

Q. How would a person of skill in the art know that?

A. Because the electrical side pertains to the electrons, and the electrons are in form of waves, and they have probability distribution being somewhere.

But the mechanical side is -- is not centered around the electrons moving around. So it's just a different situation.

And in other words, the force felt by one nanotube doesn't transmit to the other nanotubes because of that gap. Okay? And so in -- in the plain and ordinary meaning, which should encompass both the electrical and mechanical side, I would not narrow down my definition in terms of that distance.

Q. So if -- excuse me.

What you're saying now is if there was a 10-angstrom gap between these two carbon nanotubes, you would say that these carbon nanotubes are discrete; is that correct?

Or would you need to do more experimentation to figure that out?

A. In accordance with -- if -- with the meaning of this definition, these would be discrete. However, this -- because of the closeness of -- of the -- of this A and B, then in spite of the fact that they are discrete, there could be electrical effect of that. Okay.

Q. And the --

A. But the electrical effect is something else. That is -- it's still discrete even though there might be an electrical effect due to the proximity.

Q. If there was an electrical effect due to the proximity, these two carbon nanotubes would be electrically attached to one another, correct?

MR. GLENN: Objection. Form.

THE WITNESS: Could you -- could you repeat, please?

BY MR. RIFFE:

Q. Sure.

Again, in the contexts of this 10-angstrom

distance, which is what you told me earlier, if there is -- an electrical effect due to that proximity, then these two exemplary carbon nanotubes would be electrically attached to one another, correct?

MR. GLENN: Objection to form.

THE WITNESS: Electrically attached. That's another term that you are introducing. Okay. I never use that term.

BY MR. RIFFE:

Q. If there's electrical effect between these two carbon nanotubes at the 10-angstroms distance, are they attached to one another, either electrically or mechanically?

A. The 10-angstroms distance is -- as I said, is a very ballpark figure. Actually, even at 10 angstroms, the electron waves doesn't get through to a high degree. Okay? And -- and -- and so even though they are maybe 10 angstroms apart, the quality of the electrical contact is lousy.

Q. If the distance between these two carbon nanotubes was 2 angstroms but there's still a distance between them, would they still be discrete carbon nanotubes, in your opinion, as shown here on page 1 of Exhibit 1100?

MR. GLENN: Objection to form.

THE WITNESS: I think obviously the smaller the gap, the more the electrons can go -- go across from one -- from A to B. And the better is the electrical contact quality.

But in reality, it's very, very difficult to measure the distance, whether 2 angstroms or 10 angstroms. You can imagine what magnification -- how many times of magnification it would need to be able to see that gap of 2 angstroms or 10 angstroms. It's just almost impossible to -- to do this -- to actually measure that.

So the assumption that we can put a scale mark and then here it's 12 angstroms, here it's 10 angstroms, that is way too simplistic because that is too far from reality of what microscopy in this field can provide in a reliable fashion.

So the discussion is more and more towards something which is -- is far from reality.

BY MR. RIFFE:

Q. So to satisfy your definition of discrete carbon nanotube as nanotubes that are not attached to other nanotubes, is it your opinion that one in the skill of the art would need to look at the electrical and mechanical properties between the two carbon nanotubes or not?

MR. GLENN: Objection to form.

THE WITNESS: As I said, microscopy is the best technique to do that because we are talking about kind of a geometric kind of characteristic. And how this geometric characteristic affects the electrical behavior or the mechanical behavior, that's a different deal.

BY MR. RIFFE:

Q. So when you say microscopy is the best technique, are you then just suggesting to see whether or not the carbon nanotubes have space between them as shown in Exhibit 1100 on page 1?

A. Yes.

Q. Okay. Look at page 2 of Exhibit 1100.

A. Yes.

Q. Are those two carbon nanotubes depicted on page 2 of Exhibit 1100 discrete carbon nanotubes in accordance with your definition of discrete carbon nanotubes?

MR. GLENN: Objection to form.

THE WITNESS: Yes. This drawing is two-dimensional. There's a third dimension that's not shown, you know. If you just look at a two-dimensional view, it looks like that they are in physical contact. But if one looks at the third dimension as well, they

might not be.
BY MR. RIFFE:
Q. So in other words, just to be clear -- again, I agree with you that this is a two-dimensional depiction. If you look at it in 3-D or a three-dimensional depiction, there may be spacing and very significant spacing between the carbon nanotubes, correct?
A. Yes.
Q. I'm sorry. Did you say "yes"?
A. Yes.
Q. Thank you.
We're going to refer back now to your declaration, Dr. Chung.
MR. GLENN: Counsel, are we going to keep this exhibit available, or are you done with that?
MR. RIFFE: I should be done with that for now.
BY MR. RIFFE:
Q. Okay. I'm going to turn our attention now, Dr. Chung, to paragraph 84 on page 38 of your declaration.
A. 84. Okay.
Q. And at paragraph 84 -- and I want to refer to Figure 7, which you've reproduced at the top of page 38.

Do you see that also? It's Figure 7B and C.

A. Yes.

Q. Okay. With reference to that figure, what are the black arrows in Figure 7P -- B pointing to?

A. Okay. Let me look. That's -- okay. For -- there's 7B. The white arrows indicate some of the exfoliated --

(Court Reporter requested clarification.)

A. We just -- zirconium phosphate nanoplatelets, and the black arrows are individually dispersed and straight single-wall nanotubes.

Q. And in order to determine what those black arrows were pointing to, you relied upon, as you just did, paragraph 25 of the Sun reference, correct?

A. Right. Yeah. Paragraph 25 of the Sun reference describes what Sun means for those microscope photos.

Q. Okay. Looking at Figure 7B, would you be able to determine if the black arrows are pointing to individually dispersed single-wall nanotubes without the help of Sun's description in paragraph 25? Just looking -- if you were just solely looking at paragraph -- at Figure 7B?

MR. GLENN: Objection to form.

THE WITNESS: Yeah, these microscope pictures

are really, at least in the reproduction -- in the reproduction that we have available in front of us, these images are really too low in quality to -- to give justice as to what this truly conveys. So it's really hard to say just by looking at the picture.

And, therefore, basing just on what we look to find in the picture, I would go for what Sun actually described as what he sees because I can tell that he's not lying.

BY MR. RIFFE:

Q. If you were reviewing a journal manuscript, for example, for publication, would you agree that this quality of figure would not be acceptable to support a conclusion that Sun draws in paragraph 25, just by looking at Figure 5B -- I mean 7B?

MR. GLENN: Objection. Form.

THE WITNESS: I think for patents and for journal papers, they are different in the quality of the reproduction of the images. For patents, the quality of reproduction tends to be low. Okay?

And so I agree, you know, for a journal publication, one would require really high quality microscope images to support what the author means.

But there's kind of technical difficulty in the patent arena in that regard.

BY MR. RIFFE:

Q. Okay. Okay. Let's next turn to paragraph 85 and the accompanying figures below that, or included in that paragraph Figure 6A and 6B from Sun, and that's on page 39 of your declaration.

Do you see that?

A. Yes.

Q. In Figure 6A, what are the arrows pointing to?

A. In Figure 6A, the arrows indicate exfoliated zirconium phosphate nanoplatelets.

Q. And how do you know what those figures in Figure 6A are pointing to?

A. Again, the quality of the images is just too low to really allow us to see clearly. And so we just have to assume that Sun is not lying when he states what is in that figure.

Q. And Sun indicates those arrows are indicating the exfoliated zirconium, ZrP nanoplatelets in paragraph 22; is that correct?

A. Yes.

Q. I have a similar question.

Just by looking at Figure 6A, would you agree with me that without the help of Sun's description in paragraph 22 that you really wouldn't be able to determine what those arrows in Figure 6A are pointing

to?

A. At least not for sure.

Q. Okay. And that's because, again, the quality and the resolution of the figures is not great to draw those conclusions; is that correct?

A. Right.

Q. Let's go to paragraph 87 of your declaration. That starts at the bottom of page 39, the same page we were on.

And here in paragraph 87, you conclude that Sun failed to achieve discrete multiwall nanotubes based on Sun's word choice in his description, but you didn't base your conclusions on an analysis of the images of Figure 6A and 6B that we just looked at, correct?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Could you clarify, please?

BY MR. RIFFE:

Q. Sure.

In paragraph 87, you say, "In fact, Sun expressly concedes that he was unable to achieve fully exfoliated multiwall CNTs." And then you cite to paragraph 69 of Sun.

And then you go on to say, "Rather than stating that the experiment 'shows' that the multiwall

CNTs have fully been dispersed down to the individual level," you say "Sun's experiment merely suggests that they could be dispersed."

Do you see that?

A. Yes.

Q. And so your conclusion there that Sun fails to achieve multiwall CNTs -- I'm sorry.

Your conclusion that Sun fails to achieve discrete multiwall CNTs, you base that on Sun's description, not an analysis that you did of Figure 6A and 6B, correct?

MR. GLENN: Objection to form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: Even though the images in Sun's patent are low in quality, you can tell very clearly that for -- for 6 -- Figure 6B, which is for the multiwall nanotubes, the arrows indicate exfoliated nanoplatelets. No arrow for the nanotubes.

You know, the paragraph 23 of Sun just mentions arrows indicating exfoliated nanoplatelets. Doesn't mention any arrow for the nanotubes. Okay. So it is not just a matter of ignoring -- not analyzing the images. It's the absence of arrows for the nanotubes, and that absence is important.

BY MR. RIFFE:

Q. And why is it important?

A. Because it indicates that Sun is not trying to show the presence of exfoliated multiwall nanotubes.

Q. Well, isn't it correct that Sun just merely used arrows to indicate the nanoplatelets, correct?

A. No.

Q. Did you have an opportunity to ask Mr. Sun or Dr. Sun why he excluded any arrows pertaining to the multiwall CNTs?

A. I did not ask, but it's very clear from his specification, because in relation to Figure 7, which pertains to the single wall, then he has two arrows, white arrows indicating the exfoliated nanoplatelets, and black arrows are individually dispersed in straight single-wall nanotubes. Okay?

So the contrast between what he describes for Figure 7 and what he describes for Figure 6, that's very clear.

In the case of single-wall nanotube, which is Figure 7, he clearly puts arrows indicating that these are the individually dispersed single-wall nanotubes; but for Figure 7, he simply doesn't put any arrow for the multiwall nanotubes. And only arrows for the exfoliated nanoplatelets.

And it's not only -- looking at these two paragraphs of Sun, it's also supported by -- by the other parts of the specification. And it's clear from these other parts, as I discuss in detail in my -- in my declaration, that Sun is very clear-cut about his success for the single-wall case but shies away from being clear about the success, in fact, of the multiwall case.

If you look at the entirety of Sun's patent, the fact that he succeeds for the single-wall case and not succeeds in the multiwall case is very clear.

Q. And that's your testimony even though Sun says that both multiwall nanotubes and the nanoplatelets can be fully dispersed down to individual level in epoxy matrices. That's your testimony, correct?

MR. GLENN: Objection. Enforcement.

THE WITNESS: Sun, in his specification, discusses the single-wall and multiwall nanotubes often in a generalized fashion without distinguishing in his language, in the specifications. He does this generalization and just call it nanotubes, and he provides ranges of various parameters without differentiating what portion of those ranges refer to single wall or multiwall.

And so you are kind of referring to one of

those generalized statements in Sun's specification, but one needs to go into details of the specification in order to recognize his different results between the single wall and multiwall.

He conducted separate experiments for his single-wall and nano [sic] wall cases, and he presented those results for the two cases separately. One needs to look at those results in detail rather than banking on one generalized statement in the specs.

BY MR. RIFFE:

Q. Dr. Chung, you said that I was referring to one of those generalized statements, but I beg to differ. I'm looking at paragraph 87 of your declaration where you cite specifically to paragraph 69.

And so Sun specifically says that both multiwall nanotubes and nanoplatelets can be fully dispersed down to individual level in epoxy matrices. He comes right out and says that, dual dispersion, correct?

MR. GLENN: Objection to form.

THE WITNESS: Are you looking at my paragraph 89?

BY MR. RIFFE:

Q. Correct. 87. 87.

A. Paragraph 87. So what -- what did you read

from there?

Q. I -- my original question to you says that Sun says, "Both MWNTs," which are multiwall nanotubes, "and nanoplatelets can be fully dispersed down to individual level in epoxy matrices," correct?

MR. GLENN: Objection. Form. Objection. Mischaracterizes the testimony.

THE WITNESS: Where are you reading? I don't see that from my paragraph 87.

BY MR. RIFFE:

Q. In paragraph 87 at the bottom of page 39, you're citing to Sun, and he says, "Both MWNTs and nanoplatelets can be fully dispersed down to individual levels in epoxy matrices."

A. Okay.

MR. GLENN: Objection -- objection to form. Objection. Mischaracterizes the testimony.

THE WITNESS: Okay. I see what you're reading now.

Yes. That excerpt, it says, "The TEM images shown here clearly suggests -- suggests [as read] that through the aqueous dispersion, organic redispersion approach, both multiwall nanotubes and nanoplatelets can be -- can be [as read] fully dispersed down to individual levels in epoxy matrices."

So he is suggesting that it can be. He did not show that. He did, indeed, achieved that. But in the single-wall case, he was very clear in saying that he has achieved it.

BY MR. RIFFE:

Q. Okay. So you're relying upon the terms "suggestion" and "can be" to conclude that Mr. Sun did not suggest to a person of ordinary skill in the art that he achieved multiwall carbon nanotubes in a discrete form; is that correct?

MR. GLENN: Objection.

THE WITNESS: I am not relying only on this. Not only on this. I told you in detail about the Figure 6 and Figure 7 in contrast about the arrows, you know. So it's not only this -- this -- this sentence with the word "suggest" and the word "can be." But this -- this -- this sentence with the word "suggest" and "can be" corroborates with what I mentioned earlier as conveyed by the Figures 6 and 7 and the associated arrows.

BY MR. RIFFE:

Q. And you agree with me that other than your conjecture, I might say, you don't know the real reason why Mr. Sun did or did not include arrows in Figures 6A and 6B with respect to the multiwall nanotubes, correct?

MR. GLENN: Objection to form.

THE WITNESS: Again, if you look at the entirety of this document, this patent, it's very clear that he is succeeding in single-wall case and is not bashful at all in telling that; but in relation to the multiwall, it has the opposite. He didn't put the arrows and didn't put the sentence down to the same to ensure that he has succeeded in the multiwall case.

So if you look in the entirety of this document, it's very clear. You don't have to talk to Dr. Sun.

BY MR. RIFFE:

Q. Okay. Let's turn to paragraph 115 of your declaration.

A. 115.

MR. RIFFE: Yes. Start on page 51, and it proceeds over to page 52.

MR. GLENN: It's 1:10 on the East Coast. Do we want to break for lunch? I don't want to break your flow, Mr. Riffe.

MR. RIFFE: That's fine. We can break for lunch.

Do you want to do a quick one, like 30 minutes or something?

MR. GLENN: It's up to you. I don't know how

long you have to go or intend to go today.

MR. RIFFE: Yeah, I've got a little bit more to do so --

MR. GLENN: Understood.

MR. RIFFE: It's up to Dr. Chung. If she wants a full hour, then we'll take a full hour. If she wants to do a quick one, that's fine too.

THE WITNESS: How about 45 minutes?

MR. RIFFE: I was going to say we can split the baby. We'll split the difference, I should say, and do that. All right. 45 minutes. That puts us at one -- just say 1:50 -- 12:50 on the Central time?

MR. GLENN: Works for me.

(Recess: 1:09 p.m. to 1:55 p.m.)

BY MR. RIFFE:

Q. Dr. Chung, welcome back from lunch.

Did you have any conversations with counsel pertaining to the substance of your testimony during the break?

A. No.

Q. Great. Thanks.

Did you recall in your declaration -- and you're welcome to refer to paragraph 88, if you need to, of your declaration.

In your declaration, you refer to Sun's

Figure 1 as a conceptual scheme. I think it's the language you used, and you concluded that it pertains only to single-walled nanotubes as opposed to both single-wall and multiwall nanotubes. And it appears to me that you base that conclusion on -- solely on Sun's experimental results and not on Sun's general descriptions of carbon nanotubes; is that correct?

MR. GLENN: Objection to form. Objection. Mischaracterizes the witness's testimony.

THE WITNESS: First of all, about the conceptual scheme term, I recall that it's not my term but Sun's term.

BY MR. RIFFE:

Q. Okay. I apologize if I misspoke.

A. Yeah. His paragraph 14, he calls it a conceptual scheme.

Q. Okay.

A. Yeah.

Q. And your conclusions regarding Figure 1 pertaining only to single-wall nanotubes, that's based on your review of Sun's experimental results and not on Sun's general description of carbon nanotubes generally; is that correct?

MR. GLENN: Objection to form.

THE WITNESS: No, it -- as I mentioned before

lunch, the conclusion that Sun succeeded with single wall and not succeeded in multiwall is based on looking at the entirety of his patent, not just looking at some experimental results.

And -- and so in addition, it is unexpected that a certain scheme would be so generally applicable regardless of the diameter aspect ratio, length of the carbon nanotube, you know. The difference between single wall and multiwall in terms of the diameter can be very large.

The aspect ratio, also difference can be very large. And so it's kind of odd that one would expect that this scheme to be applicable to carbon nanotubes of whatever type. You know, because one knows that the -- the behavior of the nanotube differs greatly depending on the structure, the structure -- including the difference between single wall and nano -- single wall and multiwall.

BY MR. RIFFE:

Q. Sun, himself, nowhere limits Figure 1 to only single-wall nanotubes though, correct?

A. In his description, he generalizes, yeah. But one has to look at the entirety and one sees that when it comes to interpreting his own experimental results, which are separate between single wall and multiwall, he

does concede that in single wall case, he succeeded, according to the scheme of Figure 1, but he did not succeed in case of multiwall, according to the same scheme in Figure 1.

Q. And that's based on your interpreting of Sun's experimental results, correct, to draw that conclusion that Figure 1 only applies to single-wall nanotubes, correct?

MR. GLENN: Objection to form.

THE WITNESS: It's not only his experimental results. It's also his words in his specifications, as I mentioned before lunch. In a single-wall case, he was very clear-cut in the success; but in the multiwall case, no.

BY MR. RIFFE:

Q. And that specification portion you're pointing to are the experimental results section of the specification, correct?

MR. GLENN: Objection to form.

THE WITNESS: I'm not sure what you mean by experimental result section.

BY MR. RIFFE:

Q. When you talk about the experiments that you rely upon in concluding that Figure 1 -- so let me take it back.

In paragraph 75 of your declaration, you make the comment that, "While Sun describes his conceptual scheme as applicable to CNTs generally, Sun's actual experimental results show that they clearly only apply to SW CNTs and not MW CNTs."

Do you see that?

A. Yes.

Q. And so those are the experimental results I'm referring to. That's what you referred to in paragraph 75 of your declaration.

A. Yes.

Q. So what were those experimental results you were referring to in paragraph 75?

A. Those are the Sun's result. He conducted experiments in his example one, and the experiment is separate between single wall and multiwall. And he presented the results separately for the single wall and multiwall.

And in addition to providing the images in Figure 6A and 7, he provides discussion of what those images mean. So all that information is included in the conclusion concerning his success in single wall and lack of success for multiwall.

Q. Okay. And then with respect to my specific question then, when you say that in paragraph 88 that we

just looked at, that a POSITA would understand Sun's conceptual scheme in Figure 1 as teaching applicable to single-wall CNTs but not applicable to multiwall CNTs, you base that ultimately -- and I'm asking you solely upon your reading of how Sun presents his experimental results, correct?

MR. GLENN: Objection to form and objection that it mischaracterizes the witness's testimony.

THE WITNESS: I don't mean -- I don't know what you mean by how he presented it.

BY MR. RIFFE:

Q. The experimental result that you read in Sun formed the basis for your conclusion that Sun's conceptual scheme of Figure 1 only applies to single-wall nanotubes, correct?

MR. GLENN: Objection. Form.

THE WITNESS: Yeah, and his experimental results are presented by him along with his discussion of the meaning of his results.

BY MR. RIFFE:

Q. Okay. And you read paragraph 38 of the Sun reference, correct, as part of your analysis?

A. Yes.

Q. And your conclusion with respect to the applicability of Figure 1 to only single-wall nanotubes

but not multiwall nanotubes, you consider that to be true, even though of the discussion in Sun, paragraph 38, that carbon nanotubes comprise both single-wall and multiwall nanotubes, correct?

MR. GLENN: Objection to form.

THE WITNESS: Yeah. This is an instance of how he generalized in his -- quite a number of his sentences generalized to nanotubes of any type; single wall, multiwall, whatever.

But one needs to look at the entirety of the -- of the document to see that, in fact, the behavior is different. His results are different between single wall and multiwall, even though he had sentences that generalize as if single wall and multiwall are all behaving the same.

BY MR. RIFFE:

Q. Let's turn to the next, paragraph 96 of your declaration.

A. Yes.

Q. I'll get there as well.

Now, in your declaration at paragraph 96, you refer to differences in structure and behavior of nanotubes that can be attributed to aspect ratio, correct?

A. Yes.

Q. And looking back at paragraph 94 of your declaration, you refer to aspect ratios of 50 compared to 51; that is, aspect ratios that are one integer apart, correct?

A. Yes.

Q. You would agree that a 1 integer difference in aspect ratio would not have a measurable impact on the structure and behavior of the nanotubes, right?

MR. GLENN: Objection to form.

THE WITNESS: I didn't say that.

BY MR. RIFFE:

Q. I'm asking you.

Do you agree that a 1 integer difference would have no measurable immaterial impact on the structure and behavior of nanotubes?

MR. GLENN: Objection to form.

THE WITNESS: I would not say that in a general fashion. It depends. Now, if you are -- aspect ratio is 10,000 versus 10,001, it's not a big difference. But the difference between 10 and 11 could be a substantial difference.

BY MR. RIFFE:

Q. And why is that?

A. Well, because it's like the percentage difference, you know. Between 10 and 11, the percentage

difference is much bigger than 10,000 versus 10,001 in terms of the percentage difference.

Q. I understand it's percentage difference, but what material impact would it have on the structure and behavior of the nanotube between a 10 and 11 aspect ratio?

A. Well, a difference is -- can be quite a few. And I list it as being seven of these differences in paragraph 96. Okay? Obviously the bigger the difference in aspect ratio, the more is the difference. Okay?

But it's still a difference. It's just a matter of how different. Obviously, the bigger is the difference in aspect ratio, the bigger would be the difference in the resulting structure and properties.

Q. So if two carbon nanotubes -- one had an aspect ratio of 10 and another had an aspect ratio of 11, how would that increase the number of bends, if you will, which is one of -- I think that's your first difference in structure and behavior that you listed in paragraph 96.

MR. GLENN: Objection to form.

THE WITNESS: Yes. The larger -- now, let's say that we have diameter kind of fixed, okay, just -- as I said here in paragraph 96. If we consider the

diameter is fixed, just for the sake of our discussion, then a larger aspect ratio would mean a longer nanotube. Okay. And when it's longer, there would be more tendency for it to bend, so more chance of bending and therefore, the number of bends would tend to increase. Okay?

BY MR. RIFFE:

Q. How large would that larger aspect ratio need to be to be a discernible difference in a number of bends between the two nanotubes? It certainly must be greater than a difference of one, correct?

MR. GLENN: Objection to form.

THE WITNESS: No, the number of bends is -- is kind of -- you know, it's -- you can have a sharp bend or a gentle -- a not sharp bend, you know. That is, the radius of curvature of the bend is a variable in describing the nature of the bend.

So -- so even if -- compare aspect ratio of 10 and aspect ratio of 11, you can call it waviness or whatever, you know, that would be more tendency for waviness for the larger aspect ratio.

BY MR. RIFFE:

Q. So according to your testimony and your expertise, if a carbon nanotube had an aspect ratio of 10 versus a carbon nanotube with an aspect ratio of 11,

the carbon nanotube with the aspect ratio of 11 would tend to have more waviness, if you will, based on how you just testified; is that correct?

MR. GLENN: Objection to form.

THE WITNESS: Yeah. They would tend to have more waviness, yes.

BY MR. RIFFE:

Q. And how would that be discernible or measurable?

A. Oh, can be discerned by microscopy.

Q. Would an aspect ratio difference of 1 between two carbon nanotubes necessarily result in structural or behavioral differences?

MR. GLENN: Objection to form.

THE WITNESS: Necessarily increases the tendency of bending or tendency of entanglement. It necessarily increases the tendency.

BY MR. RIFFE:

Q. You would agree with me about -- that differences of aspect ratios of greater than an integer of 1, for example, would have a greater increase -- a greater tendency to increase the number of entanglements or the tendency to bend as opposed to an integer difference, correct?

MR. GLENN: Objection to form.

THE WITNESS: Yeah. Could you clarify?
BY MR. RIFFE:
Q. Yeah.
You would agree with me that as the aspect ratio differences increase, you have more of a tendency to see structural or behavioral differences, correct?
A. Yes.
Q. Okay. Now, if you were investigating the effect of aspect ratio on material properties across a range of aspect ratios, would you prepare samples for every single integer value of those aspect ratios across the entirety of the range?
MR. GLENN: Objection. Form.
THE WITNESS: The different aspect ratios over that range give different structure, different properties. And these effects might not be so simple, a linear relationship, you know. It might not be so simple. You can just extrapolate from one aspect ratio to another. And it's not so simple as I list it. It's not just a matter of the tendency to bend but the number of contact points among the CNTs and the likelihood of reaching percolation and so on.
You know, so the effect of the aspect ratio is not as simple -- simply related. It's not a simple function like a linear function. It's not like that.

Okay? And so one really needs to explore each individual aspect ratio, assuming linearity.

BY MR. RIFFE:

Q. Okay. So if you had a range of aspect ratios that span 50, let's say, in a particular sample, based on your testimony just now, you would prepare a sample for every single integer value of aspect ratio across that entire range of 50; is that correct?

MR. GLENN: Objection. Form. And mischaracterizes the witness's testimony.

THE WITNESS: Could you rephrase, please?

BY MR. RIFFE:

Q. Sure.

If you had a range of aspect ratios that span 50, 50 different aspect ratios in a particular sample, based on your most recent testimony, it's your opinion that you would need to prepare a sample for every single one of those to determine the effect it would have on a particular structure or behavioral characteristic of the carbon nanotube; is that correct?

MR. GLENN: Objection to form and mischaracterizes the witness's testimony.

THE WITNESS: The experiment in this regard is actually complicated. The reason is when you will buy a sample of carbon nanotube, they might give you an

average aspect ratio or a range of aspect ratio.

And if you want to be very sure -- I want this particular value of the aspect ratio -- well, you have to sort it out and you buy that, and it's a mix of various aspect ratios, and it's terrible work. Very tedious. You have to look microscopically and to see which piece of that nanotube has the particular aspect ratio you want.

So it's very complicated. I mean, very tedious. Not just because of the large number of aspect ratios, but because it's difficult to get a sample of CNT that is all off that particular aspect ratio.

BY MR. RIFFE:

Q. Okay.

A. So it's very tedious.

Q. That was one question I had is can you -- can you obtain a sample of -- of nanotubes, carbon nanotubes, that have a specified single or small -- very small range of aspect ratios? It sounds like that's not possible, at least today?

A. Yeah. It's --

MR. GLENN: Objection to form.

THE WITNESS: It's very hard.

BY MR. RIFFE:

Q. Okay. And when you get that bundle of

nanotubes and you want to determine certain of the nanotubes that have certain aspect ratios, it sounds like you use microscopy to go in and select particular nanotubes from those bundles and then extract those for whatever experimental purpose you have; is that correct?

A. Yes.

Q. Okay. So it sounds like -- would you agree that in order to test a particular property, like the number of bends, you could do so at several different values of the aspect ratio that are distributed across the range of values of aspect ratio, for example, that you may receive in this bundle that you obtained; is that correct?

MR. GLENN: Objection to form.

THE WITNESS: Do you mind rephrasing?

BY MR. RIFFE:

Q. Sure.

Would you agree that in order to test the particular property, like the number of bends in a carbon nanotube, you can do so at several different values of the aspect ratio distributed across a range of values?

A. Again, it sounds simple, like what you said; but in reality, it's complicated, tedious because the nanotubes that you buy, a sample of that, it's not all

the same diameter. There's a range of diameter or they give you an average diameter. Okay?

So to do this experiment in a really controlled fashion, you -- you should have the diameter fixed and just vary the aspect ratio. But that would be even more tedious than what I described a moment ago.

Q. So you would agree with me, then, though, that if you're looking at the effect of aspect ratio on any of these seven delineated structural features or behavioral features of carbon nanotubes, it's going to be almost impossible to evaluate every single different aspect ratio for that particular sample; is that correct?

MR. GLENN: Objection to form. Mischaracterizes the witness' testimony.

THE WITNESS: Well, "that particular sample," I'm not sure what you mean.

BY MR. RIFFE:

Q. If you obtain a sample of carbon nanotubes --

A. Okay.

Q. -- and you're trying to determine the effect of the varying aspect ratios of those carbon nanotubes in that sample, it would be almost impossible to analyze that on an aspect-ratio-by-aspect-ratio basis, correct?

MR. GLENN: Objection to form.

THE WITNESS: It's very tedious. Yeah. I wouldn't say impossible, but it's very tedious.

BY MR. RIFFE:

Q. Wouldn't it be better to obtain -- look at samples of that set and then determine what effect aspect ratio has on a particular characteristic?

A. What do you mean by "samples of that set"?

Q. So if you obtain a bundle of carbon nanotubes and there's a mixture of aspect ratios in that set, that sample set, you would agree with me that it may be better to take samples of carbon nanotubes and then plot the effect of the aspect ratio on that particular feature for which you're trying to determine from that set of carbon nanotubes?

MR. GLENN: Objection. Form.

THE WITNESS: I am not clear. You mean samples? Just randomly selected samples from that bundle?

BY MR. RIFFE:

Q. Yes, to see what effect the aspect ratio may have on the structural or behavioral characteristics of the carbon nanotubes.

A. But if these samples are randomly obtained from that -- that bundle, I don't see how you can investigate the effect of the aspect ratio.

Q. Okay. All right. Okay.

Let's next -- let's turn our attention next to the Farrugia reference, Dr. Chung. And that is Exhibit LGES 1007.

And in particular, I'd like to turn your attention to example one of Farrugia, which is -- begins as a full paragraph, 89 in the Farrugia reference. And let me know when you're there.

A. Yes.

Q. Dr. Chung, it says in the first sentence that -- actually, in the second sentence, that 5 grams of multiwalled CNTs are used as a starting material, correct?

A. Yes.

Q. And example one is describing a three-step purification process for multiwall carbon nanotubes; is that right?

A. I think so. Yes. Three paragraphs for the three sets. Yes. Yes.

Q. Okay. And based on your experience, is it reasonable to understand that this procedure that refers to nanotubes by weight is using a powder of nanotubes as the starting material?

MR. GLENN: Objection to form.

THE WITNESS: Yeah. It -- you can call it

powder; but, you know, powder sounds like particles, but actually it's lumps. Lumps.

BY MR. RIFFE:

Q. Lumps of nanotubes?

A. Yes.

Q. Okay. Okay. So the nanotubes in this starting -- we'll call them lumps. I think you like that term better.

The nanotubes starting with these lumps in Farrugia's example one -- let me strike that.

And in these lumps of nanotubes, the nanotubes are touching one another; is that right?

MR. GLENN: Objection to form.

THE WITNESS: Yes. They are lumps, yes. So they -- they have to touch at least with degree, yes.

BY MR. RIFFE:

Q. Sorry for the delay.

MR. RIFFE: Can we go off the record for just a moment?

(Recess: 2:25 p.m. to 2:28 p.m.)

MR. RIFFE: All right. I think that concludes my line of questioning for now, so I'll pass the witness.

MR. GLENN: We have no -- we have no questions.

MR. RIFFE: All right. Guess we can go off the record.

COURT REPORTER: May I get requests on the record for transcripts?

MR. GLENN: Yes, ma'am.

We would like a full transcript. I'd also like a dirty as quickly as possible, if I could.

MR. RIFFE: Same for us, Tamara.

(Proceedings concluded at 2:29 p.m.)

ERRATA SHEET

NAME OF CASE: LG ENERGY SOLUTION, LTD. V. MOLECULAR REBAR DESIGN, LLC
DATE OF DEPOSITION: JUNE 25, 2025
NAME OF WITNESS: DEBORAH CHUNG, Ph.D.

Reason Codes:

1: To clarify the record.
2: To conform to the facts.
3: To correct transcription error.

Page _____ Line _____ Reason _____

From _____ to _____

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From _____ to _____

Page _____ Line _____ Reason _____

From _____ to _____

Deponent's Signature _____

Date_____

DECLARATION UNDER PENALTY OF PERJURY

I, DEBORAH CHUNG, Ph.D., do hereby certify under penalty of perjury that I have read the foregoing transcript of my deposition taken on June 25, 2025; that I have made such corrections as appear noted on the Deposition Errata Page(s), attached hereto, signed by me; that my testimony as contained herein, as corrected, is true and correct.

This Declaration is executed this _____ day of _____, 20___, at _____, California.

_____

DEBORAH CHUNG, Ph.D.

STATE OF CALIFORNIA))) ss.

I, Tamara Houston, RPR, CCRR, CSR No. 7244, a Certified Shorthand Reporter in the State of California, duly empowered to administer oaths, do hereby certify:

That, prior to being examined, the witness named in the foregoing deposition was by me duly sworn to testify to the truth, the whole truth, and nothing but the truth;

That said deposition was taken down by me in shorthand at the time and place therein named, and thereafter reduced to typewriting by computer-aided transcription under my direction;

That the dismantling, unsealing, or unbinding of the original transcript will render the reporter's certification null and void.

I further certify that I am not interested in the event of the action.

In witness whereof, I have hereunto subscribed my name.

Dated: 8th of July, 2025.

Tamara L. Houston

TAMARA L. HOUSTON
CSR 7244, RPR, CCRR 140

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