UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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LG ENERGY SOLUTION, LTD.,	:	
Petitioner,	:	
-vs-	:	CASE NO. IPR2024-01006
	:	U.S. PATENT NO. 8,808,909
MOLECULAR REBAR DESIGN, LLC,	:	
Patent Owner.	:	

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Deposition of YU ZHU, PhD, an expert witness herein, taken by the Patent Owner as upon Cross-Examination and pursuant to the Federal Rules of Civil Procedure and Notice via Zoom videoconference on March 21, 2025 at 10:00 a.m., before Jennifer K. Starner, RPR, a Notary Public within and for the State of Ohio.

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S T I P U L A T I O N S

It is stipulated by and between counsel for the respective parties that the deposition of YU ZHU, PhD, an expert witness herein, called as upon Cross-Examination by the Patent Owner may be taken at this time and place pursuant to the Federal Rules of Civil procedure and Notice as to the time and place of taking said deposition; that the deposition was recorded in stenotypy by the court reporter, Jennifer K. Starner, RPR, and transcribed out of the presence of the witness; and that said deposition is to be submitted to the witness for his examination and signature, and that signature may be affixed out of the presence of the Notary Public.

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I N D E X

WITNESS:
YU ZHU, PhD

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Cross-Examination By Mr. Zinda 5

YU ZHU, PhD,

of lawful age, as having been duly sworn, as hereinafter certified, was examined and testified as follows:

CROSS-EXAMINATION

BY MR. ZINDA

Q Good morning, Dr. Zhu. How are you?

A Good morning. Very good. How are you?

Q I'm doing well. Thank you for asking. I won't ask you if you've been deposed because I now know you have been. You were deposed -- I think it was last week -- by me. So I know you're familiar with this process. I'll just repeat a few of the ground rules just to be safe. If you don't understand a question I'm asking -- because I do know that I speak pretty fast. If you don't understand a question I'm asking, can you just please ask me to clarify it?

A Yes, I can.

Q If you answer a question that I ask, I'm going to assume you understood it; is that fair?

A Yes, that is fair.

Q And then, of course, your counsel may object throughout the deposition for certain questions I ask. I'll ask you to please answer the question unless your counsel instructs you otherwise. Does that make sense?

A Yes.

Q And then breaks, you know, from our last depo, you know I'm fine taking breaks whenever you want to take breaks. Typically it's 45 minutes to an hour or so. And your counsel may chime in. The only thing I'll ask is that we don't take a break during a pending question. So if I ask you a question, I'd like you to answer it before we try to go on break. Does that make sense?

A Yes, it does make sense.

Q Now, you're here today to testify about testimony that you provided in your declaration addressing U.S. Patent 8,808,909 correct?

A Yes.

Q And for short, I'm just going to refer to that as the '909 Patent. Does that make sense?

A Yes.

Q If I could get you to go to the end of the 909 Patent, which is LGES 1001.

A At the end of the patent?

Q Yes, sir. The claims.

A Yes, I am on that page.

Q And you see in Claim 1 it says "Discrete carbon nanotubes"?

A Yes. I saw the discrete carbon nanotubes.

Q And I previously asked you -- in your

prior deposition I asked you questions about your understanding of the meaning of that term, right?

A Yes. I understand.

Q And your understanding of the meaning of that term -- is your understanding of the meaning of that term in this claim any different than your understanding of the meaning in the other patent I asked you about?

MR. IN: Objection. Form.

A In my understanding, the discrete carbon nanotube in this patent, Patent '909, describe a similar situation as the status of carbon nanotube. And it is a description of the carbon nanotube, I believe, related to the use in the lithium ion battery electrode preparation, and it would present a status like in those carbon nanotubes uniformly dispersed in the medium and forming electrode materials.

Q Okay. And then I also asked you -- if you go to Claim 7 -- oh, no I'm sorry. Excuse me. Not Claim 7. Claim 6. If you go to Claim 6.

A Okay. Claim 6.

Q And you see the last clause there that says, "Wherein the carbon nanotubes are uniformly dispersed without clustering on a dimension scale less than 1 micrometer"?

A Yes, I saw that.

Q And do you recall that I asked for your opinions about the meaning of that same phrase in the other patent, the '483 Patent?

MR. IN: Objection. Form.

A Yes. I remember we have discussed this regarding uniform dispersed nanotube and regarding there is no clustering in dimension scale less than 1 micrometer. And I have described this is because, as grown carbon nanotube, typically forming a bundled structure and the bundled structure was formed because there are strong interaction force between the wall of the carbon nanotube, which is pi pi stacking force. And due to the pi pi stacking force as grown, non-functionalized carbon nanotube, were forming bundles, and those bundles have nanotube very close to each other. And this pi pi stacking force will be disrupted by the functionalization of the carbon nanotube in which oxygen functional groups typically will be attached on the sidewall of the carbon nanotube, which prevent the wall of the carbon nanotube to be very close to each other. And we have discussed this is generally a significant distance, much larger than the pi pi stacking distance, which cause the separation of the carbon nanotube as from the bundles. And, therefore, you can achieve uniform dispersion generally by functionalization of carbon nanotube typically using oxidation functionalization.

Q And to determine whether or not carbon nanotubes meet the claim requirements of Claim 6 of the '909 Patent, you have to look at them under a microscope, correct?

MR. IN: Objection. Form.

A Microscope is one of the technique, as I mentioned, to characterize the status of the carbon nanotube dispersion. And there are also many other ways to explore what is status of the carbon nanotube. And one of the examples I have mentioned is the conductivity of the electrode composite as a whole rather than just looking on individual carbon nanotube's conductivity because the carbon nanotube needed to forming a good connected network in the electrode in order to improve the electrical conductivity of the component.

Therefore, if the conductivity of the electrode was improved, generally it's an indication of good dispersion. The dispersion was usually achieved by providing collective evidence from different characterization tools rather than just focusing on one single technique to determine exclusively whether the nanotube is dispersed without forming any clusters.

Q Well, how -- how -- I guess I'd like -- can you walk me through the ways -- all the ways you could determine -- how would you determine whether two carbon

nanotubes are more than 1 micrometer apart?

A So, first, there would be no significant bundle formed in the composite in the dispersion medium. And this can be actually explored by a number of techniques, right. So you can certainly use microscope technique to see if there's any bundles which is parallel packed carbon nanotubes. Those will be significant under microscopic technique, like, electro microscopic technique to see if there's any parallel carbon nanotube actually aggregated in a specific area. If you see those bundled areas, that is indication of the clustering. That is one technique. But, as I said, there are many other techniques. And, for example, the conductivity measurement of the composite can be an alternative technique. And if the bundled carbon nanotube is a significant portion in the dispersion in the composite medium, then generally the percolation network will be formed in relatively poor way. This means you have to use higher percentage of carbon nanotube in your composite to achieve similar electrical conductivity. So a good dispersed status generally means you -- you need a small fraction of carbon nanotube with percentage in your composite and still achieve good electronic conductivity -- electrical conductivity of the composite.

Q Okay. So you talked about -- and correct me if I'm wrong. So you said one way to determine

whether or not carbon nanotubes are more than 1 micrometer apart is microscopic. And then the other way is electrical conductivity, correct?

A Yeah. Those are the two techniques you can collectively consider to determine if -- if the -- if there's a significant cluster in your composite dispersion.

Q Are there any other techniques that you're aware of to determine whether or not two carbon nanotubes are more than 1 micrometer apart?

A Yeah. There are also some other technique. For example, you can use a technique like XPS to monitor what is oxygen and carbon spectrums and to see if there's any oxygen-containing functional group in the nanotube. If you have oxygen-containing functional group on the nanotube, then there will be a good indication that the nanotube was separated from each other. And you can also explore the XPS of carbon atoms with other atoms that exist in active materials. So if you see some bundles in between the carbon nanotubes, carbon peak or oxygen peak, with other element in active materials, that is an indication that active materials was attached with carbon nanotube as well as oxygen-containing functional group. And that is an indication that a nanotube was dispersed in active materials metrics and, therefore, the nanotube was individual -- it was dispersed well and is a discrete nanotube in this case.

So yeah.

Q So we've got -- the three that I've got down so far: Microscopic, electrical conductivity, XPS. Are there any other ways that you're aware of to determine whether or not two carbon nanotubes are at least 1 micrometer apart?

A I think it's also quite a general understanding for the -- for the POSITA and because the purpose of -- of carbon nanotubes and lithium ion battery active materials composite to forming electrode is generally dispersed conductive fillers in medium, right. In this case, the conductive filler is carbon nanotube. And this is basically understanding of how this composite need to be made. And I think based on the size of the carbon nanotube, right, typically the size of the carbon nanotube is -- with a length about a few tenths of micros and with a diameter just a few nanometer to a few tenths of nanometers. And it is generally considered needed to be -- those nanotube needs to be separated significantly based on their size of the length and the size of the diameter in order to forming a dispersed medium. So this is also quite a general understanding, I think, for the POSITA to consider that. The dispersed nanotube has separation scale larger than 1 micrometer because this is actually determined by the size characteristics of the nanotube itself.

So, in this case, people can consider those nanotube was separated beyond that distance, for example, 1 micrometer, by providing sketching scheme, which presents that status of the nanotubes should be in those composite -- in those dispersion medium and to describe the status of the -- of the nanotube dispersion.

Q Okay. Are you aware of any other way to determine whether two carbon nanotubes are at least 1 micrometer apart?

A Well, certainly this is not an exhaustive way, right. So my opinion here is that you have several techniques and you have determined based on the several techniques that carbon nanotubes is dispersed and it was separated with significant distance and is not really necessary for any of the researchers for any of the -- any POSITAs to exhaust every available technique that can be used to -- to determine whether the distance between the nanotubes are beyond a certain level. I think people already get the information by the techniques that I have mentioned in previous answers. That is enough to characterize and determine the distance between the nanotube and the status of the nanotube more importantly, whether they are well distributed in the medium, whether there are a significant amount of bundles in this nanotube dispersion. And those questions should be answered -- should already

have been answered.

And I -- as I said, certainly there's always additional technique for people to explore those conditions and characterize nanotubes as a technique. It is also important there are new techniques are coming out every decade to characterize those carbon nanotubes. But with all those technique I have mentioned, it's already forming a formed conclusion of the status of the carbon nanotube dispersion. I do not think the POSITA and other researchers will need to exhaust additional methods even though it's still possible to characterize the status of carbon nanotubes.

Q You -- one of the opinions that you offer is that Claim 6 is invalid because it would be obvious -- that claim would be obvious based on Ohata and Kavan, correct?

A This is the -- Claim 6 is -- is obvious, yeah, based on -- based on available reference I cited in my declaration.

Q And you said "available reference." That includes the combination of Ohata and Kavan, correct?

A That included Ohata and Kavan. That included the other one I cited which is Lead and Wepasnick.

Q So I want to focus on Ohata and Kavan for now.

A Okay.

Q My question to you is: Did you do any experimentation to -- did you -- did you attempt to or do any -- did you attempt to perform any experiments that replicate the combination of Ohata and Kavan as you presented in your declaration?

MR. IN: Objection to form.

A I -- I want to clarify here with your question. You mean have I done any experiment by myself to -- to confirm the conclusion from Ohata and Kavan? Is that your question?

Q Well, let's start with you. Have you done any experimentation?

A With what?

Q To replicate the combination of Ohata and Kavan?

A I have research experience of functionalized carbon nanotube, which is pretty much what Kavan has done in his work to first treat it as a carbon nanotube and oxidized it. I have done intensively for this kind of work using different oxidation reagent including different mixed acids. And I have done very detailed work about analyzing those oxidized carbon nanotubes using -- using XPS technique. And I have done those XPS determinations to calculate what is exact oxygen peak atomic

ratio as well as the weight ratio regarding different oxygen functional group like hydro carboxylic acid as well as carbolic group and other things. And I have also worked with using those carbon nanotube as electrode materials and including lithium ion batteries and -- either as anode material itself or as conductive fillers in other acting materials. Could be cathode, could be anode and could be lithium ion battery. I have done those work by myself. I build those carbon cell by myself as well and actually grow carbon nanotube by myself as well to -- built those four carbon nanotube materials even before they were functionlized. So I have done all of those procedures mentioned in Kavan's work, in Kavan's battery. And I have general understanding and also working experience of building lithium ion battery as described in Ohata.

Q Okay. So I want to -- I want to back up because I'm asking you a very specific question. My question is have you tried to replicate the experiment from the combination of Ohata and Kavan?

A Well, by the time I was working with carbon nanotube -- I think it is probably a time of 2008, 2009 -- I think it's a very obvious general understanding that you need to oxidize the carbon nanotube in order to get a better dispersion if you want to prepare a composite in the battery electrode. So it can be used in the lithium

iron phosphate. Lithium iron phosphate was very well known by that time when I was working with carbon nanotube and lithium iron phosphate composite. And it was probably introduced a decade ago at the time of 2008, 2009. And so it's very well known. And carbon nanotube needed to be dispersed is also very well known. And oxidation method has already been introduced by that time. So I've done all those things. And I think the general consideration here is if you worked with lithium ion battery research, if you are interested in using carbon nanotube, you are actually in a position to understand how to oxidize them as a dispersion and how to actually combine them together with active materials as mentioned in those patents, lithium iron phosphate, titanium oxide and so forth. Those are all known materials. And other researcher at that time I think --

Q Dr. Zhu, I'm going to have to ask you to answer my question.

A Yes.

Q It's a yes or no question and you're giving me, like, three-minute answers. That's not going to work in this process. My question is -- I'm going to move to strike your response as nonresponsive because none of your response was directed to what I asked you.

I'm asking you a very simple question. I'll back up a little bit to try to make this easier. But

you're proposing in your declaration that it would be obvious to take certain steps from Ohata and combine them with certain steps from Kavan, right?

A Yes.

Q Okay. Have you performed an experiment where you replicated those combined steps?

A Your question is whether myself did the experiment?

Q Yes. Have you ever performed the experiment?

A Well, I -- I -- I think myself not necessary to do exactly the same approach as this, too, but I think myself has done an oxidation of the nanotube. And myself has -- has understanding of putting these two together. And this is a general understanding not only by myself, but everybody working on that lithium ion battery and oxidized carbon nanotube or nanotube materials, topics by that time where everybody will do that. It's not only me.

Q And, again, Dr. Zhu, that was not my question. I'm going to strike it as nonresponsive.

I'm asking you a yes or no question. Did you perform the combination of Ohata and Kavan that you proposed in your declaration as an experiment? It sounds like to me you're telling me you did not perform an

experiment to do the combination of Ohata and Kavan. And I'm just looking for you to confirm one way or another whether that's true.

A I did all those experiments, yeah. But if you say if I explicitly referred to exact reference, I think there are a lot of reference represented in the same concept, represented the same idea. And I think that the POSITAs may refer this to reference, which are just examples that are showing the spirit of how to combine those two together, but it's -- it's obvious for many researchers by that time that this two -- this two concept can be combined by using oxidized nanotube and electrode materials. And certainly we have done those experiments in the lab and build the battery in the lab with exactly the same approach by combined oxidized nanotube and active materials of electrode to build the lithium ion battery by that time. Yeah, certainly I have done those work.

But what I say here -- what I want to emphasize is the Ohata and Kavan reference is just two of the good examples I would like to cite and to describe this as a general understanding of every battery researcher by that time. And they may have a slightly different reference, but they still follow the same concept. And this is a very well known concept by that time and it's a general understanding for the battery researchers. They don't

really need to sometimes find exactly the same -- exactly the same reference to understand this topic because it's already obvious, I think, by that time for the researchers in the battery study.

Q All right. Well, I'm moving to strike that entire response as nonresponsive and irrelevant to what I asked.

I mean, again, I'm going to ask you one last time yes or no. Maybe it's better to put it this way: Have you performed any actual experiments for purposes of this IPR proceeding?

A I certainly did a lot of the experiment, which is almost identical as some of the experiment in this IPR, like, the combined carbon nanotube in the lithium ion battery. This is my research. I have done it for 20 years.

Q When did you perform those experiments?

A It was starting from when I worked with carbon nanotube. That is back to --

Q Okay. I'm going to -- let me save us a lot of time because you just keep talking and you don't answer my questions and it's starting to get a little bit frustrating.

So I'm asking you for the purposes of this IPR -- so from when you were approached about this IPR and after, have you performed any experiments for purposes

of this IPR proceeding? I'm not asking you about your past experiments that you've done 20 years ago. I'm asking you about things you've done for this IPR proceeding.

MR. IN: Objection. Badgering.

A So let me clarify your question. You are asking me whether I've done anything after I started to work on this IPR?

Q Any experiments for purposes of this IPR proceeding.

A I -- I do not think I have -- I needed to do any experiment for this IPR proceeding because all those experiment mentioned in my declaration in my IPR is basically based on my previous experiment. And it's -- it's easier. I have done it by myself or it has been done by my graduate student or it has been done in the community and I was aware it was well discussed with other committee members in this -- in this research committee. So those are obvious results for me. I do not need to do any specific experiment in order to -- by myself after the IPR to confirm any of those descriptions and conclusions I have made in the IPR and the declaration, so yeah.

Q Dr. Zhu, is it your opinion that a person of ordinary skill in the art would consider -- would consider uniformly dispersed carbon nanotubes to be the same as discrete carbon nanotubes?

MR. IN: Objection. Form.

A So I think this is a question I probably already answered, but I would like to answer it again. And this is actually related to the purpose of this -- of this application. It will be used in lithium ion battery electrode as a conductive filler to build electrical conductive network in the electrode. So under this consideration the nanotube has conducting filler materials that in the matrix, which is electrode composite materials, needed to be distributed uniformly in order to achieve several purposes. First is to reduce the amount of the carbon nanotube weight, which means the population network needed to be built in a good way. The second is the nanotube itself needed to have good conductivity which can contribute to electrical conductivity of the composite as a whole.

So under those conditions, it's obvious that the nanotube has to be -- nanotubes have to be dispersed uniformly and connect -- forming a connective conducting pathway. And the uniform distribution and discrete carbon nanotube are very similar description under this application's purpose. So it's just used to build good, dispersed and connected electrical network in the composite to achieve this purpose and the nanotube should have those status.

Q Okay. And I want to ask you about -- if you could go to the 909 Patent, which is LGES 1001.

A Uh-huh.

Q I was going to ask you if you go to Column 4, Line 4 --

A Uh-huh.

Q -- you see where it says, "This cutting of the tubes helps with exfoliation"?

A "The cutting of the tubes reduce the length of the tube." That's what it's saying here.

Q And what does it mean when it says, in your opinion -- as a person of ordinary skill in the art, what does it mean when it says, "The cutting of the tubes helps with exfoliation"?

A The cutting of the tubes helps with exfoliation is generally used to describe how you separate individual nanotubes. So here the exfoliation more focusing on if you originally have carbon nanotube bundles and to separate individual tubes from each other. And cutting the tubes in principal could help the exfoliation because the longer tube, they form bundle, they can form an entangled bundle. And it's relatively -- require relatively more energy to separate it out. And if it's principally a shorter tube, then the chance to forming the entangled bundle will be less as compared with longer tube. So that

is what it's saying here, that cutting the nanotube will help the exfoliation, which means de-bundle those nanotubes from their initial status.

Q Okay. So this is describing a step where they -- where they cut the nanotubes to shorten them, which, in your opinion, can help untangle the nanotubes from the bundle?

A Right. In principal, yes, but it's not really necessary to say that it's needed to cut the nanotube in order to exfoliate them, right. So in principal, it will be easier to exfoliate if you have shorter tube.

Q Understood. And -- and what does -- when this passage is called for -- Line 4 to 6 talks about exfoliation, as a person of ordinary skill in the art, what is your understanding of exfoliation?

MR. IN: Objection. Form.

A So you are talking about the same, from Line 4 to Line 6?

Q Correct. Let me rephrase the question.

A Yeah.

Q From a perspective of a person of ordinary skill in the art, what is the meaning of the word "exfoliation"?

A Well, from the person of state of the art, the meaning of exfoliation means the nanotube is

de-bundled. They do not have -- have any bundled status.

Q So exfoliation refers to de-bundling and it's your opinion that discrete refers to dispersion?

MR. IN: Objection. Argumentative. Form.

A The de-bundle and the exfoliation and discrete and also well dispersed, those are some of the descriptions which describe the nanotube status in a similar fashion, I want to say. They share some similarity. So the de-bundle means -- means initially those bundled nanotubes was forming parallel lines and bundled each other and probably twisted, and it will form due to the pi pi stacking interaction. And exfoliation essentially means you have separated them from those pi pi stacking status. And, therefore, tube was not bundled and together. And this could be discrete nanotube status, right. So when it's discrete, it means that the single nanotube was not aggregated with other nanotube. And that is also dispersed status, if you can see the nanotube and dispersion medium and there are individual nanotubes distributed in the dispersion medium uniformly. This is a good distributed status, so it's dispersed well.

So those are under the consideration of prepared battery electrode composite materials. And those description of the status of the nanotube has fairly close

meaning. They are similar. They describe a similar status. They were interconnected for their meaning.

Q Understood. Give me one moment.

MR. ZINDA: I'm ready to pass the witness if you want to do your redirect then.

MR. IN: Sure. Yeah. Can we come back in ten minutes?

MR. ZINDA: Yeah, that's fine with me.

MR. IN: Okay.

MR. ZINDA: Thank you.

(Whereupon, a brief recess was taken.)

MR. IN: No further questions. Thank you.

A C K N O W L E D G E M E N T

STATE OF OHIO :
: SS:
COUNTY OF HAMILTON :

I, YU ZHU, PhD, have read the transcript of my testimony given under oath on March 21, 2025.

Having had the opportunity to note any necessary corrections of my testimony on the errata page, I hereby certify that the above-mentioned transcript is a true and complete record of my testimony.

_____

YU ZHU, PHD

(DEPOSITION CONCLUDED AT 10:50 A.M.)

C E R T I F I C A T E

STATE OF OHIO :
: SS:
COUNTY OF HAMILTON :

I, Jennifer K. Starner, the undersigned, a duly qualified and commissioned Notary Public within and for the State of Ohio, do hereby certify that before giving of the aforesaid deposition, the said YU ZHU, PhD was by me first duly sworn to depose the truth, the whole truth and nothing but the truth; that the foregoing deposition was given at the said time and place and was taken in all respects pursuant to Notice; that the deposition was taken in stenotypy by me and transcribed into typewritten form under my supervision; that the transcribed deposition is to be submitted to the witness for his examination and signature, and that signature may be affixed out of the presence of the Notary Public; that I am neither relative, attorney, nor employee of any party or their counsel and have no interest in the result of this pending action.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal of office at Cincinnati, Ohio, this 24th day of March, 2025.

Jennifer K. Starner

My commission expires:
March 7, 2029

Jennifer K. Starner, RPR
Notary Public

CHANGES AND SIGNATURE

WITNESS NAME: Yu Zhu, Ph.D., 03/21/2025

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I, Yu Zhu, Ph.D., have read the foregoing transcript and hereby affix my signature that same is true and correct, except as noted above.

_____ _____

Yu Zhu, Ph.D. Date

Sworn to and Subscribed before me

_____, Notary Public.

This_____day of _____, 20____.

My Commission Expires:

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