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

SAMSUNG DISPLAY CO., LTD., Petitioner,	)	
vs.	)	
PICTIVA DISPLAYS INTERNATIONAL, LTD., Patent Owner.	)	CASE NO. IPR2024-01095 PATENT NO. 11,828,425 B2

REMOTE DEPOSITION UPON ORAL EXAMINATION OF
RUSSELL HOLMES
HIGHLY CONFIDENTIAL
ATTORNEY'S EYES ONLY

WEDNESDAY, SEPTEMBER 3, 2025
6:05 A.M. (PACIFIC STANDARD TIME)

(All participants appeared remotely)

TAKEN AT THE INSTANCE OF THE PETITIONER

REPORTED BY:
MONNA J. NICKESON, RPR, CRR, CCR, CSR CA 14430
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I N D E X

SAMSUNG DISPLAY VS. PICTIVA DISPLAYS
CASE NO. 2:23-cv-486
WEDNESDAY, SEPTEMBER 3, 2025

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BE IT REMEMBERED that on WEDNESDAY, SEPTEMBER 3, 2025, at 6:05 A.M. (PACIFIC STANDARD TIME), the remote deposition of RUSSELL HOLMES was taken before Monna J. Nickeson, Certified Realtime Reporter, Registered Professional Reporter, Certified Livenote Reporter, Certified Court Reporter (WA 3322), Certified Shorthand Reporter (ID 1045), (OR 16-0441), (CA 14430), the following proceedings took place:

* * * * *

THE COURT REPORTER: My name is Monna Nickerson. I am a Certified Realtime Reporter, a Certified Court Reporter in California, license number 14430.

Doctor, can you please raise your right hand to be sworn?

RUSSELL HOLMES

having been first duly sworn to tell the truth, the whole truth, and nothing but the truth, testified as follows:

EXAMINATION

BY MS. ZHONG:

Q. Good morning, Professor. Can you please state your name for the record?

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A. My name is Russell Holmes.

Q. Professor, you submitted two declarations in this proceeding, correct?

A. Yes, I submitted two declarations in this proceeding.

Q. And they are Exhibit 1003 and Exhibit 1044, correct?

(Exhibit 1003 was identified.)

(Exhibit 1044 was identified.)

THE WITNESS: Correct, that's right.

BY MS. ZHENG:

Q. And do you believe that you need Exhibit 1044 to make the case of obviousness for claims 2 and 19 -- 17?

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

THE WITNESS: I'm sorry, could you repeat the question? I don't think I heard all of it.

BY MS. ZHONG:

Q. Okay. Do you think that you need Exhibit 1044 to make your case for obviousness?

MR. LEE: Objection. It calls for a legal conclusion.

THE WITNESS: So, again, I'm not

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entirely sure what you mean by "do I need?"

I think my opinion is quite clear in my original declaration. And my response and my reply declaration is responding directly to the issues raised by Dr. Pattison.

BY MS. ZHONG:

Q. Do you think you need the evidence in your reply declaration?

A. Again, I don't know what you mean by "need." I think the evidence in my reply declaration is consistent with what I showed in my original declaration.

Q. So do you think that your original -- strike that.

So do you think that the exhibits attached to your original declaration are sufficient to prove your case of obviousness?

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

THE WITNESS: So I'm not certain what you mean by "need" and so I'm hesitant to take an opinion on what's needed and what's not in an IPR proceeding.

My impression as a nonlegal expert

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is that everything I've generated and everything I've brought to the board is considered as part of the case.

In terms of what's needed and what's not, I'm not sure how to interpret that in a legal way.

BY MS. ZHONG:

Q. I didn't say "need" in this case.

A. I think you said, "do I need my reply declaration?"

Q. That's not what I asked.

A. Oh, okay.

Q. -- The question.

A. Well, so, apologies if I misstated that.

Q. Do you think that the exhibits attached to your original declaration are sufficient to prove your case of obviousness?

MR. LEE: Objection. Form.

THE WITNESS: Again, the exhibits attached to my initial declaration, I think, supported my opinion in my initial declaration for the case of obviousness.

And responding to questions raised by Dr. Pattison, I think I've expanded

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those further and supported those further in my reply declaration.

BY MS. ZHONG:

Q. Why did you cite additional evidence?

A. So in my reply declaration I'm responding directly to comments and points raised by Dr. Pattison. And so I'm responding to those by citing additional evidence to support the points I made in my initial declaration.

Q. So you don't think the exhibits attached to your original declaration is sufficient; is that right?

MR. LEE: Objection. Misstates the testimony.

THE WITNESS: No. As I already stated, I think the exhibits attached to my initial declaration supported the opinion that I took in my initial declaration.

Dr. Pattison raised some questions I think related to his interpretation of my initial declaration, and so I offered exhibits to further support my opinion in the case.

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BY MS. ZHONG:

Q. So you expanded your opinion; is that correct? In your reply declaration?

MR. LEE: Objection. Misstates the testimony.

THE WITNESS: No. As I said, I offered additional exhibits to support my opinion.

BY MS. ZHONG:

Q. And did you expand your opinion in your reply declaration?

MR. LEE: Objection. Misstates testimony.

THE WITNESS: Again, all I'm doing in my reply declaration is responding to points raised by Dr. Pattison and offering further support for my opinion.

BY MS. ZHONG:

Q. In your original declaration, you did not provide any evidence regarding the use of lithium fluoride as an n-dopant; is that correct?

(The Court Reporter requested clarification.)

MR. LEE: Objection.

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BY MS. ZHONG:

Q. Did you cite any evidence regarding the use of lithium fluoride as an n-dopant other than in Diekmann?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So, again, Diekmann cites lithium fluoride as a preferred n-dopant. So I didn't need to cite any additional evidence. It's in our primary reference.

BY MS. ZHONG:

Q. And did you cite any document as to how lithium fluoride provides -- operates as an n-dopant?

MR. LEE: Objection. Outside the scope.

THE WITNESS: No. I didn't offer any additional support beyond Diekmann for how Lithium fluoride operates as an n-dopant. But that is raised already in Diekmann. So I didn't see the need to offer further evidence.

BY MS. ZHONG:

Q. Okay. So you could have cited some

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documents but you chose not to because you didn't think it was necessary at the time of your original declaration; is that correct?

MR. LEE: Objection. Form. Outside the scope. Misstates testimony.

THE WITNESS: So I didn't choose to cite any additional references for lithium fluoride because it was already described in Diekmann, already stated in Diekmann.

BY MS. ZHONG:

Q. So you did not see a need to cite additional documents at the time of your original declaration regarding the use of lithium fluoride other than Diekmann; is that correct?

MR. LEE: Same objections.

THE WITNESS: At the time, since Lithium fluoride was already clearly disclosed as a dopant in Diekmann, I didn't see the need to include an additional reference.

(Exhibit 1050 was identified.)

BY MS. ZHONG:

Q. Exhibit 1050, Choi -- sorry. Yes, so the Choi reference, which is Exhibit 1050,

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do you know who located it?

A. I don't recall who located it. That might have been me. But at this point, it's so long ago I don't recall.

Q. Do you see that page 1 of Exhibit 1050 says:

This content was downloaded from IP address 131.212.251.152 on June 5?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Do you see on page 1 of Exhibit 1050 it's stated:

This that content was downloaded from IP address 131.212.251.152 on June 5, 2024 at 16:57 at the bottom?

A. Yes, I see that footnote on the first page.

Q. Do you know who downloaded this document?

A. Again, I don't know who downloaded this document.

Q. But it's clear that it was downloaded more than a year ago?

A. Yes, certainly.

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Q. And it was downloaded at the time of your original declaration?

A. That's approximately the time of my original declaration.

Q. Okay. But it was not attached to your original declaration?

A. No, I didn't cite this paper in my original declaration.

Q. Any reason you did not cite it?

A. I -- I don't think I saw the need to cite this and also it's not -- it's also not prior art.

Q. Okay. So you don't believe that Exhibit 1050 is prior art?

A. Again, I'm not an expert on precisely how to determine when prior art is but I'm just looking at the copyright date of 2009 and the publication date of June 22nd, 2009 and assuming that this would not be prior art based on what I've been told on priority dates.

MR. LEE: I'll object to that as calling for a legal conclusion.

MS. ZHONG: You're objecting to your own witness' testimony.

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MS. LEE: No, I was objecting to the question.

BY MS. ZHONG:

Q. Do you know who -- so you cited an -- several additional exhibits from 1049 to 1059 in your reply declaration; is that right?

A. I just --

Q. Why don't you take a look at your pages 4 and 5, the reply declaration pages 4 and 5.

A. Sure.

Yes, I'm looking at page 4 and 5.

Q. You see that on pages 4 and 5 you listed the exhibits?

A. Yes.

(Exhibit 1049 was identified.)

(Exhibit 1058 was identified.)

BY MS. ZHENG:

Q. Okay. So Exhibit 1049 to 1058, those are the exhibits, they are the new exhibits you cited for your reply declaration; is that right?

A. Yes, those are the new exhibits I cite in the reply.

Q. And who located those exhibits?

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A. So again, as I've already stated, I'm not sure if I initially found Choi or not, I found Endo, Choudhury. I believe I found Zheng as well, the two short references were also mine, so with the exception of Choi, I'm pretty confident that those are the ones that I found.

Q. When did you find Endo?

A. Again, I -- I don't know. I certainly recall reading that paper in the past, but I don't know when it was downloaded, for example.

Q. For this proceeding, were you aware of it at the time of your original declaration?

A. I actually alluded to that work in my original deposition.

Q. I was asking a slightly different question. Were you aware of it at the time of your original declaration?

A. So I --I think I answered that. I actually mentioned this work in my original deposition.

Q. You said "deposition," I was asking about declaration.

A. Oh, declaration. Again, I may have

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been aware. Again, I don't recall exactly the timeline here, especially from my original declaration since that was a while ago.

Q. Why don't we pull up your original declaration, which is Exhibit 1003.

Let's go to the last page and it was signed on July 2nd, 2024?

Do you see that?

A. I am just going to have to open it.

Yes, I see the signature page from my original declaration.

Q. Okay. So have you read -- were you aware of the Endo paper?

A. Again, I'm not certain if I was aware of it before or after that date, so I just can't say with certainty.

Again, certainly, as when I was in my deposition, I mentioned this work so it was something that I was aware of but I don't recall if I had actually looked at this paper again in the context of my declaration.

Q. Okay. So did you review this paper as part of the deposition preparation?

A. I might have seen this paper in thinking about my deposition preparation

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perhaps. Again, I was reading a lot of papers at the time. So...

Q. Now, were you aware of the Choudhury or the So paper?

A. The Choudhury paper is a paper that I found more recently in building my reply.

Q. What about the Zheng paper, Exhibit 1052?

A. Sorry, I just want to go back to that exhibit list now. You're talking 1052?

Q. Yes, the Zheng paper.

A. Yes, the 1052, I think that's one that I found in looking -- or constructing my reply.

Q. Okay. And what about the 1053 and 1054 the two Schwartz paper?

A. Those are papers I looked at in constructing my reply, primarily because they are referenced in Dr. Pattison's exhibit.

Q. Okay. Were you aware of those papers before?

A. I was certainly aware of that work, but I -- I don't think I had reconsulted those papers before for the purpose of this case.

Q. What about the Choudhury work, were

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you aware of those?

A. I'm not sure if I had seen that Choudhury paper before, so that I don't think I'm as confident in being able to answer.

Q. I'm not saying about the paper itself but the work in general, were you aware of that work?

A. Again, my answer is the same because that particular work, if I was aware of it, it would have been via that paper.

Q. Okay. What about the Zheng paper or the Jiang -- the work underlying that paper?

A. I don't think I was familiar with that work, again, prior to the work on my reply.

Q. Okay. And you are active in the OLED field?

A. I'm sorry. Are you asking, am I active in the OLED field?

Q. Uh-huh.

A. Yes, I am.

Q. You've been active in the OLED field for at least 20 years?

A. Yes, that's correct.

Q. Okay. And do you consider yourself

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to be pretty familiar with the literature in general?

A. Yes, I do.

Q. Let's take a look at Exhibit 1050 first. This is a paper by LG Display, Exhibit 1050, the Choi paper?

A. Yes, I'm looking at it.

Q. That's a paper by LG Display?

A. Yes, the authors have an affiliation of LG Display.

Q. Okay. And I think one shows the OLED stack for the device they are looking at?

A. Yes, Figure 1 shows a schematic structure of the fabricated OLED device.

Q. Okay. And --

(The Court Reporter requested clarification.)

THE WITNESS: Schematic structure.

BY MS. ZHONG:

Q. So similar to the Ma structure, between the doped ETL and the cathode, there is a pure electron injection layer; is that correct?

A. I'd like to reopen Ma as well, if we're also going to discuss that.

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Q. Sure.

And Ma, I believe is Exhibit 100 --

A. That's 1010, I have it.

Q. 1010.

(Exhibit 1010 was identified.)

THE WITNESS: Okay. And your question was related to what aspect of Ma and Choi.

BY MS. ZHENG:

Q. So in both Ma and Choi's complete device structure, there is an electron injection layer between the cathode and the electron transport layer; is that correct?

A. In Choi's device and in Ma's device, there is an electron injection layer, correct.

Q. And both of them are florescent based; is that correct?

A. I would agree, Ma's is fluorescent OLED, I want to just refamiliarize myself with Choi to make sure I can testify correctly there as well. Just give me a minute.

I don't think Choi actually discloses if this is a fluorescent emitter or a phosphorescent emitter.

Q. Okay. It's a blue emitting layer,

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right?

A. I would agree, it's a blue emitting layer.

Q. You don't know what ABH034 and SD1 is; is that right?

A. That's what I'm saying. I'm assuming SD1 is an emitter but I don't know what type.

Q. Do you know what SFC is?

A. I don't think the acronym SFC is defined.

Q. Is that a supplier?

A. Again, if I look at context, it could be the supplier since LG Chem is parenthetically cited after LGC101 but, again, I -- I haven't had to, I haven't had to know what SFC is to draw an opinion.

Q. Do you know whether SFC supplies PHOLED phosphorescence emitter material?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Do you know whether SFC supplies phosphorescent emitter materials?

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A. Again, I don't think I've actually taken a position on what SFC is. It's possible that could be the supplier, but I -- I don't know anything about SFC or what SFC stands for.

Q. Now, according to this paper, the reason why lithium quinolate is helping with a conductivity is supposedly because lithium quinolate has a lower LUMO than the electron transport matrix material; is that correct?

MR. LEE: Objection. Form.

THE WITNESS: So I'm going to reread part of Choi to make sure I familiarize myself before answering.

So can you state your question again?

BY MS. ZHONG:

Q. What's Choi's theory as to why this lithium quinolate is helping with the electronic conductivity of the electron transport layer?

A. So -- okay, so in terms of what is Choi's theory regarding what's helping the electron conductivity?

Choi points to, in some respects, the LUMO level at the interface with the

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cathode but Choi also looks explicitly at electron conduction through the layer and shows in their data that -- including LIQ improves that electron conduction.

Q. So page 062101-1, Choi states:

A lithium-Q-doped ETL can be expected to exhibit a lower electron barrier height.

Do you see that?

A. I'm looking for it.

Q. At the moment of the right-hand column last sentence remember?

A. Sorry. You said we're on page 062101 dash?

Q. One.

A. Okay. I see the sentence you're referring to.

Q. What does that sentence referring to? What is that is that sentence referring to?

A. Choi is simply staying the Lithium-quinolate-doped ETL can reduce the barrier height for injection.

Q. And why is that?

A. It could be a variety of reasons.

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As I described in my initial declaration, doped ETLs frequently have a combined effect of increasing the conductivity of the ETL, while also improving injection into the ETL.

Q. And where did you state that in your original declaration?

A. I'd have to consult my original declaration to find that text, but I can do that.

Q. Sure.

A. So, again, I touch on this point in my original declaration in paragraphs 41 and 42, describing the prior art where, in several instances, the use of a n-doped ETL means the OLED does not also require the use of an EIL necessarily.

Q. So you think that your discussion of the need to get -- strike that.

So you think that your discussion of the fact that a doped ETL allows a system to get rid of EIL is supporting your -- the theory that the doped EIL helps to reduce the injection barrier?

MR. LEE: Objection. Misstates the testimony.

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THE WITNESS: So I'll just note first, I didn't say anything about a doped EIL. What I said was a doped ETL can have the simultaneous benefit of improving conductivity through the ETL and injection into the ETL.

BY MS. ZHONG:

Q. Now, does Diekmann expressly state that the doped layer is an ETL layer versus an EIL layer?

A. So, again --

MR. LEE: Outside the scope of the reply declaration.

THE WITNESS: I'll just, again, say I was going to open Diekmann. I don't think I've talked about this issue in my reply.

Is there a specific question you want to ask regarding the reply or point to the reply in this Diekmann-related question that you're asking?

BY MS. ZHONG:

Q. Well, you're clearly taking the coaching hint from your counsel, but answer the question as posed, please.

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MR. LEE: That was not an instance of coaching. I'm just lodging my objections.

THE WITNESS: All right. I'm opening Diekmann to refamiliarize myself with the terminology.

So please restate your question, if possible.

BY MS. ZHONG:

Q. So does Diekmann expressly state that the doped layer is an electron transport layer as opposed to an electron injection layer?

MR. LEE: Objection. That is out of scope.

THE WITNESS: So Diekmann is -- discusses both electron transport and electron injection layers.

As I describe in my initial declaration, my interpretation of Diekmann's Figure 2 is that they're referring to a doped electron transport layer.

BY MS. ZHONG:

Q. I'm asking you where Diekmann says

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that expressly?

A. Right. And, again, as I stated in my original declaration, my response is that, as a person skilled in the art reading Diekmann, it's quite clear they're referring to an n-doped ETL.

Q. And that would be a doped electron injection layer?

MR. LEE: Objection. Outside the scope.

THE WITNESS: In Diekmann, since Diekmann notes explicitly that the doped layer may be next to the cathode, but not need be next to the cathode, that would indicate to a person skilled in the art that this is an electron transport layer rather than an electron injection layer.

BY MS. ZHONG:

Q. The structure that you're pointing to has the doped layer immediately next to the cathode; is that correct?

A. In that figure, that is correct. But Diekmann is clear that it need not be next to the cathode.

Q. The specific structure that you are

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relying on is explicitly next to the cathode; is that correct?

A. The structure that -- the combination that we'd be looking at with Diekmann and Ma, if that's what we're effectively referring to, would have the n-doped ETL next to the cathode.

Q. And we have established that in Ma that was electron injection layer between the doped electron transport layer and the cathode, correct?

MR. LEE: Objection. Form.

THE WITNESS: I already testified, I think, that Ma has an electron injection layer in their device.

BY MS. ZHONG:

Q. Let's take a look at Exhibit 1049, which is a Kido paper or Endo paper.

Do you it open?

A. I have it open now.

Q. Okay. Are you familiar with Professor Kido's work?

A. I'm familiar with Professor Kido's work.

Q. Do you know when he started working

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in the OLED field?

A. No, I don't know when he started working in the OLED field exactly.

Q. In the '90s?

A. Yes, I think Professor Kido was active in the '90s.

Q. So he is -- he is a person with extraordinary ability at the time of the invention, right?

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

THE WITNESS: So, again, I'm not sure what "extraordinary ability" means. I would say he was a person skilled in the art at the time of the invention.

BY MS. ZHONG:

Q. He is a person with above-average skill in the art, correct?

A. Again, I don't know if there's, like, a particular -- I'm not familiar with the legal weight of the term "above-average skill in the art."

Clearly, he's a professor running a group in this area. So he would be an expert in the area of OLEDs, I can certainly attest to

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that.

Q. Okay. He's an expert in the field of OLED at the time of the invention in 2008, 2009?

A. I think that's a fair comment.

Q. Okay. Do you know anything about Jun Endo, the first named inventor -- the author? Sorry.

A. I don't think I know anything specifically about Jun Endo.

Q. The doctor -- or Mr. Endo would be working under Professor Kido?

A. I'm sorry, you referred to them as Dr. Endo?

Q. I said, Dr. or Mr. Endo would be working under Professor Kido?

A. Generally, looking at a publication like this and seeing the same affiliation between Endo and Kido, you might assume they're working together. But I don't know who is working under who, whose -- I don't know the specifics of how the study was managed.

Q. Do you know what is the turn-on voltage for the devices in this Endo or Kido paper?

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MR. LEE: Objection. Form.

THE WITNESS: Can you point me to a specific usage, just so I can better understand the specific context you're looking at?

BY MS. ZHONG:

Q. Can you clarify what information you are seeking?

A. You asked do I know the turn-on voltage or do I know what is the turn on voltage in this paper?

Q. Uh-huh.

A. Are you looking for a particular number? Is there a more specific question about turn-on voltage that you have?

Q. Do you understand what turn-on voltage is?

A. Yes, I understand what the turn-on voltage is in an OLED.

Q. Okay. So can you determine from the information contained in this paper what the turn-on voltage is for these devices?

A. Yes. Looking at the data in this paper I can assess what the turn-on voltage is in these devices.

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Q. What are the turn-on voltages?

A. Which device would you like me to look at? There's a variety that are discussed in this paper.

Q. The lithium quinolate and the sodium quinolate ones.

A. Again, that's not specific enough. This paper looks at a few different approaches to making an OLED. So if you could point to something more specific, that would helpful.

Q. Why don't we take a look at Figure 2.

A. All right.

Q. Okay.

A. Yes. So what is your question regarding Figure 2, then?

Q. What are the turn-on voltages for each of the devices in this figure?

A. So turn-on voltage for an OLED is usually when you see the rapid increase in current and/or luminance.

When it comes to luminance, the exact threshold luminance where one pulls the turn-on voltage off can vary a little bit depending on the group and depending on the

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sensitivity of their instrument.

However, here, the turn-on voltage would be, again, when one sees this steep increase in luminance versus voltage.

So nominally, one could assess the turn-on voltage of the undoped -- or, I guess, these are devices with an electron injection layer.

So the device with no electron injection layer would be approximately a four volts or so. And then looking at the data for the dope devices, it looks like it would be something more like three or two volts, but -- but there's no data to compare it, 10 to minus 2, so...

Q. Is 10 to the minus 2 --

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Is 10 to the minus 2 candela per meter -- per square meter an acceptable luminance?

A. Can you be more specific, "acceptable luminance" for -- for what?

Q. For OLED.

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A. Is there a particular application or are you talking about a research device? What -- specifically what?

Q. Just what a person skilled in the art would consider to be an OLED.

A. So, again, I'll interpret your question I think you're trying to ask, which is, just is it acceptable for the device to be turned on? I would say yes. That may not be necessarily the standard that every group uses as a turn-on voltage and that's what I alluded to earlier, is it depends on the sensitivity of the measuring equipment as well.

I think a lot of groups will often use a threshold of 1 or 10 candelas per meter squared to take their turn-on voltage but there's some -- some variability in that.

Q. Okay. So what is the threshold your group applies?

A. I think in the past, we've reported turn-on voltages at something like one candela per meter square.

Q. Okay.

A. So... but, again, there's that -- when it comes to luminance, it depends on the

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sensitivity of your measuring apparatus.

Q. So if the turn-on voltage is beyond the 10 volts, do you consider that to be an OLED device?

MR. LEE: Objection. Scope.

THE WITNESS: So can you restate the question? The turn-on voltages above?

BY MS. ZHONG:

Q. 10 volts.

A. So you're saying if you construct an OLED --

Q. Mm-hmm.

A. -- and its turn-on voltage is high, is it still an OLED?

Q. Yes.

So if you, for example, if you look at Figures 3, the n-doped one, right?

A. Yes.

Q. I think the -- if you look at one candela per -- no, that's current density, sorry.

A. Yes.

Q. But if you look at Figure 2 -- no, that's -- 1 is slightly -- actually slightly lower than that.

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A. That's 7 volts.

Q. Yeah. (Sotto voce.)

Okay. So assume that if it's 10 volts, but then instead of 7 volts, do you consider that to be an OLED?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: So I would have to, I think, better understand more about the specifics of what your device looks like since this is a hypothetical.

Are you saying this device if it was 10?

BY MS. ZHONG:

Q. Yes. A similar structure. If it's 10.

A. So if this device was turned on at 10 volts, would it be still be an OLED?

Q. Correct?

A. Yes, it would still be an OLED.

Q. So what is an OLED?

A. So, again, I just want to make sure I'm understanding the -- the objective here.

So is there a particular aspect that this relates to my reply declaration or

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anything you can point to or is this more a general question?

Q. You mentioned OLEDs throughout your declaration, correct?

A. Yes.

Q. I'm trying the understand what your understanding of OLED is.

A. Okay. So I'll answer in the context of Endo's since that's what we're talking about.

The structure shown in Figure 2, which has an anode of indium tin oxide, a hole-transport layer of NPD and then an emissive/electron transport layer of Alq3 followed by alkaline metal complex layer, followed by aluminum is essentially the archetype of what the initial OLED developed at Kodak looks like.

Q. Okay.

A. So the first OLEDs developed at Kodak used a hole-transport layer similar to NPD, used Alq as a submissive layer and an electron transport layer.

Q. Mm-hmm.

A. And so the --

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(The Court Reporter requested clarification.)

MS. ZHONG: Alq3, I put it in the chat for you.

(The Court Reporter requested clarification.)

THE WITNESS: So, again, this is a archetypical OLED device constructed from, again, two thin film organic materials and even if the voltage was 10 volts, especially in a research paper, I wouldn't cease to call it an OLED.

Frequently in research papers, there may be investigations of -- including different layers that -- perhaps push the voltage up or push the voltage down, that doesn't necessarily mean it's no longer an OLED.

BY MS. ZHONG:

Q. Okay. OLED, in this part, electroluminescence, correct?

A. An OLED emits via electron hole injection to form an exciton. When that exciton recombines, that process is electroluminescence.

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Q. If you apply very high voltage before any light is emitted, is that necessarily through electroluminescence, or it might be through some other mechanism?

A. So that, that's a pretty broad hypothetical. I think I would have to have a better sense of the specific device and system that you're thinking about and what the actual observation looks like for the light emission.

Q. If it's a -- the same structure but if you have to apply a very high turn-on voltage, you still consider that to be an OLED regardless turn-on voltage?

A. So, again, can you -- I don't generally like to speak in absolutes, like "regardless," so can you be more specific in terms of what -- what we're talking about here?

Again, are we still talking about Endo? When you say a "large voltage," what, what do we mean here?

Q. So in your hypothetical combination, what will be the turn-on voltage?

A. What hypothetical combination are you talk referring to?

Q. Your combination of Ma and of

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Diekmann?

A. Great. I just wanted to make sure I understood the specifics.

So I'll interpret your question as to mean, if I were to take Diekmann, which already has an n-doped ETL applied to a phosphorescent OLED and replace that n-dopant that's already present as cesium, barium or lithium fluoride, perhaps, with Liq, would I expect the device to work and with reasonable voltage? Yes, I would.

Q. What would be the voltage?

A. Based on what I see in my -- I suspect the voltage would be -- would be reasonable. I can't assign an exact number. But I suspect it would be an operating OLED that emits spectrum luminescence.

Q. Have you constructed such a device?

A. Have I constructed a Diekmann-type device with an Liq-doped ETL?

Q. Correct.

A. I have not constructed that device myself.

Q. Have you ever constructed an OLED device with lithium quinolate in the electron

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transport layer?

A. I don't think I've ever constructed a device with Liq in the electron transport layer.

Q. What kind of n-doped have you used in the past for phosphorescent OLED?

MR. LEE: Objection. Scope.

THE WITNESS: So I want to make sure I understand the question that you're asking: What kind of conductivity dopants have I used in the past in the electron transport layer of a phosphorescent dopant -- phosphorescent device?

BY MS. ZHONG:

Q. When you say "conductivity dopant," what do you mean by that?

A. An N-type or P-type dopant.

Q. In the electron transport layer -- yes, sure.

A. Yeah. I don't -- I'd have to go back and look through some of my earlier publications. I don't think I've recently published a phosphorescent OLED that as an explicit N-type doping in the electron transport layer.

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Q. Have you ever used an P-doping in the electron transport layer?

A. No, I can say I never used P-doping in an electron transport layer.

Q. Do you think anyone would use P-doping in an electron transport layer?

A. I don't immediately see a reason why someone would use a P-dopant in an electron transport layer, but that doesn't mean there isn't some creative application that I'm not aware of.

Q. Okay. Now, do you see that in the Endo paper at the bottom page 1, they assign the low level of lithium quinolate as minus 2.5 electron volts from the vacuum level.

Do you see that?

A. So bottom of page 1, let me just find that. I see that sentence.

Q. Can you go back to Exhibit 1050? Figure 2, the schematics of the energy-level diagram of the Liq-doped ETL; do you see that?

A. I see -- Figure 2? Yes, I see that.

Q. Do you see that the LUMO listed there seems to be minus 3.15?

A. I see in Figure 2 that the LUMO is

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listed as 3.15.

Q. Do you know why there is a pretty significant change, difference there in the two reported numbers?

MR. LEE: Objection. Scope.

THE WITNESS: So I'll have to take a moment to just read briefly if either author is clear on how they get that number.

BY MS. ZHONG:

Q. For the Choi one, if you go to the previous page, it looks like -- for the HOMO, they identify photoelectrometer, AC-2 measurement and LUMO is adding on the UV absorption gap.

A. What I was looking for more was actual data, rather just than a description.

Q. Okay.

A. But I'm just going to take a quick look at both papers.

Q. Sure.

A. So I don't know why the energy levels are different. That's not something that impacted my opinion in my reply declaration.

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Q. So it appears that in both the Choi paper and the Endo paper, there is some noticeable difference between the LUMO level of the lithium quinolate and the ETL layer; is that correct?

MR. LEE: Objection. Form.

THE WITNESS: So what are the energies you'd like me to compare in Endo?

BY MS. ZHONG:

Q. So, for example, Endo reports the lowest unoccupied molecular orbital, which is LUMO, level of lithium quinolate is minus 2.5 electron volt from the vacuum level while that of the aluminum Q3 is minus 3.0 eV, correct?

A. I see that sentence.

(The Court Reporter requested clarification.)

MS. ZHONG: Aluminum Q3 is minus 3.0 eV.

Those things are in the document itself, the exhibit itself, so hopefully it will help you to verify the spelling.

BY MS. ZHONG:

Q. Do you see that, Dr. Holmes?

A. Sorry. Do I -- can you just tell me

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what "that" is again? Just I want to make sure I'm looking at the right thing.

Q. Okay. So in the Endo paper, do you see that the -- that LUMO level for lithium quinolate is minus 2.5 eV while that for the aluminum Q3 is minus 3.0 eV?

A. Yes, I see that sentence.

Q. So there is a 0.5 eV difference in the LUMO level?

A. Yes, I see the sentence that states Liq is minus 2.5 eV, or its LUMO, and Alq is minus 3.0 eV for its LUMO. So they're, at least according to Endo, would be --

(The Court Reporter requested clarification.)

THE WITNESS: Yes, I can repeat my answer.

So I was just stating that the -- I do see that the Liq LUMO, at least according to Endo, is minus 2.5 electron volts from the vacuum level, while the LUMO for Alq3, according to Endo, is minus 3.0 eV from the vacuum level. I see that.

BY MS. ZHONG:

Q. So there 0.5 eV difference in the

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LUMO levels; is that correct?

MR. LEE: Objection. Form.

THE WITNESS: The difference between 2.5 and 3.0 is 0.5 eV difference.

BY MS. ZHONG:

Q. Is that considered to be significant energy gap?

MR. LEE: Objection. Outside the scope.

THE WITNESS: Can you tell me what you mean by "Is that considered to be a significant energy gap"? Significant in what respect?

BY MS. ZHONG:

Q. As far as electron injection is concerned.

MR. LEE: Outside the scope.

THE WITNESS: So, again, I think it all depends. I'm not sure how I interpret that per se, and it's not something I've really thought about in terms of what energies are significant or not when it comes to electron injection.

BY MS. ZHONG:

Q. Okay. Do you see that the -- what

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Endo says is with lithium Q's LUMO level being minus 2.5 eV it makes the barrier height for electron injection for aluminum cathode to the organic layers lower for aluminum Q3?

Do you see that?

A. I see that Endo is stating that, yes.

Q. And do you think that the lowering of the injection barrier -- strike that.

So if the Lithium Q LUMO, instead of minus 2.5 eV it will be minus 2.9 eV -- or not -- minus 2.95 eV, would the reduction in barrier height be significant enough for there to be material -- meaningfully more electron injection into the organic layers?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: I'm sorry, again, I think "meaningfully" -- and this isn't something I've had to develop an opinion on in my reply declaration.

So I don't know how much the current would necessarily change in changing these LUMO levels from one number to another. It's not something I've had to think about

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in detail for this case.

BY MS. ZHONG:

Q. Okay. So if the lithium Q's LUMO level is at the same level as aluminum Q3, do you think that it would help reduce the barrier -- injection barrier?

MR. LEE: Same objection. Outside the scope.

THE WITNESS: So, again, as I already said, that's not something I've had to develop an opinion on for the purposes of my declaration or reply declaration.

And so in terms of what the energy levels are that change injection by a certain amount or a different amount, that's just not something I have an opinion on to offer here.

BY MS. ZHONG:

Q. I'm just asking you, do you have an understanding as to why there is a reduction in the injection barrier by incorporating lithium quinolate?

MR. LEE: Objection. Scope.

THE WITNESS: So are you asking -- that's a different question.

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Are you requesting about Endo and why Endo argues there's a difference in injection barrier with Liq?

BY MS. ZHONG:

Q. Sure, you can answer that question.

A. Well, is that what you're asking? I guess, I'm not clear on what the question is you'd like me to answer.

Q. You can answer that question.

A. Okay. So then, to answer that, I'll just consult Endo's conclusion.

So, again, Endo, in looking at the use of Liq as a dopant in the ETL, hypothesizes that their data suggests that alkaline metal ions in the complexes are actually being reduced free metal by the interaction with the cathode and that that's actually doping the interface as a means to improve the injection.

Q. So Endo's theory is that lithium quinolate is reduced to lithium-free metal; is that correct?

A. That's correct.

Q. Do you know how much reduction there is, the extent of the reduction?

A. Endo doesn't describe the extent of

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reduction.

Q. Okay. But Endo's theory is that lithium quinolate is going to be reduced to lithium metal?

A. Yes.

Q. And why does Endo state that lithium quinolate reduces the injection barrier for aluminum Q3?

A. Is there a particular part of Endo you're referring to when you say they state that?

Q. The end of page 1.

A. Sorry, where in the end of page 1? The paragraph we were just talking about?

Q. Yes.

A. I don't see a reference to barrier lowering in that last little paragraph we were discussing. Is there a particular sentence I'm missing?

Q. It says:

The lowest unoccupied molecular orbital, LUMO, level of lithium Q is minus 2.5 eV from the vacuum level while that of aluminum Q3 is minus 3.0 eV, making the barrier heights for electron injection from aluminum

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cathode having a work function of minus 4.2 eV, to the organic layers lower for aluminum Q3.

Do you see that?

A. I do.

Q. Okay.

A. But you asked the question about the injection getting better with Liq. That sentence doesn't talk about that.

Q. I said why is the barrier height lower?

A. With -- just for Alq?

Q. What does this sentence mean?

A. This sentence is simply saying that if you look at a simple energy alignment between the cathode and each of these materials, the energy difference between the cathode and Alq is smaller than the energy difference between the cathode and Liq.

Q. And so that's a situation that's reversed from the Choi situation?

MR. LEE: Objection. Form.

THE WITNESS: So I just want to reopen Choi. Can you just -- I assume you're pointing to Figure 2. Can you just re-ask the question specifically for Choi?

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BY MS. ZHONG:

Q. So in Choi the energy difference between the cathode and lithium Q's LUMO is smaller than the energy difference between aluminum and the ETL LUMO; is that correct?

A. That's what Figure 2 shows.

Q. Okay. And in Endo, they used -- instead of using a LUMO level of minus 3.15, they were hypothesizing that the Lithium Q LUMO level is minus 2.5 eV, right?

A. Endo lists the LUMO level of Liq as minus 2.5 eV.

Q. So instead of minus 2.5 eV, if the Lithium Q's LUMO level is actually minus 3.15 eV as reported by Choi, then the barrier height between aluminum and aluminum lithium Q would be smaller than that between aluminum and aluminum Q3; is that right?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So in looking at Figure 2, the deeper LUMO, the 3.15 LUMO, would bring it closer to the cathode.

BY MS. ZHONG:

Q. Okay. So the LUMO level of lithium

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quinolate is kind of important in Endo's theory as to why things working or not working, right?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: So I didn't have to -- the LUMO level of Liq wasn't something that impacted my opinion in my initial declaration or my reply declaration. So it's not something that I've actually looked at as part of the proceeding.

And since the Endo actually is describing Liq as disassociating to form a free lithium metal. I don't think the LUMO level of Liq is as important.

BY MS. ZHONG:

Q. Do you know what evidence Endo actually has that free lithium is formed?

A. So Endo, in their discussion of their results -- actually I want to reread one part of Endo here just to make sure I answer your question correctly.

So Endo, in their work, is -- is arguing that the disassociation of Liq to form lithium, and ultimately dope their -- their ETL, is the most consistent model that's --

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that's basically reflecting their data.

They also extensively compare this hypothesis to prior work relating to other complexes and note that this idea of institute doping where, basically, a complex is used and then a metal is essentially freed after deposition of, let's say, the cathode has been described before in the literature and applied previously, for example, for lithium fluoride.

And so they're also grounding their hypothesis in prior work that has also suggested the generation of lithium from other complexes.

Q. Okay. But isn't the fact that part of Endo's theory is that the -- because the LUMO level is Liq is actually higher than the LUMO level of aluminum Q3, such that the energy gap between aluminum and lithium Q is larger than the energy gap between aluminum and aluminum Q3 such that the simple energy diagram is not going to explain the improvement in the experiment results.

MR. LEE: Objection to form.

BY MS. ZHONG:

Q. That's why we went forward with a

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proposal of reduction of lithium complex to free metal.

MR. LEE: Objection. The form.

THE WITNESS: So, again, I can't speak to, you know, what was, what was their thought process in terms of, you know, how they -- how they came about their hypothesis.

I think if you read Endo, they spend a significant amount of the text referring to prior work on in situ doping to support their claim that that's what's going on here.

And also make a strong parallel to lithium fluoride, also having this sort of character to further solidify the behavior of Liq versus other dopants that behave in a similar way.

So I think they actually are very strong in their description of Liq as an in situ dopant just looking at the prior art.

BY MS. ZHONG:

Q. So you agree with Endo that free lithium is formed when cathode is deposited on

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the same quinolate; is that correct?

A. I think that Endo's interpretation of Liq is consistent with the rest of the literature and what I did a -- when I wrote my initial declaration, I pointed out prior art that also suggested Liq would disassociate. So I think that Endo's conclusions are sound.

Q. Okay. So let's see what we can agree.

You agree that lithium quinolate would disassociate into anode lithium cation and some kind of an anion?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. I'm sorry about my accent.

So we agree that lithium quinolate would disassociate into lithium cation and anion, or it would be reduced into lithium metal; is that correct?

MR. LEE: Objection. Form. Misstates testimony.

THE WITNESS: So what I have pointed to in my original declaration and in my reply declaration, is that there is ample

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support in the literature to suggest that Liq, when it sees the cathode metal will disassociate.

BY MS. ZHONG:

Q. And would disassociating to either lithium cation or lithium metal; is that correct?

A. Again, I haven't had to take a position necessarily on the precise chemical path via which the doping occurs, whether there's a cation, whether it's a pure metal, whether both are formed at different stages, that's not something that impacted my opinion.

What impacted my opinion was that there is significant prior art that indicates that disassociation will occur.

Q. But you don't know what the disassociation species will be; is that correct?

A. Again, I haven't had to take a specific position on the chemical pathways of the disassociation and how that ultimately leads to doping.

The prior art is quite clear that there will be a disassociation and that that

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will permit doping of the electron transport layer.

Q. Okay. Do you know whether small metals such as lithium or lithium cation would form in this disassociation?

A. So I think that's -- that's what I just answered, which is that the prior art suggests that lithium quinolate will disassociate but the specifics of whether it's immediately LI plus or LI metal, and again, that's not, not something that I've taken an opinion on in my reply declaration.

Q. And do you know the extent of the disassociation?

A. Again, I don't think that's something that's impacted my opinion. The prior art is clear that the disassociation essentially occurs.

Q. Okay.

MS. ZHONG: Why don't we take a break.

THE COURT REPORTER: Off the record.

(A recess was taken.)

BY MS. ZHONG:

Q. So, Dr. Holmes, there are only two

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papers cited before 2008 that included an electron transport layer doped with lithium quinolate; is that correct?

A. So I'm just going to consult my exhibit list, my reply declaration.

Yes, that's correct.

Q. So let's just be clear. One is Ma, Exhibit 1010, and the other is the Endo paper, 1049; is that correct?

A. Yes.

Q. And in both of those papers, the electron transport layer is the aluminum quinolate or aluminum Q3; is that correct?

A. That's correct -- no, that's not necessarily correct. So in Endo -- let me just check Endo here for a moment.

Q. You're right. So Endo --

(The Court Reporter requested clarification.)

(Parties speaking simultaneously.)

THE WITNESS: Yeah, I'll just -- so in Endo --

BY MS. ZHONG:

Q. Go ahead.

A. I'm just going to note that in Endo,

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they both -- they both, Alq and BPhen with Liq, and so there's -- -- those are both electron transport layers and both of them are demonstrated as doping.

And then in Ma, Ma actually dopes BPhen with Liq, and there, BPhen is again serving as the end if the electron transport layer. So I would disagree with your initial assessment.

BY MS. ZHONG:

Q. So in both cases, the aluminum Q3 is the emissive layer; is that correct?

A. In both Ma and in Endo, yes, the light emission is coming from Alq3.

Q. So in both systems, there is an Alq3 component in their OLED stack?

A. In both papers, Alq3 is the emissive material in the OLED stack.

Q. Okay. So there is Alq3 material in that OLED stack somewhere?

A. Yes, it's the emissive material so it's within the stack.

Q. Let's now go to the Choudhury paper or the So paper.

Do you know -- are you familiar with

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Professor So, Franky So?

A. Let me just open the paper first.

Q. So that will be Exhibit 1051.

(Exhibit 1051 was identified.)

THE WITNESS: I have it.

Please repeat your question.

BY MS. ZHONG:

Q. Do you know Professor So, Franky So?

A. Yes, I know Professor So.

Q. Do you know, is he an expert in the field of OLED at the time of the invention?

MR. LEE: Objection. Outside the scope.

THE WITNESS: Yes, I would categorize Franky So as an expert at the time of the invention.

BY MS. ZHONG:

Q. Do you know Dr. Choudhury? The first name of the inventor of Exhibit 1051?

(Exhibit 1051 was identified.)

THE WITNESS: I don't know Choudhury; nor do I know if he's a graduate student or someone who already has a Ph.D.

BY MS. ZHENG:

Q. If you look at the footnote with the

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star, do you see that there's Professor F. So, Dr. K.R. Choudhury?

A. Yes, I see that.

Q. Does that indicate to you that he has a Ph.D.?

A. Yes, it does. I hadn't recalled that designation.

Q. And what is a definition of POSITA?

A. So I'll go back to my, I guess initial declaration to answer that question.

Q. Mm-hmm.

A. Let me just open it.

Q. So page 44.

A. Just opening it.

So as I write in paragraph C4 on page 44: A POSITA, in my opinion, at the time of the alleged invention would have had a bachelor's degree in chemistry, physics, or a comparable field of study, and at least three years of research or industrial experience with organic optoelectron light-emitting devices.

Q. Okay. So would Dr. Choudhury be someone with above average skill set at the time of the invention then?

A. So again, I didn't have to consider

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Dr. Choudhury's educational or personal background at the time of the invention. I don't know a bachelor degree they had but I assume they would have had some sort of bachelor's degree in these areas, clearly have a Ph.D. so they have experience in this area, too, it's quite possible that they would have been a person skilled in the art.

Q. Okay. So he would have more than three years of research, correct, given his Ph.D.?

A. Again, I don't know the specifics of Dr. Choudhury's background in general. If someone has a Ph.D., that would imply they have more than three years of research, but I can't comment on the specifics of Dr. Chaudhry's background without knowing what his background is.

Q. Okay. What's -- how long does an average Ph.D. -- strike that.

How long does it take to get a Ph.D. on average?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: So getting a Ph.D. in

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my group, on average, takes about five to five and a half years.

BY MS. ZHONG:

Q. Is that typical --

A. Maybe average of five and a half years.

Q. Okay. Is that typical for people in your field to get a Ph.D. within that time period?

A. I think that would be typical for students in science and engineering, yes.

Q. So would you think that someone who graduated from your group would possess above-average skill set as defined by you?

A. Yes, I would.

Q. Would you expect the same for people graduating from a reputable university -- like a -- with a Ph.D. from a reputable university?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So I think I want to understand a little bit more specifics on what you mean by a "reputable university."

In my description of a person skilled in the art, let's go back to my

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declaration again. Just open that paragraph again.

So what I note again is that bachelor's degree in chemistry, physics or comparable field of study --

BY MS. ZHONG:

Q. Mm-hmm.

A. -- and at least three years of research or industrial experience with organic optoelectron light-emitting devices.

And so the "and" is important. And --

Q. Mm-hmm.

A. -- so for students graduating from my group, I know what their experience is and I know that they have the relevant experience of organic optoelectron light-emitting devices, I'd have to know a little bit more about what you mean about this hypothetical case in order to answer with certainty.

Just being a reputable university -- I can't remember if that's the terminology you used -- doesn't necessarily say whether or not you have three years of experience in organic optoelectronic light emitting devices.

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BY MS. ZHONG:

Q. Does Professor So's research focus on optoelectronic OLED device?

A. Some of Professor So's research focuses on organic optoelectronic light-emitting devices, but I don't know where Dr. Choudhury received their Ph.D. or training, per se.

Q. Is University of Florida -- does Dr. So have a reputable program in OLED?

A. Yes, Dr. So has a reputable program in OLEDs.

Q. Now, in Exhibit 1051, that system again involves the use of aluminum Q3, correct?

A. I'm going to have to open Exhibit 1051. This is Choudhury. Okay. Let me go to that.

Yes. So in Choudhury, Alq3 is what's being investigated, yes.

Q. Do you see in Table 1 of Choudhury, there is the reported conductivity for undoped aluminum Q3 and a 4 percent doped aluminum Q3?

A. Yes, I see Table 1.

Q. For an OLED application, what would be a suitable conductivity range for the

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electron transport layer?

A. I don't think I have -- I haven't had to establish such a range in my declaration or reply declaration. And so I don't have a specific range of conductivities that I could point to as being suitable or unsuitable.

Q. And the 4 percent, is that weight percent or the molar percent?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Weight percent or molar percent?

A. I'll have to just look at Choudhury to see they're specific on that.

It's weight percent.

Q. And does lithium fluoride exist only as lithium canide and fluoride or they're bound in some kind of crystal structure?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So can you rephrase your question? I'm not sure I understand what you're asking.

BY MS. ZHONG:

Q. So lithium fluoride, does it exist

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only as a lithium cation and lithium anion, or there's a crystal structure with many lithium fluoride bound together?

MR. LEE: Objection to form. Outside the scope.

THE WITNESS: So, again, I don't think I'm understanding what you're asking.

So you're saying can Lithium fluoride exist in a crystal structure where there's many lithiums and fluorines bound together?

BY MS. ZHONG:

Q. Correct.

A. So that's not something that I've had to consider in the context of my reply declaration or my work in this proceeding.

Is there a specific connection to Choudhury that you want me to make or to my reply declaration?

Q. So lithium fluoride is a Lewis structure, right? That's what chemists typically call them, the Lewis structure.

So what is the actual form of lithium fluoride that existed?

MR. LEE: Objection. Form.

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BY MS. ZHONG:

Q. In the material?

MR. LEE: Objection. Form.

THE WITNESS: So in what material? Just as standalone lithium fluoride? So lithium fluoride is a salt.

BY MS. ZHONG:

Q. Okay.

A. If you're purchasing Lithium fluoride from a chemical supplier, you purchase raw lithium fluoride powder. Lithium fluoride is a salt and presumably it could be present as a fine crystal and granular material, in which you'd have lithiums and fluorines bound to each other. I'm not sure if that's what you're getting at, but --

Q. Sure.

A. I don't think I follow what the question is asking.

Q. So in what form is lithium -- does the lithium fluoride exist in the Choudhury paper? Either as a dopant or as a pure lithium fluoride injection layer?

MR. LEE: Objection. Form.

THE WITNESS: So Choudhury discusses

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doping of lithium fluoride into Alq3. And Choudhury proposes that what ultimately happens is Lithium fluoride is activated by the cathode to become, essentially, an in situ dopant.

BY MS. ZHONG:

Q. And their proposal is that it's going to react with aluminum Q3, right?

A. Their proposal is that an anion of Alq3 is formed.

Q. Okay. What if they -- instead of Alq3, it's another -- it's an organic electron transport layer, like BPhen, what would be formed?

A. I suspect you'd form the same thing, that you'd also form some sort of anion. But that's not something that I've had to specifically look in detail at as part of my reply declaration.

Q. What kind of anion?

A. I don't think I follow the question.

Q. So their proposal the anion is aluminum Q3 radical anion, correct? In the Choudhury paper?

A. Yes, that's correct.

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Q. Okay. What would be the corresponding anion in the BPhen system?

A. So, again, I haven't gone and actually looked at what the specific electric chemistry would be in a variety of different electron transport layers.

Q. And do you see that PDF page 6 they have a reaction that seems to have the Gibbs free energy of almost zero, which is a neutral reaction?

A. I see that.

Q. So instead of a aluminum Q3, if it's BPhen, do you know what's the energy -- what the Gibbs free energy would be?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I didn't investigate what the Gibbs free energy would be for a reaction of Liq and BPhen.

BY MS. ZHONG:

Q. So do you think the reaction would be favorable and take place?

MR. LEE: Objection. Outside the scope.

THE WITNESS: Again, it's not

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something I considered. The exhibits I've presented show that Alq can act as an n-dopant and Alq can associate.

In fact, Endo also shows -- pardon me, Liq, not Alq. And Endo shows, again, that Liq also serves as a dopant in BPhen.

So in the specific case of BPhen, there is prior art to support its use of Liq as well.

BY MS. ZHONG:

Q. But in that -- in both systems, there is Alq3 somewhere in the OLED stack, correct?

MR. LEE: Objection. Form.

THE WITNESS: So when you say "in both systems," just so I'm clear, what are the two that you're comparing?

BY MS. ZHONG:

Q. Endo, Ma, and now let's also adding the Choudhury, in all three systems, somewhere in the OLED stack there's aluminum Q3, correct?

A. All three of those devices use Alq3 as an emissive layer.

Q. As an emissive layer and/or as an electron transport layer, correct?

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MR. LEE: Objection. Form.

THE WITNESS: So Choudhury also uses Alq3 as an electron transport layer that's doped with lithium fluoride. They also have an electron transporting blocking layer of PCP.

Ma uses Alq as an emissive layer with doped BPhen as the electron transport layer.

And then in Endo, Alq, depending on the device, can serve either as the emissive layer and the electron transport layer or just the emissive layer with BPhen.

BY MS. ZHONG:

Q. And according to this paper by Choudhury, they actually experienced that the aluminum seems to be able to diffuse throughout the entire layer, correct?

MR. LEE: Objection to form.

THE WITNESS: Can you point to a particular part of Choudhury?

BY MS. ZHONG:

Q. Sure. PDF page 6. And why don't you do a search of the word "shorting,"

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s-h-o-r-t-i-n-g.

A. Okay. Let me just reread that paragraph.

Q. Yeah. Just read the paragraph for context.

A. Okay. Can you just please restate your question?

Q. Okay. Is it true that according to the Choudhury paper aluminum will diffuse through the OLED stack?

A. So I don't think I would characterize the passage that you've pointed me to as necessarily supporting that.

Choudhury references some prior work that has suggested that silver atoms can diffuse through layers of an OLED stack. And they speculate in their work that metal diffusion may be part of the reason that they saw a greater instance of shorts in single-carrier devices.

And so they're hypothesizing that there could be diffusion of the cathode, but I don't think they have said that they think there is metal diffusion through the OLED stack. They seem to be referring specifically

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to their single-carrier devices.

Q. What is a single-carrier device?

A. A single-carrier device is usually a structure that's designed only to carry either electrons or holes. And it's frequently used as a way to look at electron or hole transport.

Q. So they're referring to electron-only devices or hole-only devices?

A. Single-carrier devices can be also be referred to as electron or hole-only devices.

Q. Okay. So you think that the BCP paper -- BCP layer between the aluminum Q3 electron transport and aluminum Q3 emissive layer is going to stop the diffusion of the metal?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I haven't had to consider the diffusion of the metal through the OLED stack and the degree to which BCP or another layer stops it. So that's not something that I've considered as part of my declaration or reply declaration.

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BY MS. ZHONG:

Q. Do you know whether lithium fluoride would diffuse through the BCP layer?

A. I -- again, I haven't considered whether or not lithium fluoride would diffuse through the BCP layer as part of my declaration or reply declaration.

Q. What's the ability you-- strike that.

So as between lithium quinolate and lithium fluoride, which one has a better ability to refuse through the electron transport layer?

MR. LEE: Objection. Form.

THE WITNESS: So you're asking between lithium fluoride and lithium quinolate, which one has an ability to diffuse through the electron transport layer?

BY MS. ZHONG:

Q. Yeah, which one is a better diffuser?

A. A better diffuser? I haven't considered explicitly the -- the diffusivity of lithium fluoride versus Liq in electron

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transport layers.

With Liq, what I point to is, the Diekmann explicitly calls out molecular dopants as being attractive for a lower diffusivity and Liq being a molecular dopant would fit that -- fit that preference stated in the Diekmann.

Q. Is lithium fluoride also a molecular dopant?

A. So I haven't considered how to characterize lithium fluoride as a molecular dopant, whether it's a molecule or not. I think Liq is a molecular dopant.

Q. An electron dopant that can disassociate; is that right?

A. Liq is a molecular dopant that can dissociate when it molecular that's what the prior art supports.

Q. Do you have any idea of the extent of illuminate diffusion?

MR. LEE: Objection.

THE WITNESS: Is there a particular structure, are you saying in Choudhury or the single-carrier devices? I am not sure I understand what the context is.

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BY MS. ZHONG:

Q. Do you think the reaction between the cathode and lithium fluoride or lithium quinolate doped ETL, the extent of the reaction of diffusion is going to differ based on whether it's a single-carrier device versus a full OLED?

MR. LEE: Objection. Form.

THE WITNESS: So I haven't considered how the diffusion of the cathode metal might depend on OLED architecture.

But I will highlight again, just that, Choudhury is pointing to that as only a hypothesis for shorting in their single-carrier devices.

BY MS. ZHONG:

Q. Do you think their hypothesis is consistent with what Endo is saying?

MR. LEE: Objection, form.

THE WITNESS: Can you be more specific? What specifically about Choudhury/Endo are you asking is consistent?

BY MS. ZHONG:

Q. Is Choudhury's hypothesis of what's

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going on there in their system is consistent with Endo's hypothesis of what is going on in his system?

MR. LEE: Objection. Form.

THE WITNESS: In my opinion, what Choudhury demonstrates is that lithium fluoride is essentially an in situ dopant, that lithium fluoride mixed with Alq on its own does not necessarily change the formidable position of Alq3 and that that comes with the metal deposition on lithium fluoride and Alq to realize that change in behavior and that is analogous to what Endo is saying for Liq.

And so comparing Choudhury and Endo, it shows that the lithium fluoride and Liq are operating through similar mechanisms.

BY MS. ZHONG:

Q. And when you say "in situ dopant," you mean that you need to have an activated metal to diffuse into that layer to activate the lithium complex. Is that what you mean?

A. I don't know that I'd use the term "activated" metal. What I'm saying is that the in situ doping requires the deposition of the

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cathode.

Q. And the cathode basically activates the lithium complex?

A. The cathode leads to some disassociation of the lithium complex that then results in doping, or some reaction that then results in doping.

Q. And you don't know what that is?

A. Well, in Choudhury, there's a hypothetical reaction that's listed that we've already discussed, so...

Q. And that's specific to alum Q3?

A. I don't know that it's specific to aluminum Q3 and in my opinion, it's probably not specific to aluminum Q3, but I don't have a, as I said, the thermodynamics of other reactions available?

Q. And would the radical anion be stable for a pure organic compound?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So, again, I'm not sure what you mean by with the "radical anode be stable for a pure organic compound." Can you rephrase your question?

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BY MS. ZHONG:

Q. Why don't you do a word search of "radical anion"?

A. Okay.

Q. Do you see the words "radical anions"?

A. I do.

Q. What's the radical -- what is a -- what are the radical anions in the equation below?

A. So this isn't something that I've had to opine on in my declaration or reply declaration. And so assessing specifics of radical anion behavior isn't something that I've offered a specific opinion on in my reply.

Q. And do you see that the next paragraph says: A formation of radical anion of aluminum Q3 is responsible for the n-doping effect?

A. Yes, I see that sentence.

Q. Okay. Do you know whether there is corresponding formation radical anion of the organic electron transport layers?

A. So I --

Q. Is that something you considered?

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A. So I would refer to Alq as an organic electron transport layer.

So Alq is commonly referred to as an organic semiconductor. It's an organic electron transport layer.

Q. It includes a metal?

A. I'm sorry?

Q. It includes a metal center?

A. Yes. But it's still referred to as an "organic semiconductor."

Q. Okay. And do you know what will be the corresponding radical anion in electron transport layer with no metal --

A. That's not something --

Q. -- pure organics --

A. That's not something that I considered in my reply; -- or it's not something that I opined on in my reply.

The data -- the data is sufficient in showing that Liq will act as n-dopant.

Q. Do you know whether BPhen will form radical anion?

A. With Liq, LiF, is there -- can you ask the question more specifically?

Q. Well, can BPhen form a radical anion

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in the presence of lithium complexes?

A. So I think I've already noted that that's, that's not something that I've looked into deeply. I don't have the corresponding reaction for BPhen.

Q. Okay. Do you have an opinion one way or the other?

A. My opinion is that Liq serves as a N-dopant in BPhen based on the prior art.

Q. Okay. Does BPhen form any kind of radical anion in the presence of lithium quinolate?

A. I think that's the question I just answered, that I -- I haven't looked into the reactions specifically between Liq and BPhen, my opinion isn't informed by the prior art that shows the Liq is N-dopant in BPhen.

Q. Okay. So you have no opinion whether a radical anion is formed in BPhen in the presence of lithium quinolate; is that correct?

A. In looking at, for example, Endo, Endo is using their data to support the idea that Liq leads to lithium doping of BPhen.

I have not had to take a further

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opinion on what anion might form and what it might look like.

Q. Okay. So Endo paper is 2002, correct?

A. Just confirming that. Yes, the Endo paper is 2002.

Q. Ma is 2008?

A. Ma is 2008, correct.

Q. And when is the next paper that actually used lithium quinolate in the documents that you relied on?

MR. LEE: Objection. Outside the scope.

THE WITNESS: Sorry. Just want to make sure I understand, what is the question you're asking? When is the next paper?

BY MS. ZHONG:

Q. When is the next paper that actually uses lithium quinolate to document electron transport layer?

A. In terms of prior references, those are the two papers that I'm relying on as lithium quinolate doped electron transport layer.

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Q. Okay. We can look beyond 2008 and 2009.

A. Oh, okay.

So the additional paper that I note that has the lithium quinolate doped electron transport layer is the Choi paper, which is 2009.

Q. Okay. And what -- which one is the first one that actually uses lithium quinolate in connection with a PHOLED phosphorescence emitter?

A. So with Ma and Endo, as we've already discussed, both of those devices use Alq3 as an emissive layer, which is florescent emitter.

And as I, as I mentioned in Choi, I don't think it's obvious whether or not their emitter is fluorescent or phosphorescent because it's a proprietary chemical.

Q. Okay. And when is the one that you know that is using a phosphorescent material?

MR. LEE: Objection to form.

THE WITNESS: So the exhibits I'm citing -- well, the exhibits I brought -- I brought to this proceeding don't apply a

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phosphorescent emitter with an Liq doped ETL.

BY MS. ZHONG:

Q. And do you know when is the first example that you know for sure there is the use of lithium quinolate together with phosphorescent material?

A. That's not something I had to look into as part of my declaration, reply declaration, in terms of specifically when it was applied to a phosphorescent emitter.

As I argue in both my declaration and reply declaration, it would have been obvious to a person skilled in the art to apply lithium quinolate as an n-dopant in the ETL of a phosphorescent OLED just because at the time of the '425, there were many prior art examples of n-doped ETLs and phosphorescent OLEDs using a variety of dopants.

Q. And do you know a Dr. Katona?

A. Dr. Katona. Can you give me a first name and an affiliation?

Q. Thomas Katona. I'm not exact sure of his affiliation.

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Do you know a Dr. Thomas Katona?

A. I may have -- I may have met Dr. Thomas Katona before, but I'm actually not positive.

Q. Do you know that he is the expert for Samsung in the district court case for the '425 patent?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: I was not aware of that.

BY MS. ZHONG:

Q. So I assume you did not talk to him regarding his opinion in district court on this case, correct?

A. No.

Q. And you did not read his deposition transcript, correct?

A. No, I have not read his deposition transcript.

Q. So do you want me -- do you prefer to use Exhibit Share or Dropbox?

A. I have both of them open. So we can attempt whichever you'd prefer. I'd like to be able to download anything that you're going to

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try to show me.

Q. Definitely. I think you can do both. Do it either way?

THE COURT REPORTER: For my benefit, do you mind putting it in Exhibit Share.

MS. ZHONG: Yeah. So I'm going to copy stuff over.

So I have copied over into the marked exhibit, Exhibit 1, Dr. Katona's June 13th, 2025 transcript. And I will mark this entire transcript as confidential and Dr. Katona's transcript as confidential, outside counsels' eyes only.

(Exhibit 1 was marked.)

MR. LEE: I'm going to take a second to review the newly introduced exhibit and lodge my objections before we continue testimony. I have not been able to download the exhibit yet.

MS. ZHONG: You need to refresh it. I see it there.

THE COURT REPORTER: Counsel, do you want me to separate the confidential from the original.

MS. ZHONG: I don't think so. Nope.

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We will just file anything under seal. That's fine.

MR. LEE: I'm going to object to this document as irrelevant, hearsay and based on foundation because Dr. Holmes has testified that he has not reviewed any transcript of a deposition of Dr. Katona.

And also object to the inclusion of this document in the transcript or into the exhibits as against the board's rules and improper attempt to run around the board's rules preventing introduction of new exhibits with the sur-reply.

BY MS. ZHONG:

Q. Dr. Holmes, do you have the exhibit?

A. I have it open.

Q. Can you please go to page 132?

A. Yes, I'm at 132.

Q. Do you see the exchange between -- page 132, lines 4 through 9?

A. I see that.

Q. Do you see the exchange concerns whether a lithium quinolate blend is necessarily n-doped?

MR. LEE: Objection. Misstates the

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document.

BY MS. ZHONG:

Q. Is that correct?

MR. LEE: Objection. Outside the scope. And I'm going to object to this entire line of questioning as improper, outside the scope.

BY MS. ZHONG:

Q. Is that correct?

A. Can you restate the question?

Q. So the question is, a lithium quinolate blend is necessarily n-doped, correct? That was the question, correct?

MR. LEE: Objection. Outside the scope. I'm going to object to this entire line of questioning as improperly seeking to have the witness simply read exhibits that cannot be properly part of the record into the record through this deposition transcript.

And if you continue, I'm going to ask to take a break to consider whether we need to call the board on this issue.

MS. ZHONG: Sure.

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BY MS. ZHONG:

Q. Dr. Holmes, please answer the question.

A. Can you please restate the question?

Q. Okay. If your counsel does not trying to interrupt the deposition again.

So the question is that a lithium quinolate blend is necessary n-doped, correct? And the answer that Dr. Katona provided is:

I think we have covered this multiple times that lithium quinolate can be an n-dopant and also cannot be.

That's the exchange, correct?

MR. LEE: And I'll lodge the same objections.

THE WITNESS: So, again, I haven't reviewed this document, as I've already noted.

It looks like this is a 300-page deposition transcript. And I can't render an opinion on this document without having had time to look at it in detail and understand all the associated exhibits and arguments.

This is apparently from a district

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court case. That's not something that I've been involved in.

And so I think it would be inappropriate for me to offer any opinions on this particular document.

BY MS. ZHONG:

Q. I'm not asking you to render an opinion. I'm asking you whether that's the exchange that just took place. I haven't asked my next question yet.

Can you answer the question that's posed rather than taking the coaching objection from your counsel?

MR. LEE: Objection. Argumentative. Objection. I mean, you're clearly, by admission of counsel, you are just seeking to introduce a document that cannot be introduced into this proceeding by having the witness just read what's been provided to him. You're here to ask him cross-examination --

MS. ZHONG: Exactly. I am entitled to ask him a question to see whether he has considered all the available relevant information. Clearly, he hasn't. So

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stop --

MR. LEE: This is evidence that the deponent testified that he has not --

(Parties speaking simultaneously.)

MS. ZHONG: Listen, you have -- stop interrupting me -- stop interrupting his answer. Okay? He is in the middle of answering it and --

MR. LEE: You asked the question --

(Parties speaking simultaneously.)

MS. ZHONG: Stop doing that. It's improper.

MR. LEE: You asked the question and I'm lodging my objection in response to your --

MS. ZHONG: Okay. You've already lodged it. And you've interrupted this deposition enough. I know you don't like this line of question, but you should have prepared your witness for.

MR. LEE: This is not a document that Dr. Holmes has reviewed as he has already testified.

MS. ZHONG: And I'm entitled to ask for his opinions, so stop.

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MR. LEE: You're entitled to ask him questions about -- to cross-examine him on the substance --

MS. ZHONG: Exactly. So stop --

(Parties speaking simultaneously.)

MR. LEE: -- testimony which he has provided in his reply declaration, which this is not responsive to.

MS. ZHONG: It is responsive to. So stop. Let me ask my question.

BY MS. ZHONG:

Q. Dr. Holmes, did you see the exchange on page 132, lines 4 to 9.

Do you see that?

MR. LEE: Objection. Form. I'm going to object to having the witness read from a transcript that he has never reviewed before into the transcript of this proceeding because that is a runaround against the board's rules preventing introduction of the exhibits with sur-reply.

MS. ZHONG: Well, you should have introduced this one. There is a board rule of the duty of candor, anything that's

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inconsistent with the positions. And it has not been filed before. You guys should have filed it. You have not done that.

That's the same thing in the 223 proceeding. You've done it again and again, and I'm just surprised you guys are doing this.

MR. LEE: Counsel, Pictiva Display is not a party to the proceeding in which this deposition was taken. And so I do not understand why you believe that we would have any access to this transcript. That's not what the board rules require.

So can you, you know, refer me to what the board rules are? That's --

MS. ZHONG: You may consult your co-counsel who used to a deputy chief judge and see whether you have a duty of candor to the board to disclose inconsistent positions.

And if he says on the record that you don't have a duty, great. We'll take that to the board.

MR. LEE: We don't disagree that there is a duty. We disagree that

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there's --

MS. ZHONG: You say you don't --

(Parties speaking simultaneously.)

MR. LEE: We disagree that that somehow requires us to somehow find an exhibit which we are not privy to and that --

MS. ZHONG: You guys are privy to. You have -- is that why you refuse to answer --

(Parties speaking simultaneously.)

(The Court Reporter requested clarification.)

MR. LEE: As I was saying, we also disagree that there's any consistency, but let's also just stop shouting and just -- you know, we can talk about it on a break, if you would like, but I'm going to object to this entire line of questioning as totally improper.

MS. ZHONG: And you state that 100 times already. And let me just put on the record, Covington -- we asked Covington to enter into an appearance in district court. You refused to do it but you insisted on

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having access to the expert report in the district court and you also have access -- my understanding is you have access to all those transcript as well.

So to state that you have no access to them, that's a blank lie.

MR. LEE: I understand --

MS. ZHONG: That's not the truth. Okay?

MR. LEE: I understand that it is Pictiva that's been seeking to file these papers from the district court, and it was Pictiva's request that we, you know, agree to some arrangement in order that -- that the available to Pictiva in these proceedings. So...

BY MS. ZHONG:

Q. So, Dr. Holmes, do you agree with Dr. Katona, that a lithium quinolate plant is not necessarily n-doped and lithium quinolate does not necessarily have to act as an n-dopant in the blend?

MR. LEE: Objection. Outside the scope. Objection. Form.

THE WITNESS: So I see the text that

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you're pointing to. Lines 4 through 9.

I would have to know more context about Dr. Katona's position to understand what blends he's referring to and what the full scope is of what he's saying.

I unfortunately can't offer an opinion just based on one response from Dr. Katona about what he's thinking and what his opinion is.

BY MS. ZHONG:

Q. So is it a position that lithium quinolate and electron transport layer is necessarily acting as an n-dopant?

MR. LEE: Objection. Outside the scope. Objection. Misstates testimony.

THE WITNESS: So in looking at lithium quinolate in electron transport layer, based on what I've reported on in my declaration and my reply declaration, I am using support from the literature to support the usage of Liq has an n-dopant in a variety of ETLs, that's what I can be confident in -- in offering as my opinion.

In terms of the more general questions that are being considered here,

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again, I'd have to better understand the full scope of what's going on.

BY MS. ZHONG:

Q. Is lithium quinolate in electron transport layer necessarily an n-dopant?

MR. LEE: Objection. Asked and answered. Objection. Beyond the scope.

THE WITNESS: Lithium quinolate, as I've described in my declaration and reply declaration, can be used as an n-dopant and have shown that it's an n-dopant in variety of electron-transport material.

Lithium quinolate could be also be used as an electron transport layer itself, in which case, it clearly wouldn't be an n-dopant, it would be the ETL.

BY MS. ZHONG:

Q. Okay. So if lithium quinolate is blended with another organic material that can act as an electron transport layer, is lithium quinolate necessarily an n-dopant?

MR. LEE: Objection. Outside the scope. Objection. Form.

THE WITNESS: What I've emphasized and what I've said and in my declaration,

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reply declaration is that I'm relying on the prior art that clearly shows Liq has a dopant in several electron transport materials.

BY MS. ZHONG:

Q. So if lithium quinolate is a major phase, is that still a dopant?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. So if lithium quinolate is a major phase of the planned, is that still a dopant?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: So I didn't, in my declaration or reply declaration, have to form an opinion on whether there's an upper limit of where Liq is no longer a dopant in a given material.

Of course, in neat film, it's no longer a dopant, it's the electron-transport material. I suspect there could be some upper limit but it is not something that I had to draw a specific opinion on.

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BY MS. ZHONG:

Q. Okay. Why don't we take a look at Exhibit 1049, the Endo paper.

A. Okay.

Q. Sorry. I think it might be the Choi paper -- yeah, Choi paper, Exhibit 1050, actually.

A. Okay.

Q. And do you see that he has plans ranging from 3, 2, 1 electron transport layer to lithium Q to 1, 2, 3 or 1, 2, 5 electron transport layer to three parts of lithium quinolate or five parts of lithium quinolate?

MR. LEE: Misstates the document.

BY MS. ZHONG:

Q. Do you see the --

A. Is there a particular figure you're pointing to?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Figures 3. Figure 3.

A. Yes, I see Figure 3 and I see the date as a function of concentration of Liq in the ETL.

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Q. Okay. So for -- when ETL to lithium quinolate, when ETL seems to be the minor component, is lithium quinolate still a dopant?

MR. LEE: Objection. Outside the scope. Misstates the document.

THE WITNESS: So, again, I think what I answered already was that I -- I wasn't asked or I didn't have to take an opinion on where the upper limit might be for Liq or any other dopant, for that matter, when it ceases to be a dopant.

Certainly in neat film, it's not a dopant anymore but I didn't form an opinion on what that threshold might be for different dopants.

BY MS. ZHONG:

Q. So if the plan is 80 percent lithium quinolate, 20 percent ETL, you still consider lithium quinolate to be a dopant?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So, again, that's not what I said. What I said was that I didn't establish a firm upper limit on when a particular dopant would stop being a

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dopant.

BY MS. ZHONG:

Q. And I'm asking for a specific composition.

MR. LEE: Objection.

BY MS. ZHONG:

Q. 80 percent, 80 percent is similar quinolate. 20 percent ETL, is that -- is lithium quinolate acting as a dopant?

A. So I think I already answered that, that I didn't form an opinion on what the upper limit would be on when Liq is a dopant and when it's not a dopant.

Q. What is a "dopant"?

A. So a dopant in the context of -- again, if you can go back to my first declaration, is a material that's added to an electron transport layer that increases the conductivity.

Q. So the electron transport layer can be 1 percent of the material and 99 percent the material can be the dopant that's added to it?

MR. LEE: Objection. Misstates the testimony.

THE WITNESS: Again, that's not what

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I said. What I said is that I did not form an opinion on what the upper limit is for a particular combination of the dopant and the ETL, and in this case, the Alq and -- and Alq. And so that's not something that I drew an opinion on in my reply or in my initial declaration, and so I'm -- I'm hesitant to establish an opinion right now.

BY MS. ZHONG:

Q. So I'm asking you the question. So if you have a composition that's 65 percent lithium quinolate, 35 percent of the electron transport layer, is lithium quinolate an n-dopant or not? Or you have not formed an opinion?

MR. LEE: Objection. Beyond the scope.

THE WITNESS: I think I've answered that several times for different hypothetical compositions that you've offered.

But in my declaration, in my reply declaration, I haven't taken an opinion on what the upper limit would be for -- for doping.

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I obviously acknowledge that Liq, too, can be used in a neat film, in which case, it's obviously no longer a dopant but I -- I didn't specify a particular concentration at which one goes from doping to non-doping with -- with Liq.

It's not something that I had to do to form my opinions.

BY MS. ZHONG:

Q. So I'm asking very specific composition and I need to have an answer.

65 percent by weight is quinolate, 35 percent electron transport layer is lithium quinolate acting as a n-dopant?

A. Again --

MR. LEE: Objection. Outside the scope. Asked and answered and argumentative. He's provided an answer, Counsel.

MS. ZHONG: Do you want to make additional speaking objections?

MR. LEE: That was not a speaking objection.

MS. ZHONG: You may want to consult your co-counsel.

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BY MS. ZHONG:

Q. Dr. Homes, please answer the question.

A. I'm happy to answer --

MR. LEE: Same objections.

THE WITNESS: I'm happy to answer the question again.

Where Liq is no longer n-dopant, if there's a concentration that's a critical point where one would no longer consider it a dopant is not something that I formed an opinion on in my declaration or reply declaration.

It is not something that I had to form an opinion on because the prior art characterizes Liq as an N -- dopant. And so --

(The Court Reporter requested clarification.)

THE WITNESS: Prior art characterizes Liq as a dopant. And so in the combinations that I'm making between Ma and Suzuki or Ma and Diekmann, the prior art supports the use of Liq as a dopant, and that's on which I'm basing my opinion

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and building those combinations.

And so, again, I didn't have to take a position on an upper limit for when Liq would no longer be a dopant. And, again, I'm not going to form a new opinion here on something that I haven't already considered and thought carefully about.

BY MS. ZHONG:

Q. So you have not -- for the specific composition I provided, you do not have an opinion as to whether for that specific composition lithium quinolate is serving as a dopant or not; is that correct?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: Again, I have not formed an opinion in my declaration or reply declaration on where there's an upper limit for when Liq may no longer be a dopant in an ETL.

BY MS. ZHONG:

Q. For a 1-to-1 mixture by weight of ETL to lithium quinolate, do you have an opinion as to whether lithium quinolate serves as a dopant in that context?

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MR. LEE: Objection. Outside the scope. Form.

THE WITNESS: So what I'll consider, and the way I built my opinion and considered the prior art, is in looking at, for example, the prior art, you know, looking at whether it's Ma, for example, or Endo, you know, 1-to-1, there is still referred to as doping.

And so depending on the system, depending on the data, there could be other things for other systems that need to be considered, but certainly, Ma and Endo would categorize that as doping.

BY MS. ZHONG:

Q. Is that how you would characterize it?

A. Again, from my perspective, as I've already noted, I'm basing my opinion on the prior art. And so I am looking at the prior art and assessing the community's interpretation of Liq as a n-dopant for the ETL.

And so the question of, again, specific concentrations that are being applied,

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didn't impact my opinion in that regard.

Q. So in your opinion, lithium quinolate can be the major phase and still be a dopant; is that correct?

MR. LEE: Objection. Misstates the testimony. Outside the scope. Incomplete hypothetical.

THE WITNESS: So I have not said that. What I've said is that Liq, based on the prior art, can be an n-dopant in the ETL of an OLED.

And that, in forming my opinions, in writing my declaration and reply declaration, I did not take a position on a specific concentration that would be, say, an upper limit or when a material may or may not cease to be a dopant.

BY MS. ZHONG:

Q. Do you typically call something that's, like, 65 percent of the composition a dopant?

MR. LEE: Objection. Form. Outside the scope. Relevance.

THE WITNESS: So when you say "typically," can you refer me to what

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you're referring to? Because the word "dopant" can mean a lot of different things.

BY MS. ZHONG:

Q. So outside this litigation, have you ever described a mixture of material -- strike that.

So outside the context of this litigation, have you ever used dopant to describe a material that's 65 percent of the blend?

A. So --

MR. LEE: Objection. Was that the complete question? Because I'm going to lodge my objection as outside the scope. Lack of relevance.

THE WITNESS: So in a mixture of materials, in preparing a mixture of materials, one can refer to co-doping, for example, a mixture of materials.

BY MS. ZHONG:

Q. So both components are dopants?

MR. LEE: Objection. Misstates testimony. Outside the scope. Relevance.

THE WITNESS: So I just want to make

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sure I'm clear on if this is referring to a particular part of my reply declaration so that I can make sure that I'm commenting on the correct aspect of what you're looking for.

BY MS. ZHONG:

Q. I'm so glad you picked up the hint from your counsel.

A. I'm sorry, can you just repeat?

Q. I said, I'm so glad you picked up a hint from your counsel.

A. I see.

Q. So for the -- you mentioned that outside the litigation, when you are referring to a mixture, you call them co-doping.

So my question to you is. If you have materials A and B mixed together, are you referring to both components as dopants?

MR. LEE: Objection. Misstates the testimony. Outside the scope. Relevance.

THE WITNESS: What I said previously was that, in some instances, when one creates a mixture of two materials, the action of creating that mixture can be co-doping.

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BY MS. ZHONG:

Q. Are both materials considered dopants, then?

A. I don't think --

MR. LEE: Beyond the scope.

THE WITNESS: I don't think for the purposes of this particular proceeding I had to consider questions of doping and terminology for doping.

My opinion is formed based on the fact that when specifically consider n-doping of the electron transport layer, there's ample support in the prior art for Liq to serve as an n-dopant in the electron transport layer.

And so questions related to upper limit for concentration, whether something's called a dopant versus something else, didn't come into forming my opinion.

BY MS. ZHONG:

Q. Okay. You seem to be avoiding my question.

So my question to you, when you say "co-doping," is that referring to mixing A and

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B together?

MR. LEE: Objection. Argumentative. Outside the scope. Relevance.

THE WITNESS: So what I mentioned earlier, and I'll just restate, is that the practice of including two materials in a mixture can sometimes be referred to as co-doping.

BY MS. ZHONG:

Q. Okay. And so do you consider both A and -- the material A and the material B in the mixture to be dopants, then?

MR. LEE: Objection. Outside the scope. Relevance. Asked and answered.

THE WITNESS: Again, I would have to know more about the specifics of the situation that we're describing in order to comment any further on this hypothetical.

BY MS. ZHONG:

Q. So can you give me an example where you are referring to mixing A and B together as co-doping?

A. I don't have --

MR. LEE: Outside the scope. Relevance.

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THE WITNESS: I don't have an example off the top of my head regarding co-doping. That's not something that I thought about in the context of the '425 IPR. And so it's not something that I have an immediate example off the top of my had head. I'd have to think more about that and find appropriate literature.

THE COURT REPORTER: Is it possible to take a break?

MS. ZHONG: Sure.

(A recess was taken.)

BY MS. ZHONG:

Q. Dr. Holmes, simply because lithium quinolate is used in an electron transport layer doesn't mean that it will be used as an n-dopant; is that correct?

A. So I'll interpret your question to mean that is Liq necessarily an n-dopant? I suspect there's instances where it may not be.

Q. So the mere presence of lithium quinolate in the electron transport layer doesn't mean lithium quinolate is being used as an n-dopant. It can be used as a matrix

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material or host material; is that correct?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So, again, I -- those terms I haven't had to consider in the context of the '425.

I have based my testimony on where Liq is explicitly used as an n-dopant in the prior art, and that's how I've supported my combinations that I've described in my declaration.

BY MS. ZHONG:

Q. Can you answer the question that I posed, which is, the mere presence of lithium quinolate in the electron transport layer doesn't mean lithium quinolate is being used as an n-dopant; is that correct?

MR. LEE: Objection. Form. Outside the scope. Asked and answered.

THE WITNESS: So I've noted before that Liq can be used as an electron-transport material in its own right, in which case, it wouldn't be a dopant.

And I've commented already that my

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opinion is based on the fact that Liq has been previously used as an n-dopant in a variety of electron transport materials.

Whether there's some threshold for when it may or may not be a dopant, that's not something that I've taken a position on and not something that I've had to have to inform my opinion.

BY MS. ZHONG:

Q. Can you please take a look at Exhibit 1050, the Choi paper?

A. Yes.

Q. And can you please go to Figure 2?

A. Yes, I see Figure 2.

Q. In Figure 2, the box on the left-hand side, do you see there is a solid box with dash lines in there?

A. Yes, I see the box.

Q. What does the presentation -- representation mean?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So in Figure 2, let me just make sure there isn't something more specific in Choi. Give me a one moment to

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read the text associated with Figure 2.

So Figure 2 is described by Choi, on the first page of the paper, it is just an energy-level diagram for part of the OLED that they are considering in their work and the solid box would represent presumably the HOMO-LUMO levels of an ETL, although they are not labeled explicitly; so it's not obvious what material they're referring to, but they would refer to an ETL.

BY MS. ZHONG:

Q. Okay. What's a dashed box? What -- what -- what are the dashed lines?

A. So the dashed lines in Figure 2, by virtue of the fact that they are labeled and that Liq is being noted as related to those dashed lines, would presumably be the HOMO-LUMO level of Liq.

Q. So why the HOMO-LUMO for lithium quinolate illustrated as dashed lines within the box rather than as a solid box itself?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: So -- well, again, I don't know why Choi, for example, did that.

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But it might just indicate that there's two materials in that layer, for example.

BY MS. ZHONG:

Q. Does that indicate one is a dopant, the other is a matrix material?

A. No.

MR. LEE: Objection. Same objections.

THE WITNESS: I don't think that specifies anything about the composition of the -- of the layer.

BY MS. ZHONG:

Q. Can you pull up Exhibit 1054, the second Schwartz paper?

(Exhibit 1054 was identified.)

THE WITNESS: Yeah, I just have to download it. Yes, I have it.

BY MS. ZHONG:

Q. Does this paper mention the lithium quinolate or lithium-quinolate complex in any way?

A. I'm just going to quickly skim the paper to make sure I answer the lithium complex part of your question correctly.

I don't think this -- this paper

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does not mention lithium quinolate and I don't think this paper mentions lithium complexes.

Q. Okay. This is an academic paper, correct?

A. Yes. This is from an academic group.

Q. Can you go to the figure in the experiment section on page 2, Figure 1?

A. Yes, I'm looking at Figure 1.

Q. Do you see the energy diagram on the lower left-hand corner?

A. Yes, I see the energy diagram.

Q. Okay. Do you see the Novaled HTL system?

A. I see the box labeled "Novaled HTL."

Q. And Novaled HTL system would be Novaled's proprietary system?

A. That would be my presumption.

Q. Okay. But it's available to the academic institute, like, like a based group, research group, right?

A. That's an important distinction because this -- this group worked closely with Novaled. So just because it's available to this group would not mean it would be widely

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available.

Q. Did you attempt to get Novaled's material?

A. At any point in my career, is that what you're asking?

Q. Around that time, yeah.

A. No, I've never attempted to get Novaled's material.

Q. Not at any point in your career?

A. No. In general, I prefer not to use proprietary systems because when you do use them, it makes it more challenging to understand specifically why the device might be getting better or -- or worse.

Q. Do you know whether the material is available to industrial groups?

A. I don't know the specific availability of Novaled's HTL material.

Q. Do you know the academic groups that's working with Novaled at the time?

A. So are you --

MR. LEE: Beyond the scope. Relevance.

THE WITNESS: So I just want to make sure I'm clear, are you -- are you asking,

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did I know any of these researchers at the time?

BY MS. ZHONG:

Q. No. I'm just asking you: Do you know how many academic research groups Novaled was collaborating at the time?

MR. LEE: Objection. Outside the scope and relevance.

THE WITNESS: No, I don't. It's just that Novaled was basically a company that had come out of this group, the technology came from this group. And so that's why I know they were working together. I don't know the breadth of the full collaboration, scope.

BY MS. ZHONG:

Q. Okay. And did you know anyone who trying to get Novaled's system -- strike that.

Do you know of any academic groups who attempted to get access to Novaled's proprietary materials and got turned down?

A. I don't know of a specific academic group who's tried to get Novaled material and turned down. But if that were to be occur, I probably wouldn't be made aware of it.

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Q. Okay. Do you see that there are several materials where you have material A column, material B? Do you see that, for example -- an example is NBP, column Ir(MDQ)2(acac)?

MR. LEE: Objection. Form.

THE WITNESS: You're referring to the labels in the energy diagram in Figure 1?

BY MS. ZHONG:

Q. Yes.

A. I see the -- the -- yes, I see that usage, yeah.

Q. And what is a does a colon signify?

A. What the use of the colon, what does that signify?

Q. Yes.

A. Usually if it's a -- a mixture of multiple materials, there would be a colon or maybe a dash between the two materials to indicate that there two materials are present in the layer.

Q. And does it like -- what's the material before the colon?

MR. LEE: Objection. Outside of the

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scope.

THE WITNESS: Again, it depends on the situation, you know, the -- if I look at TCTA-TPBi, you know, those two materials are -- are both probably there in similar quantities. And so it doesn't necessarily imply -- imply a composition per se.

BY MS. ZHONG:

Q. Uh-huh.

What about for the iridium one?

A. Which iridium one?

Q. The two iridium ones.

A. So in -- in both of those films, iridium complex is the emitter.

Q. So they're dopants?

A. They're certainly the emissive dopant.

Q. Okay. You would not consider them to be the host materials, would you?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: So in these situations, I'd have to better understand what the -- what the specifics are to make that kind of assessment. It's not the

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something that I have to think about in context of -- of this work.

Certainly, the iridium complexes would be the emitter and -- and they are included in that layer as an emissive dopant.

BY MS. ZHONG:

Q. Have you ever referred to an emitter as a host material?

MR. LEE: Objection. Outside the scope. Relevance.

BY MS. ZHONG:

Q. In your academic work, that is?

MR. LEE: Same objections.

THE WITNESS: I'd -- I'd have to go back and look at my publications as if I've actually referred to -- yeah, how I've referred to emitters before. It's quite possible I have but it's -- it's not something that I -- I thought about in preparation for these proceedings or in preparing my declaration or reply declaration.

BY MS. ZHONG:

Q. Can you give an example where you

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actually -- you have cited several papers, your own papers, correct, in this proceeding?

MR. LEE: Objection.

THE WITNESS: I've cited one of my papers as an exhibit in this proceeding.

BY MS. ZHONG:

Q. Did you refer to the emitter as the host material or -- in that paper?

MR. LEE: Objection. Beyond the scope. Relevance.

THE WITNESS: I haven't reviewed that paper in a while, but I can do so right now and make sure I answer correctly your question. Just have to find that exhibit.

Is that exhibit on Exhibit Share even? I don't see it. But I might be missing something.

BY MS. ZHONG:

Q. Do you have the Dropbox? That should have the full exhibit.

A. Oh, yes. I can open the Dropbox.

Again, I haven't looked at that exhibit. Do you know what the exhibit number is?

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Q. You can take a look at your -- your reply declaration pages 2 through 4.

A. Oh, right. Right.

Actually, I don't think I have cited my work in --

Q. In this proceeding?

A. Yeah, I'm thinking about the '164 IPR proceeding.

Q. Okay.

So do you recall any instance where any of the papers you cited refers to the -- refers -- strike that.

Do you recall any of the papers that you have reviewed or cited in this proceeding, labels the emitter material as the host material?

MR. LEE: Outside the scope. Relevance.

THE WITNESS: So I -- it's not something that I had to consider in my declaration, or reply declaration. I'd have to go back through the exhibits to see if there's any instance where that occurs. I don't have an example off the top of my head right now.

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BY MS. ZHONG:

Q. You have recently found Zheng paper, correct, Exhibit 1052?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. You have recently found the Zheng paper, Z-h-e-n-g, Exhibit 1052.

A. Yes, I reference the Zheng paper.

Q. In the Zheng paper, lithium quinolate is used as an injection layer, correct?

A. If you give me one second, I just want to make sure that I have it open.

Thank you.

Yes, in the Zheng paper, they're looking at comparing the performance of lithium fluoride and lithium quinolate as an injection layer.

Q. That is the same as in the Liu paper, Exhibit 1018, correct?

(Exhibit 1018 was identified.)

MR. LEE: Objection. Form.

THE WITNESS: Just in terms of what you mean "that is the same," can you

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clarify more specifically with what you're comparing?

BY MS. ZHONG:

Q. In the Liu paper, lithium quinolate is also used as an electron injection layer, correct?

A. Yes. I'm just going to open the paper. Yes, in the Liu paper as well, lithium quinolate is being applied as a electron injection layer.

Q. And so do you consider the Zheng paper to be duplicative or cumulative -- not duplicative.

Is the Zheng paper accumulative of the information contained in the Liu paper?

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

THE WITNESS: I'm happy to compare those two exhibits. Can you just tell me what you mean by "duplicative" or "cumulative"? I'm not familiar with the weight of those terms.

BY MS. ZHONG:

Q. Does Zheng teach anything beyond what Liu does for the purpose of your

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declaration?

A. I just want to review, review for a moment here.

So Zheng offers further support for the similar use of Liq and LiF, basically, again pointing to how the community views these two materials and used these two materials.

And Zheng also echoes some aspects of Liu in terms of the advantages of Liq as well.

Q. Does Zheng teach you anything that Liu doesn't?

A. So to answer that, I want to just take a quick look at my reply declaration.

So in comparing Liu and Zheng, I think they're supporting a similar application of Liq and LiF. They offer slightly different perspectives on a slightly different hypotheses on how Liq and LiF operate, but in both cases, they support the conclusion that these materials are very similar in how they are used and ultimately how they would be expected to behave as materials and OLEDs.

Q. Okay. And do you see in Zheng, how they compared the performance of the devices

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made with aluminum Q3 electron transport layer versus to pure organic electron transport layer, DPVBi and MEH-PPV?

A. Is there a figure you're referring to specifically? So Figure 3?

Q. There's Figure 3 and compared to Figure 2, I believe. Yes -- Figure 1.

A. I see that they're examining several different systems, yes.

Q. And for the two pure organic electron transport layers, the turn-on voltage did not drop significantly compared to the undoped layer; is that correct?

MR. LEE: Objection. Form.

THE WITNESS: When you're referring to the two pure electron transport layers, you're referring to Figure 3?

BY MS. ZHONG:

Q. Yes, to pure organic electron transport layers in the MEH-PPV?

A. So -- so I'll just note that -- I'll just note that DPVBi --

Q. Mm-hmm.

A. -- and MEH-PPV are not really electron transport layers. They can carry

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electrons but they are not generally regarded as good electron transport layers in the same way that maybe Alq might be.

These materials are being selected for this particular study to just show some diversity of application across different emitters and also in the case of MEH-PPV, solution-process polymer devices as well.

And so the way I would read this data is that Liq and LiF lead to a reduction in turn-on voltage across all systems, whether it's Alq in Figure 1 or these other perhaps less optimized devices in Figure 3.

Q. In the case of the two materials shown in Figure 3, the turn-on voltage only drops slightly, correct? Turn-on voltage?

(The Court Reporter requested clarification.)

MR. LEE: Objection. Form. Objection. Outside the scope.

THE WITNESS: So in Figure 3, the turn-on voltage does get smaller -- is improved in both cases with the electron injection layer. It's challenging to know what the precise turn-on voltage is, of

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course, just because the data is not plotted logarithmically. And so, you know, the current density data is linear and so the turn on is going to be buried somewhere in that -- that very low current regime of behavior.

So it's clear, looking at the forward current, that the device is improved, but in terms of the specifics of the turn-on voltage, that's -- that's perhaps harder to assess.

Looking at the inset luminance current density behavior, it's clear that there's a substantial improvement in luminance from the device regardless of which injection layer is used.

BY MS. ZHONG:

Q. Given the large turn-on voltage, is light emitted through electroluminescence or some other mechanisms may be going on as well?

MR. LEE: Objection to form. Misstates the document.

THE WITNESS: So I'll first just restate what I said before, which is that, it's actually, you characterize turn-on

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voltage as large, that's not actually straightforward to assess from Figure 3 because you don't have the data plotted logarithmically.

And so I wouldn't necessarily characterize the turn-on voltage as -- as "large" per se. But I have absolute certainty that the emission from this device is electroluminescence.

BY MS. ZHONG:

Q. Because what?

A. Pardon me?

Q. What's the basis?

A. Well, that's a -- as a person skilled in the art, I understand how an OLED works, I understand how an OLED looks and I don't see a competing mechanism that would be capable of giving so much luminance out of these devices and so the -- and the literature is pretty clear that in such structures, you have electroluminescence exciton recombination as to mechanism for light- --

(The Court Reporter requested clarification.)

THE WITNESS: Sorry.

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In -- in such -- I don't know where you want me to start.

In such structures, you have exciton, e-x-c-i-t-o-n recombination as to your source of luminescence and so you have electroluminescence here.

Let me look more closely at Zheng to see if there's additional evidence for that, but that's not something that certainly I would have thought would be in question in looking at -- at Zheng, but let me have a quite look to see if I can provide additional support for that.

Yeah, so the further support that I'd offer is that in the conclusion, the authors do clearly note that Liq is also very effective, to be used as an electron injection layer for DPVBi based blue OLED and MEH-PPV base orange polymer OLED, those are the corresponding emission colors of those materials that were well-known at the time of this paper.

And so, again, that would -- that would lead the reader to believe that this is, in fact, operating as one would expect,

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which is the electrons are in holes, are being injected, excitons are being formed and those excitons are recombining to give you the characteristic light emission of the emissive material, either DPVBi or MEH-PPV.

So I don't have any concern about there being some other process active here.

BY MS. ZHONG:

Q. So is DPVBi the -- actually the emission layer?

A. So in these devices, DPVBi, the device is very simple, it's only indium tin oxide, TPD, DPVBi and then the DIL cathode structure, and so DPVBi is the emission layer and the structure is the -- is the emissive material in these structures.

BY MS. ZHONG:

Q. So there is no electron transport layer?

A. Well, so DPVBi is playing the role as well as the electron-transport material. It has to because electrons need to get into the device.

Q. So the electron is injected directly

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into the device, right, through the lithium fluoride or lithium quinolate layer?

MR. LEE: Objection.

THE WITNESS: So electrons are being injected from the cathode into the device and -- and having to travel through DPVBi.

BY MS. ZHONG:

Q. So TPD is a hole-transport material, right?

A. Yes. TPD is a hole-transport material and this device serving as the hole-transport layer.

Q. So the holes enter into the DPVBi layers through TPD?

A. So my -- again, I don't have an energy diagram here but yes, my assumption would be that holes from TPD are entering DPVBi to form excitons.

Q. Okay. And electrons are entering through DPVBi, so --

(The Court Reporter requested clarification.)

THE WITNESS: So -- yeah, I'll just restate simply.

So holes are traveling through TPD,

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electrons would be traveling through DPVBi and then excitons are forming in DPVBi to recombine them as light.

BY MS. ZHONG:

Q. And is that the same for the device containing MEH-PPV?

A. Yes, similar. So in the device containing MEH-PPV, MEH-PPV is the light-emitting material and it has to also be able to transport electrons as well.

And so you would have holes being injected from PEDOT into MEH-PPV and excitons formed in MEH-PPV so that they can recombine and emit light.

In this context, PEDOT actually is P-E-D-O-T.

Q. Sorry.

Do you know the bulking level for cesium and barium?

MR. LEE: Objection. Form.

THE WITNESS: Is there a particular reference you want to point me to to answer that question?

BY MS. ZHONG:

Q. Based on your experience, what's a

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doping level when you use cesium or barium as an n-dopant?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: So I haven't previously used cesium or barium as a n-dopant, so I don't think I have a reference point to -- to provide there from my own work.

BY MS. ZHONG:

Q. What about for lithium?

MR. LEE: Same objections.

THE WITNESS: I don't think I've used lithium as a dopant in my prior work either but I'd have to recheck my -- my publication record.

BY MS. ZHONG:

Q. Have you ever used an n-dopant electron-transport material before?

MR. LEE: Objection. Form.

THE WITNESS: Just in any of my prior work?

BY MS. ZHONG:

Q. Correct.

A. I'd have to think carefully about

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various publications I've been involved in. I don't think I've published on n-doping explicitly in the ETL, but I'd have to go back and look more carefully at some of my older publications but I certainly haven't recently.

Q. Now, I understand that you only cited two pre-2008 paper on using lithium quinolate as a dopant in -- strike that.

You have only cited two pre-2008 paper in which lithium quinolate is used -- is mixed as an electron-transport material for the electron transport layer.

Are these the only two papers you came across?

MR. LEE: Objection. Form. Misstates testimony.

THE WITNESS: So I, as I mentioned earlier, yes, there's two papers that I'm referencing, Endo, et al. and Ma, et al., that use Liq as an explicit dopant for n-doping in ETL.

Those are the only two that I included. I didn't see the need to look for any additional support of the opinion that I came to.

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BY MS. ZHONG:

Q. Okay. Did you manage to locate any other ones that you just -- that you did not cite?

A. I don't think there's -- if memory serves me, any other publications that I -- I didn't cite but, again, I didn't look exhaustively because I felt like Ma, then subsequently Endo, supported the position that I had to take in this respect in my opinion. I think my opinion was substantiated by those -- those references already.

Q. Okay. And those papers are six years apart?

A. Yes, 2002, 2008, those two papers are six years apart, I would agree with that.

Q. Is there a charge transfer file from one LUMO to another?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: What do you mean by "it"?

BY MS. ZHONG:

Q. I don't think I said "it." Is there a charge transfer, not file transfer, is there

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charge transfer from the LUMO of one material to the LUMO of another material?

A. Okay. I heard you say, "Is 'it' charge transfer," so you're -- can you just restate your question again?

Q. Is there charge transfer from a LUMO of one material to the LUMO of another material?

MR. LEE: Objection. Form.

THE WITNESS: So again, what materials are we talking about specifically?

BY MS. ZHONG:

Q. ETL and lithium quinolate, for example.

A. Can you specify a particular ETL? Like, can it -- whether or not there's charge transfer between any two materials will depend on the LUMO alignment.

Q. The ETL in Diekmann?

A. Okay. So I didn't have to take an opinion in terms of whether or not there's charge transfer between the ETL of Diekmann and Liq.

You know, looking at the preferred

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dopants of Diekmann, Diekmann implies that there's electron donation from cesium, barium and lithium fluoride to the electron transporter. Not being specific about which combination, for example, they are looking at. But --

Q. Mm-hmm.

A. -- in Diekmann, it's implied there's some charge transfer for some of the dopants.

Q. Okay. And cesium has a relatively low, either you call HOMO or whatever the -- ionization potential where the -- where electrons can be removed and injected into the LUMO of the electron transport layer, correct?

MR. LEE: Objection. Form.

THE WITNESS: Cesium has a low work function which is what allows electrons to potentially be injected into the LUMO of electron-transport material.

BY MS. ZHONG:

Q. Lithium quinolate does not have a comparable HOMO level, correct?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So, again, there's --

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first of all, cesium doesn't have a HOMO level either. Cesium has a work function, and so the -- the terminology of using HOMO-LUMO for cesium isn't -- doesn't work.

Lithium quinolate, as we've used discussed already in the context of Choudhury and lithium fluoride would be an in situ dopant which would mean that it's an initial HOMO and LUMO would not be representative of any charge transfer process if there was one.

You'd be looking at the eventual reaction with -- with lithium as is described in Choudhury.

BY MS. ZHONG:

Q. But you don't know what the reaction product is when the electron-transport material is not -- is neither -- is not aluminum Q3, correct?

MR. LEE: Objection. Misstates testimony.

THE WITNESS: What I've said before is that I don't have a specific reaction for every ETL combined with Liq or LiF. But the prior art supports that Liq will be

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an n-dopant in other ETLs like BPhen, like Alq.

BY MS. ZHONG:

Q. Did you say Liq or Alq?

A. That it would be a dopant in BPhen or Alq. The Liq would be a dopant in BPhen or Alq.

Q. So your position now is that lithium quinolate will necessarily be an n-dopant in other ETLs; is that correct?

MR. LEE: Objection. Misstates testimony.

THE WITNESS: Can you please restate the question? I wasn't clear if you said "will" or "won't."

BY MS. ZHONG:

Q. Is it now your position that lithium quinolate will necessarily be an n-dopant when it is mixed into an ETL material?

MR. LEE: Objection. Outside the scope. Asked and answered.

THE WITNESS: So my position is that there's support in the prior literature for Liq being a dopant in several ETLs and that a person skilled in the art would then see

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that Liq is an n-dopant that offers functionality. An OLED would have motivation to combine that with Diekmann with an expectation of success.

BY MS. ZHONG:

Q. And what makes you believe that when lithium quinolate mixed -- is mixed with Diekmann's L -- strike that.

What makes you believe that when lithium quinolate is mixed with Diekmann's electron transport layer, it will serve as an n-dopant?

A. Well, so one of Diekmann's electron transport layers is Alq and so there's the opportunity in combining Ma and Diekmann to use Liq in Alq of which there is support for n-doping.

And then second to that, there's prior work at the time, primarily, again, by He and Pfeiffer and others, that show that there's many other suitable ETLs as well.

So Diekmann only lists three, but a person skilled in the art would understand that there's other ETLs that certainly would work as well.

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Q. Okay.

A. So I think that there's plenty of flexibility there for a person skilled in the art to use Liq and Diekmann with an expectation of success.

Q. Did you cite a document where Alq3 is use as electron transport layer in connection with a phosphorescent OLED?

A. Let me just consult my exhibits so I can answer that. Just give me a moment here.

Yes, I have two exhibits on record --

Q. Okay.

A. -- that are phosphorescent and OLEDS that utilize Alq as an electron transport layer.

Q. Which exhibits?

A. 1013 and 1014.

Q. The Baldo one?

A. They are both Baldo references.

Q. Are they for white light emitting?

A. No, you had asked me about a phosphorescent OLED. One that's in the red and one that's in the green.

Q. What about for white light emission?

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(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. What about for white light emission as in Diekmann?

MR. LEE: Object to form.

THE WITNESS: Just so I'm clear, you're asking, do any of the exhibits I have cited use Alq in a white OLED?

BY MS. ZHONG:

Q. Correct. Including -- and including a PHOLED.

A. Right, I'm going to have to look at my exhibits again.

So I reference only two -- only two of my exhibits pertain to white light-emitting devices that also contain the phosphorescent --

Q. Mm-hmm.

A. -- emitters and neither of them use Alq.

Q. Okay. And is the phosphorescence system in the Baldo one, the same as in Diekmann or Suzuki?

MR. LEE: Objection. Form.

THE WITNESS: Can you be more

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specific about what about Baldo you're comparing to Diekmann or Suzuki?

BY MS. ZHONG:

Q. Is it the same PHOLED system?

A. So I have to reconsult Diekmann and Suzuki to answer that. Just give me one moment.

Q. And are all the other -- the organic phosphorescent (indecipherable)?

(The Court Reporter requested clarification.)

THE WITNESS: So Suzuki does list the phosphorescent emitter used in both of those Baldo papers as possible emitters in their work as well.

I need to look at Diekmann to see if that's the same.

Diekmann lists the emitter in the -- I think in the second Baldo paper, I mentioned as an emitter in their structure as well. So iridium, tris iridium phenylene is listed in both patents as an emitter and platinum octaethylporphyrin is listed in Suzuki.

(The Court Reporter requested

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clarification.)

THE WITNESS: Sorry. How about we'll just call it Ir(ppy), i-r-p-p-y, let's do that.

Ir(ppy) is listed as an emitter in both Diekmann and Suzuki and that's the emitter used in the second Baldo paper. And platinum octaethylporphyrin is listed as an emitter in Suzuki, so PtOEP and that's the emitter used in the first Baldo paper.

BY MS. ZHONG:

Q. Does the Baldo paper use the same stack structure as Diekmann?

A. So the Baldo paper is not an n-doped ETL and so it's not an identical stack to Diekmann's Figure 2 because Diekmann's Figure 2 has an n-doped ETL.

Q. Okay. So other than the n-doped, the ETL, does Baldo have the same material set as in Diekmann or the structure as in Diekmann?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So again, Diekmann, it's -- I would say it's similar, you know,

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Diekmann's device is configured or with an intent to make white light; Baldo's device is green light-emitting device, and so there's obviously differences in architecture.

BY MS. ZHONG:

Q. What about the organic materials, like the hole-transport layers?

A. So in my opinion, Diekmann is very open as to what can be used as its various transport materials, so I think that the layers included in Baldo could potentially be applied in Diekmann, it would just depend on the specific architecture, but this is increasingly hypothetical in terms of trying to match materials up.

Q. Well, paragraph 104 of your opening declaration, you are referencing a very specific structure in Diekmann, correct? In the material set?

MR. LEE: Objection. Outside the scope.

THE WITNESS: Yeah, let me just refer back to my declaration.

So what was the paragraph you'd like

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me to look at in my original declaration?

BY MS. ZHONG:

Q. Paragraphs 104 and paragraph 105.

A. Let me just reread them.

Q. And feel free to consult Diekmann page 91 that is cited.

A. Again, in my original declaration, what I'm commenting on there is specifically the emissive layer, the emissive layer is the device, right, the structure of the three layers Diekmann is using or one example of Diekmann could use to emit white light, I'm not actually specifying a particular hole-transport layer there in my declaration.

Q. So is it your testimony that you're not relying on the specific structure disclosed on page 91 of Diekmann?

MR. LEE: Objection. Misstates testimony.

THE WITNESS: No, that's not my testimony. In regards to Diekmann, that structure would absolutely be an acceptable version of the device provided that the structure is finished with a hole-blocking layer, which is noted in Figure 2 and

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Liq-doped ETL layer.

So the description of Diekmann on -- in paragraph 91 is only half of a device. They don't offer the electron-transporting side of the structure, but, no, the HIL and HTL there would be -- would be certainly what I'd be using as the example for Diekmann.

BY MS. ZHONG:

Q. Well, why don't you take a look at the part that it actually -- Diekmann page 91 that is cited -- that paragraph 104 and 154 are based on.

A. All right. So is there -- I have -- is there a particular aspect that isn't consistent with what I just said?

Q. Well, so 91 --

A. Yes.

So the first two --

Q. It mentions an organic layer stack 4 with the following layers starting from the cathode layer.

A. So, right, if you read all of that paragraph, first of all, they're clearly starting from the anode layer and so that

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cathode I'm interpreting must be anode because they are talking about the hole transporting side of the device.

Q. Mm-hmm.

A. So they talk about TNATA and spiro-TAD, which are going to transport holes. They talk about three emissive layers, which will generate white light; and then they do not specify explicitly the blocking layer and n-doped ETL.

So what I said a few moments ago was the structure listed in that paragraph is completely acceptable, one would just have to complete the structure explicitly so that it matches Figure 2 with the blocking layer and n-doped ETL and a cathode.

Q. Okay. So this one does specify what the hole injection and hole-transport layer needs to be, right?

A. TNATA and spiro-TAD are explicitly described as hole-carrying materials, so that's my interpretation and this is essentially half a device that's been explicitly characterized -- described not characterized.

Q. And are those the same materials

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used in the Baldo paper?

A. The -- let me just take a look here.

The only material with certainty I can say is the same is Ir(ppy), iridium phenylpyridine.

Q. Okay. But none of the other ones?

A. Well, I can't say with certainty because some of the other materials listed are, again, proprietary materials. I assume they are not the same but I don't know that for a fact.

Q. They don't have the same hole-transport materials, correct?

A. Baldo is not using the same hole-transport materials but these materials would be compatible with Baldo's device.

Q. Do you know why Baldo did not use n-doped transport layer?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I can't say with certainty why -- what Baldo was thinking.

I suspect it's because they were trying to showcase just the emitter, those two papers I cite are, basically, the first

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two significant papers on phosphorescent and OLEDs.

And so, you know, I think at the time, they would have been focusing on just showing the community that they had phosphorescence rather than immediately trying to incorporate as many different components to the device as possible.

But if you look at the reply declaration and the initial declaration, the work of Pfeifer came soon after which did combine p and n-doping with phosphorescence.

BY MS. ZHONG:

Q. Okay. But they do not use aluminum Q3?

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. They did not use aluminum Q3, correct?

A. Pfeifer does not use aluminum Q3.

Q. Do you think Pfeifer represents an advance compared to Baldo's structure?

MR. LEE: Objection. Outside the

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scope. Relevance.

THE WITNESS: So I didn't necessarily have to think about what one event is over another. I think Pfeifer was an advance in the sense that they demonstrated the application of doping in a phosphorescent OLED. So I think that was the advance.

BY MS. ZHONG:

Q. Does Pfeifer -- is Pfeifer's device -- strike that.

Did Pfeifer's devices have higher performance than Baldo?

MR. LEE: Objection. Form.

THE WITNESS: So by a "higher performance," can you specify what particular parameter you're interested in me comparing?

BY MS. ZHONG:

Q. What parameters do you typically compare?

A. Several parameters, I might typically compare. I'm just curious what you would like me to think about in terms of performance.

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Q. What are those parameters?

A. So, again, as I've specified in my declaration or reply declaration, you know, efficiency, for example, would be a parameter of interest in building an OLED.

Q. And what else?

A. Stability is another parameter of interest in building an OLED.

Q. Anything else?

A. I think certain one would consider voltage as well, but in many respects, that's built into power efficiency.

Q. Okay. So why don't we compare the efficiency of the Baldo device versus a Pfeifer device.

And in the Pfeifer paper you're referring to Exhibit 1016; is that correct?

(Exhibit 1016 was identified.)

THE WITNESS: I think that's correct. I just have to pull it again now. Yes, 1016.

MR. LEE: I'm going to object and ask for a clarification on what the pending question is? I don't think there were two questions there.

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BY MS. ZHONG:

Q. How does the efficiency of the Baldo device compared to the Pfeifer device?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: So just give me a moment to compare these two references. That's not something that I considered in preparing my reply declaration or my initial declaration.

So comparing the quantum efficiency of the Baldo device and Pfeifer device, I think it's instructive -- just give me one second. Sorry.

So look at Figure 3 of Pfeifer, the quantum efficiency of Pfeiffer's device and Baldo's device is actually very similar.

So Baldo's device is effectively the -- the Baldo-type structure is effectively the data in the squares which shows a peak efficiency of nominally 10 percent.

And then Pfeifer's architecture which has a different blocking layer and thinner emissive layer is the circle data

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which is also about 10 percent.

So in terms of --

(The Court Reporter requested clarification.)

THE WITNESS: I'll try to say the same thing.

So again, looking at Figure 3, the data in the squares, the square symbols is, basically, Baldo's device. Within an NPD, HTL or CBP Ir(ppy) emissive layer.

The data in the circles is effectively Pfeifer's structure with an improved blocking layer of Ir(ppz) or at least a different blocking layer, I guess, I'd say of Ir(ppz). And that same emissive layer of 5 nanometers.

And the quantum efficiency in both cases is similar, it's about 10 percent. And if one goes back to Baldo and looks at Figure 2, that's very similar to what Baldo reports for that same structure as well, about 8 to 9 percent.

So from a quantum efficiency

perspective, the devices are very similar.

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BY MS. ZHONG:

Q. What about stability-wise?

A. Neither of these publications report on stability.

Q. Okay. So Diekmann didn't really result in a better performing device as far as efficiency is concerned; is that correct?

A. As far as the quantum efficiency is concerned.

Q. What about current efficiency or power efficiency?

A. So power efficiency would improve with doping because power efficiency also reflects turn-on voltage and so I don't think -- let me just see if Pfeifer compares that on an equal footing as well. Give me one moment.

It's actually challenging to make a direct comparison, Pfeifer's power efficiencies are larger, presumably because the voltage has been reduced, but I'd have to look more closely at this because I think there's several differences relative to Baldo device, including both doping and also the blocking layer and full transport layer as well.

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So I think what I can confidently say is that the quantum efficiency is comparable, the power efficiency is likely higher but this work is also three years later than Baldo's and Baldo was the initial demonstration and so it doesn't surprise me that it would be higher.

Q. So as a researcher in the OLED field, would you start -- for subsequent work, would you start out with a Pfeifer structure or a Baldo structure?

MR. LEE: Objection. Outside the scope.

BY MS. ZHONG:

Q. In order to make better OLEDs?

MR. LEE: Objection. Form. Outside the scope.

THE WITNESS: So I can start with either structure. It would depend on what my particular contribution was going to be to -- to trying to improve the OLED.

So in my own work, we do build structures still that are similar to Baldo's from time to time with maybe different transport layers, but it all

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depends on what you're trying to showcase.

If what you're trying to showcase is just the discovery of, say, a new emitter, for example, and how efficient it is, you might not go through the additional effort of p- and n-doping a stack.

If your goal is to instead show the absolute lowest possible voltage perhaps for a device, then you might then say, okay, now it's important to also try to dope to make sure we're getting that full reduction in voltage that comes with doping.

So I think it really depends on what it is you're trying to accomplish, what your priorities are and you know, how the project is being executed.

BY MS. ZHONG:

Q. So in your research, how often do you use aluminum Q3 as electron transport layer?

MR. LEE: Objection.

(The Court Reporter requested clarification.)

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BY MS. ZHONG:

Q. So in your research, how often do you use aluminum Q3 as the electron transport layer?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: So again, I'd have to go back and consult my publication list to see when we've used Alq and when we haven't.

We frequently will make devices with a variety of electron-transport materials, depending on what we're trying to study.

So, again, I don't think there's necessarily one that I would say is always the winner because we might pick them for different reasons. In fact, sometimes we might pick the electron transport layer for some interesting physical property it might have and that might be what we're studying in that particular incarnation.

We're not always looking to, say, make a device that just has a record of efficiency.

So, again, what I use in terms of my

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ETL, in my opinion, is not relevant because I think what's relevant is what a person skilled in the art would have used at the time of the '425 in constructing their device.

BY MS. ZHONG:

Q. That's fair.

So in the 4200 rate, what kind of ETL have you used in your group?

A. So, again, I'd have to go back and look at publications. I've certainly we've used Alq as an ETL and certainly have used BPhen and DPVBi as ETLs as well. We've used different materials depending on the application.

Q. Which one of them have you used with PHOLEDs?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I think I'd have to go back and look at my publications to better understand where I've used everything.

Sometimes it might just depend on the, again, device or experiment we're carrying out. So I don't think I can

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exhaustively categorize that right now.

BY MS. ZHONG:

Q. Do you recall use Alq3 with PHOLED in your research before 2008?

A. Again, I'd have to go back and look at my prior publications to see if I used Alq in a PHOLED prior to 2008.

Q. What about other research projects in Dr. Forrest research group while you were there?

MR. LEE: Objection. Outside the scope. Relevance.

THE WITNESS: Again, I would have to go back. That's more than 20 years now. And all I'll point to is clearly Baldo -- Baldo's paper and Baldo was in the Forrest group, they were using Alq with a phosphorescent demonstrating that it is certainly a possible example of a phosphorescent OLED that precedes that 2008 period.

BY MS. ZHONG:

Q. Okay. But you have not cited any references in which Alq3 is used as electron transport layer in a white light-emitting

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system; is that correct?

MR. LEE: Objection. Form.

THE WITNESS: No. As I said before, I referenced two different papers by Schwartz that talk about white OLEDs that contain phosphorescent and florescent materials but they do not use Alq as an electron transport layer.

BY MS. ZHONG:

Q. Okay. So you cited Schwartz because it's related to white light emission?

A. So Schwartz --

MR. LEE: Objection.

THE WITNESS: Schwartz is --

MR. LEE: Form.

THE WITNESS: Schwartz is an example where p- and n-doping are successfully and effectively applied in a white device that contains phosphorescent emitters.

BY MS. ZHONG:

Q. Okay. Did you have a chance to review your original -- the deposition transcript?

A. I haven't looked at it since I reviewed it for errors.

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Q. And you've corrected all the errors, right?

A. To the best of my knowledge, everything's has been corrected.

Q. And you're not correcting any of the testimony from that transcript, correct?

A. No.

Q. Does a blocking layer solve the issue of metal diffusion into emission layer?

A. So a blocking layer helps to mitigate the question of metal diffusion into the interlayer and prior work, especially by Pfeifer showing the first demonstration of p- and n-doping with phosphorescent and OLEDs, demonstrates how high efficiency can be realized and essentially even with an n-doped ETL as long as a blocking layer is present.

Q. Does a blocking layer blocks diffusion by lithium that's generated from disassociation of lithium quinolate?

A. So I don't know -- I haven't specifically looked at the diffusion of lithium -- from lithium quinolate, it's not something I have quantitatively examined.

But a blocking layer would help to

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mitigate such an issue, if that issue were present, which it may not even be present.

Q. Does a blocking layer mitigate the diffusion by cesium?

A. Again, when applied in a device with a cesium n-dopes ETL, the blocking layer is helping to mitigate issues related to diffusion of cesium.

Q. And does it help mitigate issues related to diffusion caused by cesium to the extent as it would help with problem caused by diffusion of the lithium anion or lithium metal from in situ doping of lithium quinolate?

MR. LEE: Objection. Form.

THE WITNESS: Can you just ask that again, please?

BY MS. ZHONG:

Q. Sure.

A. Thanks.

Q. It's your opinion that a blocking layer will mitigate problems caused by cesium diffusion, correct?

A. Yes, my opinion is that should there be issues related to cesium diffusion, a blocking layer will help to mitigate those

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issues that high efficiency can be realized.

Q. Okay. And the same is true for problems caused by lithium diffusion, correct?

A. Yes, the prior art literature supports that a blocking layer also helps to permit realization of high efficiency when using a lithium dopant by helping to mitigate any diffusion issue there.

Q. Okay. And does a doping layer mitigate problems caused by cesium diffusion to the same extent as that caused by the lithium diffusion?

MR. LEE: Objection. Form.

THE WITNESS: So the prior art has certainly shown that blocking layers can function effectively in both cases, and that, in the case of cesium, presumably by virtue of the fact that it's a larger, less diffusive atom, one can use a thinner blocking layer.

BY MS. ZHONG:

Q. So a blocking layer for cesium would have been thinner than the blocking layer for lithium; is that correct?

MR. LEE: Objection. Misstates the

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testimony.

THE WITNESS: So what I'm pointing to is that prior art has suggested that the blocking layer can be -- can be thinner.

BY MS. ZHONG:

Q. In which case? For cesium?

A. For cesium.

Q. Is there anything in the prior art that indicates the blocking layer's thickness that would be appropriate when lithium fluoride is used as a dopant, for example?

MR. LEE: Objection. Form.

THE WITNESS: So I didn't look extensively on what the specific blocking layer thickness would be for lithium fluoride.

In my exhibits, all I could do would be to point to Choudhury, since they used a BCP blocking layer in their device.

BY MS. ZHONG:

Q. Is that thinner or thicker when compared to cesium-based system?

A. Again, it's not something I considered in detail so I'd have to look at Choudhury to even consider that question.

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Q. Okay.
A. It appears to be similar to cesium.
Q. Okay. And at least by weight percent, in Choudhury, the doping level is much lower than in Ma, right, as far -- at least as far as weight percentage is concerned?
MR. LEE: Objection. Outside the scope.
THE WITNESS: So I'd like to review Ma again.
BY MS. ZHONG:
Q. Sure.
A. I would say that the concentration is different. Certainly, Ma and Choudhury have some overlap in the range they are considering.
Q. In Ma, it gets 17 weight percent, 33 weight percent of 50 weight percent, correct?
A. Yes.
Q. And in Choudhury, they did not go up beyond 10 percent, correct?
A. So, yeah, Choudhury is certainly looking at smaller concentration but Choudhury looking up to 10 percent and Ma starting at 17 percent, I guess I wouldn't view those as

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entirely incompatible.

It's not clear why Ma doesn't look at smaller percentages as well but it's quite possible those might have also been interesting to consider.

Q. Okay. How do you convert weight percentage to molar ratios?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So to convert molar percent to weight ratios, so you'd have to just consider the molecular weights of the different components actually being looked at.

BY MS. ZHONG:

Q. So, for example, 17 weight percent is in quinolate in BPhen. In order to convert that to molar ratio, I take 17 weight percent, divide it by the molecular weight of lithium quinolate and then take the 83 weight percent divided by the molecular weight of BPhen, take the sum of it and then calculate the respective molar percentage; is that right?

MR. LEE: Objection. Outside the scope. Relevance.

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THE WITNESS: So again, I didn't consider this in my reply declaration or my initial declaration but if I'm going to answer that question, I am going to have to write down what you just said so that I can assess whether or not I agree.

Can you just repeat what you just said?

BY MS. ZHONG:

Q. Okay. So let's say you have a mixture of X weight percent of lithium quinolate in a mixture of lithium quinolate and a BPhen. Do you have that?

A. Yes.

Q. So in order to calculate the molar percentage, I take the X weight percent, divided by the molecular weight of the lithium quinolate and separately, I take the weight percent, which is one minus the X percent of BPhen, and divide it by the molecular weight of BPhen, and then I summarize those two numbers together. That will be my denominator.

And to calculate the molar percent of the lithium quinolate, I take the 17 -- like the X weight percent divided by BPhen and --

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over that denominator; is that correct?

MR. LEE: Objection. Form. Outside the scope. Relevance.

THE WITNESS: Just give me a moment I'm just writing it out and I want to make sure I get this correct.

So I'm not certain this is exactly what you said or not, but if I were to try and calculate the mole percent, yes, I would take the weight percent of the component of interest, divided by its molecular weight and then divide that by the sum of the weight percents of the first component divided by its molecular weight, plus the weight percent of the second component divided by its molecular weight, effectively, it would be moles over total moles.

BY MS. ZHONG:

Q. Can you estimate the mole percent of lithium fluoride in Choudhury's system when the lithium fluoride doping level is about 4 weight percent?

MR. LEE: Objection. Outside the scope. Relevance.

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THE WITNESS: I can't calculate that unless I have the respective molecular weights of the various components.

BY MS. ZHONG:

Q. Okay. You cite the molecular weight of lithium fluoride in your declaration. I thought you did. Exhibit 1056.

(Exhibit 1056 was identified.)

THE WITNESS: Yes, I see it.

BY MS. ZHENG:

Q. Okay.

A. So, so are you asking me to do the arithmetic and calculate the mole fraction of lithium fluoride in Alq?

Q. Yes. Do you have an estimate?

A. No.

MR. LEE: Objection. The same, the same objections.

THE WITNESS: I'd need the molecular weight of Alq3 in order to perform that calculation.

BY MS. ZHONG:

Q. So I put it in the link to Ossila website, can you click on that?

MR. LEE: Counsel, is this an

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exhibit to the transcript or the proceedings?

MS. ZHONG: So the URL link is https://www.ossila. The o-s-s-i-l-a.com/products/Alq3.

MR. LEE: Is this an exhibit to the proceedings already? Counsel?

BY MS. ZHONG:

Q. Dr. Holmes, are you able to access the link?

A. Yes, I have it open.

Q. Okay.

MR. LEE: Object to this line of questioning based on this URL that has not been made an exhibit to this deposition or in the proceedings --

MS. ZHONG: Okay.

MR. LEE: -- as irrelevant, hearsay and based on foundation and I object to the inclusion of whatever testimony she is trying to elicit from this website as against the board's rules and improper and run around the board rule regarding submission of new exhibits with sur-replies.

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MS. ZHONG: Well, partly, that's because you guys are withholding relevant information. Clearly, you have documents from June 2024 and you held it to your chest to send back us.

BY MS. ZHONG:

Q. Dr. Holmes is Ossila a supplier of OLED materials?

MR. LEE: Objection. Relevance. Scope.

THE WITNESS: My understanding is Ossila is a supplier of materials and testing implements for OLEDs and solar cell research.

BY MS. ZHONG:

Q. Okay. So do you think that the information posted on its website regarding its product is something that you can rely on?

MR. LEE: Objection. Relevance. Outside the scope.

THE WITNESS: So I don't know that for a fact. I'll point out that I have found in the past references on Ossila's website to things like HOMO-LUMO levels that I don't necessarily agree with.

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BY MS. ZHONG:

Q. What about molecular weight?

A. I've never use -- I don't think I've used Ossila as a reference for molecular weight. So, again, if I was trying to get the molecular weight, I'd probably just calculate it myself based on the formula.

Q. So what would be the molecular weight for Alq3?

A. I'd have to look up the formula. I don't know. Alq3 is short-hand for the molecule. I don't know off the top of my head the number of carbons and different species that exist in Alq molecule.

Q. Well, there's a structure on page 2 of Exhibit 1049.

A. Okay. So would you like me to calculate the molecular weight of Alq by hand to check it against Ossila's data?

Q. Sure.

A. Fair enough. Is this a particular periodic table that I should be using?

Q. I think aluminum is typically 27, right?

MR. LEE: Objection. Outside the

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scope.

BY MS. ZHONG:

Q. Hydrogen is 14. Oxygen is around 16.

A. Oh. So you don't want me to use the actual atomic mass? You want me to use the most common isotope? Is that what you're asking me to do?

Q. I think it ends up to be around the same.

MR. LEE: Objection. Form. Outside the scope. Relevance.

THE WITNESS: Okay. I'll get to work on that.

Am I permitted to use a calculator?

BY MS. ZHONG:

Q. Sure. It's not a test. So I get 27 carbons, 18 hydrogens and 1 aluminum, 3 nitrogen, 3 oxygen.

A. I've got that as well. I have everything together.

Q. It might be around 459.

A. Going faster than I am.

Yes, I got 459 grams per mole.

Q. Okay. So the Alq is around 459 and

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lithium fluoride, according to your exhibit, is around 25ish, I think. It's 25.94. Let's round it up to 26.

MR. LEE: Is there a question?

BY MS. ZHONG:

Q. So what will be the molar weight percent of lithium fluoride in the 4 weight percent mixture of lithium fluoride in aluminum Q3?

MR. LEE: Objection. Outside the relevance.

THE WITNESS: So let me write down -- again, so you said 4 percent, that's not a concentration used in Choudhury but is that the one you're interested in?

BY MS. ZHONG:

Q. I thought they used 4 weight percent, didn't they?

A. They used 3, 6 and 10.

Q. Okay. We can use 3 weight percent then.

A. All right. Give me a few moments.

(The Court Reporter requested clarification.)

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THE WITNESS: I'm going to double-check my calculation.

BY MS. ZHONG:

Q. Okay.

A. Okay. Using the approach that -- that you discussed and we discussed earlier, I get a mole percent of 0.353 mole percent.

(The Court Reporter requested clarification.)

THE WITNESS: 0.353 mole percent. I'll just note, though, that I'm doing this a calculator built into Windows and I'm not super confident in my ability to type into this thing. But that is what I get right now, that's my mole percent.

BY MS. ZHONG:

Q. It's pretty close to what I'm getting. I'm getting 35.3 percentage, so...

A. 35.3?

Q. Yes.

A. No. I said 0.35.3. If you're putting in weight percents as a percentage already, you wouldn't multiply by 100 percent again at the end.

Q. Yes, so it's 35.3 percent, right?

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A. No. If you're going to do a calculation of weight percent -- so, okay, when you did the calculation, did you put 3 percent -- 3 weight percent in as 3 weight percent or 0.03?

Q. I put it as 3.

A. So if you put it as three, you have already accounted for the percentage. You can't multiply by 100 twice.

Q. I'm not. So it's three divided by 26, divided --

A. Dividing by 3 over 26, plus 97 over 459.

Q. Correct. So you get 0.353, which is --

A. Mole percent.

Q. I don't think that's right. Because --

A. Yeah.

Q. -- three -- so if you have a mixture of 100 grams, so 3 grams will be lithium fluoride and 97 grams will be the aluminum Q3, right?

A. I understand.

Q. And you can look at that mixture,

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you get 35.3 percent -- 3.35 percent before you take any of the percentage?

A. Yes.

Q. So when you convert it to the molar percent, it's 35 point whatever that is saying, right?

A. Yeah, I think I understand.

Q. So we agree that a 3 weight percent mixture of lithium fluoride was Alq's 3 convert to around 35 to 35.5 --

A. Yes.

Q. -- mole percent of lithium quinolate?

A. Yes, because the Alq is heavier.

MS. ZHONG: Okay. We're going to take a break. It's -- I don't know what time it is. It's 12:30 Central Time right now. Do you want to take a lunch break or -- or we -- go off the record and discuss that.

THE COURT REPORTER: I'm off the record.

(A recess was taken.)

BY MS. ZHONG:

Q. So welcome back, Dr. Holmes.

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So before the break, you estimated that a 3 weight percent lithium fluoride in aluminum Q3 would actually contain 35 mole percent of lithium fluoride, correct?

A. Yes, that's what was calculated.

Q. Okay. You don't know the percentage of disassociation of lithium fluoride?

A. No.

Q. Okay. And you don't know for cesium and barium what is the typical loading, correct?

MR. LEE: Objection to form.

THE WITNESS: No, I don't have a typical loading for cesium or barium.

BY MS. ZHONG:

Q. Do you know any range of loading that might happen?

A. No, if you look in the exhibits I cite, in fact, they don't specify their loading.

Q. So it could be 1 mole percent, 2 mole percent, 3 mole percent, we just don't know, right?

A. As I already said, they didn't specify their loading, so...

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Q. And you have checked before the break, that the blocking layer is about the same thickness whether it's cesium or fluoride; is that right?

MR. LEE: Objection. Misstates testimony.

THE WITNESS: What I said before the break, and maybe I'll just pull the exhibit explicitly because I don't think I mentioned it last time. Give me a moment.

Yes, in my Exhibit 1019, there's a comment to the fact that the different size and diffusivity of cesium emits a thinner blocking layer than lithium doping.

In their particular device, they have a 10 nanometer blocking layer of BPhen, that happens to be the same thickness as the same BCP layer in Choudhury.

So these two references happen to use the same blocking layer thickness for cesium and lithium fluoride.

(Exhibit 1019 was identified.)

BY MS. ZHONG:

Q. Does BCP and the BPhen have very

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similar chemical structures?

A. Yes.

Q. Is aluminum 3 used as blocking layers?

A. Again, what's used as a blocking layer depends on the device being made and the emitter being selected.

Q. So it's context-dependent or device-dependent?

A. Yes, it's device-dependent but there are instances where it could be used.

Q. Can you please go to Exhibit 1049? PDF, page 3.

A. Okay.

Q. Look to the right-hand column and search for the word "We presume."

A. Hold on. I need to redownload it. It's not letting me search. It doesn't appear that the document, it's on the Veritext site, it looks like it is a scanned document so it can't be searched. So I'm going to open the one in the Dropbox.

Q. I think it's the same.

A. It also can't be searched?

Q. Yes.

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A. Then I'll just search the paragraph then. Explain it to me again. Page 3 and what was the second column.

Q. Right-hand column below the figure --

A. Yes, I see it.

Q. -- 1, 2, 3, 4, 5, 6, 7.

Yeah, the eighth line --

A. Yeah, I see the line.

Q. So is the -- so the Endo paper is assuming that the reduction of the lithium compound occurs up to about 5 nanometers from the cathode interface; is that correct?

MR. LEE: Objection. Misstates the documents.

THE WITNESS: So that sentence says that they presume that in the case of lithium compound dopants, thermal reduction by aluminum occurs to a thickness of 50 angstroms from the aluminum interface.

(The Court Reporter requested clarification.)

THE WITNESS: Sorry.

Endo says: We presume that in the case of lithium compound dopants, thermal

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reduction by aluminum occurs to a thickness of approximately 50 angstroms from the aluminum interface, so I see that statement.

BY MS. ZHONG:

Q. So 50 angstroms of 5 nanometer?

A. Yes.

Q. So you agree with my statement?

A. I don't remember what your statement was.

MR. LEE: Objection.

BY MS. ZHONG:

Q. My statement is: The Endo paper presumes that the reduction of the lithium compound occurs up to about 5 nanometers from the cathode interface; is that correct?

MR. LEE: Objection. Misstates the documents.

THE WITNESS: So I agree to that sentence is written on the paragraph we're talking about in the Endo paper, yes.

BY MS. ZHONG:

Q. Now Endo also -- it says: Only at the lithium compound cause lower electron mobility of the electron transport layer due to

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trapping electrons or stabilizing polarons by their dipole.

Do you see that sentence?

A. I see that sentence, yes.

Q. Do you know what they mean by that?

A. I didn't think deeply about what they would mean by that in the context of my reply declaration.

Q. Do you have an understanding at all?

A. Any understanding of what?

Q. That sentence.

A. It seems that Endo is suggesting that unreacted compounds might cause issues with the electron mobility.

Q. What do they mean by "trapping electrons"?

A. Trapping electrons would usually mean electrons getting stuck in a lower energy site.

Q. You mean the electrons get trapped in the ETL sites?

A. I was trying to define "trapping" without using the word "trapping." But trapping simply means there's an impediment for the electron and the electron getting caught

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again in a lower energy site. That is what "trapping" means, is that the electron is falling into a lower energy site of being trapped.

Q. Okay. Where is that lower energy site?

A. I'm not necessarily agreeing that that's what's going on. I'm just telling you what trapping means.

Q. And what does stabilizing polarons by their dipoling?

A. I haven't had to think about specifically what stabilizing polarons by their dipole would mean. And so I'd rather not speculate on the fly as to what Endo might mean by that comment.

Q. How would a POSITA understand that sentence?

A. Stabilizing polarons might mean that, so a polaron in an organic semiconductor is a charge carrier, like a hole or an electron that's effectively coupled to the dielectric environment.

So when a charge moves through organic semiconductor, it doesn't move in the

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same way a carrier would through something like silicon, it actually moves and the polarizes the local dielectric of the material as it's moving and there's some binding between the charge and the dielectric environment because of that polarization.

So I suspect that a more stabilized polaron would be one that might be more bound to the dielectric environment perhaps, so...

Q. Okay. So is Endo speculating that the unreacted lithium is going to impede the electron hopping so the electron transfer layer?

MR. LEE: Objection. Misstates the document.

THE WITNESS: Again, this was the one sentence in Endo where they really allude to this and I don't think there's enough there to really understand exactly what they may have meant by this comment.

BY MS. ZHONG:

Q. How many times have you reviewed this document?

A. Several. I don't know the exact number.

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Q. And you have read this sentence several times?

A. Yes.

Q. Okay. And you believe you have an understanding of what the whole paper is about?

A. Yes, of course.

Q. Including this sentence?

A. I have an understanding of what they're saying here, but this is a presumption they clearly make. This is not something that is supported extensively throughout the paper by data. They are merely trying to offer some additional hypothesis or potential model right at the very end of the paper, right, this is right before the conclusion of the paper and certainly not the emphasis of the paper.

So I think what there is to understand about this particular sentence is, basically, just this particular sentence, which is why there's not a lot I can really offer on it.

Q. Okay. Do you know why the electrons can tunnel to the BPhen better than aluminum Q3?

MR. LEE: Objection. Outside the

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scope.

THE WITNESS: Can you point to a particular passage where you're referring to tunneling of electrons through BPhen versus through Alq3?

BY MS. ZHONG:

Q. Let me put it this way: It seems that BPhen provides better performance than aluminum Q3 at the same doping depth, correct?

MR. LEE: Objection to form.

THE WITNESS: I'd like to just look at the figures again to make sure I agree with that.

I would agree that BPhen provides a slightly increase luminance in current when dope Liq versus Alq.

BY MS. ZHONG:

Q. And do you see that before the "we presume," that sentence, it says: Although the increased thickness leads to the lower drive voltage in metal-dope devices, the results observed for metal complex-doped devices are the opposite.

Do you see that sentence?

A. I see that sentence.

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Q. Is Endo saying that typically if you have a cesium, lithium or barium-doped device, as the doping thickness increases, the driving voltage decreases, but for the lithium quinolate or -- and fluoride-based com- -- doping, as a thickness increases, the voltage, the driving voltage increases?

A. I'm sorry, can you just maybe restate that again?

Q. Okay. So when Endo states: Although the increased thickness leads to the lower drive voltage in metal-dope devices, the results observed for metal complex-doped devices are the opposite.

Do you see that?

A. Yes, I see that.

Q. So is Endo saying that when you increase the doping thickness for an OLED device with metal doping, for example, cesium-doped, lithium-doped, ETL, the drive voltage will actually decrease with increasing thickness?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So I haven't reviewed

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reference 11, which is the reference that's tied to that statement regarding metal-doped devices.

My general understanding of doping is that when one uses conductivity doping, the voltage becomes fairly insensitive on thickness because you're reducing the resistance of that layer.

So I'm not sure of the context of that reference 11, I haven't reviewed it before. But usually one uses conductivity dopants to actually reduce the resistance so that the device voltage eventually becomes less dependent on the thickness of that layer.

BY MS. ZHONG:

Q. So what is your understanding of the increased thickness leads to lower drive voltage in metal-doped devices?

A. Again, as I said, I haven't reviewed that reference and that's actually not what I would typically have thought would happen.

So there may be a different architecture, there may be other things going on in that prior work but I'd have to review it

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to know the specifics of the comparison.

Q. Okay.

A. When I looked at Endo, if you actually compare the thickness dependence, it's pretty marginal if you look at the data for Liq at 50 and Liq at 300.

Q. And metal-dope devices refers to cesium, barium -- strike that.

So the metal-doping devices would be understood to refer to OLEDs device whereas electron-transport layers doped with metals such as cesium, lithium, barium; is that correct?

A. I think a person skilled in the art would likely go and check 11 if they were interested to understand more about that result before making an assumption as to the range of metals included.

I don't think Endo mentions cesium, and so I guess I would be careful to make a conclusion on what metals may or may not be included in that metal-dope devices comment.

Q. Okay. But you did not check the reference?

A. I didn't check the reference, no.

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Q. Okay. Any reason you didn't?

A. Yeah, because looking at the data in Figure 4 and Figure 5, the improvement with Liq is quite clear and the thickness dependence is, again, marginal. There really isn't much of a thickness dependence between 50 and 300.

So I didn't see the need to go and do an exhaustive comparison as a function of thickness to the prior art.

Q. But one of your proposed modification is to replace the ETL layer, in the electron transport layer with lithium quinolate, right?

MR. LEE: Objection.

THE WITNESS: So Diekmann is not exclusively using metals, right --

(The Court Reporter requested clarification.)

THE WITNESS: Yeah, that's one of the of the premiere -- Diekmann's preferred dopants, though not exclusive, are cesium, barium, and lithium fluoride. So any of those could be the dopant to be replaced in Diekmann.

BY MS. ZHONG:

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Q. Lithium fluoride. Which one has worst diffusion, lithium fluoride or lithium quinolate?

A. Again, I answered that this morning. I don't have quantitative data on the difference in diffusion between lithium fluoride and lithium quinolate.

The motivation a person skilled in the art would have would be that lithium quinolate is a clearly a molecular dopant and that's something that Diekmann explicitly states would be desirable.

Q. But you don't know whether lithium fluoride is a molecular dopant or not, right? Would a POSITA view lithium fluoride as a molecular dopant or not, right?

A. I haven't taken an opinion on whether or not lithium fluoride is a molecular dopant.

Q. Okay. Do you know if the lithium fluoride, when it's used to dope the electron transport layer, whether it exists as a single pair of lithium and fluoride or some kind of aggregate of lithium and fluoride pairs, right?

MR. LEE: Objection. Outside the

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scope. Asked and answered.

THE WITNESS: That, again, is not something that I considered. Doesn't impact the opinion that I've drawn in this case.

BY MS. ZHONG:

Q. Okay. The molecular weight for lithium fluoride, one pair is around 26 AMU, correct?

A. I think that's the number that we used before lunch to calculate the mole percent, yes.

Q. Okay. And lithium quinolate, according to your exhibit, is around 137-ish -- 150 -- let me see.

A. The 151.09 is what I cite.

Q. Okay, 151.

So if there are six lithium fluoride pairs that's aggregated together, the molecular weight would be around 150, correct?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I'm not sure what that means, to have six lithium fluorides, I don't know if I necessarily count lithium

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fluorides in that way.

If you're just saying, does six times lithium fluoride equal that number, I'll assume it does based on what you're saying.

BY MS. ZHONG:

Q. Okay. 26 times six is more than a 150, right, probably 156?

A. If you say so.

Q. Can you verify?

A. Sure.

Yes, 156.

Q. And 156 is greater than 151, right?

A. 156 is greater than 151.

Q. And you don't know whether lithium fluoride exists as a monomer or hexamer or even higher oligomers, right?

A. No.

Q. So the doping effect or conductivity effect by lithium quinolate actually results from the lithium metal?

A. So as I described in my original declaration and then further, that's in my reply declaration responsive to Dr. Pattison's comments, Liq is a n-dopant that increases the

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conductivity of the ETL, that's clear from Ma's work, which I discussed extensively in my initial declaration.

Dr. Pattison takes a narrow position that an n-dopant must participate in direct charge transfer with the ETL and in my reply declaration what I point out is that Liq will also perform this process at the cathode interface as well.

In a way, very analogous to lithium fluoride which is listed as a preferred dopant by Diekmann.

Q. You didn't quite answer my question.

A. Okay, can you restate your question?

Q. So whatever the effect lithium quinolate may have on the conductivity of the electron transport layer, that is due to the formation of lithium metal on the same cation; is that correct?

A. No, I think that's incorrect and isn't consistent with what I said.

As I point out in my initial declaration, Ma demonstrates experimentally that adding lithium quinolate to an electron transport layer leads to an increase in

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conductivity that Ma suggests is coming from a change in the mobility of the ETL.

Dr. Pattison's testimony suggested that n-doping must solely be related to a charge transfer dopant, which is something I don't agree with.

And in my reply, I demonstrate that under this narrow definition, Liq would still be an n-dopant by virtue of the fact that when it sees the cathodes metal, it will ultimately n-doped via lithium the ETL.

Q. Okay. In this mechanism of electron donation, the electrons are donated from the reduced lithium; is that correct?

A. So again, I didn't take that as a specific position on the chemistry and the reaction that actually occurs.

What I'm using is the prior art to support my opinion that Liq will act as a dopant that is disassociated at the interface.

Whether it's lithium or lithium metal plus or anion that's formed, that's not something that I've offered an opinion on.

Q. Do you recall your testimony earlier that the prior art you have seen seems to be

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suggesting a lithium quinolate is affecting the conductivity due to in situ doping which involves the release of metal lithium metal, correct?

A. But whether it's lithium metal neutral or lithium cadine is something that I'm not taking a specific opinion on, is what I'm saying.

Q. Okay.

A. You asked me about both for today.

Q. So the effect of lithium quinolate on the number of negative charges, if any, would be due to deformation of lithium and lithium cadine; is that correct?

A. So, again, as I just said, I haven't offered a reaction pathway for how lithium quinolate goes from a neutral molecular species, through intermediate states, to some final dope ETL.

If I look at that question in the context of Choudhury and Choudhury is suggesting that the analogous lithium fluoride is doping by forming lithium plus and a corresponding anion.

Q. So are you taking -- is it your

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opinion that lithium quinolate would react in a similar fashion?

A. I think it's potentially consistent with the fact that there's a doping effect that's observed but I'm not committing to a particular chemistry because I don't have enough evidence to be able to propose a reaction with an associated, say, delta G associated with it.

Q. And in Choudhury's reaction mechanism --

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Choudhury --

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. Does Choudhury reaction mechanism involve the release of either metal, iron or metal -- strike that.

So does the Choudhury reaction mechanism involve either the release of lithium metal or lithium cadine?

A. Can you clarify what you mean by the

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word "release"?

Q. Form.

A. So in Choudhury's reaction, there is ultimately a complex formed, at least proposed by the reaction between a lithium quinolate and Alq anion.

Q. What about in Endo, they suggest that there is reduction to form free metal; is that correct?

A. Let me just open Endo again.

Yes, Endo is proposing that there's thermal reduction of metal --

(The Court Reporter requested clarification.)

THE WITNESS: Sorry. I understand.

Okay. Yeah, I can repeat it.

So Endo says that there's thermal reduction of metal -- that thermal reduction of metal ions occurs in Liq when the cathode is deposited on to it.

BY MS. ZHONG:

Q. That means that there is lithium metal forming?

A. Yeah, like, in looking at Endo's description, they note that the reaction may

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also produce byproducts derived from the aluminum ion and the organic ligands liberated from the complexes.

So I would say that there could be several things formed based on Endo's interpretation of their data.

Q. It involves at least the -- strike that.

It involves, at least, the formation of lithium metal; is that correct?

A. So Endo, in their abstract, describes their results as being reduced to free metal by thermally activated aluminum.

Q. And free metal means lithium; is that right?

A. If it's a lithium complex, then I would interpret "free metal" to be that lithium is being released.

Q. Okay. Does Choi offer any theory on the possible reaction of the mechanism?

A. I'll have to review Choi. Let me do that now.

Choi doesn't offer details on the reaction mechanism, they simply qualify it as Liq as being an n-type doped ETL.

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Q. Okay. But Choi speculates that lithium Liq-doped to the ETL can be expected to exhibit a lower electron barrier height, correct?

A. Can you point to a particular paragraph?

Q. PDF page 2.

A. Mm-hmm.

Q. The end of that -- the paragraph on the right.

A. Yes, I see the line.

Q. And that's opposite from Endo, correct?

A. I guess I'm trying to understand what's opposite from Endo.

Q. So in Choi, lithium quinolate LUMO is depicted as being lower than the LUMO of the ETL; is that correct?

A. So, yes, we talked about this this morning. They offer different perspectives on the -- I think we talked about this this morning, different perspectives on the LUMO of Liq.

Q. Understood.

So according to Choi, Choi's view is

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that lithium quinolate has a lower LUMO than the ETL for that particular ETL they are using?

A. Yes, the energy levels Choi is citing for Liq would place the LUMO within the ETL and its graphic of Figure 2.

Q. So the LUMO of lithium quinolate in Choi has a lower LUMO than the LUMO of the electron transport layer?

A. That's what's shown in Figure 2 of Choi.

Q. Okay. And in Endo, forget about the absolute values, relatively, the lithium quinolate has a higher LUMO than the aluminum Q3 -- aluminum Q3 LUMO, correct?

MR. LEE: Objection.

A. That's what's noted in Endo.

BY MS. ZHONG:

Q. How does the LUMO level of -- strike that.

How does a LUMO level of lithium quinolate compare to BPhen?

A. I'd have to consult some of my exhibits to remind myself of the LUMO level of BPhen but I can do that.

Q. Sure.

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A. So in Exhibit 10 -- 1030, he lists the LUMO BPhen as 3.0 electron volts.

(Exhibit 1030 was identified.)

BY MS. ZHENG:

Q. So it would be would higher than 3.15 and lower than 2.5?

A. Yes, it would be similar to Alq as noted by Endo.

Q. What is TTPI's LUMO level?

A. I don't recall TTPI's LUMO level off the top of my head and I don't think it's in -- and I don't think I've pulled an exhibit that has TTPI's LUMO, but I can check. I'm going to search a couple of my exhibits.

I don't think I have a number for TTPI'S LUMO in my exhibits.

Q. Can you please take a look at your reply declaration, page 23?

A. Page 23?

Q. Uh-huh. Correct.

A. Okay. I'm looking at it.

Q. So the quote you have on Choudhury is specific to the Alq3; is that correct?

A. The quote I have for Choudhury is taken from the Choudhury paper, so that's for

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Alq lithium fluoride.

Q. And you continue to say that: Choudhury concludes that doping leads to a gradual filling of intrinsic charge traps in the material resulting in higher low field carrier mobility compared to n-doped samples.

Do you see that?

A. Let me just find that passage.

Q. Last two lines on page 23.

A. I see that -- that text.

Q. What does it mean that, "doping leads to gradual filling of the intrinsic charge traps in the material"?

A. So when a material is deposited in film, there's going to be some concentration of intrinsic traps in the material, just from potentially a disorder that might exist in the films since these are amorphous --

(The Court Reporter requested clarification.)

THE WITNESS: Since these are amorphous in films. And so when one introduces charge carriers in the way that Choudhury is arguing, some of these traps may be filled and once they are filled,

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they no longer impact subsequent electrons traveling through the layer.

BY MS. ZHONG:

Q. And in the material, is that referring to the electron-transport material?

A. Choudhury is talking about the electron-transport material.

Q. And the filling of the intrinsic charge traps, it's filling by the lithium quinolate molecules, cations, electrons or what?

A. It would be filling by electrons.

Q. So the electron fills all those charge traps?

A. I think they're finding is that the electrons would fill at least some of them, which would increase the mobility of electrons through the material.

Q. Okay. So those, because those electrons then will no longer be trapped by those traps in the material?

A. Any subsequently injected electron, now that trap is filled and so it's not going to have as -- as detrimental effect on the transport.

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Q. Is that the same mechanism as Ma's?

A. No. Well, not necessarily, it's quite possible something like that could be happening in Ma as well, but Ma speculates that their change in mobility is related more to the specifics of the hopping that exists in the electron-transfer material.

In terms of the role of charge generation, that's something that Ma doesn't use as part of their explanation.

Q. And their hopping looks at the relative normal LUMO levels of the lithium quinolate resisting the electron-transfer material; is that right?

A. I'm going to open Ma to better answer that.

Yes. So Ma is looking at ultimately LUMO and LUMO difference between BPhen and Liq being small, and arguing that that ultimately enables improved transport through the layer.

Q. So if Endo's LUMO and LUMO levels are correct, does that mean this hopping mechanism would not occur in aluminum Q3 and lithium quinolate?

A. I didn't look into the details of

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what Ma's hopping mechanism -- how it would depend on, say, the energy difference between the two materials in the ETL, so I don't think I can speculate on that.

Q. So the newer papers you have cited, they report the number of electrons in the doped material versus the undoped materials or are they just reporting the conductivity?

A. Can you point me to some specific papers because there's several that I have cited here?

Q. Exhibit 1049, Exhibit 1050, 51, 52.

A. I may be missing something but I don't know that 1049 actually reports in detail on the number of carriers. Can you direct me to where in 1049 that's discussed?

Q. I'm just asking you whether they discussed that.

A. Oh, I thought you made a statement saying they report the number of carriers.

So 1049 is basing their conclusions on device data, as is often the case with doping, to look at the improvement in device data; and in 1049, they are not doing an explicit measurement of number of carriers.

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What were the other exhibits?

Q. Exhibit 1050.

A. 1050. So Choi again, I don't think they offer any direct measure of a carrier. They base their assessment on improved device performance here.

Q. What about for Choudhury, Exhibit 1051?

A. So Choudhury, I'll look at it a little more closer because they do talk about concentrations but I want to make sure that I get the context correct.

Yes. So Choudhury does, for at least one sample, list their carrier concentration in table 1.

Q. You mean -- are you referring to the Number N?

A. Yeah, that's carrier concentration.

Q. Do you believe that the articles after 2008 is reflective of the state of art at the time of the invention?

A. Can you just clarify, you're saying any article published since 2008? Or just published today?

Q. Are articles published after 2008 in

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your opinion -- strike that.

For articles published after 2008, the priority date, in your opinion, do they reflect the state of the art at the time of the invention?

MR. LEE: Objection. It calls for a legal conclusion.

THE WITNESS: So I didn't consider -- I didn't consider that question, what would reflect the state of the art, in terms of material continuing being published today.

In general if I look at the OLED community, there's continual advancement; and so I think, generally, if you're looking almost 20 years after a piece of work, it would be hard for that 20-year-old piece of work to still be the state of the art.

And for the material from today to not have improved in some way on those devices.

BY MS. ZHONG:

Q. So if a particular combination you proposed did not appear until three or four

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years after the invention date, does it -- does that have any bearing on whether a person of ordinary skill in the art would have arrived at the invention at the time with --

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

THE WITNESS: So the -- again, the way I've built my opinion, my declaration or reply declaration, is that in my opinion, it would have been obvious for a person skilled in the art prior to, like at the time of the invention or prior to the invention, to make the combinations that I'm proposing.

And so, no, I don't think just because that combination doesn't end up in the literature shortly after the patent date would -- that that weakens the opinion any more on the combination. I don't think so.

BY MS. ZHONG:

Q. So does the fact that the particular combination does not appear in literature for another five to six years, would that at least indicate it lacks an interest in making that

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combination?

MR. LEE: Objection. It calls for a legal conclusion. Outside the scope.

THE WITNESS: So I never thought about it in that way, and don't think that that's true.

The way I've constructed my opinion and the way I've looked at the prior art is what would a person skilled in the art have been able to see and what would they see as fruitful combinations that would have a highly likely of success?

And so I haven't thought at all about how long after the '425 patent date something would have to be reduced to practice in the literature, to then back influence my opinion on whether it would have been obvious. My opinion is that these combinations would have been obvious at the time.

BY MS. ZHONG:

Q. Okay. I understand what your opinion is. But let's see whether we can -- I want to get some factual basis.

Kido is a well-known group at the

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time of the invention, right?

A. Yes.

Q. People working in the, in that field, generally knows about that group, correct?

A. Yes, that's correct.

Q. And do they follow their work generally?

MR. LEE: Objection.

THE WITNESS: Again, the community reads Kido's work, certainly.

BY MS. ZHONG:

Q. So there should be well-aware of Exhibit 1049, for example?

A. Again, I think that the community would follow Kido's work, certainly.

Q. They would be aware of Exhibit 1049, for example, of Kido work?

A. Again, it would be -- if it's in the literature if they are following the work, they would be aware of all of his work. And so I'm hesitant to single out 1049 versus the dozens of other papers. But I think, in general, the community is following Kido's work including 1049.

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Q. Okay. And the fact is, the next paper lithium quinolate or using lithium quinolate in electron transport layer is the Ma paper as far as you can locate, correct?

MR. LEE: Objection. Misstates facts. Lacks scope.

THE WITNESS: As I said earlier, the Ma paper and Endo paper are the only two prior art references that I cite. I did not exhaustively look for additional references but those are the two that I cite in my declaration and reply.

BY MS. ZHONG:

Q. Is there anything preventing you from doing a more exhaustive search?

A. No.

MR. LEE: Objection. Relevance. Outside the scope.

THE WITNESS: No.

BY MS. ZHONG:

Q. Did you ask counsel to help you with the search?

MR. LEE: Objection to the extent it calls for privileged communications.

THE WITNESS: I'll also answer that,

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then, no.

BY MS. ZHONG:

Q. Okay. Do you consider yourself to be a pretty good researcher as far as locating the relevant literature?

A. Yes, I do.

Q. Okay. So if you want to find a particular paper on a particular topic, you usually find them, right?

A. Well, again, that -- there's some truth to that but you have to remember as well that p- and n-doping was something that was still emerging in the early 2000s, and so, you know, you might have to sometimes look harder than other times to find the paper. Sometimes the terminology is different, sometimes you have to search for particular molecules, so -- but, yes, I think I'm effective in finding literature.

Q. Okay. And the priority for the '425 is, you used with the 2008, right?

A. As I note in my original declaration, yes.

Q. Okay. And so that's not early 2000, that's more the end of 2000s, right?

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A. Again, I was referring more to the time period where the Endo paper resides, in 2002.

Q. Okay. But I assume that when you were searching for prior art, you did not limit yourself to 2002, right? You looked all the way through 2008; is that correct?

MR. LEE: Objection. Relevance. Outside the scope.

THE WITNESS: Yes, I didn't limit myself to 2002, but I also, given the scope of my opinion and the scope of the questions involved, I also felt that in my original declaration, Ma supported my opinion to the level that it needed to be supported.

BY MS. ZHONG:

Q. Okay.

A. So looking at Ma already, as a known n-dopant showing good performance of an OLED, to me that was already sufficient to make the combination with Diekmann.

And so my objective was not to provide an exhaustive review on doping and organic semi-conductors up to the year 2008.

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Q. Do you think that it's relevant to find literature where lithium quinolate is used as a n-dopant in the electron-transfer layer?

A. Yes.

Q. Okay. And the more you can find, the more it will support your theory, correct?

MR. LEE: Objection. Outside the scope. Lacks relevance.

THE WITNESS: Yes.

BY MS. ZHONG:

Q. But the fact is, you searched and besides Ma, you only located the Endo paper, correct? Or at least the -- only cited to the Endo paper?

A. Those are the two references I'm citing to support the doping of Liq into an ETL.

Q. Did you locate other papers?

A. None that I'm aware of at the moment.

Q. Okay. So I just want to make sure that there's not another lithium quinolate -- strike that.

There's not another reference involving lithium quinolate as a dopant in the

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electron-transfer layer that you're aware of but did not cite; is that correct?

A. There's no other --

MR. LEE: Objection to form of the question.

THE WITNESS: There isn't another reference that I'm aware of at the moment that I could have cited.

BY MS. ZHONG:

Q. Okay. And --

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. So the use of lithium quinolate as an electron injection layer, those papers include the Liu paper, the (indecipherable) paper, and the Schmitz Exhibit 2027; is that correct?

A. That's correct. Those three are included, but I just want to consult my exhibit list to make sure one wasn't missed. Just give me a moment.

I think Endo should be on that list as well, because in addition to showing the doping of the ETL, Endo also demonstrates LI --

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or Liq and Li derivatives or Li complexes as EILs, as well but those would be the references I cite.

Q. Do you know why both Ma and Choi used a separate electron injection layer in addition to the doped electron transfer layer?

A. So in Ma, this is something I talk about and talked about in my original declaration and in original deposition, Ma is doing that, in my opinion, to remove the effect of Liq or at least minimize the effect of Liq on injection.

And so in Ma's device, they're looking at trying to show a change in conductivity of the ETL and the cleanest way to do that is to go and actually remove or minimize changes in injection due to whatever you're doing to the electron transport layer. So by including lithium fluoride as an EIL, they've already improved injection largely and can then better focus the analysis of their increased current flow to the doping effect of Liq in the ETL.

Q. But when Ma was making its electron-only device, it did not include any

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electron injection layer, correct?

A. Let me go back and look at Ma.

That's true. In the electron-only device, there is no additional LiF layer, it's in the OLED.

Q. Okay. So if they want to evaluate purely the effects of lithium quinolate doping, shouldn't they be doing that in the electron-only device?

A. They could. In this case, the electron-only device is also fairly thick which is a another way to focus an attention to the bulk transport and the transport layer rather than to injection.

And so normally when, you know, one tries to evaluate bulk transport, one would try to make the resistance of the ETL, the biggest resistance that the electron sees. And so at 50 nanometers, they've probably realized that.

And so I would say they're still showcasing the bulk transport of the film.

Q. So based on their electron-only device met test results, how many (indecipherable) of conductivity increase is there?

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A. I'm sorry, I missed that. How many what of conducted in increase?

Q. What's the amount of the conductivity increase based on the electron-only device?

A. I don't think they actually calculate their conductivity, but let me just --

Q. From the electron-only device test result from the current -- Figure 5, for example?

A. No, I can't estimate just from Figure 5.

Q. So you don't think that you can estimate the increase in bulk conductivity of the doped film from Figure 5 of Ma?

A. No, what I said is I can't give you a specific number. I can see clearly that the conductivity is going up, but I don't know the specific numerical value by which it's going up.

Q. Can you give me a range of number? Is it like two to three fold increase, in order of magnitude, two orders of magnitude, three orders of magnitude? Can you tell?

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A. No, not just from that data.
Q. What else do you need?
A. So to get conductivity from current density, you'd have to first calculate the field across the device and you might also need to think about what regime you're in.
So I'd probably want to have the data on like a logarithmic plot versus voltage as well so that I could see the full range of the current voltage behavior.
Q. So you cannot make any estimate, based on Figure 5, as to the -- the degree of improvement in conductivity; is that correct?
A. Again, I wouldn't be comfortable pulling a number out of the data without being able to see the full range.
What I can say is, qualitatively, there is an increase based on the fact that the electron current is improving as a result of doping here, at least up to 33.
Q. Can you even estimate as to the order of magnitude of improvement?
MR. LEE: Objection. Asked and answered.
THE WITNESS: Again, I'm not able to

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estimate a quantitative number. So no, I wouldn't be comfortable estimating an order of magnitude improvement or even a factor of whatever number.

BY MS. ZHONG:

Q. What about based on the plotting of the figures?

A. Again, I think that there's -- well, my opinion is there's sufficient data here, first of all, in the electron device that a person skilled in the art would see an improvement in electron transport and an improvement in conductivity even if the exact number isn't known. And then importantly, too, would see the favorable device performance that comes from using Liq as an n-dopant.

Q. So does the fact that the current density increased by about two to threefold means that conductivity increases only two to threefold?

A. So just so I'm clear, tell me which data you're pointing to. Which concentrations are we looking at here?

Q. Do you see -- is it true that the current density increased from about

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130 milliamp per -- per centimeter squared to around 370 milliamp percentage squared?

MR. LEE: Objection. Form.

THE WITNESS: Again, for which concentrations are we talking about?

BY MS. ZHONG:

Q. Figure 5.

A. There's four curves there, I just want to know which two you want me to compare.

Q. The n-doped that says 33 percent.

A. Okay. And you're looking at 12 volts, presumably, here?

Q. Sure.

A. For the n-doped at 12 volts, it looks like, yeah, approximately 335. We only have per centimeter squared. And for the 33, yeah, maybe three, 370, something like that.

Q. Okay. So does the fact that current density increases by like, say, threefold means the conductivity increased by a threefold in the bulk?

A. So, again, it depends on -- so conductivity is a proportionality effectively between current and field. And so the current density here is plotted as a function of

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voltage. And so in terms of comparing exact currents at a specific voltage, what you'd really like to know is what the electrofield is of those voltages rather than the voltage itself.

And so I'm hesitant to pick two points of the same voltage because I don't know if they're at the same electric field necessarily.

So I can say with certainty that the current is going up and the conductivity is improving but in terms of picking two precise points to compare, I'd want to see more of the data and I'd want to think a little bit about, what would the field be in this device?

Q. And the field is a function of the thickness?

A. Field is a function of the thickness, the voltage applied but it can also be a function of the conductivity of the layer as well.

Q. And so, again, you don't believe that, just by looking at the current density curb, you can conclude that the conductivity only went up by two to threefold; is that

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right?

A. I don't think I'm comfortable making a quantitative assessment of the conductivity just from this data alone, but I can confidently say that the conductivity has increased.

Q. But you can't tell whether the conduct of the increase is by a factor of 10, a factor of 100, a factor of 1,000 or --

MR. LEE: Asked and answered.

THE WITNESS: As I said before, I'm not comfortable assigning some numerical value to what that increase would be and I'll just note as well that I don't think a person skilled in the art would need to have the numerical value in order to see value in using Liq as an n-dopant.

BY MS. ZHONG:

Q. Based on this graph, is it possible that the increasing conductivity is three orders of magnitude?

A. So as I've already said, I can't assign a specific quantitative value to the increase in conductivity, it's not something that I've sought to do in my declaration or

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reply declaration, so I'm not comfortable doing that now or trying to bookend it based on some very large or very small numerical range.

Q. So you can't exclude the possibility that the conductivity increase is over three orders of magnitudes, for example, correct?

A. So, again, that's not how I would phrase it, but I'm not willing to give a quantitative number just based on this data.

THE COURT REPORTER: We've been going an hour and a half, I could use a break.

MS. ZHONG: Sure.

(A recess was taken.)

BY MS. ZHONG:

Q. Can you please turn to your reply declaration, paragraph 35?

A. Sure. Let me just open it. Okay.

Q. The supposed additional benefits you stated in paragraph 35, those were not stated in your original declaration; is that correct?

A. Let me reread paragraph 35.

Q. Okay.

A. I'm going to open my original declaration as well.

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Q. Let me point you to, for example, paragraph 144. Actually starting on 142.

A. Let me read this quickly.

Q. I think 144 is where you were trying to justify the use of lithium quinolate.

A. What is the specific inconsistency you're pointing out?

Q. I'm just asking you, the new theory that -- the additional benefits, you did not state them in your original declaration, correct?

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

THE WITNESS: So I'll just note first that in my original declaration and I'll just read this explicitly:

It was well-understood that metal -- dopant metal lines could diffuse in the OLED, during film, growth and operation compromising performance.

So this is essentially noting that a dopant with a reduced diffusion constant in the ETL would lead to an overall improvement in performance. And when looking at my reply --

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BY MS. ZHONG:

Q. Does your original declaration mention anything about --

MR. LEE: If you could just let the witness finish his testimony.

THE WITNESS: Yeah, let me just finish my thought. I had so many PDF documents open here, I needed to find my reply.

So I would say that when looking at, for instance, the quote I pull from Zheng, et al., talking about the stability of elemental metals and how that's an issue, that certainly is consistent with the deterioration in device performance.

Lifetime is a part of performance, in addition to efficiency.

And so I don't think there's an inconsistency there and I don't think there's a new theory there. It's just additional support for Diekmann's stated objective of -- or stated preference for a molecular dopant.

BY MS. ZHONG:

Q. Where in your report is mentioned

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the missing calcium, magnesium, et cetera, and not stabling air?

A. Let me go back. In my initial report, I don't explicitly call out that lithium and magnesium and calcium are not stable in air.

What I say is that the dope preference preferably has a low diffusion constant within the stack as is usually the case with large atoms or molecules, for example.

Q. So --

A. In looking -- pardon me.

Looking at Diekmann, the discussion of Diekmann is also about trying to move away from more diffusive atomic species like lithium, for example.

Q. So is there a connection between diffusivity and air stability?

A. Let me just open my reply again.

Again, I'm not pointing to -- I'm noting, obviously, the air instability of those metals just because that's part of the quotation from Zheng.

But I'm also noting that, "and

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sometimes may react with and diffuse into organic material and deteriorate the device."

I think Zheng explicitly calls out diffusion as a challenge. Right? The fact that Zheng also calls out the air stability is something that I'm including, just because of the fact that it's part of Zheng's discussion.

But what I'm pointing to here in this discussion is that the diffusion issue is something that Diekmann raises. The diffusion issue is a problem for performance is something I raised in my original declaration and I'm just further commenting on that here in the reply.

Q. Okay. So your original declaration did not comment on the air stability of the calcium barium versus the lithium quinolate, correct?

A. Let me go back to my original declaration.

Again, I don't think I commented specifically on the air stability of those materials. I mention the use of calcium in the context of view, but again, it's been a while since I've gone through my original declaration

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in detail but I don't think I have commented specifically on air stability.

Q. You did not -- you also did not comment on the advantage of using lithium quinolate versus lithium fluoride, such as lithium fluoride needs higher temperature for evaporation and the thickness control issue, correct?

A. I didn't comment explicitly on that.

Q. Okay. What's the air stability of lithium fluoride versus lithium quinolate?

MR. LEE: Objection. Form.

THE WITNESS: I didn't consider the what the air stability of lithium fluoride versus lithium quinolate as part of my declaration or reply.

BY MS. ZHONG:

Q. Have you done any experiment to determine the relative diffusivity of lithium quinolate versus lithium fluoride?

A. No, I haven't done any experiments to measure that exclusively.

Q. Have you done any literature search to determine the relative diffusivity of lithium quinolate versus lithium fluoride?

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A. I'm not aware of any literature that compares the diffusivity of those two species.

Q. Now, can you please take at that look at your paragraph 38?

A. Is this in the reply or the original declaration?

Q. Reply.

A. Reply, okay.

I'm there.

Q. Now, you quoted in paragraph 38, certain passages from Exhibit 2003, Kim from -- 2011, correct?

(Exhibit 2003 was identified.)

THE WITNESS: That's correct.

BY MS. ZHENG:

Q. Okay. And according to your excerpt, Kim's structure again has a two nanometer lithium quinolate injection layer, correct?

A. That's correct.

Q. Okay. For the Exhibit 2024 structure, Kim 2013, do you know if there's a separate lithium quinolate layer or not?

(Exhibit 2013 was marked.)

MR. LEE: Objection. Form.

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THE WITNESS: I'll have to just have a look at Exhibit 2024. Is that not in the Veritext?

(Exhibit 2024 was identified.)

BY MS. ZHONG:

Q. It should be.

A. Oh, I see. None of the -- it doesn't look like the Pictiva exhibits are there. I can go to Dropbox. It is fine.

Q. The Dropbox is more complete. And I'll direct your attention to Figure 1.

A. Okay. I'm looking at Figure 1.

Q. Does that indicate to you that there's a separate lithium quinolate neat layer, like injection layer between the dopant TPBi layer and the aluminum cathode?

A. Yes, there is a separate lithium quinolate layer there.

Q. And this one is not a white light-emitting OLED, correct?

A. You're referring to Exhibit 2024 still?

Q. Correct.

A. No, this was presumably a green lighting-emitting device.

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Q. Okay. What about Exhibit 2003?

(The Court Reporter requested clarification.)

THE WITNESS: Green light-emitting device, green.

BY MS. ZHONG:

Q. What about Exhibit 2003?

A. 2003. Let me just remind myself if the emitters are there.

Yeah, 2003 is also not a white light-emitting device.

Q. Are you aware of any literature where this lithium quinolate doped layer is used with three stacked emission layer?

A. No, I'm not.

Q. Does the fact that lithium quinolate is known to be a good electron ejector like -- strike that.

Does the fact that lithium quinolate was known to be a good electron -- strike that.

Does the fact that lithium quinolate was known to have good electron injection property make it an n-dopant?

MR. LEE: Objection. Outside the scope.

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THE WITNESS: So what I'm relying on to decide that Liq is an n-dopant is not that it's been used as an EIL. It certainly had been previously used as an EIL. I'm relying on the fact that it's previously been used as n-dopant in the ETL.

And so I hesitate to generalize that any EIL is automatically a dopant.

BY MS. ZHONG:

Q. Now, the Endo devices, that involves lithium quinolate doped electron transport layer, they did not use a separate lithium quinolate or some kind -- some other electron injection layer, correct?

A. So Endo's devices can be considered as really, there's probably, I guess, you could say, two class of devices that's covered in Endo.

One is a series of devices where there is essentially a neat layer of an EIL material. And then the other is a class of devices where the ETL has been doped with the lithium complex and they investigate both of them.

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So when they dope the ETL with the lithium complex, they don't include an additional EIL.

Q. Okay. But since Endo, the four papers that we have lithium quinolate ETL, they all use a separate electron injection layers, correct?

MR. LEE: Objection. Form.

THE WITNESS: So what are the four papers again? I just want to make sure I'm clear. The two Kim papers and --

BY MS. ZHONG:

Q. The Ma paper. So the Ma paper, the Kim paper, maybe both of them are Kim's. So the two Kim papers and the Choi paper.

A. In those four papers, in their OLEDs, use an EIL.

Q. Okay. So since Endo, at least for the paper that we can find between 2008 and 2013, those devices are included as separate electron injection layer for the lithium quinolate doped electron transport layer; is that correct?

MR. LEE: Objection. Misstates the testimony and outside the scope.

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THE WITNESS: So those four papers you have lusted, the two Kim papers, Ma, and Choi, all include an EIL.

BY MS. ZHONG:

Q. Did you find any other papers on the use of lithium quinolate doped electron transport layer between 2008 and 2013?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I didn't look explicitly for papers that are post-priority date.

BY MS. ZHONG:

Q. But the papers of record in that time period, they are included, lithium quinolate electron injection layer, correct?

A. So, again, if we're referring to those same four papers, the two Kim papers, the Ma paper and Choi paper, they include an EIL.

I just want to make sure that that's clear because Ma isn't including Liq as an EIL, they are including lithium fluoride.

Q. But they all include some kind of electron injection layer separate from the doped electron transport layer?

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A. Those four papers all include an EIL.

Q. Do you have any theory on why they are including a separate electron injection layer --

MR. LEE: Objection.

(The court reporter requested clarification.)

BY MS. ZHONG:

Q. Do you have a theory as to why those four devices are -- include a separate electron injection layer when lithium quinolate supposedly has good electron injection property?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So with regard to Ma, I think I've already stated my opinion regarding the EIL in Ma.

I haven't thought about developing a theory or opinion on why these other papers utilize Liq as an EIL.

BY MS. ZHONG:

Q. Is there a reason why Endo did not include a separate electro injection layer when

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it dopes its electron transport layer?

MR. LEE: Objection. Outside the scope.

THE WITNESS: So I would rely on what I've said previously and what I said in my initial declaration, which is, since the electron transport layer is doped, it doesn't need to improve injection. It already is. It doesn't need a separate electron injection layer.

BY MS. ZHONG:

Q. Doesn't it want to separate the effects of electron injection from the doping effects on conductivity?

MR. LEE: Objection. Outside the scope. Calls for speculation.

THE WITNESS: Again, I don't know the motivation of Endo. Their objective may have been just been to show a high efficiency and that you can get a good working OLED using these different lithium complexes, but I am not going to speculate on what they might have been thinking.

BY MS. ZHONG:

Q. But for whatever reason, the papers

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after Endo, at least those of record, or used a separate electron injection layer together with lithium quinolate doped electron transport layer, right?

A. Those four papers we have discussed, the two Kim papers, the Ma paper and Choi, all used an electron injection layer in their OLED.

Q. And the structure you relied on, Diekmann doesn't have a separate electron injection layer, right?

A. No. In my opinion, an electron injection layer isn't necessary.

Q. What about Suzuki, is there a separate electron injection layer?

A. No, I don't think an electron injection layer is necessary there as well.

Q. So in the four structures with a separate electron injection layer, is lithium quinolate providing electron injection?

MR. LEE: Objection. Form.

THE WITNESS: So the Ma structure where lithium fluoride is being used as the electron injection layer, lithium fluoride is likely providing most of the injection benefit in that device by design.

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In the other three structures, lithium quinolate being used as an EIL, it could very well be assisting an injection. That's presumably why it might be used there, but it's hard to know what the balance might be between that layer and the doped ETL.

BY MS. ZHONG:

Q. Does a reaction between -- so there's a reaction from the deposit aluminum cathode, does that happen to the lithium quinolate if there is an intervening pure electron injection layer?

MR. LEE: Objection. Form.

THE WITNESS: So that's not something that I've -- if I had to consider because the combinations that I'm proposing would not have an EIL. So I haven't developed an opinion on specifically how much the doped ETL might be activated when there's an EIL present in the path.

BY MS. ZHONG:

Q. Do you know what Ma's device performance will be if it removed the lithium fluoride layer?

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MR. LEE: Objection. Outside the scope.

THE WITNESS: Let me just open Ma again.

So if lithium fluoride was simply removed from the device, what would be the performance be?

BY MS. ZHONG:

Q. Uh-huh.

A. I suspect it would be very similar.

Q. Have you done any experiments to verify it?

A. No, I haven't constructed Ma's device to verify that.

Q. And have you conducted an experiment to see what the effects would be if lithium quinolate is removed as an electron injection layer from Choi and the two Kim papers?

MR. LEE: Objection. Outside the scope.

THE WITNESS: I haven't carried out any experiments to look at that issue in Choi and the two Kim papers.

BY MS. ZHONG:

Q. And you do agree that Ma does not at

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least -- strike that.

And you agree that Ma does not expressly mention anything about increased electron density due to lithium quinolate doping in the electron transport layer, correct?

A. Ma attributes the increase in electron conductivity to the mobility effect that we've discussed earlier.

MS. ZHONG: So thank you very much. Dr. Holmes, I'll pass the witness.

MR. LEE: Let me just take 15 to check my notes and then go back on the record at 3:15 Central. Around there?

MS. ZHONG: Sure.

(A recess was taken.)

EXAMINATION

BY MR. LEE:

Q. So, Dr. Holmes, earlier today, you were asked by counsel whether you have cited any references in which Alq3 is used as an electron transport layer in a white light-emitting phosphorescent OLED; do you recall that that?

A. Yes, I recall that.

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Q. Does Diekmann, which is Exhibit 1004, teach a white light-emitting phosphorescent OLED?

(Exhibit 1004 was identified.)

THE WITNESS: Yes, Diekmann does.

BY MS. LEE:

Q. And does Diekmann teach Alq3 as an electron transport layer?

A. That's one of the electron-transport materials in Diekmann as an ETL, yes.

Q. And does Suzuki, which is Exhibit 1006, teach a white light-emitting phosphorescent OLED?

A. Yes. Suzuki is also teaching a white device --

Q. And does Suzuki teach Alq3 as electron transport layer?

A. I'll just go back to Suzuki and double-check.

Yes, Suzuki also teaches Alq3 as electron-transport material.

MR. LEE: Those are all the questions I have. Thank you, Dr. Holmes. I'll repass the witness.

EXAMINATION

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BY MS. ZHONG:

Q. Dr. Holmes, does Diekmann expressly combine Alq3 with the materials you cited in your paragraph 104 of the original declaration?

A. So I'll go and consult my original declaration.

So in paragraph 104 and 105, I am referring to the emissive layers that Diekmann is proposing.

In paragraph 91 of Diekmann, Diekmann describes the hole transporting side of the device on the emissive layer.

Q. So for that particular structure, you're (indecipherable) --

(The Court Reporter requested clarification.)

BY MS. ZHONG:

Q. So for the specific structure you're relying on in your original declaration, nothing expressly states the particular structure you're relying on is using an Alq3 as the electron transport layer; is that correct?

A. Paragraph 91 doesn't list any electron transport layer, but Diekmann does list Alq along with Blq and TPBi as possible

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electron transport layers.

Q. Okay. In your original declaration, you never analyzed whether Alq3 can be used as an electron injection layer for the white light, correct?

A. I did not analyze whether Alq can be use as electron injection layer in my original declaration.

Q. And the same for Suzuki, correct?

A. I didn't analyze Alq as an electron injection layer in Suzuki.

Q. So in Suzuki, if you pull up Exhibit 1006, it's in the Dropbox.

(Exhibit 1006 was identified.)

THE WITNESS: Yes, I have it.

BY MS. ZHENG:

Q. Go to paragraph 333, that will be PDF page 49.

A. I'm getting there.

Okay. I'm there.

Q. Okay. That is a paragraph where Suzuki mentioned its electron transport layer was a high-end in nature, doped with impurities, that's a paragraph where it's talking about what you believe is to be the

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n-doped transport layer; is that correct?

MR. LEE: Objection. Misstates testimony.

THE WITNESS: In paragraph 333, Suzuki is talk about n-doped electron transport layer.

BY MS. ZHONG:

Q. And Suzuki cited some specific references there, correct?

A. There's several references in that paragraph.

Q. Do any of them use aluminum Q3?

A. I didn't consult the Japanese patent references.

Q. You did or you did not? Sorry?

A. I did not.

Q. Okay.

A. The Journal of Applied Physics Paper is one of my exhibits by He and it uses BPhen, if memory serves me.

Q. Okay. So in the examples that Suzuki mentioned to have the n-doped electron transport layer, the specific example you're able to locate is using BPhen, not aluminum Q3; is that correct?

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MR. LEE: Objection. Misstates the reference.

THE WITNESS: So I guess I want to make sure I understand the question that you're asking or can you restate that?

BY MS. ZHONG:

Q. Sure.

So in Suzuki, the paragraph 333 that describes the supposedly n-doped electron transport layer, the only specific reference of the electron transport layer that's suitable for electron doping is in the He paper and that's used BPhen and not aluminum Q3; is that correct?

MR. LEE: Objection. Misstates reference.

THE WITNESS: The He paper uses BPhen, but I think that's an overly narrow reading of what Suzuki is showing there.

As I show in my declaration and I think I comment in my reply declaration as well, at this point in time, many ETLs and many dopants have been combined successfully in OLEDS, including in phosphorescent devices.

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And so I don't read paragraph 333 as specifically pointing only to BPhen.

BY MS. ZHONG:

Q. Have you cited any single example where aluminum Q3 is used in white lighting, expressly as such?

A. So in both Diekmann and Suzuki, it is one of the possible electron transport layers that can be utilized.

Q. Not the question I'm asking.

A. Okay.

Q. Do you have any specific example, an expressively disclosed device, white lighting device that uses aluminum Q3, do you cite any single one such example?

A. I don't cite a single example in that way.

Q. Okay. So you don't have a single example of a white lighting device that expressly uses aluminum Q3; is that correct?

MR. LEE: Objection. Misstates the testimony.

THE WITNESS: In the exhibits that I'm presenting, I don't have a white light-emitting device outside of Diekmann

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and Suzuki that has an explicit structure with an Alq ETL. However, that doesn't prevent the use of Alq as a doped ETL especially since Diekmann --

(The Court Reporter requested clarification.)

THE WITNESS: I don't know if I said "exclusive," but that it has an Alq ETL.

And what I was going to continue to say is that that doesn't prevent the use of an n-dope Alq layer as the ETL, especially given the prior art that -- as a multitude of examples of blocking layer devices and that Diekmann also has that and so does Suzuki in their structure.

BY MS. ZHONG:

Q. Okay. Can you point me to where Diekmann discloses a complete device structure where aluminum Q3 where is used for white lighting?

A. So Diekmann doesn't disclose a complete structure in the way you're asking.

Q. Okay. And Suzuki doesn't describe such a structure either, correct?

A. In both of these patents, there's a

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large number of possible materials that could be combined to make the stated device.

MS. ZHONG: Okay. I don't have any further questions. Thank you very much.

MR. LEE: Nothing for me either. So I think we can go off the record and, maybe there's more spellings we can resolve while we are here.

THE COURT REPORTER: I'm off the record.

(The deposition of RUSSELL HOLMES concluded at 1:46 p.m. Pacific Daylight Time.)

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DEPOSITION ERRATA SHEET

Our Assignment No. 7567672

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DECLARATION UNDER PENALTY OF PERJURY

I declare under penalty of perjury that I have read the entire transcript of my deposition taken in the above-captioned matter or the same has been read to me, and the same is true and accurate, save and except for changes and/or corrections, if any, as indicated by me on the DEPOSITION ERRATA SHEET hereof, with the understanding that I offer these changes as if still under oath.

Signed on the _____ day of _____ 20___.

_____

RUSSELL HOLMES

Subscribed and sworn to on the ____ day of _____ 2025 ____ before me.

_____

Notary Public, in and for the State of

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C E R T I F I C A T E

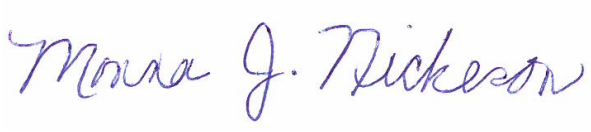
I, MONNA J. NICKESON, CCR, CSR, CLR, RPR, CRR, the undersigned Certified Court Reporter, authorized to administer oaths and affirmations in and for the states of Washington (3322), Oregon (16-0441), Idaho (1045), and California (14430), do hereby certify:

That the sworn testimony and/or proceedings, a transcript of which is attached, was given before me at the time and place stated therein; that the witness was duly sworn or affirmed to testify to the truth; that the testimony and/or proceedings were stenographically recorded by me and transcribed under my supervision. That the foregoing transcript contains a full, true, and accurate record of all the testimony and/or proceedings occurring at the time and place stated in the transcript.

That I am in no way related to any party to the matter, nor to any counsel, nor do I have any financial interest in the event of the cause.

IN WITNESS WHEREOF I have set my hand on

September 4, 2025



MONNA J. NICKESON, CCR, CSR, CLR, RPR, CRR

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KEE LEE

Kylee@cov.com

September 4, 2025

RE: Samsung Display Co., LTD. v. Pictiva Displays International

9/3/2025, Russell J. Holmes, Ph.D, (#7567672).

The above-referenced transcript has been completed by Veritext Legal Solutions and review of the transcript is being handled as follows:

__ Per CA State Code (CCP 2025.520 (a)-(e)) – Contact Veritext to schedule a time to review the original transcript at a Veritext office.

_XX_ Per CA State Code (CCP 2025.520 (a)-(e)) – Locked .PDF Transcript - The witness should review the transcript and make any necessary corrections on the errata pages included below, notating the page and line number of the corrections. The witness should then sign and date the errata and penalty of perjury pages and return the completed pages to all appearing counsel within the period of time determined at the deposition or provided by the Code of Civil Procedure. Contact Veritext when the sealed original is required.

__ Waiving the CA Code of Civil Procedure per Stipulation of Counsel - Original transcript to be released for signature as determined at the deposition.

__ Signature Waived – Reading & Signature was waived at the time of the deposition.

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__ Federal R&S Requested (FRCP 30(e)(1)(B)) – Locked .PDF Transcript - The witness should review the transcript and make any necessary corrections on the errata pages included below, notating the page and line number of the corrections. The witness should then sign and date the errata and penalty of perjury pages and return the completed pages to all appearing counsel within the period of time determined at the deposition or provided by the Federal Rules.

__ Federal R&S Not Requested - Reading & Signature was not requested before the completion of the deposition.

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Samsung Display Co., LTD. v. Pictiva Displays International

Russell J. Holmes, Ph.D (#7567672)

E R R A T A S H E E T

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(Russell J. Holmes, Ph.D) Date

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California Code of Civil Procedure

Article 5. Transcript or Recording

Section 2025.520

(a) If the deposition testimony is stenographically recorded, the deposition officer shall send written notice to the deponent and to all parties attending the deposition when the Original transcript of the testimony for each session of the deposition is available for reading, correcting, and signing, unless the deponent and the attending parties agree on the record that the reading, correcting, and signing of the transcript of the testimony will be waived or that the reading, correcting, and signing of a transcript of the testimony will take place after the entire deposition has been concluded or at some other specific time.

(b) For 30 days following each notice under subdivision (a), unless the attending parties and the deponent agree on the record or otherwise in writing to a longer or shorter time period, the deponent may change the form or the substance of the answer to a question, and may either approve the transcript of the deposition by signing it, or

refuse to approve the transcript by not signing it.

(c) Alternatively, within this same period, the deponent may change the form or the substance of the answer to any question and may approve or refuse to approve the transcript by means of a letter to the deposition officer signed by the deponent which is mailed by certified or registered mail with return receipt requested. A copy of that letter shall be sent by first-class mail to all parties attending the deposition.

(d) For good cause shown, the court may shorten the 30-day period for making changes, approving, or refusing to approve the transcript.

(e) The deposition officer shall indicate on the original of the transcript, if the deponent has not already done so at the office of the deposition officer, any action taken by the deponent and indicate on the original of the transcript, the deponent's approval of, or failure or refusal to approve, the transcript. The deposition officer shall also notify in writing the parties attending the deposition of any changes which the deponent timely made in person.

(f) If the deponent fails or refuses to approve the transcript within the allotted period, the

deposition shall be given the same effect as though it had been approved, subject to any changes timely made by the deponent.

(g) Notwithstanding subdivision (f), on a seasonable motion to suppress the deposition, accompanied by a meet and confer declaration under Section 2016.040, the court may determine that the reasons given for the failure or refusal to approve the transcript require rejection of the deposition in whole or in part.

(h) The court shall impose a monetary sanction under Chapter 7 (commencing with Section 2023.010) against any party, person, or attorney who unsuccessfully makes or opposes a motion to suppress a deposition under this section, unless the court finds that the one subject to the sanction acted with substantial justification or that other circumstances make the imposition of the sanction unjust.

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VERITEXT LEGAL SOLUTIONS

COMPANY CERTIFICATE AND DISCLOSURE STATEMENT

Veritext Legal Solutions represents that the foregoing transcript is a true, correct and complete transcript of the colloquies, questions and answers as submitted by the deposition officer. Veritext Legal Solutions further represents that the attached exhibits, if any, are true, correct and complete documents as submitted by the deposition officer and/or attorneys in relation to this deposition and that the documents were processed in accordance with our litigation support and production standards.

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