UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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SAMSUNG DISPLAY CO., LTD.,

Petitioner,

v.

PICTIVA DISPLAYS INTERNATIONAL LTD.,

Patent Owner.

_____

Case No. IPR2024-01095

Patent No. 11,828,425

_____

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Washington, D.C.

Thursday, April 24, 2025

Deposition of RUSSELL J. HOLMES, Ph.D., a witness herein, called for examination by counsel for Patent Owner in the above-entitled matter, pursuant to notice, the witness being duly sworn by MARY GRACE CASTLEBERRY, a Notary Public in and for the District of Columbia, taken at the offices of Covington, 850 10th Street, N.W., Washington, D.C., at 9:05 a.m., Thursday, April 24, 2025, and the proceedings being taken down by Stenotype by MARY GRACE CASTLEBERRY, RPR, and transcribed under her direction.

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P R O C E E D I N G S

Whereupon,

RUSSELL J. HOLMES, Ph.D.,

was called as a witness by counsel for Patent Owner, and having been duly sworn by the Notary Public, was examined and testified as follows:

EXAMINATION BY COUNSEL FOR PATENT OWNER

BY MS. ZHONG:

Q. Good morning, Dr. Holmes.

A. Good morning.

Q. Can you state your name --

A. Russell Holmes.

Q. Can you please state your name for the record.

A. Russell Holmes.

Q. Thank you. You have submitted a declaration in this IPR2024-01095, is that correct, for the '425 patent?

A. That's correct, I have submitted a declaration for the '425 patent.

(Exhibit No. 1003 was identified for the record.)

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BY MS. ZHONG:

Q. And that is Exhibit 1003, is that correct?

A. Yes, my declaration is Exhibit 1003.

Q. I remember you testified last Friday that you spent about -- a total of 120 hours between the two proceedings. Is that correct?

A. Last Friday, I said I had spent at least 120 hours, yes. I've gone back and checked my time sheets and I've now spent I think about 170 hours across both cases.

Q. 170 hours across both cases?

A. Both cases, yes.

Q. That includes your preparation for the deposition, is that correct?

A. That includes everything I've spent on both cases. So writing, preparation, anything I've tracked my hours for, correct.

Q. Do you know -- subtracting the preparation time for the deposition, do you know how much time you've spent total?

A. I'd have to go back to my work sheets to actually know that number. So, no, I don't know that

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number unfortunately.

Q. Okay. Let me ask you a question. What is an electron injection layer?

A. In the context of an OLED, an electron injection layer is a layer of material at the cathode, electron transport material interface that's designed to improve electron injection from the cathode into the OLED.

Q. And what is an electron transport layer?

A. An electron transport material -- or electron transport layer is a material that, depending on its composition, could have a couple of functions. The most important function is that it takes electrons from the previous layer, which is the cathode or the electron injection layer of present, to the next layer in the stack, which might be the emissive layer, it might be an additional electron transport layer, but it's basically conducting electrons to the next layer in the stack.

In some instances, the electron transport layer might serve as both the electron injection layer and the electron transporting layer.

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Q. And when does a single layer serve both the purposes as an electron injection layer and an electron transport layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: In my declaration, I discuss instances which you described. When an electron transport material is doped, it can serve the function of electron conduction and then it also can favorably improve injection from the cathode into the OLED as well.

BY MS. ZHONG:

Q. So let's talk about a layer that is doped with an alkaline metal. Do you have that in mind, an electron transport material that's doped with an alkaline metal.

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. And how does that alkaline metal helps with electron injection?

A. So I think you might be crossing terms there. You asked about an electron transport material doped with an alkaline metal and then asked

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specifically about injection. So not the conduction, just the injection portion of the function of that layer?

Q. Let's take one step back. Let's say there is a material that's doped with Lithium.

A. Okay.

Q. And do you consider that to be an electron injection layer or electron transport layer?

A. What is the material being doped with Lithium? Can you offer some additional specificity there?

Q. What are some of the materials you're aware of being used in OLED that is doped with alkaline metals?

A. Well, I guess I'll draw the attention to one of my exhibits which is Ma where the electron transport material Bphen is being doped with an alkaline metal like, you know, Lithium or Lithium complex or some of the other exhibits from He where an electron transfer material Bphen is doped with an alkaline metal like cesium. So those would be some examples. So Bphen could be an example of a suitable

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electron transport material doped with an alkaline metal.

Q. So let's start with Bphen. For Bphen doped with cesium or Lithium, does that serve the purpose of an electron injection layer?

A. No. Bphen doped with cesium or Lithium is the electron transport layer. It's just been doped and typed. But the point is is that because of the way it's being doped, you're increasing the conductivity and you're also increasing the ability to inject into that layer. So it's not an electron injection layer. It's just that that layer is also capable of improving electron injection.

Q. And how does it help -- how does the addition of the alkaline metal help with the electron injection?

MR. WEIDENFELLER: Objection.

THE WITNESS: In general, the addition of an alkaline metal will help the conductivity in the layer as an electron transport layer that's been n-doped. And then there's a variety of different ways that doping can also help electron injection,

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but notably the injection barrier is being impacted in some favorable way.

BY MS. ZHONG:

Q. How is the injection barrier affected in some favorable way by adding, for example, cesium or Lithium in the metal?

A. So again, I think that depends on the dopant and the material being doped and the cathode ultimately being utilized as well. But again, I think what I would say is that you're reducing the magnitude of the electron injection barrier and hence making it easier for electrons to be injected into the OLED.

Q. And let's take the Bphen, the cesium of Bphen and Lithium as an example.

A. Okay.

Q. And how does that reduce the injection barrier?

MR. WEIDENFELLER: Objection.

THE WITNESS: So the specific mechanism and the specific details of that interaction beyond what I've already said, which is that functionally

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the electron barrier is reduced, are not things that I considered in detail in preparing my opinions for this case.

BY MS. ZHONG:

Q. What about instead of using a Lithium metal, you used a neutral molecule --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- when doping. Do you have that in mind?

A. Can you give me an example of what you're referring to?

Q. So one of the -- the compound that we will be talking about, and it's cited in the '425 patent, is a Lithium Q or Lithium quinolate, correct?

A. Yes, I'm aware.

Q. So if you dope, let's say, Bphen with Lithium Q, does it help with reducing the injection barrier?

(Exhibit No. 1010 was identified for the record.)

THE WITNESS: So I'm going to rely on the exhibits I consulted to render my opinion today.

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Looking specifically at Ma, so this is Exhibit 1010, Ma actually does dope Bphen with Liq. But in Ma's device, it's not obvious if it's also improving injection because Ma is also utilizing a separate electron injection layer of Lithium fluoride. And that's actually intentional because that allows the focus of the doping to really be on the conductivity rather than on the electron injection portion of the device.

BY MS. ZHONG:

Q. Okay. Besides Ma, did you cite another document where the electron transport layer is doped with Lithium Q?

A. I did not cite any other documents where the electron transport layer is explicitly doped with Liq.

Q. Are you aware of any system at the time of the invention where the electron transport layer was doped with Lithium Q besides the Ma system?

A. I'm aware of prior work from the Kido Group, Yamagata University doping Liq, but it is not work that I examined closely for the purposes of my

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opinion.

Q. And you did not cite it?

A. No, I did not cite it.

Q. Do you know what electron transport material was the Kido Group using?

A. I don't recall off the top of my head.

Q. So besides the Kido Group and the Ma group work, were you aware of any other systems?

A. I'm aware of other instances where Liq is certainly being utilized prior to the date of the '425. And so, again, the example I'll point to is the exhibit by Liu where Liq is actually being utilized as an electron injection layer as a neat material. So this is Exhibit 1018. So that's an earlier reference utilizing Liq as an EIL in an OLED.

(Exhibit No. 1018 was identified for the record.)

BY MS. ZHONG:

Q. But that layer is using pure on neat Liq, correct? The Liq is not used as a dopant into another material.

A. Liq is not being used as a dopant in that

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exhibit.

Q. So let me be more specific. Besides in the Kido Group, were they -- strike that.

Was the Kido Group also using Lithium Q as a neat material or a pure film or was it using Liq as a dopant into another material?

A. The prior work that I'm thinking of is Liq being used as a dopant into another material.

Q. But you don't recall what material --

A. I don't recall.

Q. -- was --

A. I don't recall the electron transport layer that Quito was using.

Q. Okay. In Quito's work, do you recall whether they used a separate electron injection layer?

A. I don't recall that detail of Quito's work.

Q. And do you recall in Quito's work what kind of emission system were they using?

MR. WEIDENFELLER: Objection.

THE WITNESS: Unfortunately, I don't

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recall the details of what the emitter was in Quito's work.

BY MS. ZHONG:

Q. Do you recall whether that emitter was a fluorescent emitter or was it a phosphorescent emitter?

A. As I noted already, I don't recall what the specifics of the emissive layer were in that particular work.

Q. Was there a particular reason why you relied on Ma?

A. So what I found useful about Ma was that Ma again was focusing specifically on the electron transport material and the conduction aspect of the doping. And so because Ma uses an injection layer of Lithium fluoride, it allows the effect of the doping to be more directly tied to the conductivity of electrons in the electron transport layer.

I also felt that the device data in Ma was compelling as well, showing optimization with doping, showing electron-only devices. And so for me looking at Ma as a person skilled in the art, there'd be a

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reason to combine Ma and expect success whether combining with Diekmann or Suzuki, the two primary references I'm using for my opinion.

Q. Did you look at Ma yourself?

A. Ma was provided to me by counsel to consider.

Q. What about Suzuki or Diekmann?

A. Again, I don't remember exactly who provided what in terms of which references were mine and which came from counsel, but I think Diekmann and Suzuki were provided to me.

Q. Now, in Diekmann, Diekmann mentioned three specific electron transport materials, correct?

A. Is there a particular place in Diekmann that you want to point me in describing the three materials you're referring to?

Q. Why don't you go to page 8 and the original page 5. So if you look at the lower right-hand column, there is a page number, for example, but at the top there is another page number.

A. So I have the translation of Diekmann, so I assume you mean page 5, then?

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Q. The original page 5.

A. Yeah, original page 5. Got it. Eight out of 261, yeah. I'm on the same place as you. Fine.

Q. In the second paragraph starting with, "For example, the electron conducting layer," do you see that?

A. I see that paragraph.

Q. And do you see that for the electron conducting layer, Diekmann mentions three materials in particular?

A. Yes, I see that.

Q. And one of the materials is aluminum Q3, correct?

A. Yes, I see that.

Q. And the second one is BAlq, is that correct?

A. I see that.

Q. And the third one is TPBi, correct?

A. Yes, that's correct.

Q. Do you know what is a triplet energy for the aluminum Q3 or Alq 3?

A. I don't off the top of my head know the

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triple energy for Alq 3.

Q. Is it higher -- is it sufficient to confine the triplet energy, for example, for iridium (ppy)3?

MR. WEIDENFELLER: Objection.

THE WITNESS: So are you asking if it has a higher triplet energy than Ir (ppy)3?

BY MS. ZHONG:

Q. Correct.

A. Again, I don't know what the triplet energy of Alq 3 is, so I would be speculating on what that precise alignment might be.

Q. So you did not look into that?

A. I certainly considered questions related to architecture and material selection, but I didn't look specifically at what the triplet energy of Alq 3 would be in a device.

Q. Do you know approximately based on your work where the triplet energy for the Alq 3 is?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I wouldn't want to approximate a number without consulting the

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literature and finding what the precise number might be.

BY MS. ZHONG:

Q. Do you know what is triplet energy level for BAlq?

A. I don't know the precise triplet energy for BAlq.

Q. Do you know whether it's at a level that they can find the triplet energy for the iridium (ppy)3?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, as of the case of Alq 3, if I don't know the precise energy level, it's challenging for me to comment whether or not it will confine the triplet energy of Ir (ppy)3.

BY MS. ZHONG:

Q. I was just wondering whether you know the relative energy levels between those two molecules.

A. Well, again, even though I know relative energy levels, I'd need to know something about what the actual energy level of BAlq is. So I -- you know, you're asking from a relative perspective. I

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don't know how to assign even a relative number to that in terms of the alignment without knowing what they are.

Q. So you don't have a sense of like which one is higher, which one has a higher triplet energy --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- between the iridium (ppy)3 and BAlq, is that right?

MR. WEIDENFELLER: Objection.

THE WITNESS: For BAlq, no, I don't know if they're similar or if one is slightly lower or if one is slightly higher. No, I don't actually know that off the top of my head.

BY MS. ZHONG:

Q. Okay. What about TPBi. How is its triplet energy compared to the iridium (ppy)3?

A. So I don't know the specific triplet energy of TPBi, but TPBi is routinely used as an electron transport material in phosphorescent OLEDs. And so there I suspect its triplet energy is higher

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than Ir (ppy)3.

Q. Are you aware of any literature where TPBi was doped with Lithium Q?

A. No, I'm not aware of a specific paper where TPBi has been doped with Liq.

Q. Do you know what is the tendency for Lithium liberation or Lithium dissociation when -- let me withdraw and ask.

Let's go to your declaration. Why don't we go to your description of Diekmann on page 45, paragraph 68.

A. Okay. I see it.

Q. And in paragraph 68, and it's on page 46 of the declaration, you have reproduced figure 2A of Diekmann, correct?

A. Yes. Top of 46, yes.

Q. And figure 2A is the configuration you rely on in your analysis as to why Diekmann renders '425 obvious, correct?

A. Yes, that's the embodiment of Diekmann that I'm using.

Q. And in particular, you are relying on

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layer 402 as the n-doped electron transport layer, is that correct?

A. That's correct.

Q. And your position is that it would be obvious to use a Lithium Q doped layer 402 in this configuration, this figure 2A configuration of Diekmann, right?

A. My position is that a person of skill in the art would see it obvious to replace the existing N type dopant in 402 that Diekmann already describes with Liq. Liq would be the dopant.

Q. And in this figure 2A, layer 402 is immediately next to the cathode 3, is that correct?

A. It is next to the cathode. But as Diekmann notes, that it necessarily does not have to be next to the cathode. It certainly can be next to the cathode, but it does not necessarily have to be next to the cathode. But it is next to the cathode in figure 2A.

Q. And in figure 2A, let's say you are correct, a person of ordinary skill in the art would dope 402 with Lithium Q. And when you deposit

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cathode directly on top of it, do you know whether any Lithium will be liberated?

MR. WEIDENFELLER: Objection.

THE WITNESS: So all I can state on that point is referring back to Liu, which is an exhibit I already mentioned earlier. Liu shows that Liq can release or can be dissociated upon metal deposition. Whether or not that happens for Liq doped into an ETL of Diekmann, I -- it's hard to say.

BY MS. ZHONG:

Q. And is Lithium liberation a concern in a phosphorescent system?

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you be more specific in terms of what you mean by "is a concern"?

BY MS. ZHONG:

Q. So based on your experience, if Lithium atom or Lithium cation is liberated upon deposition of a cathode, what would be the generation of those Lithium atoms or cations be a concern to an OLED designer?

MR. WEIDENFELLER: Objection.

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THE WITNESS: No, not necessarily. For example, Lithium fluoride is routinely used as an electron injection layer in OLEDs. And one mechanism by which Lithium fluoride is thought to operate is that when aluminum strikes the Lithium fluoride, the Lithium fluoride is dissociated, which would lead to some Lithium release, as you're putting it, and then perhaps reaction with the surrounding matrix.

But the concern would not necessarily -- or the issue would not necessarily dissuade someone from applying Lithium or Lithium-based material as the EIL or the dopant in a transport layer because there's many examples of Lithium doped phosphorescent devices that work fantastically, that have very high efficiency. So no, I don't think it's a significant concern.

BY MS. ZHONG:

Q. So Lithium diffusion is not a concern?

MR. WEIDENFELLER: Objection.

THE WITNESS: So that's not quite the same question. You were asking is Lithium dissociation a concern in phosphorescent OLEDs. Bphen actually does

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note the potential issue associated with dopant diffusion, which is a general undesirable feature in an OLED with doping that needs to be certainly considered when designing the device. It's something that could be an issue for both fluorescence and phosphorescent OLEDs.

But if you look at the prior art that I cite extensively in my declaration, that was already a solved issue at the time of the '425 work by He and Pfeiffer and even work at Novaled had shown that the blocking layer that's typically included in a phosphorescent OLED allows the doped layer to be spaced from the emissive layer and reducing the concern related to dopant diffusion.

BY MS. ZHONG:

Q. Does Ma have an undoped blocking layer in its structure?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm just going back to Ma so I can reference their architecture accurately for you. So Ma's device architecture is one where the emissive layer in Ma is this 29-meter thick layer of

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Alq 3. There is not an additional layer between Alq 3 and Bphen doped with Liq. However, a person skilled in the art would realize that the interface between NPB and Alq 3 is where the emission originates.

NPB and Alq 3 is arguably the most famous bi-layer OLED that had ever been demonstrated, since it was the first, and the low hole mobility of Alq 3 prevents holes from passing far into Alq. And so even though Ma doesn't have an explicit blocking layer, a person skilled in the art would understand that the excitons in Alq are at the hole transport layer side of Alq such that the rest of that Alq layer is probably serving as a blocking layer or at least a spacer between the recombination zone and the N type Bphen layer.

So while there isn't an explicit blocking layer, I think that functionality is actually built into Ma's device architecture.

BY MS. ZHONG:

Q. Does Ma show results where they have an Liq doped Bphen layer plus an undoped Bphen layer?

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A. Are you asking do they compare devices where in one case you have an Liq doped Bphen layer and in other cases where you don't have an Liq doped Bphen layer? Like doped versus undoped?

Q. I'm talking about whether they have compared -- strike that. Whether they have any device performance data for a structure where they have a bi-layer -- electron transport layer where the bi-layer being you have the Alq doped Bphen plus an undoped Bphen --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- versus a referenced structure where you only have an undoped Bphen.

MR. WEIDENFELLER: Objection.

THE WITNESS: So I think I understand what you're asking but, I'll just make sure. So you're asking do they have a device where they -- so looking at the first column on page 811 where they have their architecture, a comparison where they only have 50 nanometers of Bphen between Alq and Lithium fluoride versus a structure where they have undoped Bphen

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followed by doped Bphen?

BY MS. ZHONG:

Q. My understanding is that when you have a blocked layer as in Liu -- not in Liu. In He.

A. Oh, yeah. Right.

Q. Usually it's cathode. You may or may not have electron injection layer, then you have doped Bphen layer, then you have an undoped Bphen layer, then you have the emission layer, is that correct?

A. That's correct in He, but that need not be the only way to realize a blocking layer. The blocking layer doesn't have to be undoped electron transport layer. But in He, yes, in He the blocking layer is the undoped electron transport layer and then it's followed by the doped electron transport layer.

Q. Does Ma have any -- did Ma make any device where it has -- let's just call that -- let's take one step back. Let's call that structure where you have a doped Bphen layer next to an undoped Bphen layer, let's just call that a bi-layer structure for discussion. Is that okay?

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A. For the purposes of this discussion, we can call it that.

Q. Okay.

A. A bi-layer electron transport layer. I'm not committing beyond that. But, yes, for this discussion, I understand where you're going.

Q. Okay. So does Ma have any performance data for this bi-layer electron transport structure --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- compared to one where you basically have an undoped Bphen layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: To my knowledge, Ma does not show an architecture where there is an undoped layer of Bphen followed by a doped layer of Bphen in the way that He does and in the way that you're describing.

This said, I cite extensively the prior literature on doping in phosphorescent OLEDs in my declaration and it was well-known at the time of the

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'425 how to realize efficient phosphorescent OLEDs based on P and N type doped transport layers with blocking layers.

So a person skilled in the art would certainly look at Ma and either interpret it in the way where I am, where part of that Alq layer is serving as a spacer layer or blocking layer, or would look at that transport layer and realize they could implement He's type of structure as well.

BY MS. ZHONG:

Q. You brought up a pretty good question. Alq 3 is not a phosphorescent system, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: Alq 3 at room temperature emits fluorescence.

BY MS. ZHONG:

Q. And in the normal OLED operating temperature, is Alq 3 considered to be a fluorescent OLED system?

A. Alq 3 would be considered a fluorescent material.

Q. The Diekmann emission system is different

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from Alq 3, right?

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. Let me put it this way. The specific Diekmann emissive layer that you're relying on is not Alq 3, correct?

A. I am not relying necessarily on Alq 3 being an emitter in Diekmann.

Q. Okay. Let's go to your declaration page 62 where you are analyzing element 1F.

A. Okay. I am there.

Q. So in paragraph 104, you pointed out a very specific emission system for Diekmann, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: In paragraph 104, I point out what Diekmann describes as their radiation emitting regions.

BY MS. ZHONG:

Q. And that is the radiation emitting region you are relying on for element 1F, correct?

A. That is the radiation emitting region I'm relying on for the embodiment of Diekmann, yes.

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Q. Do you know what is SEB-010?

A. When you say do I know, do you mean specifically do I know what the molecule is?

Q. Do you know what the material is?

A. I don't know what that material is. It's, I assume, a proprietary material.

Q. And do you know what SEB-020 is?

A. Again, that's a proprietary material. I don't know the specific architecture of that particular molecule. But what I do know is that that combination of presumably a host and guest would give blue light emission.

Q. Do you know what is TMM-004?

A. I have to assume it's a host, but I don't know specifically what it is because, again, I assume that's a proprietary material.

Q. Do you know what is TMM-04?

MR. WEIDENFELLER: Objection.

THE WITNESS: So that's the material I think you just asked me about in the context of the green emitting layer and I don't know what it is. That's, again, a proprietary material, I assume.

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BY MS. ZHONG:

Q. I think that for the green one, it's TMM-004 and for the red one, your citation only says TMM-04.

A. I'm looking at the following page as well. Let me just check to see if Diekmann -- if that's my issue or if that's Diekmann's issue.

Q. It's TMM-04, not 004.

A. For the red, yes. Yes, you're right. So, yep, that's right. So, no, I also don't know what the structure would be for TMM-04.

Q. And you also don't know what TER012 is either, right?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. Again, I assume these are all proprietary materials and so their structures are not in the open literature. I'm relying on the associated reference that I cite in Exhibit 1028, Klein, which further identifies these as blue, green and red-emitting emissive layers.

(Exhibit No. 1028 was identified for the record.)

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BY MS. ZHONG:

Q. But, for example, you don't know what their relative energy level is?

MR. WEIDENFELLER: Objection.

THE WITNESS: No, I don't know what the energetics of these materials.

BY MS. ZHONG:

Q. Is Lithium diffusion more of a concern -- strike that. Is Lithium diffusion a more serious concern for the phosphorescent system than for a fluorescent system?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I'll just start by answering that Lithium diffusion, while it can be an issue, was already a problem that was resolved and solved by the time of the -- or at least mitigated by the time of the '425 patent. And that's evidenced by prior work on phosphorescent doping by whether it's He, Pfeiffer or others from that group.

In terms of, again, whether it's a serious issue, Lithium diffusion or any metal diffusion into the emissive layer of an OLED would be a problem for

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singlets and triplets, fluorescent emitters and phosphorescent emitters. So in both cases, it's an issue.

BY MS. ZHONG:

Q. Is it more of a concern for the phosphorescent system because of the prevalence of the triplet energy level?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, I'll just highlight first that this was a problem that had already been resolved. Quenching issues in phosphorescent OLEDs were certainly of interest because of the fact that phosphorescent OLEDs have the potential to effectively be 100 percent internally efficient. And so there was interest in trying to make phosphorescent OLEDs that effectively at peak efficiency had virtually no loss associated with them.

So, you know, trying to mitigate things like quenching was part of trying to realize those ultrahigh efficiencies that came from phosphorescent OLEDs. But it was already known at the time that

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blocking layers were useful in phosphorescent OLEDs to combine the triplet and the emissive layer and then once doping was introduced to the community, it was found those blocking layers could also help to prevent dopant diffusion from making its way to the EML.

So I would make -- I just want to make sure it's clear that these issues are ones that were already mitigated or at least reduced by the time of the '425 patent.

BY MS. ZHONG:

Q. Now, the He system and the other system that you were referring to where they used a blocking layer, those were not with Lithium Q, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. The only exhibit I'm citing that uses Liq as a dopant is Ma.

BY MS. ZHONG:

Q. Okay. And Ma didn't use -- Ma didn't really show the performance of the bi-layer structure where you have one -- where the electron transport layer consists of a doped Bphen plus an undoped

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Bphen, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: As we already discussed, Ma doesn't examine a structure in which there's an explicit undoped Bphen layer between the Alq layer and the doped Bphen layer.

BY MS. ZHONG:

Q. Okay. And so instead of the Alq 3 emission layer, if you have a phosphorescent system, do you know where the emission would occur in that phosphorescent system?

MR. WEIDENFELLER: Objection.

THE WITNESS: It's hard to know just replacing Alq -- again, I think I need more specificity. So what exactly is the device architecture you'd like me to consider?

BY MS. ZHONG:

Q. The Diekmann architecture you relied on.

A. Oh, the Diekmann architecture, it already has a phosphorescent emitter. It's got Ir (ppy)3 in it.

Q. And where is the light generated?

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MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. Because you mentioned like in the Ma system, you believe that a light is generated at the interface between the NPB and Alq 3, correct?

A. In the Ma --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. Yeah.

A. In the Ma system, that's correct. That's what I said. In the Diekmann device, it's not -- it's harder for me to say exactly where the recombination zone will be without knowing more about the specifics of the other emissive layers that we've talked about. Those proprietary materials are ones where I don't necessarily know their energy levels and so I can't say with certainty whether the recombination zone will be on one side of the emissive side layer versus the other versus in the middle.

Q. And in fact, the -- strike that.

And if you look at paragraph 104, the way

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you're discussing it, it appears that it's a three-layer emissive layer structure, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: Paragraph 114 in my disclosure?

BY MS. ZHONG:

Q. 104.

A. Oh, 104. I'm sorry. I misheard you.

Q. Page 63.

A. Yeah, let me just refresh myself on that paragraph again. Yes, that would be multiple radiation emitting regions in Diekmann.

Q. And are they stacked on top of each other?

A. Yes. That would be the way to read what Diekmann is saying and so they would be stacked.

Q. Okay. And do you know whether -- so the iridium (ppy)3 or the phosphorescent layer would actually be sandwiched between the red and the blue, right?

THE REPORTER: I'm sorry, could you repeat that again? I missed the very beginning of the

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question.

BY MR. ZHONG:

Q. Okay. Let me restate it. So the green phosphorescent emission layer will be sandwiched between the red emission layer and the blue emission layer, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I actually just want to go back to paragraph 91 of Diekmann just to make sure I'm clear on that aspect of it. Just give me one moment, please.

Yes, the way that embodiment is described is the iridium (ppy)3 containing layer is between the blue and the red emissive layers.

BY MS. ZHONG:

Q. So there will be a hole electron recombination in the red emission layer as well, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: There would be exciton recombination in the red emitting layer as well.

BY MS. ZHONG:

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Q. And in the prior art, in order to address the Lithium diffusion issue, there's usually an undoped blocking layer between the phosphorescent emission layer and the doped electron transport layer, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So in the prior art in the context of the other exhibits showing doping of phosphorescent devices, there is a blocking layer. But that's also true in general of phosphorescent OLEDs. There is frequently a blocking layer adjacent to the emissive layer. So it's not exclusively in the context of just doping. That's something in general that you find in phosphorescent OLEDs.

BY MS. ZHONG:

Q. And that what you call a blocking layer is usually undoped, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: What I'm referring to as a blocking layer is usually undoped.

MS. ZHONG: Can we take a five-minute break?

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THE WITNESS: That sounds good. Five minutes.

(Recess.)

BY MS. ZHONG:

Q. So we were discussing Bphen doped electron transport layer before the break. Is Lithium Q a neutral molecule?

MR. WEIDENFELLER: Objection.

THE WITNESS: My understanding is Lithium Q is a neutral molecule. It's not something I considered deeply in my analysis of Ma. But, yeah, my understanding is Lithium Q is a molecule.

BY MS. ZHONG:

Q. Do you consider Lithium Q to be an n-dopant?

A. Ma teaches it as an n-dopant, which is what I'm basing my opinion on. So, yes, I consider Liq to be an n-dopant.

Q. And what is the definition of an n-dopant?

A. So I think a person skilled in the art would define an n-dopant as a dopant that increases the conductivity of an electron transport material.

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Q. So if the improvement in the electron conductivity is through the improved electron mobility rather than the increase in the number of electrons, do you still consider that to be n-dopant?

MR. WEIDENFELLER: Objection.

THE WITNESS: By the definition I just offered, then, yes. And that's the definition I'm applying in Ma as well where Ma is noting, based on their data, that there does appear to be an increase in mobility. So yes.

BY MS. ZHONG:

Q. Ma does not say there is an increase in the number of electrons, does it?

MR. WEIDENFELLER: Objection.

THE WITNESS: Ma specifically focuses on the change in mobility and specifically via the improvement in hopping transport in the electron transport material.

BY MS. ZHONG:

Q. And you interpret the reference to the hopping rate to be an increase in the electron mobility, is that right?

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MR. WEIDENFELLER: Objection.

THE WITNESS: So the term "hopping" is how electrical transport is described in disordered organic thin films like Bphen or the other materials we're discussing here. And so I'm looking at the term "electron hopping" as essentially transport in that electron transport material.

BY MS. ZHONG:

Q. Isn't it the case that in the case of n-doping, you are looking at the HOMO level of the dopant and the LUMO level of the acceptor and see where there's a match?

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you just rephrase that again, please?

BY MS. ZHONG:

Q. Sure. When you discussed doping and organic material and doping and inorganic material, you usually examine the ionization potential of the dopant and the electron affinity of the acceptor, is that correct?

MR. WEIDENFELLER: Objection.

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THE WITNESS: If you're looking at electron or n-doping in an organic thin film, energy alignment is one thing that you might consider.

BY MS. ZHONG:

Q. Yeah. And the energy alignment that you consider is the ionization potential of the dopant and the electron affinity of the acceptor or the doped material, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So is there a specific mechanism you're trying to point to in specifically calling out those energy levels?

BY MS. ZHONG:

Q. I'm just asking is that the general understanding of how the n-doping occurs?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I've already defined what n-doping and n-dopant mean and it's in the context of what the conductivity of the electron transport material is. And I guess I need to better understand what you're asking about, what you're referring to to answer your question more effectively.

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(Exhibit No. 2100 was identified for the record.)

BY MS. ZHONG:

Q. Let me put a document into the Dropbox. Can you please refresh your Dropbox link and see whether you see an Exhibit 2100.

A. Yes, I see the exhibit.

Q. Can you please open it up. And for the record, Exhibit 2100 is U.S. Patent Number 7,911,129.

A. I have it open.

Q. And the title of the patent is Arrangement for an organic pin-type light-emitting diode and method for manufacturing. And it's by -- it's assigned to Novaled.

A. Yes, I see it's assigned to Novaled.

Q. And can you please go to column number 10. And in particular, can you look at column 10, lines 46 to the end of that paragraph.

A. Okay. Let me just read the whole paragraph.

Q. Sure.

A. Okay. I've read the paragraph.

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Q. And can you also read the paragraph in column 10, line 61 through 64.

A. Okay. I've read that paragraph as well.

Q. So the disclosures in column 10, lines 46 to 60 is discussing the energy level alignment for n-doping in organic materials, is that correct?

A. It's discussing the energy level alignment for n-doping -- I'm just reading their language again. It's discussing the energy alignment for -- yes, for a mechanism to dope these particular materials via a specific energy alignment with the doping.

Q. Okay.

A. Or dopant.

Q. And according to this disclosure here, they seem to be suggesting that to dope an organic material with cesium, the electron affinity of that material to be doped should be above 1.9 eV, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you just point out the line to me again? I haven't previously reviewed this

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document. Lines 62 or 3?

BY MS. ZHONG:

Q. Column 10, line 61 to 64, for example. In particular, 63 to 64.

A. I see the sentence that says, "The following applies in the case of doping with cesium EA (O2) greater than 1.9," if that's what you're referring to.

Q. And EA refers to electron affinity, correct?

A. EA is defined in the previous paragraph as electron affinity.

Q. According to this disclosure here, for a molecular n-dopant, the electron affinity of the matrix should not drop below 0.5 eV of the ionization potential of the donor, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: What line specifically are you pointing to?

BY MS. ZHONG:

Q. Column 10, line 56 to 60. Then also take a look at 61 to 63.

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A. I see the sentence you're referring to regarding to molecular n-dopant.

Q. And according to that disclosure for the molecular n-dopant, the electron affinity of the matrix to be doped should be within 0.5 eV of the ionization potential of the donor, is that correct?

A. So --

MR. WEIDENFELLER: Objection.

THE WITNESS: I'll note that that's what that sentence says. I don't know what the broader context of the patent is because I haven't read it.

I'll also note that the doping being alluded to here in this patent is a doping by charge transfer. And as we've already discussed, the conductivity can be improved via charge carrier number or mobility. And in Ma, they're arguing based on their data that what's happening is an increase in the mobility of electrons in the electron transport layer.

BY MS. ZHONG:

Q. And you don't consider that to be a charge transfer?

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MR. WEIDENFELLER: Objection.

THE WITNESS: I don't have to make an assessment as to whether or not it's a charge transfer and I didn't go in detail to consider whether or not there was a charge transfer event in Ma, because all I needed from Ma was the fact that there's a favorable improvement in performance with an n-doping of Liq and Bphen.

And so for me, a person skilled in the art would already be using either Diekmann or Suzuki, which already have N type doping, see Ma's favorable performance with an alternate labeled N type dopant and understand that there'd be a potential benefit now and an expected improvement in some aspects of device performance by using Liq as the dopant in those other embodiments.

BY MS. ZHONG:

Q. I understand your position, but let's take -- let's see whether there's something that we can agree with. Do you agree that Liq is a molecular n-dopant?

MR. WEIDENFELLER: Objection.

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THE WITNESS: Liq, I agree, is a molecular n-dopant and that would be part of the motivation for a person skilled in the art to replace something like cesium as taught in Diekmann.

BY MS. ZHONG:

Q. Is Lithium fluoride a molecular n-dopant?

A. I haven't thought about whether or not Lithium fluoride is a molecular n-dopant, so I don't have an opinion on Lithium fluoride.

Q. According to this Exhibit 2100 and the disclosure in column 10, for example, lines 56 to 63 in particular, if Lithium Q improves the conductivity through charge transfer, then according to this document, its ionization potential should be normally 0.5 eV above the matrix that it wants to dope, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, since I haven't examined Exhibit 2100 in detail, I'm hesitant to render any further opinion on how it might apply to Liq or different molecules that aren't specifically noted in the paragraphs that you're calling out.

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BY MS. ZHONG:

Q. Okay. And it specifically mentioned the Bphen as the matrix material, correct, in column 50 to --

A. Fifty-one, yeah. Bphen is called out as a well-known, yes, electron transporter that could be doped.

Q. So they were thinking of like doping Bphen?

A. As I've already noted in reference to He, Bphen was a widely examined dopant by the group whose research eventually became Novaled.

Q. And in this particular paragraph, they mention that for a molecular n-dopant, for example, if they want to dope Bphen, then the electron affinity of the matrix should not be below the ionization potential of the donor minus 0.5 eV, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, I just want to make sure I know where you're pointing since I don't know this document. Can you again just tell me by

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line what you're referring to again with those energy levels?

BY MS. ZHONG:

Q. Line 56 to 63.

A. Okay. I see those energetic requirements.

Q. So you agree with the energetic requirements that are stated in the previous questions?

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you state what specifically from the previous questions you're asking me to agree with?

BY MS. ZHONG:

Q. Okay. So according to this document, if you use a molecular n-dopant of which Lithium Q is an example, then the electron affinity of the matrix such as Bphen should not be below the ionization potential of the donor less than 0.5 eV, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I think that might be an oversimplification of what a molecular n-dopant could

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be and how it could function. And so as I've already mentioned, in the context of Ma, n-doping simply means that the conductivity of the electron transport material is being improved. And what's being discussed in Ma with Liq is one mechanism to improve that conductivity and Ma's data supports that conclusion that Liq is a molecular n-dopant in Bphen.

What you're pointing at in this Novaled document -- and again, I can't make a broad generalization as to what this discloses because I've only read here a dozen or so lines -- is talking about charge transfer. And when you're saying for a molecular dopant, it must satisfy some specific energy alignment, that might be for the purposes of Novaled treating molecular n-dopant that's operating by charge transfer. But what I'm trying to stress is that's not the only way to dope material as is shown in Ma.

BY MS. ZHONG:

Q. Understood. But you have not reached a conclusion as to whether there is -- Ma dopes the Bphen through charge transfer or some other

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mechanism, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm only taking what Ma is describing in terms of their data. And Ma's position is that they think Bphen is likely improved due to mobility.

BY MS. ZHONG:

Q. And you don't think the factor that the mobility is improved or the LUMO/LUMO overlap is improved, that implies there was charge transfer?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm not taking any position on whether or not there's charge transfer in Ma because I don't think a person skilled in the art would need to see that in order to combine Ma with the other references that I'm forwarding regarding the '425. So I'm --

BY MS. ZHONG:

Q. I'll ask -- go ahead.

A. I'm looking at Ma's data and Ma's conclusions of the favorable impact of Liq as a dopant in Bphen on transport and on OLED performance

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and using that to make my assessment of whether or not a person would find it obvious to combine Ma with these other references and expect success.

Q. So you don't -- I'm asking a slightly different question.

A. Okay.

Q. Why don't we pull up Ma --

A. Sure.

Q. -- and go to page 813.

A. Okay. I'm looking at it.

Q. And Ma is, for the record, Exhibit 1010.

A. Yes.

Q. And I assume that you are referring to the first full paragraph in the right-hand column of page 813 when you say that Ma improves the conductivities through electron mobility or electron hopping, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: That's the paragraph that I'm referring to in my discussion here and also Ma's data as well showing the favorable improvement in current flow through the electron-only devices.

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BY MS. ZHONG:

Q. And based on those data and the explanation, can you infer when there is charge transfer between the Lithium Q and Bphen?

A. So before I answer your question, I'm just going to reread that paragraph and question.

Q. Sure.

A. So again, I'm relying on Ma's interpretation of the results and Ma does not appear to consider an increase in electron density due to a charge transfer interaction, but Ma doesn't also entirely exclude it as well.

Q. Can you draw a conclusion one way or the other whether there is charge transfer in Ma?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I didn't -- I certainly considered mechanism but didn't feel that that impacted my opinion. And so I don't think I have any further opinion to offer on whether or not there is or isn't charge transfer between Liq and Bphen in Ma. I'm relying on the fact that Ma is clearly showing an improved performance and an

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n-doping of Liq and Bphen and a favorable improvement in device behavior.

BY MS. ZHONG:

Q. Can you please go to Diekmann page -- original page 91.

A. I'm there.

Q. In the last paragraph, in particular the fifth line from the bottom, "The organic layer stack 4 has a doped layer 402" --

A. Yes, I see it.

Q. -- "with a dopant 410, which acts as an electron donor." Do you see that?

A. I see that.

Q. And is Lithium Q acting as an electron donor in Ma?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, as I just noted in Ma, Ma is arguing that Liq is improving the mobility of electrons in the transport material. Ma does not specifically prevent the interpretation that Liq might be a donor, but that's not what they're explicitly teaching.

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BY MS. ZHONG:

Q. Okay. So based on the maximum improvement, it does not imply that Liq is acting as an electron donor in particular?

A. So again, I want to be careful. I don't think Ma excludes that because it's not clear -- you know, so again, if I refer back to Liu, Liu teaches that Liq and subject to metal deposition has the ability to dissociate. Ma does not use that and does not consider that in detail in thinking about their conductivity. So in Ma's explanation, it would be more on the mobility side than on any sort of carrier increase aspect. But I don't think Ma's analysis necessarily would exclude that, but that's certainly not what they're focusing on in Ma.

Q. Okay. So is Lithium -- strike that.

So when Bphen or another electron conducting material is doped with an alkaline metal like Lithium and cesium, is Lithium or cesium acting as an electron donor?

A. So usually in the literature, an alkaline metal like Lithium or an alkaline metal like cesium

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would be considered as an electron donor as a dopant.

Q. What about Lithium fluoride. Is that considered to be an electron donor through the generation of Lithium?

A. I don't really -- I wasn't required and didn't really feel it impacted my decision in terms of what the mechanism for Lithium fluoride was. So I don't think I have a strong opinion to offer on Lithium fluoride here.

Q. What about for Lithium Q. Do you have an opinion --

A. So --

Q. -- that indicates -- let's not talk about Ma. Let's talk about Liu where Lithium Q is acting in an electron injection layer.

A. So Liu teaches that Liq as an electron injection layer does dissociate to some degree when it sees the metal deposition.

Q. And so it acts as an electron donor so at least through the dissociation into Lithium, is that right?

MR. WEIDENFELLER: Objection.

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THE WITNESS: I guess I wouldn't classify it to that degree necessarily. I think all Liu teaches is that Liq can dissociate. How -- what happens after that is not something I had to consider to make my opinion.

BY MS. ZHONG:

Q. Okay. In your opinion, in your expert opinion, is Lithium Q an electron donor?

MR. WEIDENFELLER: Objection.

THE WITNESS: I think I've already noted that my opinion on Lithium or on Liq is informed by Liu and is informed by Ma in the context of how I'm applying those prior art references with Diekmann and with Suzuki.

And so in the context of Ma, Liq is mainly serving to improve mobility. That's what Ma is arguing. And in the context of Liu, that's really a very different system because it's a neat film of Liq rather than doped into an electron transport material. So I don't have any further speculation to offer on what Liq may or may not be doing.

BY MS. ZHONG:

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Q. Okay. Let me ask it this way. Do you see any evidence in Ma that Lithium Q is acting as an electron donor?

A. Ma does not present Liq explicitly as an electron donor. But if Liq was an electron donor, again, that would only serve to help potentially as well. But I don't think a distinction needs to be made for a person skilled in the art to understand the advantages of applying Liq as a molecular n-dopant in the devices of Diekmann and Suzuki.

Q. Do any of the documents you cited present evidence that Lithium Q served as -- strike that.

Does any of the references you cited present evidence that Lithium Q acts as an electron donor?

MR. WEIDENFELLER: Objection.

THE WITNESS: So before answering your question, I want to just briefly review the two Liq-related references that I cite.

BY MS. ZHONG:

Q. Sure.

A. All right. Can you just reask your

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question, please?

Q. Okay. My question is, of the references that you cited, does any of them present evidence that Lithium Q serves as an electron donor?

MR. WEIDENFELLER: Objection.

THE WITNESS: So there's only two references I cite that discuss Liq. Ma does not strictly refer to Liq as a donor. Again, Ma suggests that the high conductivity of Bphen Liq may be originated from the short hopping life of the electron transport which is more of an argument for mobility, but I just want to emphasize that they are arguing that it may be originated and so it's certainly possible that other factors might be important.

In the context of Liu where Liq is being used as an electron injection layer, the mechanism between Liq and silver is thought to lead to Lithium generation, but they don't specifically qualify that as electron donor behavior.

(Exhibit No. 1006 was identified for the record.)

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BY MS. ZHONG:

Q. Can we go to Suzuki, Exhibit 1006, in particular, paragraph 333, PDF 49, original page 48.

A. Okay. Just give me a second. All right. You said paragraph, was it 338?

Q. 333.

A. Oh, I'm sorry, 333.

Q. So the first paragraph of that page.

A. Yes, of course. I know that sentence as well.

Q. And do you see the sentence, "In addition, an electron transport layer with a high N nature doped with impurities can also be used"?

Do you see that sentence?

A. I see that sentence.

Q. What does it mean by a high N nature doped with impurities?

A. So the terminology N nature is very unusual and I think might reflect the fact that this was a translation. But a person skilled in the art would read the sentence, "In addition, an electron transport layer with a high N nature doped with

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impurities can also be used," that would simply mean an n-doped electron transport layer.

Q. And when he said the high N nature, that means the dopant is acting as an electron donor, right, to increase the electron density in the material?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. All I'm saying is that that line means that basically in addition an n-doped electron transport layer can also be used, is the way that a person skilled in the art would interpret that sentence. So I'm just saying that N nature doped with impurities just means that whatever that dopant has done has led it to be N type increased conductivity for electrons consistent with how I described earlier.

BY MS. ZHONG:

Q. Do you know whether -- you did not submit patent application JP H4-297076 here, right?

A. No, I didn't submit that patent application.

Q. Did you review it?

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A. I did not review that patent application.

Q. And so you don't know what kind of system it is describing there, correct?

A. In that -- what I chose to focus on was the fact that examples include those described and there's these Japanese patents, but then there's also this peer-reviewed article, Journal of Applied Physics by He, that is one of the exhibits I cite in my declaration that clearly identifies with the definition I'm offering and the interpretation I'm offering of that sentence. So again -- go ahead.

Q. Go ahead.

A. No. I was just going to add that in that JP 2004, this is back to He doping Bphen with a dopant to increase conductivity which supports my interpretation of that first sentence.

(Exhibit No. 1019 was identified for the record.)

BY MS. ZHONG:

Q. And that peer-reviewed article is Exhibit 1019, correct?

A. I'm going to double-check that. That does

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sound correct, but just give me a moment. Yes, yes. 1019 by He.

Q. And the particular structure you're referring to is Bphen doped with cesium, correct?

A. What I'm -- that is the particular structure that He is looking at. But what I'm referring to more generally is just the fact that clearly an electron transport layer with high N nature doped impurities means an electron transport layer with a conductivity dopant is the way I'm referring to He, which I think is the way Suzuki is also referring to He.

Q. And we discussed earlier cesium was considered to be an electron donor, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: In the context of n-doping, cesium is usually considered as an electron donor.

BY MS. ZHONG:

Q. In the area of the semiconductor, when you talk about n-doping and p-doping, you are talking about the increase in the number of holes and the number of electrons, correct?

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MR. WEIDENFELLER: Objection.

THE WITNESS: Can you be a little more specific by what you mean by semiconductor? What type of semiconductor? Organic, inorganic? What are we --

BY MS. ZHONG:

Q. Let's talk about silicon.

A. Okay.

Q. That's the most prevalent semiconductor, right?

A. I agree.

Q. And when you do n-doping of silicon, you are basically increasing the electron density in that -- by introducing impurities into silicon to increase the electron density in the silicon, correct?

A. In a conventional inorganic semiconductor like silicon, usually an n-doped sample of silicon has a substitutional impurity that is donating an electron to the lattice.

Q. So you meant conventional inorganic semiconductor when you talk about n-doping, it's

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through the increase of the electron density in the silicon metals, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: In the context of doping an inorganic conventional semiconductor like silicon, that the impurities are normally there to add -- an N type impurity would be there to add an electron to the lattice.

I think it's really important to stress here, though, that doping in inorganic materials and doping in organic materials are two very different things. In an inorganic material, when a substitutional impurity is included, say, arsenic in silicon, that would be an N type dopant that would give you additional electrons.

One really important difference to start would be that, you know, you need very little dopant to effect a substantial change in conductivity. Doping in organic semiconductors is not nearly as efficient and the mechanisms are generally thought to be different. And so I would hesitate to draw too many parallels just in terms of verbiage to the

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conventional semiconductor literature.

BY MS. ZHONG:

Q. And do you know why the conducting mechanism in organic material is different than from a traditional semiconductor material -- traditional inorganic semiconductor material?

A. Yes. The conductivity mechanism is different because of the fact that in a crystalline silicon sample, one has wide bands. So when a silicon crystal is formed, you have strong covalent bonds between the silicon atoms, you have strong interatomic overlap of the electron wave function and so you get wide bands, conduction band/valence band, and that facilitates effective band-like transport in a conventional semiconductor like silicon.

In the organic materials that are at issue here, these are generally glassy, amorphous, thin films. Certainly polycrystalline films might be used, but frequently are not used in OLEDs. And when one has an amorphous material, one no longer has the same sort of band structure that you have in crystalline silicon.

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And also there is the important detail that in an organic semiconductor, especially the ones using OLEDs, we don't usually think even in terms of conduction band/valence bands. We think in terms of molecular orbitals like HOMO and LUMO. And so that changes the energy structure of the material relative to a conventional semiconductor and also leads to differences in conductivity as you were asking about. Again, it's band like in a material like silicon and in an organic semiconductor, you usually have hopping type transport that's certainly activated.

Q. So in organic semiconductor materials, the hopping occurs through hopping from the LUMO of one material onto the LUMO of another?

MR. WEIDENFELLER: Objection.

THE WITNESS: In organic semiconductor material, electron transport will -- so electron transport through, say, an electron transport material will generally proceed via hopping between adjacent molecular LUMOs.

BY MS. ZHONG:

Q. And is that why Ma talks about LUMO/LUMO

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hopping or the LUMO/HOMO orbital overlap?

MR. WEIDENFELLER: Objection.

THE WITNESS: In general, since electron transport occurs in a LUMO, that is going to be part of the discussion of transport of electrons through an electron transport material.

BY MS. ZHONG:

Q. So do you still have Ma available? Can we go back to page 813?

A. Yeah. I'm looking at Suzuki, but I can go back to Ma. Okay. Page 813.

Q. Page 813, right-hand column, the first full paragraph.

A. Yes.

Q. And do you see that in the middle of that paragraph, there is a sentence starting with, transport manifolds. "Transport manifolds along with their LUMO are expected to exhibit a certain extent of overlap after mixing ratio goes beyond 17 weight percent."

Do you see that?

A. I see that sentence, yes.

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Q. And isn't that talking about LUMO/LUMO spatial overlap between a Lithium Q molecule and a Bphen molecule?

A. So, again, I didn't have to think -- or I considered, but the specific details of what Ma is referring to in terms of transport manifolds are expected to exhibit a certain extent of overlap is not something that impacted my opinion. Ma might be referring to spatial overlap. Ma might be referring to energetic overlap. And Ma might be referring to both.

Q. Do you see a couple of sentences below it says, "Therefore, the high electron conductivity of Bphen:Lithium Q may be originated from short hopping length for electron transport, compared to the pure Bphen"?

A. Yes, I see that sentence.

Q. And does that provide an indication as to whether they're talking about short spatial difference between the LUMO/LUMO of Bphen and Lithium Q or the energy level?

MR. WEIDENFELLER: Objection.

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THE WITNESS: So that sentence, my interpretation is that it's referring to short spatial like, that they're actually referring to the hopping distance for the electron and the electron transport material.

BY MS. ZHONG:

Q. So the short spatial difference between the LUMO of the two molecules?

A. I don't know if -- I guess I wouldn't quite describe it as a spatial distance between the LUMOs. I think it's probably more appropriate to just say between the molecules. But, yeah, maybe if you could be more specific in terms of what you're getting at regarding LUMOs, maybe I could be more effective in answering that.

Q. Because when you say the hopping occurs, usually it's between the LUMOs of the two adjacent molecules, correct?

A. Yes.

MR. WEIDENFELLER: Objection.

THE WITNESS: I understand that. It's just normally a person skilled in the art wouldn't

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necessarily describe it as hopping between like -- the electron has to live in the LUMO, but you wouldn't normally describe as hopping between two LUMOs. You'd just say between two molecules.

BY MS. ZHONG:

Q. Okay. But it's between the LUMOs of two adjacent molecules.

A. The transport would be between the LUMOs of two adjacent molecules.

Q. So Ma's postulation or theory is that by adding Lithium Q to Bphen, it may be decreasing the molecular distance between two adjacent molecules to facilitate electron hopping among adjacent molecules?

MR. WEIDENFELLER: Objection.

THE WITNESS: So is your question what Ma is actually arguing for the change?

BY MS. ZHONG:

Q. Yeah. Correct.

A. I think the sentence that we've been discussing, "Therefore, the high electron conductivity of Bphen:Liq may be originated from short hopping length for electron transport, compared

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to the pure Bphen HTL." I think it's clearly stating what Ma's intended function -- or Ma's hypothesis is to explain the results, which is that there is a change in the hopping length in the doped film versus the neat film.

Q. Do you have a background in chemistry?

A. I don't have any degrees in chemistry.

Q. But do you consider yourself to be a person of -- knowledgeable in the chemical art?

A. Is there a specific part of the chemical art you're referring to?

Q. In general.

A. I would not qualify myself as an organic chemist.

Q. Do you consider yourself to be a physicist?

A. I have a degree in physics. I don't generally consider myself with the labels that I place on my expertise. I consider myself a person of skill in the art of organic electronic materials and devices.

Q. So do you consider yourself to be someone

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knowledgeable about touch sensors or gesture controls?

A. I consider myself to be someone knowledgeable in generally how such functionality would be integrated with an OLED.

Q. Have you ever designed a system where you integrated touch sensors into an OLED?

A. I have not previously designed a system with touch-sensing capability in OLED.

Q. And is the design of integrating touch sensor into an OLED usually done by someone with an electro engineering degree?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, I suspect that that design could be carried out by people with a variety of degrees depending on what other additional training they might have. I'm not well versed in what the backgrounds are of engineers who carry out that function in industry.

BY MS. ZHONG:

Q. Do you know whether it's implemented by someone with a chemistry degree?

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MR. WEIDENFELLER: Objection.

THE WITNESS: Again, as I just said, I'm not sure what kind of background would carry out those tasks in an industry. So I don't have knowledge of who does those particular tasks in different settings.

BY MS. ZHONG:

Q. What about for gesture control?

MR. WEIDENFELLER: Objection.

THE WITNESS: My response would be the same. Again, it depends on the individual. It depends on the organization. So I don't have knowledge of that.

BY MS. ZHONG:

Q. And can you please take a look at your definition of a person of ordinary skill in the art. That will be on page 44 of your declaration.

A. Yes, I'm at page 44 of my declaration.

Q. And paragraph 64 in particular.

A. Yes.

Q. You have defined a person of ordinary skill in the art as someone who had had a bachelor's

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degree in chemistry, physics, or a comparable field of study, and at least three years of research or industrial experience with organic optoelectronic light-emitting devices.

Do you see that?

A. I see that.

Q. What do you consider to be the comparable field of study to chemistry and physics?

A. So comparable fields of study could be things like electrical engineering, material science engineering, and the like.

Q. And the research or industrial experience that is specified is in OLEDs in particular, correct?

A. I think what I say specifically is, yeah, organic optoelectronic light-emitting devices, but that would certainly include OLEDs, yes.

Q. Do you consider solar cell to be an organic optoelectronic light-emitting device?

A. I would consider a solar cell to be an organic optoelectronic device and a solar cell under some instances can emit light. Again, I haven't thought deeply about solar cells in terms of this

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context, but that's, I guess, what I can offer as my thoughts on solar cells.

Q. What about photovoltaics. Do you consider that to be an organic optoelectronic light-emitting device?

A. I would consider photovoltaics to be an organic optoelectronic device. And photovoltaics and solar cells are essentially very similar devices.

I guess one thing I'll add just since you've asked about this is that in the context of researching solar cells, which is something that my group has also worked on over the years, even though the function might be for electrical power generation rather than light emission, a lot of the core understanding in terms of transport, exciton behavior, good electrodes, these sort of things, are general to electronic devices built from organic semiconductors.

And so here I have called out specifically organic optoelectronic light-emitting devices and haven't thought specifically about photovoltaic devices, but I think it's important to understand

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that these are not necessarily completely dissimilar areas of investigation.

Q. The material sets are very different, correct?

A. I'm not sure how you define "very different," and so maybe I'm offer my opinion, then. The materials used in OLEDs and solar cells, the combination has a different intended outcome, but they are still organic thin films, they are still generally conjugated molecules and you're still generally worrying about what happens to excitons, whether they're generated electrically or generated optically.

And so there might -- the materials in the solar cell are designed to broadly absorb light. That's something we generally would avoid in an OLED. But a lot of the physics of how that material operates can be transferred.

Q. For example, Bphen is not really used in photovoltaics, correct?

A. Actually, Bphen can be used in photovoltaics. One of the most common small molecule

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exciton blocking layers used in organic solar cells, a material known as Bathocuproine, which is a very similar molecule to Bphen, almost identical save two methyl groups. And so that material was widely used even at the time of the '425 as an exciton blocking layer in a solar cell.

And the exciton blocking layer in a solar cell is essentially spacing the acceptor layer of the solar cell, which is one of the layers that generates photo current, from the cathode in order to optimize light absorption. So actually a material like Bphen was extensively used. And I suspect there's probably references that use Bphen though I'm certainly not aware of them on the fly.

(Exhibit No. 2101 was identified for the record.)

BY MS. ZHONG:

Q. I have just placed an Exhibit 2101 into the Dropbox. Can you refresh to see if you have it?

A. Yes, I'm refreshing it right now. Okay. I have it open.

Q. Exhibit 2101 is a Chemical Review article

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2007 by Walzer and title of the article is Highly Efficient Organic Devices Based on Electrically Doped Transport Layers.

Do you see that?

A. Yes. Yeah, I've got it open in front of me.

Q. Can you please go to page 1244, which is PDF page number 12.

A. Yes, I've got it open.

Q. And do you see there's a figure 14?

A. Yes, I see there's figure 14.

Q. And do you see that figure 14, the caption is "N type doping of molecular materials relevant for OLED and organic solar cells requires different electron affinities"? The first sentence in the caption.

A. I agree that's the first sentence, yes.

Q. So according to this Chemical Review article, they consider the material requirement for the Bphen and organic solar cells would use different materials with different electron affinities, is that correct?

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MR. WEIDENFELLER: Objection.

THE WITNESS: I need to look more closely at the rest of the caption. I don't recall seeing this figure before.

BY MS. ZHONG:

Q. Sure.

A. Okay. So I've read the caption. Can you ask the question again?

Q. So my question is, according to this article, they consider that the material requirements for the organic solar cells and for the OLEDs are different, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I can't answer that question the way you're asking it because you're arguing -- or you're asking in this article. I haven't read this article and so I can't offer an opinion on the article.

BY MS. ZHONG:

Q. If you just limit it to figure 14, is that what's stated here?

A. So figure 14, second sentence says, "While

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organic solar cells may be doped with donors having a HOMO around 4 electron votes, OLEDs require stronger donors with a HOMO at about 3 electron volts." Is that the sentence you're pointing to?

Q. I'm referring to figure 14's caption in general.

A. Well, that is the second sentence of figure 14's caption, but that's the -- is that the sentence you'd like me to consider?

Q. That's part of the consideration. So the caption in general, does that imply that the material requirements for the OLEDs and the organic solar cells are different?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I don't think I can generally conclude what this paper is teaching just based on the three sentences and the caption in the figure. I think I already commented that in the context of organic solar cells and OLEDs, you have a different function, but it's the underlying principles that govern the materials and the things that one has to worry about that are similar is I

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think what I had previously answered.

In terms of what these authors are arguing for these materials in the context of solar cells and OLEDs, again, I'd have to look at the paper more broadly to understand what they're talking about.

BY MS. ZHONG:

Q. Structurally, OLEDs and organic solar cells can be quite different as well, correct?

A. Structurally, there could certainly be differences in how an OLED and organic solar cell might look.

Q. For example, in organic solar cells, you can have -- the materials in a particular layer can be segregated, right? They don't have to be homogeneous in a sense.

MR. WEIDENFELLER: Objection.

THE WITNESS: Sorry. I need to better understand what you mean by segregated. What -- can you give me a more explicit example of what you're asking me to consider?

BY MS. ZHONG:

Q. So in organic solar cells, if you have a

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mixed layer, the materials in that particular layer can be discontinuous, correct?

A. So in a solar cell, there are a variety of ways to make them. The simplest organic solar cell that one can make would be a bulk material between two electrodes. So one layer between two electrodes, in which case you're relying on the built-in electric field between those two electrodes to dissociate an exciton.

The next simplest architecture is a bi-layer in which one has an electron donor material and an electron acceptor material stacked on top of each other where excitons are generated in one or both materials and dissociated at the interface.

If I'm understanding your question correctly, you're talking about a mixed device. In a mixed device, you still need to be able to get electrons and holes out of the mixture. And so I don't necessarily agree with the comment that things can be discontinuous.

(Exhibit No. 2102 was identified for the record.)

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BY MS. ZHONG:

Q. Can you please refresh your exhibit -- the Dropbox link and see whether you see an Exhibit 2102.

A. Yes, I see it.

Q. The Forrest patent application. Do you see that?

A. Yes, I see it.

Q. Can you please go to figure 9B, 9C through 9G.

A. I see the subfigures you're pointing to.

Q. And do you see that they're discontinuous layers 953a through d?

A. I do.

Q. And we discussed this particular figure last Friday, correct?

A. Yes, we discussed this in the context of the '164 patent deposition.

Q. Okay. And you mentioned that this is a structure specific to solar cells and it has no relevance to OLED.

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you let me know when I

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said that? When did I say this has no relevance to OLEDs? Are you saying I said that last week during our previous deposition or today?

BY MS. ZHONG:

Q. Previous deposition. That's my recollection.

A. I don't have a strong recollection of everything that I said last week. And in preparing for the '425 deposition today, I wasn't aware that I would be looking at exhibits from the '164 deposition.

Q. So let me ask you, would you use this structure, a similar structure in OLED with discontinuous 953a-d with nanocrystals?

MR. WEIDENFELLER: Objection.

THE WITNESS: I haven't thought about whether or not I would utilize this structure for an OLED like those we're talking about today in the context of the '425.

BY MS. ZHONG:

Q. And so you think that discontinuous nanocrystals can also be used in the OLED structure?

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A. I -- that's not what I said. I said I haven't thought about in the context of the '425 whether or not this would be utilized in an OLED structure or not. I'm not taking an opinion on whether or not there's an incarnation where such a structure might be useful. It's not something I've thought about in the context of this particular proceeding.

Q. Well, have you given any thought as to whether this particular structure would be relevant to an OLED structure?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, is there a specific part of my declaration that you're trying to point me towards here? I want to make sure I understand the context of what you're asking just because I hadn't thought so much about solar cells and this Forrest reference in the context of the opinion I'm offering on the '425.

BY MS. ZHONG:

Q. Because I want to understand how much cross-teaching there really is from the solar cell

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literature and the OLED literature.

A. Okay. Are there specific things that you want to know regarding cross-teaching? It looks like you're looking at a very specific Forrest patent. What I can answer is that clearly Forrest is teaching that this structure is at least somewhat beneficial for a solar cell. If there's a particular version of this that is being applied to an OLED, I'd be happy to comment on it.

Q. Do you know whether you can have discontinuous nanocrystal layers in OLED structure as taught here?

A. So I think what I've already commented on in answering some of the other questions I've been asked today is that usually when processing OLEDs, one strives to make amorphous glassy thin films rather than something that's more polycrystalline-like, which is what Forrest is showing here in this Exhibit 2102.

So I think I've already testified to that and, you know, I don't think I have anything to add beyond that.

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Q. Why is it in the OLED you are trying to make a more amorphous material versus a more polycrystalline or semi-crystalline material?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm not necessarily taking the position that that's what you're trying to do. I'm just stating that that's what's generally done.

BY MS. ZHONG:

Q. And why was it generally done and is -- strike that.

Why was it generally done that you, for the OLEDs, usually you form an amorphous materials versus a more polycrystalline or semi-crystalline materials?

MR. WEIDENFELLER: Objection.

THE WITNESS: Amorphous materials, amorphous glassy thin films tend to be flat, which tends to offer the ability to form thin layers and multilayer stacks without the potential issue of fabrication defects that might hurt yield. And so that's one advantage to the fact that you're using an amorphous glassy film.

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Beyond that, I haven't, you know, prepared in detail an opinion on why glassy films might be preferential to polycrystalline materials in an OLED.

BY MS. ZHONG:

Q. And does that apply to the encapsulation layer in OLED as well?

MR. WEIDENFELLER: Objection.

THE WITNESS: Does what apply to the encapsulation layer of OLED as well? Can you just give me a straight question there and then I can try to answer?

BY MS. ZHONG:

Q. Does your observation that in OLED manufacturing, it typically forms amorphous films, does that observation also apply to the encapsulation layer of the OLED?

A. The encapsulation layer in an OLED can be formed via a variety of different methods as I'm sure we'll discuss more at some point today. The same design principle or the same observation I'm making regarding amorphous glassy organic films would not necessarily apply to the encapsulation.

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The encapsulation is made up of different materials, sometimes inorganic. The layers can be thicker. And so I don't think as a general rule you would apply it in the same way to the encapsulation.

Q. Would it apply to the organic layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: Is your question about the organic active layers again? The actual layers seeing current flow?

BY MS. ZHONG:

Q. No, the organic layer encapsulation.

A. Well, first of all, it's not a requirement that there is an organic layer in the encapsulation. It might just be inorganic barrier layers. In the situation where there might be an organic layer in the encapsulation, one could have a variety of morphologies and so, no, I don't think it necessarily would have to be amorphous. There may be benefits, frankly, for it not to be amorphous in some cases.

Q. What would be the benefits of not being amorphous? Strike that.

What would be the benefits of

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crystallinity instead of amorphousness?

A. So, again, if one -- maybe I'll just rely on one of my exhibits since this is a question that actually comes up. So just give me a moment and I'll point you to an exhibit.

(Exhibit No. 1008 was identified for the record.)

THE WITNESS: So, for example, in Lee, which is Exhibit 1008, Lee is actually building an encapsulation layer that is based at least in part on polymer materials, so organic materials as you're alluding to. And Lee actually reaches that tuning the crystallinity of those polymer layers in an alternating stack with an inorganic layer could be beneficial.

And the main -- well, two considerations are that a crystalline material or more crystalline material, need not be single crystalline, a more crystalline material could exhibit improved barrier properties because it's denser and hence has just less porosity where diffusion of oxygen or water might occur. But the less crystalline material, more

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amorphous material, might have benefits in terms of flexibility, mechanical flexibility.

And so this is why there's a bit of a balance and it depends on the application and depends on the exact architecture what one might go for because that polymer layer could serve multiple purposes in different structures.

BY MS. ZHONG:

Q. What about the thermomechanical properties when it goes through thermal cycles?

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you be more specific on what materials we're talking about and what the cycling is?

BY MS. ZHONG:

Q. For the encapsulation layer materials that's discussed in Lee.

MR. WEIDENFELLER: Objection.

THE WITNESS: Okay. So specifically what is the question, then? Sorry. I'm familiar with what Lee's encapsulation is and so tell me more about what thermomechanical question you'd like to

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understand.

BY MS. ZHONG:

Q. So when you have a more crystalline material, how does that affect the, for example, the mechanical properties such as adhesion, delamination, cracking, those properties as it goes through the thermomechanical testing?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't think I considered -- well, I considered the full -- I considered all of Lee. I don't think my opinion relied on subsequent thermomechanical testing of the device. Lee requires a thermal treatment to form the crystalline layer, so I'm not sure if I have an answer for you.

BY MS. ZHONG:

Q. My question is do you know what is the resulting reliability of that device with a highly crystalline layer versus one that's kind of more amorphous?

A. Yeah. So that I can speak to. So I guess I'll first just note that Lee's encapsulation -- and

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this is the embodiment shown in like figure 2, for example, of Lee -- is not just a highly crystalline layer. So Lee is very specific in what their structure looks like. They have two different polymer layers that are both parylene based and those polymer layers are separated by an inorganic barrier layer.

Now, in Lee's work, the inorganic barrier layer is itself a barrier to the environment. But what's interesting about Lee's result and what was something Lee emphasizes in their work is that those parylene polymer layers, despite being polymers and despite polymers normally being in the encapsulation only to break up the defect structure of adjacent inorganic materials, Lee actually comments explicitly those parylene layers themselves are also barrier layers, too. And so one attractive aspect of Lee is the fact that in principle, all of the layers of their stack might serve as barriers, which is significant.

Coming to your question, you know, again, Lee is intentional in that, you know, polymer

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inorganic barrier layer, polymer stack, one of the polymer layers is meant to be more crystalline than the other. And Lee realizes that by either -- they propose an optical treatment, which is probably the most sensible way to realize this, but an optical treatment that actually crystalizes one of the layers more so than the other. And so what Lee shows them is that you have this balance between flexibility and barrier properties. You've got polymers which are generally inherently more flexible than all inorganic encapsulations, but you also have this polymer with the variable crystallinity that allows you to get the barrier properties as well.

So, again, my opinion didn't -- the expectation of success a POSA would have in, say, looking at Lee versus Diekmann or looking at Lee versus Suzuki is really based on the fact that, in considering Lee versus Diekmann, Lee is actually pretty explicit that, you know, Diekmann's approach is something that they're improving on, right, because Diekmann proposes either all inorganic or inorganic interspaced with a polymer. So Lee's

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approach would be a better barrier layer and by virtue of the fact that it's pertaining so much polymer, to your question, would also give it flexibility, too.

And then in looking at Lee with respect to Suzuki, you know, Suzuki has an all inorganic barrier layer. Their layers are both basically silicon-based barrier materials. And so Lee has the advantage of breaking up the defect structure of adjacent materials which allows improved barrier properties.

And so I think a person skilled in the art would look at Lee's use of these polymers, which are known to be flexible even in a semi-crystalline state, as suitable for a flexible device. And so I think that's sort of where the picture of Lee in terms of flexibility would come in.

Q. What I want to know is, for the parylenes in a high crystallinity structure, when it goes through thermal cycles, are they more likely to actually crack as they go through the thermal cycles and delaminate?

MR. WEIDENFELLER: Objection.

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THE WITNESS: So again, when you're saying thermal cycles, you mean in operation just as an OLED? So just turning the OLED on and off? What thermal cycle are you referring to? I just want to understand what the extremes are of the treatment you're considering and if it's something that the device practically encounters or something more extreme.

BY MS. ZHONG:

Q. So the OLED devices usually undergo thermomechanical testing, reliability tests, right?

A. Yeah. So an OLED will undergo reliability tests, certainly. That usually just involves measurements of voltage and electroluminescence intensity under different conditions, right, whether it's humidity, temperature or just excitation. And then I suppose a flexible device would undergo some level of mechanical testing as well. But in terms of like the thermomechanical cycling, I'm not sure what the specifics would look like there.

I think all I would say is looking as a person skilled in the art at Lee, a person skilled in

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the art would understand that a polymer is going to offer improved flexibility over an all inorganic stack and be motivated to utilize one accordingly.

(Exhibit Nos. 1020 and 1021 were identified for the record.)

THE WITNESS: The other thing I'll call out, too, is just the fact that if you look at Exhibit 1020, for example, or Exhibit 1021 -- let's go to 1021. So 1021 is actually showing an example of a multilayer barrier coating, not quite like what's in Diekmann, but an example of a polymer inorganic stack-type barrier coating, which I think is kind of what we're talking about here a bit, and shows that you can see improved performance and stability even on flexible devices. You know, I think in figure 3 in that exhibit, they're actually encapsulating plastic.

And so a person skilled in the art would realize, based on the prior art at the time, that the polymer in the coating does not necessarily present an obstacle. And in fact, looking at the exhibits I'm citing would give you an expectation of success.

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Q. Now in Exhibit 1021, they use polyacrylate, correct?

A. Yeah, the polymer is polyacrylate.

Q. And Lee specifically disparaged the use of polyacrylates, correct, in paragraph 008, correct?

A. I'll go to the paragraph just to make sure I don't get ahead of myself. What paragraph again? Can you just point me to?

Q. Paragraph 008 of Lee.

A. I'm just going to quickly reread it to make sure I'm on the same page.

Yes, right. They are commenting on the fact that there is an issue with polyacrylate coatings or at least that -- perhaps it's not necessarily an issue, but that improved barrier performance is always desirable.

Q. And Lee does not present any performance data, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm just going to read them in Lee. Lee does not present device data but does allude to incarnations integrating OLEDs. And so Lee

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is certainly not -- Lee is certainly considering applications in the OLED space.

BY MS. ZHONG:

Q. I understand. Does Lee present any data of its invention compared to the conventional PML structure with alternating inorganic layer and polyacrylate layers such as the one presented in Chwang or Exhibit 1021?

A. So in 1021, you're referring to figure 1B, I assume, something like that?

Q. Exhibit 1021, figure 3, that provides you with the structure of the encapsulation, correct?

A. Yeah. The caption of figure 3 does provide the structure, but Lee provides their structure.

Q. Yeah. And Exhibit 1021 provides how the performance changes over time in figure 1B, is that right?

A. Yes, yes, that's what I was referring to. Figure 1B is the performance data.

Q. Okay. And we don't really know how Lee's performance would be compared to figure 1B, for

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example, right?

MR. WEIDENFELLER: Objection.

THE WITNESS: I just want to reread a couple of paragraphs of Lee here. Just give me one moment, please.

So Lee doesn't show that data specifically, but especially if you read the introduction of Lee including paragraph 8 to which you already referred to and paragraph 7, it's pretty clear that Lee has a good understanding of where their invention is fitting into the encapsulation landscape and why it's advantageous.

Really all Lee is seeking to do is replace the polyacrylate, which is not an effective barrier material, with a material that is. And a person skilled in the art would recognize that parylene is not going to cause issues as a -- it's another polymer. And so really I don't think a person skilled in the art would see any problem with that, especially given all of the context that Lee offers in terms of understanding the challenges for OLEDs.

And this is notable even in paragraph 33

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where, you know, Lee is taking great care to think carefully about how you'd realize that more crystalline layer via optical methods, understanding that a thermal treatment to some OLED materials might not be ideal. And so I actually think it's pretty clear in Lee that they have a good understanding of the challenges in making an OLED and I think a person skilled in the art would see this as simply replacing one polymer that only has sort of that decoupling functionality with just another polymer now that is going to offer advantage of being a barrier layer as well.

BY MS. ZHONG:

Q. Are you aware of any actual devices being made at the performance reported?

A. I didn't specifically look in the literature for parylene-based package devices.

Q. Are you aware of any, in your 20 years of experience, are you aware of any OLED devices that actually have parylene encapsulation especially with two parylene layers with different crystallinity?

A. So again, I tend to think about these

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sorts of questions in the context of the academic literature and the patent literature. I don't have a paper or patent off the top of my head that I can call out that is using the specific encapsulation on OLED. But I don't think that would limit a person skilled in the art from reading this particular patent and understanding the benefit to combining it with Diekmann and/or Suzuki.

Q. And you would think that if something actually works, people will adopt them and actually implement them in actual devices, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So can you clarify what you mean by if something actually works? I just want to better understand --

BY MS. ZHONG:

Q. Well, like, for example, Lee, do you think it's a good idea, people would try it?

A. Yeah.

Q. It's been almost 20 years since it was published. You would think that if it's so obvious, someone would have tried it.

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A. Well, you know --

Q. So have you seen an example? That's my question.

A. Well, so there's obviously a lot of nuance to the question you're asking. You know, the place where this sort of high-level encapsulation is practiced is an industry. You know, most of the work that's published in the literature and even a significant fraction of the work that's published in patents is carried out by academic labs. And in academic labs, when one's focusing on, say, trying to make a more efficient OLED, one isn't simultaneously trying to necessarily make the most longest lived, best moisture barrier device, right?

Encapsulation and keeping up moisture and oxygen is really something that is a bigger concern when you're making an industrially relevant, you know, device. And so I don't necessarily think that if this is a good idea, you'd even see it in the academic literature because it might only be practiced at an industrial level.

When academics tend to encapsulate their

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device, they frequently use the simplest, quickest possible solution that is often a can, just encapsulating with another layer of glass and seal of epoxy which albeit is a bit crude, but for the purposes of what an academic's looking for, which is to be able to test the device over a few weeks, it's sufficient.

When one thinks about trying to make an OLED that can be tested for hundreds of thousands or millions of hours, that's a different story. And so I don't know that this encapsulation isn't being used. It's quite possible that this encapsulation is widely utilized right now. But, yeah, I don't have knowledge of that.

Q. So you have no knowledge that this method was used/adopted by any of the companies making OLEDs in the industry, correct?

A. I do not have knowledge of what those specific encapsulation techniques look like for an industrial device.

Q. Okay. But companies also publish their research, correct?

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A. Rarely. Companies tend not to publish their research actually, so I would say that's largely incorrect. Companies file patents that are often designed, you know, to reveal perhaps essential components of their technology along with unessential components of their technology, but companies as a rule don't generally publish their research.

Q. Do you consult for the industry?

A. I don't currently consult for industry.

Q. In your past consultation, are you aware of any OLED devices that actually use the teachings of Lee?

A. Anything I may have learned as a consultant in the past would be covered by a nondisclosure agreement and confidentiality agreements and so I would not be able to discuss those details even if I had them.

Q. Do you have knowledge?

A. I can say that I don't have knowledge about the encapsulation utilized in industry.

Q. And do you know how the utilization of the optical method would affect the further dissociation

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of Lithium in the doped layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: Can you just restate that? I just want to make sure I understand. Are you talking still about Lee?

BY MS. ZHONG:

Q. Well, the base devices that you are discussing all have an n-doped -- strike that.

So the devices -- the OLED devices that you propose all have a Lithium Q doped electron transport layer, correct?

A. Yes. I am combining Ma with either Suzuki or Diekmann, which both already have an n-doped layer and simply replacing that n-doped -- and dopant, sorry, as Liq, yes.

Q. So if you add Lee's encapsulation to that device and you use Lee's teaching of the optical treatment to get one layer more crystalline than the other, do you know what the effect of that treatment would be on the electron transport layer --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

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Q. -- at the diffusion of Lithium, for example? Or generation diffusing of Lithium, for example?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I don't know what the effect of the treatment would be on Lithium generation if there is any or Lithium diffusion if there is any. What I can say in general, and it's something that I already alluded to in Lee and I think is important and indicative of the care they're taking in designing their solution, is that Lee does indicate the reflective layer could be introduced -- thin reflective layer could be introduced into the packaging that would allow the optical excitation that's being used to anneal one of the parylene layers to be more crystalline to not pass into the OLED.

And so they considered the fact that if you're even trying to crystallize the parylene layer by optical means, which is probably a sensible way to go, they considered the idea of including a thin reflective layer into the encapsulation so that you

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don't also bake the underlying parylene layer and the organic layers underneath.

BY MS. ZHONG:

Q. But is there going to be heat that's going to be transferred downwards --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- to the organic layers of the OLED stack?

A. So that I can't comment on. I think that clearly there is not going to be so much heat transferred that you would also crystallize the underlying parylene layer. Otherwise that would be inconsistent with Lee's invention, right? So Lee's invention requires really that you have a difference in crystallinity or at least that's one of the embodiments that they're pushing is that there is a difference in crystallinity.

So if the heat just uniformly diffused and you had steady-state, then you wouldn't be able to realize that. But the extent to which there's heating underneath, I don't have the information to

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answer that question. And I felt that whether or not there was some heat transfer didn't change my opinion of Lee and the expectation of success that a person skilled in the art would have in combining Lee with the other -- with Diekmann or Suzuki.

Q. So there can be a temperature gradient, but you don't know what that temperature gradient is, correct?

A. I don't know anything specific about what the temperature profile would look like during any of Lee's proposed treatments.

Q. Okay. So if you look at paragraph 28 of Lee, it appears that the phase transition of crystallinity, the temperature to induce those are actually pretty high, right? Anywhere between 200 to 400 degrees as listed here in this paragraph.

A. Yeah, I just -- can I just reread that paragraph?

Q. Sure.

A. So I guess I want to offer perhaps a different interpretation here. So paragraph 27, I think, is important to first consider with paragraph

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28. So paragraph 27 first importantly highlights that the as-deposited parylene film itself can be utilized as a barrier layer. And so that's noted in the final sentence of the paragraph. And what they're noting in paragraph 27 is that the degree of semi-crystallinity could be varied with annealing.

In paragraph 28 and the temperature cited there, I think Lee is referring to something different which is you could -- is arguing that the parylene could have multiple stable solid phases and that these could potentially be also accessed by going to higher temperatures like 200 to 290, 350 to 400. I don't read those two paragraphs as a requirement that one needs to utilize those higher temperature phases. And those higher temperature phases, for example, could be useful if you're trying to encapsulate a flexible substrate, right, where you might not be worried as much about the organic thin films.

But yeah. So even if you look at the other -- look at the final sentence of 28, "Furthermore, it will be appreciated that the

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annealing concepts described above may be extended to other systems." I think actually Lee is teaching fairly broadly a variety of different incarnations that could be applied using parylene derivatives. Because even parylene itself, you know, that's a general moniker. There's other forms of parylene that probably have different thermal properties.

Q. Do you know what annealing temperature Lee's parylene systems -- strike that.

What's the suitable annealing temperature for Lee's system?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, when you say what is the suitable annealing temperature, how are you defining suitable or what criteria?

BY MS. ZHONG:

Q. Suitable for Lee's purpose or suitable for the OLED devices.

A. Yeah. And I guess my read of Lee -- so I'm going to reread another portion of Lee before answering.

Again, I don't think I can offer a

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specific temperature. Lee makes fairly clear in paragraph 27, that in the target -- or one embodiment would be looking at a range of between 10 and 70 percent crystallinity. Lee does not specifically offer complete processing details for how those different crystallines needs to be realized.

And in the previous paragraph in 26, it's clear there's a range of processing conditions that could be utilized to volatilize the relevant material. So I don't think I can offer a specific temperature as prescribed by Lee. But it's clear that Lee understands that that temperature needs to be compatible with the organic layers that are underneath.

Q. Does Lee mention doped -- does Lee mention an OLED device with a doped electron transport layer?

A. Let me just take a quick look at Lee. I don't think Lee mentions an OLED explicitly with N doping, but Lee speaks about OLEDs in a very general sense and it's not specific to a particular architecture.

Q. Okay. And does Lee offer any guidance on

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what the temperature -- the appropriate temperature would be for any OLED devices, OLED systems?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I want to look at one more paragraph here before answering.

BY MS. ZHONG:

Q. Sure.

A. So again, my read of Lee is that Lee is offering a general solution that is sensitive to the thermal constraints that come with an OLED making an organic stack but is not offering a specific prescription for a specific OLED architecture.

Q. So in order for you to arrive at the right annealing condition for Diekmann or Suzuki's device, a person of ordinary skill in the art would have to do trial and error in order to arrive at the right condition, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: So in combining references in -- in combining these references, it would be my opinion and I think the expectation of a person skilled in the art that there would be some routine

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optimization of the, in this case, encapsulation.

And so the expectation would be that a person skilled in the art would see Lee and then would adapt their own deposition equipment, process equipment accordingly and then optimize on their equipment probably for the actual device lifetime or, at a minimum, the water vapor transmission rate through the encapsulation itself.

BY MS. ZHONG:

Q. And do you know which particular parylene system would be suitable for Diekmann or Suzuki?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm sorry, I missed, which particular what system?

BY MS. ZHONG:

Q. Oh, so Lee used the parylene systems, correct?

A. Oh, which parylene system. I'm sorry. I misunderstood. Which specific parylene system? I didn't -- I considered the fact that Lee is very general in allowing the user to have significant flexibility in which parylene system they choose to

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utilize, but I didn't render a specific opinion on which parylene system would be most suitable for Diekmann or Suzuki.

Q. Can a parylene system work with the Suzuki or Diekmann system?

MR. WEIDENFELLER: Objection.

THE WITNESS: That's something I didn't have to form a detailed opinion on. I think in my opinion, looking at Lee, a person skilled in the art would be motivated to apply Lee and select an appropriate parylene system of the several provided by Lee in the text to improve the stability and encapsulation of Diekmann and Suzuki.

BY MS. ZHONG:

Q. Okay. So based on your expert opinion, for the Diekmann system, which parylene system would you use?

A. So that's not something I've -- I've certainly considered Lee in full, but I haven't thought about in terms of an opinion on what specific parylene system I would use for Diekmann.

Q. What about for Suzuki -- go ahead.

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A. I was just going to say, and the same goes for Suzuki. I haven't come up with a specific process for what that would look like. And again, I think a person skilled in the art, that would be part of the routine optimization of taking what Lee is describing and applying it on your own processing equipment and subject to your own constraints. There may be constraints related to cost. There may be constraints related to other things. I didn't use those constraints to form my opinion.

MS. ZHONG: We've been going on for a while and it's almost noon Eastern Time. So do you want to take a lunch break or do you want to go for another session?

THE WITNESS: No, this seems like a reasonable time to do lunch. Yeah.

MS. ZHONG: Okay. So let's go off the record.

(Whereupon, at 11:53 a.m., the deposition in the above-entitled matter was recessed, to reconvene at 12:57 p.m., this same day.)

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AFTERNOON SESSION

(12:57 p.m.)

EXAMINATION BY COUNSEL FOR PATENT OWNER (RESUMED)

BY MS. ZHONG:

Q. Dr. Holmes, can you please go to page 82 of your report, starting with paragraph 139.

A. Sure. Let me just get there. Yes, I see it.

Q. And between paragraphs 139 and 146, you are discussing the reasons why you believe a POSITA would have combined Diekmann and Ma, is that correct?

A. Yes, that's correct, in terms of dependent claim 2, yes.

Q. And can you summarize the reasons for why a person of ordinary skill in the art would have combined Ma and Diekmann?

A. Yes. So if -- those paragraphs of my declaration are combining Ma and Diekmann in the following ways. So Diekmann already teaches an OLED with an N type or n-doped electron transport material, and Ma is teaching an OLED with an n-doped electron transfer material that has Liq. Diekmann

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doesn't teach Liq per se.

And a person skilled in the art seeing that Diekmann is raising issues related to dopant diffusion and commenting that molecular dopants are an option would see Liq as a molecular dopant and as a path to reduce diffusion issues in Diekmann and potentially improve OLED behavior.

Q. And when you talk about the improved OLED behavior, you mentioned specifically two aspects, correct? One is a reduced driving voltage and the other is improved power efficiency, correct?

A. Yeah, in the context -- just hold on. Let me just take a quick look at the paragraphs. Yeah. So those were the specifically OLED efficiency and performance improvements. I guess when I say performance, I'm also allowing for that to include lifetime as well. And so the issue of diffusion could lead to performance -- or improvements in -- or mitigating the issue of diffusion. Pardon me. Could lead to performance improvements as well as lifetime improvements as well, just performance in general. But in terms of efficiency, yes, I'm referring to a

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lower operating voltage and higher power efficiency.

Q. And regarding efficiency in the context of OLEDs, there are different efficiency parameters, correct? There is luminescence efficiency, there is power efficiency, there is a quantum efficiency, correct?

A. That's right, yes.

Q. And so which efficiency are you referring to in specific?

MR. WEIDENFELLER: Objection.

THE WITNESS: So in 141, I'm calling out Ma's finding that's related to current efficiency and power efficiency. The power efficiency is the efficiency that's most impacted by the device driving voltage because the power efficiency is effectively a measure of optical power outproduced by the OLED divided by electrical power consumed. So any favorable reduction in driving voltage stands to improve the power efficiency.

Ma also comments, though, that the current efficiency is improved as well because there's increased charge balance in their device.

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BY MS. ZHONG:

Q. What is current efficiency? Is it also called luminescence efficiency?

A. Is it also called luminescence efficiency? Can you point to where luminescence efficiency is being used? I just want to make sure I'm on the same page. I can define current deficiency, but --

Q. So let's take like one step back. What's the current efficiencies unit?

A. So current efficiency is in units of candelas per ampere, so amps. So it's basically now a measurement of light output by the OLED in units of candelas per unit of current injected into the device. So candelas per amp is the unit of current efficiency.

Q. And do you know whether that efficiency in the unit you just mentioned is also called luminescence efficiency in some other context?

A. It may be. I'm not aware if I've used that inadvertently perhaps. Here I'm trying to use Ma's language. Luminescence efficiency I could see potentially being used as current efficiency. That

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wouldn't surprise me. But I -- if there's a particular reference, I would want to look at the units.

Q. And in paragraph 141, you have reproduced Ma figure 3, correct?

A. Yes, I've reproduced Ma figure 3 just below paragraph 141, yes.

Q. And in figure 3 of Ma, the referenced device is without p-doping or n-doping, correct?

A. That's correct.

Q. And then you have also a 4 weight percent F4-TCNQ.

A. Yes, Ma is using both N and P type doping.

Q. And for the current corresponding to the 4 weight percent F4-TCNQ, is that with 33 percent Lithium Q?

A. I'm going to just go back to Ma and double-check. Yeah, the p-doped devices in figure 3 are based on an n-doped layer of 33 weight percent Liq into Bphen.

Q. So according to this graph of Ma, it looks like as far as power efficiency is concerned, the

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optimal level of doping for the HTL layer is between 0.3 and 2 weight percent, correct?

A. Yep. I'm just looking at Ma again to make sure I'm answering correctly. You said the optimum appears to be between .3 and what was the other bound of the question?

Q. Two, 2 weight percent.

A. Well, it's not obvious. The optimum -- there isn't enough data to say what the optimum is because the optimum could say also, for example, be .2 weight percent, right. But it's not -- it's clearly better with doping and you reach an optimum, but it need not be between .3 and 2. It might be between zero and .3 as well.

Q. Okay.

A. But there is an optimum.

Q. Yeah. But based on figure 3, do you see that the zero percent and the 4 weight percent p-doping, they are performing less well than the 0.3 to 2 weight percent ones, right?

A. So the -- sorry, which two are you looking at again?

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Q. So the best performing one for power efficiency is at 0.3 weight percent.

A. Yes, I agree with that statement.

Q. And then what you have, the next best performing one is a 2 weight percent one.

A. I agree.

Q. And that one is not -- is slightly better than the undoped ones, the zero weight percent ones, correct?

A. Well, zero weight percent is still doped N-type.

Q. Yeah, but zero weight, no doping, no p-doping?

A. Correct, no p-doping, yes. So in the case of zero weight percent, F4-TCNQ, there is only N doping, yes.

Q. So doesn't that indicate to you for 30 weight percent N doping, the optimal level of doping for the hole transport layer or HTL layer would be somewhere between 0.3 and 2 weight percent?

A. No. As I already noted, I think it just indicates the optimum doping level is somewhere

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between zero and 2 percent. Because you don't -- the point at .3 weight percent it's quite -- it's possible that .2 might have been better than .3, right?

Q. Okay.

A. So I would agree that, you know, the optimum is below 2, right?

Q. Okay.

A. But I don't think you can necessarily say that it's on the high side of .3.

Q. I see. How about for current efficiency. Do you see a similar trend?

A. So let me just look closely at that image. It's -- you know, depending on which current density you look at, the trend is similar, though perhaps not to the exact same degree.

Q. And when Ma concluded that 30 percent weight Lithium Q is the optimum doping for the electron transport layer, that's based on their electron-only device testing, correct?

A. Yes, that's based on their electron-only device testing, yes.

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Q. For the electron-only device testing -- strike that.

Would the trend you observed for electron-only device testing be the same as in a real device with a fixed p-doping amount?

A. Can you be more specific as to which trend, which figure you want me to consider?

Q. For example, the driving voltage trend.

A. So which figure are you pointing to in Ma? I just want to make sure I'm looking at the right data.

Q. So Ma has many current density with voltage --

A. Yes.

Q. -- curves, right?

A. Yes.

Q. And there's an electron-only device, current density versus voltage one.

A. So figure 5.

Q. And I believe for the electron-only one, that's probably the only figure they have there.

A. Yes. So they show some in figure 6 as

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well. But figure 5 is what you're considering.

Q. Figure 6, right?

A. Oh, figure 6, not figure 5?

Q. No, figure 5 or figure 6.

A. Okay.

Q. Figure 5. Let's just look at figure 5.

A. Okay. So figure 5. And so what was the question you're asking?

Q. So in figure 5, based on the electron-only device testing, the conclusion is that the optimal doping level seems to have reached somewhere around -- between 33 and 50 percent, right?

A. Again, for the same reason I mentioned with F4-TCNQ, I don't see why the optimum has to be on the high side of 33. So I think the optimum would be somewhere between --

Q. Seventeen and --

A. -- 17 and 50, yeah.

Q. Okay. So instead of an electron-only device, and if you have a complete device with a hole transport layer, with the emission layer, et cetera, right? Are you going to see a similar trend? For

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example, the 33 weight percent is going to perform better than 50 percent and 17 weight percent?

A. So specifically, are you asking will the current voltage characteristic of the device look the same as an electron-only device?

Q. Yeah, at least trend-wise.

A. So I'll just first say that isn't something that I looked deeply at in my analysis of Ma in terms of thinking about how the trend would look for the whole device in terms of the current density voltage characteristic.

In general, an electron-only device is only considering part of the total device and so the trend may not be necessarily the same. It again depends on the degree of balance between the electron and hole currents when you go to the full device. And that's what Ma is getting at in figure 6. That's how they're deciding -- like in figure 5, they're optimizing the concentration. In figure 6, they're trying not to match it to the current through the hole side of the device.

Q. So in figure 6, for each fixed

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concentration of the ETL, they're trying to see what is the optimal doping level for the hole injection layer?

A. In figure 6 in my opinion, what they're doing is trying to match at least at some scale the hole current through the hole side of their device and the electron current through the electron side of their device. And this is one approach to try and realize charge balance in your device.

Q. So in figure 6, what they observed is for 33 weight percent doped ETL, the current density curve for the black square line is overlapping with a 0.3 weight percent doped HIL, is that -- and then they decided that's where the charge balance would be achieved in the complete device, is that correct?

A. That's how Ma is using figure 6.

Q. And is it always the case if you add Lithium Q to an organic electron transport layer, you are going to see reduced driving voltage and improved current efficiency?

A. So, again, as I've noted earlier in the day, the only exhibit that I'm presenting that has

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Liq as an n-dopant in an electronic transport material is Ma. And so I don't think I can offer a more general opinion. But a person skilled in the art who's already using N doping as is in Diekmann and as is in Suzuki would see Liq as an alternate dopant to replace their n-dopant with.

Q. But do they know whether the resulting doped layer would offer better performance than an undoped layer?

A. So that -- I guess I want to make an important distinction here. They're not comparing it to an undoped layer, right? So an important difference between Ma and between the combinations that I'm using for my opinion is that in Ma, Ma is comparing to basically an undoped or partially doped device.

In Diekmann and Suzuki, the inventor has already decided that they are making a doped device. And so the comparison wouldn't be necessarily to an undoped device because that decision is already made. The doping's already there. And so here the question would be is there an expectation of success in using

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Liq as the n-dopant as an alternative to whatever n-dopant is already being used.

And I think based on Ma, there's an expectation that Liq would work and hence could improve device performance. But even in the case where device performance only stayed constant perhaps, Liq offers additional advantages as a molecular dopant from the perspective of diffusion because it's a bulky molecule.

Q. Have you done any testing to see whether Liq offers reduced diffusion?

A. I have not --

Q. Compared to cesium or Lithium, for that matter.

A. I have not --

MR. WEIDENFELLER: Objection.

THE WITNESS: I have not done any testing myself. But Diekmann acknowledges the challenge and acknowledges molecular dopants as an alternative to elemental metals, and a person skilled in the art would recognize Liq as a molecular dopant that would fit that bill.

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BY MS. ZHONG:

Q. But we've also established that at least based on Liu, when aluminum is deposited on Lithium Q a neat film, there is some Lithium dissociation or Lithium generation happening, correct?

A. That is what Liu teaches for a neat film of Liq under a metal cathode. But even in the case where some Lithium were generated, as a person of skill in the art -- a person skilled in the art would look and expect that there would be potentially less Lithium generated than strictly Lithium metal going in as an n-dopant. And so I think even still there'd be an expectation for success.

Q. But with the reduced amount of Lithium -- let's take one step back.

Do you know what's the relative performance in terms of power efficiency, luminescence efficiency, current efficiency and driving voltages are of a cesium or Lithium doped electron transport layer versus a Lithium Q doped transport layer?

MR. WEIDENFELLER: Objection.

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THE WITNESS: Again, I think I made clear the references that I'm using and I don't have a direct comparison between Liq doped and alternate doped electron transport materials in terms of performance.

BY MS. ZHONG:

Q. Okay. And do you know what's the relative device life due to Lithium diffusions are for those two systems?

A. So again, not as a comment on stability aside from saying that improved charge balance would be expected to improve stability. But in terms of the actual measurement of diffusion, that's not included.

One thing I will add, though, is that, you know, Ma's data in comparing, say, figure 3 and looking at the square data without doping versus the circle data, which is just zero percent F4-TCNQ does clearly show that there is an efficiency improvement even with just Liq. And so a person skilled in the art would at least appreciate that Liq is bringing favorable and doping behavior to the device.

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Q. Is that behavior -- does that behavior apply to every single electron transport materials or it's specifically the Bphen system that Ma is looking at?

A. I don't see any reason why it wouldn't be more general than Bphen, but Ma only considers Bphen.

(Exhibit No. 2007 was identified for the record.)

BY MS. ZHONG:

Q. Can you please pull up Exhibit 2007. So Exhibit 2007 is a --

A. Hold on. I actually don't see it. 2007?

Q. Exhibit 2007.

A. Yeah, I don't see it. Just give me a second.

Q. You don't see it in the IPR '425 folder?

A. I see --

Q. It's 2007 Sasaki, effects of energy level alignment.

A. Okay. I'm just sorting by most recently modified. So I see a couple of other papers we haven't discussed yet. So let me scroll down.

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Q. If you want to do the name, by name.

A. 2007, Sasaki. Yep, I've got it now.

Q. So Exhibit 2007 is a paper by Sasaki with the name Effects of Energy-Level Alignment on Operating Voltages of Blue Organic Light-Emitting Diodes. Is that the article you pulled up?

A. That's the article I'm looking at.

Q. And can you take a look at figure 1 on the second page?

A. I see figure 1.

Q. And can you see that there is a device 3?

A. I see device 3, yes.

Q. And in device 3, the cathode is aluminum. It has an electron injection layer, Lithium Q, and then it has an electron transport layer of undoped Bphen. Do you see that?

A. Yes, I see that.

Q. So on that particular page, the right-hand side column, second column, and so the tenth line in that paragraph starting with, "Although." "Although we fabricated a blue OLED with Lithium Q used as the EIL and Bphen doped with Lithium Q used as the ETL,

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its operating voltage was much higher than that of device 3."

Do you see that sentence?

A. I see that sentence.

Q. And does that indicate to you that the author of this paper also made another device where instead of undoped Bphen it's Bphen doped with Lithium Q?

A. That sentence says that the authors made a blue OLED with Liqs as EIL and Bphen doped with Liq used as the ETL.

Q. So the difference between that alternative device and device 3 is that the ETL is replaced with a Lithium Q doped Bphen layer, is that correct?

A. I actually don't know if that's the only difference. Let me just read that sentence again. It doesn't actually say that everything else is being held constant. So I don't know that for certain.

(Exhibit No. 2105 was identified for the record.)

BY MS. ZHONG:

Q. Let's see what I have. Can you pull up

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Exhibit 2105, which is the supplemental information for the paper in Exhibit 2007.

A. Yeah. Let me just refresh. Okay. I have it open.

Q. And can you please first check to make sure that this looks like the supplemental information for Exhibit 2007?

A. Again, I'm assuming this is the supplemental information if that's what you're telling me it is and that's where you've obtained it, I don't have any ability to check if it's not.

Q. Why don't you go to PDF page number 3.

A. Sure.

Q. And do you see there's device 3 and there's device 5?

A. Oh, pardon me. I was looking at document page 3. So document page 2, looking at figure S1?

Q. Yes.

A. Yes.

Q. And do you see that there's a device 3 and device 5 and the only difference appears to be the ETL layer or electron transport layer in device 3

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it's undoped?

A. Uh-huh.

Q. And in device 5, it's one-to-one Bphen and Lithium Q?

A. I see that.

Q. And let's go back to Exhibit 2007.

A. Actually, I'd like to make a comment on figure S1 while we're here.

Q. Sure.

A. Figure S1.A is a really nice schematic of the architecture of these two devices. And I'll just note that Bphen plus Liq here is being used without a blocking layer against the emissive layer of the device which is not generally how one would deploy conductivity doping in an OLED.

Q. That's also the structure in Ma, right? There is not an explicit --

A. But I've already commented --

Q. -- blocking --

A. But I've already commend on how Ma is working. This device has an explicit host and guest emissive layer which likely would indicate to persons

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skilled in the art that the charge transport is more effectively optimized than it would be just in Alq.

And so I suspect that if this device is suffering problems with efficiency, it's probably suffering because of the fact that there's quenching between the emitter and the transport layer. And I suspect that if a blocking layer was placed into this device, the authors would have seen an improvement in performance.

Q. But as manufactured or as fabricated, according to the inventor, the authors of the paper, they saw a reduced performance in the terms of the driving voltage, correct?

A. Did they say driving voltage or efficiency?

Q. I believe so. If you go back to Exhibit 2007, they mention that the --

A. I'll just look at figure S1 since you've given me that. The correct density voltage characteristics and luminescence voltage characteristics are there for both devices. I'd say there's a marginal change in driving voltage except

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looking at where the turn-on is actually occurring for these devices.

And again, I would argue that, in my opinion, device 5 is not a well-crafted device in terms of how one should use a doped transport layer. And frankly, I'm surprised given how recent this reference is that there isn't a blocking layer between the emissive layer and the Bphen doped ETL.

So if I look at the luminance, the turn-on voltage for these two devices is very similar, 3-point whatever, just over three volts and just under three volts. So, yeah, I'm happy to go look at that passage in the main text. What was the exhibit number again, 21 --

Q. 2007, Exhibit 2007.

A. 2007, right. And did you want to go back to that discussion of figure 2A B?

Q. Yes. And Sasaki and the co-authors, their view is that the one with Lithium Q doped Bphen has -- operating voltage was much higher.

So in Exhibit 2007, according to Sasaki and the co-authors, their view is that the device

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with Lithium Q doped Bphen has a much higher operating voltage than that with the undoped Bphen, is that correct?

A. So again, going back to the -- I'm just going to open up the SI in the other tab here. All right. What was that exhibit? I'm sorry, can you tell me again what the exhibit number was for the SI?

Q. I think it's 2105.

A. Okay. I'm going to get them both open now. And the other one was 2007.

Q. 2007.

A. Great. So if I -- again, I haven't read this paper before or looked at this paper before, but as an expert in OLEDs and someone who's certainly thought about blue OLEDs, if I look at figure S-1 in the SI and compare these two architectures and it does look like they're identical with the exception of Liq doping and the electron transport layer. And then I look at the corresponding electrical behavior in B and C, I think the turn-on voltage is very similar. The forward current is lower for the doped device. But again, as I've already noted, that's

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because this is not an optimized use of the doping. This is not taking the teachings of the literature into account when actually making a doped device.

So I think it's quite clear why Liq might not lead to an enhancement in device 5 because the blocking layer hasn't been properly applied here.

Q. This is a 2022 article, right?

A. If you say so. I can look at the -- it looks like it was actually --

Q. It's 2023 published, but I -- yeah. Sorry. It has a copyright date of 2022, but looks like it might have been published on --

A. It was published on December 4th, 2022, according to the details of the article. It was received August 30th, 2022.

Q. So it's a 2022 article?

A. I would agree, yes.

Q. So it's 13, 14 years later than '425 patent?

A. Uh-huh.

Q. And presumably these are -- these are at least people with ordinary skill in the art.

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A. Is that a question you want me to address or --

Q. Do you agree that they probably have -- they probably meet your definition of person of ordinary skill in the art?

A. I assume that whoever the lead investigator is, the PI who's the corresponding authors here, would probably meet it. I don't know enough about the others to know if they're a first-year student or some secondary contributor to the work. But I would agree that someone on this list is meeting my definition of a person skilled in the art.

Q. And device 5 is the device they fabricated as a comparison device to device 3, right?

A. In figure S-1, they are comparing device 5 to device 3.

Q. And if you go back to Exhibit 2007 and if you look at the device number 2.

A. Okay. Device 2, I'm looking at it.

Q. Figure 1.

A. Yeah.

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Q. For that one, it also doesn't have an undoped blocking layer, correct?

A. It does not appear to have a layer between the EML and the ETL.

Q. And you don't really know for the EML and the Merck-specific HTL whether the light is generated at the -- near the interface with the HTL such that you effectively have an electron blocking layer, is that right?

A. I don't know anything about what a Merck-specific HTL would offer. And again, as I said, I've only just been introduced to this paper and these device architectures.

Q. So at least in this device structure between device 3 and 5, the addition of the Lithium Q to Bphen without optimization does not really lead to improved performance.

A. So as I've said, and I'll say this clearly again because I think this is actually, you know, an issue with the device architecture. I think what this data is actually showing is that these fluorescent emitters can be quenched by an

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interaction with a doped layer, which is something that I think earlier in the day seemed to only be discussed in the context of phosphorescent emitters. These are fluorescent emitters.

And my expert opinion of what's happening in this device is that you're generating singlet excitons on a fluorescent guest and they're interacting with the doped layer being quenched. And so I think the reason why they don't see improved performance is likely because of the fact that they don't have a blocking layer between the doped layer and the emissive layer.

Even if this was prior art, which it's not, I don't think a person skilled in the art would look at this and be dissuaded by the use -- by their application of Liq. I think they would look at this and say, well, if my goal is to ultimately use Liq or a dopant in general, which this group doesn't appear to be doing in their other devices per se, I'm going to include a blocking layer. And I think this actually just further emphasizes that that quenching is something that's important to consider in

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fluorescent and phosphorescent OLEDs when making design decisions.

Q. When you say "the quenching," are you talking about the quenching induced by Lithium diffusion?

A. Not necessarily. Because just the fact that -- so in a doped layer in general, there might be quenching if it's adjacent to the emissive layer. It's so unusual to see a doped layer right next to the emissive layer. And so there can be quenching in general with doped electron transport molecules.

Q. If there is no diffusion of the dopant, why would there be quenching in the emissive layer?

A. Because an exciton in the emissive layer can interact with at least the first few nanometers of the transport layer via Forster transfer.

Q. So how thick a blocking layer do you usually need to have in order to prevent that quenching effect?

MR. WEIDENFELLER: Objection.

THE WITNESS: I guess I'll go and consult my own exhibits. But again, the blocking layer is

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not only serving that function because it could also be helping to prevent issues with diffusion and so it's not the only constraint. But typical Forster radius, again, might be on the order of 3, 4 nanometers, something like that. But again, it depends on the materials involved.

So if you go back and look at He, Exhibit 1019, their blocking layer is 10 nanometers of undoped Bphen. That would certainly be sufficient to prevent energy transfer that has a characteristic length scale of 3, 4 nanometers.

(Exhibit No. 2103 was identified for the record.)

BY MS. ZHONG:

Q. And can you pull up Exhibit 2103?

A. Sure.

Q. Exhibit 2103 is an article published in organic electronics by Felipe A. Angel.

A. Yes, I see the article.

Q. And I think this is also a pretty recent article although I can't figure out when it was published. So it was received on April 13th, 2018,

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published and accepted -- available online on May 16, 2018, correct?

A. I see that on the bottom of the first page.

Q. And the device structure in this paper is, if you look at experimental section in the sentence bridging page 1 and 2 is a 20 angstrom layer of molybdenum oxide and then you have an NPB layer and then you have an aluminum Q3 layer and then a Bphen layer and Liq as the electron injecting layer, right?

A. So again, I haven't seen this paper. I'm going to read that whole paragraph before I --

Q. Sure.

A. -- respond. Okay. I've read the paragraph in question.

Q. Actually, can you look at figure 2 on page 221.

A. I see it.

Q. And in the figure 2 structure, the electron transport layer is Bphen doped with Lithium Q with varying concentrations, correct?

A. All right. So this is a different

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structure now?

Q. Isn't that the same structure?

A. Well, the one you had me read earlier wasn't doped Bphen with Liq. Bphen was an optional ETL and Liq was the electron injecting layer.

Q. Okay. So for the figure 2 structure.

A. Okay. Then let -- I'm just going to go ahead and read the corresponding paragraph. Okay. I see the structures.

Q. And in this structure, for the electron transport layer, for the emission layer and for the hole transport layer, the materials for those three layers are the same as in Ma, correct?

A. So for the -- repeat your question, please.

Q. So if you look at the device structure that's shown in figure 2.

A. Uh-huh.

Q. The hole transport layer, the emission layer and the electron transport layer, those three layers have the same materials as those used in Ma, is that correct?

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A. I guess I want to be careful here because Ma really has a 40 nanometer doped hole transport layer followed by a 10 nanometer NPB layer. And Ma refers to that doped MTDATA layer in the experiment section as a p-doping HTL. So I don't think I would agree that the hole transport layers are the same. NPB is being used in both devices, varying different thicknesses. Alq is being used in both devices, varying different thicknesses. Bphen Liq is being used in both devices with different thicknesses.

So I can agree those materials are in the device, but I don't think I would agree that they're using the same hole transport layer.

Q. In Ma, what you have is Alq 3 as the emissive layer, correct?

A. In Ma, Alq is emitting light.

Q. And adjacent to the emissive layer Alq 3 on the cathode side is Bphen doped with Lithium Q, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: On the other -- you're saying between Alq and the cathode?

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BY MS. ZHONG:

Q. Yes.

A. Bphen is --

Q. Immediately adjacent to the Alq 3 layer on the cathode side, that's Bphen doped with Lithium Q, correct?

A. That's correct.

Q. And in Ma, immediately adjacent to the Alq 3 emissive layer on the anode side is NPB, is that correct?

A. Yes. NPB is on the Anode side of the Alq.

Q. And similarly, in this Exhibit 2103, you have Alq 3 as the emissive layer?

A. Again, without knowing more about what they're trying to accomplish, it's difficult to say. But in my opinion, Alq is likely serving as the emission layer in this device, but I don't see any emission spectra that would tell me as such.

Q. And adjacent to the Alq 3 on the cathode side is Bphen doped with Lithium Q in this Exhibit 2103, correct?

A. Yes. A thinner layer of Bphen than in Ma,

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but it is Bphen doped with Liq. And then Liq is also being used as an EIL.

Q. And on the anode side immediately adjacent to Alq 3, you also have an NPB, the sticker, correct?

A. NPB is adjacent to Alq in this paper.

Q. And if you look at the figure 2 of Exhibit 2103, is it correct that as the Lithium Q doping concentration increases, there seems to be an increase in the driving voltage and a slight decrease in the external quantum efficiency?

A. In figure -- which one, 2A?

Q. Figure 2.

A. Again, without knowing the details of what is actually being presented and discussed in this paper, all I can do is look at the points on the graph. But I think to make a conclusion on what's actually happening and how it might be different than Ma, especially given that Ma has p-doping as well, it's really not possible for me to do that just looking at these points.

Q. What does it show on the -- so what does it show in figure 2A?

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MR. WEIDENFELLER: Objection.

THE WITNESS: So again, I can read figure 2A in terms of the labels on the axes and the data points in the plot. But I want to stress that what's important here is that I don't have the context of what this author is actually trying to accomplish. And even though in their device architecture they may have the same materials in the structure, the thickness and the fact that the p-doping in Ma is missing is important.

I think if what we're trying to assess is clearly does Liq improve performance as the ETL, that's clear in figure 3 of Ma comparing the undoped device and the Liq-only doped device.

BY MS. ZHONG:

Q. Isn't it true that the molybdenum oxide is acting as a hole injection layer?

A. Molybdenum oxide can act as a hole injection layer, but I have no way of knowing if it's offering the same benefit as MTDATA F4-TCNQ at Ma's concentration or not.

Q. Do you know what Diekmann is using for its

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hole injection layer or hole transport layer?

A. Sorry, I'm still looking at the reference you just put in front of me. What Diekmann is -- Diekmann lists several materials that are possible candidates for the electron transport and electron injection materials.

Q. So for the one that you specifically rely on, what is the hole transport layer?

A. I don't think I actually specifically call out a specific hole transport material in Diekmann, but I can go back to that part of my disclosure. Just let me find that.

Yes. So what I do on page 69 of my declaration regarding dependent claim 5, hole transport layer that is p-doped, I include some of the examples from Diekmann essentially as hole conducting layers. And so spTAD is a notable example and I use that as part of the embodiment because spTAD is material that's been previously shown to be p-doped in OLEDs as in He and Pfeiffer.

Q. And that's not the same one as used in Ma, correct?

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A. Ma uses MTDATA.

Q. And it's different than the one you just mentioned, right, spTAD?

A. Yes. But both of those materials, based on the prior art, have been p-doped prior to the '425 being issued.

Q. And do they have the same doping effect?

A. Both those materials can be effectively doped with a dopant like F4-TCNQ. I don't know specifically if the concentration dependence is the same for both of them.

Q. So, for example, we don't know, when you use spTAD, you are going to have a similar charge balance system as Ma was able to get with its MTDATA?

A. I actually think a person skilled in the art would have a high expectation of success in that regard just because of the fact that charge balance device is based off doped, MTDATA and doped, spTAD were already known at the time. And so I think actually a person of skill in the art would have a high expectation of success potentially.

Q. Are you aware of any OLED system where the

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electron transport layer is a lithium Q doped electron transport layer and the hole transport layer is a p-doped spTAD?

A. I am not aware of a reference off the top of my head that would have the structure you're describing.

Q. And is the doping performance dependent on the thickness of the layers?

A. Can you clarify what you mean by doping performance?

Q. Strike that. Is the OLED performance in terms of driving voltages, current and the power efficiency dependent on the thickness of the doped electron transport layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: In general, the efficiency and voltage of an OLED will depend on the thickness of their constituent layers. In the case of an OLED with doped transport layers, there will still be some dependence on thickness, but it might be reduced because of the fact that the doping helps to reduce the resistance in those layers.

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BY MS. ZHONG:

Q. And would it be -- would the performance of the OLED in terms of driving voltages, current and the power efficiency dependent on the concentration gradient in the electron transport layer of the dopant?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't think we've talked about dopant being graded in an electron transport layer.

BY MS. ZHONG:

Q. So we talked about this morning about the -- you have a doped layer, then an undoped layer, a bi-layer structure, correct?

A. Yes, what we call the bi-layer structure. Okay.

Q. Okay.

A. Can you reask your question with that context, please?

Q. So does the performance of the OLED, for example, its driving voltage, its power efficiency, its current efficiency, do those performance

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parameters depend on the electron transport layers structures, for example, whether it's a monolayer, whether it's a bi-layer structure or whether there's a concentration gradient of the dopants across the electron transport layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: So the question you're asking is very broad. It's effectively asking does the performance of an OLED depend on the precise thickness, layer structure and composition of the electron transport layer. And the answer is yes, an OLED performance will depend on how the electron transport layer is configured.

BY MS. ZHONG:

Q. And if you have a bi-layer structure -- and by bi-layer, what I mean is a doped electron transport layer adjacent to an undoped electron transport layer.

A. So a blocking layer and a doped transport layer, yeah.

Q. Okay. A doping -- strike that.

So let's say we have an OLED device with a

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doped electron transport layer and a blocking layer.

A. I understand.

Q. And assume that the dopant in that OLED is Lithium Q.

A. Okay.

Q. How much of performance improvement there would be compared to an undoped electron transport layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: So just so I'm clear, we're talking about an arbitrary OLED where the only difference is the electron transport layer consists either of a fully undoped electron transport layer or a layer that has undoped electron transport material as a blocker followed by doped electron transport material with Liq?

BY MS. ZHONG:

Q. Correct, with the layer thickness optimized in each case.

A. So that's a very hypothetical question obviously. I don't think I can say what the improvement in performance would be without knowing

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more about the device, without knowing more about is it initially p-doped on the hole side, without knowing more about the emissive layer.

I think the important point to make is that when we're talking about the context of Diekmann and Suzuki, we're not starting with an undoped transport layer. It's already doped and so now it's just a question of is there a reason to try using Liq in place of whatever the existing dopant is. And so I think that's what I just want to stress in terms of how a person of skill in the art would look at the relevant exhibits.

Q. And in your opinion, the reason why a person of ordinary skill in the art would have placed the more common dopant, for example, Lithium or cesium is because Lithium Q has a high molecular weight, so its diffusion rate is lower?

MR. WEIDENFELLER: Objection.

THE WITNESS: So that -- certainly there would be the fact that it's a molecular n-dopant that would be attractive to a person skilled in the art. And just as Lithium was eventually replaced to some

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extent with cesium, a person skilled in the art would be looking to try and realize the benefits of something that is bulkier and less able to diffuse through the transport material.

However, I think that the performance improvements noted in Ma would also mean that a person skilled in the art could expect to see potentially better performance on the N type doping side as well. But that's something that one would have to try in their own device to know how much better the switch to Liq might be from a voltage or efficiency perspective.

BY MS. ZHONG:

Q. And was that something -- strike that. Would that improvement necessarily happen?

MR. WEIDENFELLER: Objection.

THE WITNESS: So you're asking me to speculate on if the addition of n-doping will always improve a device?

BY MS. ZHONG:

Q. No. I'm saying whether the n-doping with Lithium Q would necessarily improve the device

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performance in structures that you have specified for Suzuki and Diekmann.

MR. WEIDENFELLER: Objection.

THE WITNESS: So I think I actually just spoke to that in the second reason a person skilled in the art would have a motivation to use Liq. And so, again, with Diekmann or Suzuki using something that's obviously not Liq to start, the person of ordinary skill in the art would have the reduced diffusion molecular dopant motivation and expectation for success in applying Liq, but also would have the stated benefits of Liq as a dopant in Ma that could lead to improved performance from an efficiency or voltage perspective as well. But as I noted earlier, how much and how big depends on the device and that's something that a person skilled in the art would be motivated to try.

BY MS. ZHONG:

Q. Would there necessarily be an improvement?

MR. WEIDENFELLER: Objection.

THE WITNESS: That's not something that I can answer with certainty a priori.

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BY MS. ZHONG:

Q. And is your opinion that the diffusion rate decreases with molecular weight?

A. So can you just confirm what you mean by diffusion rate and what the diffusing species is and what it's diffusing in?

Q. Well, you tell me. When you have a Lithium Q doped Bphen or Lithium Q doped electron transport layer, which species is diffusing?

MR. WEIDENFELLER: Objection.

THE WITNESS: Okay. So in my declaration, the species it's diffusing is the dopant and that's consistent with how Diekmann is noting this problem as well. And when one is thinking about diffusion in a solid, one mechanism for diffusion is through empty space. In a crystalline materials, these would be strictly defined as interstitial sites, open sites between the atoms of the lattice. In something that's more amorphous, it might just be porosity.

And the general thinking that a person skilled in the art would have is that the larger and bulkier the dopant becomes, the fewer open spaces

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it's going to be able to fit through. And so if you have a dopant that is larger -- and molecular weight could certainly tie to size -- if you have a dopant that is larger, it's just not going to be able to take advantage of as many sizes of pores to diffuse through your electron transport material.

And so your question about am I tying diffusivity to molecular weight, I think I'm more comfortable tying it to size, but size and molecular weight can sometimes go in the same direction.

BY MS. ZHONG:

Q. And is it also a function of the concentration of the dopants?

A. Generally, when one defines a diffusion coefficient or a diffusivity, the diffusivity is a property of the material and of the material it's diffusing through. And so usually the diffusivity is not going to be concentration-dependent, though in a highly nonideal solution, that might be the case as well. Usually the flux will be concentration dependent. And so normally a diffusive flux can be written as the product of a diffusion coefficient at

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a concentration gradient in whatever the diffusing species is.

Q. And when you're talking about diffusion rate, you are referring to the flux, right?

A. No, I think I -- I don't think I said diffusion rate. I talked about diffusion coefficient and then the flux is the product of the diffusion coefficient and the concentration gradient driving diffusion. Strictly diffusion will usually only occur in the presence of a concentration gradient. Could be over short length scales, but usually over a concentration gradient.

Q. So in the case of Ma, at 33 weight percent, you are almost talking about one-to-one molecular ratio, right, of the Bphen versus Lithium Q?

A. Yes.

Q. So it's really different than a normal doping situation where you think about the dopant is really a very minor component of the entire mixture, right?

MR. WEIDENFELLER: Objection.

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THE WITNESS: I guess I'm not sure what a normal doping level would necessarily be.

BY MS. ZHONG:

Q. For example, for the P dopant side, you're talking about 0.3 weight percent, 2 weight percent, right?

A. Yes, I acknowledge it's different for the p-doping and the n-doping side of the device.

Q. And what's the normal doping amount when you dope with alkaline metal?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I don't know what a normal doping amount is. We can certainly go to one of several references. And maybe I'll do that now.

BY MS. ZHONG:

Q. Sure.

A. Yeah. So -- and this is why I wanted to check. In He, for example, no specific --

Q. Can you refer to --

A. I'm sorry.

Q. Exhibit 1019?

A. Exhibit 1019, yes. In He 1019, no

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specific doping concentration for cesium is given because the authors note that it's challenging to actually calculate and so they base their optimization of the cesium doping on subsequent measurements of conductivity.

(Exhibit No. 1016 was identified for the record.)

THE WITNESS: In Pfeiffer, which is Exhibit 1016, I think it's the same. They also don't list a specific concentration for the n-dopant, I think for the same reason. And then in the second He reference, I also include -- I'll find it and let you know the exhibit.

(Exhibit No. 1030 was identified for the record.)

BY MS. ZHONG:

Q. Is it 1030?

A. It probably is. Yes, it's 1030. Yes, same problem. So I'm not sure what a normal doping would be, especially at the time because it was challenging to measure deposition rates, at least according to these authors, of cesium using

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conventional quartz -- crystal monitors.

Q. And you have used Lithium doped Bphen in your experiments, correct?

A. I have not used Lithium doped Bphen myself, but I am on -- I am a contributing author on a publication that I believe uses Lithium doped Bphen.

Q. And do you know what's the doping percentage?

A. I don't have that paper in front of me, so I don't know off the top of my head.

Q. So let's say we have two OLEDs. Everything is the same except that in the electron transport layer, one has a 17 weight percent Lithium Q doped in Bphen and the other one has 33 weight percent Lithium Q doped in Bphen.

Do you have that in mind?

A. Yeah, I have that in mind except Ma, Ma basically looks at similar structures. So, yes, I have that in mind.

Q. And for those two structures, what's the relative amount of Lithium Q diffusion in the two

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systems?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I actually -- I don't know that quantitatively because, again, I'm relying in these proceedings on Ma and Ma doesn't cover Liq diffusion explicitly, so I don't think I can really offer any additional answer on that question.

BY MS. ZHONG:

Q. Would there be more diffusion or at least flux of diffusion in the 33 weight percent one since the concentration gradient is higher?

A. So I want to make sure I'm clear. Where is the concentration gradient higher?

Q. So on one side you have 33 weight percent lithium Q and on other side is zero, right?

A. Which interface are you referring to?

Q. It's interfacing with the aluminium Q.

A. Okay. So the emissive layer, yeah.

Q. The diffusion in relative amount is diffusion into the emissive layer.

A. Yes, I understand. Again, it's actually hard to say. So if I was talking about the diffusion

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of like carbon and iron, a very well behaved system, then the flux would scale nicely with the diffusion coefficient times the concentration gradient. I don't have enough information about the mechanisms for diffusion in Liq to really be able to answer that question with certainty in terms of whether there'd be a difference or not.

Q. And do you know whether there is necessarily a lower diffusion taking into consideration of the fact that some Lithium may be generated and the Lithium Q concentration is pretty high in the electron transport layer versus a system that's doped with more traditional cesium or Lithium electron transport layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: So if I remember the first part of that question --

BY MS. ZHONG:

Q. Okay. Let me just --

A. Yeah, maybe ask it again. That would be helpful.

Q. Okay. So let's take two OLEDs and

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everything being the same except that the electron transport layer for any one system is a Lithium Q doped Bphen, okay?

A. Yes, I understand.

Q. And based on Ma, appears that the effect of doping needs to be 17 weight percent or 33 weight percent. Those are pretty high concentrations, right?

A. Again, I've already commented. I'm not sure what "pretty high" means. So I don't think I'm going to offer any further opinion on what pretty high might mean, but they are higher in the ETL than the HTL in Ma.

Q. And you have another device. Everything else being the same except that the electron transport layer is doped with cesium or Lithium, okay? And let's assume that the doping level is 5 weight percent. So in those two systems, which one has a higher dopant -- which one has a total -- higher total diffusion of the dopants or the generated in Lithium impurities?

MR. WEIDENFELLER: Objection.

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THE WITNESS: So I don't think I have enough information to say one way or the other. What I would -- the general comment that I think I've already made, but I'll apply here as well is I understand trying to link it to a concentration gradient and that's because that's, you know, one of the ways that we think about diffusion. But if the diffusivity of the diffusing species is low, then the concentration gradient is less relevant because a very small number of times any concentration gradient will still be a very small number.

And so a person skilled in the art would look at Liq and look at the fact that it's a bulkier molecule than elemental Lithium or cesium and recognize that that has the ability to have a larger -- or a lower diffusion coefficient for diffusion in the electron transport layer and that would be the motivation to combine as an n-dopant in Diekmann or Suzuki.

Q. And do you know what is the concentration of the generated Lithium in the Lithium Q doped ETL layer?

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MR. WEIDENFELLER: Objection.

THE WITNESS: As I said this morning, I don't have certainty as to what the level of Lithium generation is even if there is any. All I can speak to is that in Liu, Liu comments that there is Lithium generation when depositing metal on top of a layer of Liq. But I don't have any quantitative details on what that concentration would be if it's present.

BY MS. ZHONG:

Q. And do you know what is the concentration of the free Lithium atom or cation that can diffuse through the -- an alkaline metal doped electron transport layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: That's sort of -- those sort of details were not something that impacted my opinion and I didn't look into them. So, no, I don't have any information to offer on that.

BY MS. ZHONG:

Q. So, for example, if the atom or the cation, the free cation are bound up by the electron transport layer to form some kind of coordination

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compounds or some kind of complexation, then the Lithium would become less mobile in those situations, right?

MR. WEIDENFELLER: Objection.

THE WITNESS: I didn't consider that line of reasoning for my arguments or my opinion. My opinion was based strictly on the fact that Diekmann is pointing to the diffusion issue of the dopant as being a problem, Liq being a larger, and dopant, as taught by Ma, would allow a person skilled in the art to address that problem. I didn't go into thinking about what the specific interactions might be between dopants and other molecules.

BY MS. ZHONG:

Q. What about Lithium fluoride. What is its diffusion coefficient compared to Lithium Q?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I haven't looked at that and so I don't know.

BY MS. ZHONG:

Q. Do you know whether it's higher or lower?

A. No, I don't. As I've already said, I

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don't know what the diffusion coefficient is for Liq and I separately don't know what the diffusion coefficient is for Lithium fluoride, so I'm not able to answer that question.

Q. And Lithium fluoride is one of the named preferred dopant in Diekmann, correct?

A. Lithium fluoride is a listed dopant in Diekmann.

Q. And you have no opinion whether Lithium fluoride is a molecular dopant or it's considered to be a salt with free cations and anions --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- or what the form of Lithium fluoride exists as a dopant. You don't have any of those opinions, right?

A. I didn't need to take an opinion on what Lithium fluoride's function would be in Diekmann's device. My emphasis was simply on looking at whether or not Ma and Diekmann would teach to the claims.

Q. But your person of ordinary skill in the art, wouldn't they ask what is a motivation to

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replace Lithium fluoride with Lithium Q?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I think a person of ordinary skill in the art would see Diekmann and realize that there's a benefit to utilizing a molecular n-dopant. And I'm not taking a position on what Lithium fluoride should be classified as, but Liq certainly can be classified as a molecular n-dopant and so that would be the motivation to combine.

BY MS. ZHONG:

Q. So what would be the advantage of using Lithium Q over using Lithium fluoride?

A. So again, I'm not qualifying what Lithium fluoride is as a molecular -- whether it's a molecular n-dopant or not. I think the advantage a person skilled in the art would see is that Liq is a molecular dopant and so that would be the potential advantage they would see in trying to apply it. How it relates to Lithium fluoride is not something I had to think about to come to my opinion.

MS. ZHONG: Why don't we take a

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five-minute break.

THE WITNESS: Sure. That sounds good.

(Recess.)

BY MS. ZHONG:

Q. Can we take a look at the figure 2A of Diekmann that you rely on?

A. Sure. Let me go find it.

Q. So the first appearance of that figure is on page 46 of your report.

A. Yep. I'm just pulling it up. Yes, I see it.

Q. And so in figure 2A of Diekmann, there is a layer 402 that's doped. That's to cathode 3, correct?

A. Yes, that's correct.

Q. And then there is an unlabeled layer between layer 401 and 402, correct?

A. I'm sorry, can you repeat that question again?

Q. So in figure 2A of Diekmann, do you see that between layer 402 and layer 401, there is another layer, but it's not labeled with anything?

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A. That's true. I agree.

Q. Do you know what that layer is?

A. I think a person of skill in the art would recognize that as a blocking layer or an undoped electron transport layer in the device.

Q. And what about the layer between 401 and anode 2.

A. So the layer between 401 and anode 2 could be a hole transport layer. It could be a series of hole transport layers. Could be p-doped.

Q. So in figure 2A, 402 is shown as a doped layer with those little circles corresponding to dopants, correct?

A. Yes.

Q. And the other layers, no dopants are shown, correct?

A. In the other layers, no dopants are shown, including in the emissive layer, which Diekmann teaches is also doped with an emitter.

Q. And for the emissive layer, so for -- let's look at paragraph 104 of your declaration.

A. Okay.

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Q. And it's on page 63 of your report.
A. Yes, I see it.
Q. And for that one, we discussed this morning that you basically relied on three layers, correct?
A. Yes, as we discussed this morning, three different layers, each in a different color.
Q. And do you think that this limitation is met if we rely only on one of the three layers?
A. Can you rephrase your question? The limitation claim 1F or --
Q. Limitation 1F.
A. Oh, okay. So we're talking about 1F. If we rely on just one of the three layers. So I considered all three layers and I considered all three layers because of the way the claim limitation is actually written.

And so element 1F notes that wherein the layer sequence comprised at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared to UV during operation. And so using

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Diekmann's three layers, you're getting that full range of emission, blue, green and red, to meet the requirement of this element of claim 1.

Q. Okay. So my question to you is that if the -- you interpreted this claim as covering the -- every single wavelength between the infrared to UV.

A. Yes, I'm interpreting this element of the claim to cover effectively the visible. So from the UV to the infrared.

Q. But the three layers are generating red, green and blue lights, right?

A. Yes. Based on the reference I cite on the following page to Klein, they're generating red, green and blue light.

Q. And other than iridium (ppy)3, you don't know what the emitter materials are for the red and the green, right?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. As we've already talked about, the materials listed other than Ir (ppy)3 are presumably proprietary materials whose structure is probably not public.

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BY MS. ZHONG:

Q. And so you don't know what the emission spectrums are, correct?

A. I don't know what their specific emission spectra are. But as I note in paragraph 103, I'm also relying on Diekmann teaching that the electromagnetic radiation generated by the radiation emitting component may in particular have a spectrum with wavelengths in an ultraviolet to infrared spectral range.

And so I'm taking knowledge of those three emitters being blue, green and red with the fact that Diekmann is teaching that you need to cover the full range of the visible. That's at the bottom of 62 in my declaration.

BY MS. ZHONG:

Q. I understand.

A. Okay. Yeah.

Q. But right after the sentence that you quoted in paragraph 103, it says, "In particular, it may be advantageous if the spectral comprises at least one wavelength visible to an observer,"

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correct?

A. Is this in Diekmann now you're quoting to?

Q. Yes.

A. Sure. Let me just go to that so I can make sure I'm on the same page as you. This is still around Diekmann 76?

Q. Yes, page 676.

A. All right. Hold on. I'm not sure I'm in the right place. So 76 of Diekmann?

Q. Yes.

A. Oh, page -- I'm sorry.

Q. Page 76.

A. Yep, yep. Okay.

Q. And the last paragraph.

A. Yep. Hold on. So this is this paragraph starting the electromagnetic radiation, correct?

Q. Yes, starting with the --

A. Yep, yep, yep. So in particular, it may be advantageous, that's the sentence you're pointing to, correct?

Q. Correct.

A. Okay. Yep. All right.

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Q. So it seems -- go ahead.

A. No. I was going to say, remind me what your question was.

Q. Okay. So reading the sentence immediately after the one you quote, it seems to be saying that have a spectrum with wavelength in an ultraviolet to infrared spectral range, that can be satisfied by a spectrum that comprised just one wavelength visible to an observer, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: That's not how I interpreted the claim or it's not how I --

BY MS. ZHONG:

Q. I'm just saying like -- sorry.

A. No, I said that's not how I interpreted that passage in Diekmann, but I'll reread it right now again.

Q. Okay.

A. Yes. So I guess I -- Diekmann -- so I guess I don't see necessarily the conflict here. So my interpretation of the claim element, which obviously belongs to the '425 and not Diekmann, is

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that the claim is intending for emission from the ultraviolet to the infrared. And Diekmann certainly is arguing that and also has a red/green/blue triple emissive layer embodiment that would further support this broad emission.

And further I think supporting the read that I'm offering of Diekmann is the fact that part of the focus of Diekmann -- and there's obviously many things Diekmann is doing -- but part of the focus in Diekmann is for solid state lighting, is a white lighting device and a white lighting device would ideally have spectral components throughout the visible. Otherwise it would have a low color rendering index and wouldn't be able to reproduce all of the colors that are needed to illuminate an internal space.

Q. So if the red, green and blue emission spectrum, they don't exactly overlap which makes the green emission spectrum -- is very narrow and it ends before the green emission spectrum starts to -- the green emitter starts to emit and the green emitter and emission is at a point before the red emitter

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starts to emit. So basically there are gaps between the mission spectrum for the red, green and blue. Do you still consider that configuration to satisfy element 1F of the '425?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I didn't consider alternate, I guess, emitter configurations that could satisfy or not satisfy the claim language. What I did was read Diekmann as a person skilled in the art. Understand that my reading of the sentence in question is when one has a spectrum from the ultraviolet infrared range consistent with Diekmann's interest at least in some embodiments in making a white lighting element, and also consistent with Diekmann's use of red, green and blue emitters.

The type of device you're describing would not be a well suited white light-emitting device and so to me it would be one that would be, you know, less within the same scope of what Diekmann is teaching. Because a device that basically has -- you know, if you want to take an extreme -- a delta function emission spectrum in the blue, green and

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red, you'll have an extremely low color rendering index and would be a very poor illuminate. And so I think reading Diekmann in the context that Diekmann's written, I don't think that would be consistent with what they're trying to invent.

BY MS. ZHONG:

Q. What do you mean by a white light emission device? So if you have a display that can render color, like a white color, do you consider that to be a white light-emitting device?

A. So, no. What I'm referring to in this case is an OLED that, when energized, emits white light. So a single device that when energized emits white light. And certainly when OLEDs grew in efficiency and performance, there was additional interest in groveling their application and solid state lighting for illumination, general lighting was a significant potential next application for OLEDs.

And so I'm actually referring to a device where, based on Diekmann and based on the claim language, the device itself is emitting -- or sorry, the OLED itself, pardon me, not the device -- the

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OLED itself is emitting white light.

So, for example, a three emissive layer that are stacked in a single device.

Q. But each of the layers only is emitting one of the -- a part of the spectrum, right?

A. It's actually possible to -- yeah, so in Diekmann's embodiment, each of the layers is responsible for emitting a different part of the spectrum. But as we've discussed, all three of those layers are within the single OLED and so that OLED, when energized, will emit white light.

Q. When you say within a single OLED, what do you mean by that?

A. So element 1F is saying wherein the organic layer sequence, and so when I say a single OLED, I mean within, you know, Diekmann's embodiment in figure 2A, within three layers, red, green, blue, replacing 401, right? So if you look at figure 2A, the emissive layer 401 would now be Diekmann's emissive layer of SEB-10, SEB-20, TMM-4:Ir(ppy) and TMM-4:TER12, right? So, I mean, a single OLED device as shown in Diekmann figure 2A.

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Q. So instead of the three emissive layers being vertically stacked, what if they are horizontally placed. Do you still consider them to be within a single OLED device?

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. Because they share the same electron transport layer and the hole transport layer.

MR. WEIDENFELLER: Objection.

THE WITNESS: So I didn't consider alternate embodiments of -- again, of what else would meet 1F mainly just because I -- in my opinion, Diekmann's three emissive layers replacing 401 in figure 2A would meet the specification of the claim. So I don't have an opinion to offer on the other embodiments that might meet or not meet the claim language.

BY MS. ZHONG:

Q. Do you have an opinion as to whether the aluminum Q3 emissive layer alone would meet the claim language?

A. AL -- sorry, can you rephrase your

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question?

Q. So instead of the RGB multiple emissive layer structure as in Diekmann, if you just have the aluminum Q3 layer as your emission layer as in Ma, do you consider that to meet the limitation recited in element 1F?

MR. WEIDENFELLER: Objection.

THE WITNESS: Well, element 1F requires generation of electromagnetic radiation from the UV to the infrared. I'm not aware that Alq generates emission from the UV to the infrared.

BY MS. ZHONG:

Q. So in your opinion, you don't believe that Alq 3 layer alone meets element 1F?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I don't have the data in front of me to be able to comment on whether or not Alq would meet 1F. The way I have applied -- or the way I have interpreted 1F and the way I have applied Diekmann towards 1F is that whatever the embodiment is that's being used to satisfy this claim has to be one radiation emitting region configured to

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generate radiation from UV to infrared.

And so the opinion I'm taking is that Diekmann satisfies that by virtue of the comment that they're trying to realize a spectrum from the ultraviolet to the infrared and that they have an embodiment that allows emission in the red/green/blue simultaneously with three emissive layers.

BY MS. ZHONG:

Q. Do any of your references show how an n-doped electron transport layer would -- strike that.

Do any of your references discuss how the device would perform where the OLED layer -- let me withdraw and reask that question.

Which of your references discuss a device with multiple emissive layers in a single OLED device?

MR. WEIDENFELLER: Objection.

THE WITNESS: Just give me a moment to double-check my references. Let me do one more check. Okay. There's several references beyond Diekmann that have either multiple emissive layers or

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a combination of emissive layers.

(Exhibit No. 1013 was identified for the record.)

BY MS. ZHONG:

Q. And which have those?

A. Sure. Let me go through them one by one. The first is in Exhibit 1013, Baldo, et al.

Q. Does this one have a doped electron transport layer?

A. No, it does not use a doped electron transport layer.

(Exhibit No. 1029 was identified for the record.)

BY MS. ZHONG:

Q. And what's the next one?

A. The next one where I speculate that it's a -- it has multiple emitter layers would be in Exhibit 1029, page 21.

Q. Page 21?

A. Uh-huh.

Q. If it says it has a wide PIN structure, that means they have multiple emissive layers?

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A. No, the PIN aspect only refers to the doping. That's why I said I speculate this one has multiple emissive layers because to cover the white, it's likely using multiple emissive layers and it's clearly noted as a white device, but I --

Q. Yeah, that's what I meant. You are inferring that there are multiple emissive layers because it is white light-emitting, is that correct?

A. That's correct.

Q. What's the next one?

A. Exhibit 1030.

Q. Okay. And before we go to Exhibit 1030, for Exhibit 29, do you know what the dopant is?

A. This is the Novaled reference again?

Q. Yes.

A. No, I don't think there's any information beyond what's shown in the slide, so I don't know the specific dopant.

Q. And you don't know whether it's a molecular dopant or whether it's a metal dopant, correct?

A. Pardon me. I thought you were referring

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to the emitter dopant. You're talking about conductivity dopants?

Q. Correct, the electron transport dopant.

A. I would infer based on the data shown on page 7 of the same slide deck from Novaled that it's most likely a molecular n-dopant, but I don't know that for a fact. But they're advertising that on slide 7 as part of this slide deck.

Q. And you don't know whether that molecular dopant is a Lithium salt or whether they're -- back then it was popular for people to look at the -- what they call the high-lying HOMO molecular dopant, for example, such as tungsten hpp4, cobalt and chromium type of molecular dopants, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't know what the molecular dopant is that they're referring to.

BY MS. ZHONG:

Q. And you said the next one is Exhibit 1030?

A. Yes, 1030. If you look at figure 1 of 1030, this is a double emissive layer OLED where both emissive layers are configured to emit light from

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Ir(ppy)3.

Q. And do you know what is the dopant used here?

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. What is the n-dopant used in figure 1?

A. At the bottom of page 1, right column, the n-dopant used in figure 1 is cesium.

Q. But in this emissive layer, there is only iridium (ppy)3. It doesn't have multiple emissive layers, right?

MR. WEIDENFELLER: Objection.

THE WITNESS: So again, if you look closely at the exhibit, this is specifically called out as a double emissive layer OLED. So there are two emissive layers, but they are both emitting from Ir (ppy)3.

BY MS. ZHONG:

Q. So the double emissive layer is with different host materials. One is with TCTA. The other one is with TAZE and both are doped with the same iridium (ppy)3?

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MR. WEIDENFELLER: Objection.

THE WITNESS: That's correct. That's what's shown in figure 1.

BY MS. ZHONG:

Q. So in both layers, it's green light -- strike that.

For both of the emissive layers, it's green light, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: In this paper, both emissive layers emit green light.

BY MS. ZHONG:

Q. So in this paper, it doesn't have a red emission layer and a blue emission layer, then a green emission layer as in Diekmann.

A. No. Figure 1 only has the two emissive layers and each emissive layer is doped with Ir (ppy)3. So the emission will look like emission from Ir (ppy)3 from both layers.

Q. What's the next one?

A. I believe that's all of them.

Q. And you did not come across with any

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references where Lithium Q is used and multiple emission layers are used, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: As we discussed earlier, no, I haven't come across any references where Liq is used with multiple emission layers.

BY MS. ZHONG:

Q. I'm not restricting using Lithium Q in the electron transport later. It can also be in the electron injection layer.

A. Oh, pardon me. So your question is am I aware of any papers where Liq is used as the electron injection layer and that device also contains several emission layers?

Q. So my question is are you aware of any OLED devices where Lithium Q is used as either electron injection layer or electron transport layer and also contains multiple emission layers?

A. That is not something that I looked for in my preparation of my declaration. There are certainly many papers in which red, green and blue layers are stacked in an OLED to make a white OLED.

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I'm not aware of one that fits the constraints you're describing off the top of my head, but it's not something I looked for.

Q. And besides Diekmann, of the references we just discussed, which one has a white emission layer and an n-doped electron transport layer besides Diekmann?

MR. WEIDENFELLER: Objection.

THE WITNESS: Are you specifically asking about the exhibits we just discussed?

BY MS. ZHONG:

Q. The exhibits that you have submitted or any other paper that you are aware of.

A. So of the exhibits that we just went through, the Novaled slide deck is likely the one that would show what you're describing. The other exhibits I called out weren't designed to generate white light.

Q. But for the Novaled one, you're not sure whether the dopant is Lithium salt or not, correct?

A. I don't have knowledge of Novaled's dopant.

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Q. So based on your expert knowledge and experience, do you know what kind of molecular dopant was Novaled developing back then?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't have knowledge of what kind of dopant Novaled was developing back then.

BY MS. ZHONG:

Q. And do you know whether Novaled was using Lithium Q or exploring Lithium Q in their products back then?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't know if Novaled was looking at Liq in their products.

BY MS. ZHONG:

Q. Do you know whether Novaled was looking at any Lithium salt in their PIN structures back then?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't have any knowledge of what Novaled was looking at, whether it's Lithium salt or otherwise, in their PIN structures.

BY MS. ZHONG:

Q. By the way, what is your hourly rate?

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A. What is my what?

Q. What is your hourly rate.

A. Oh, I'm sorry.

Q. What is your hourly consulting rate?

A. My hourly consulting rate is $600 per hour. And then I have a higher rate for deposition and courtroom testimony that I think was set at $150 per hour.

Q. How many times have you worked for Samsung before?

A. With the exception of the '164, I haven't worked for Samsung before.

Q. How many times have you worked with Covington before?

A. This is the first time I've worked with Covington, the '164 and the '425.

Q. You have your own research group, correct?

A. I do.

Q. And what are the educational background of the researchers in your research group?

A. You're asking what are the educational backgrounds effectively of my graduate student

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researchers?

Q. And post-docs.

A. So I work in a department of chemical engineering and material science. As such, the majority of students that I recruit into my research group are pursuing either a Ph.D. in chemical engineering and material science. The undergraduate training of those students is generally either chemical engineering, material science or physics most frequently would be the three that are most commonly in my group.

Q. How long does it usually take them -- strike that.

How long does it usually take before they become an independent researcher?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm not sure how to define independent researcher in this context. Can you be more specific as to the traits that you would be ascribing to that moniker?

BY MS. ZHONG:

Q. So what is the goal of a Ph.D. trainee?

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A. That's a good question. In my opinion, the goal of a Ph.D. is to take a student from a position where they have a lot of energy, but perhaps don't necessarily have the ability to efficiently direct it in terms of being critical of their experiments, being critical of their data, how to design experiments. And then after their Ph.D., have them emerge ready to take on challenges that might come with their future career, whether in academia or industry. And --

Q. And -- go ahead.

A. No. I was just going to say, and in that process, they are becoming an independent researcher.

Q. And where in that process is the skill level of a POSITA for?

A. So in defining a person skilled in the art for this particular proceeding, my thinking was specifically about an experienced -- either an experienced third-year graduate student, just finished their third year, and is now competent and able to look at the literature, able to critically look at their data, able to decide next steps or

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someone who has gone through a similar level of maturation, training and growth in an industrial setting related to work in organic electronics. And that's very much consistent with how I prescribe the development of graduate students in my group.

What I tend to say to them is obviously at the beginning of their career, you know, they will be doing experiments that while they're consulted on, senior students and I will be helping them to decide what's next. But what I tend to say is that in your third year, you should have now that independence to be able to look at your data, clearly decide what the next step is, synthesize that with the literature and what else is happening in the research group and be able to make those independent decisions.

And what I always like to say to the students is that, in your fourth year, you should be coming to me with a great idea for an experiment and then when I agree with you it's a great idea, you should say to me, and I already did it and show me the data and show me that you were right. And that's when I start to know as the advisor that that student

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is ready for their next challenge in their professional development.

Q. So in your opinion, a person of ordinary skill in the art should be someone who can take the literature, independently assess the significance of the teaching in the literature and decide what to do with the literature data, is that correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't think I -- I hope I didn't make it sound quite that independent. I think a person skilled in the art should be able to look at the literature, understand what the literature is teaching and see how that literature could be beneficial to what they're trying to accomplish and work on.

And so in the context of the current proceeding, which I'll just use as the obvious example, someone should be able to understand the challenges they're trying to resolve in their research, look at the literature and then be able to say, ah, that's something now that I'm being taught that will allow me to make my device better. I'm

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going to go into the lab and try and optimize it as needed. And I think that is consistent with what would be needed for a person skilled in the art and with what's needed for this particular case.

BY MS. ZHONG:

Q. When were you first exposed to OLEDs?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I first started reading about OLEDs as a -- let me be careful. So with intensity as a first-year graduate student, but I first started reading about OLEDs as a senior undergraduate as I was beginning to consider potential universities for graduate study.

BY MS. ZHONG:

Q. And did you take any classes as an undergrad student?

A. I took many classes as an undergraduate student.

Q. No, sorry, did you take any classes in OLEDs as an undergrad student?

A. I have to think a little bit back now. I didn't take any classes as an undergraduate student

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that were focused entirely on OLEDs. And I don't recall learning about OLEDs as an undergrad student in class.

Q. And so what you learned about OLEDs in undergrad is when you were looking at different grad programs and trying to figure out what you wanted to do, is that correct?

A. Yeah, that's correct. And also I had a general interest towards the end of my undergraduate studies in more engineering applications of physics. And so my undergrad training is in physics. I had worked very much on fundamental characterization related to physics as an undergrad and I had an interest in trying to understand how I could maybe move into more of an applied space.

And so looking at just what was -- what types of materials were interesting and emerging, I did come across organic semiconductors and that was one of the areas that I was interested in looking at for graduate school.

Q. At the time that you mentioned, 2008-2009, was it typical to offer undergrad classes in OLEDs?

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MR. WEIDENFELLER: Objection.

THE WITNESS: When you say was it typical, at what schools, where? That's a very broad question. Can you be more specific?

BY MS. ZHONG:

Q. So in the physics department or chemistry department, those are the relevant fields that you have defined for a person of ordinary skill in the art, correct?

A. That's correct. Well, those and associated fields as well, but those are two that I list explicitly.

Q. So in those associated departments, do they offer classes -- undergraduate classes in OLEDs?

A. Again, I can't speak for all of the -- again, I did my undergraduate training in Canada, so I can't speak for all of the degreed programs in chemistry and physics that might exist. You know, in general, I think that whether or not there's an explicit course depends oftentimes on whether or not there's a faculty member of that particular institution that works in the area.

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Certainly I teach an undergraduate course and I bring elements of OLEDs and organic solar cell into my class. So seniors in chemical engineering and material science at the University of Minnesota can learn about OLEDs as undergrads.

Q. But that's not necessarily the case. In a lot of universities, they don't have an OLED program or that does not have a professor that specializes in OLEDs.

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I think I addressed that. But it's hard for me to know what's available and what's not. All I can really speak to is my own experience in that respect. Increasingly, though, OLEDs are so ubiquitous that I would be surprised if they weren't at this stage used as an example in classes on organic chemistry and physical chemistry.

BY MS. ZHONG:

Q. I'm not talking about today. I'm talking about back in 2008-2009.

MR. WEIDENFELLER: Objection.

THE WITNESS: I think my comment would

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hold even in 2008-2009. Certainly a chemist who is doing any kind of research and looking for ways to better engage their undergraduates in sophomore organic chemistry class or a junior level physical chemistry class would naturally try to find exciting applications.

And even in 2008-2009, while obviously the commercialization was not quite where it was today, I think that would have been a potential example, but I can't say with certainty where OLEDs were taught and where OLEDs weren't taught.

BY MS. ZHONG:

Q. Do you have any research collaboration with Samsung?

A. I don't have any research collaboration with Samsung and never have.

Q. And in paragraph 5 of your declaration, you mentioned several classes that you are teaching. Are those undergrad classes or graduate level classes?

A. Sure. Let me just go back to my declaration. Those are all offered as undergrad

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classes. The course I teach in solar cell physics is listed as an undergrad class and sometimes there might be one or two grad students who take it, but it is primarily undergrad. All the other ones are exclusively undergrad classes.

Q. So which of these classes that you introduced -- strike that.

In which of these classes do you actually teach OLED-related materials?

A. Sure. So in my class on solar cell physics, I actually have taught students about OLEDs. And the reason why is because, in the context of talking about organic solar cells, it's helpful to at least acknowledge the wide commercialization and operation of OLEDs as sort of a general motivator for organic semiconductors. So I talk about OLEDs in my class in solar cell physics.

I have talked about OLEDs in my transport and kinetics class and did this semester. And then I've also talked about OLEDs in my electronic and magnetic properties of materials class which is where it's probably most obvious. And my introductory

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material science class I have not taught for many, many years, so I don't remember if I also found a way to talk about OLEDs in that class, but it wouldn't surprise me if I did.

Q. So what do you teach about OLEDs in those classes? Do you talk about N doping of electron transport layer?

A. Well, it depends on the class and I don't know if I can remember my lecture notes on the spot. But in the context of electronic and magnetic properties of materials, I make -- I teach students in that class about LEDs based on inorganic semiconductors like gallium arsenide or gallium nitride and then I comment on the fact that those technologies, while very efficient, are not easy to produce. They're expensive devices. And then I use that as a way to introduce the concept of OLEDs focusing mainly on structure of the device and how it works and the fact that it uses molecules.

In the transport and kinetics class, there I talk about the fact that OLEDs use amorphous thin films, something we touched on this morning, because

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a big part of that class is on how materials are processed, but frequently the materials examples used are metals. And so I always try to bring some of my own expertise and personality into the class and so I sort of will say to them, okay, you just learned about metals. Now let's talk about the phone in your pocket, and comments on thin film behavior there.

And then in the solar cell physics class, my discussion is a little bit more high level. I would share with them the layer structure. So they actually would know for sure what ETL, HTL, EML mean in that class. I might even share with them the concept of a phosphorescent dopant, though I don't remember if I did that last fall. And then there I sort of focus on some of the unique functionality of displays based on these devices, whether it's flexible or, you know, foldable or these sorts of interesting form factors that are only possible -- well, not only possible -- but largely only possible with OLEDs rather than LCD displays. So those are some of the ways I interweave aspects of OLEDs into these classes.

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Q. Do you teach what kind of materials you use to dope the electron transport layer, for example? Or would that be too specific?

A. I think I have alluded to the fact that one can dope organic semiconductors, but I don't think I've taught them specifically about Lithium or cesium versus what other options there might be. So I can't say for certain, but I don't think that would be something I'd emphasize.

Q. Let's take a look at paragraph 28 of your declaration.

A. Okay. All right. I found it.

Q. So you want the excitons to form in the emission layer, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: Are you referring to a particular device structure here? Is this for the figure on 17?

BY MS. ZHONG:

Q. Any of the structures that you have depicted from page 17 to page 19.

A. Sure. Yes, usually you're forming

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excitons in the emissive layer with the intent of emitting light.

Q. And you don't want the excitons to be formed in -- strike that.

You don't want the exciton to be formed in a layer other than the emission layer, is that correct?

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. Or the emissive layer.

A. What was the last thing you added there, or the what layer?

Q. Or the emissive layer.

A. In my opinion, you want the excitons to form in the emissive layer and to recombine and emit light from the emissive layer.

Q. So a person of ordinary skill in the art would understand that it is important to form electrons in holes in the emissive layer, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: A person skilled in the art would understand that it's important to form excitons

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in the emissive layer.

BY MS. ZHONG:

Q. And they would also understand the importance of not forming excitons in a layer that is not an emissive layer, correct?

A. Yes. A person skilled in the art would understand that the objective is to form excitons in the emissive layer.

Q. Emissive layers consist of hosts and guests, correct?

A. An emissive layer may consist of a host and guest, but an emissive layer might also be a neat material.

Q. And when the emissive layer consists of a host and a guest, what is the typical percentage of the host?

MR. WEIDENFELLER: Objection.

THE WITNESS: So if I look in my declaration, what I note at the bottom of page 16 is the EML generally consists of two different types of molecules referred to as host and guest with the host encompassing roughly 90 percent of the film, but with

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the guest responsible for light emission. And that 90 percent of the film is a nominal number for a typical phosphorescent OLED.

BY MS. ZHONG:

Q. And when you say 90 percent, is that a weight percentage? Molar percentage? Volume percentage?

A. So in the context of a vapor-deposited device, which is what I have in mind here, generally it's volume percent based on the way the composition is measured. But in fact, if the densities of the materials are similar, the weight percent/volume percent will also be similar.

Q. Are the densities of the host materials and guest materials typically similar?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, it depends on the host and guest. I don't know off the top of my head what the densities are of the various materials. I'm just noting that, if they are similar, then the volume percent and weight percent would also be similar.

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BY MS. ZHONG:

Q. Do you know what's the -- for iridium phosphorescent emissive materials, do you know what their typical densities are?

A. I don't know the density of, again, something like iridium (ppy)3, so I don't want to hazard a guess at what the density would be.

Q. And do you know what the typical emissive organic materials -- strike that.

Do you know what is a typical host material's density are in the emissive layer?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I want to make sure I'm clear. When you say density in the emissive layer, you're not referring to the composition of the emissive layer. You're referring to the mass density, is that correct?

BY MS. ZHONG:

Q. Yes. Do you know what is the typical density for the host materials are?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I don't know -- again,

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I'd be hazarding a guess at what I think the typical density is. So I don't know off the top of my head what the density would be for some of these materials.

BY MS. ZHONG:

Q. And when the emission layer consists of a host and a guest, do they exist as a physical mixture or do they form some kind of complexes?

MR. WEIDENFELLER: Objection.

THE WITNESS: When I consider the behavior of the host and the guest in the emissive layer, I think of them as a simple mixture.

BY MS. ZHONG:

Q. What about for the n-doped electron transport layer. Do you consider them just as a physical mixture or do you believe there is some kind of a complexes formed?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I'm not -- I consider them as a physical mixture. I haven't thought about whether or not a complex might form be it in the EML or other layers of the stack. So I don't have

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anything further to add on that.

BY MS. ZHONG:

Q. In paragraph 29, it says that selection of the materials that are included -- in 29, you say, "The selection of the materials that are included in the EML of the OLED strongly determines the light-emitting efficiency of the device."

Do you see that?

A. Yes, I see that, that sentence.

Q. What do you mean by that?

A. Sure. So when one is defining the EML of an OLED, the biggest choice one that makes that impacts efficiency is whether or not one is using a fluorescent emitter or a phosphorescent emitter. A simple fluorescent emitter, the injection of electrons and holes into the emissive layer and generation of excitons on that emitter lead to 75 percent of the excitons being forbidden from undergoing radiative recombination. So in a fluorescent material, the triplets are not able to emit light. And so as a result, the fluorescent material, even if you do everything correctly,

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already loses three-quarters of its potential efficiency.

Using a phosphorescent material where the triplet becomes radiative via intersystem crossing allows one to get around that bottleneck and realize the potential quadrupling in efficiency just by selection of the material. And so that choice of whether you're choosing a fluorescent material that emits out of the singlet or a phosphorescent material that emits out of the triplet and is able to harvest all electrically generated excitons is a huge factor in whether or not the device you're going to construct has a very high efficiency or a much lower efficiency.

And again, this is independent of what other decisions you make. Well, it's not necessarily independent, but it's mostly independent of the decisions you make in the device because of the fact that the triplets in a fluorescent material are quantum mechanically disallowed from emitting light. There's a spin selection rule that prevents them from radiatively recombining. So that means that

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three-quarters of the excited states you electrically generate, even if you do everything well, are dark.

While in the phosphorescent emitter, you form singlets and triplets. The singlets convert into triplets and the triplets can emit light, which means that now all of those electrically generated excited states can be harvested for light emission. And so my usage of the term "strongly" there is referring to the type of dopant that one selects to start.

Q. Okay. So the first sentence in paragraph 29 is referring to the emitted materials where they are choosing a phosphorescent material or fluorescent material, is that correct?

A. When I say the -- again, obviously the host can matter, too. But when I say strongly determines, I'm noting the fact that you can have a significant dependence on efficiency just coming from how you select the emissive layer.

Q. And related to that is to make sure that there is not going to be premature or nonradiative quenching of the triplet energy levels, especially in

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the phosphorescent system, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: No, I'll just restate that. So the nonradiative recombination of the triplets will happen by default in a fluorescent material. So in a fluorescent material, the triplets are not nonradiative. There's very little you can do unless you move to a more exotic emitter, but the triplets are going to be nonradiative and so there you've lost the triplets already.

And then in the case of the phosphorescent emitter, the triplet is now your radiative recombination channel and you're trying to optimize the formation and recombination of triplets on that phosphorescent guest.

BY MS. ZHONG:

Q. But in the phosphorescent system, it is important for you to make sure there's not going to be any triplet exciton quenching in order to like maximize the efficiency, for example, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: In a phosphorescent OLED,

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with a phosphorescent emitter, you want to maximize the rate of recombination of triplets on the phosphorescent guest.

BY MS. ZHONG:

Q. And diffused impurities like alkaline metal species can act as quenching sites and therefore reduce the efficiency of the phosphorescent system, is that right?

A. Impurities in the emissive layer in OLED, be they metallic or otherwise, can impact the efficiency of a fluorescent and phosphorescent OLED.

Q. Do you know whether the Lithium Q would affect the -- strike that.

Do you know whether Lithium Q can act as quenching sites for the triplet energy levels in a phosphorescent system?

A. So based on the data I have, I don't know for a fact whether or not Liq would be a quencher for a phosphorescent system or a fluorescent system for that matter.

Q. Do you think at the time of the invention, a person of ordinary skill in the art would expect

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that the Lithium Q can act as a quenching site?

A. As I've said before, I think that that's not the question a person skilled in the art would be asking. I think a person skilled in the art would be asking can I replace the anti-dopant that I'm already using in Suzuki and Diekmann with Liq and have an expectation of success. And I think the answer to that is yes.

Again, Diekmann and Suzuki already used doping. Both of them permit that doping to be used with the phosphor. And so I think that would be the question a person of skill in the art would ask and they would have an expectation that Liq being a molecular dopant would be potentially less mobile and, based on the prior art, would also know that blocking layers are routinely used in OLEDs and can mitigate this issue as well.

Q. But in Ma, it does not specifically specify an independent blocking layer, correct?

(Exhibit No. 1014 was identified for the record.)

MR. WEIDENFELLER: Objection.

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THE WITNESS: Ma does not -- again, as we discussed earlier, Ma does not specifically have a blocking layer. I've already given my opinion on how I think Ma is working. But P and n-doping, especially in phosphorescent OLEDs, was already so well-known at the time of the '425 that this would be knowledge to a person skilled in the art.

And frankly, even beyond that, blocking layers were routinely introduced into phosphorescent OLEDs even that weren't dopant, right? And so even if you look at -- might as well cull one of these out.

So if you look at, for example, Exhibit 1014, which is a seminal paper on iridium phosphorescence applied in OLEDs, you can see in their figure 1 that they're using NPD as a hole transport layer. They're using Alq as an electron transport layer. And then a blocking layer of BCP in contact with the EML. This is from 1999. Every person working in OLEDs has effectively read this paper. It is an extremely important paper. And would understand that blocking layers are something

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that are routine to include in an OLED. And in this device, it's not even doped and the blocking layer's being included.

So the idea of including a blocking layer would not be something a person skilled in the art would be surprised by. They might already be doing it even if they weren't doping.

BY MS. ZHONG:

Q. You're not offering an opinion as to when Ma first became available, correct? Why don't you take a look at paragraph 74 of your declaration.

A. Okay. I've seen paragraph 74.

Q. And you stated here that you are informed that Ma is prior art to the '425 patent, correct?

A. That's correct. That's what I state there.

Q. You are not independently forming an opinion as to whether Ma qualifies as prior art, correct?

A. Again, whether or not it qualifies as prior art is usually something that I would leave to the attorneys to advise me on.

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Q. Okay.

A. Yeah.

Q. And you are not offering any facts or opinions regarding how -- the search capability of Synthetic Metals online publication back in 2008 or 2009, correct?

A. No, I haven't been asked to offer any opinion on the searchability of any of the exhibits I pull out. I think that looking at Ma, I just happened to open the exhibit backups that you asked about and I see it was available online August 29th, 2008, but I'm not offering any broader opinion on how searchable any of these papers might have been.

Q. And do you know, back in August 29, 2008, when it says it's made available online, was it available only to subscribers or it's available to any general public --

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. -- members?

A. Yeah. I don't have knowledge of how the agreements work in terms of how these journals are

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available. All I could say --

Q. Go ahead.

A. I was just going to add, all I can say is that in August of 2008 and earlier than that, I was pulling journal articles online routinely. And Synthetic Metals is certainly a journal that I read at the time, but I don't have any broader knowledge of whether it was publicly available, subscription based. I don't know.

Q. And were you pulling the articles that has been published for a while or are you pulling the articles that was posted online but before they become published on paper? Do you know what I mean?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I don't know if I can answer that because I don't know the last time I looked at an article on paper. Certainly I haven't looked at anything on paper since 2008 and I think it probably would have been maybe in very early graduate school would have been the last time I looked up a paper in the library. For my graduate training, everything was done online. And so I don't know the

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specifics of how a paper publication date would have related to an online date. When things were available online, that was when we as researchers were reading them.

BY MS. ZHONG:

Q. And when it becomes available online, how do you search for those papers?

A. The way I tend to search for those papers is I'll use things like Web of Science, Science Direct, Google Scholar. These are, you know, common ways that academics and --

Q. Okay.

A. Okay.

Q. Once they become -- so after an article becomes posted online, do you know when they get indexed?

MR. WEIDENFELLER: Objection.

THE WITNESS: I have no knowledge to how that process works and the timing and -- no, I don't.

One thing I'll just note, though, is I want to make sure it's clear, using the terminology "posted online" makes it sound like the author is

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like posting this on their website and then hoping it gets favorably reviewed and published.

Generally, my experience is when articles are published online, they've already gone through peer review. And so I don't know specifically for this journal or any other ones we're looking at, but the term "posted" has a bit of a negative connotation. I just wanted to clarify.

BY MS. ZHONG:

Q. Understood. What I mean is you don't know how long after the journal -- once the article -- strike that.

You don't know how long after the journal published or makes the article available on its website the article actually gets indexed, right?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. As I've said already, I don't have any knowledge whatsoever of the indexing process. I just know that journals send out table of contents alerts when issues are available and there's ways to search things online, but I don't know how indexing works and what the timing is of all that.

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BY MS. ZHONG:

Q. And I also want to confirm that as far as Lithium Q doped electron transport layer is concerned, Ma is the only article you cited, correct?

A. Ma is the only article I cite in the context of Liq doping. I also have Liu as an exhibit, which is Liq EILs, and that was mainly because I felt Ma was sufficient to teach a person skilled in the art about this material as a dopant.

Q. And let's take a look at your paragraph 145 on page 85.

A. I'm sorry, paragraph 145, is that what you said?

Q. 145.

A. Great. Thank you. Okay. I'm there.

Q. So you state that use of Lithium Q as a dopant in an OLED electron transport layer was well-known in the art at the time, and it was specifically taught by Ma.

Do you see that sentence?

A. I see that sentence.

Q. And you mentioned doing so would be a

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routine practice for a POSITA to implement with a high probability of success. Do you see that?

A. I see that as well.

Q. What do you mean by doing so?

A. Let me just reread the previous sentence to make sure I'm clear. What I mean the "doing so would be a routine practice" would mean that switching from one N type dopant to Liq would be a routine practice.

Q. And when you mentioned routine practice, what do you mean by routine practice?

A. I mean it's something that a person of skill in the art could accomplish and expect success with just some routine optimization of the device.

Q. And what are those routine optimization?

A. In this particular case, the routine optimization would likely be thickness and composition of the doping. So thickness of the active -- the electron transport layer, possibly the whole transport layer and then the doping concentration of the electron transport layer and possibly the hole transport layer.

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Q. And when you say probability of success, what's your definition of success?

A. So high probability of success would be that here, realizing, first of all, implementation of Liq into their device so that they could take advantage of the reduced diffusion that would come with the molecular n-dopant. So that's one.

And then the other probability of success would be that the device operates with potentially higher efficiency and lower voltage. So essentially high probability of success would be expecting to still have a good performing OLED but now integrated with a molecular n-dopant that can offer benefits from the diffusion perspective.

Q. And can you take a look at paragraph 228 on page 130 of your declaration.

A. Okay.

Q. And the language here in paragraph 228 is pretty similar to that in 145, correct?

A. Yes. So the context --

Q. Almost identical.

A. Yes, the context is very similar. This is

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now taking Suzuki, which already teaches an n-doped layer, and again saying that it would be routine practice to switch from the n-dopant in Suzuki to Liq with expectation of success.

Q. And the routine practice and the probability of success here means the same thing as in paragraph 145, correct? So your use of the term routine practice and the probability of success in paragraph 228 are the same -- is the same as your use of those terms in paragraph 145, correct?

A. In both cases, I am defining routine practice as meaning POSA would look at Ma and either Suzuki or Diekmann and realize that this is switching one dopant for another and with only routine optimization would expect to be able to make a well-performing device and take advantage of the reduced diffusivity of an n-type or a molecular n-dopant.

Q. And the routine optimization is as you have mentioned, adjusting the dopant concentration and the thickness of the layer?

A. Those would be examples of what I would

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call routine optimization. Anytime one looks at the literature, sees an interesting material that would potentially make your own device better, a person of skill in the art would not expect necessarily that it's going to work under exactly the same conditions that is seen in the literature. And so there's an expectation that some optimization would have to go into making that material work its best in your particular device.

Q. And what other optimization would you routinely do besides the thickness and concentration?

A. Just to be clear, are you asking in general what are other optimizations that I would call routine in OLED?

Q. In your proposed modification of Diekmann.

A. I see. In both Diekmann -- both Diekmann and Suzuki already teach blocking layers. So I don't think there's a need to introduce an additional layer. And so again, at least as I think about this right now, I think the most relevant routine optimizations would be thickness and doping concentration in the doped conductive layers.

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

THE WITNESS: Okay.

(Recess.)

BY MS. ZHONG:

Q. So in your declaration, especially in the background sections, you mentioned the importance of high efficiency for the OLED systems, correct?

A. Is there a particular place I'm doing that that you can just direct me?

Q. For example, paragraph 29 of your declaration.

A. Thank you. Let me just go there. Oh, a paragraph we already discussed. Yes, I discussed the units of efficiency, sure.

Q. So is the operability of an OLED device defined by its various efficiencies?

MR. WEIDENFELLER: Objection.

THE WITNESS: What do you mean by operability?

BY MS. ZHONG:

Q. So when do you consider yourself -- strike

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that.

Is there a minimum requirement of efficiency for an OLED structure that you have fabricated before you say you have actually obtained an OLED device that actually works?

MR. WEIDENFELLER: Objection.

THE WITNESS: So if I understand your question, you're saying is there some baseline level of efficiency you need to realize before you can call it an OLED?

BY MS. ZHONG:

Q. Yes. Or luminescence level or --

A. In my opinion, and I think this is consistent with what the person of skill in the art, in the community would say, if the device is emitting electroluminescence, then it's an OLED. And so even a device that might not be, say, optimized, right, if it's emitting electroluminescence, then it's -- you know, it's an OLED.

I suppose an exception would be if it's -- you know, if it's a -- perhaps if it's a device not -- if it's a material not designed perhaps to

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emit electroluminescence and you're applying several thousand volts to it or something like that. But yeah, if you're making a device like the kind I'm discussing in my background of my declaration and it has some measurable efficiency, then it's emitting electroluminescence and it would be an OLED.

Q. And what's your definition of if it's emitting electroluminescence?

A. Well, electroluminescence is the process of electron hole recombination where the electrons and holes are being injected by some applied voltage so that electron recombination leads to exciton confirmation and light emission. So generally, electroluminescence is defined -- I should say electroluminescence is usually defined as just the process of injecting electrons in holes and then recombining them to emit light.

(Exhibit No. 2104 was identified for the record.)

BY MS. ZHONG:

Q. Can you, for example, pull up Exhibit 2104.

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A. 2104 you said?

Q. Correct.

A. Okay. Let me find it. Okay. I have it open.

Q. And let's go to one of the figures that have luminescence. Can you go to figure -- this one doesn't have the absolute one. Go to figure 3 on page 1680.

A. Okay. I see the figure.

Q. And do you see that figure 3B is -- the Y axis is luminescence?

A. The Y axis is luminance in figure 3B, yes.

Q. So the Y axis is luminance and it's log scale, right, going from 10 to the minus 1 to 10 to the 4th, correct?

A. On the vertical axis, the scale goes from 10 to the minus 1 to 10 to the 4th, I agree.

Q. Okay. And what is the minimum level of luminance -- what's the minimum luminance required before you say the device is electroluminescent?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, can you restate that

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again, please, for me?

BY MS. ZHONG:

Q. Okay. So you see that the luminance level can vary from 10 to the minus 1 to 10 to the 4th, for example.

A. Yeah.

Q. And is there a minimum level that the luminance level had to be met before you say there's electroluminescence?

MR. WEIDENFELLER: Objection.

THE WITNESS: So in my opinion -- again, in my opinion in the context of the OLEDs I'm talking about in my background in my declaration, if you have measurable electroluminescence, you have electroluminescence. And so if you're measuring electroluminescence, you wouldn't then therefore say, well, this is not enough electroluminescence, so I don't have electroluminescence. You either have it or you don't. So if you're measuring electroluminescence, then there's electroluminescence to be measured.

BY MS. ZHONG:

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Q. Even if it's in the noise region?

A. Well, if you're only measuring noise, then you're not necessarily measuring luminescence, right? So I think part of doing the measurement properly would be understanding what the sensitivity of your equipment is and then making your conclusion accordingly.

Q. So any level of luminance above the noise level, you consider that to be an OLED?

MR. WEIDENFELLER: Objection.

BY MS. ZHONG:

Q. So if a device can emit something -- so if you have a device that can emit electroluminescently above a noise level, you consider that to be an OLED device?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I'll first just say this is not something that came up in the context of my rendering an opinion for the '425. So I'm not prepared to offer an opinion on how noise might impact because I think the subsequent question then is, well, how far above the noise floor does it have

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to be to be electroluminescence and I'm not going to offer an opinion on that because it's not something I've thought about. I think the point is that if a device emits electroluminescence, then it's emitting electroluminescence. I'm not really sure how much more I can add to that.

BY MS. ZHONG:

Q. And you can generally drive electroluminescence by increasing voltages, correct?

A. So when you say you can drive electroluminescence, can you just clarify exactly what you mean by that?

Q. You can generate -- by increasing the driving voltage, usually you can like have increased electroluminescence, correct?

A. So when you increase the -- so again, in my opinion, when you increase voltage across an OLED, you'll usually increase the current flowing through the OLED. And usually when you increase the current flowing through an OLED, you'd also see an increase in the brightness or the luminance of the device.

But as you can see, even in the data in

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front of us, the current voltage characteristics have a complicated functional dependence and so the degree to which you would see an increase in luminance with voltage depends on what part of the curve you're in.

Q. And there is no upper limit on what that driving voltage needs to be, right?

A. Can you just clarify, when you say what that driving voltage needs to be, what you mean by that?

Q. For example, if you first detect electroluminescence at 120 volts, do you still consider that to be an OLED?

A. Well, I think I alluded to that when you first asked the question a few moments ago. The qualification I made there is that there's a distinction in the literature between electroluminescence and an OLED. And so the earliest demonstrations of electroluminescence from organic materials were in the late '50s and early 1960s where effectively researchers made bulk single crystals of organic compounds like anthracin or naphthalene and then put crude electrodes on either side of those

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crystals. And those crystals were very thick and those electrodes were very crude and there were no transport blocking layers and things of this nature. And so under kilovolts of applied voltage, those crystals emitted electroluminescence. It was very inefficient, but they emitted electroluminescence.

But nobody refers to those results as the first OLED. The first OLEDs are really identified as the first thin film devices that were initially demonstrated at Kodak and then more widely developed by many groups and companies in the '90s. And so that's the one distinction I'm making is that electroluminescence is a phenomenon that one observes when one puts current through a material under an applied voltage, it sees light. An OLED is something that's a little more specific. And at least for people skilled in the art, the situation you're describing, putting several hundred volts across a material that probably is not really meant to show efficient electroluminescence, there might be more debate as to whether or not that's an OLED despite it having electroluminescence.

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Q. So what you mean is that the voltage that's applied across the cathode and anode needs to be relatively low.

A. Again, I'm not going to -- I'm not sure relatively means in the way you're using it and I don't have some voltage range that I can use to quantify that. My point is just to say that a lot of materials will exhibit electroluminescence because of the fact that you can apply very large voltages, but not all of those materials showing electroluminescence would be quantified as OLEDs.

Q. So when do you go from a material that's electroluminescent versus a material that you consider to be -- strike that.

When do you -- what is the point of transition or the range of transition when you look at a device that you say if it's only electroluminescent versus you say this is an OLED?

MR. WEIDENFELLER: Objection.

THE WITNESS: I want to make sure I'm really clear here. I am not taking the opinion that, for a given device, there might be some range of

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voltages where it's an OLED and some where it's not. That is not the opinion that I'm offering.

What I'm saying is that the community, when considering what an OLED is, generally the historical development of OLEDs is set to have begun with the development of electroluminescence in thin films. The work that had been done far earlier on thick crystals, stand-alone crystals with crude contacts where the voltages and fields required were enormous is generally just referred to as organic electroluminescence.

BY MS. ZHONG:

Q. Okay. And what's the definition of thin films?

A. Again, I haven't had to define thin film for these proceedings and so I don't want to offer any further definition. I just have already said that the first OLEDs are regarded as those that were developed at Kodak and then developed by other researchers in the '90s.

Q. And what is a range of thickness for the OLEDs that you have been working with?

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MR. WEIDENFELLER: Objection.

THE WITNESS: Can you ask that question again?

BY MS. ZHONG:

Q. So what is a range of the film thickness for the OLEDs you have been working with?

MR. WEIDENFELLER: Objection.

THE WITNESS: The range -- there is no upper limit per se. A thin film can actually be a thick as well. The moniker of thin film is generally referring to the fact that the film is on a substrate, that there's some substrate associated with the film and the device.

BY MS. ZHONG:

Q. But what's a typical thickness of a thin film?

MR. WEIDENFELLER: Objection.

THE WITNESS: I hesitate to define one. Thin films can have any thickness. The typical thickness of thin films in OLEDs, you know, one could look at any of the exhibits, by Pfeiffer, He, Baldo. There's several different versions of OLEDs in the

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exhibits that have typical thicknesses of the different layers involved. The total thickness could be 100 nanometers, could be several hundred nanometers. It all depends on the device that's envisioned and how it's being built.

BY MS. ZHONG:

Q. So for the driving voltage, is there a desired upper limit?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, one doesn't usually think about an upper limit on voltage because the objective is generally to operate the device at as low a voltage as possible to avoid having an issue with power efficiency in the OLED.

BY MS. ZHONG:

Q. So if you have a thick film but you have to apply, say, 50 volts or even 100 volts in order to generate an electroluminescence, do you still consider it to be an OLED?

MR. WEIDENFELLER: Objection.

THE WITNESS: At that point, I don't think I could really offer an opinion. These sorts of --

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that sort of a device, again, wouldn't generally be something that comes up in the OLED literature because you're using a very crude structure and have a very high voltage. And so I don't think there's really anything further I can offer because this question of what is an OLED and what is electroluminescence is not something I've considered for my declaration and I think I've already offered the opinion I can offer on these topics.

BY MS. ZHONG:

Q. So what's a typical driving voltage range that you have seen in literature?

MR. WEIDENFELLER: Objection.

THE WITNESS: So what is the typical driving voltage range just for an OLED in literature?

BY MS. ZHONG:

Q. Correct.

A. Sure. I can go to some of the exhibits and get a perspective on that. So, for example, Exhibit 1016, Pfeiffer et al., figure 1 shows a plot of electroluminescence intensity. So that's again luminance in candelas per meters squared versus

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voltage and you can see some typical luminance voltage characteristics there.

And so in terms of what a typical voltage is, it depends on what you're trying to realize. The voltage will often be determined by the brightness required for the associated application.

Q. And what's a typical brightness required for an OLED?

MR. WEIDENFELLER: Objection.

THE WITNESS: As I just noted, it depends on the application.

BY MS. ZHONG:

Q. And for white light-emitting emission application, what's the typical luminescence required?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I don't know off the top of my head what the luminance spec is right now for a commercial white LED or OLED. I'm not sure. And also, I'd have to take into account the fact that once you integrate an OLED into a lighting element, there's all kinds of optical management and luminare

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physics that I don't even want to speculate on that also can manipulate the brightness. So I don't know what the relevant level would be for a given application per se.

BY MS. ZHONG:

Q. And in Exhibit 2104, if you look at figure 4A, is it correct that according to figure 4A of Exhibit 2104, as you -- the OLED with doped Lithium Q has a higher driving voltage than one that's undoped?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I haven't seen this paper before. I'm not even sure if it's prior art. It doesn't look like it is. So you're asking me about figure 4?

BY MS. ZHONG:

Q. Yes. And the structure I believe is on page 1679.

A. All right. Let me read the paragraph. All right. What was your question regarding this architecture?

Q. If you look at figure 4A.

A. Yes.

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Q. Is it correct that as the Lithium Q percentage increases, the driving voltage increased?

A. Are you asking me to look at the black symbols?

Q. Correct.

A. So in figure 4A, not knowing anything else about this publication or what it's trying to accomplish, the black symbols are increasing with Liq percentage.

Q. And the red line are showing the luminance, correct?

A. Yes.

Q. And according to figure 4A the luminance decreases slightly as you increase the Lithium Q percentage, correct?

A. One thing that's important to note in the way this data is plotted is that the luminance axis is actually --

Q. On the right-hand side.

A. Yeah, I'll just finish the comment -- is actually pretty zoomed in. And so since this is a log plot, the actual change in luminance is marginal.

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And I suspect that if error bars were placed on these data points, might not be statistically meaningful.

Q. That's what I'm saying. Based on this one, it only decreases slightly. The luminance only decreases slightly as the Lithium Q percentage is --

A. Yeah. And what I'm saying is that if there's error bars put on these data points, you might not be able to make that inference at all based on the statistics. They might be within error, which might mean they're statistically the same. And frankly, I don't know what the error bars on voltage are either because I'm not familiar with this particular work or this device.

Q. And if you look at 4B, figure 4B, the inset, does it appear that the external quantum efficiency decreases as the Lithium Q percentage increases?

MR. WEIDENFELLER: Objection.

THE WITNESS: It's not clear to me what that inset is plotting. It's missing a Y axis.

BY MS. ZHONG:

Q. So if you look at B, external quantum

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efficiency versus current density for the device upon mixing percentage of mixing lithium in the mETL.

A. So not the inset. Because the inset doesn't have a vertical label on the axis.

Q. Isn't that the inference, that the inset is plotting the EQE percentage versus the lithium Q percentage?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm not sure what to infer without reading the text on figure 4B.

BY MS. ZHONG:

Q. Okay. Read the caption for A. It says driving voltage, luminescence, and, bracket, inset of panel B, external quantum efficiency of the blue devices upon mixing percentage of lithium Q and mETL under a constant current density of 25 milliamp per square centimeters.

A. I see that.

Q. So does that inform you that the inset in figure 4B, that the Y axis is the external quantum efficiency?

A. That would be how I'd interpret the inset

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of panel B.

Q. Okay. And with that understanding, does the inset of figure 4B shows that the external quantum efficiency decreases as the electron transport layer is doped with lithium Q?

A. Assuming there's no other changes being made to the architecture, the inset seems to suggest a reduction with percent, at least initially.

Q. Okay.

A. But it's worth noting that in figure 4C, there's a remarkable improvement in stability with doping. And so while in this case you have a, I'd argue small reduction in efficiency, the gain you're getting in stability might be as much as a hundred times, a hundred X.

And to me it's clear, without having read the paper and just looking at the panel, that the advantage just looking at this figure is that clearly there's something very favorable happening with stability as Liq is added to the electron transport layer. And as we've discussed, stability is also an important parameter, especially when talking at the

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commercial level for OLED performance.

Q. Now, look at your Exhibit 1003, paragraph -- between paragraphs 139 and 146. Can you tell me where lifetime is discussed in these paragraphs?

A. Can you just tell me the call-outs again? I was still looking at the papers in front of me.

Q. So paragraphs 139 through the end of that section which I believe ends in 146.

A. Okay. So the full ground 2 is what you're saying?

Q. Yes.

A. I'm going to reread that so I can respond appropriately. So in my opinion, I guess there's two things I'll note on this. The first is that a person skilled in the art constructing an OLED understands that there's efficiency and lifetime that are potentially of interest when making an OLED.

And second of all, a person skilled in the art would understand that the discussion in paragraph 144, in referring to the need to minimize dopant diffusion, when I say compromising performance, I'm not limiting that only to efficiency. A person would

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understand that that includes all aspects of the OLED performance, because of the fact that impurities in the emissive layer cannot only quench excitons, but can also serve as sites for degradation, can serve as places where reactions might occur. There's all kinds of other detrimental things that could happen.

So while I don't necessarily call out the words "lifetime" in the paragraphs you specified, I think a person skilled in the art would understand that in paragraph 44, it's included in part of performance.

The other thing to note, too, is that Ma specifically calls out the fact that in their opinion, the improved charge balance present in an Liq doped device would be expected to lead to better lifetime because of the fact that you're no longer accumulating an excess of one carrier type in an imbalanced device. So I think a person skilled in the art reading grounds 2 and understanding that we're using Ma and reading Ma would see the discussion of lifetime in the conclusion of Ma as well.

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Q. Lifetime does not appear in these paragraphs, correct? The word "lifetime."

MR. WEIDENFELLER: Objection.

THE WITNESS: Yeah, I already acknowledged that lifetime doesn't appear in the paragraphs, but the word "performance" does, and lifetime does appear in Ma.

BY MS. ZHONG:

Q. Okay. And when you talk about the metal ion diffusion in an undoped system, there would not be any metal ion diffusion, correct? Let me put it this way.

A. Sure.

Q. In an undoped electron transport layer, there would not be any metal ion diffusion from that electron transport layer into the emissive layer, correct?

A. So that's a really interesting question. Even in an undoped system, if your electron transport layer isn't optimized in terms of its thickness, you could have issues where even the cathode metal might serve as a quenching site as well.

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Q. And do you have any evidence that Lithium Q doping would reduce the metal ion diffusion compared to an undoped system?

A. Well, so Lithium -- Liq doping is -- you know, the objective of using a molecular dopant there is to reduce the diffusion of another dopant. And so comparison to an undoped system, there is no dopant diffusion in the undoped system. What I'm referring to is metal diffusion at the cathode electron transport layer interface. And so I don't think there's a comparison to be made for dopant diffusion between an Liq device and a device that isn't doped.

Q. What I'm saying is that do you know whether the addition of Lithium Q to the electron transport layer is going to limit or reduce the metal ion doping, for example, from the cathode?

A. I don't know if it would impact the metal ion doping from the cathode. That is a phenomenon that can usually be addressed by making the electron transport layer the correct thickness, basically making it thicker than the penetration depth of those metal ions. As we discussed, a person skilled in the

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art would recognize Liq as a molecular dopant, has the potential to reduce dopant diffusion in comparison to, say, elemental metals.

Q. And the improvement in lifetime observed in the Ki paper, that cannot be due to the reduced metal ion diffusion, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm sorry, you're referring to 2104 again?

BY MS. ZHONG:

Q. Yeah, 2104, figure C. So what you see is that the lifetime is increased over -- in comparison to an undoped system, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: In figure 4C, the lifetime is increasing in comparison to an undoped system, assuming that the rest of the structure is the same.

BY MS. ZHONG:

Q. Okay. And in an undoped system, there's not going to be any dopant diffusion, correct?

A. There is no dopant -- no conductivity dopant in the electron transfer material, so there

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would not be dopant diffusion in that sense.

Q. Okay. And so whatever the reason for the improvement for the lifetime, it cannot be due to the reduction in the dopant ion diffusion, correct?

A. Again, I haven't read this paper. I don't know exactly what the specifics are. But as I said earlier, it seems that in figure 4C, there's a favorable improvement in stability with Liq doping.

Q. All my point is whatever reason for that improvement is, it has nothing to do with metal ion diffusion, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't know for a fact whether or not there is any role played for that in the initial degradation even of the zero percent device. So it's challenging for me to attribute all of the different factors that might be changing as one includes Liq. But I think as a person skilled in the art, I can look at that data and see that there is a favorable improvement in device lifetime with Liq addition.

BY MS. ZHONG:

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Q. But the improvement in the lifetime is not due to the dopant metal ion diffusion, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: Again, I'm not -- can you clarify exactly what you're asking in that respect?

BY MS. ZHONG:

Q. Well, you are pointing me to paragraph 144 of your declaration.

A. Yes.

Q. In particular, you were pointing to the sentence stating that at the time, it was well understood that dopant metal ions could readily diffuse in the OLED during film growth and operation, compromising performance, correct?

A. Yes.

Q. And the dopant metal ion diffusion just does not occur in undoped system -- undoped Bphen system, correct?

A. I understand your question. Again, I don't know how -- so if I just compare the doped devices, say, 17 to 33 to 50, there is still an improvement in stability that's quite significant,

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even going from 17 percent Liq to 50 percent Liq. I don't know the specifics of whether that's related to dopant diffusion or not or changes to dopant diffusion or not. That's not something I can comment on. I don't know if the dopant diffusion changes here.

Q. And if it's all Lithium Q, the diffusion coefficient doesn't change, correct?

A. Again, that was the assumption I made earlier, but I don't know that for a fact because I'm not aware of a measurement of Liq's diffusion coefficient versus concentration.

Q. And you have no idea what the -- so let's take one step back. As a person of ordinary -- would a person of ordinary skill in the art expect the Lithium Q diffusion to be significantly different going from zero percent to 17 weight percent to 33 weight percent and 50 weight percent?

A. Well, there is no Liq in the zero percent device. So I don't understand how there can be Liq diffusion.

Q. Okay. So we agree that for the zero

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weight percent Bphen or that the undoped Bphen device, there is no Liq diffusion?

MR. WEIDENFELLER: Objection.

THE WITNESS: I think I can restate that as I agree that for the zero percent Liq device, there is no Liq.

BY MS. ZHONG:

Q. And if there's no Liq, there's no Liq diffusion, correct?

A. If there is no Liq in that film, then there is no Liq diffusing in that film.

Q. And would a person of ordinary skill in the art expect that the metal ion diffusion due to the cathode metals be different in an undoped -- in an OLED device with an undoped Bphen versus 17 weight percent doped Bphen, 33 weight percent doped Bphen or 50 weight percent doped Bphen?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't think there's enough information to make an assessment on how the metal diffusion would be different as a function of composition.

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BY MS. ZHONG:

Q. Okay. And can a person of ordinary skill in the art -- strike that.

Would a person of ordinary skill in the art have any expectation or knowledge regarding the Lithium Q diffusion rate in an OLED device with 17 weight percent doped Bphen versus 33 weight percent doped Bphen versus 50 weight percent doped Bphen?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm sorry, you lost me on the question there. Can you please restate it?

BY MS. ZHONG:

Q. Let's say you have three OLED devices and the only difference is one has an electron transport layer with 17 weight percent Lithium Q doped in Bphen. The second one has 33 weight percent Lithium Q doped in Bphen and the third one has 50 weight percent Lithium Q doped in Bphen. Do you have in mind those three devices?

A. Yes, I think I understand the devices you're describing.

Q. So among those three devices, what would a

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person of ordinary skill in the art view regarding the Lithium Q dopant diffusion rate?

MR. WEIDENFELLER: Objection.

THE WITNESS: So I'm going to answer that in a pretty specific way because I think I already answered it in the context of Ma. So this particular publication we're talking about was published in 2022. So this is, what, 14 years after the '425 and well after Ma as well. And so a person of skill in the art at the time that's relevant here for the '425 would look at Ma, would see a molecular dopant, would understand the challenges in using elemental metal dopants and would have an expectation of success that Liq would have a reduced diffusion in the transport material.

Beyond that, in terms of specific diffusion coefficients for Liq with various electron transport materials, I don't know what those diffusion coefficients would be. And I think a person skilled in the art would have to do some experimentation to find them out specifically.

But the fact that Liq was a molecular

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n-dopant at that point and that that was an objective of the community to replace elemental metals with molecular N dopants would have been what the person of skill in the art had to see to be motivated to apply Liq in Diekmann and Liq in Suzuki.

BY MS. ZHONG:

Q. But as between Liq and undoped ones, would they expect that there's -- strike that.

At the time that you mentioned, did a person of ordinary skill in the art know what is the relative amount of diffusion for the Ma system versus one that's doped with cesium or Lithium or Lithium fluoride at a much lower doping concentration?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't have any knowledge that a person skilled in the art would necessarily have specific numbers, but honestly, I didn't look for them. What a person skilled in the art at that point in time is that they would have looked for a molecular n-dopant. That was the level of development at the time in trying to find an alternate dopant.

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In terms of the quantitative details of, you know, how different is the diffusion coefficient, how different is the transport indifferent -- transport materials, that is not the threshold for which a person skilled in the art would hold themselves to to have an expectation of success. Their goal would be to take an existing N type dopant, replace it with a promising molecular N type dopant that's clearly already been shown in Ma to yield successful device performance and try it in the structure of Diekmann and Suzuki.

Whether the diffusion coefficient is one number or the other, I don't know that that would have been available to a person skilled in the art at the time. But whether it is or not doesn't affect my opinion as to whether or not they'd be motivated to combine these two works.

BY MS. ZHONG:

Q. So my next question to you is, do you know what is a doping rate -- strike that.

If you dope the electron transport layer with Lithium fluoride, Lithium or cesium, what is the

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minimum amount of doping do you have to have in order for you to see an improved conductivity?

MR. WEIDENFELLER: Objection.

THE WITNESS: That's not something I looked at. That's -- certainly for cesium, Lithium, it's in the literature and would have been available to a person skilled in the art at that point. At least knowing the improvement of conductivity was in the art, but I don't know those numbers. Again, they aren't things that would have impacted my decision and my opinion on combining Ma with Diekmann or Ma with Suzuki.

BY MS. ZHONG:

Q. And when you add Lithium Q to an electron transport layer, there comes a point where Lithium Q actually becomes the major component of the electron transport layer, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: What do you mean by major component?

BY MS. ZHONG:

Q. So, for example, when you -- at 33 weight

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percent of Lithium Q in Bphen, we said that's a one-to-one molar ratio, correct?

A. You had said that's one to one or about one to one. I haven't done that calculation.

Q. Okay. Dr. Randall, who is another expert for Samsung, had opined that 33 weight percent is about one-to-one molar ratio. So I'm just going off his numbers.

A. Okay. I don't know his calculation, but I can entertain the numbers.

Q. Okay. And so as you increase the percentage of Lithium Q in the mixture, Lithium Q is going to become the major component in the sense that there are going to be more Lithium Q molecules than the Bphen molecules, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I agree at some point you'll have more Liq molecules than Bphen molecules. Eventually you'll have only Liq molecules.

BY MS. ZHONG:

Q. And let's go to the extreme case when you have only the Liq molecules.

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A. Uh-huh.

Q. And would the diffusion in that case still be lower than an electron transport layer of Bphen with lightly doped alkaline metal?

MR. WEIDENFELLER: Objection.

THE WITNESS: I think I've attempted to answer this before. I don't know specifically what the diffusion coefficient of Liq or an alkaline metal would be or how it's going to change with concentration. What I can assert is that a person skilled in the art at the time of the '425 would understand the value of transitioning to a molecular n-dopant and that's the basis upon which I formed the opinion in my declaration.

BY MS. ZHONG:

Q. But we also know that at high concentration, you have a higher flux. You tend to have a higher flux, correct?

A. Again, the context of that statement that I think I did actually add to in a later discussion is the concentration gradient is only relevant if the species diffusing can actually diffuse. And so if

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the diffusion to coefficient is sufficiently low, then the concentration gradient may not matter.

Q. But you don't really know, for Lithium Q, first of all, which species is actually diffusing, whether it's the Lithium Q molecule or it's the Lithium cation, correct?

A. I'm not taking a position on whether or not there's any diffusion, frankly, whether -- because again, Liq as a molecular n-dopant could very well solve that problem and may have minimal diffusion. I think this discussion is very hypothetical. But I have not -- I don't know the degree to which Liq disassociates and so I don't know the degree to which Liq might generate Lithium.

I think we've already talked about the Liu reference where, you know, there's some speculation that when it sees a cathode deposition, there could be some dissociation. But I haven't thought about how that transfers into the doped structures of Ma.

Q. So you don't really know like in the mixed film of the electron transport layer, the concentration of the Lithium species that can

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actually diffuse? You have not really made that determination, correct?

A. So to be clear, you're asking me if I quantitatively know the concentration of Lithium species in Ma's doped Liq Bphen ETL that are available for diffusion as well as their diffusion coefficient?

Q. Yes.

A. I think I've answered several times that I don't have that information.

Q. It doesn't have to be very precise. Do you even know the order of magnitude?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. As I said, I don't know what those numbers are. But I'll emphasize again what I've said already that that does not limit or impact my opinion for this grounds and it would not impact a person's skill in the art's expectation for success in combining Ma and Diekmann or Ma and Suzuki. And so I don't think a person skilled in the art would require that level of specificity before seeing the advantages and trying to combine Ma and

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Suzuki or Ma and Diekmann with a sufficient expectation for success.

BY MS. ZHONG:

Q. So your assumption is that the Lithium Q does not dissociate, or at least not dissociate to a significant extent in the mixed film, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: I don't think I've said that. I don't think I've taken an opinion on Liq dissociation in Bphen. What I've said is that Ma teaches that Liq -- again, they use the terminology may -- but may impact the mobility of the film and that that's the mechanism to improve the conductivity of the n-doped layer.

And then with that I also acknowledge in Liu that when used as a film as an EIL, cathode deposition can lead to some dissociation. But I'm not taking a position on whether or not Liq is disassociating in Ma or not or the extent to which it's disassociating because I don't think that's necessary and I don't think persons skilled in the art would see that as essential to combining.

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The data in Ma is very clear that there is an improvement and that Ma is teaching Liq as an anti-dopant and that's what a person skilled in the art would have to see.

BY MS. ZHONG:

Q. The improvement that Ma shows is the decrease in the driving voltage and a slight increase in the efficiency, correct?

A. Ma shows an increase in efficiency and reduced driving voltage and the fact that this is a molecular n-dopant. And while Ma isn't providing stability data or operational degradation data, Diekmann makes clear the interest in having dopants that would not diffuse as readily as alkaline metals like Lithium. And so that's the additional advantage that a person skilled in the art would see in Ma.

Q. I understand. Does Ma provide any indication as to the relative diffusion rate of the dopant or Lithium in its system?

A. Sorry, can you ask that again?

Q. Does Ma provide any data that Lithium Q actually has a reduced diffusion rate compared to

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elemental -- compared to the alkaline metals themselves?

A. Ma does not specifically make that comparison. Ma is only focused on Liq as a dopant and Bphen and the case as we've discussed where there's no Liq doped as well. But a person skilled in the art reading Diekmann and understanding as a person skilled in the art that increased, you know, basically molecular bulk if you like, increased size, is going to frustrate diffusion of the dopant in the electron transport material.

Q. But you did not determine the equilibrium between the Lithium Q versus the dissociated system, dissociated state, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: No. As I've noted before, I have not offered an opinion on whether Liq disassociates at all in Bphen and, if it did happen to dissociate, the level to which it disassociates.

BY MS. ZHONG:

Q. Okay.

A. But allow that Liq being a molecule,

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inserting the same amount of Lithium versus Liq, a person skilled in the art would likely expect that, again, even if Liq disassociates partially, that it's likely going to be less mobile and that it likely won't completely dissociate.

Q. Ma also does not provide any lifespan or lifetime data, correct?

A. Ma does not provide data on device lifetime or device degradation. However, Ma does note, in the final line before the conclusion, "So, we can predict that the complete Device C should have a good lifetime." And so that's based on the assessment that when there's charge imbalance in the emissive layer of an OLED and one builds up either excess electrons or excess holes, that can compromise the device performance. And so they are noting that their device at least in their mind would be expected to have improved lifetime.

Q. Did they say improved lifetime or does it just say it's good lifetime?

A. I guess they're saying it's a good lifetime.

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Q. Did Ma state that the undoped device would have a bad lifetime?

A. Ma doesn't state anything else about their devices. But I think a person skilled in the art would read the paragraph and understand that what Ma is trying to teach is that a well balanced device that doesn't lead to substantial accumulation of one carrier type in the emissive layer would be beneficial for a lifetime.

Q. Does Ma show any data that the doped system that was slightly unbalanced electrons and holes would have worse lifetime than one that's balanced? Strike that.

Does Ma show any data that shows the lifetime of the device with undoped Bphen would have been worse lifetime than one with doped Bphen?

A. I'm going to reread Ma's paragraph to make sure I answer your question accurately. So Ma notes that, in that same paragraph, "For the stability of the devices, we have known that in undoping devices such as device A" -- so that's a fully undoped structure -- "the number of holes is much more than

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the electrons." So what they're saying, first of all, is that in device A, they're hole rich, essentially an excess number of holes.

"So, a surplus of holes at the NPB/Alq interface increases the probability that Alq3 cations are formed, which are known to be unstable." So Ma is acknowledging that in their undoped device, there are going to be issues with stability and that those issues are arising from an excess density of holes and that that will lead to rapid device degradation.

And so I think Ma is disclosing here -- and I didn't examine reference 30, but they are offering a reference -- that their undoped device does not have good lifetime, as they're putting it.

And then they go on to note that because -- when they introduced this PIN device with novel n-doping and p-doping and that's where they can predict that the complete device that's doped properly with balanced electron hole transport should have good lifetime.

So while Ma does not show data, I think they are clearly pointing to the literature. They

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show clearly that they have an understanding of what the stability of device A is and why it would be unstable and then do clearly note why they're optimized doped device should be improved.

Q. Can you achieve charge balance by using alkaline metals and Lithium fluoride in Ma's system?

A. Well, Ma's already using Lithium fluoride as an EIL.

Q. If Ma dopes its Bphen with cesium, Lithium or Lithium fluoride, can it achieve charge balance?

A. That I don't know for a fact. I'm not familiar with this particular device being doped with cesium or Lithium.

Q. And so assuming that you have optimized doping levels for the Lithium Q system versus an OLED device of Ma structure but with Bphen, doped with optimized level of cesium, Lithium or Lithium fluoride, does a person of ordinary skill in the art know which one would have better lifetime?

A. I don't think it's possible to -- so let me make sure I understand your question. The various materials you listed were cesium, Lithium fluoride,

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and what was the last one?

Q. Lithium.

A. Lithium. And you're asking which of those have a better lifetime?

Q. Versus Lithium Q.

A. Without making those devices, it's hard for me to conclude with certainty, but a person skilled in the art would understand that using Liq as a molecular n-dopant would bring potential advantages by reducing dopant diffusion.

Q. And would those advantages already exist with Lithium fluoride?

A. As I've said earlier, I don't take a position on Lithium fluoride and I'm not sure how to think about whether that would be a molecule or not.

Q. Lithium fluoride is a neutral compound, correct?

A. I'm sorry, the court reporter has a question. What was your question?

Q. I'm asking you is Lithium fluoride a neutral compound?

A. I don't -- Lithium fluoride is --

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actually, under what circumstances?

Q. As used in the film, OLED film.

A. So when Lithium fluoride is used in an OLED film, my understanding is that what you're starting with in the deposition source is a neutral compound, but I don't know if there's some dissociation even in the source of Lithium fluoride. It's a salt. So I'm not sure exactly what its behavior would look like in the deposition source.

It's deposited frequently as a neat material, as an EIL, and while there's a couple of different pictures of how its operation works in literature, I think the most common opinion is that the Lithium fluoride is dissociated when the metal strikes the Lithium fluoride film.

Q. What about when Lithium fluoride is doped in a Bphen. Do you know in what state they would exist?

A. That's not something I considered in the context of forming my opinion and so I don't have an opinion on how Lithium fluoride would look with Bphen. I think that's something I mentioned earlier.

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Regarding whether or not there's coordination, I actually don't know.

Q. And you've never compared the diffusion ability of Lithium fluoride versus Lithium Q, correct?

A. When you're asking me if I've compared it, are you asking if I've made these measurements or looked in the literature?

Q. Yes.

A. Yes to which one?

Q. Lithium Q versus Lithium fluoride.

A. Sorry. Are you asking if I've actually done experiments comparing them or if I've just researched in the literature comparing them? What specifically?

Q. Either.

A. Oh. No on both counts. I have never studied diffusion of these dopants experimentally myself and I did not look extensively for measurements of diffusion of these dopants in the literature.

Q. And do you know whether Lithium fluoride

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exists as monomers when they were deposited or they exist as multimers, basically Lithium fluoride is aggregated?

A. I don't think I've ever thought about that and so I don't have an opinion on that.

Q. And do you have an opinion as to whether Lithium Q is deposited as a monomer, as a dimer, as a trimer, hexamer?

A. Again, that's not something I even thought about as relevant when forming my opinion. I think asked earlier, I considered Liq and Bphen as a mixture.

Q. What about barium. Do you know its diffusion constant compared to Lithium Q?

A. I don't.

Q. So in Ma, does the addition of Lithium Q to the Bphen layer help reduce the injection barrier?

A. That's a good question. I don't think it does. And I think that's why Ma intentionally includes a 1 nanometer Lithium fluoride electron injection layer under their cathode. And so I think I mentioned this very early in the day, that that

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allows all of these different electron transport layers to have good injection from aluminum because Lithium fluoride is there now to provide the assistance for electron injection which allows Ma's data shown in figure 5 to focus on the actual transport of electrons in the doped electron transport material.

And so I don't think Ma is looking at a change in injection. I think Ma is looking at a change in conductivity and transport within the electron transport layer.

Q. So is it your opinion that for a Lithium Q doped electron transport layer, you still need to have an independent electron injection layer?

A. No, that's not the opinion I'm stating. What I'm saying is that in Ma -- so in doing the experiments Ma is doing, Ma is trying to de-couple potential changes in injection from potential changes in transport or in Ma's case mobility.

And by including Lithium fluoride at the interface, Ma is essentially ensuring that all the devices they're constructing have suitably good

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electron injection from aluminum into the electron transport material which allows Ma's results to be focused on how the conductivity is actually being changed with doping.

I don't take any position on whether or not Lithium fluoride is needed with a Bphen Liq doped layer. But as I note in my declaration, there is prior work from He in both cases and Pfeiffer that does indicate that when one has a doped electron transport layer, an injection layer may no longer be needed because the doped electron transport layer not only addresses the conductivity issue, but also the injection issue as well.

Q. Do you know how the OLED device in Ma would behave if you removed the Lithium fluoride layer and uses only the Lithium Q and Bphen next to the cathode?

A. That's basically the inversion of the question I was just answering. I don't know that for a fact. In that case, if LIF is removed, then now the electronic transport layer will be both improving conduction and potentially also improving injection,

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but I don't know how that device specifically would look without seeing the data.

Q. So are fluorescent OLEDs generally less efficient than phosphorescent OLEDs?

A. As I note in my declaration, simple fluorescent OLEDs are less efficient than phosphorescent OLEDs.

Q. When you say simple fluorescent OLEDs, what do you mean by simple?

A. Well, there's a lot of different ways one can generate fluorescence. And a simple fluorescent emitter would be a fluorescent emitter that only emits from the singlet state that the triplets are not radiative. More recently, there has been work to realize emitters known as thermally activated delayed fluorescence emitters or TADF emitters. These are emitters that emit from the fluorescent singlet state, but because of their design, the singlet and triplet are merely to generate energy rather than in a simple fluorescent emitter where the triplet is much lower energy.

Under certain conditions in those

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materials -- and they have to be designed to get that energetic alignment. It's not something that one finds naturally frequently -- the triplet could actually be excited back into the singlet. And so what then happens is that with those fluorescent emitters -- and they're still fluorescent because they're emitting out of the singlet -- they show what's called prompt fluorescence, which is the initial excitation of the singlet, recombining and emitting light. And then they also showed delayed fluorescence, which is excitons that went through the triplet, sat for a while and then came back to the singlet and then emit fluorescence.

And so if you look in the time domain, these materials will show fluorescence and then a slow decay of fluorescence. These sorts of materials can be quite efficient. They can be as efficient as phosphorescence emitters because they offer another route to harvest the triplets that in a simple fluorescent emitter, which is what was happening at the time of the '425, those triplets would be not radiative.

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The other example of a nonsimple incarnation of fluorescence would be in a so-called phosphor-sensitized OLED where one uses a phosphorescent material, perhaps an iridium-containing material, to mix the singlet and triplet state and then use that to effectively pump the singlet of a fluorescent material which can also lead to high efficiency, though that hasn't been deployed as widely for applications.

And then the last case is what's known as triplet-triplet annihilation fluorescence, which is a situation where now you have a fluorescent emitter, it emits from the singlet state, and the triplets you generate actually annihilate with each other to create another singlet which gives you an additional boost of fluorescence. And so when I say simple fluorescence, I'm talking about essentially not those versions of fluorescence because they can all show higher efficiency than a simple fluorescent device.

Q. So my question to you is, at the time of the '425 invention, were those types of more complicated fluorescence systems, no?

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A. I didn't -- so I know that phosphor-sensitized fluorescence was known and I expect that triplet-triplet annihilation fluorescence was known. But I think largely at the time of the '425, fluorescence was viewed to be a less efficient path to electroluminescence and phosphorescence. But I haven't done a literature search to find out exactly when the first papers on these topics came out.

Q. So at the time of the '425 inventions or the '425 patent -- so at the time of the '425 patent, when literature talks about fluorescent system, you usually think about a single fluorescent system unless something else in the paper indicates it's one of those more exotic fluorescent species, is that correct?

A. In my opinion, usually if there's a process going on that's meant to increase the efficiency of the fluorescent emitter, that will usually be called out in the work. The only instance in which it may not be the case is if the authors aren't aware that it's happening.

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Q. So for an electron transport layer with 33 weight percent Lithium Q, which one is a host and which one would be the guest?

MR. WEIDENFELLER: Objection.

THE WITNESS: So what is the broader context of the question?

BY MS. ZHONG:

Q. So in a mixture of the Bphen with Lithium Q, with 33 weight percent Lithium Q, which one would you consider to be the host and which one would you consider to be the dopant or the guest?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm going to go back and consult Ma before answering your question. So in terms of your terminology is what is the host and what is the guest, I think I'd prefer to use the language actually in the -- in Ma which refers to Liq as the n-dopant and Bphen is, again, the electron transport material. And when Ma uses that terminology, Ma doesn't put any restriction on when it might apply and when it might not apply.

BY MS. ZHONG:

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Q. If Lithium Q is 70 weight percent of the mixture, do you still consider Lithium Q to be the dopant?

MR. WEIDENFELLER: Objection.

THE WITNESS: Ma doesn't consider that sort of extreme doping of Liq into Bphen.

BY MS. ZHONG:

Q. What about 50 weight percent?

A. In Ma, there is no distinction at 50 weight percent, 33 weight percent, 17 weight percent where there's any change in terminology. Ma refers to Liq as an n-dopant and a person skill in the art would see it as such.

Q. But to you, dopant doesn't have to be the minor phase of the mixed layer, is that correct?

The Lithium Q does not have to be the minor phase of the mixed electron transport layer, is that correct?

A. I didn't consider any instances where Liq wasn't the minor phase of the electron transport layer and so I didn't offer an opinion on how the terminology might change outside of the range in Ma.

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I'm relying on the fact that Ma refers to Liq consistently as the n-dopant in the ETL and that's the terminology language that I applied in my analysis.

Q. Even when the ratio of Lithium Q and Bphen is one to one, you still consider Lithium Q as the n-dopant?

A. Yeah. I think what I just said is that in Ma, Ma doesn't put any bookends on when Liq is a dopant or when it's something else. Ma refers to Liq as a dopant and even at 50 weight percent, there's an improvement in electron transport. And so I think that a person skilled in the art would look at Ma, see Ma's usage of the term Liq as an n-dopant in Bphen and apply it accordingly.

Q. And when you say there's an improvement, an improvement over what? What's the baseline?

A. I'm looking at figure 5 where the baseline current is zero percent Liq in the ETL and all of the configurations that Ma considered show increased current flow through the ETL compared to that undoped case.

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Q. So as long as there is an improvement in conductivity versus an undoped layer, you consider those to be n-dopant.

A. I am not generalizing an opinion there. I am simply saying what Ma presents. And so Ma does not change their terminology across the data set they examine. They show what looks like n-doping across the range of concentrations they look at and so a person skilled in the art would refer to Liq as the n-dopant in Ma's work.

Q. And even though somewhere between 33 percent and 50 weight percent you see a decrease in the conductivity, you would still consider the Lithium Q to be an n-dopant?

MR. WEIDENFELLER: Objection.

THE WITNESS: I am essentially saying what Ma is considering it at and how I used it. So Ma refers to Liq as an n-dopant, does not bottleneck the range or bookend the range and so that's the way a person skilled in the art would read what Ma is doing.

BY MS. ZHONG:

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Q. And I want to confirm a number of things. Lithium is an electron donor when it's doped into an electron transport layer, correct?

MR. WEIDENFELLER: Objection.

THE WITNESS: Which electron transport layer?

BY MS. ZHONG:

Q. Any electron transport layer.

MR. WEIDENFELLER: Objection.

THE WITNESS: I --

BY MS. ZHONG:

Q. When you use Lithium to dope an electron transport layer, that Lithium acts as an electron donor, is that correct?

A. Whether or not something is an electron donor or an electron acceptor depends on relative energy alignment. And so without knowing what you're doping Lithium in, I can't offer a blanket statement on Lithium will always be an electron donor in any electron transfer material.

I recall you showing me an exhibit this morning that had specific prescribed energy

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alignments and so that's why I asked what is Lithium being doped in.

Q. Well, Diekmann mentions using Lithium as a preferred n-dopant, correct?

A. Yes.

Q. So in that case, is Lithium acting as an electron donor?

A. In an instance where Lithium can serve as an electron donor, it would act as an electron donor. I just -- your question was in any electron transport layer and there does depend on some energetic alignment. So when Lithium is a dopant -- and again, maybe the best thing to do would be to pick a paper where they're actually doping with Lithium. So, for example --

Q. Exhibit 1019?

A. I was actually going to go to Exhibit 1016.

Q. Okay.

A. So this is Pfeiffer. They're doping Lithium with Bphen. In that case, Lithium is an electron donor in Bphen.

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Q. And is that the same in Exhibit 1019?

A. I have to go to 1019. So Exhibit 1019 is not using Lithium.

Q. Sorry. So in Exhibit 1019, the dopant is cesium, correct?

A. As shown in figure 1 in Exhibit 1019, the dopant is cesium.

Q. And cesium is acting as electron donor in that case, correct?

A. My understanding of how cesium operates in this case is that it is acting as an electron donor to Bphen.

MR. WEIDENFELLER: I think we're getting close to the seven hours here. Can you tell us?

THE REPORTER: Yes, six hours and 48 minutes on the record.

BY MS. ZHONG:

Q. And you have not made any determination as to if the Lithium Q acts as an electron donor in -- strike that.

And I think you confirmed this morning that based on Ma's own disclosure, there's no

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indication that Lithium Q acts as electron donor in that system, correct?

A. So, again, in Ma -- I'll just point to the relevant entry again so it's clear. This is Ma page 813 in the first full paragraph. That's when Ma is describing what may be going on to describe their data and, as we've discussed, Ma says the high electron conductivity may be originated from short hopping length. Ma does not specifically discuss electron donation, but frankly they don't rule it out either.

Q. And if barium is used to N dope an electron transport layer, is barium acting as an electron donor in that case?

A. I have less experience thinking about barium, but my -- let me just take a quick look here. I just want to consult one reference.

Yes, so based on the literature and the reading of Diekmann, barium would likely also serve as an electron donor.

Q. And does Diekmann view Lithium fluoride also as an electron donor?

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A. I don't recall how Diekmann specifically describes or if Diekmann specifically describes Lithium fluoride. I know Lithium fluoride is certainly listed, but I don't recall at this point whether or not it's listed explicitly as an electron donor or just an n-dopant.

Q. So on page 91 of Diekmann for the 402 layer, it specifically mentions that the dopant acts as an electron donor, correct?

A. This is paragraph 91 -- top of the page 91?

Q. Uh-huh.

A. And which paragraph would you like me to look at?

Q. For Diekmann, the last paragraph.

A. Okay. Let me just read it. Yes, I see the line you're talking about.

Q. It mentions that the organic layer stack 4 has a doped layer 402 with a dopant of 410 which acts as an electron donor, correct?

A. Yes, I see that line.

Q. So in Diekmann's device in figure 2A, the

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dopant in layer 402 acts as electron donor, correct?

A. I don't read Diekmann as limiting in that way. My impression as a person skilled in the art is that the majority of dopants available at the time would likely have been electron donors. And so Diekmann is probably writing that stipulation based on what some of the most common dopants would have been. However, a person skilled in the art, again, seeing Ma identify a molecular n-dopant I don't think would look at Diekmann and think that that's excluded, especially since Diekmann teaches a molecular P type dopant.

Q. And is Lithium fluoride a preferred dopant in Diekmann?

MR. WEIDENFELLER: Objection.

THE WITNESS: I'm not sure about preferred. Lithium fluoride is listed in Diekmann.

BY MS. ZHONG:

Q. Why don't you take a look at your paragraph 144. And in particular, do you see there it is stated Diekmann preferred n-dopants cesium, barium and Lithium fluoride?

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A. I'm still reading it. Yes, I see that line.

Q. So based on your own summary here, is Lithium fluoride one of Diekmann's preferred n-dopants?

A. That's what the sentence you're pointing to says. But I'll just add to you that, again, as I just noted, a person skilled in the art would not see that preference as limiting because n-dopant simply means a compound that increases conductivity and Ma teaches such in their work on Liq.

Q. Did you cite any document indicating that would not be the understanding by a person of ordinary skill in the art?

MR. WEIDENFELLER: Objection.

THE WITNESS: No, I didn't think I had to cite additional a document because a person of ordinary skill in the art would have that understanding.

BY MS. ZHONG:

Q. Despite the fact that Diekmann specifically says that it's n-dopant acts as an

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electron donor?

MR. WEIDENFELLER: Objection.

THE WITNESS: That taken plus the fact that Diekmann also teaches that dopant diffusion is something that needs to be dealt with in the device as well and that a molecular n-dopant would allow one to satisfy that particular aspect of Diekmann, too.

BY MS. ZHONG:

Q. There are molecular n-dopant that is not Lithium Q that serves as electron donors, correct?

A. Is there a particular one you're asking me that I'm aware of?

Q. Are you aware of any other than Lithium Q?

A. Certainly there are others, but I'm not aware of many actually, certainly not at this time. There might be other molecules, but there's -- I don't think they were widely known.

Q. What about the tungsten hpp4?

A. I'm sorry?

Q. Tungsten hpp4.

A. I'm not familiar with that compound.

Q. And you were working in the -- you

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graduated in -- you got your Ph.D. in 2008 and 2009, right?

A. I received my Ph.D. in 2006.

Q. Okay. And were you doing post-doc at the time or you already had your own research group at the time?

A. No, I started running my research group in 2006. I didn't do a post-doc.

Q. So in 2008 and 2009, you already had your own research group for two to three years, correct?

A. That's correct.

Q. And you were not aware of that tungsten hpp4?

A. I was not aware of the compound you're describing.

MS. ZHONG: Okay. I don't have any further questions. Subject to the redirect by your counsel, I think I'm done with mine.

MR. WEIDENFELLER: Okay. Thank you. Why don't we take a short break and reconvene.

(Recess.)

MR. WEIDENFELLER: There is no redirect.

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MS. ZHONG: So we are done today, right?

MR. WEIDENFELLER: Yes.

MS. ZHONG: Thank you. Sounds good.

(Whereupon, at 5:56 p.m., the taking of the instant deposition ceased.)

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CERTIFICATE OF REPORTER

UNITED STATES OF AMERICA) ss:
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I, MARY GRACE CASTLEBERRY, RPR, the officer before whom the foregoing proceedings were taken, do hereby certify that the foregoing transcript is a true and correct record of the proceedings; that said proceedings were taken by me stenographically to the best of my ability and thereafter reduced to typewriting under my supervision; and that I am neither counsel for, related to, nor employed by any parties to this case and have no interest, financial or otherwise, in its outcome.

<%11099,Signature%>
Notary Public in and for
The District of Columbia

My commission expires: 7/14/2026

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SCOTT C. WEIDENFELLER, ESQ.
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APRIL 29, 2025

RE: Samsung Display Co., LTD. v. Pictiva Displays International
4/24/2025, Russell J Holmes, Ph.D, (#7301766).
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.

__ 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.

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__ 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 (#7301766)

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(Russell J Holmes, Ph.D) Date

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Federal Rules of Civil Procedure

Rule 30

(e) Review By the Witness; Changes.

(1) Review; Statement of Changes. On request by the deponent or a party before the deposition is completed, the deponent must be allowed 30 days after being notified by the officer that the transcript or recording is available in which:

(A) to review the transcript or recording; and

(B) if there are changes in form or substance, to sign a statement listing the changes and the reasons for making them.

(2) Changes Indicated in the Officer's Certificate. The officer must note in the certificate prescribed by Rule 30(f)(1) whether a review was requested and, if so, must attach any changes the deponent makes during the 30-day period.

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