TRANSCRIPT MARKED CONFIDENTIAL

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

PICTIVA DISPLAYS INTERNATIONAL LTD., Plaintiff, vs. SAMSUNG ELECTRONICS CO., LTD., SAMSUNG ELECTRONICS AMERICA, INC., Defendants.	Civil Action No. 2:23-cv-00495-JRG

ZOOM VIDEOTAPED DEPOSITION OF FRED SCHUBERT
Troy, New York
Wednesday, December 11, 2024
Volume I

Reported by:
LORI M. BARKLEY
CSR No. 6426
Job No. 7046685
PAGES 1 - 171

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IPR2024-01093

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

PICTIVA DISPLAYS INTERNATIONAL LTD.,	)	
Plaintiff,	)	Civil Action No.
vs.	)	2:23-cv-00495-JRG
SAMSUNG ELECTRONICS CO., LTD., SAMSUNG ELECTRONICS AMERICA, INC.,	)	
Defendants.	)	

Zoom Videotaped deposition of Fred Schubert, Volume I, taken on behalf of Plaintiff, at Troy, New York, beginning at 9:51 a.m. and ending at 6:29 p.m. on Wednesday, December 11, 2024, before LORI M. BARKLEY, Certified Shorthand Reporter No. 6426.

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WITNESS
FRED SCHUBERT

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Troy, New York; Wednesday, December 11, 2024

9:51 a.m.

VIDEO OPERATOR: Good morning. We are on the record at 9:51 a.m. on December 11th, 2024. 07:51:09 07:51:10

Please note that this deposition is being conducted virtually. Quality of the recording depends on the quality of camera and internet connection of participants. 07:51:17 07:51:20 07:51:23 07:51:28

What is seen from the witness and heard on screen is what will be recorded. Audio and video recording will continue to take place unless all parties agree to go off the record. 07:51:29 07:51:31 07:51:34 07:51:38

This is media number one of the recorded deposition of Dr. E. Frank Schubert in the matter of Pictiva Displays International LTD versus Samsung Electronics Company LTD, filed in the United States District Court for the Eastern District of Texas, Marshall Division. Case number 2:23-cv-00495-JRG. 07:51:39 07:51:43 07:51:48 07:51:52 07:51:56 07:51:59

This deposition is being conducted remotely using virtual technology. My name is JoAnn Yager, representing Veritext Legal Solutions and I'm the videographer. The court reporter is Lori Barkley from the firm Veritext Legal Solutions. 07:52:11 07:52:13 07:52:17 07:52:22 07:52:25

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I am not related to any party in this action nor am I financially interested in the outcome. If there are any objections to proceeding, please state them at the time of your appearance. 07:52:27 07:52:30 07:52:34 07:52:36

Counsel and all present will now state their appearances and affiliations for the record beginning with the noticing attorney. 07:52:37 07:52:39 07:52:42

MS. CARSON: This is Rebecca Carson of Irell & Manella on behalf of Pictiva. 07:52:43 07:52:48

MS. BAILY: Melissa Baily from Quinn Emanuel on behalf of the Samsung defendants. 07:52:50 07:52:54

FRED SCHUBERT,

having been administered an oath, was examined and testified as follows:

EXAMINATION

BY MS. CARSON: 07:53:19

Q. Could you please state your name for the record. 07:53:19 07:53:21

A. Eric Fred Schubert. 07:53:21

Q. And, sir, you've been retained as an expert on claim construction issues by Samsung; is that right? 07:53:28 07:53:31 07:53:39

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A. I've been retained, I believe, by the Quinn Emanuel law firm. 07:53:40 07:53:45

Q. And they retained you on behalf of Samsung? 07:53:49

A. Yes. That is my understanding. 07:53:52

Q. When were you retained? 07:54:00

A. It was the June 2024 timeframe. 07:54:14

Q. And you've submitted a declaration in this case; is that right? 07:54:18 07:54:23

A. Yes. 07:54:33

Q. How long did you spend reviewing materials and preparing that declaration? 07:54:33 07:54:36

A. Overall, I spent more than 100 hours on the case. But less than 200 hours. 07:55:00 07:55:05

MS. CARSON: I've added Exhibit 1 to the Exhibit Share folder. 07:55:13 07:55:17

(Exhibit 1 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. If you could just open that up. Let me know when you've got access to it. 07:55:18 07:55:44

A. I've received it. 07:55:46

Q. Is that a copy of your declaration that you submitted in this case? 07:55:47 07:55:50

A. Yes. 07:56:07

Q. And did you write this declaration yourself? 07:56:08

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A. This declaration is a product of collaboration with counsel. I wrote it in part. 07:56:26 07:56:28

Q. Did anyone else write any portions of it? 07:56:37

A. Yes. 07:56:43

Q. And who wrote other portions of the declaration? 07:56:43 07:56:46

A. The legal portion was written by counsel. 07:56:49

Q. Were any of the portions related to the terms that you're opining on for construction written by counsel? 07:56:53 07:56:57 07:57:00

A. Ultimately, I wrote the report. I authored the report. It's my report. But some parts, they have been drafted by counsel. 07:57:27 07:57:32 07:57:41

Q. Are you able to tell me what percentage of the declaration you wrote versus counsel? 07:57:44 07:57:52

A. Counsel wrote the legal portion, the table of contents. But I am the one who is responsible for the technical content. 07:58:04 07:58:11 07:58:26

Q. I understand your response as you signed it. My question is a little bit different. I'm just asking if you're able to tell me what percentage of the rest of the declaration did you do a first draft versus counsel? 07:58:32 07:58:34 07:58:37 07:58:39 07:59:03

MS. BAILY: Asked and answered. Go ahead, Fred. 07:59:04 07:59:06

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THE WITNESS: I don't recall a specific percentage. 07:59:10 07:59:11

BY MS. CARSON: 07:59:13

Q. Just to be clear, sitting here right now, you're not able to tell me what percentage of your declaration you were the drafter for; is that right? 07:59:26 07:59:28 07:59:32

MS. BAILY: Asked and answered. Mischaracterizes the testimony. 07:59:40 07:59:47

MS. CARSON: I'm not sure, Ms. Baily, if you're familiar with the rules in the Eastern District of Texas. But you're not allowed to do any objection other than form or privileged. So I'd just ask you to comply with those rules. 07:59:51 07:59:53 07:59:55 07:59:58 08:00:01

Q. Could you answer the question, sir? 08:00:14

A. Can I hear the question again? 08:00:16

Q. Sure. The question was sitting here right now, you're not able to tell me what percentage of your declaration you drafted as opposed to counsel; is that right? 08:00:17 08:00:22 08:00:24 08:00:45

A. I am responsible for the technical content. I authored the declaration including its technical content. But as I said, counsel has written sections. 08:00:45 08:00:50 08:00:58 08:01:10

For example, the legal section was exclusively written by counsel. 08:01:10 08:01:12

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Q. Are you able to testify under oath as to whether counsel wrote any of the sections on specific terms? 08:01:18 08:01:20 08:01:23

MS. BAILY: Object to form. 08:01:26

THE WITNESS: The specific term sections were a collaboration between myself and counsel. And I authored -- I am the author of these sections. And these sections have been a product of my collaboration with counsel. 08:01:37 08:01:39 08:01:47 08:01:56 08:02:03

BY MS. CARSON: 08:02:07

Q. When you say you're the author, does that mean you yourself drafted and wrote them? 08:02:07 08:02:15

MS. BAILY: Object to form. 08:02:18

THE WITNESS: The declaration is the product of my opinions. 08:02:22 08:02:26

MS. CARSON: Move to strike as nonresponsive. 08:02:31 08:02:36

Q. When you say you were the author of these sections, did you personally draft and write them? 08:02:37 08:02:39

MS. BAILY: Object to form. 08:02:44

THE WITNESS: I have provided my opinions to counsel. I have communicated with counsel. I have conveyed my opinions to counsel. And I received assistance from counsel with respect to the typing process. 08:02:50 08:02:55 08:02:59 08:03:06 08:03:10

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BY MS. CARSON: 08:03:13

Q. Do you have a paper copy of your declaration with you today? 08:03:22 08:03:26

A. No. 08:03:34

Q. Do you have any other documents or materials with you today? 08:03:35 08:03:37

A. Printed documents? 08:03:44

Q. Yes. 08:03:45

A. No. 08:03:47

Q. Do you have any documents opened on your computer screen other than the exhibit that I have introduced? 08:03:47 08:03:50 08:03:52

A. No other documents. 08:03:55

Q. What materials did you review before you formed your opinions in this case? 08:04:07 08:04:09

A. With respect to claim construction, I reviewed the asserted patents, their file histories, the preliminary claim constructions offered by the parties, and the documents that are cited in my claim construction declaration. 08:04:16 08:04:25 08:04:37 08:04:45 08:05:00

Q. Did you read each of the patents at issue in this case from front to bottom? 08:05:01 08:05:07

A. Yes. 08:05:11

Q. And did you read the entirety of every one of the file histories? 08:05:12 08:05:15

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A. Not the entirety of the file histories. But the relevant parts. 08:05:27 08:05:30

Q. Did you read the entirety of any of the file histories for any of the patents in suit? 08:05:31 08:05:37

A. I read all the file histories. Some of the references may have been in a different language. And I read the relevant parts. 08:05:53 08:06:00 08:06:07

But if you want to be specific, I would need to have a look at the file histories. Maybe there was a short one there that I read completely. Maybe there's a long one there that I haven't read completely but just the relevant parts. 08:06:11 08:06:15 08:06:20 08:06:22 08:06:25

But generally I read the author sections. I read what the applicant states or communicates with the USPTO. I read the modification of the claim language. I may read some of the prior art references that I find in the file histories. 08:06:27 08:06:32 08:06:44 08:06:55 08:07:04

But I'm not reading -- typically I'm not reading every single prior art that is found in the file history. 08:07:08 08:07:12 08:07:22

Q. Did you read all of the prior art that is specifically discussed in an office action or response? 08:07:25 08:07:28 08:07:30

A. Some of it, yes. 08:07:41

Q. But not all of it? 08:07:42

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A. Sometimes I may read all of it. Sometimes I may not read all of it. 08:07:50 08:07:52

Q. Did you review Samsung's invalidity contentions? 08:08:02 08:08:04

A. I have started reviewing some of the IPRs, inter partes reviews or petitions. And those petitions include some of the asserted prior art. But I have not completed that process. 08:08:22 08:08:30 08:08:47 08:08:56

Q. Did you review any of those IPR petitions before you submitted your declaration in this case? 08:08:59 08:09:01

A. In part, yes. 08:09:25

Q. Which IPR petitions did you review prior to forming your opinions in the declaration? 08:09:27 08:09:35

A. I recall that all of the petitions were available to me. And I recall that there are six asserted patents and seven IPR petitions. 08:09:53 08:10:01 08:10:10

And I started reviewing them in a chronological manner. And I may have gotten to petition number 2 or 3. That is my recollection. 08:10:19 08:10:23 08:10:28

Q. When you say chronological order, do you mean the order in which they were filed? 08:10:38 08:10:40

A. No. 08:10:45

Q. What do you mean by chronological order? 08:10:45

A. I mean the chronological order of the issue dates of the asserted patents. 08:10:50 08:10:55

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Q. Is there a reason you didn't review all of the IPR petitions that have been filed before you formed the opinions in your declaration? 08:11:05 08:11:13 08:11:16

MS. BAILY: Object to form. 08:11:23

THE WITNESS: The time available played a role. 08:11:53 08:12:01

BY MS. CARSON: 08:12:03

Q. So you didn't have time to review all of them before you submitted your declaration? 08:12:03 08:12:06

MS. BAILY: Object to form. 08:12:13

THE WITNESS: I'm in the process of reviewing the prior art. And I have not completed that process with respect to my claim construction declaration. 08:12:18 08:12:19 08:12:27 08:12:35

I did not see a need to review the petitions in their entirety. I reviewed some parts of the petition. But at this point, I have not reviewed the IPR petitions or the prior art in its entirety. 08:12:38 08:12:45 08:12:54 08:13:03

BY MS. CARSON: 08:13:17

Q. And that's not something that you thought was critical before you opined on claim construction in this case; is that right? 08:13:17 08:13:19 08:13:24

MS. BAILY: Object to form. 08:13:25

THE WITNESS: Some parts of the petitions and some parts of the patent owner preliminary 08:13:37 08:13:40

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response, I consider relevant. 08:13:47

I'm also aware that for some of the IPRs, 08:13:55

there have been a preliminary reply and a preliminary 08:14:01

sur-reply. 08:14:12

And I have reviewed at least one of those. 08:14:15

But I have not reviewed all the IPR documents in 08:14:24

their entirety. 08:14:33

BY MS. CARSON: 08:14:40

Q. Do you know if the PTAB has issued any 08:14:40

decisions in any of those IPRs? 08:14:47

A. I have heard there was one decision by the 08:14:56

PTAB. But I have not seen related documents. 08:15:07

Q. So did you read the decision? 08:15:12

A. No. 08:15:19

Q. Your background is in electrical and 08:15:31

computer engineering; is that right? 08:15:34

A. Here in academia my affiliation is with 08:15:46

electrical and computer engineering. However, my 08:15:50

research activities and work activities have gone 08:15:55

somewhat beyond electrical engineering. 08:16:02

Q. All of the degrees you received from your 08:16:09

schooling were in electrical engineering, correct? 08:16:12

A. Correct. 08:16:24

Q. You don't hold yourself out to be an expert 08:16:25

in chemistry; is that right? 08:16:36

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MS. BAILY: Object to form. 08:16:37

THE WITNESS: During my Ph.D., I worked for four years in a solid state chemistry department. 08:16:42 08:16:47

Subsequently, when I worked in industry, I worked for eight years in the material science division of AT&T. 08:16:54 08:16:56 08:17:02

So I have been exposed to a lot of chemistry, material science, materials processing during my professional career. 08:17:09 08:17:17 08:17:21

BY MS. CARSON: 08:17:26

Q. Do you hold yourself out as an expert in chemistry? 08:17:26 08:17:31

MS. BAILY: Object to form. 08:17:32

THE WITNESS: I have acquired some expertise in the field of chemistry. But I have not represented myself as an expert in chemistry. 08:18:02 08:18:06 08:18:12

BY MS. CARSON: 08:18:20

Q. You don't have any degrees in chemistry, correct? 08:18:20 08:18:25

A. I have no academic degree in chemistry. But I have worked for four years in the solid state chemistry department of a research institute. And I have worked for eight years in the Material Science Division of the AT&T Research Laboratories. 08:18:28 08:18:35 08:18:43 08:18:56 08:19:01

Q. And when was that? 08:19:12

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A. I worked in the Solid State Chemistry Department of the Max Planck Institute from 1981 to 1985. And I worked in the Material Science Division of AT&T Research Division from 1988 to 1995. 08:19:28 08:19:36 08:19:49 08:20:03

Q. Since 19 -- you said 1995? 08:20:24

A. Correct. 08:20:37

Q. Since 1995, have you done any research in the area of chemistry? 08:20:41 08:20:44

MS. BAILY: Object to form. 08:20:49

THE WITNESS: I have done research in microelectronics, optoelectronics, materials deposition, materials removal. And that inevitably included chemistry. 08:20:51 08:20:57 08:21:01 08:21:07

For example, I have built a chemically assisted ion beam etching system. And in that type of work, chemistry is inevitably part of it. 08:21:11 08:21:16 08:21:29

BY MS. CARSON: 08:22:08

Q. Do you have any degrees or research experience with organic chemistry? 08:22:08 08:22:10

MS. BAILY: Object to form. 08:22:15

THE WITNESS: Yes. 08:22:23

BY MS. CARSON:

Q. And what is that that you're referring to? 08:22:23

A. I have worked in the field of organic light emitting diodes and displays made of organic light 08:22:29 08:22:33

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emitting diodes. 08:22:41

Q. Could you turn to paragraph 13 of your declaration? Let me know when you're there. 08:23:27 08:23:29

A. Yes. 08:23:46

Q. And in paragraph 13, you discuss your experience at AT&T Bell Laboratories; is that right? 08:23:47 08:23:51

A. Yes. 08:24:01

Q. And was that the experience that you mentioned in the early '90s? 08:24:01 08:24:03

A. The first sentence of paragraph 13 refers to the time when I worked for AT&T. The second sentence refers to technical consulting services that are more recent, that happened after my employment with AT&T. 08:24:08 08:24:23 08:24:34 08:24:41

Q. By technical consulting services, do you mean expert work? 08:24:49 08:24:53

MS. BAILY: Object to form. 08:25:01

THE WITNESS: Most of it, yes. But not limited to expert witness technical consulting. 08:25:02 08:25:05

BY MS. CARSON: 08:25:14

Q. Okay, I see. In this paragraph, you have a sentence here that says, "one project concerned the enhancement of carrier mobility in amorphous and polycrystalline silicon TFTs." 08:25:15 08:25:18 08:25:23 08:25:27

Where did you do that work? 08:25:32

A. Here at my home institution, RPI, Rensselear 08:25:45

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Polytechnic Institute. 08:25:50

Q. And how long ago did you work on that? 08:25:53

A. Are you asking for that particular project? 08:26:30
Or generally my activities in OLEDs? 08:26:32

Q. That particular project. 08:26:38

A. That particular project was probably 08:26:50
somewhere around 2010. 08:26:52

Q. And you state that it was, "concerned with 08:26:59
the enhancement of the carrier mobility in amorphous 08:27:00
and polycrystalline silicon TFTs." 08:27:07

Just for the record, what is "TFTs." 08:27:10

A. Thin film transistors. 08:27:13

Q. And can you tell me a little bit more about 08:27:20
what you were doing? 08:27:23

A. We investigated the properties of TFTs and 08:27:40
their dependence on device parameters including the 08:27:48
carrier mobility. 08:27:55

Q. And your goal was to enhance carrier 08:28:04
mobility? 08:28:07

A. I can't recall all the details. But your 08:28:33
statement may be correct. 08:28:35

Q. What is carrier mobility? 08:28:37

A. Carrier mobility is a quantity that connects 08:29:04
the carrier velocity to an electric field that the 08:29:10
carrier is subjected to. 08:29:19

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Q. And what types of things were you doing to try to enhance carrier mobility in this project? 08:29:24 08:29:46

MS. BAILY: Object to form. 08:29:53

THE WITNESS: The carrier mobility may depend strongly on the properties of the material. And we investigated different materials. 08:29:55 08:30:38 08:30:50

BY MS. CARSON: 08:30:53

Q. And did you measure the carrier mobility of those materials? 08:30:53 08:30:56

A. We measured the properties of the TFT. And the properties of the TFT as a result of various parameters including the carrier mobility. 08:31:10 08:31:20 08:31:26

Q. And did you compare the measurements of the various materials? 08:31:37 08:31:40

A. I don't have a specific recollection. But I would assume so. 08:31:42 08:31:53

Q. What was the conclusion of that project? 08:31:56

A. The conclusion was that the properties of TFTs depend on the silicon material and the type of silicon material. For example, amorphous silicon or polycrystalline silicon. And additionally, on the fabrication method of those materials. 08:32:40 08:32:46 08:33:00 08:33:13 08:33:27

Q. Were you able to determine which particular materials had better carrier mobility for TFTs? 08:33:34 08:33:39

A. Can I hear the question again? 08:33:54

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Q. Were you able to determine which particular materials had better carrier mobility for TFTs? 08:33:55 08:33:58

A. The only material we worked with at that time was silicon. We did not work with other materials for this TFT project. 08:34:09 08:34:11 08:34:20

Q. Were you able to determine whether amorphous silicon or polycrystalline silicon had better carrier mobility? 08:34:25 08:34:29 08:34:44

A. My recollection is that polycrystalline silicon has a higher mobility. 08:34:44 08:34:47

Q. So during that research, you were able to compare the carrier mobility of those two different types of silicon and determine which had a higher carrier mobility; is that right? 08:34:53 08:35:00 08:35:04 08:35:09

A. I would not express it in this manner. I would say that we investigated the properties of the TFTs. 08:35:16 08:35:22 08:35:30

And the properties of the TFTs depend on various parameters such as geometrical parameters and other non-geometrical parameters including the carrier mobility. 08:35:31 08:35:36 08:35:48 08:35:54

Q. And I think you testified that your recollection is that polycrystalline silicon has a higher carrier mobility. 08:35:59 08:36:00 08:36:03

How did you determine that during that 08:36:07

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investigation? 08:36:10

A. I don't have a good recollection. But my 08:36:38
recollection is that we investigated the properties 08:36:40
of the TFTs. 08:36:48

Q. What properties are you referring to? 08:36:58

A. The threshold voltage, the transconductance, 08:37:16
and the breakdown wattage. 08:37:30

Q. And when you say you investigated those 08:37:43
properties, did you measure them somehow? 08:37:45

MS. BAILY: Object to form. 08:37:48

THE WITNESS: Yes. 08:37:56

BY MS. CARSON: 08:37:57

Q. How did you measure them? 08:37:57

A. Using measurement instruments. 08:38:06

Q. And then you compared those measurements 08:38:19
between the two materials to determine which had 08:38:23
better carrier mobility? 08:38:28

MS. BAILY: Object to form. 08:38:32

THE WITNESS: I would express it in the 08:38:40
following manner: We investigated the properties of 08:38:41
the TFTs. And the properties of the TFTs are the 08:38:48
quantity we are interested in. The properties of the 08:39:03
TFT is what we are interested in. 08:39:09

The TFT and its quality is expressed through 08:39:16
the parameters that I mentioned. And those 08:39:27

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parameters were of interest to us. And these parameters, we measured using electronic measurement instruments. 08:39:31 08:39:38 08:39:46

BY MS. CARSON: 08:39:53

Q. And then how did you use those to try to enhance carrier mobility? 08:39:55 08:40:03

MS. BAILY: Object to form. 08:40:10

THE WITNESS: I'm not sure if I understand your question. But what we did was we fabricated TFTs, thin film transistors made of silicon. And the silicon was either in its amorphous or polycrystalline form. 08:40:37 08:40:39 08:40:46 08:40:58 08:41:04

And these two forms were grown or deposited or fabricated by different methods. And we compared the properties of the TFTs that we had fabricated. 08:41:08 08:41:18 08:41:28

BY MS. CARSON: 08:41:40

Q. And then based on that comparison, you were able to conclude which one of them had better carrier mobility? 08:41:40 08:41:43 08:41:52

MS. BAILY: Object to form. 08:41:52

THE WITNESS: We did not assess or measure the carrier mobility. But we measured the properties of the TFTs. And the properties of the TFTs are a result of various parameters. And one of these parameters is the carrier mobility. 08:42:08 08:42:17 08:42:23 08:42:34 08:42:41

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BY MS. CARSON: 08:42:51

Q. And based on your work investigating these issues and making these measurements, you were able to determine that polycrystalline silicon has higher carrier mobility than amorphous silicon; is that right? 08:42:51 08:42:58 08:43:06 08:43:10 08:43:14

MS. BAILY: Object to form. 08:43:14

THE WITNESS: I don't recall the details. But generally I recall that the mobility of polycrystalline silicon is higher than the mobility of amorphous silicon. 08:43:20 08:43:21 08:43:35 08:43:42

BY MS. CARSON: 08:43:49

Q. Did you publish any papers? Or document this project in anyway? 08:43:49 08:43:54

A. Usually there is paperwork associated with any project. There are project reports. But I don't recall a journal publication that we would have published in conjunction with this project. 08:44:16 08:44:30 08:44:38 08:44:44

Q. What did you do with the results of the project? 08:44:52 08:44:56

A. I don't recall the details. But I would assume that the results of the project found their way into a project report. 08:45:12 08:45:14 08:45:23

Q. And what's a project report? 08:45:28

A. Say that again? 08:45:33

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Q. What is a project report? 08:45:34
A. The project report is a written document 08:45:44
that reports on the project including its results. 08:45:56
And specifically given to a sponsor of the project. 08:46:12
Q. Do you recall who sponsored this project? 08:46:16
A. I do not. 08:46:30
Q. Do you keep copies of project reports for 08:46:30
the work that you do? 08:46:33
A. Usually I do. But in around 2015 to 2020, I 08:46:47
made a transition from local computer to cloud 08:46:57
computing. And at that time, I did not transfer 08:47:10
everything to the cloud. 08:47:13
So currently, it's not on the computer 08:47:17
system that I am using. Here in my office, I have 08:47:21
some other computers, some backup things, some old 08:47:30
hard drives. 08:47:37
And I don't know what's on them. I have not 08:47:38
looked at them for at least five years. 08:47:43
Q. So do you know if you have a copy of the 08:47:51
project report for this project? 08:47:53
A. I do not have a copy on the computer system 08:47:59
that I'm currently using. And my current computer 08:48:02
system is a cloud computer. And it's not in the 08:48:05
cloud. 08:48:10
Q. But you're not sure if you have a copy in 08:48:11

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your backup computing systems? 08:48:13

A. Yeah. I wouldn't call it backup computer 08:48:22
systems because they're not a backup anymore. All 08:48:24
the backup is done by the cloud provider. 08:48:27

But I have some unused computer equipment 08:48:30
here in my office. And this includes at least two 08:48:36
computers. It includes multiple hard drives that are 08:48:41
no longer in active use. 08:48:55

And at the present time, I don't know what's 08:48:57
on those local computer storage components. So I 08:49:07
can't tell you what is on those older pieces of 08:49:22
equipment. 08:49:30

I have not used them for the last five years 08:49:30
because I don't need them at the present time. All 08:49:32
my documents are on a cloud computer. 08:49:40

MS. CARSON: Why don't we take a break. 08:49:46

VIDEO OPERATOR: Counsel, do you agree to go 08:49:48
off the record? 08:49:53

MS. BAILY: Yes. 08:49:53

VIDEO OPERATOR: Going off the record. The 08:49:55
time is 10:49 a.m. 08:49:56

08:54:00

(Recess taken.)

09:02:05

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VIDEO OPERATOR: We're back on the record at 11:02 a.m. 09:02:06 09:02:17

09:02:17

BY MS. CARSON:

Q. Could you turn to page 40 of your declaration? 09:02:19 09:02:23

A. Yes. 09:02:44

Q. And on page 40 is the start of the section of your declaration regarding the '223 patent. The first term you have opined on here is metal complex; is that right? 09:02:46 09:02:51 09:02:58 09:03:08

A. Correct. 09:03:09

Q. What is a metal complex? 09:03:10

A. The construction that I support is that a metal complex is not a compound composed of one or more metal atoms and one or more oxygen atoms. 09:03:23 09:03:35 09:03:42

Q. And is it your understanding that that's the plain-and-ordinary meaning of metal complex? 09:03:53 09:03:55

MS. BAILY: Object to form. 09:04:04

THE WITNESS: My understanding is that this is the meaning in the context of the '223 patent, including its prosecution history. And, I guess, recent documents that are part of the prosecution history. 09:04:11 09:04:12 09:04:24 09:04:36 09:04:38

/// 09:04:41

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BY MS. CARSON:

Q. So if one of your students asked you what a metal complex is, how would you respond? 09:04:42 09:04:44

MS. BAILY: Object to form. 09:04:50

THE WITNESS: Are you asking that outside the context of the '223 patent? 09:04:54 09:04:55

BY MS. CARSON: 09:05:00

Q. Correct. 09:05:06

A. The field of technology is very wide. And so it somewhat depends on the field that we are talking about. And the context that we are talking about. 09:06:19 09:06:24 09:06:30 09:06:34

And a metal complex is certainly a chemical compound that includes a metal that is also a complex. 09:06:34 09:06:41 09:06:48

But I have not formed an opinion outside the '223 patent on the term metal complex. I have not rendered an opinion on that topic. 09:06:49 09:06:52 09:06:58

Q. What is a complex? 09:07:03

A. I have not really formed an opinion on a complex. And I assume that this is also outside the context of the '223 patent? 09:07:16 09:07:42 09:07:50

But a complex has multiple components. And is used in the field of metal complex chemistry. 09:07:55 09:08:16

Q. Can a complex have only two elements? 09:08:21

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A. I would not wish to exclude that possibility. It depends on the specifics. 09:08:53 09:09:08

Q. What specifics does it depend on? 09:09:10

A. I'm not certain. And I don't understand if you're talking about the context of the '223 patent or if you're talking about the word complex in general. 09:09:32 09:09:32 09:09:38 09:09:45

Q. Let's start just in general. What specifics would it depend on just based on your general understanding of what a complex is as to whether a compound with just two elements would qualify as a complex? 09:09:45 09:09:48 09:09:53 09:09:59 09:10:03

MS. BAILY: Object to form. 09:10:04

THE WITNESS: I would not want to exclude the possibility that a complex has two chemical elements. 09:10:24 09:10:58 09:11:08

BY MS. CARSON: 09:11:09

Q. Can you give me any examples of complexes that have just two elements? 09:11:09 09:11:12

A. No specific complex comes to mind at the present time. 09:11:56 09:12:03

Q. Okay. So going back to your construction in the context of the '223 patent, your construction is a "metal complex that is not a compound composed of one or more metal atoms and one or more oxygen 09:12:03 09:12:05 09:12:10 09:12:14

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atoms."

Within that construction, what would a person of skill in the art understand the portion of your construction that refers to a "metal complex" to mean? 09:12:29 09:12:30 09:12:34 09:12:37

MS. BAILY: Object to form. 09:12:50

THE WITNESS: Based on the construction or based on the proposed construction, a person of skill would understand that certain compounds are excluded. And the compounds that I excluded are composed of at least one metal atom and at least one oxygen atom. 09:12:51 09:12:53 09:13:01 09:13:15 09:13:24

BY MS. CARSON: 09:13:37

Q. Under your construction, would all compounds other than those that are composed of one or more metal atoms and one or more oxygen atoms be a metal complex? 09:13:37 09:13:41 09:13:44 09:13:49

MS. BAILY: Object to form. 09:14:03

THE WITNESS: No. A metal complex is understood to include a metal. 09:14:17 09:14:18

BY MS. CARSON: 09:14:24

Q. So under your construction, would all compounds that include a metal but are not composed of one or more metal atoms and one or more oxygen atoms meet your construction of a metal complex? 09:14:24 09:14:29 09:14:37 09:14:41

MS. BAILY: Object to form. 09:15:04

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THE WITNESS: Can I hear the question again? 09:15:05
BY MS. CARSON: 09:15:05
Q. Under your construction, would all compounds 09:15:05
that include a metal but that are not composed of one 09:15:08
or more metal atoms and one or more oxygen atoms meet 09:15:14
your construction? 09:15:18
MS. BAILY: Object to form. 09:15:23
THE WITNESS: No. For example, sodium 09:15:33
chloride, NaCl, is not a metal complex. 09:15:40
BY MS. CARSON: 09:15:53
Q. And why is that? 09:15:53
A. Sodium chloride is not understood to be a 09:16:18
metal complex in the art. 09:16:21
Q. Why? 09:16:28
A. It is understood as an alkaline metal salt. 09:16:32
Q. What elements make up sodium chloride? 09:17:10
A. Sodium and chlorine. 09:17:18
Q. Sodium is a metal, correct? 09:17:24
A. Correct. 09:17:30
Q. So not all compounds that include a metal 09:17:32
are metal complexes; is that fair? 09:17:42
A. Yes. 09:17:55
Q. Your construction notes that a metal complex 09:18:01
is not a compound composed of one or more metal atoms 09:18:06
and one or more oxygen atoms. You don't dispute that 09:18:11

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a metal complex can include one or more metal atoms, correct? 09:18:16 09:18:22

MS. BAILY: Object to form. 09:18:22

THE WITNESS: A metal complex can include one metal atom. That is correct. And a metal complex can include two metal atoms. That is also correct. 09:18:50 09:18:53 09:19:01

BY MS. CARSON: 09:19:14

Q. So even though your construction says it is a not a compound composed of one or more metal atoms, you do concede that a metal complex does have to have at least one metal atom, correct? 09:19:14 09:19:17 09:19:21 09:19:26

MS. BAILY: Object to form. 09:19:29

THE WITNESS: There may be an ambiguity created by you not having read my construction in its entirety. 09:19:39 09:19:47 09:19:47

So my construction is a metal complex that is not a compound composed of one or two -- one or more metal atoms and one or more oxygen atoms. 09:19:47 09:19:51 09:19:59

BY MS. CARSON: 09:20:12

Q. Is your construction intended to exclude situations where a compound has one or more metal atoms, one or more oxygen atoms, and one or more additional elements such as carbon or hydrogen? 09:20:13 09:20:16 09:20:20 09:20:24

MS. BAILY: Object to form. 09:20:33

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THE WITNESS: Can I hear the question again? 09:20:44
BY MS. CARSON: 09:20:46
Q. Sure. Is your construction intended to 09:20:46
exclude situations where a compound has one or more 09:20:48
metal atoms, one or more oxygen atoms, and one or 09:20:51
more additional elements such as a carbon or 09:20:56
hydrogen? 09:21:03
MS. BAILY: Object to form. 09:21:04
THE WITNESS: Yes. 09:21:11
BY MS. CARSON: 09:21:11
Q. So it is your position that a metal complex 09:21:11
can never include oxygen? 09:21:14
MS. BAILY: Object to form. 09:21:20
THE WITNESS: Based on statements that the 09:21:28
applicants made during prosecution, it is my 09:21:32
understanding that a metal complex is not a compound 09:21:39
that is composed of at least one metal atom and at 09:21:48
least one oxygen atom. 09:21:59
BY MS. CARSON: 09:22:03
Q. Even if it contains other types of elements? 09:22:03
MS. BAILY: Object to form. 09:22:16
THE WITNESS: Correct. 09:22:17
BY MS. CARSON: 09:22:18
Q. And that's based on a statement in the 09:22:18
prosecution history that the reference Pictiva 09:22:40

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disclosed -- strike that. 09:22:52

Absent what you identify as an alleged 09:23:00
disclaimer in the prosecution history, would you 09:23:04
agree that metal complexes can include oxygen? 09:23:10

MS. BAILY: Object to form. 09:23:27

THE WITNESS: Outside the context of the 09:23:28
'223 patent, yes. 09:23:30

BY MS. CARSON: 09:23:32

Q. And you agree that metal complexes can be 09:23:37
made of more than two different elements, correct? 09:23:39

MS. BAILY: Object to form. 09:23:43

THE WITNESS: Yes. 09:24:02

BY MS. CARSON: 09:24:03

Q. Can you give me an example of a metal 09:24:03
complex that would satisfy your construction? 09:24:07

MS. BAILY: Object to form. 09:24:15

THE WITNESS: A metal complex that includes 09:24:19
a tungsten atom, carbon atoms, and hydrogen atoms 09:24:38
would not be excluded under this construction. 09:25:12

And would constitute a metal complex. Or I 09:25:15
should say could constitute a metal complex. 09:25:19

BY MS. CARSON: 09:25:33

Q. What is a metal oxide? 09:25:33

MS. BAILY: Object to form. 09:25:37

THE WITNESS: And your question is general? 09:26:25

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Not in the context of the '223 patent? 09:26:27
BY MS. CARSON: 09:26:30
Q. Yes. What does a person of skill in the art 09:26:30
generally understand a metal oxide to be? 09:26:32
A. I would like to answer the question with 09:26:52
respect to organic compounds and inorganic compounds. 09:26:54
If we have an inorganic compound and the inorganic 09:26:59
compound is referred to as a metal oxide, then the 09:27:06
compound typically includes metal atom and oxygen 09:27:18
atoms. 09:27:26
For example, aluminum oxide, Al2O3, is a 09:27:33
metal oxide. Or zinc oxide, ZNO, is a metal oxide. 09:27:50
In the context of organic compounds, I would 09:28:02
need to do a bit more research because I have not 09:28:14
opined on this question. 09:28:23
But I would say an organic compound that may 09:28:25
be described as an oxide, there could be additional 09:28:29
carbon atoms. 09:28:38
BY MS. CARSON: 09:28:45
Q. Are you able to identify any examples of 09:28:46
metal oxides that include elements other than metal 09:28:50
and oxygen? 09:29:01
A. In the context of inorganic compounds, yes. 09:29:06
In the context of organic compounds, I would need to 09:29:10
think a bit about it. 09:29:23

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Q. So what metal oxide do you have in mind in the context of inorganic compounds that consists of something other than just metal and oxygen? 09:29:26 09:29:32 09:29:37

MS. BAILY: Object to form. 09:29:55

THE WITNESS: As I said earlier, for inorganic compounds, we typically have one or more metal atoms and one or more oxygen atoms. 09:30:19 09:30:32 09:30:39

For example, aluminium oxide, AL2O3, we have two aluminium atoms and we have three oxygen atoms. Now, if we go to a different compound, such as NAOH, we can say that it's sodium hydroxide so -- 09:30:44 09:30:58 09:31:03 09:31:18

BY MS. CARSON: 09:31:34

Q. And it's your position that sodium hydroxide is metal oxide? 09:31:34 09:31:37

A. I wasn't finished. 09:31:44

Q. Okay. 09:31:46

A. So I was just going to say that sodium hydroxide is not strictly speaking an oxide. It's hydroxide but it has oxygen in it. I'm finished. 09:31:53 09:32:02 09:32:09

Q. So would you consider sodium hydroxide to be a metal oxide? 09:32:17 09:32:20

MS. BAILY: Object to form. 09:32:31

THE WITNESS: I would consider it as a metal hydroxide as sodium hydroxide. I'm just pointing out that the name of the compound, hydroxide, includes 09:32:32 09:32:35 09:32:39

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oxide. 09:32:48

But sodium hydroxide is different from 09:32:50
sodium oxide. Those are different compounds. 09:32:52

BY MS. CARSON: 09:32:57

Q. I understand that. So I think maybe we got 09:32:58
a little bit astray. My question was whether you are 09:33:02
able to identify for me any metal oxide, an example 09:33:04
of a metal oxide, that includes something other than 09:33:08
metal atoms and oxygen atoms? 09:33:13

A. In the context of organic compounds? Or in 09:33:20
the context of inorganic compounds? 09:33:22

Q. Either. 09:33:25

A. In the context of inorganic compounds, the 09:33:36
metal oxide typically consists of metal atoms or a 09:33:43
metal atom and oxygen atoms or one oxygen atom. 09:33:56

If you're asking me in the context of 09:34:05
organic compounds, organic compounds based on 09:34:08
standard nomenclature include carbon. 09:34:17

And I would need to do a little bit more 09:34:27
research. I've not opined on that particular 09:34:28
question. 09:34:33

But I would not want to exclude that such 09:34:33
compounds exist that are metal oxides in the context 09:34:46
of organic compounds. 09:34:56

/// 09:34:59

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BY MS. CARSON:

Q. But are you able to identify any example of an organic compound that would be considered a metal oxide that includes something other than metal and oxygen? 09:35:00 09:35:04 09:35:09 09:35:14

MS. BAILY: Object to form. 09:35:20

THE WITNESS: I've not articulated an opinion on that topic. I can just say that the compound that I understand you are talking about has at least a metal atom, has at least an oxygen atom, and because your question related to organic compounds, would include also carbon. 09:35:29 09:35:30 09:35:34 09:35:38 09:35:45 09:35:52

But I would need to do further research to be more specific. 09:36:01 09:36:03

BY MS. CARSON: 09:36:05

Q. So you're not able today to identify any compound that would qualify as a metal oxide regardless of whether it's organic or inorganic, that contains something other than just metal and oxygen? 09:36:05 09:36:12 09:36:15 09:36:22

MS. BAILY: Object to form. 09:36:26

THE WITNESS: You mean off the top of my head? 09:36:34 09:36:35

BY MS. CARSON: 09:36:36

Q. I'm saying, yes, in response to my question here today. 09:36:36 09:36:39

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A. I would need to do further research to answer the question. 09:37:18 09:37:20

Q. That's not something you looked into before forming your opinions in this case, correct? 09:37:22 09:37:28

A. I looked quite a bit. And I considered the issues at hand quite a bit, including the specifics that we are talking about right now. 09:37:52 09:37:55 09:38:02

But as I said, based on my review of the relevant documents, I came to the conclusion that the construction that is offered here, which is based on clear statements of the applicants, is a viable -- is a good -- is an appropriate construction. 09:38:07 09:38:10 09:38:15 09:38:28 09:38:41

Q. And just so that we're clear, the statement you're referring to is the statement in paragraph 101 of your declaration where (as read): 09:38:46 09:38:50 09:38:57

> The applicant stated a person of ordinary skill in the art understands that a metal oxide is a compound composed of one or more metal atoms and one or more oxygen atoms. 09:39:06 09:39:09 09:39:11 09:39:14 09:39:16 09:39:19 09:39:20
>
> Is that right? 09:40:35

A. I believe what you said. And I don't recall 09:40:35

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exactly what you said. But, if you know, if you look at paragraph 103 of my declaration, I state here that (as read): 09:40:39 09:40:41

> Based on the statements made by applicant, applicant disclaims any metal complexes that were a compound composed of one or more metal atoms and one or more oxygen atoms. 09:40:50 09:40:57 09:41:02 09:41:08 09:41:12

Q. And you're reading that statement to disclaim compounds that contain oxygen atoms. But not compounds that contain metal atoms; is that right? 09:41:18 09:41:20 09:41:25 09:41:41

A. I'm not sure if I understand your question. But what is excluded are compounds composed of at least one metal atom and at least one oxygen atom. 09:41:41 09:41:43 09:41:57

Q. You're not opining that this is a disclaimer of compounds that contain metal atoms, correct? 09:42:09 09:42:11

A. Can I hear the question again? 09:42:23

Q. You're not reading this as a disclaimer of any compound that contains a metal atom, correct? 09:42:24 09:42:26

A. Correct. 09:42:38

Q. But you are reading it as a disclaimer of any compound that contains an oxygen atom? 09:42:38 09:42:41

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A. I'm reading this as a disclaimer for any compound that is composed of at least one metal atom and at least one oxygen atom. 09:42:54 09:42:59 09:43:08

Q. A metal complex has to have at least one metal atom, correct? 09:43:10 09:43:13

MS. BAILY: Object to form. 09:43:19

THE WITNESS: Correct. 09:43:28

BY MS. CARSON: 09:43:29

Q. So you're reading the statement as just excluding oxygen from metal complexes? 09:43:29 09:43:35

MS. BAILY: Object to form. 09:43:38

THE WITNESS: If it includes one metal atom and one oxygen atom, that compound would not qualify as metal complex because applicants have disclaimed such compounds. 09:44:05 09:44:07 09:44:17 09:44:27

BY MS. CARSON: 09:44:39

Q. You agree that they did not disclaim compounds that contain metal, correct? 09:44:39 09:44:44

A. A compound that includes a metal may be excluded or may not be excluded. And the exclusion is given by the claim construction. 09:44:59 09:45:02 09:45:17

The specific specifics, the specific conditions, the specific configuration of what is excluded has been spelled out by the applicants during the prosecution. 09:45:20 09:45:26 09:45:28 09:45:36

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Q. Does this disclaimer apply to anything other than a compound that contains oxygen? 09:45:39 09:45:43

A. I don't understand the question. 09:46:02

Q. What does this alleged disclaimer disclaim other than any compound that has oxygen in your view? 09:46:03 09:46:07

MS. BAILY: Object to form. 09:46:18

THE WITNESS: The disclaimer relates to compounds that are composed of at least one metal atom and at least one oxygen atom. 09:46:22 09:46:27 09:46:32

BY MS. CARSON: 09:46:43

Q. Given that by definition, a metal complex includes a metal atom, is there anything other than a compound -- any compound containing oxygen that would be excluded by this disclaimer? 09:46:43 09:46:47 09:46:51 09:46:56

MS. BAILY: Object to form. 09:47:00

THE WITNESS: I'm not sure if I understand your question. 09:47:20

But if we have a compound and we find in this compound -- we find that the compound is composed of at least one metal atom and at least one oxygen atom, then this compound is this specific compound or one of the specific compounds that are disclaimed by the applicants. 09:47:22 09:47:29 09:47:36 09:47:39 09:47:44 09:47:53

I'm just going by the words that applicants used. 09:48:00 09:48:08

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BY MS. CARSON: 09:48:11

Q. Do you dispute that the definition of metal oxide is a binary compound of oxygen element and another metal -- strike that. 09:48:11 09:48:17 09:48:22

Do you dispute that the ordinary meaning of a metal oxide is a binary compound composed of an oxygen element and another metal chemical element? 09:48:26 09:48:30 09:48:36

MS. BAILY: Object to form. 09:48:55

THE WITNESS: In the framework of inorganic chemistry, I would agree to that. 09:48:56 09:48:58

BY MS. CARSON: 09:49:02

Q. And a binary compound is a chemical substance that's made of two different elements only, correct? 09:49:02 09:49:05 09:49:10

MS. BAILY: Object to form. 09:49:13

THE WITNESS: I have rendered an opinion on binary compounds. But in the field of inorganic chemistry, two-element compounds based on my recollection, can be referred to as binary compounds. 09:49:40 09:49:41 09:49:47 09:49:55

BY MS. CARSON: 09:50:12

Q. In your declaration on page 42, you quote a passage from the Ikeda reference, which is what the applicants were distinguishing in the prosecution history, correct? 09:50:12 09:50:15 09:50:20 09:50:24

A. Yes. 09:50:34

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Q. And this was that disclosure from Ikeda that the examiner had relied on as allegedly disclosing a metal complex, correct? 09:50:36 09:50:41 09:50:46

MS. BAILY: Object to form. 09:51:02

THE WITNESS: I don't recall what the examiner relied on. But this may have been one piece that the examiner relied on. 09:51:19 09:51:20 09:51:27

BY MS. CARSON: 09:51:32

Q. All of the metal oxides identified in your declaration on page 42 are binary compounds, correct? 09:51:32 09:51:39

A. No. 09:51:56

Q. Which one's not a binary compound? 09:51:58

A. ITO. 09:52:07

Q. And what does that contain other than metal and oxygen? 09:52:09 09:52:13

A. It includes two metal elements and oxygen. It's not a binary compound. 09:52:21 09:52:29

Q. Does it include anything other than metal elements and oxygen elements? 09:52:32 09:52:36

A. ITO just includes indium, tin, and oxygen. So three elements. 09:52:45 09:52:59

Q. And indium and tin are metals, correct? 09:53:00

A. Correct. 09:53:14

Q. So ITO includes only metal and oxygen, correct? 09:53:14 09:53:33

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A. Correct. 09:53:33

Q. If you look at the last little paragraph above the paragraph 102 on this page, there's a statement there from the prosecution history that says (as read): 09:53:35 09:53:45 09:53:50 09:53:52

"In direct contrast, applicants assert that in the presently claimed application, the organic electronic layer is obtained by joint vaporation of a metal complex, which comprises a central metal atom with an organic compound. 09:53:53 09:53:55 09:53:57 09:54:01 09:54:04 09:54:08 09:54:11

Do you see that? 09:54:13

A. Yes. 09:54:42

Q. Oxygen can be part of an organic compound, correct? 09:54:45 09:54:49

MS. BAILY: Object to form. 09:54:57

THE WITNESS: If you're just talking about organic compounds in general, outside the context of the '223 patent, then, yes, organic compounds can include oxygen. 09:55:16 09:55:17 09:55:25 09:55:31

BY MS. CARSON: 09:55:39

Q. If you neutralize vinegar with sodium 09:55:53

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carbonate, you'd get sodium acetate, correct? 09:55:59
MS. BAILY: Object to form. 09:56:02
THE WITNESS: I would need to see the 09:56:23
chemical reaction equation in front of me to answer 09:56:25
the question. 09:56:38
BY MS. CARSON: 09:56:38
Q. Sodium acetate is composed of sodium, which 09:56:38
is a metal, oxygen, carbon, and hydrogen; is that 09:56:41
right? 09:57:08
A. I would need to see either the chemical 09:57:08
formula or the chemical structure, atomic structure, 09:57:10
and the associated names in front of me in order to 09:57:20
answer the question. 09:57:23
Q. Do you consider sodium acetate to be a metal 09:57:24
oxide? 09:57:30
MS. BAILY: Object to form. 09:57:31
THE WITNESS: I'm sorry. I did not hear the 09:57:35
name of the compound. 09:57:38
BY MS. CARSON: 09:57:39
Q. Sodium acetate? 09:57:39
A. And can I hear the question again? 09:57:57
Q. Is sodium acetate a metal oxide? 09:58:00
A. I would need to see the chemical formula or 09:58:22
the atomic structure in order to answer the question. 09:58:25
Q. So you don't know whether sodium acetate is 09:58:35

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a metal oxide without doing some further research? 09:58:37

MS. BAILY: Object to form. 09:58:47

THE WITNESS: I intend that had my answer does not include any speculation. I am currently under oath and would like to give you an accurate answer. 09:59:00 09:59:02 09:59:05 09:59:11

You mentioned the compound sodium acetate. I think I know what you're talking about. But I'm not 100 percent sure. So I would need to have the chemical formula in front of me or the atomic structure. 09:59:11 09:59:20 09:59:23 09:59:27 09:59:32

And I don't wish to speculate. And for that reason, I would need more information to answer your question. 09:59:33 09:59:39

BY MS. CARSON: 09:59:46

Q. Do you know what the reaction product is when sodium reacts with methanol? 09:59:46 09:59:48

A. I'm not sure. I would need to speculate. 10:01:03

Q. What's your guess? 10:01:06

MS. BAILY: Object to form. 10:01:14

THE WITNESS: Well, my guess is that sodium as an element is very reactive. And it is known that sodium reacts readily with water. 10:01:15 10:01:20 10:01:31

Now, methanol, we have a carbon atom, we have three hydrogen atoms, we have an OH group. And 10:01:43 10:01:50

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when sodium reacts with water, sodium hydroxide is being formed. 10:02:07 10:02:20

So I wouldn't be surprised if there would be a reaction between metallic sodium and methanol. 10:02:22 10:02:25

MS. CARSON: Why don't we take a break? 10:02:51

VIDEO OPERATOR: Counsel, okay to go off the record? 10:02:53 10:02:54

MS. BAILY: Yes. 10:02:54

10:02:55

VIDEO OPERATOR: Going off the record. The time is 10:02 p.m. (sic). 10:02:56 10:02:57

10:13:47

(Recess taken.)

10:13:52

VIDEO OPERATOR: Back on the record. The time is 12:13 p.m. 10:13:58 10:14:01

BY MS. CARSON: 10:14:07

Q. Did you review the patent specification of the '223 patent to see whether it disclosed any examples of metal complexes that contain oxygen? 10:14:07 10:14:11 10:14:15

A. I reviewed the patent specification. And I reviewed it more than once, specific parts more than once. I don't recall if I reviewed it regarding the specific point you mentioned. 10:14:25 10:14:38 10:14:45 10:14:54

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MS. CARSON: I've introduced Exhibit 2 into the folder. 10:14:56 10:15:01

(Exhibit 2 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. Let me know when you've been able to open it. 10:15:20 10:15:23

A. Yes. I've been able to open it. 10:15:39

Q. And could you turn to figure 3. 10:15:41

A. Yes. 10:15:54

Q. And the compound in the middle of this figure 3, the ir(ac), that compound would be excluded from your definition of metal complex, correct? 10:15:57 10:16:01 10:16:10

MS. BAILY: Object to form. 10:16:23

THE WITNESS: Based on my recollection, the middle compound shown in figure 3 is a light-emitting material. 10:16:42 10:17:29 10:17:47

And in that sense, it's not a transport material. But if we would apply that construction to this particular compound, then it would be excluded. 10:17:52 10:18:00 10:18:08

BY MS. CARSON: 10:18:14

Q. And that's because that compound contains metal atoms and oxygen atoms, correct? 10:18:16 10:18:22

A. Based on my recollection, this metal compound is a light-emitting material. And this 10:19:15 10:19:22

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light-emitting material is not intended to coordinate during full vaporization. 10:19:28 10:19:39

And so the application of this particular chemical is different from what we are talking about in the context of the metal complexes that are identified in the claim construction. 10:19:44 10:19:50 10:19:58 10:20:04

But putting that aside, the claim construction that I support would exclude this particular compound because applicants said that this particular compound is not what applicants have in mind. 10:20:08 10:20:16 10:20:21 10:20:33

MS. CARSON: I'm introducing Exhibit 3. 10:21:07

(Exhibit 3 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. Let me know once you've been able to pull it up. 10:21:45 10:21:47

A. I have it. 10:21:47

Q. One second, I'm trying to find the right page. Okay. Could you turn to PDF page 62? 10:22:16 10:22:21

And by the way, did you review -- was this one of the petitions that you reviewed before forming your opinions? 10:22:28 10:22:36 10:22:38

A. Not in its entirety. 10:22:44

Q. So if you go to the bottom of the page -- it 10:22:46

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says 55 but it is PDF page 62. 10:22:51

Are you there? 10:22:55

A. Yes. Page 55. 10:23:01

Q. And you see that the second sentence in the first full paragraph there reads (as read): 10:23:02 10:23:07

> The electron transport layer is electron conducting and formed by joint vaporization of (1) a metal complex LIQ as an n-dopant.

10:23:09 10:23:12 10:23:15 10:23:21

Do you see that? And that's referring to the diagram on the left, that's lithium Q, correct? 10:23:31 10:23:32

A. Yes. 10:23:48

MS. BAILY: Object to form. 10:23:48

BY MS. CARSON: 10:23:49

Q. And your construction of metal complex would exclude lithium Q from being a metal complex, correct? 10:23:49 10:23:54 10:23:59

MS. BAILY: Object to form. 10:23:59

THE WITNESS: Yes. 10:24:23

BY MS. CARSON: 10:24:24

Q. Were you aware that Samsung had taken the position before the PTAB that lithium Q was a metal 10:24:24 10:24:26

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complex when you formed your claim construction opinion? 10:24:30 10:24:34

A. It is my understanding that the molecule structure that shows the Liq originates in the Ma, M-A, publication. And the Ma publication is not subject to the disclaimer made by the applicants of the '223 patent. 10:25:14 10:25:22 10:25:52 10:26:01

So we're talking about two different contexts. That's all I'm saying. 10:26:12 10:26:15

Q. You understand this is a petition, an IPR petition for the '223 patent, right? 10:26:17 10:26:20

A. Yes. 10:26:28

Q. And you understand that Samsung has taken the position that within the context of the '223 patent for purposes of this IPR petition, lithium Q is a metal complex? 10:26:28 10:26:29 10:26:32 10:26:38

MS. BAILY: Object to form. 10:26:49

THE WITNESS: I do not have enough context to understand all the aspects that are involved here. And I do not know if Samsung responded to something else. 10:26:50 10:26:52 10:27:00 10:27:09

I do not have enough context. And I would just need to have a closer look at this petition in order to answer your question. 10:27:10 10:27:13 10:27:22

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BY MS. CARSON: 10:27:24

Q. But your independent opinion is that within the context of the '223 patent, lithium Q is not a metal complex; is that correct? 10:27:24 10:27:30 10:27:37

MS. BAILY: Object to form. 10:27:41

THE WITNESS: It is my position that this particular compound, lithium Q, has been disclaimed by the applicants of the '223 patent. 10:27:59 10:28:01 10:28:07

BY MS. CARSON: 10:28:14

Q. And so therefore the claims of the '223 patent in your independent view would not include -- strike that. 10:28:14 10:28:17 10:28:29

In your independent view, lithium Q could not qualify as a metal complex within the context of the '223 patent, correct? 10:28:31 10:28:41 10:28:44

MS. BAILY: Object to form. 10:28:50

THE WITNESS: Correct because applicants have disclaimed this compound. 10:28:52 10:29:05

BY MS. CARSON: 10:29:12

Q. I want to move on to wherein the organic compound coordinates to the metal complex due to the joint vaporization. 10:29:12 10:29:17 10:29:20

This is on page 44 of your declaration. And your proposed construction is (as read): 10:29:25 10:29:28

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Wherein the organic compound coordinates to the metal complex in the gas phase after the organic compound and the metal complex are jointly vaporized. 10:29:29 10:29:32 10:29:35 10:29:36 10:29:38

Is that right? 10:30:09

A. Yes. 10:30:09

Q. Okay. You agree that "due to" in the claim connotes causal relationship? 10:30:10 10:30:15

A. The wording "due to" indicates a causal relationship. Yes, I agree. 10:30:29 10:30:31

Q. And would you agree that just because X happens after Y does not mean that Y caused X? 10:30:35 10:30:45

MS. BAILY: Object to form. 10:30:53

THE WITNESS: In your example, Y may be caused by X. Or Y may not be caused by X. 10:31:04 10:31:07

BY MS. CARSON: 10:31:12

Q. So the term "after" you used in your proposed construction may indicate causation. But it doesn't necessarily indicate causation; is that right? 10:31:13 10:31:16 10:31:20 10:31:25

MS. BAILY: Object to form. 10:31:25

THE WITNESS: The word "after" in my construction indicates that the two compounds need to 10:31:39 10:31:43

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be in the vapor state. 10:31:57

For example, if we have two evaporation 10:32:09
sources that are physically separate, then 10:32:12
coordination between the two compounds cannot happen. 10:32:23

So the two compounds need to be accessible 10:32:28
to each other in the vapor phase. And when the 10:32:33
compounds are in their crucible or source container, 10:32:42
they are separate. 10:33:01

But after they have transitioned to the 10:33:04
vapor phase, for example, by evaporation, the two 10:33:08
compounds can access each other and can coordinate to 10:33:18
each other. 10:33:23

MS. CARSON: I'm going to move to strike 10:33:29
everything after vapor state. 10:33:30

Q. So this is just a simple question: "After" 10:33:32
does not mean caused by, correct? 10:33:35

MS. BAILY: Object to form. 10:33:39

THE WITNESS: In your example, if Y happens 10:33:59
after X, Y can be caused by X. Or Y may not be 10:34:18
caused by X. So both possibilities are available. 10:34:27

If we just look at the word "after," it 10:34:39
indicates a temporal sequence. And the compounds 10:34:48
need to enter the vapor state in order to coordinate 10:34:52
to each other. 10:35:00

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BY MS. CARSON: 10:35:19

Q. Is your construction intended to exclude 10:35:19
situations where coordination occurs during joint 10:35:26
evaporation as opposed to at some point after joint 10:35:33
evaporation -- joint vaporization? 10:35:37

MS. BAILY: Object to form. 10:35:37

THE WITNESS: What my construction indicates 10:35:54
is that the organic compound and the metal complex 10:35:55
initially may be in a liquid or a solid state. In 10:36:01
that state, the two materials are physically 10:36:06
separated. 10:36:14

Now, once the two materials have transferred 10:36:24
to the vapor state and are in a joint space or are in 10:36:27
the same space above the evaporation sources, then 10:36:36
the two compounds have physical access to each other. 10:36:40
And when they have physical access to each other, 10:36:47
they can coordinate. 10:36:49

BY MS. CARSON:

Q. Do you dispute that coordination that 10:36:57
occurred during joint vaporization would satisfy the 10:36:59
claim --

(Reporter clarification.)

Do you dispute that coordination that 10:37:14
occurred during joint vaporization would satisfy the 10:37:20
claim under the construction? 10:37:25

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MS. BAILY: Object to form. 10:37:30

THE WITNESS: During joint vaporization, the way I see it is originally the two materials are in their respective source containers. They may be in the liquid state or solid state. 10:37:54 10:38:01 10:38:05 10:38:12

At that time in that state, no coordination can occur because they are physically separated. Once the two compounds have been vaporized, they are in a vapor state or gas state. 10:38:14 10:38:21 10:38:26 10:38:32

And they are located in the same general space. If they are located in the same space, the molecules have access to each other and can coordinate. 10:38:37 10:38:40 10:38:48 10:38:55

So I can say during the states where we have both compounds in the vapor phase in the same space, coordination can occur. 10:38:57 10:39:06 10:39:20

BY MS. CARSON: 10:39:45

Q. Is there a difference between simultaneous vaporization and joint vaporization? 10:39:45 10:39:49

MS. BAILY: Object to form. 10:39:53

THE WITNESS: I would say it depends on the context. I don't wish to over interpret words. 10:40:20 10:40:22

"Jointly vaporized" is one term. 10:40:26

"Simultaneously vaporized" is another term. 10:40:38

Joint vaporization in my understanding 10:40:46

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conveys that we have two compounds and both of them are vaporized. 10:40:54 10:41:06

Simultaneous vaporization, I would say is pretty similar. We have two compounds and they are initially in a liquid or solid state. And they are transferred to the vapor state. And that happens at the same time. 10:41:12 10:41:22 10:41:24 10:41:30

BY MS. CARSON: 10:41:44

Q. Could you take a look at column one, line 60, of the '223 patent? And there is a statement in the patent there that (as read): 10:41:44 10:41:48 10:42:01

> By virtue of the joint vaporization of the metal complex within organic compound, these two compounds interact with one another in the gas phase or when they meet one another on a substrate surface. 10:42:02 10:42:04 10:42:08 10:42:10 10:42:13 10:42:16

Do you see that? 10:42:20

A. Yes. 10:42:26

Q. You'd agree that the specification contemplates two different times when coordination can occur by virtue of joint vaporization either in the gas phase or when the compounds meet one another 10:42:28 10:42:32 10:42:34 10:42:38

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on the substrate surface? 10:42:43

MS. BAILY: Object to form. 10:42:46

THE WITNESS: Based on my understanding, the specification is broader than the claims. 10:42:53 10:42:55

BY MS. CARSON: 10:42:57

Q. Okay. 10:42:57

A. The specification that you point to is broader than what is claimed. 10:42:58 10:43:05

Q. Okay, and claim 2, which is where the term that you construed appears, doesn't specifically mention the gas phase, correct? 10:43:10 10:43:17 10:43:20

MS. BAILY: Object to form. 10:43:34

THE WITNESS: I missed a few other words that you said. 10:43:34 10:43:36

BY MS. CARSON: 10:43:38

Q. Claim 2, which contains the phrase that you construed, does not specifically reference the gas phase, correct? 10:43:38 10:43:42 10:43:46

MS. BAILY: Object to form.

THE WITNESS: Claim 2 includes the wording, "due to joint vaporization?" Vaporization in my view implies transitioning from the solid phase or liquid phase to the gas phase. 10:44:01 10:44:03 10:44:15 10:44:23

BY MS. CARSON: 10:44:28

Q. So you in your construction limited claim 2 10:44:28

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to the gas phase, correct? 10:44:32

MS. BAILY: Object to form. 10:44:45

THE WITNESS: In my construction, I said that the coordination between the two compounds occurs -- needs to occur in the gas phase when the molecules have an opportunity to meet each other. 10:45:07 10:45:10 10:45:21 10:45:34

And that claim is based on -- the claim interpretation is based on the wording, "Due to the joint vaporization." 10:45:45 10:45:53 10:45:56

BY MS. CARSON: 10:46:06

Q. Are you familiar with the concept of claim differentiation? 10:46:06 10:46:08

A. Yes. I have heard of it. 10:46:15

Q. Before you formed your opinions, did you review the claims of the '223 patent to see whether any of them mentioned "in the gas phase." 10:46:17 10:46:18 10:46:20

A. I reviewed all the asserted claims. 10:46:29

Q. Did you specifically check to see whether any of them included the limitation, "in the gas phase." 10:46:34 10:46:38 10:46:53

A. I reviewed all the claims. And kept all relevant points in mind during my review. 10:46:53 10:46:57

MS. CARSON: Move to strike as nonresponsive. 10:47:02 10:47:03

Q. If you could just answer. Did you review 10:47:03

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the claims to see whether there were any claims that referred specifically to coordination occurring in the gas phase? 10:47:05 10:47:09 10:47:13

MS. BAILY: Object to form. 10:47:28

THE WITNESS: I reviewed all the claims. And kept the relevant points in mind. 10:47:31 10:47:35

BY MS. CARSON: 10:47:38

Q. Do you know without going back and looking whether there are any claims that specifically refer to coordination occurring in the gas phase? 10:47:41 10:47:43 10:47:47

A. I do not know off the top of my head. 10:48:20

Q. Okay. Let's talk about "chain-like structure" for a moment. And your construction for "chain-like structure," is (as read): 10:48:23 10:48:26 10:48:39

> A structure where two metal complexes are linked by an organic compound. Or a structure where two organic compounds are linked by a metal complex. 10:48:43 10:48:46 10:48:48 10:48:52 10:48:54

Would your construction -- or under your interpretation of the claim, would a structure where two metal complexes are linked by more than one organic compound qualify as a chain-like structure? 10:49:01 10:49:03 10:49:09 10:49:15

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MS. BAILY: Object to form. 10:49:28

THE WITNESS: So we moving to the next term, "chain-like structure," correct? 10:49:33 10:49:36

BY MS. CARSON: 10:49:40

Q. That was what my question was about, yes. 10:49:40

A. On page 50 of my report? 10:49:42

Q. Yeah. 10:49:45

A. And can I hear the question again? 10:49:51

Q. Sure. The question is, is your proposed construction intended to exclude a situation where two metal complexes are linked by multiple organic compounds as opposed to an organic compound? 10:49:53 10:49:57 10:50:02 10:50:05

MS. BAILY: Object to form. 10:50:22

THE WITNESS: And in that example, the multiple organic compounds are bonded to each other? 10:50:23 10:50:24

BY MS. CARSON: 10:50:36

Q. Yes. 10:50:36

A. I don't see that bond between the two organic compounds being contemplated in the '223 patent. We have oligo-mers, O-L-I-G-O-M-E-R-S. 10:50:48 10:50:51 10:50:56

And the number of subcomponents is limited and specified to be approximately two to eight. And I don't see those two organic compounds form a connection via a chemical bond. I don't see this concept that you are envisioning disclosed in the 10:51:24 10:51:42 10:52:05 10:52:13 10:52:16

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'223 patent. 10:52:25

Q. So I'm just trying to get a simple answer as to whether "chain-like" would include a situation where you have metal complex, organic compound, organic compound, metal complex in a row. 10:52:25 10:52:29 10:52:33 10:52:37

MS BAILY: Object to form.

THE WITNESS: Understood. So the organic complex -- the organic compound has coordinated with the metal complex. Then we have basically two molecules. 10:52:43 10:52:50 10:52:52 10:52:57

But they are separate. I don't see -- in your question, I don't see how are the two organic compounds linked? I don't see that. 10:53:01 10:53:06 10:53:10

BY MS. CARSON: 10:53:15

Q. So it's your position that that wouldn't constitute "chain-like." 10:53:15 10:53:17

A. Maybe I don't understand your question. If you can show me in the '223 patent that there is a bonding between the two organic compounds or between two organic compounds contemplated, I may be able to answer your question but -- 10:53:25 10:53:28 10:53:38 10:53:42 10:53:48

Q. I'm really, sir, just trying to understand what your construction means. Because your construction is, "a structure where two metal complexes are linked by an organic compound. Or a 10:53:51 10:53:53 10:53:54 10:53:58

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structure where two organic compounds are linked by a metal complex." 10:54:01 10:54:06

So is it your position that the only thing that would qualify as a chain-like structure under the '223 patent is where there are three components linked in one of the orders that you identify in your construction? 10:54:06 10:54:09 10:54:21 10:54:25 10:54:29

MS. BAILY: Object to form. 10:54:33

BY MS. CARSON: 10:54:34

Q. Or can chain-like include more than those three components? 10:54:34 10:54:38

MS. BAILY: Object to form. 10:54:41

THE WITNESS: So if we have those configurations: Metal complex bonded to an organic compound, then the organic compound is in turn bonded to a metal complex. 10:54:50 10:54:51 10:54:58 10:55:02

If we have that configuration, then we have a chain-like structure. Alternatively, if we have an organic compound bonded to a metal complex and that metal complex in turn is bonded to a second organic compound, then we also have a chain-like structure. 10:55:07 10:55:09

BY MS. CARSON:

Q. And in your view, are those the only two structures that qualify as chain-like?

MS. BAILY: Object to form.

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THE WITNESS: I wouldn't characterize it as my view. I would characterize it as the view of the '223 patent, the specification of the '223 patent.

BY MS. CARSON:

Q. Your proposed construction would exclude any other structures, correct?

MS. BAILY: Object to form.

THE WITNESS: My construction for a chain-like structure to be present would need to have configurations as disclosed in the proposed construction. That is a series of metal complex, organic compound, metal complex. Or organic compound, metal complex, organic compound.

You can have other things. But for a chain-like structure, those are the configurations that are envisioned in the '223 patent.

BY MS. CARSON:

Q. So because of that, your opinion is chain-like structure is limited to only the specific configurations that you identify in your proposed construction, correct?

MS. BAILY: Object to form.

THE WITNESS: I follow that construction because it is based on the '223 patent.

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BY MS. CARSON:

Q. So the answer is, yes, your construction is limited to just the precise configurations that are identified in the construction, no more, no less?

MS. BAILY: Object to form.

THE WITNESS: These configurations based on the '223 patent are required. You can have other configurations. But these configurations are the required configurations.

THE REPORTER: Rebecca, I need to go off the record because my Real Time stopped.

MS. CARSON: Sure.

VIDEO OPERATOR: Going off the record. The time is 12:58 p.m.

(Whereupon at the hour of 12:58 p.m., a luncheon recess was taken. The deposition was resumed at 1:41 p.m., the same persons being present.) 11:42:00

11:41:27

VIDEO OPERATOR: Back on the record. The time is 1:41 p.m. 11:41:27 11:41:59

11:42:02

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MS. CARSON: On the break, I added some exhibits to the Exhibit Share folder. I want to start with Exhibit 4, which is a copy of the '389 patent. 11:42:03 11:42:05 11:42:07 11:42:12

(Exhibit 4 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. Could you open that one up? 11:42:14

A. Yes. 11:42:32

Q. If you could scroll back to the claims. And in particular, I want to draw your attention to claim 34. 11:42:33 11:42:35 11:42:38

One of the elements of claim 34 is, "selectively depositing at least one planarization layer upon said devices," correct? 11:43:03 11:43:06 11:43:11

A. Correct. 11:43:17

Q. And you've provided a number of constructions for terms within that limitation, correct? 11:43:17 11:43:20 11:43:23

A. Yes. 11:43:29

Q. The term refers to "selectively depositing at least one planarization layer." You agree that that would encompass a situation where only one planarization layer is deposited upon the devices? 11:43:30 11:43:37 11:43:46 11:43:50

A. Yes. 11:44:01

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Q. And it would also encompass a situation where multiple planarization layers are deposited upon the devices? 11:44:01 11:44:04 11:44:07

A. Yes. 11:44:12

Q. And the first term from this limitation that a you construed is, "upon said devices." 11:44:22 11:44:24

Is that right? On page 11 of your declaration? 11:44:30 11:45:00

A. Yes. 11:45:00

Q. And you've opined that "upon said devices" should be construed as "directly on said devices." 11:45:02 11:45:06

A. Yes. 11:45:13

Q. Just to be clear, it's your position that a layer that is indirectly on the device would not meet the limitation, correct? 11:45:17 11:45:22 11:45:25

MS. BAILY: Object to form. 11:45:30

THE WITNESS: A layer that is not directly on the said devices would not meet the claim limitation. 11:45:42 11:45:45 11:45:49

BY MS. CARSON: 11:45:49

Q. So under your proposed construction, is it fair to say that only one planarization layer would be able to be upon the device because only one of them would be directly on the device? 11:45:51 11:45:55 11:46:02 11:46:05

MS. BAILY: Object to form. 11:46:08

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THE WITNESS: If we have two planarization layers as contemplated in claim 34, then the group of planarization layers would need to be directly on said devices. 11:46:20 11:46:24 11:46:43 11:46:48

BY MS. CARSON: 11:46:53

Q. So it's your position that if there are multiple planarization layers, the second or third or fourth layer would still be upon the device under your construction even though it's not directly touching the devices? 11:46:53 11:46:57 11:47:04 11:47:07 11:47:10

MS. BAILY: Object to form. 11:47:15

THE WITNESS: No. My opinion is that if we have a group of planarization layers, such as two planarization layers, then the group of planarization layers needs to be directly on and in contact with said devices. 11:47:20 11:47:23 11:47:29 11:47:37 11:47:43

BY MS. CARSON: 11:47:47

Q. In a situation where there are multiple planarization layers, only one layer would directly touch the device, correct? 11:47:47 11:47:50 11:47:53

MS. BAILY: Object to form. 11:47:58

THE WITNESS: Only the bottom part of the lower-most planarization layer would touch said devices. 11:48:11 11:48:15 11:48:25

/// 11:48:26

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BY MS. CARSON:

Q. And the other planarization layers in the group of planarization layers would be indirectly on the device via the intervening first planarization layer, correct? 11:48:27 11:48:32 11:48:34 11:48:40

MS. BAILY: Object to form. 11:48:50

THE WITNESS: The way I look at it is that the group of planarization layers, such as two planarization layers, would be directly on and in contact with said devices. 11:48:51 11:48:53 11:49:00 11:49:10

BY MS. CARSON: 11:49:16

Q. But the only one that would directly contact the said devices would be the bottom planarization layer, correct? 11:49:16 11:49:20 11:49:24

MS. BAILY: Object to form. 11:49:34

THE WITNESS: If there are two planarization layers or a group of planarization layers, then the group is directly on and in contact with said devices in this example. 11:49:39 11:49:41 11:49:45 11:49:54

BY MS. CARSON: 11:49:56

Q. So in a situation where there's a group of planarization layers, it would be your position that the second layer could still satisfy your construction because the group is directly on the devices? 11:49:56 11:50:00 11:50:05 11:50:11 11:50:18

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MS. BAILY: Object to form. 11:50:18

THE WITNESS: No. My position is that if there is a group of planarization layers and the group of planarization layers is directly on and in contact with said devices, then the claim limitation is met. 11:50:30 11:50:34 11:50:40 11:50:49 11:50:57

BY MS. CARSON: 11:51:05

Q. And the part of the group of planarization layers that would be directly in contact with the said devices would be the bottom layer, correct? 11:51:05 11:51:07 11:51:09

MS. BAILY: Object to form. 11:51:14

THE WITNESS: I would view it as the group being directly on and in contact with said devices. 11:51:20 11:51:21

BY MS. CARSON: 11:51:33

Q. Does the patent use the term group of planarization layers -- actually we can strike that. I don't want to waste the time because we're running short on time. 11:51:33 11:51:36 11:52:25 11:52:27

So when a planarization layer is deposited -- strike that. 11:52:29 11:52:34

Do you deposit one planarization layer at a time? Or a group of planarization layers typically? 11:52:35 11:52:39

MS. BAILY: Object to form. 11:52:49

THE WITNESS: It may depend on the circumstances. It may depend on the intention of the 11:52:58 11:52:59

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person of skill performing the process. 11:53:06
BY MS. CARSON: 11:53:19
Q. And in a situation where -- strike that. 11:53:21
So claim 34 doesn't specify whether in a 11:53:24
device that has multiple planarization layers, 11:53:30
whether they need to be deposited one at time or all 11:53:35
together, correct? 11:53:38
MS. BAILY: Object to form. 11:54:01
THE WITNESS: I'm not sure if I understand 11:54:03
the question. If we have multiple planarization 11:54:05
layers -- 11:54:11
BY MS. CARSON: 11:54:11
Q. Okay. Let's backup. 11:54:11
Suppose you have a system where one 11:54:15
planarization is selectively deposited on the 11:54:21
devices? 11:54:26
Are you with me? 11:54:26
A. Yes. 11:54:29
Q. And then subsequently a second planarization 11:54:33
layer is selectively deposited on top of the first 11:54:37
planarization layer. 11:54:42
Under your construction, would that second 11:54:46
layer be "upon said devices." Or would it be upon 11:54:49
the first planarization layer? 11:54:58
MS. BAILY: Object to the form. 11:55:03

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THE WITNESS: The example that you propose would practice the limitation in my opinion. 11:55:04 11:55:07

BY MS. CARSON: 11:55:17

Q. So the second planarization layer that I mentioned could be used to satisfy the claim? 11:55:17 11:55:21

MS. BAILY: Object to form. 11:55:30

BY MS. CARSON: 11:55:30

Q. In my example. 11:55:31

A. I don't think so. I would say that if there are two planarization layers and the two planarization layers have been deposited directly on and in contact with the devices, then these two planarization layers fall within the spirit and word of the claim limitation that we are talking about. 11:55:32 11:55:37 11:55:41 11:55:45 11:55:50 11:55:56

Q. Even though only one of them is directly touching the devices, correct? 11:56:03 11:56:06

MS. BAILY: Object to form. 11:56:13

THE WITNESS: In my view, the two layers or the two planarization layers considered collectively -- considered collectively that it's the group of planarization layers is deposited directly on and in contact with the devices. 11:56:13 11:56:16 11:56:25 11:56:33 11:56:41

And for that reason, meets the claim limitation. 11:56:44 11:56:49

/// 11:56:49

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BY MS. CARSON:

Q. Which layer in the group directly touches the devices? 11:56:49 11:56:52

MS. BAILY: Object to form. 11:56:58

THE WITNESS: The touching is enabled by the devices being in physical contact with the two planarization layers that we're considering here. 11:57:17 11:57:20 11:57:29

BY MS. CARSON: 11:57:32

Q. Do the devices in that scenario physically touch those layers? 11:57:32 11:57:37

A. I would phrase it in the following way: The devices touch and are in contact with the bottom part or the bottom surface of the two planarization layers. 11:57:51 11:57:59 11:58:05 11:58:13

Q. You'd agree with me that the devices don't touch any part of the second layer in that scenario, correct? 11:58:13 11:58:17 11:58:28

MS. BAILY: Object to form. 11:58:28

THE WITNESS: I think it would be useful to look at the whole picture. And if we look at the whole picture, we look at the two planarization layers. 11:58:29 11:58:31 11:58:36 11:58:41

We look at them as a group. Or we look at them as two of them. And the planarization layers or the group of planarization layers is in contact with 11:58:41 11:58:46 11:58:56

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and is directly on said devices. 11:59:06

MS. CARSON: So move to strike as 11:59:11
nonresponsive. I want you to listen really closely 11:59:13
to my question 'cause I'm not asking whether it's in 11:59:16
contact with some part of the group. 11:59:19

Q. I'm asking a really simple question. Are 11:59:21
the devices in direct physical contact with the 11:59:24
second planarization layer? 11:59:28

MS. BAILY: Object to form. 11:59:37

THE WITNESS: It is in physical contact with 11:59:40
the said devices. And that includes -- the group 11:59:43
includes the first planarization layer and the second 11:59:49
planarization layer. 11:59:53

MS. CARSON: Move to strike as 11:59:59
nonresponsive.

Q. You're still not answering my question. My 12:00:00
question is not with the group. My question is just 12:00:03
if we're considering only that second planarization 12:00:06
layer. 12:00:09

Does that second planarization layer 12:00:10
physically touch the devices? 12:00:12

MS. BAILY: Object to the form. 12:00:19

THE WITNESS: A person of skill would look 12:00:34
at the planarization layers collectively. And come 12:00:36
to the conclusion that they are in physical contact 12:00:47

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and directly on said devices. 12:00:53

BY MS. CARSON: 12:00:59

Q. Are you refusing to answer my question, sir? 12:00:59

I'm not asking you about the group. I'm asking about 12:01:02

the second layer. Does the second layer touch the 12:01:05

devices? 12:01:08

MS. BAILY: Object to form. Argumentative. 12:01:09

Asked and answered. 12:01:11

THE WITNESS: If the second planarization 12:01:32

layer is directly on the first planarization layer. 12:01:33

And the first planarization layer is directly on said 12:01:42

devices, then the planarization layers, plural, are 12:01:47

in direct contact and directly on said devices. 12:01:59

BY MS. CARSON: 12:02:06

Q. Is the second planarization layer, singular, 12:02:07

directly on the said devices in that scenario? 12:02:11

MS. BAILY: Same objection. 12:02:23

THE WITNESS: The two planarization layers, 12:02:30

including the first and the second planarization 12:02:34

layer, are in physical contact and directly on said 12:02:37

devices in this example. 12:02:45

BY MS. CARSON: 12:02:49

Q. So for the ladies and gentlemen of the jury, 12:02:49

you are either unable or unwilling to answer my 12:02:53

question as to whether just the second planarization 12:02:57

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layer in that scenario is in physical contact with the said devices. 12:03:00 12:03:03

MS. BAILY: All the same objections. You're mischaracterizing the testimony. You're arguing with the witness. He's already answered the question, Ms. Carson. 12:03:07 12:03:09 12:03:11 12:03:13

THE WITNESS: I will be happy to convey my view to the jury that if there is more than one planarization layer, and the two planarization layers are deposited sequentially, then the bottom surface of the two planarization layers are directly on and in physical contact with said devices, which in my opinion satisfies the claim limitation. 12:03:14 12:03:27 12:03:30 12:03:35 12:03:50 12:03:55 12:04:05

BY MS. CARSON: 12:04:26

Q. Could you take a look at figure 1? You there? 12:04:26 12:04:41

A. Yes. 12:04:42

Q. Is layer 110 upon the devices? 12:04:42

MS. BAILY: Object to form. 12:05:00

THE WITNESS: Layer 110 is directly on and in contact with layer 108. 12:05:58 12:06:04

BY MS. CARSON: 12:06:19

Q. Are you finished? 12:06:19

A. Yes. 12:06:20

Q. So in this scenario, would layer 110 satisfy 12:06:20

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your construction of "upon the devices." 12:06:26

MS. BAILY: Object to form. 12:06:38

THE WITNESS: I understand that layer 108 is a barrier layer. And a barrier layer is not really part of a device. But it's the barrier layer. 12:06:59 12:07:03 12:07:24

So in this particular case, layer 110 is not directly on the device. But rather directly on the barrier layer 108. 12:07:28 12:07:48 12:07:52

BY MS. CARSON: 12:08:08

Q. So is your answer, no, 110 would not satisfy your construction of being upon the devices? 12:08:08 12:08:13

MS. BAILY: Object to the form. 12:08:52

THE WITNESS: Correct. 12:08:53

BY MS. CARSON: 12:08:54

Q. Your position that "upon" requires depositing the planarization layer directly on the devices is based on an argument that the applicant disclaimed the position that "upon" could mean indirectly on when it distinguished the Fujii reference in the prosecution history, correct? 12:08:54 12:08:57 12:09:00 12:09:08 12:09:10 12:09:14

A. Yes. 12:09:26

Q. And in particular, you point to figures 1A and 1B of the Fujii reference. And those are depicted on page 13 of your declaration? 12:09:26 12:09:29 12:09:34

A. Yes. 12:09:44

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Q. Fujii discloses a method for forming fluorescent screens of a plasma display, correct? 12:09:45 12:09:53

A. I don't recall at the moment if Fujii discloses a plasma display. But it discloses a display. 12:10:08 12:10:10 12:10:17

Q. Is it your understanding that the two figures that you show on page 13 show the full method that was disclosed by Fujii? 12:10:22 12:10:23 12:10:32

MS. BAILY: Object to form. 12:10:50

THE WITNESS: The two figures show part of the process where a layer 4 is deposited on an underlaying structure, underlying structure. 12:10:51 12:10:58 12:11:08

BY MS. CARSON: 12:11:17

Q. There's several additional steps in the method disclosed by Fujii, correct? 12:11:17 12:11:22

A. Can I hear the question again? 12:11:32

Q. There are several subsequent steps in the method disclosed by Fujii that occur after 1A and 1B, correct? 12:11:33 12:11:35 12:11:41

A. I would need a copy of the Fujii patent to be sure. But probably additional steps follow the figure 1B image. 12:11:47 12:11:57 12:12:11

Q. Do you know whether the portion you include in your report constitute the whole figure 1? 12:12:13 12:12:18

MS. BAILY: Object to form. 12:12:29

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THE WITNESS: I do not recall at the moment. I reviewed a lot of prior art articles. And I do not recall at the moment. 12:12:40 12:12:42 12:12:45

BY MS. CARSON: 12:12:46

Q. Was Fujii one of the references that you read in it's entirety? 12:12:46 12:12:48

A. No. I read it with respect to the relevant parts. 12:12:59 12:13:04

Q. So on you didn't read the whole reference, right? 12:13:05 12:13:14

A. That is probably correct. I have not read the Fujii reference in its entirety. I limited my review to relevant parts. 12:13:16 12:13:19 12:13:25

MS. CARSON: Okay. Could you take a look at Exhibit 5, which is the Fujii reference. 12:13:28 12:13:33

(Exhibit 5 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. And you'll see on page two of the PDF that's where figures 1A and 1B come from, correct? 12:13:53 12:13:58

A. Yes. 12:14:07

Q. And you'll see there's additional steps 1C through you 1H depicted, correct? 12:14:07 12:14:12

A. Yes. 12:14:29

Q. And the planarization layer or the alleged 12:14:30

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planarization layer that was discussed in the prosecution history was item 4, correct, of the photoresist? 12:14:39 12:14:42 12:14:48

A. Correct. 12:14:53

Q. And in Fujii, the photoresist is selectively removed after UV curing, correct? 12:14:54 12:14:59

A. It appears that way. 12:15:05

Q. And once we get to step 1D and beyond, the photoresist is not above the devices, which are depicted as 9, correct? 12:15:32 12:15:43 12:15:47

MS. BAILY: Object to form. 12:15:55

THE WITNESS: Can I hear the question again? 12:16:03

By MS. CARSON: 12:16:06

Q. Once we get to step 1D and beyond in Fujii, the photoresist is not above the devices, which are depicted as item 9, correct? 12:16:06 12:16:10 12:16:17

MS. BAILY: Object to form. 12:16:30

THE WITNESS: You say feature 7 is not above feature 9? 12:16:44 12:16:47

BY MS. CARSON: 12:16:48

Q. Correct. 12:16:48

A. The way I look at figure 1D, I see feature 7 being at a higher level than feature 9. And being at a higher level, one may describe as above or at a higher level. 12:16:56 12:17:02 12:17:09 12:17:22

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Q. So it's your position that in figure 1D, item 7 is on or above item 9? 12:17:24 12:17:35

MS. BAILY: Object to form. 12:17:49

THE WITNESS: I just would like to clarify your usage of "on." And so "on" we are not talking about upon, right, I mean, not directly on. 12:18:15 12:18:18 12:18:31

So you're just saying on. And so on means -- can mean directly on or indirectly on. 12:18:34 12:18:38

BY MS. CARSON:

Q. So either one of those, right? I'm just trying to like see what you're saying. 12:18:48 12:18:50

So are you saying that when you view figure 1D, it is your professional opinion that item 7 is on either directly or indirectly item 9? 12:18:53 12:18:57 12:19:11

MS. BAILY: Object to form. 12:19:24

THE WITNESS: I can readily answer your question if you go to figure 1C. 12:19:25 12:19:27

BY MS. CARSON: 12:19:32

Q. Please so I don't have to move to strike and we don't waste more time. Just focus on my question: In figure 1D, is item 7, in your professional expert opinion, on either directly or indirectly item 9, the devices? 12:19:33 12:19:35 12:19:38 12:19:42 12:19:50

MS. BAILY: Object to form. 12:19:53

THE WITNESS: It's a little bit a boundary 12:19:54

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case. 12:19:59

If we take the middle of feature 9, and if 12:20:07

we would draw a vertical line that goes upward, we 12:20:16

would not have that line intersect feature number 7. 12:20:26

However, if we consider on or above to mean 12:20:30

just to be at a higher level, then I would say 12:20:41

feature number 7 is at a higher level than feature 12:20:46

number 9. 12:20:53

MS. CARSON: Move to strike everything from 12:20:55

"however" on. 12:20:57

MS. BAILY: Obviously we'll oppose that. 12:21:02

And the other motions to strike. 12:21:04

BY MS. CARSON: 12:21:26

Q. What is your understanding of what it means 12:21:26

to make something more planar? 12:21:28

MS. BAILY: Object to form. 12:21:34

THE WITNESS: To make something more planar, 12:22:00

could imply to make it more plane-like. 12:22:03

BY MS. CARSON: 12:22:16

Q. Is another word for that "flatter"? 12:22:16

MS. BAILY: Object to form. 12:22:22

THE WITNESS: One could express it in this 12:22:35

manner. But there is no requirement to express it in 12:22:38

this manner. 12:22:43

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BY MS. CARSON:

Q. That's how you, yourself, expressed it in your declaration, correct? 12:22:46 12:22:48

MS. BAILY: Object to form. 12:22:55

BY MS. CARSON: 12:22:56

Q. If we look at paragraph 56, you state (as read): 12:22:57

> The '389 patent makes clear throughout that the material in that planarization layer acts to add a layer on top of another layer that makes the surface more planar or flatter. 12:22:59 12:23:02 12:23:04 12:23:06 12:23:09 12:23:11

Correct? 12:23:12

MS. BAILY: Object to form. 12:23:19

THE WITNESS: What paragraph?

BY MS. CARSON: 12:23:23

Q. 56. 12:23:23

A. Yes, correct. 12:23:40

Q. It's your position that if a layer of material provides a more planar or flatter surface but it doesn't interrupt the propagation of defects from one layer to another that would not count as a 12:23:41 12:23:46 12:23:55 12:23:59

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planarization layer within the context of the '389 patent, correct? 12:24:03 12:24:06

MS. BAILY: Object to form. 12:24:12

THE WITNESS: If the propagation of defects is not interrupted, if the defects propagate, then the planarization layer does not meet its intended purpose and would not qualify as planarization layer as claimed. 12:24:30 12:24:33 12:24:47 12:24:53 12:25:00

BY MS. CARSON:

Q. Under your construction, a layer would only qualify as a planarization layer if it both interrupts the propagation of defects from one layer to another layer as well as -- does it reproduce the topography of the underlying layer, correct? 12:25:05 12:25:07 12:25:11 12:25:15 12:25:24

A. Can I hear the question again? 12:25:39

Q. Sure. It was kind of a bad question. So I'll rephrase. 12:25:40 12:25:43

I'm just trying to get at whether if a layer interrupts the propagation of defects from one layer to another but it doesn't -- but it reproduces the topography of the underlying layer, that wouldn't be enough under your construction to count as a planarization layer, correct? 12:25:43 12:25:51 12:25:54 12:25:58 12:26:02 12:26:06

MS. BAILY: Object to form. 12:26:11

THE WITNESS: I generally agree that both 12:26:25

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conditions need to be met. One condition is the interruption of defects. And the other condition is the planarization aspect that is the topography of the underlayer, of the underlying layer is not reproduced. 12:26:27 12:26:30 12:26:35 12:26:40 12:26:51

BY MS. CARSON: 12:26:51

Q. So just to be clear, if you have a layer that makes it flatter and it interrupts the propagation defects, but it reproduces the topography of the underlying layer, that would not qualify as a planarization layer under your construction, correct? 12:26:51 12:26:55 12:26:58 12:27:03 12:27:06

MS. BAILY: Object to form. 12:27:17

THE WITNESS: If it is a conforming layer, if it reproduces the topography of the underlying layer, then it would not meet the claim limitation, I agree. 12:27:18 12:27:21 12:27:27 12:27:34

MS. CARSON: So can you take a look at Exhibit 6. 12:27:36 12:28:02

(Exhibit 6 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. Exhibit 6 is US Patent Application Publication number US2002/0140347. 12:28:03 12:28:07

Have you seen this before? 12:28:17

A. It looks somewhat familiar. But I'm not 100 12:28:46

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percent sure. 12:28:51

Q. If you could look at figure 6. 12:28:51

A. Yes. 12:29:01

Q. Do you agree that layer 151A reproduces the topology of the underlying layer 140? 12:29:07 12:29:15

MS. BAILY: Object to form. 12:29:25

THE WITNESS: Can I hear the question again? 12:29:54

BY MS. CARSON: 12:29:56

Q. Do you agree that layer 151A reproduces the topology of the underlying layer 140? 12:29:57 12:30:01

MS. BAILY: Object to form. 12:30:12

THE WITNESS: I heard you use the word topology. That's not the word I used. I used topography. 12:30:13 12:30:16 12:30:26

BY MS. CARSON: 12:30:27

Q. Sorry. Does 151A reproduce the topography of the underlying layer 140? 12:30:27 12:30:31

MS. BAILY: Object to the form. 12:30:51

THE WITNESS: That's not really something I opined on in my expert report. 12:30:52 12:30:53

BY MS. CARSON: 12:30:56

Q. You're not able to tell from looking at the diagram that it reproduces the corners there? 12:30:56 12:30:58

MS. BAILY: Object to form. 12:31:06

THE WITNESS: Well, I understand that the 12:31:13

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'389 patent has some statements about metal layers and potentially about the conformality of metal layers. 12:31:19 12:31:25 12:31:36

And at the present time, I do not know what 151A is. It looks like a conformal layer to me -- 12:31:42 12:31:45

(Reporter clarification.)

-- conformal layer to me. So I have not formed an opinion -- expressed an opinion on this particular patent. 12:32:00 12:32:08 12:32:16

And given that there are various statements in the '389 patent relating to metal layers and what constitutes a planarization layer and what doesn't, I would hesitate to make -- to express an opinion here. 12:32:20 12:32:22 12:32:28 12:32:36

For example, I do not know if 151A is an organic layer? Or what kind of layer it is. 12:32:49 12:32:56

BY MS. CARSON: 12:33:02

Q. So the specification of this patent describes it as a polymer layer. 12:33:02 12:33:05

MS. BAILY: Object to form. 12:33:25

BY MS. CARSON: 12:33:26

Q. I'm assuming that layer 151A is a polymer layer. Would you agree that it reproduces the topography of the underlying layer 140? 12:33:26 12:33:30 12:33:37

MS. BAILY: Object to form. 12:33:40

THE WITNESS: It's not an opinion that I 12:34:01

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write up in my report. I don't think the Weaver application is a publication that I relied on. 12:34:06 12:34:10

This is a complex subject matter. And I hesitate to give an answer that does not take into account all the aspects that are disclosed in the '389 patent. 12:34:21 12:34:25 12:34:30 12:34:37

I would need to study this in greater detail. And a quick answer may not do justice to the complexity of the matter at hand. 12:34:38 12:34:42 12:34:56

BY MS. CARSON: 12:34:58

Q. Yeah, I'm just trying to get a sense of how you would apply your construction. So if you were attempting to apply your construction of planarization layer to layer 151A, would it meet your construction? 12:34:58 12:35:00 12:35:04 12:35:08 12:35:15

MS. BAILY: Object to form. 12:35:18

THE WITNESS: At this point, I have no knowledge on the ability of layer 151A to interrupt defects such as dust particles. 12:35:29 12:35:30 12:35:42

BY MS. CARSON: 12:35:52

Q. Are you able to tell whether it reproduces the topography of the underlying layer by looking at the diagram? 12:35:52 12:35:55 12:35:59

MS. BAILY: Object to form. 12:36:02

THE WITNESS: To answer your question, I 12:37:30

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would like to review the relevant parts of the Weaver patent in greater detail. 12:37:32 12:37:41

As shown, I would assume that at some point layer 151 would have extended further to the right or to the left. The structure that is shown here is somewhat schematic. It is like an artist's view. 12:37:44 12:37:52 12:37:57 12:38:02

And if we would have -- if I would have the real structure as it practically occurs on a wafer -- if I would have access to that information, I could more easily answer your question. 12:38:13 12:38:20 12:38:28 12:38:34

BY MS. CARSON: 12:38:36

Q. How about 152C? Does that layer reproduce the topography of the underlying layer 151C? Or would you also have to look at the actual wafer to determine it for that layer? 12:38:36 12:38:47 12:38:50 12:38:54

MS. BAILY: Object to form. 12:38:58

THE WITNESS: I would have to look at the patent in greater detail. And also at the '389 patent because there are some specific statements about metal layers and conformal depositions. 12:39:03 12:39:04 12:39:07 12:39:11

And I think figure 6 looks like a sketch to me. This is how I envision it. The inventor might have drawn the structure as the inventor envisioned the structure rather than as the structure ultimately looks like in practice. 12:39:17 12:39:25 12:39:32 12:39:37 12:39:47

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BY MS. CARSON: 12:39:51

Q. So if all one had was this figure to evaluate whether the topography was reproduced, you're saying that wouldn't be possible just based on looking at this figure alone without more information? 12:39:51 12:39:58 12:40:01 12:40:04 12:40:06

MS. BAILY: Object to form. 12:40:19

THE WITNESS: To give you a good answer, I would like to see how Weaver for this '347 patent describes figure 6. 12:40:20 12:40:30 12:40:42

And I would also like to see the specific disclosures of the '389 patent with respect to conformal layers or metal layers. 12:40:47 12:40:53 12:41:00

And it was not part of my expert report. And was not an opinion that I rendered in my expert report. 12:41:06 12:41:12 12:41:17

So I would appreciate the opportunity to have a closer look at Weaver for the '347 patent and also the '389 patent to express or to articulate -- to find my opinion. 12:41:18 12:41:24 12:41:33 12:41:38

BY MS. CARSON: 12:41:42

Q. Can you turn your attention real quick to figure 5? 12:41:42 12:41:46

A. Yes. 12:41:52

Q. In your expert opinion, does this figure 5 12:41:52

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show the topography of any of the layers shown? 12:41:57

MS. BAILY: Object to form. 12:42:04

THE WITNESS: If I look at these images, they look like boundary cases to me. 12:42:31 12:42:33

For example, if the top surface of a planarization layer is completely flat, then it would be easier to answer your question. And I would say that the topography in that case is not reproduced. But the topography has become flatter. 12:42:40 12:42:44 12:42:53 12:42:57 12:43:06

And if we have another situation where let's say we have a metal layer and that a metal layer deposits just on the top of a island or feature but not on the side walls, then such a metal layer would not be considered a planarization layer. 12:43:15 12:43:30 12:43:42 12:43:56 12:44:03

And it is in fact excluded as a planarization layer in the '389 patent. 12:44:09 12:44:11

BY MS. CARSON: 12:44:21

Q. Could you take a look at paragraph 58 of your report or your declaration? 12:44:21 12:44:23

A. Yes. 12:44:39

Q. In paragraph 58, you note some statements by the application in a July 19th, 2004 response to a non-final rejection. 12:44:39 12:44:43 12:44:52

Is it your position that this statement is a disclaimer of planarization layers that do not 12:44:59 12:45:06

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interrupt the propagation of defects from one layer to another layer? 12:45:09 12:45:12

MS. BAILY: Object to form. 12:46:24

BY MS. CARSON:

Q. Are you able to answer my question? 12:46:25

A. Yes. I have been trying to see which is the sealing material, sealing material, seal, like a seal, sealing material, 20 prime. 12:46:26 12:46:35 12:46:41

And I have looked at my report to find out to -- to identify the sealing material 20 prime. And that's taken some time because the statement that the applicants made is that this particular layer, the sealing material 20, is not a planarization layer since it does not -- since it is not used to interrupt the propagation of defects. 12:46:45 12:46:50 12:46:56 12:47:06 12:47:17 12:47:21 12:47:27

To me, this statement means that the propagation of defects from one layer to another layer must not occur for the planarization layers envisioned by the inventors. 12:47:31 12:47:44 12:47:47 12:48:05

Q. Do you know if the inventors distinguished this particular reference or the sealing material 20 in any other ways? 12:48:09 12:48:11 12:48:18

MS. BAILY: Object to form. 12:48:46

THE WITNESS: To answer your question, I would need to have a look at the July 19, 2004 12:48:46 12:48:47

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response by the applicants. 12:48:54

MS. CARSON: Why don't we look at it, 12:49:08

Exhibit 7. 12:49:11

(Exhibit 7 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. And page 283. 12:49:14

A. I have it. 12:49:34

Q. So on page 283, this is where your quote comes from, correct? And you'll note that the sealing material, the applicant described as an adhesive. 12:49:36 12:49:39 12:49:43 12:49:47

Do you see that?

A. 283? 12:49:55

Q. Yeah, page 283. About the middle of the first paragraph, you'll see the applicant stated (as read): 12:49:55 12:49:58

> Rather than being a planarization layer, the sealing material 20 of Boronson is an adhesive that's used to bond the encapsulation enclosure 30 to the substrate 10? 12:50:01 12:50:02 12:50:06 12:50:08 12:50:11

Do you see that. 12:50:13

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A. Are you saying 283 or 383? 12:50:14

Q. 283. 12:50:17

A. 283. And you reading from the first paragraph? 12:50:38

Q. You see in the middle of the paragraph, there's a word that's underlined that says adhesive? 12:50:39 12:50:41

A. I do. 12:50:45

Q. So the applicant said (as read): 12:50:45

> Rather than being a planarization layer, the sealing material 20 of Boronson is adhesive that's used to bond the encapsulation enclosure 30 to the substrate 10. 12:50:46 12:50:48 12:50:51 12:50:54 12:50:57
>
> Do you see that? 12:51:00

A. Yes. 12:51:06

Q. Do you also see down a few sentences, it says, "the sealing material 20 of Boronson is not deposited upon said devices as specified in claim one." 12:51:06 12:51:08 12:51:12 12:51:15

Do you see that? 12:51:16

A. Yes. 12:51:28

Q. So would you agree with me, sir, that the applicant distinguished this Boronson reference on 12:51:29 12:51:31

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grounds other than the facts or in addition to the facts that the sealing material 20 is not used to interrupt the propagation of defects from one layer to another layer? 12:51:33 12:51:36 12:51:41 12:51:44

MS. BAILY: Object to form. 12:51:53

THE WITNESS: Generally, yes, I would say that the applicants identified more than one difference. One of the differences being that the layer 20 could not serve as a planarization layer because it does not interrupt the propagation of defects such as dust particles. 12:51:56 12:51:58 12:52:05 12:52:15 12:52:25 12:52:28

BY MS. CARSON: 12:52:43

Q. So the difference that you identified in paragraph 58 of your report was just one of multiple differences that the applicant identified in this remarks? 12:52:43 12:52:58 12:53:03 12:53:12

A. I generally agree. And I focused on the statements that I thought and I believe is relevant in the present context. 12:53:31 12:53:36 12:53:46

Q. Did you read the Boronson reference? 12:53:51

A. I believe that I had a lot of references available to me. And I do not recall off the top of my head if I have reviewed the Boronson reference. 12:54:01 12:54:07 12:54:14

Q. Paragraph 59 is what you use as the source for the portion of your construction that requires a 12:54:26 12:54:30

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planarization layer to not reproduce the topography of the underlying layer, correct? 12:54:41 12:54:44

A. Yes. 12:55:01

Q. And if you could go ahead and turn to page 237 of the file history that we were just reviewing? 12:55:02 12:55:08

A. 237, yes. 12:55:30

Q. And the remarks that you quote were in connection with the applicant's arguments distinguishing the Palmans references that's discussed on this page, correct? 12:55:32 12:55:36 12:55:41 12:55:46

A. Yes. 12:55:52

Q. Did you read the Palmans reference? 12:55:52

A. Same answer as I gave before: I have received many prior art references. I do not recall off the top of my head if Palmans was one of them. 12:56:03 12:56:06 12:56:16

I can say that if I reviewed the Palmans reference, I reviewed it to a limited extent. And not from A to Z or from front to back. 12:56:23 12:56:29 12:56:39

Q. Were you aware that the metal studs that the examiner had identified as the planarization layer in the Palmans reference did not provide a flat surface? 12:56:45 12:56:52 12:56:56

MS. BAILY: Object to form. 12:57:05

THE WITNESS: I would have to -- I would need to have a look at the metal studs. 12:57:13 12:57:14

///

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BY MS. CARSON:

Q. Do you see here in the last paragraph on the page, the applicant argued, "moreover the metal studs 5 cannot be used as a planarization layer because the metal studs 5 do not provide a flat surface." 12:57:22 12:57:28 12:57:32 12:57:35

Do you see that? 12:57:39

A. I do. 12:57:47

Q. You didn't include anything in your declaration disputing or contradicting that statement by the applicant, correct? 12:57:48 12:57:50 12:57:51

A. Can I hear the question again? 12:58:27

Q. You didn't -- strike that. 12:58:29

You didn't include anything in your declaration disputing or contradicting that statement by the applicant that the metal studs of the Palmans reference did create a flat surface, right? 12:58:32 12:58:35 12:58:38 12:58:45

MS. BAILY: Object to form. 12:59:22

THE WITNESS: My argument is based on the last sentence in this paragraph. And the last sentence in this paragraph refers to metal. And discloses that metals do not cover up imperfections but reproduce the topography of these defects. 12:59:22 12:59:28 12:59:33 12:59:45 12:59:53

That's what I relied upon. And I see there are additional statements relating to metal studs. 13:00:03 13:00:06

At the moment, I do not recall what the 13:00:10

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studs 5 are. So to answer your question, it would be helpful for me to look at the detailed disclosure of the metal studs. 13:00:17 13:00:24 13:00:32

MS. CARSON: So, sir, please just listen to my question. I move to strike as nonresponsive. 13:00:34 13:00:36

Q. My question wasn't about what you think about the metal studs. Or what analysis you could do. 13:00:38 13:00:39 13:00:41

I'm simply asking you to confirm that you did not dispute or address that sentence -- the first sentence of that paragraph, saying that the metal studs do not create a flat surface in your declaration? 13:00:42 13:00:43 13:00:47 13:00:50

There's nothing in your declaration about that, correct? 13:00:53 13:00:56

MS. BAILY: Object to form. 13:00:58

THE WITNESS: I do make statements about metals in general. And metal studs are a particular metal configuration. 13:01:21 13:01:22 13:01:29

But I agree that I don't recall using metal studs as a point of discussion in my declaration. 13:01:32 13:01:40

BY MS. CARSON: 13:01:47

Q. In your declaration, you did not reference, discuss, or mention the fact that the applicants distinguished the Palmans reference by stating (as 13:01:57 13:02:01 13:02:07

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read):

> The metal studs 5 cannot be used as a planarization layer because the metal studs 5 do not provide a flat surface.

Correct? That sentence is not addressed in your declaration, correct? 13:02:10 13:02:12 13:02:14 13:02:17 13:02:17 13:02:21

A. I don't see that sentence quoted in my declaration. 13:03:02 13:03:06

Q. If you could go back to the '389 patent. And take a look at column 6, line 6 to 16. 13:03:07 13:03:20

Do you see there that's describing figures 4A and 4B? 13:03:51 13:03:53

A. Yes. 13:03:55

Q. And if you look about midway in the paragraph, this is describing (as read): 13:04:01 13:04:03

> An embodiment where the barrier layer 408 is selectively deposited in a manner known in the art -- e.g. through a mask or screen -- situated on top of the OLED devices.

13:04:06 13:04:09 13:04:12 13:04:15 13:04:22

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Do you see that? 13:04:24

A. I do. 13:04:27

Q. And if you look at the figures that this is describing, figures 4A and 4B, do you agree that the shape of 408, the barrier layer, is different in figure 4B than it is in figure 4A? 13:04:28 13:04:31 13:04:43 13:04:47

A. The top surface is similar. But the side surfaces are somewhat different. 13:05:12 13:05:15

Q. In figure 4B, some of the portion on the side is removed, correct? 13:05:21 13:05:24

A. I'm not sure if I understand the question. But 408 has been selectively deposited. 13:05:39 13:05:40

And the deposition process is area selective. So we do not find 408 in all areas. But we find 408 only in specific areas. 13:05:48 13:05:54 13:06:02

MS. CARSON: Move to strike as nonresponsive. 13:06:07 13:06:07

Q. My question was, if you look at figure 4A versus 4B, a portion of 408 that you can see in 4A is removed when we look at 4B, correct? 13:06:08 13:06:12 13:06:19

MS. BAILY: Object to form. 13:06:38

THE WITNESS: Can I hear the question again, please? 13:07:13 13:07:15

BY MS. CARSON: 13:07:16

Q. If you compare figure 4A with 4B, 4B 13:07:16

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reflects that a portion on the side of the items labeled 408 has been removed or changed, correct? 13:07:25 13:07:33

MS. BAILY: Object to form. 13:07:40

THE WITNESS: My understanding is that layer 406 of has been removed at certain points. If you go back to 406 and you read the last sentence, the last sentence says, "figure 4B shows the next step in the processing after that portion of the unwanted organic layer 406 is removed by methods known in the art." 13:07:44 13:07:47 13:07:52 13:07:59 13:08:07 13:08:15

This was the last sentence. And it indicates that layer 406 has been removed. 13:08:21 13:08:24

BY MS. CARSON: 13:08:31

Q. And in the process of removing layer 406, the shape of 408 changed, correct? 13:08:31 13:08:35

MS. BAILY: Object to form. 13:09:13

THE WITNESS: If we just go by what the figures disclose, I would agree. But if we go by what has been described in column 6, we remove layer 406 and the removal of that layer should not affect feature 408 in a major fashion. 13:09:14 13:09:16 13:09:19 13:09:31 13:09:44

MS. CARSON: Move to strike everything from "but" onward. 13:09:54 13:09:55

Q. I'd like -- 13:09:58

MS. BAILY: We obviously oppose that motion. Can I have a standing -- I don't know, Rebecca, can I 13:10:01 13:10:04

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have a standing -- 13:10:07

MS. CARSON: Sure. I've never heard of 13:10:09
somebody doing that on the record. But that's fine. 13:10:10

Okay, I want to take a break now. But I 13:10:13
just want to note for the record, sir, I really 13:10:16
appreciate that you're trying to be careful. 13:10:19

But we've had like a lot of lengthy delays 13:10:21
after my questions, a lot of nonresponsive answers. 13:10:27
And I just want to make a formal request to counsel 13:10:29
to speak to the witness and to try to encourage him 13:10:32
on the break to be a little bit more responsive to my 13:10:35
questions. 13:10:38

Otherwise, I do think we're probably going 13:10:38
to have to move to seek additional time with the 13:10:41
witness through the court because I feel like my 13:10:43
questions are being obstructed. 13:10:46

And the witness is not responding. And I 13:10:48
hope it's not intentional. But it's just -- there's 13:10:51
been a lot of delays just after I've asked questions. 13:10:54

And in terms of just providing a lot of 13:10:57
information that I'm not seeking through the 13:11:01
questions. 13:11:03

MS. BAILY: Okay, I'm not sure I -- yeah, I 13:11:05
disagree with the characterization. There's 13:11:08
definitely no intent to delay. I will talk to the 13:11:13

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witness at the break. 13:11:13

Obviously, I don't think anything has happened that justifies more time at all. But we'll see what we can do. 13:11:15 13:11:16 13:11:21

MS. CARSON: Yeah. We can take that up later. But I just want to flag it. And we definitely will be here for the full seven hours given that we haven't gotten through very much material yet. 13:11:22 13:11:23 13:11:25 13:11:27 13:11:31

So let's take our break. 13:11:32

VIDEOGRAPHER: Going off the record. The time is 3:11 p.m. 13:11:34 13:11:35

(Recess taken.)

13:23:37

VIDEO OPERATOR: Back on the record. The time 3:23 p.m. 13:23:37 13:23:39

13:23:42

BY MS. CARSON:

Q. I want to turn to the '164 patent. For that patent, you propose different constructions for matrix and matrix material, correct? 13:23:43 13:23:47 13:23:52

A. Yes. 13:23:57

Q. So you'd agree that a matrix material and a 13:23:59

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matrix are two distinct things, correct? 13:24:03

A. Correct. 13:24:08

MS. CARSON: In case you need to reference it, I've introduced as Exhibit 8 a copy of the '164 patent. 13:24:15 13:24:16 13:24:24

(Exhibit 8 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. But can you confirm for me that none of the claims of the '164 patent recite a matrix as opposed to a matrix material? 13:24:25 13:24:30 13:24:38

A. Yes. I can confirm that the claims use the word matrix in conjunction with matrix material. 13:24:58 13:25:04

Q. So there's no separate limitation in the claims for just a matrix, correct? 13:25:10 13:25:15

A. Matrix is not used in isolation in the claims. 13:25:42 13:25:46

Q. So in other words, in claim one, the claim required a first matrix material, a second matrix material and a third matrix material. But it doesn't actually recite or require a matrix, correct? 13:25:46 13:25:49 13:25:56 13:26:01

A. Yes. Based on my understanding and based on the claim construction of matrix, the mixture of the first, second, and third matrix material is the matrix. 13:26:22 13:26:23 13:26:27 13:26:37

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Q. But the claim doesn't recite an element that says "a matrix," correct? 13:26:39 13:26:47

MS. BAILY: Object to the form. 13:26:52

THE WITNESS: Correct. Matrix is not used in isolation. But matrix is used in conjunction with material. So matrix material. 13:26:53 13:26:55 13:26:59

BY MS. CARSON: 13:27:07

Q. Claim one of the '164 patent recites at least one organic functional layer, correct? 13:27:07 13:27:18

A. Correct. 13:27:23

Q. And you'd agree that the element of at least one organic functional layer could include a device that comprises multiple organic functional layers? 13:27:23 13:27:27 13:27:31

A. Yes. 13:27:45

Q. Do the claims of the '164 patent recite or specify the number of matrices included in the at least one organic functional layer? 13:27:46 13:27:54 13:28:01

MS. BAILY: Object to form. 13:28:07

THE WITNESS: Can I hear the question again? 13:28:16

BY MS. CARSON: 13:28:19

Q. Do the claims of the '164 patent specify the number of matrices included in the at least one organic functional layer? 13:28:19 13:28:23 13:28:28

MS. BAILY: Object to form. 13:28:32

THE WITNESS: And for the term matrix, 13:28:45

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you're assuming the construction that I proposed? 13:28:47
BY MS. CARSON: 13:29:02
Q. I'm not assuming any construction. I'm just 13:29:02
asking whether the claim specifies how many matrices 13:29:05
are included in the at least one organic functional 13:29:15
layer? 13:29:18
A. In one organic functional layer, there is 13:29:26
based on my understanding one matrix. 13:29:29
Q. Where is that in the claim? Does the claim 13:29:34
recite that? 13:29:36
MS. BAILY: Object to form. 13:29:42
THE WITNESS: In isolation? 13:29:42
BY MS. CARSON: 13:29:48
Q. I'm just saying, does the claim -- does 13:29:48
claim one specify how many matrices there are? 13:29:50
A. I go by the identification of the matrix as 13:30:06
disclosed in the specification. And the 13:30:20
specification essentially says that one matrix or the 13:30:28
matrix is composed of three matrix materials. 13:30:35
Q. Sure. So I understand the specifications. 13:30:42
But I'm asking about the claim. The claim doesn't 13:30:44
recite a matrix, correct? 13:30:49
A. It's not recited in isolation, correct. 13:30:52
Q. And the claim doesn't specify the number of 13:30:56
matrices that can be included in the at least one 13:31:02

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organic functional layer, correct? 13:31:05

A. I would say it this way: That the organic 13:31:13
function layer that is recited in claim one is 13:31:15
identified as a emission layer in claim one. 13:31:18

So if we have one emission layer and the 13:31:23
emission layer is composed of the three matrix 13:31:29
materials, then we have one matrix. And that matrix 13:31:32
is composed of the three matrix materials. 13:31:35

If we have more than one organic function 13:31:43
layer, then we have multiple emission layers. 13:31:45

Q. And the patent describes embodiment in the 13:32:02
specification where each layer can have a matrix, 13:32:05
correct? 13:32:08

MS. BAILY: Object to form. 13:32:20

THE WITNESS: My recollection is that the 13:32:20
'164 patent defines a matrix as something that is 13:32:22
composed of three matrix materials. So for the 13:32:33
matrix to exist, we need the three different matrix 13:32:37
materials. 13:32:48

MS. CARSON: Move to strike as 13:32:49
nonresponsive. That wasn't my question. 13:32:50

Q. My question was, the patent describes 13:32:52
embodiments where each layer can have a matrix, 13:32:54
correct? 13:33:14

MS. BAILY: Object to form. 13:33:14

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THE WITNESS: Each layer -- which layer are you referring to? Are you referring to the hole transport layer, the electron transport layer, and the first matrix material? 13:33:19 13:33:22 13:33:25 13:33:33

BY MS. CARSON: 13:33:38

Q. I'm referring to the organic functional layers that are discussed. And you agree with me that the patent contemplates that there can be multiple organic functional layers, right? 13:33:38 13:33:40 13:33:43 13:33:47

A. There can be multiple emission layers. The organic function layer is identified as an emission layer. And there can be multiple emission layers. 13:33:49 13:33:52 13:34:00

But this is a bit rare. But it is within the scope of the claim that we have multiple emission layers. 13:34:03 13:34:07 13:34:11

But usually there's only one emission layer in OLED, O-L-E-D, organic light emitting diode. 13:34:11 13:34:14

Q. And the patent says that in addition, there can be other functional organic layers, such as a hole induction layer, a hole transport layer, and an intermediate layer, and an electron transport layer, and electron injection layer in addition to the emission layer, correct? 13:34:25 13:34:32 13:34:34 13:34:37 13:34:45 13:34:48

A. In claim one, I don't see that possibility because the organic functional layer is identified as 13:34:58 13:35:00

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emission layer. 13:35:05

The last limitation -- the last limitation 13:35:09
identifies the organic functional layer as an 13:35:17
emission layer. 13:35:23

MS. CARSON: Try to focus on my question. 13:35:26
And move to strike as nonresponsive. 13:35:27

Q. I'm not asking about the claim. I'm asking 13:35:30
about the embodiments in the specification. 13:35:32

Could you turn your attention to column 4? 13:35:35

A. Yes. 13:35:49

Q. In column 4, lines 16 to 28, the patent 13:35:49
discusses an embodiment where there are multiple 13:35:57
organic functional layers and each of these layers 13:36:02
has a matrix, correct? 13:36:06

A. Can I have the question again. 13:37:14

Q. In column 4, lines 16 to 28, the patent 13:37:15
discusses an embodiment where there are multiple 13:37:21
organic functional layers. And each of these layers 13:37:24
has a matrix, correct? 13:37:27

A. Yes. 13:38:04

Q. Could you turn your attention to column 5, 13:38:05
lines 3 to 17? 13:38:18

Column 5, lines 3 to 17, describe an 13:38:25
embodiment where the recombination zone can be 13:38:39
distributed within one functional layer or over 13:38:43

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several layers, correct? 13:38:47

A. I have read the paragraph you indicated. 13:39:48

And I would like to hear your question again. 13:39:51

Q. Column 5, lines 3 to 17, describes 13:39:57

embodiments where the recombination zone can be 13:40:02

distributed within one functional layer or over 13:40:07

several layers, correct? 13:40:10

MS. BAILY: Object to form. 13:40:25

THE WITNESS: Your question has two aspects. 13:40:41

And maybe we can look at these two aspect separately. 13:40:43

So what I see here in the paragraph is that 13:40:49

the recombination zone can be shifted within the 13:40:52

light-emitting layer. 13:41:08

For example, from the borders of the 13:41:09

light-emitting layer to the middle. That I can 13:41:11

verify. And I agree with you that it is disclosed in 13:41:16

this paragraph. 13:41:20

BY MS. CARSON: 13:41:21

Q. Do you see the second sentence, sir? Can 13:41:21

you read that for me? 13:41:24

A. "The recombination zone can thereby be 13:41:30

distributed within one layer or over several layers." 13:41:33

Q. Okay. So the patent describes that 13:41:41

embodiment -- strike that. 13:41:45

The patent describes embodiments where the 13:41:50

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recombination zone can be distributed within one layer or over several layers, correct? That's what you just read? 13:41:53 13:41:56 13:42:11

A. Yes. 13:42:12

Q. It's your position that a matrix is a continuous phase of the mixture of matrix material. What do you mean by "continuous phase." 13:42:18 13:42:20 13:42:28

A. Continuous phase means that there are no regions in which we have voids? Or in which we have phase separation. 13:42:38 13:42:42 13:42:55

And continuous phase in my view also includes the fact that we have the three matrix materials present throughout -- continuously throughout the matrix. 13:42:55 13:42:59 13:43:08 13:43:17

Q. Outside the context of the '164 patent, can you have a matrix that only includes one material? 13:43:23 13:43:27

A. Completely outside the context of the '164 patent, I would assume that matrix material can have different meanings and there can be materials in which there is only one matrix material. 13:43:41 13:43:44 13:43:48 13:43:54

Q. And outside the context of the '164 patent, a person of skill would understand that you could also have a matrix that includes two materials, correct? 13:44:00 13:44:04 13:44:05 13:44:10

A. I'm not sure if I understand the question. 13:44:21

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But one can have a mixture of two materials. I agree with that. 13:44:22 13:44:28

MS. CARSON: If you could take a look at Exhibit 9. 13:44:59 13:45:00

(Exhibit 9 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. Have you seen Exhibit 9 before? 13:45:17

A. I think I saw an image of it. 13:45:37

Q. Do you see on page two -- did you review this in connection with your declaration or somewhere else? 13:45:46 13:45:49 13:46:04

A. Certainly not in its entirety. I have seen the figure of the title page before. And saw discussions on that page, on that figure. 13:46:05 13:46:08 13:46:15

Q. Based on your opinions regarding the constructions of matrix and matrix materials would 3C and 3B in this diagram be considered matrix materials or only 3A? 13:46:20 13:46:27 13:46:38 13:46:43

MS. BAILY: Object to form. 13:46:55

THE WITNESS: Initially, I would be open. And not foreclose the possibility that 3B or 3C can be referred to as a matrix material. 13:47:12 13:47:14 13:47:26

BY MS. CARSON: 13:47:33

Q. What additional information would you need 13:47:33

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to have in order to make that determination? 13:47:35

A. The '164 patent gives a number of examples 13:47:54
of matrix materials. And these examples are given 13:48:06
just before the claims section. 13:48:26

And the collection of materials enclosed in 13:48:30
the '164 patent includes a charge-transporting 13:48:43
material. This figure, the figure of Sugiura, 13:48:53
S-U-G-I-U-R-A, includes a region labeled as region 3B 13:49:07
that is a charge-transporting material. 13:49:20

And I wouldn't want to exclude that this 13:49:26
material, 3B, can be referred to as a matrix 13:49:32
material. 13:49:38

Q. Does the figure show a continuous phase of 13:49:42
the mixture of 3A, 3B, and 3C? 13:49:48

MS. BAILY: Object to the form. 13:49:53

THE WITNESS: If these little circles 13:50:20
contain only one matrix material, then I would say 13:50:22
that this is not a matrix because it does not include 13:50:24
a continuous phase of matrix materials. But rather 13:50:29
agglomerations of materials as expressed by the 13:50:48
circle features or circular features. 13:50:54

BY MS. CARSON: 13:51:01

Q. Can a dopant be a matrix material? 13:51:01

MS. BAILY: Object to form. 13:51:07

THE WITNESS: A matrix material may be 13:51:28

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referred to as a dopant if a material or if a matrix includes multiple matrix materials. 13:51:30 13:51:36

One of the matrix materials may be referred to as a dopant. For example, a patent may include -- may disclose, a matrix containing two materials. One material is present in greater quantity. Another material is present in a smaller quantity. 13:51:48 13:51:50 13:51:58 13:52:05 13:52:08

The material in a smaller quantity may be referred to as a second matrix material or may be referred to as a dopant. 13:52:13 13:52:15 13:52:24

It is pretty much up to the choice of words made by the inventor. 13:52:26 13:52:35

BY MS. CARSON:

Q. If the dopant only forms islands in a matrix, would that be considered a matrix material? 13:52:42 13:52:46

MS. BAILY: Object to form. 13:53:09

THE WITNESS: The way I have interpreted matrix is that a matrix is a continuous phase of a mixture of matrix material. 13:53:26 13:53:31 13:53:36

So if we have a mixture of materials, it can be a matrix. But if we do not have a mixture, then I would not call it a matrix because it is not a mixture of matrix materials. 13:53:42 13:53:44 13:53:52 13:53:56

BY MS. CARSON: 13:54:04

Q. So is it fair to say that -- strike that. 13:54:04

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You opined that the term "charge carrier mobility" is indefinite in the '164 patent, correct? 13:54:42 13:54:45

A. Correct. 13:55:01

Q. Is it your position that a person of skill in the art would not know what charge carrier mobility is? 13:55:01 13:55:03 13:55:10

A. Outside the context of the '164 patent, charge carrier mobility has a meaning. But the way it is used in the claim and the way it is used in the specification is problematic. And I can be more specific if you wish. 13:55:16 13:55:20 13:55:23 13:55:30 13:55:35

Q. Outside the context of the '164 patent, what would a person of skill understand the term charge carrier mobility to refer to? 13:55:47 13:55:50 13:55:56

A. Charge carrier mobility relates the velocity of a charge carrier to the electric field that the charge carrier is subjected to. 13:56:02 13:56:07 13:56:19

If we have a certain electric field in the high mobility, we obtain a high carrier velocity. If we have a certain electric field and have a low mobility, we obtain a small carrier velocity. 13:56:25 13:56:28 13:56:33 13:56:36

Q. And in paragraph 138 of your declaration, you opine that the principal reason for why charge carrier mobility is allegedly indefinite in the context of the '164 patent is because it's highly 13:57:02 13:57:07 13:57:14 13:57:19

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dependent on surrounding environment and is not an intrinsic property of a material; is that right? 13:57:25 13:57:29

A. That is one of the reasons, yes. It is not an intrinsic property of the material. It is not an inherent property of the material. But depends on various factors. 13:57:38 13:57:40 13:57:44 13:57:48

Q. So is it your position that it's not possible to compare two materials and determine which one has a higher charge carrier mobility? 13:57:52 13:57:55 13:58:01

MS. BAILY: Object to form. 13:58:25

THE WITNESS: There are two points to my answer. 13:58:26 13:58:29

And one relates to the claim language. And to make my answer as short as possible, if we look at claim number 4, claim number 4 mentions a charge carrier mobility of the first matrix material. 13:58:30 13:58:39 13:58:46 13:58:57

The first matrix material is usually the light-emitting material and is specified as light-emitting material in claim number one. 13:59:03 13:59:10 13:59:13

And in this material, we have electrons and holes. So we would have a electron or hole mobility. 13:59:20 13:59:24

Now which one are we comparing to the other mobilities? That is an ambiguity that would make it difficult or impossible for a POSA to compare the mobilities that are specified in claim number 4 13:59:27 13:59:30 13:59:41 13:59:50

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because there are for the light-emitting layer two mobilities. 13:59:57 14:00:03

This was the first aspect. There's a second aspect. 14:00:06 14:00:11

And if you go to the specification, there's an equation. And the equation is described as that the mobility can be determined by the equation. 14:00:13 14:00:17 14:00:27

There are two problems with the equation. The first problem is a POSA could not apply -- could not use the equation to determine the mobilities that are specified in the claims. 14:00:35 14:00:37 14:00:45 14:00:50

The second problem is the equation does not give mobility. But instead it gives a frequency. So the equation that allegedly allows a POSA to determine the mobility doesn't give the mobility. It gives a frequency. And that's the second problem. 14:00:55 14:00:59 14:01:06 14:01:10 14:01:13

BY MS. CARSON: 14:01:17

Q. Is it your position that there weren't any well-known techniques at the time of the '164 invention for measuring charge carrier mobility? 14:01:17 14:01:19 14:01:27

A. Yes and no. If we take a hole transport layer, HTL, in isolation, we can measure the mobility. If we take the electron transport layer, ETL, in isolation, we can measure the mobility. 14:01:48 14:01:52 14:02:01 14:02:08

However, claim 4 requires that we compare 14:02:16

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that to the mobility of the first matrix material, the light-emitting layer. 14:02:19 14:02:29

And in the light-emitting layer, we do not have single carrier transport. We have electrons and holes that recombine. 14:02:30 14:02:34

And neither the specification nor the claims make clear which mobility of the light-emitting layer are we supposed to compare. 14:02:46 14:02:48 14:03:01

So in other words, there is no established measurement technique for measuring simultaneously the electron mobility and the hole mobility within matrix -- within the light-emitting matrix that is disclosed as the light-emitting layer. 14:03:05 14:03:08 14:03:15 14:03:25 14:03:38

To make that point more clear, I wish to refer to figure 4, which is the simulation -- figure 4 of the '164 patent, which is a simulation. 14:03:39 14:03:45 14:03:52

And there we have feature number 30, 3-0, which is the emission layer. And in this emission layers we have electrons and holes. 14:03:59 14:04:09 14:04:14

There is no technique that would allow us to measure electron and hole mobility in this emission layer. 14:04:17 14:04:19 14:04:28

Q. In paragraphs 139 to 142 of your report, you identify some things that you say could change the charge carrier mobility; is that right? 14:04:47 14:04:55 14:05:02

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Environmental factors, the presence of a dopant? 14:05:04

A. Correct. 14:05:15

Q. Did you do any testing or studies to support your opinion that the things you mentioned in these paragraphs would cause charge carrier mobility to change significantly? 14:05:15 14:05:18 14:05:21 14:05:24

MS. BAILY: Object to form. 14:05:31

THE WITNESS: I have based these statements on my experience and knowledge in the field. But I have not conducted experimental tests. 14:05:43 14:05:44 14:05:46

BY MS. CARSON: 14:05:49

Q. And did you cite any publications or third-party testing or studies to support your opinions in this paragraph? 14:05:50 14:05:55 14:06:02

A. I referred to the '164 patent itself. If you look at the quotes found at the end of paragraph 139, the '164 patent states that (as read): 14:06:23 14:06:26 14:06:39

> The mobility of electrons and holes can depend on the molecule distance and which in turn depends on the relative concentrations of the materials. And these relative concentrations play a role. 14:06:44 14:06:49 14:06:53 14:07:03 14:07:06 14:07:11

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So based on that statement, the distance can vary, the distance between the charge transporting molecules can vary. 14:07:19 14:07:23 14:07:27

And the gap between these molecules has a great influence on the mobility. And the inventors expressed this fact by the equation that is disclosed in the '164 patent. 14:07:28 14:07:37 14:07:43 14:07:55

So my support was, in part, also the '164 patent. 14:07:56 14:08:02

MS. CARSON: So move to strike as nonresponsive. 14:08:05 14:08:07

Q. Did you cite any publications or third-party testings or studies to support your opinions in paragraphs 139 to 142? 14:08:07 14:08:10 14:08:14

And by third-party publications or studies, that would exclude the patent itself. 14:08:26 14:08:31

Are you able to answer the question? 14:09:05

A. Yes. I'm able to answer the question. I don't see any, as you put it, third-party publications. I'm happy to name a third-party publication if you wish. 14:09:07 14:09:10 14:09:14 14:09:23

But I have not cited one here in these paragraphs that you asked me that look at. 14:09:25 14:09:27

Q. Did you ask Samsung whether they perform any testing of their own products to determine charge 14:09:33 14:09:40

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carrier mobility for the materials that they use in the accused devices? 14:09:46 14:09:51

A. I have not asked questions of the Samsung company. 14:10:00 14:10:08

Q. Did you ask to review any documents from Samsung regarding the testing of their products to determine the charge carrier mobility for the materials used in those products? 14:10:11 14:10:22 14:10:29 14:10:33

A. For purposes of claim construction, I have not done this because I believe that the patent itself and the trial history are relevant for claim construction and not so much what people in the field may do. 14:10:41 14:10:46 14:10:56 14:11:08 14:11:12

Q. So the answer is, no, you did not review any documents from Samsung regarding whether they're able to measure the charge carrier mobility for the materials that are used in the accused products? 14:11:12 14:11:17 14:11:21 14:11:25

A. I don't think I am in possession of such documents. 14:11:36 14:11:39

Q. Did you ask whether any such documents exist? 14:11:39 14:11:41

A. I have not inquired in this regard. 14:12:01

Q. You have also opined that claim 13, which recites a method for the production of an electronic device according to claim 1, is indefinite, correct? 14:12:03 14:12:06 14:12:09

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A. Yes. 14:12:29

Q. Do you agree that claim 13 recites a method for producing an electronic device? 14:12:30 14:12:33

A. Not entirely. It is my understanding that claim one is incorporated into claim 13. And claim one does not disclose a method. 14:12:43 14:12:45 14:12:51

Q. I'm asking about claim 13 though. So claim 13 states a method for the production of an electronic device, according to claim one. 14:12:55 14:12:59 14:13:05

So do you agree with me that the claim states on its face that it's a method for producing an electronic device? 14:13:08 14:13:11 14:13:14

A. Well, as I said before, based on my understanding, claim one is incorporated in claim 13. And claim one is not a method claim. 14:13:20 14:13:22 14:13:27

Therefore, claim 13 because it incorporates claim one, is not limited to a method claim. 14:13:32 14:13:36

Q. Do you understand that in patent law there's a difference between a method for producing or manufacturing a device and a method for using a device? 14:13:52 14:13:54 14:13:56 14:14:01

MS. BAILY: Object to form. 14:14:11

THE WITNESS: I have only limited familiarity with patent law. 14:14:11 14:14:12

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BY MS. CARSON: 14:14:15

Q. Does claim 13 recite a method for using a device? Or a method for producing a device? 14:14:15 14:14:19

MS. BAILY: Object to form. 14:14:26

THE WITNESS: My understanding is that claim 13 incorporates claim 1. Claim 1 is an apparatus claim. And claim 13 appears to be a mixed claim. 14:14:34 14:14:36 14:14:45

BY MS. CARSON: 14:15:00

Q. What's your understanding of what a mixed claim is? 14:15:00 14:15:03

A. I'm just saying that claim 13 includes method steps and also apparatus features. So is includes both. And that's what I refer to. 14:15:10 14:15:17 14:15:28

Q. Do you dispute that a person of skill in the art would be able to produce the device described in claim 1 using the steps recited in claim 13? 14:15:33 14:15:50 14:15:54

A. In my view, a person of skill would be confused by claim 13 because it has -- it discloses a method but also discloses an apparatus for -- in claim 1, it's called a device. 14:16:19 14:16:30 14:16:42 14:16:50

So claim 1 is a device claim or apparatus claim. Claim 13 discloses both: A method and then by means of incorporating claim number 1, it also includes a device or an apparatus. 14:16:53 14:17:01 14:17:12 14:17:16

Q. And when you say claim 13 discloses a 14:17:22

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method, it's a method for producing a device, correct? 14:17:45 14:17:46

A. If I read claim 13, there is a method. But it's not limited to a method because claim 1 is incorporated. 14:17:48 14:18:16 14:18:21

Q. And it's the method for producing the device, correct? 14:18:23 14:18:26

MS. BAILY: Object to form. 14:18:33

MS. CARSON: Strike that. Let me clarify. 14:18:34

The method part of claim 13 is a method for producing the device -- not for using the device, correct. 14:18:37 14:18:40 14:18:44

MS. BAILY: Object to form. 14:18:48

THE WITNESS: If we just go by the first line of claim number 13, it discloses a method for the production of an electronic device. 14:19:06 14:19:07 14:19:11

But if you look at claim 13 in its entirety, including the incorporation of claim 1, we have method, steps and device features. And it is unclear to me how they are incorporated in one claim. 14:19:16 14:19:20 14:19:27 14:19:37

MS. CARSON: All right. I'm going to move on to another patent. But let's maybe take a quick break because I need to get something to drink. 14:19:50 14:19:51 14:19:54

VIDEO OPERATOR: Counsel, do you agree to go off the record? 14:19:57 14:19:58

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MS. BAILY: I just want to note for the record before we go off that my audio dropped from around 1:08 to 1:11 p.m. Pacific Time. 14:20:01 14:20:09 14:20:12

So I had no audio at that time and then I reconnected. I'm sure it's fine. I'm just noting for the record. And I haven't gone back to look at the transcript during that time either. 14:20:16 14:20:19 14:20:24 14:20:25

But we can go off the record and take break. 14:20:27

VIDEO OPERATOR: Going off the record. The time is 4:20 p.m. 14:20:30 14:20:30

(Recess taken.)

14:32:39

VIDEO OPERATOR: Back on the record. The time is 4:33 p.m. 14:32:39 14:33:36

14:33:39

BY MS. CARSON:

Q. I want to turn to the '425 patent. And just before we get into the terms, are you aware that Pictiva has recently moved to amend to add a patent related to the '425 that recently issued, the '250 patent? 14:33:40 14:33:49 14:33:53 14:33:59 14:34:04

A. I have heard of that. But I have not seen the patent. 14:34:10 14:34:14

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Q. So you have not reviewed the '250 patent? 14:34:14
A. Correct. 14:34:17
Q. And in connection with forming your opinions for the claim construction terms for the '425 patent, did you review any of the other patents in the patent family? 14:34:21 14:34:23 14:34:29 14:34:34
A. I recall only the '425. 14:34:41
Q. So the first term you opined on for the '425 is the (as read): 14:34:52 14:34:56

> Organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation.

Is that right? 14:34:57 14:34:59 14:35:03 14:35:05 14:35:09 14:35:11 14:35:15 14:35:16
A. Correct. 14:35:27
Q. And essentially the portion of that term that you construed is, "in a spectral range from infrared radiation to UV radiation during operation," correct? 14:35:32 14:35:39 14:35:43 14:35:48
A. Yes. 14:36:04

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Q. And you have construed that to mean in a spectral range that includes the full spectrum from infrared radiation to UV operation during operation? 14:36:05 14:36:08 14:36:12

A. Yes. 14:36:36

Q. What is a spectral range? 14:36:37

MS. BAILY: Object to form. 14:36:46

THE WITNESS: A spectral range is a range of wavelengths starting at one particular wave length and ending at another particular wavelength. 14:37:02 14:37:04 14:37:08

BY MS. CARSON: 14:37:15

Q. When you say that includes the full spectrum from infrared radiation to UV radiation, what range is that referring to? 14:37:16 14:37:22 14:37:37

A. It ranges from the infrared. And the infrared is about 750 nanometer. That's where the IR, infrared or IR, range starts. 14:37:50 14:37:55 14:38:04

And it reaches to the UV range. And the UV range starts at about 400 nanometer. 14:38:12 14:38:25

And the spectral range therefore includes the visible spectrum. And the visible spectrum is in the middle between the IR, infrared, and UV, ultraviolet, spectrum. 14:38:33 14:38:42 14:38:47 14:38:59

Q. Okay, are you -- strike that. 14:39:04

So is it your position that when you say the full spectrum, does that refer to 400 nanometers to 14:39:11 14:39:14

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750 nanometers? 14:39:26

A. At least. Correct. It could reach into the UV, it could reach into the IR. But given the claim language, "from infrared to UV means" that the spectral range at least encompasses the visible spectral range. 14:39:30 14:39:32 14:39:41 14:39:49 14:39:57

Q. So would a sequence that generates electromagnetic radiation in a spectral range from 400 nanometers to 750 nanometers satisfy your construction? 14:40:08 14:40:11 14:40:17 14:40:25

MS. BAILY: Object to the form. 14:40:44

THE WITNESS: Yes. 14:40:45

BY MS. CARSON: 14:40:46

Q. And would a organic layer sequence -- strike that. 14:40:50 14:41:02

Would an organic layer sequence comprising at least one radiation emitting region configured to generate electromagnetic radiation in a spectral range from say 250 to 460 nanometers also satisfy your construction? 14:41:08 14:41:14 14:41:19 14:41:23 14:41:34

MS. BAILY: Object to form. 14:41:48

THE WITNESS: The spectral range that you mentioned does not reach to the IR, infrared, end of the spectrum. So the spectral range that you proposed is not a spectral range from the IR to the 14:41:50 14:41:52 14:41:57 14:42:02

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UV. 14:42:11
BY MS. CARSON: 14:42:12
Q. I think I misspoke, sorry. Let me try 14:42:13
again. 14:42:15
I guess what I'm trying to get at is that -- 14:42:16
so would any range that starts below 400 nanometers 14:42:19
and goes to above 750 nanometers satisfy your 14:42:35
construction? 14:42:41
MS. BAILY: Object to form. 14:42:44
THE WITNESS: Can I hear the question again? 14:42:55
BY MS. CARSON: 14:42:57
Q. Would any region that starts below 400 14:42:57
nanometers and goes to above 350 (sic) nanometers, 14:43:01
satisfy your construction? 14:43:07
MS. BAILY: Object to form. 14:43:15
THE WITNESS: I heard you said 350. Did you 14:43:16
mean 750? 14:43:18
BY MS. CARSON: 14:43:23
Q. So let's start over. Where does UV 14:43:23
radiation start? 14:43:26
A. At about 400 nanometer. 14:43:28
Q. And where does infrared start? 14:43:35
A. At about 750 nanometer. 14:43:37
Q. So would any spectral range that starts 14:43:39
below 400 and goes to above 750 satisfy your 14:43:43

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construction? 14:43:55

MS. BAILY: Object to form. 14:43:57

THE WITNESS: If the radiation emitting region emits from the two wavelengths you mentioned or between the two wavelengths you mentioned, then, yes, it would satisfy the proposed construction. 14:44:11 14:44:14 14:44:17 14:44:22

BY MS. CARSON: 14:44:40

Q. So in your construction when you refer to full spectrum, you're not referring to the full spectrum of infrared radiation, right? 14:44:40 14:44:44 14:44:51

A. Infrared radiation does not need to be included. But it needs to reach to the infrared radiation. 14:45:02 14:45:04 14:45:10

Q. So you're not saying it needs to include the full spectrum of all UVA radiation and all infrared radiation. You're just saying it has to go from some point in UVA or UV to some point in infrared? 14:45:13 14:45:16 14:45:21 14:45:26

A. Yes. At a minimum, it has to reach from the long-wavelength end of the UV spectrum to the short-wavelength end of the IR spectrum. 14:45:38 14:45:41 14:45:45

Q. And just to make sure we have a clear record, when you say long-wavelength end of the UV spectrum, what are you referring to? 14:45:52 14:45:55 14:45:59

A. I refer to 400 nanometer. 14:46:01

Q. And when you're referring to the 14:46:04

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short-wavelength end of the IR spectrum, what are you referring to? 14:46:06 14:46:11

A. I refer to 750 nanometer. Pictiva refers to a wavelength of 730 nanometers. That wavelength is equally acceptable. 14:46:12 14:46:35 14:46:44

Q. So if it went from 400 nanometers -- if it went at least from 400 nanometers to 730 nanometers, that would meet your construction? 14:46:52 14:46:56 14:47:02

A. If the emission goes from the 400 nanometer to the 730 nanometers, that would be equally acceptable. That would meet my construction. 14:47:06 14:47:11 14:47:17

And I'm just pointing out that the boundary between visible and IR is not a strict quantity. It can vary from 700 to 750 nanometer. So 750 is acceptable, 730 is acceptable. Even 700 would be acceptable. 14:47:19 14:47:21 14:47:29 14:47:37 14:47:41

Q. So what part of Pictiva's construction do you disagree with? 14:47:48 14:47:51

A. Based on my understanding, Pictiva refers to a spectral range. And it is not clear to me -- it is not clear from the proposed construction, where the radiation emitting region starts to emit. 14:48:07 14:48:23 14:48:26 14:48:46

That means at which wavelength, the light-emitting region starts to emit. And at what wavelength the light-emitting region ends to emit. 14:48:57 14:49:03 14:49:05

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Q. So is it your position that it's clearer to say a spectral range that includes the full spectrum from infrared radiation to UV radiation without specifying specific points in the spectrum than to say a spectral range from the wavelength in the infrared range, which is between about 730 nanometers to about 300 micrometers to a wavelength in the UV radiation range between about 400 nanometers to about 40 nanometers? 14:49:12 14:49:15 14:49:21 14:49:26 14:49:31 14:49:36 14:49:45 14:49:50 14:49:55

MS. BAILY: Object to form. 14:49:59

THE WITNESS: Well, I can only give you my understanding of Pictiva's construction. And it appears to me that based on Pictiva's construction, any spectral range, for example 400 nanometer to 500 nanometer. Would satisfy the claim limitation. 14:50:14 14:50:15 14:50:20 14:50:24 14:50:31

However, based on my understanding, the radiation-emitting region needs to emit electromagnetic radiation in a spectral range that reaches from IR to UV. So it needs to include the entire visible spectrum. 14:50:36 14:50:44 14:50:48 14:50:55 14:51:04

BY MS. CARSON: 14:51:10

Q. I think I understand. 14:51:10

A. It needs to include the entire visible spectrum at a minimum. It can reach into the UV. It can reach into the IR. But doesn't have to reach. 14:51:14 14:51:17 14:51:23

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It just needs to get to the boundary. So in other words, the entire visible spectrum needs to be emitted by the radiation-emitting region. 14:51:26 14:51:29 14:51:41

Q. So just by way of example, a blue light typically covers the spectral range from 380 to 500 nanometers, correct? 14:52:07 14:52:13 14:52:23

A. Approximately, yes. 14:52:24

Q. And so that would not satisfy the construction, correct? 14:52:25 14:52:27

A. Correct because it does not range from IR to UV. 14:52:32 14:52:39

Q. And, similarly, a red light, which typically covers spectral ranges starting at 620 nanometers wouldn't satisfy the construction, correct? 14:52:42 14:52:53 14:52:58

A. Correct. Only red light without any green or blue components would reach to the IR. But it would not reach to the UV. And the claim requires IR through UV. 14:53:04 14:53:06 14:53:12 14:53:20

Q. But what you're saying is that if it covers the full spectrum of visible light from 400 to 730 nanometers, that would satisfy your construction? 14:53:29 14:53:31 14:53:39

A. Yes. 14:53:47

Q. Let's turn to the '547 patent. 14:54:53

Okay, so the first term that you address is an, "organic layer sequence which emits an 14:55:24 14:55:28

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electromagnetic radiation having a first wavelength spectrum during operation." 14:55:32 14:55:37

Is that right? 14:55:48

A. Yes. 14:55:48

Q. And so I want to address the first part of the construction first. So you've interpreted an organic layer sequence to mean an active layer and electrodes; is that right? 14:55:49 14:56:01 14:56:06 14:56:11

A. Yes. 14:56:19

Q. Does the specification use the term active layer anywhere? 14:56:22 14:56:26

MS. CARSON: The '547 patent is Exhibit 11 in your Exhibit Share folder if you need to look at it. 14:56:40 14:56:43

(Exhibit 11 was marked for identification by the court reporter and is attached hereto.)

THE WITNESS: I see it as disclosing active region. 14:58:04 14:58:07

BY MS. CARSON: 14:58:12

Q. Is there a difference between an active region and an active layer? 14:58:12 14:58:16

A. Active implies that it is light-emitting. And the active layer is a layer that emits light. An active region is a region that emits light. And active layer and active region are coextensive, 14:58:29 14:58:37 14:58:47 14:58:54

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basically the same region. 14:59:06

Q. So you didn't intend active layer to mean 14:59:07
something different from active region? 14:59:10

A. If we look at the figures of the '547 14:59:22
patent, then we see that active region is region 11. 14:59:35
We also see that -- so if we go, for example, to 15:00:02
figure 1A, then 11 is the active region or 15:00:08
light-emitting region. 15:00:21

And 1 is the organic layer sequence. And 1 15:00:28
includes 10. And 10 is an electrode. 15:00:37

Q. So I'm not sure I understood the answer to 15:01:06
that question. Are you intending for active layer to 15:01:12
mean something distinction from how the patent refers 15:01:15
to active region? 15:01:19

A. No. I think they are pretty much the same 15:01:33
thing. It is a layer. It is also a region. And the 15:01:34
active region emits light, the active layer emits 15:01:37
light. Typically the OLEDs have layers. 15:01:43

Q. You agree that an organic layer sequence 15:02:01
could refer to multiple layers, correct? 15:02:06

MS. BAILY: Object to form. 15:02:15

THE WITNESS: Yes. 15:02:18

BY MS. CARSON: 15:02:21

Q. Under your construction, you're converting 15:02:27
the term organic layer sequence to an active layer 15:02:30

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and electrodes. 15:02:37

Are you intending to limit the claim to a single layer? 15:02:42 15:02:46

MS. BAILY: Object to form. 15:02:52

THE WITNESS: No. 15:03:07

BY MS. CARSON: 15:03:07

Q. Okay. 15:03:07

A. I'm just going by the terminology used in the '547 patent. 15:03:24 15:03:28

Q. Going back to this figure that we were looking at, figure 1, I think you mentioned that 10 is an electrode? 15:03:36 15:03:38 15:03:43

A. Correct. 15:03:49

Q. And in column 10, lines 5 to 6, it describes 10 as an electrode. Not electrodes plural, correct? 15:03:50 15:04:06

A. Correct. Ten is an electrode. 15:04:16

Q. So in figures 1A and 1B, the organic layer sequence does not include both anodes and cathodes, correct? It just includes an electrode? 15:04:19 15:04:22 15:04:28

A. Can I hear the question again? 15:04:35

Q. In column 10, lines 5 to 6, it describes 10 as an electrode, not electrodes plural? 15:04:42 15:04:53

A. Correct. 15:05:00

Q. So the organic layer sequence shown in figures 1A and 1B does not necessarily include both 15:05:00 15:05:04

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anodes and cathodes, correct? 15:05:11

MS. BAILY: Object to form. 15:05:15

THE WITNESS: Only one electrode is shown in figure 1A and figure 1B. But it would be understood that they are two electrodes. 15:05:39 15:05:41 15:05:54

One can be referred to as anode. And the other one can be referred to as cathode. 15:06:00 15:06:04

BY MS. CARSON: 15:06:10

Q. But the description of this organic layer sequence that's depicted in 1A and 1B just refers to a single electrode, correct? 15:06:10 15:06:12 15:06:16

A. Only a single electrode is shown in these images. But it would be understood that an OLED has two electrodes. 15:06:27 15:06:30 15:06:40

Q. All right. When a person of skill in the arts read columns 10, lines 5 to 6, you're saying -- it's your opinion they would understand an electrode 10 to refer to two electrodes? 15:06:42 15:06:46 15:06:52 15:07:00

MS. BAILY: Object to form. 15:07:06

THE WITNESS: No. Not necessarily. I'm just saying that if you look at the pictorial disclosure of figure 1A, we have element 1. 15:07:08 15:07:10 15:07:17

And element 1 includes electrodes 10. And based on the pictorial disclosure, the organic layer sequence 1 includes electrode 10. 15:07:23 15:07:35 15:07:39

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BY MS. CARSON: 15:07:50

Q. Your proposed construction requires electrodes plural, correct? To be in the active layer? 15:07:50 15:07:54 15:07:58

A. Correct. 15:08:02

Q. And actually strike that. 15:08:03

Your construction requires that the organic layer sequence has multiple electrodes, correct? 15:08:05 15:08:10

A. That would be understood that there are two electrodes, one referred to as anode. And the other one referred to as cathode. 15:08:23 15:08:28 15:08:32

Q. So your proposed construction would exclude the embodiment described in column 10 where there's an optoelectronic device that has an organic layer sequence 1 and an electrode, singular, in an active region, correct? 15:08:39 15:08:42 15:08:45 15:08:50 15:08:55

MS. BAILY: Object to form. 15:09:18

THE WITNESS: I'm not sure if I follow you. 15:09:19

Any OLED will have two electrodes. And the embodiment that is described here in column 10 also has two electrodes. 15:09:21 15:09:26 15:09:29

And I don't see that embodiments being excluded by the claim construction that I propose. 15:09:37 15:09:41

BY MS. CARSON: 15:09:51

Q. Are you disputing that it describes the 15:09:51

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embodiment as the device that has an organic layer sequence 1 and an electrode 10 and an active region 11? 15:09:53 15:09:57 15:10:14

MS. BAILY: Object to form. 15:10:14

THE WITNESS: I think that description is fine. However, it is understood that there are two electrodes. And I have not come across an OLED with only one electrode. There is always without exception an anode and a cathode that is associated with a OLED. 15:10:18 15:10:19 15:10:19 15:10:26 15:10:30 15:10:36 15:10:41

BY MS. CARSON: 15:10:50

Q. I'm not asking about an OLED, though. I'm asking about the claim and the patent, right? So the patent discloses an organic layer sequence which emits a electromagnetic radiation having a first wavelength spectrum during operation. 15:10:50 15:10:52 15:10:57 15:11:00 15:11:03

And you proposed to construe an organic layer sequence as an active layer and electrodes. And I guess I'm just here in column 10 of the patent, it's describing an embodiment where it has an organic layer sequence and an electrode, singular, right? 15:11:05 15:11:08 15:11:15 15:11:20 15:11:25

A. Correct, my -- 15:11:34

Q. And that would be excluded from your construction unless we added another electrode that 15:11:37 15:11:39

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is not referenced in this paragraph or shown on the figure. 15:11:44 15:11:48

MS. BAILY: Object to form. 15:11:53

THE WITNESS: No. That's not how I see it. 15:11:55

I see it in the following way. If we look at figure 1A, we see that the electrode 10 is part of the organic layer sequence 1. 15:12:00 15:12:02 15:12:11

So numeral one is the organic layer sequence. And based on figure 1A, electrodes 10 is included in the organic layered sequence. 15:12:17 15:12:20 15:12:28

Now, the other electrode, which I say must exist, is not shown in figure 1A. However, trying to be fair, if the '547 patent includes one electrode, number 10, feature number 10, in the organic layer sequence, feature number 1, then the undoubtedly existing second electrode in the spirit of fairness could also be included in the organic layer sequence. 15:12:33 15:12:36 15:12:49 15:13:02 15:13:08 15:13:15 15:13:22

BY MS. CARSON:

Q. And -- 15:13:29

(Speaking simultaneously.) 15:13:29

A. -- found in my proposed construction. 15:13:29

Q. Could it also be included somewhere else besides this organic layer sequence? 15:13:32 15:13:35

MS. BAILY: Object to form. 15:13:53

THE WITNESS: I think the most reasonable 15:14:17

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thing, the natural thing for a POSITA would do, is come to the conclusion that the second electrode is not shown, but it does exist. 15:14:21 15:14:28 15:14:37

And following the annotation or better following the content of figure 1A, the electrode shown is part of the organic layer sequence. 15:14:43 15:14:54 15:15:05

And the electrode not shown naturally would also be part of the organic layer sequence. 15:15:08 15:15:13

BY MS. CARSON: 15:15:20

Q. But you haven't identified any portion of the patent that says that second electrode must be part of the organic layer sequence, correct? 15:15:20 15:15:24 15:15:28

A. Well, without reading the '547 patent, I can say that the spirit and the wording of the '547 patent conveys that there are two electrodes -- 15:15:57 15:16:00 15:16:06

Q. In paragraph 75, the portion -- 15:16:13

MS. BAILY: He wasn't done with his answer. 15:16:16

BY MS. CARSON: 15:16:25

Q. The portion of the specification that you quote in paragraph 75 to support your proposed construction, refers to an electrode, not electrodes, correct? 15:16:25 15:16:26 15:16:31 15:16:38

A. Yes. But other parts of the '547 patent certainly make clear that there are two electrodes. 15:17:05 15:17:08

Q. You didn't quote any other portions of the 15:17:34

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specification referring to electrodes in paragraph 75 or 76, correct? 15:17:39 15:17:46

A. I have no specific citation. But I maintain my view that a person of skill would not exclude that there are two electrodes. And an embodiment with a single electrode does not exist. 15:18:50 15:18:56 15:19:05 15:19:11

Q. Except for the one in column 10, where it describes the figure as including an electrode in the organic layer sequence, correct? 15:19:15 15:19:20 15:19:23

MS. BAILY: Object to form. 15:19:26

THE WITNESS: No. I would say that a person of skill would understand that the OLED has two electrodes. That's pretty much an inherent feature that an OLED has a cathode and an anode. 15:19:31 15:19:32 15:19:35 15:19:46

To envision a single-electrode OLED, would not function, would not work. The electrical current flows into the device by means of the anode. And the electrical current flows out of the device by means of the cathode. 15:19:49 15:19:53 15:20:08 15:20:14 15:20:18

And for that reason, we need both anode and cathode. 15:20:22 15:20:25

BY MS. CARSON: 15:20:26

Q. And it's your position that there's no way to design an OLED device where one of the electrodes is not part of the organic layer sequence? 15:20:26 15:20:28 15:20:36

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MS. BAILY: Object to form. 15:21:02

THE WITNESS: One could limit the meaning of organic layer sequence to just organic materials. 15:21:03 15:21:08

However, figure 1A discloses that an electrode is part of the organic layer sequence. So the way the '547 patent describes the features of the OLED, the electrode, which is not -- which typically is not an organic material but rather a metal or a conductive transparent oxide is part of the organic layer sequence. 15:21:19 15:21:27 15:21:39 15:21:55 15:22:08 15:22:19 15:22:27

That is the choice that the inventors made. And I'm just following what the inventors have disclosed. 15:22:29 15:22:33 15:22:42

BY MS. CARSON:

Q. So a couple followups. So just to be clear, you're saying that in order to have an OLED device, you have to have an active layer with two electrodes, all OLED devices have that structure. 15:22:44 15:22:46 15:22:51 15:23:00

Is that what you're saying? 15:23:02

A. Yes. An OLED device has to have two electrodes, an anode and a cathode. 15:23:08 15:23:10

Q. So any OLED device would satisfy this claim element because you're saying inherently OLED devices have to have an active layer with two electrodes? 15:23:13 15:23:17 15:23:21

MS. BAILY: Object to form. 15:23:27

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THE WITNESS: No. That's not really what I'm saying. I mean there is additional features or requirements in the proposed construction. 15:23:32 15:23:34 15:23:41

BY MS. CARSON: 15:23:47

Q. Can you take a look at column 4, line 46 through 54. Here it's describing (as read): 15:23:48 15:23:58

> An embodiment where the first electrode can be arranged on a substrate. The organic layer or the layer sequence comprising one or more functional layers composed of organic materials can be applied over the first electrode. 15:24:03 15:24:06 15:24:10 15:24:15 15:24:16 15:24:18 15:24:21

Do you see that? 15:24:23

A. Yes. 15:24:27

Q. So is it your position that that is disclosing an embodiment where the first electrode is part of the organic layer sequence? 15:24:28 15:24:30 15:24:34

MS. BAILY: Object to form. 15:24:53

THE WITNESS: The pictorial disclosure of figure 1A shows an electrode being part of the organic layer sequence. 15:24:53 15:24:59 15:25:08

And if we apply that disclosure consistently 15:25:10

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across the patent, if we are consistent with this disclosure, if we follow what the inventors are teaching us, if we use the guidance of the '547 patent, then we would say in the figure 1A example, the electrodes is part of the organic layer sequence. 15:25:14 15:25:24 15:25:33 15:25:46 15:25:53

And if we follow that teaching throughout the patent, then we would come to the conclusion that the electrodes are part of the organic layer sequence. 15:26:03 15:26:08 15:26:12 15:26:21

BY MS. CARSON:

Q. Is it your understanding, sir, that the patent claims are limited to -- strike that. 15:26:21 15:26:28

Is it your understanding that that's shown in a figure that describes one embodiment limits the claims? 15:26:31 15:26:33 15:26:37

A. No. 15:26:45

Q. And in this column 4, this section I just referred you to, it discusses having an organic layer sequence that is applied over the first electrode, correct? 15:26:45 15:26:47 15:26:52 15:26:58

A. Correct. 15:27:01

Q. And if you apply a layer over the first electrode, that electrode is not part of the layer, correct? 15:27:02 15:27:05 15:27:11

A. One would think so. But look at figure 1A, 15:27:11

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there the disclosure, the information conveyed is different so -- 15:27:23 15:27:27

Q. I'm not talking about figure 1 or the embodiment described in figure 1. I'm talking about the embodiment that's described in column 4. 15:27:32 15:27:33 15:27:36

And in column 4, it describes an embodiment where you have a first electrode. And then you have organic layer sequence that's applied over the first electrode. 15:27:38 15:27:42 15:27:48 15:27:51

And then you have functional layers, which can comprise the active region that connect. And then the second electrode is applied over the functional layers. Or over the at least one organic layer. 15:27:52 15:27:56 15:28:04 15:28:06 15:28:13

So in that embodiment that's described in column 4, are you saying that one of skill in the art would understand that when the inventor said you apply the organic layer sequence over the electrode, that what they really meant was that the organic layer sequence included the electrode? 15:28:13 15:28:16 15:28:20 15:28:24 15:28:31 15:28:32

MS. BAILY: Object to form. 15:28:40

THE WITNESS: I follow your reasoning. I fully follow your reasoning. However, we need to be consistent. 15:28:41 15:28:42 15:28:47

Either the electrodes are part of the 15:28:50

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organic layer sequence or they're not. And either way is fine with me. 15:28:53 15:28:58

However, we want to be consistent. And being inconsistent here, having a different disclosure here and there is not satisfying. 15:29:00 15:29:04 15:29:09

So the problem is to some extent, the inconsistency that we find in the '547 patent. 15:29:12 15:29:17

And by the construction that I have chosen, I have tried to overcome the inconsistency that is described in the '547 patent. And that you are pointing out. 15:29:23 15:29:29 15:29:33 15:29:37

Basically what you're doing is you point out look here, in this description, the electrode is not part of the organic layer sequence. But in that description, the electrode is part of the organic layer sequence. 15:29:40 15:29:42 15:29:46 15:29:52 15:29:56

And so I cannot change the inconsistent disclosure of the '547 patent in this regard. 15:29:58 15:30:09

And it's not a -- in my view, it's more like an naming, a nomenclature issue. It's not a fundamental issue. 15:30:12 15:30:16 15:30:23

I'm just saying there are different disclosures in the '547 patent. And I have followed a certain disclosure that is made in the '547 patent. 15:30:29 15:30:31 15:30:33

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BY MS. CARSON: 15:30:38

Q. And do you understand that it is a common canon of claim construction that the claims should be interpreted to encompass all of the embodiments disclosed in the patent specification? 15:30:38 15:30:43 15:30:46 15:30:54

MS. BAILY: Object to form. 15:30:59

THE WITNESS: Correct. And my construction does not exclude any embodiment based on the facts. Or based on the contention that there would be an LED -- there would OLED having only one electrode because such OLED does not exist. 15:31:00 15:31:02 15:31:06 15:31:10 15:31:17

BY MS. CARSON: 15:31:24

Q. But your construction would exclude a situation where the electrodes are not included in the organic layer sequence and are instead included either below or above the organic layer sequence as described in the embodiment that we were just looking at from column 4, right? 15:31:31 15:31:34 15:31:36 15:31:42 15:31:47 15:31:52

MS. BAILY: Object to form. 15:32:11

THE WITNESS: I would not see an exclusion based on that. 15:32:28 15:32:29

BY MS. CARSON: 15:32:32

Q. So it's your opinion that the portion of your construction that refers to an organic layer sequence being an active layers and electrodes would 15:32:32 15:32:39 15:32:45

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not exclude a situation where the electrodes were not part of the organic layer sequence. And were instead positioned below and above the organic layer sequence as well as perhaps a functional layer if it's included? 15:32:50 15:32:57 15:33:06 15:33:15 15:33:19

MS. BAILY: Object to form. 15:33:27

THE WITNESS: My view is that any prior art product -- that any prior art device or any accused device will have a light-emitting active layer and will also have electrodes. 15:33:27 15:33:31 15:33:39 15:33:49

So the feature or the features that I mentioned in my construction, active layer and electrodes, you will find in all prior art devices and you will find in all accused devices. 15:33:51 15:33:54 15:33:59 15:34:05

Therefore, I don't see the exclusion that you're mentioning. 15:34:09 15:34:14

BY MS. CARSON: 15:34:19

Q. So is it not actually your position that an organic layer sequence requires an active layer and electrodes to be -- 15:34:20 15:34:23 15:34:30

A. Sorry. 15:34:35

MS. BAILY: Could you ask the question again? 15:34:42 15:34:46

MS. CARSON: Sure. 15:34:46

Q. I'm just describing to figure out when you 15:34:47

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construe an organic layer sequence to mean an active layer and electrodes, are you taking the position that the electrodes have to be part of the active layer? 15:34:49 15:34:52 15:34:57 15:35:01

A. Some publications will say so. Some other publications will not say so. 15:35:08 15:35:10

Q. I'm asking what you're saying. It's your construction. 15:35:12 15:35:15

MS. BAILY: Object to form. 15:35:25

THE WITNESS: Based on the description of the '547 patent that there are two electrodes and based on the pictorial disclosure of figure 1A, which includes electrodes 10 as part of the organic layer sequence, I have followed the teachings of the '547 patent. And interpreted the organic layer sequence as the active layer and the electrodes. 15:35:27 15:35:29 15:35:32 15:35:39 15:35:47 15:35:56 15:35:59

But there is no exclusion that would be based on these terms because every OLED in the prior art and every accused device will have an active layer and will have two electrodes. 15:36:02 15:36:08 15:36:16 15:36:23

BY MS. CARSON: 15:36:29

Q. Okay. So you're not saying the electrodes have to be part of or in the same layer as the active layer. 15:36:29 15:36:32 15:36:39

A. The active layer typically is between the 15:36:43

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two electrodes. 15:36:46

Q. And a system that had additional layers between the two electrodes would not be excluded by your construction? 15:36:47 15:36:51 15:36:56

A. Correct. If there is like a hole transport layer or an electron transport layer, those layers may be present as well. 15:36:57 15:37:01 15:37:09

Q. The other part of your construction is that you've construed would emit an electromagnetic radiation having a first wavelength spectrum during operation to mean a wavelength spectrum which corresponds to the entire wavelength spectrum of the electromagnetic radiation emitted by the organic layer sequence during operation; is that right? 15:37:15 15:37:20 15:37:24 15:37:27 15:37:41 15:37:45 15:37:47

A. Correct. 15:37:55

15:38:12

Q. And I think we went over this with an earlier patent. But what is the wavelength spectrum? 15:38:12 15:38:13

A. The wavelength spectrum starts at a starting wavelength and ends at a ending wavelength. 15:38:20 15:38:25

And if we look at the claim of the '547 patent -- if we look at claim one of the '547 patent, you can see that a first wavelength spectrum is disclosed, for example, in column 14, line 57. 15:38:32 15:38:45 15:38:57 15:39:01

And then if you go further down in claim 15:39:15

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one. If you go to column 15, line number 4, you see what is being disclosed here is one part of the second wavelength spectrum. 15:39:20 15:39:38 15:39:46

So the claims disclose part of a wavelength spectrum. And they disclose the wavelength spectrum. 15:39:50 15:39:59

And so when we say part of, we mean a part of. And if we say, the spectrum, we mean not part of the spectrum but the full spectrum. That is my reasoning. 15:40:07 15:40:14 15:40:23 15:40:28

We have a clear disclosure of the spectrum. And the part of the spectrum. And so part of the spectrum is a fraction of the spectrum. And the spectrum naturally is the whole spectrum or the entire spectrum. 15:40:30 15:40:34 15:40:39 15:40:44 15:40:50

Q. In your opinion, what is the difference between "in as unimpeded manner as possible" and "substantially without alteration of its spectral components" in the parties competing constructions of transparent? 15:41:11 15:41:16 15:41:24 15:41:29 15:41:33

MS. BAILY: Object to form. 15:41:41

THE WITNESS: In an "as unimpeded manner as possible" means to me there is no intention of impeding. 15:42:02 15:42:04

We design the optical structure in such a way that the light is getting through -- we transmit 15:42:11 15:42:14

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the light. 15:42:19

But even a window pane, a window glass pane, 15:42:21
modifies the intensity by a small amount. 15:42:42

And so we design a window to be transparent. 15:42:49
The light is going through the window in as an 15:42:54
unimpeded manner as possible. 15:43:01

And the same principle holds here. That is 15:43:03
we have a (inaudible) layer that is a transparent. 15:43:08
And if it's transparent, it will let the light go 15:43:18
through, it will let the light pass through. 15:43:24

And we intend it to go fully through. But 15:43:34
sometimes practical circumstances have some 15:43:41
limitations. 15:43:50

BY MS. CARSON: 15:43:53

Q. So to evaluate whether a particular device 15:43:53
or a particular component satisfied your construction 15:43:56
of "in as an unimpeded manner as possible," would you 15:44:02
have to look at the intent of those who designed it? 15:44:08

A. No. 15:44:12

MS. BAILY: Object to form. 15:44:12

BY MS. CARSON: 15:44:17

Q. No? Are you able to identify any objective 15:44:17
criteria sitting here today that a person of skill in 15:44:20
the art could use to determine if something is "in as 15:44:25
unimpeded manner as possible. " 15:44:29

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A. I can give you examples. For example, a window glass pane is transparent. The glasses of eyeglasses are transparent. I can give you more examples. 15:44:33 15:44:37 15:44:48 15:45:00

MS. CARSON: Let's take a break. 15:45:01

VIDEO OPERATOR: Counsel, do you agree to go off the record? 15:45:07 15:45:14

MS. BAILY: Yes. 15:45:14

VIDEO OPERATOR: Going off the record. The time is 5:45 p.m. 15:45:16 15:45:17

15:59:26

(Recess taken.)

15:59:29

VIDEO OPERATOR: Back on the record. The time is 5:59 p.m. 15:59:32 15:59:33

BY MS. CARSON: 15:59:36

Q. All right. I want to turn to the '492 patent. 15:59:36 15:59:43

And you've provided constructions for optoelectronic component and passive electric component, correct? 15:59:48 15:59:55 15:59:57

A. Yes. 16:00:15

Q. Are the proposed constructions that you 16:00:16

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provided for those terms what you would consider to be the plain-and-ordinary meaning? 16:00:17 16:00:23

MS. BAILY: Object to form. 16:00:31

THE WITNESS: I would say they are the plain-and-ordinary meaning in the context of the '492 patent. 16:00:42 16:00:59 16:01:10

BY MS. CARSON: 16:01:14

Q. Your proposed construction for optoelectronic component would exclude an electronic component that sensed or detected electromagnetic radiation if it didn't convert that energy, correct? 16:01:16 16:01:20 16:01:28 16:01:31

MS. BAILY: Object to form. 16:01:42

THE WITNESS: No. A detector receives optical energy and converts it into electrical energy. So a photo detector would be included in that construction. 16:01:49 16:01:51 16:01:59 16:02:04

Similarly, a sensor which senses optical energy -- senses it by converting it into electrical energy. And the electrical energy is then provided to some sensing instrument. 16:02:05 16:02:13 16:02:19 16:02:24

But I would say that detectors and sensors are included in this construction. 16:02:27 16:02:32

BY MS. CARSON: 16:02:51

Q. Is it your opinion that optoelectronic components and passive components are mutually 16:02:51 16:02:56

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exclusive within the context of the patent? 16:02:58
A. Yes. 16:03:41
Q. Within the context of the patent, would you consider a photo resistor to be a passive component or an optoelectronic component? 16:03:41 16:03:43 16:03:47
MS. BAILY: Object to form. 16:04:10
THE WITNESS: A photo resistor would receive optical energy that would modify electrical energy or that that would be converted into electrical energy. And therefore a photo resistor in my opinion would be an optoelectronic component. 16:04:11 16:04:14 16:04:27 16:04:35 16:04:39
BY MS. CARSON: 16:04:44
Q. Outside the context of this patent, are photo resisters typically considered passive electronic components? 16:04:44 16:04:46 16:04:52
MS. BAILY: Object to form. 16:04:54
THE WITNESS: I've not looked into this question. Photo resistor didn't come up. But if a component is used to detect optical energy and converts this optical energy into some kind of electrical energy, I would consider it to be an optoelectronic component. 16:05:03 16:05:07 16:05:14 16:05:21 16:05:25 16:05:30
BY MS. CARSON: 16:05:34
Q. What if it only detects optical energy but doesn't convert it? 16:05:34 16:05:38

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MS. BAILY: Object to form. 16:05:40

THE WITNESS: I do not understand what kind of device you are envisioning. 16:05:50 16:05:53

BY MS. CARSON: 16:06:03

Q. Are you testifying that all photo resisters convert energy? 16:06:03 16:06:06

A. Based on my understanding, photo resisters receive optical energy. And their resistance changes when being illuminated. 16:06:14 16:06:18 16:06:34

And this change in resistance leads to a current flow or to a change in current flow. And this change in current flow can be further used to sense or to detect an optical signal. 16:06:37 16:06:44 16:06:52 16:07:00

Q. Your construction of passive electronic component refers to the examples of the capacitor or a resistor, correct? 16:07:19 16:07:23 16:07:29

A. Correct. 16:07:32

Q. There are other types of passive electronic components other than capacitors and resistors, correct? 16:07:35 16:07:38 16:07:42

A. Yes. For example an inductor. But inductors are relatively rare. 16:07:46 16:07:49

Q. Is it your position that a component that absorbs electromagnetic radiation would be an optoelectronic component or a passive component? 16:08:17 16:08:20 16:08:29

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A. Well, just absorbing is not enough. Anything -- any object will absorb some electromagnetic radiation. 16:08:39 16:08:42 16:08:47

And it needs to convert it to an electrical signal. So if you have an optical stimulus, an optical signal or optical energy, that optical signal is impinging on the device. 16:08:51 16:08:56 16:09:05 16:09:14

And as a result of the detection process, we obtain an electrical signal. 16:09:23 16:09:26

Q. All right. Your response was "just absorbing is not enough." 16:09:30 16:09:36

Did you mean a component that just absorbs electromagnetic radiation would not be considered an optoelectronic component? Or what are you referring to? 16:09:38 16:09:41 16:09:46 16:09:48

A. I'm referring to the fact that the optical energy needs to be converted into electrical energy. We could say light needs to be converted to a current. Or light causes a current. Or we could say a change of the light intensity causes a change in the current flow. 16:09:52 16:09:54 16:10:00 16:10:08 16:10:16 16:10:22

So we have like electrical current, we have electrical voltage, those are the electrical signals. And we can generally talk about these electrical signals as electrical energy. 16:10:29 16:10:33 16:10:37 16:10:39

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Q. So not quite my question. My question is just really simple. It's would you consider a component that only absorbs electromagnetic radiation to be an optoelectronic component within the context of the patent? 16:10:45 16:10:47 16:10:50 16:10:57 16:11:01

A. I would need to have some more information. Would that component that you're envisioning, would that have any electrical signal that would change based on the optical signal? 16:11:04 16:11:06 16:11:09 16:11:18

Would it work as a detector? Would it sense if light is absorbed by some means? Would the electrical signal, the output signal, would that change in any way if light is being absorbed? 16:11:26 16:11:29 16:11:33 16:11:36

That is the information that I would need. 16:11:40

Q. So under your proposed construction, you'd need more information than just that a component absorbs electromagnetic radiation to determine whether it was an optoelectronic component or a passive electronic component? 16:11:43 16:11:49 16:11:53 16:11:56 16:11:59

A. If that component converts optical energy to electrical energy, it's an optoelectronic component. And that's the information I would need to know. I can envision both possibilities. 16:12:08 16:12:14 16:12:21 16:12:36

Q. In your proposed -- or in Samsung's proposed construction for passive electronic component, 16:12:40 16:12:50

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there's a note in the box, "phrase is limiting to the extent it's a preamble." 16:12:55 16:12:57

And I just want to confirm you didn't provide any opinions in that section of your report from paragraph 161 to 167 to support or evidence that the preambles of claim 1 and 16 are limiting, correct? 16:13:00 16:13:07 16:13:09 16:13:20 16:13:28

A. I think that's a fair statement, correct. 16:13:28

MS. CARSON: Introduce an exhibit. 16:14:22

(Exhibit 12 was marked for identification by the court reporter and is attached hereto.)

BY MS. CARSON:

Q. Let me know when you've had a chance to pull it up. And if you could direct your attention to claim 10. 16:14:23 16:14:26 16:14:43

Are you there? 16:15:07

A. Not yet. Yes, I am there. 16:15:25

Q. So claim 10 recites a method for producing an optoelectronic assembly, correct? 16:15:28 16:15:33

A. Correct. 16:15:41

Q. And an optoelectronic assembly can have both passive components and optoelectronic components, correct? 16:15:41 16:15:44 16:15:50

A. Correct. 16:15:53

Q. And so the first step is forming a passive 16:15:54

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electronic component, correct? 16:15:59

A. Yes. 16:16:15

Q. And part of forming that passive electronic component is that the passive electronic component comprises a second electronically conductive layer on the first electronically conductive layer, correct? 16:16:16 16:16:18 16:16:27 16:16:31

A. Yes. 16:16:40

Q. And if you look further down in the claim, the second layer demarcates a component region performing an optoelectronic component, correct? 16:16:40 16:16:44 16:16:47

A. Yes. 16:17:15

Q. And that component region is part of the passive electronic component? 16:17:16 16:17:18

A. Say that again, please. 16:17:40

Q. The component region is part of the passive electronic component? 16:17:41 16:17:47

Do you see the limitation that says, "applying the dielectric in a structured fashion to the second layer such that dielectric demarcates a component region." 16:18:22 16:18:22 16:18:25 16:18:30

A. Yes. I see that. 16:18:36

Q. And the second layer that they're referring to where you would demarcate the component region is part of the passive electronic component, correct? 16:18:37 16:18:39 16:18:43

A. No. 16:18:54

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Q. Above it says, "the passive electronic component comprising a second electronically conductive layer." 16:18:55 16:18:57 16:19:01

Do you see that? 16:19:02

A. Yes. 16:19:19

Q. Are you saying that in the later element where it refers to the second layer, it's not referring back to a second electronically conductive layer? 16:19:20 16:19:22 16:19:25 16:19:30

A. Can you please repeat your question? 16:19:34

Q. When it says the second layer in the element that starts, "applying the dielectric in a structured fashion," that's referring to the second layer that's described as being part of the passive electronic component above, correct? 16:19:40 16:19:44 16:19:47 16:19:52 16:19:56

A. I do not agree with your characterization. And let me explain why. 16:20:14 16:20:16

If you go to the '492 patent, and if we look at figure 16, figure 16 is the embodiment that is being described in claim 10. 16:20:19 16:20:35 16:20:47

And you see that the dielectric layer 28 is applied in multiple regions. 28 is applied in the capacitor region on the left-hand side. 16:20:57 16:21:14 16:21:21

And 28 is also applied in the optoelectronic component region, which is shown as a diode on the 16:21:29 16:21:34

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right-hand side. 16:21:39

And we see that the passive component, the 16:21:42

capacitor, on the left-hand side is clearly separated 16:21:46

and not part of the optoelectronic component, which 16:21:55

is shown on the right-hand side of figure 16. 16:22:02

Q. Do you dispute that an OLED layer is an 16:22:30

optoelectronic component? 16:22:33

A. No. An OLED is an optoelectronic component. 16:22:40

Q. You've opined that plurality of capacitors 16:22:45

and or resisters in claim 6 is indefinite, correct? 16:22:54

A. Correct. 16:23:11

Q. And your reasoning is that neither claim 1 16:23:12

nor claim 2 recites a resistor? 16:23:20

A. Correct. 16:23:32

Q. The preamble of claim 1 is a method for 16:23:33

producing a passive electronic component, correct? 16:23:40

A. Correct. 16:23:50

Q. And you've proposed that passive electronic 16:23:50

component should be construed to mean an electronic 16:23:53

component such as a capacitor or resistor? 16:24:00

A. Correct. 16:24:09

Q. So under your construction, claim 1 would be 16:24:09

describing a method for producing a passive 16:24:12

electronic component, which could include a capacitor 16:24:16

or resistor, correct? 16:24:19

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A. No. In claim 1 what is being described is a capacitor. And claim 1 would also -- based on your interpretation, would also include an inductor because an inductor is a passive electronic component as well. 16:24:26 16:24:36 16:24:48 16:24:51 16:24:55

But neither an inductor nor a resistor are described or taught in claim 1. And for that reason, I have come to the conclusion that a capacitor is being disclosed. 16:24:59 16:25:03 16:25:09 16:25:18

A person of skill reading claim 1 would understand that based on the layer sequence and based on the structure, a capacitor is disclosed. And not a resistor and not an inductor. 16:25:22 16:25:25 16:25:28 16:25:32

Q. So despite your construction of passive electronic component encompassing both capacitors and resistors, you're saying that it's your belief that claim 1 is limited to disclosing a capacitor? 16:25:42 16:25:48 16:25:52 16:25:57

A. What is being detailed after the preamble is the capacitor. And is not a resistor. 16:26:07 16:26:10

What is detailed after the preamble is not an inductor. What is detailed is a capacitor. And based on that, there is neither a resistor nor an inductor described in claim 1. 16:26:15 16:26:20 16:26:30 16:26:37

Q. So does the term passive electronic component in the preamble of claim 1 describe the 16:26:48 16:26:55

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invention? 16:27:06

MS. BAILY: Object to form. 16:27:16

MS. CARSON: Actually strike that. 16:27:22

Q. Does the term passive electronic component in the preamble of claim 1 impact the scope of the claim at all in view of your opinion that the steps limit it to a capacitor? 16:27:23 16:27:27 16:27:33 16:27:38

MS. BAILY: Object to form. 16:27:44

THE WITNESS: Yes. I believe that the preamble excludes optoelectronic components for what is being described in claim 1. 16:27:51 16:27:53 16:28:06

BY MS. CARSON: 16:28:11

Q. All right, I have no further questions. You're a mute. Or we can't hear you. 16:28:23 16:28:31

MS. BAILY: I was thinking out loud. I don't think there was any confidential information discussed. 16:28:37 16:28:39 16:28:43

I'm going to preliminarily designate the transcript. And I should be able to withdraw it tomorrow. I just want to make sure there's that confidential information in the transcript. 16:28:47 16:28:49 16:28:52 16:28:54

MS. CARSON: I'm pretty sure I didn't introduce anything so yeah -- 16:28:56 16:28:57

MS. BAILY: I'm 99 percent sure. I'll just check. And then I should be able to withdraw it in 16:29:02 16:29:05

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its entirety. 16:29:08

MS. CARSON: Okay. 16:29:09

MS. BAILY: That's it. 16:29:11

MS. CARSON: So we can go off the record. 16:29:13

VIDEO OPERATOR: This completes today's deposition. We are going off the record. The time is 6:29. 16:29:16 16:29:17 16:29:20

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I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed on _____, 2024, at

_____, _____.

_____

SIGNATURE OF WITNESS

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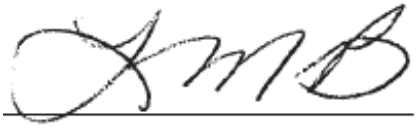
STATE OF CALIFORNIA) ss.
COUNTY OF LOS ANGELES)

I, Lori M. Barkley, CSR No. 6426, do hereby certify:

That the foregoing deposition proceedings were taken before me at the time and place therein set forth and were recorded stenographically by me, and were thereafter transcribed under my direction and supervision, and that the foregoing pages contain a full, true and accurate record of all proceedings and testimony to the best of my skill and ability.

I further certify that I am neither counsel for any party to said action, nor am I related to any party to said action, nor am I in any way interested in the outcome thereof.

IN WITNESS WHEREOF, I have subscribed my name this 18th day of December, 2024.



LORI M. BARKLEY, CSR No. 6426

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REBECCA CARSON, ESQ.

Rcarson@irell.com

December 18, 2024

RE: Pictiva Displays International LTD v.
Samsung Electronics Co. LTD
12/11/2024, Fred Schubert, Volume I, (# 7058037).
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.

__ Signature Waived - Reading & Signature was waived at the time of the deposition.

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__ Federal R&S Requested (FRCP 30(e)(1)(B)) - Locked .PDF Transcript - The witness should review the transcript and make any necessary corrections on the errata pages included below, notating the page and line number of the corrections. The witness should then sign and date the errata and penalty of perjury pages and return the completed pages to all appearing counsel within the period of time determined at the deposition or provided by the Federal Rules.

_X_Federal R&S Not Requested - Reading & Signature was not requested before the completion of the deposition.

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Federal Rules of Civil Procedure

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(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:

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IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

PICTIVA DISPLAYS INTERNATIONAL LTD. Plaintiff, v. SAMSUNG ELECTRONICS CO. LTD., and SAMSUNG ELECTRONICS AMERICA, INC., Defendants.	Civil Action No. 2:23-cv-00495-JRG JURY TRIAL DEMANDED

DECLARATION OF DR. E. FRED SCHUBERT

Exhibit
0001

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E. "network-like structure" 51

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I, Dr. E. Fred Schubert, declare as follows:

I. Introduction

1. I am qualified and authorized to attest to the matters set forth in this declaration. I have knowledge of the facts set forth in this declaration based on my own personal information or investigation into the relevant subject matter.

2. I have been retained as an expert to provide opinions regarding the understanding of a person of ordinary skill in the art in connection with certain terms in the claims of U.S. Patent Nos. 6,949,389 (the "'389 patent"), 8,314,547 (the "'547 patent"), 8,558,223 (the "'223 patent"), 8,723,164 (the "'164 patent"), 9,257,492 (the "'492 patent"), and 11,828,425 (the "'425 patent") (collectively, the "asserted patents").

3. I am being compensated at my usual hourly rate of $525 per hour. I am also being reimbursed for any out-of-pocket expenses. I have no financial interest in, or affiliation with, any party in this case. My compensation does not depend in any way on the outcome of this case, the substance of my testimony, or opinions that I express.

4. In rendering my opinions, I have considered the asserted patents, their file histories, the parties' claim construction disclosures, and any other documents referenced, discussed, or listed in my declaration, and my own knowledge and experience in the relevant fields. I have also reviewed the productions associated with the claim construction disclosures in this case.

5. My analysis of the materials produced in this matter is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date. I reserve the right to amend or supplement my opinions based on additional documents or evidence I am presented, including without limitation any arguments or expert declarations advanced by the plaintiff in this case.

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II. Qualifications and Experience

6. I have extensive experience in the design and implementation of flat panel display devices, including the design, fabrication, processing, and packaging of the light emitting diodes (LEDs), transistors, capacitors, electrodes and semiconductor materials that are commonly used in LED displays and organic LED (OLED) displays.

7. I am currently an active tenured full professor in the Department for Electrical, Computer, and Systems Engineering at the Rensselaer Polytechnic Institute ("RPI") located in Troy, New York.

8. I have also held additional positions at RPI. For example, from 2002 to 2012, I was a professor in the Department of Physics, Applied Physics, and Astronomy. From 2008 to 2009, I served as the founding director of RPI's Engineering Research Center for Smart Lighting, which was funded by the National Science Foundation (NSF).

9. Before I moved to RPI, from 1995 to 2002, I was a professor in the Department of Electrical and Computer Engineering at Boston University. I also served as the director of Boston University's Semiconductor Devices Research Laboratory.

10. Prior to my university career, from 1985 to 1995, I was a post-doctoral member of the technical staff, member of the technical staff, principal investigator, and member of management at AT&T Bell Laboratories in Holmdel, New Jersey, and Murray Hill, New Jersey.

11. I earned my Ph.D. degree in 1986, Master of Science degree in 1981, and Bachelor's degree in 1978, all in Electrical Engineering, from the University of Stuttgart in Germany.

12. I have published over 300 technical articles, most at highly competitive refereed conferences and rigorously reviewed technical journals. These papers relate to active-matrix displays, LCDs, LEDs, OLEDs, semiconductor electronics (e.g., field-effect transistors, thin-film

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transistors, and bipolar junction transistors), semiconductor lasers and photo-detectors. These technologies are the foundations of flat panel display devices such as OLED display devices.

13. During my tenure in industry (AT&T Bell Laboratories), I was part of a working group on flat-panel displays. I have also performed technical consulting services in the field of OLED displays and associated TFTs (thin film transistors). One project concerned the enhancement of the carrier mobility in amorphous and poly-crystalline silicon TFTs. I have also served as technical expert witness in cases that concerned OLED displays, including the architecture of OLED pixel circuits.

14. At RPI, I regularly teach courses on microelectronic devices (such as TFTs) and displays (such as OLED displays). Light emitting diodes (LEDs and OLEDs) are routinely used as back lighting sources and emissive-pixel sources, and I have worked on and developed LEDs for these applications.

15. I am the author or editor of several books. For example, I authored the textbook "Light-Emitting Diodes," 1st, 2nd, 3rd and 4th editions, published by Cambridge University Press, Cambridge, UK (1st and 2nd editions) and Google Books (3rd and 4th editions). In this book, I provide a comprehensive review of the state-of-art technologies for designing, fabricating, processing, and manufacturing LEDs, including OLEDs. This textbook is well-known in the field of LEDs and it is routinely used by researchers and engineers working on LEDs and OLEDs.

16. In addition to my research, I have been teaching for more than 20 years. I have taught numerous undergraduate and advanced graduate courses on display devices, light-emitting diodes, integrated optoelectronics, microelectronics technology, solid-state devices, and semiconductor devices. I have also advised close to 50 Ph.D. and M.S. students while at the RPI

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and Boston University, in areas such as LEDs, TFTs, semiconductor electronics, semiconductor lasers, and solar cells.

17. I have been actively involved in multiple technical communities, including the American Physical Society (APS), Institute of Electrical and Electronics Engineers (IEEE), Optical Society of America (OSA), Society for Optical Engineering (SPIE). I have served in the organizing committees of many technical conferences, including, for example:

- Program committee member and chair of "Display and Solid-State Lighting Devices" conference for OSA/IEEE Conference on Lasers and Electro-Optics (CLEO), 2003 - 2005.
- Member of the International Advisory Committee of First International Conference on Display LEDs (ICDL), Seoul, Korea, January 31 - February 2, 2007.
- Sub-Committee Chair of Track 6: Displays, Solid-State Lighting, Photovoltaics, and Energy-Efficient Photonics of Asia Communications and Photonics Conference (ACP), Shanghai, China, November 11 - 14, 2014. ACP is the largest and the most influential conference in Asia and Pacific Rim for communications and photonics technologies.

18. My research has been recognized by multiple organizations, universities, and institutions. The following is a set of honors and awards that I have received:

- Elected Fellow of the IEEE in 1999. According to the IEEE definition, "the grade of Fellow is one of unusual professional distinction conferred by the Board of Directors only upon a person of extraordinary qualifications and experience."
- Elected Fellow of the SPIE in 1999. According to the Society's bylaws, a Fellow "shall be distinguished through his achievements and shall have made outstanding contributions in the field of optics, or optoelectronics, or in a related scientific, technical, or engineering field."
- Elected Fellow of the OSA in 2001. OSA Fellows are elected by the OSA Board of Directors.
- Elected Fellow of the APS in 2001.
- Honored with RPI Medal as Senior Constellation Chair in 2002.

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- Recipient of "Scientific American 50 Award" of 2007, as published in the January 2008 issue of Scientific American.
- Received "2008 Rensselaer Polytechnic Institute Trustee Faculty Achievement Award" in 2002, 2008, and 2012.

19. Additional details about my employment history, fields of expertise, and publications are further included in my attached curriculum vitae.

III. Legal Standards

20. I am not a lawyer, and I do not intend to offer any opinions as to the interpretation of the law. However, I have a general understanding of claim construction based on my experience with patents and my conversations with counsel.

21. I am informed that a patent may include two types of claims, independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim.

22. I am informed that claim construction is a matter of law to be decided by the Court. I understand that claim terms are presumed to have their plain and ordinary meaning, as understood by a person of ordinary skill in the art at the time of the invention, in the context of the patent specification, the prosecution history, and any other relevant evidence.

23. I am informed that to determine how a person of ordinary skill in the art would understand a claim term, one should look to those sources available that show what a person of skill in the art would have understood the disputed claim language to mean. Such sources include the words of the claims themselves, the remainder of the patent's specification, the prosecution history of the patent and the cited references (all considered "intrinsic" evidence), and "extrinsic" evidence, such as dictionary definitions, learned treatises and the opinions of qualified experts concerning relevant scientific principles, the meaning of technical terms, and the state of the art.

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24. I am informed that, in construing a claim term, one looks primarily to the intrinsic patent evidence, including the words of the claims themselves, the remainder of the patent specification, and the prosecution history.

25. I am informed that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient.

26. I am informed that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else. In making this determination, the claims, the patent specification, and the prosecution history are of paramount importance. Additionally, the specification and prosecution history must be consulted to confirm whether the patentee has acted as its own lexicographer (i.e., provided its own special meaning to any disputed terms), or intentionally disclaimed, disavowed, or surrendered any claim scope.

27. I understand that a person of ordinary skill in the art is deemed to read a claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification. For this reason, the words of the claim must be interpreted in view of the entire specification. The specification is the primary basis for construing the claims and provides a safeguard such that correct constructions closely align with the specification. Ultimately, the interpretation to be given a term can only be determined and confirmed with a full understanding of what the inventors actually invented and intended to envelope with the claim as set forth in the patent itself.

28. I understand that while intrinsic evidence is of primary importance, extrinsic evidence, *e.g.*, all evidence external to the patent and prosecution history, including expert and

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inventor testimony, dictionaries, and learned treatises, can also be considered. For example, technical dictionaries may help one better understand the underlying technology and the way in which one of skill in the art might use the claim terms. Extrinsic evidence should not be considered, however, divorced from the context of the intrinsic evidence. Evidence beyond the patent specification, prosecution history, and other claims in the patent should not be relied upon unless the claim language is ambiguous in light of these intrinsic sources. Furthermore, while extrinsic evidence can shed useful light on the relevant art, it is less significant than the intrinsic record in determining the legally operative meaning of the claim language.

29. I understand that, through the patent claims, an applicant must particularly point out and distinctly claim the subject matter which it regards as its invention. I understand that a patent is invalid for indefiniteness if its claims, read in light of the specification delineating the patent, and the prosecution history, fail to inform, with reasonable certainty, those skilled in the art about the scope of the invention.

30. I understand that an applicant's arguments in the prosecution history that objectively convey to one of skill in the art that certain subject matter that is not included within the claimed invention can be used in litigation to restrict the scope of the claims. I understand that this doctrine of prosecution history disclaimer promotes the public notice function of the intrinsic evidence and protects the public's reliance on definitive statements made during prosecution. I understand that prosecution history disclaimer can arise from both claim amendments and arguments made to the PTO. I understand that any such disclaimer must be both clear and unmistakable to one of ordinary skill in the art.

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IV. Level of Ordinary Skill in the Art

31. I understand that the claims must be understood from the perspective of a person of ordinary skill in the art at the time of the alleged inventions. I also understand that to determine the level of skill of a person of ordinary skill in the art, one must consider several factors including the types of problems encountered in the art, the solutions to those problems, the rapidity with which innovations are made, the sophistication of the technology, and the education level of active workers in the field.

32. In my opinion, a person of ordinary skill in the art ("POSITA") relevant to the asserted patents at the time of the invention would have at least the following qualifications.

33. A POSITA at the time of the alleged invention of the '389 patent would have had a bachelor's degree in Electrical Engineering, Materials Science, or a related field, and at least one year of experience in display technologies. Additional education might compensate for a deficiency in experience, and vice-versa. I understand that this is the level of ordinary skill in the art proposed by SDC and Dr. Subramanian in IPR2024-01222 and IPR2024-01223, and is agreeable to me.

34. A POSITA at the time of the alleged invention of the '547 patent would have a bachelor's degree in electrical engineering, physics, or a comparable field of study, and at least three years of research or industrial experience with semiconductor (organic or inorganic) optoelectronic devices and/or lighting or displays. An individual with additional education could have less research or industrial experience and vice versa. I understand that this is the level of ordinary skill in the art proposed by SDC and Dr. Eden in IPR2024-00855, and is agreeable to me.

35. A POSITA at the time of the alleged invention of the '223 patent would have had a university degree in chemistry and additional expertise or a second university degree in the field

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of electrical engineering, particularly optoelectronics, or alternatively a university degree in electrical engineering and additional expertise or a second university degree in the field of chemistry. The person of ordinary skill in the art has spent several years studying the structure and function of organic optoelectronic components, in particular OLEDs, and has detailed knowledge of the chemical structure of light-emitting organic layers and the transport of charge carriers to these layers. In this respect, the person of ordinary skill in the art works at the interface between electrical engineering/physics (charge carrier transport and light emission processes in optoelectronic components) and chemistry, in particular organic chemistry (materials and layer stack combinations suitable). I understand that this is the level of ordinary skill in the art proposed by SDC and Dr. Rand in IPR2024-001094, and is agreeable to me.

36. A POSITA at the time of the alleged invention of the '164 patent would have had a Bachelor's degree in chemistry, physics, or a comparable field of study, and at least three years of research or industrial experience with organic optoelectronic light-emitting devices. An individual with additional education could have less research or industrial experience and vice versa. I understand that this is the level of ordinary skill in the art proposed by SDC and Dr. Holmes in IPR2024-01093, and is agreeable to me.

37. A POSITA at the time of the alleged invention of the '492 patent would have had a bachelor's degree in Electrical Engineering, Physics, or a comparable field of study, and at least three years of research or industrial experience with semiconductor (organic or inorganic) optoelectronic devices and/or lighting or displays. An individual with additional education could have less research or industrial experience and vice-versa. I understand that this is the level of ordinary skill in the art proposed by SDC and Dr. Kattamis in IPR2024-01187, and is agreeable to me.

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38. A POSITA at the time of the alleged invention of the ’425 patent would have had a Bachelor’s degree in chemistry, physics, or a comparable field of study, and at least three years of research or industrial experience with organic optoelectronic light-emitting devices. An individual with additional education could have less research or industrial experience and vice versa. I understand that this is the level of ordinary skill in the art proposed by SDC and Dr. Holmes in IPR2024-01095, and is agreeable to me.

39. I meet each of these criteria and consider myself a person with at least ordinary skill in the art pertaining to each of the asserted patents. I would have been such a person at the time of the invention of each of the asserted patents.

40. I applied these levels of skill of a person of ordinary skill in the art for purposes of my analysis in this declaration.

41. The opinions that I express in this declaration would not change if the appropriate level of ordinary skill in the art was ultimately determined to be slightly higher or lower than what I have listed above. Additionally, I reserve the right to respond to any differing level of ordinary skill in the art offered by Pictiva or its experts.

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V. ’389 Patent Terms

A. “upon said devices” (cl. 34) and “upon said mask and said plurality of devices” (cl. 41)

Term	Pictiva’s Construction	Samsung’s Construction
“upon said devices” (cl. 34)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, “upon the earlier-mentioned devices”	“directly on said devices”
“upon said mask and said plurality of devices” (cl. 41)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, “upon the earlier-mentioned masks and the earlier-mentioned multiple devices”	“directly on both said mask and said plurality of devices”

42. In my opinion, based on my reading of the patent and prosecution history as a whole, and based on my knowledge as a POSITA, a POSITA would understand “upon said devices” in claim 34 to mean “directly on said devices” and would understand “upon said mask and said plurality of devices” in claim 41 to mean “directly on both said mask and said plurality of devices.” This is based on the use of the word “upon” in the patent and in the prosecution history.

43. Claim 34 requires “selectively depositing at least one planarization layer upon said devices”; claim 41 requires “depositing at least one planarization layer upon said mask and said plurality of devices.” Thus, both claims require depositing planarization layer “upon” “devices.”

44. A POSITA would have the above understanding of “upon” based on the use of “upon” in the patent specification. For example, the patent references, for an embodiment, an “organic layer” that is “deposited upon the OLED devices,” where that layer is referenced as the “layer over the OLED devices,” indicating that “upon” means “directly on” in this context. See

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’389 patent at 4:56-58 (“Once the organic layer is deposited upon the OLED devices, UV-light is used to selectively cure the layer over the OLED devices to produce the desired cross-linking.”).

45. During the prosecution history, the patent applicants addressed the term “upon,” and they made clear that “upon” a device means that the planarization layer is “directly on” the device, as opposed to being merely above a device.

46. The applicants for the ’389 patent addressed the term “upon said devices” in their November 18, 2003 response to an office action. The applicants stated: “Claims 1, 10-12, 19-21, 25-27, 34 are rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,703,433 by *Fujii* et al. *(‘Fujii’)*.” *Id.* at 13. The applicants then sought to overcome this rejection by asserting that the disclosure in *Fujii* does not constitute “depositing at least one planarization layer upon said devices.” Specifically, the applicants asserted:

> “Applicants submit that *Fujii* does not disclose ‘depositing at least one planarization layer upon said devices’. In *Fujii,* the photoresist 4 is deposited on barrier ribs 2. See column 4, lines 30-33. The barrier ribs 2 are not devices but rather, the barrier ribs 2 are insulating separators that separate plasma pixels. The electrode 9 and the fluorescent substance 3 together may comprise a device, however, the barrier ribs 2 are not devices. In Applicant's specification at, for example, page 6, lines 29-31, devices are described as, for example, active areas on a substrate; in addition, on page 7, lines 3-5, devices are described as, e.g., an OLED display, an organic detector, or an organic solar cell. Since the photoresist 4 is deposited on the barrier ribs 2, *Fujii* does not disclose ‘depositing at least one planarization layer upon said devices’ underline added) as recited in claim 1.”

Id. at 13.

47. The applicants of the ’389 patent thus asserted that *Fujii* did not include depositing a planarization layer “upon said devices” because, according to the applicants, the relevant layer in *Fujii* (the “photoresist 4”) was deposited “on barrier ribs 2” and ***not*** “upon” the relevant devices (which the applicants indicated could be the “electrode 9 and the fluorescent substance 3”).

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48. The relevant disclosures in *Fujii* make clear that the applicants of the '389 patent asserted that a planarization layer that is merely ***above*** a device is not "upon" that device; rather, the planarization layer is only "upon" the thing on which it is directly on.

49. The relevant disclosures in *Fujii*—primarily USPN 5,703,422 4:10-33—address *Fujii* Figures 1A and 1B, below:

FIG. 1A

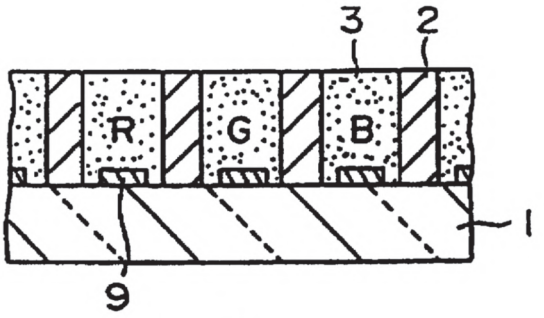
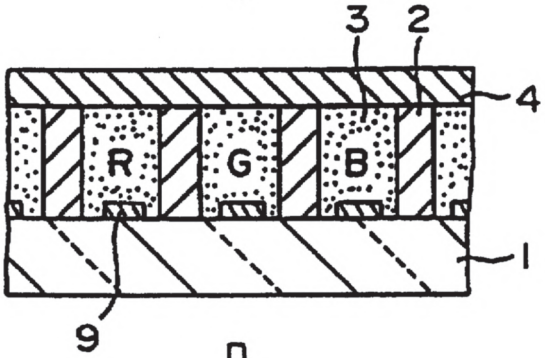


FIG. 1B



50. The relevant "planarization layer" is labeled 4 in Figure 1B, above, and the applicants of the '389 patent contend that "[s]ince photoresist 4 is deposited on barrier ribs 2, *Fujii* does not disclose 'depositing at least one planarization layer upon said devices" (emphasis in original), where "[t]he electrode 9 and the fluorescent substance 3 together may comprise a device."

51. While Figure 1B, above, appears to indicate that photoresist 4 (the planarization layer) is directly on both the barrier rib 2 and the device (9 and 3 together), the discussion in *Fujii*

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makes clear that this is not the case. Specifically, *Fujii* states that, in Figure 1A, "discharging spaces defined by barrier ribs 2 which have been formed on a glass substrate (rear plate) 1 are filled with three types of pastes of fluorescent substances 3 for red (R), green (G), and blue (B) colors." '422 patent 4:18-22. *Fujii* states: "Next, the fluorescent pastes 3 are dried so as to remove a solvent contained in an organic binder thereof." *Id.* 4:27-29. As made clear by this language, and other associated disclosures throughout the *Fujii* patent, a POSITA would understand that this evaporation step causes the paste, labeled as 3, to lose volume such that the substance after evaporation remains on the barrier ribs (2) and the substrate (1) but the substance no longer fills the discharge spaces (the cavities holding the material) up to the top of the cavities. Next, *Fujii* states: "Then, the substrate 1 is heated at a temperature in the range from 50° to 80° as shown in FIG. 1(b). Thereafter, a light-hardening type dry film (OSBR film made by Tokyo Ouka Kogyo Kabushiki Kaisha) is laminated on the substrate 1 as a photoresist 4."

52. Thus, while the applicable "planarization layer" in *Fujii* (the photoresist 4 in Figure 1B) is directly on the barrier ribs 2, it is not directly on the relevant "device" (components 3 and 9 together) because the substance labeled 3 does not fill the entire cavity that photoresist 4 covers. However, as shown by Figure 1B, the relevant planarization layer (4) is above the relevant device (3), and there are no intervening layers (other than some empty space) between the planarization layer and the relevant device. Thus, by asserting that photoresist 4 is not deposited upon the device (3 and 9, together), but photoresist 4 is deposited upon barrier rib 2, the applicants of the '389 patent made clear that the claim term "deposited upon said devices" means "deposited directly on said devices."

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B. "planarization layer"

Claims	Pictiva's Construction	Samsung's Construction
34, 35, 41, 46	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, a layer that can provide a planar surface	"a layer of material that planarizes such that the propagation of defects from one layer to another layer is interrupted and the topography of the underlying layer is not reproduced."

53. Based on my read of the patent and prosecution history and based on my understanding as a POSITA, a POSITA would understand the term "planarization layer" in claims 34, 35, 41, and 46 to mean: "a layer of material that planarizes such that the propagation of defects from one layer to another layer is interrupted and the topography of the underlying layer is not reproduced."

54. As recognized by the patent itself, "planarization layer" was a well-understood concept in the art at the time of the alleged invention. *See, e.g.*, '389 patent at 1:17-37. Planarization layers have key attributes to a POSITA and the patent itself and the prosecution history of the '389 patent use the term "planarization layer" consistent with the well-understood meaning of that layer.

55. Notably, planarizing techniques in the art included a number of different approaches. For example, in one common planarization technique, material is removed from an underlying layer to make that underlying layer more planar; this approach of removing material to planarize is used in the context of the well-known technique called chemical mechanical planarization ("CMP"). However, the '389 patent makes clear that it utilizes only planarization performed by addition of material (the planarizing material) to an underlying layer to make the underlying layer more planar. That is, the intrinsic record of the '389 patent as a whole, including the specification and the claims, makes clear that the planarization layer claimed in the '389 patent is a layer of a particular planarizing material that is deposited on an underlying layer (as opposed

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to, say, a layer that has become more planar through the removal of material). *See, e.g.*, '389 patent at 7:4-5 ("[G]enerally any printing techniques suitable to deliver the desired planarization layer material can be used."); 6:57-61 ("As organic layer 506 is deposited selectively; there may be no need to cure the layer. It should be appreciated that the cure and patterning aspects could be independent; —relating to the type of material and deposition technique of for [sic] the planarization layer.").

56. One characteristic of the "planarization layer" is that the layer of material planarizes. The '389 patent makes clear throughout that the material in the "planarization layer" acts to add a layer on top of another layer that makes the surface more "planar," or flatter. In the "Background" section, the patent states, regarding prior art (and referring to certain items in Figure 1): "Typically, for PML ['polymer multi-layer'] structures, a planarization layer 106 is formed on top of OLED structure 104. Planarization layer 106 typically is an organic layer (e.g. acrylate or the like) and is provided to give a planar surface for the deposition of the PML structure 112 a." '389 patent at 1:30-35. Creating a more planar surface on one layer in order to allow better deposition of a subsequent layer was a common technique in the art at the time of the alleged invention.

57. Another well-accepted characteristic of a planarization layer that goes hand in hand with planarizing is that the layer of material interrupts the propagation of defects from one layer to another layer. *See, e.g.,* '389 patent at 4:33-41 ("It should be appreciated that layer 304 could also be any suitable planarization layer. For example, an inorganic or hybrid planarization layer might also suffice as a buffer layer that has desirable planarizing and/or protecting properties from the barrier layer deposition process. . . . Such an organic layer might provide a planar structure on which to deposit a barrier layer and to substantially cover point defects (e.g. dirt particles) in lower

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layers. It is generally desirable that the organic layer be deposited in sufficient quantity so that any such layer is no longer 'conformal' to the point defect—i.e. any point defects are not geometrically projected upwards into layers deposited above.").

58. A layer of material that does not have this smoothing over property is not a planarization layer. The applicants stated that a material cannot be a "planarization layer" where it is "not used to interrupt the propagation of defects from one layer to another layer." July 19, 2004 Response to Non-Final Rejection at 11 ("[T]his 'sealing material 20' is not a planarization layer since it is not used to interrupt the propagation of defects from one layer to another layer".). Thus, the claim term "planarization layer" in the '389 patent does not include materials that do not "interrupt the propagation of defects" in this way.

59. The applicants also stated "metals cannot be used as a planarization layers" because "[m]etals . . . that are evaporated onto a layer do not cover-up the imperfections of the underlying layer, but rather the metals reproduce the topography of the underlying layer." Nov. 24, 2003 Response to Non-Final Rejection at 16. Thus, the applicants made clear that the "planarization layer" they claimed could only encompass a layer that "cover[s]-up the imperfections of the underlying layer" and that does not "reproduce the topography of the underlying layer."

C. "selectively depositing"

Claims	Pictiva's Construction	Samsung's Construction
34, 35, 41	Plain and ordinary meaning to a person of ordinary skill in the art in light of the specification	"depositing a material in only desired areas, such that no additional processing must be performed for removing unwanted material."

60. The concept of "selectively depositing" comes up throughout the '389 patent, including in a number of claims and throughout the specification. The '389 patent, as its title states, is generally directed to "Encapsulation for organic light emitting diodes devices." The

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patent explains: "Encapsulation is a way to protect the OLED device from the damaging environmental effects—primarily from oxygen and moisture." '389 patent at 1:8-9. The patent describes certain purported drawbacks of a certain type of prior-art encapsulation, known as "polymer multi-layer," or "PML:

> The problem with this PML technique is that the only part of the device that requires encapsulation is the OLED structure itself—and not, e.g., the electrical contact pads. In fact, the contact pad must typically be exposed for electrical mating with external driver circuitry. So, at a minimum, additional processing must be performed for the removal of the PML structure over these areas. . . . Another potential problem with the current PML techniques is that by having the PML layer over the scribe and break lines and/or the glue lines the integrity of the sealed package may be deteriorated, for example by delamination of the PML layer over these areas.

'389 patent at 2:17-29.

61. In other words, the patent describes certain drawbacks of a prior art approach in which an encapsulation structure covers the entire underlying layer rather than just certain parts of it.

62. The patent discloses several embodiments that purport to achieve, in different ways, the goal of encapsulating only portions of the underlying layer, and the claims reflect these distinctions. For example, the "Summary of the Invention" section of the patent describes an embodiment in which the planarization layer is deposited "selectively" ('389 patent at 5:2), and it describes another embodiment in which the "planarization layer is deposited as an unpatterned liquid film"; that latter embodiment then requires "removing said areas of unwanted planarization layer." *Id.* at 2:60-64. A POSITA would recognize this distinction as being reflected in the claims; for example, claims 25 and 34 are similar, except claim 34 requires "selectively depositing at least one planarization layer," whereas claim 25 requires "depositing" (not "selectively depositing") the planarization layer, and claim 25 further requires "wherein said planarization layer is deposited as

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an unpatterned liquid film," and "removing said areas of unwanted planarization layer." Similarly, claim 1 is also somewhat similar to claim 34, but claim 1 requires "depositing" (not selectively depositing) the planarization layer, and claim 1 requires several additional steps, including "removing area of the at least one planarization layer that are not hardened." This embodiment is also generally described in the "Summary of Invention" section. '389 patent at 2:41-54.

63. The specification also implies that "deposited in a patterned fashion" constitutes "selective deposition." *See* '389 patent at 6:53-63 ("Organic layer **506** is deposited in a patterned fashion as well as barrier layer **508**. As organic layer **506** is deposited selectively; there may be no need to cure the layer."). As a POSITA, I understand "deposited in a patterned fashion" to require that deposition be done in certain areas but not others (as opposed to an "unpatterned deposition," in which a material is deposited indiscriminately).

64. Reading the claims in the context of one another, in light of the intrinsic record as a whole, it is my opinion that a POSITA would understand the claims and the disclosed embodiments in the '389 patent to distinguish between merely "depositing" a material and then later removing portions of that material that are in unwanted areas, and "selectively depositing," in which the material is deposited where desired in the first instance, and no later removal steps are needed. Specifically, in my opinion, a POSITA would understand "selectively depositing" in claims 34, 35, and 41, in the context of the intrinsic record as a whole, to mean "depositing a material in only desired areas, such that no additional processing must be performed for removing unwanted material."

65. Throughout the patent, where a material is deposited initially only where it is desired, the term "selective deposition" is used. On the other hand, where a process that can include deposition of a material followed by removal of material from areas where that material is

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not wanted, the patent calls that "deposition" (and not "selective deposition"). Among other reasons, this understanding of "selectively depositing" is required to appreciate the differences between various claims, some of which use the term "depositing," by itself (in an unqualified manner), along with later steps to remove unwanted material, while other claims use the term "selectively depositing."

66. The specification's explanation of "selectively depositing" is consistent with this understanding. *See, e.g.*, '389 patent at 6:66-7:5 ("The manner of selectively depositing the organic layer and the barrier layer may be accomplished in a variety of ways. For example, organic layer may be selectively deposited though *[sic]* a shadow mask (as depicted as mask **510**) or by ink jet deposition or other screen printing techniques. In fact, generally any printing techniques suitable to deliver the desired planarization layer material can be used."). A shadow mask is used to define places where deposition is to occur. By referring to a shadow mask as an example of selectively depositing, the specification makes clear that deposition through a mask can allow for deposition to be "confined over desired areas." '389 patent at 7:41-46 ("The mask might be such that it could be brought into contact with the OLED sufficiently well so that the encapsulation organic is confined over the desired areas and does not seep under the areas where the encapsulation organic is not desired (e.g. contact pads)."). This is consistent with my understanding of deposition of a material through a shadow mask.

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D. "depositing at least one planarization layer upon said mask and said plurality of devices; removing said mask from said substrate"

Claim	Pictiva's Construction	Samsung's Construction
41	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "depositing at least one planarization on the earlier-mentioned mask and the earlier-mentioned multiple devices; removing the earlier-mentioned mask from the earlier-mentioned substrate"	"depositing at least one planarization layer upon said mask and said plurality of devices; **then** removing said mask from said substrate" (emphasis added)

67. For claim 41 of the '389 patent, in my opinion, a POSITA would understand that the claim element "depositing at least one planarization layer upon said mask and said plurality of devices" must be performed before the claim element "removing said mask from said substrate" (i.e., the two steps must be performed in the order they appear in the claim). This understanding is required by the claim language itself, other disclosures in the patent, and a POSITA's understanding of the use of a mask to deposit a planarization layer.

68. In the '389 patent, the purpose of using a mask with respect to the planarization layer is to "selectively deposit" the planarization layer. *See* '389 patent at 6:66-7:3 ("The manner of selectively depositing the organic layer and the barrier layer may be accomplished in a variety of ways. For example, organic layer may be selectively deposited though a shadow mask (as depicted as mask **510**) or by ink jet deposition or other screen printing techniques.").

69. Regarding the relevant claim language: three steps in claim 41 use the word "mask." One of these steps references "a mask"; the other two steps reference "said mask." The two steps with the language "said mask" each reference an already-discussed mask, but the step that references "a mask" does not; thus, in my opinion, the step that merely references "a mask" would come first among these three steps. That is, the first mask-related step to be performed is:

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"depositing a mask on top of said substrate, such that mask openings are placed on top of said devices." The next two steps listed in the claim—the other two mask-related steps—must be performed in the order they appear in the claim because, otherwise, the claim language would not make sense, and a POSITA would not understand a reasonably certain way to perform the claim.

70. The two options for sequencing the steps after "depositing a mask. . ." would be:

(A) "depositing at least one planarization layer upon said mask and said plurality of devices"

Then

"removing said mask from said substrate";

Or:

(B) "removing said mask from said substrate"

Then

"depositing at least one planarization layer upon said mask and said plurality of devices"

71. Option "B" would require "depositing a mask," then "removing said mask," then "depositing at least one planarization layer upon said mask." This sequence does not make sense: depositing then removing the mask (and doing nothing in between) would not accomplish anything technically meaningful; it would like be putting a stencil in place then removing the stencil, without applying any paint or ink to the stencil while it is in place. Further, interpreting the claim to require depositing a planarization layer "upon said mask" after that mask had been removed has no reasonably certain meaning to a POSITA because there is no indication of where the mask goes after it is removed, or what deposition is contemplated upon that removed (but unplaced) mask. Option "B" is also ambiguous grammatically because "depositing at least one planarization layer

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upon ***said*** mask" (emphasis added) has an unclear antecedent where the earlier-discussed mask had already been removed.

72. On the other hand, option "A," above—performing the two steps in the order they appear in the claim—would follow the expected sequence, both technically an grammatically. Under Option "A," a mask is deposited; then a planarization layer is deposited "upon said mask"; then the mask is removed. This approach can achieve type of deposition over a mask contemplated throughout the patent.

73. In my opinion, this interpretation is also consonant with the related disclosures throughout the patent, and it is not inconsistent with any disclosures in the patent. For example, the patent references "the mask's removal after encapsulation organic deposition." '389 patent at 7:38-39. (The patent sometimes references the planarization layer as an "organic" layer. *See* '389 patent at 1:32-33 ("Planarization layer 106 typically is an organic layer. . . .")). *See also id.* at 7:57-60 ("Once deposited, then the organic layer may or may not be cured—either partially or completely prior to the removal of mask 604. The mask could be removed by any means known in the art—e.g. by peeling it off; mechanical removal if a stencil, and the like."); *id.* at 7:66-8:1 ("After the mask is removed, then barrier layer 608 is selectively deposited over the planarization layers covering the OLED devices."). There are no disclosures in the patent that suggest a contemplated approach would include depositing a mask, then removing that mask, then depositing a planarization layer on that mask.

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VI. ’547 Patent Terms

A. “an organic layer sequence which emits an electromagnetic radiation having a first wavelength spectrum during operation”

Claims	Pictiva’s Construction	Samsung’s Construction
1	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, where, “a first wavelength spectrum” denotes a spectral distribution of electromagnetic radiation having a first spectral component(s) and relative intensities. No other parts require construction	“an active layer and electrodes which emits an electromagnetic radiation with a first wavelength spectrum which corresponds to the entire wavelength spectrum of the electromagnetic radiation emitted by the organic layer sequence during operation”

74. In my opinion, the term “an organic layer sequence which emits an electromagnetic radiation having a first wavelength spectrum during operation,” as used in the ’547 patent and as understood by a POSITA at the time of the alleged invention, refers to “an active layer and electrodes which emits an electromagnetic radiation with a first wavelength spectrum which corresponds to the entire wavelength spectrum of the electromagnetic radiation emitted by the organic layer sequence during operation.”

75. A POSITA at the time of the alleged invention would understand that “an organic layer sequence which emits an electromagnetic radiation is “an active layer and electrodes which emits an electromagnetic radiation” based on the ’547 patent specification. The ’547 patent specification states that “[t]he optoelectronic device has ***an organic layer sequence 1*** and ***an electrode 10 and an active region 11***. In this case, as explained in the general part of the description, ***the organic layer sequence 1 can have functional layers or layer sequences and is embodied as an OLED***, for example. In particular, the ***active region 11 of the organic layer sequence 1 is suitable for emitting electromagnetic radiation 15*** having a first wavelength spectrum.” ’547 patent at 10:5-12 (emphases added). The organic layer sequence is highlighted

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in yellow and is identified as part 1 below with the electrodes outlined in red and identified as part 10 and the active region is outlined in blue and identified as part 11 as shown in Figs. 1A and 1B below:

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FIG 1A

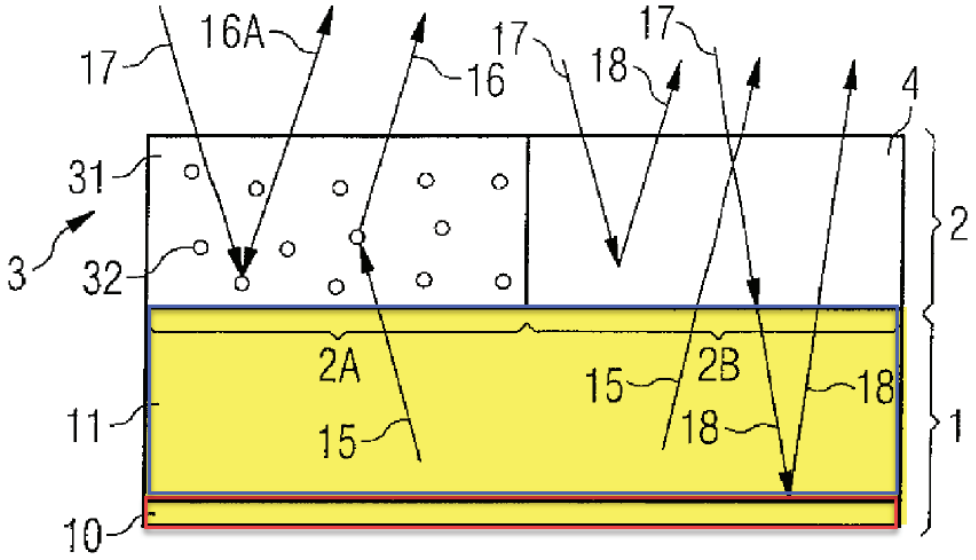
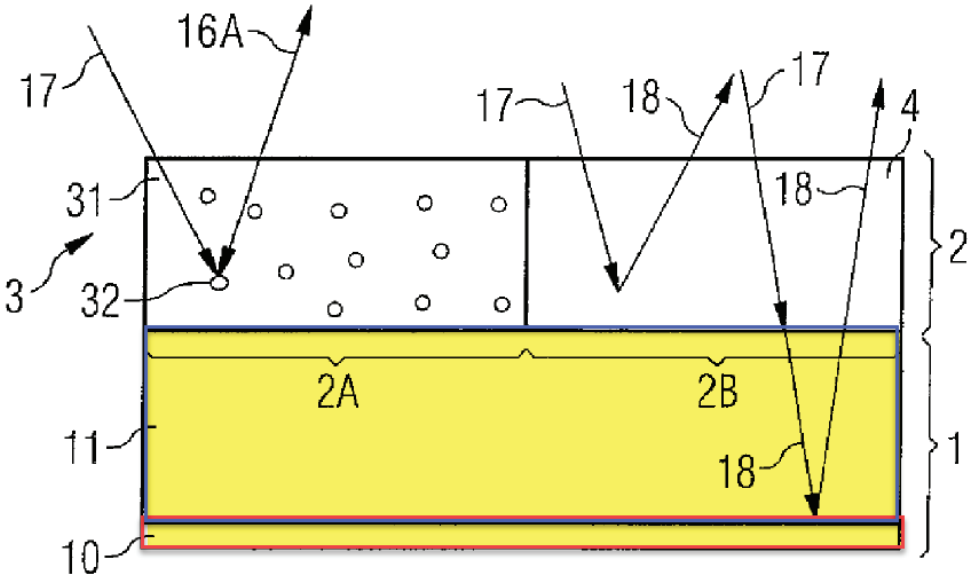


FIG 1B



76. The ’547 patent distinguishes the organic layer sequence (part 1 in Figures 1A and 1B) from the “structured layer” (part 2 in Figures 1A and 1B) which include the wavelength

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conversion and filter layers. '547 patent at Abstract. A POSITA would understand from this description of the specification that "an organic layer sequence which emits an electromagnetic radiation" is "an active layer and electrodes which emits an electromagnetic radiation."

77. Additionally, a POSITA would understand that the term "an organic layer sequence which ***emits an electromagnetic radiation having a first wavelength spectrum during operation***," as used in the '547 patent and as understood by a POSITA at the time of the alleged invention, refers to "an active layer and electrodes which ***emits an electromagnetic radiation with a first wavelength spectrum which corresponds to the entire wavelength spectrum of the electromagnetic radiation emitted by the organic layer sequence during operation***." The electromagnetic radiation has a first wavelength spectrum that is the entire electromagnetic radiation emitted by the organic layer sequence during operation. A POSITA would understand that the electromagnetic radiation is the full emission during operation and not a subset or portion of the wavelength spectrum.

78. My opinion that "an organic layer sequence which ***emits an electromagnetic radiation having a first wavelength spectrum during operation***," as used in the '547 patent and as understood by a POSITA at the time of the alleged invention, refers to "an active layer and electrodes which ***emits an electromagnetic radiation with a first wavelength spectrum which corresponds to the entire wavelength spectrum of the electromagnetic radiation emitted by the organic layer sequence during operation***" is confirmed by the '547 patent specification. For example, the '547 patent specification states that "An optoelectronic device comprises ***an organic layer sequence (1), which emits an electromagnetic radiation (15) having a first wavelength spectrum during operation***….In this case, the first regions (2A) each have a wavelength conversion layer (3) designed to convert at least partially electromagnetic radiation (15) ***having***

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the first wavelength spectrum into an electromagnetic radiation (16) having a second wavelength spectrum." '547 patent at Abstract. A POSITA would understand that the first wavelength spectrum during operation is the entire wavelength spectrum during operation.

79. I disagree with Pictiva's proposed construction. A POSITA would not understand "a first wavelength spectrum" denotes a spectral distribution of electromagnetic radiation having a first spectral component(s) and relative intensities. Pictiva's proposed construction would render this claim term meaningless, as the first wavelength spectrum could be a single spectral component, multiple spectral components, a single intensity or multiple intensities. A POSITA would understand the claimed first wavelength spectrum as being the entire wavelength spectrum—not a component or single intensity within the wavelength spectrum.

80. Thus, it is my opinion that a POSITA at the time of the alleged invention would understand "an organic layer sequence which emits an electromagnetic radiation having a first wavelength spectrum during operation" means "an active layer and electrodes which emits an electromagnetic radiation with a first wavelength spectrum which corresponds to the entire wavelength spectrum of the electromagnetic radiation emitted by the organic layer sequence during operation."

B. <u>"the filter layer is transparent to the electromagnetic radiation having the first wavelength spectrum"</u>

Claim	Pictiva's Construction	Samsung's Construction
1	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, where "transparent to an electromagnetic radiation having the first wavelength spectrum" Means "permitting an electromagnetic radiation having the first wavelength spectrum to pass through"; no other parts require construction	"the filter layer is transparent to the electromagnetic radiation having the first entire wavelength spectrum so it permits an electromagnetic radiation having the first wavelength spectrum to pass through in as unimpeded manner as possible"

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81. In my opinion, the term "the filter layer is transparent to the electromagnetic radiation having the first wavelength spectrum," as used in the '547 patent and as understood by a POSITA at the time of the alleged invention, refers to "the filter layer is transparent to the electromagnetic radiation having the first entire wavelength spectrum so it permits an electromagnetic radiation having the first wavelength spectrum to pass through in as unimpeded manner as possible."

82. A POSITA at the time of the alleged invention would understand that "the filter layer is transparent to the electromagnetic radiation having the first wavelength spectrum" means "the filter layer is transparent to the electromagnetic radiation having the first entire wavelength spectrum so it permits an electromagnetic radiation having the first wavelength spectrum to pass through in as unimpeded manner as possible." A filter layer being transparent to a wavelength spectrum means that it is transparent to the entire wavelength spectrum. In order for the filter layer to be transparent to this entire wavelength spectrum, the filter layer needs to pass the emission in as unimpeded manner as possible. If the filter layer is impeding the emission by altering the spectral components, then it is not transparent. This is because, if the filter layer only partially passes through a portion of the wavelength spectrum or impedes the emission, then it is no longer transparent. Instead, the filter layer would be at least partially opaque.

83. My opinion that "the filter layer is transparent to the electromagnetic radiation having the first wavelength spectrum" means "the filter layer is transparent to the electromagnetic radiation having the first entire wavelength spectrum so it permits an electromagnetic radiation having the first wavelength spectrum to pass through in as unimpeded manner as possible" is confirmed by the '547 patent specification. For example, the '547 patent specification states that "the filter layer is designed to convert electromagnetic radiation having the third wavelength

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spectrum into heat or thermal radiation, while ***electromagnetic radiation having the first wavelength spectrum can pass through the filter layer preferably in as unimpeded a manner as possible***. This means, in particular, that ***the electromagnetic radiation emitted by the organic layer sequence during operation remains substantially unaffected by the filter layer***." '547 patent at 3:55-62. Similarly, the '547 patent describes transparent as "the electromagnetic radiation 15 having the first wavelength can pass through the filter layer 4 in ***an unimpeded manner and substantially without any alternation of its spectral components***. To put it another way, the filter layer 4 ***is transparent to electromagnetic radiation 15 having the first wavelength spectrum***." *Id*. at 10:36-42. A POSITA would understand from these descriptions of transparent in the '547 patent specification that the filter layer is transparent to the electromagnetic radiation having the first entire wavelength spectrum so it permits an electromagnetic radiation having the first wavelength spectrum to pass through in as unimpeded manner as possible.

84. Additionally, a POSITA would understand from the '547 patent's disclosure that transparent to the electromagnetic radiation having the first entire wavelength spectrum means the emission passes through the filter in as unimpeded manner as possible, as the '547 patent refers to other filter layers as "at least partially opaque." For example, the '547 patent specification states "a ***filter layer***, which is ***at least partially opaque*** to an electromagnetic radiation having a third wavelength spectrum, which corresponds to at least one part of the second wavelength spectrum." '547 patent at 1:34-37. The '547 patent describes the non-transparent filter layer as a "filter layer [that] can be designed ***at least partially to absorb the electromagnetic radiation*** having the fourth spectrum." *Id.* at 9:3-5. A POSITA would understand that transparent means the emission passes through the filter in as unimpeded manner as possible, as partial absorption or blocking would not be "at least partially opaque" and not "transparent."

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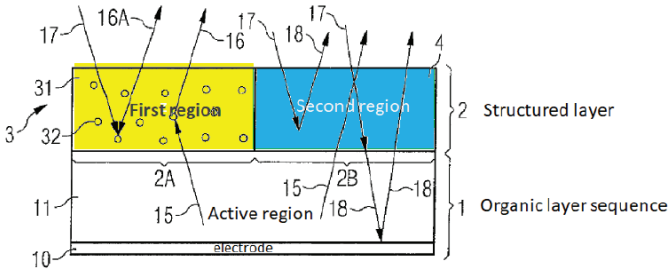
85. Additionally, a POSITA would understand a transparent filter must pass the entire first wavelength spectrum through the filter without alteration of its spectrum as the '547 patent states "***'partially' denotes a partial spectrum of a spectrum, for example of the first spectrum***. In particular, the ***partial spectrum of a spectrum can consist of a part of the spectral components of this spectrum***. Furthermore, ***'partially' can also denote a part of an intensity of a spectrum or partial spectrum***." '547 patent at 2:40-45. A POSITA would understand from these disclosures in the '547 patent that a transparent filter would not absorb or block a portion of or part of the spectral components of the first wavelength spectrum.

86. I disagree with Pictiva's proposed construction. A POSITA would not understand "transparent to an electromagnetic radiation having the first wavelength spectrum" as meaning "permitting an electromagnetic radiation having the first wavelength spectrum to pass through." Pictiva's proposed construction fails to distinguish "transparent" from "at least partially opaque" which renders this limitation meaningless. Moreover, Pictiva's proposed construction contradicts Pictiva's statements to the U.S. Patent & Trademark Office. In its Preliminary Patent Owner Response, Pictiva described the '547 patent's disclosure of a filter layer that was transparent:

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For instance, Figure 1A depicts an orgnaic layer sequence 1 that emits an electromangetic radiation 15 having a first wavelengh spectrum. EX1001, 10:9-12.

FIG 1A



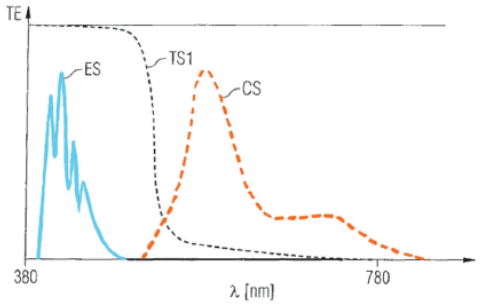
It further teache that

the electromagnetic radiation 15 having the first wavelength can pass through the filter layer 4 in an umimpeded manner and ***substanitally without any alternation of its spectral components***. To put it another way, the filter layer 4 ***is transparent to electromagnetic radiation 15 having the first wavelenght sepctrum***. EX1001, 10:36-42.

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That is, being transparent to emission having a first wavelength spectrum implies the emission would pass through the filter "substantially without any alteration of its spectral components." *Id.* Figure 2 depicts the same.

FIG 2



(Figs. 1A, 2, annotated)

In Figure 2, the blue curve depicts an "emission spectrum" of "***a spectral profile of the electromagnetic radiation 15 emitted by the organic layer sequence 1***." EX1001, 11:30-47. The orange CS curve depicts a conversion spectrum that "***represents the wavelength spectrum which is emitted by the wavelength conversion layer*** 3" (*i.e.*, emission having a second wavlength spectrum) that "comprises a yellow wavelength range and a red-green wavelength range, respectively." *Id.* "The curve designated by TS1 indicates a transmission spectrum of the filter layer 4." *Id.*

As Figure 2 shows, "the filter layer 4 is transmissive to blue light and thus to the electromagnetic radiation 15 [having a first wavelength spectrum] emitted by the organic layer sequence 1, while it is opaque to electromagnetic radiation having a yellow wavelength range and a red and green wavelength range [i.e., a third wavelenght spectrum which corresponds to at least one part of the second wavelength spectrum]." *Id.*

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IPR2024-00855 POPR at 58-60.

87. Thus, it is my opinion that a POSITA at the time of the alleged invention would understand "the filter layer is transparent to the electromagnetic radiation having the first wavelength spectrum," as used in the '547 patent to mean "the filter layer is transparent to the electromagnetic radiation having the first entire wavelength spectrum so it permits an electromagnetic radiation having the first wavelength spectrum to pass through in as unimpeded manner as possible."

C. "a filter layer which is at least partially opaque to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum"

Claim	Pictiva's Construction	Samsung's Construction
1	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, where "at least partially opaque to an electromagnetic radiation" means "at least partially block an electromagnetic radiation"; and "second/third wavelength spectrum" means "spectral distribution of electromagnetic radiation having second/third spectral component(s) and relative intensities." No other parts require construction	"a filter layer which is not transparent to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum"

88. In my opinion, the term "a filter layer which is at least partially opaque to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum," as used in the '547 patent and as understood by a POSITA at the time of the alleged invention, refers to "a filter layer which is not transparent to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum."

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89. A POSITA at the time of the alleged invention would understand that "a filter layer which is at least partially opaque to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum," means "a filter layer which is not transparent to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum."

90. A filter layer being transparent to a wavelength spectrum means that it is transparent to the entire wavelength spectrum. In order for the filter layer to be transparent to this entire wavelength spectrum, the filter layer needs to pass the emission in as unimpeded manner as possible. If the filter layer is impeding the emission by altering the spectral components, then it is not transparent. This is because, if the filter layer only partially passes through a portion of the wavelength spectrum or alters spectral components, then it is no longer transparent. Instead, the filter layer would be partially opaque.

91. My opinion that "a filter layer which is at least partially opaque to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum" means "a filter layer which is not transparent to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum" is confirmed by the '547 patent specification. For example, the '547 patent specification states "a ***filter layer***, which is ***at least partially opaque*** to an electromagnetic radiation having a third wavelength spectrum, which corresponds to at least one part of the second wavelength spectrum." '547 patent at 1:34-37. The '547 patent describes the non-transparent filter layer as a "filter layer [that] can be designed ***at least partially to absorb the electromagnetic radiation*** having the fourth spectrum." *Id.* at 9:3-5. A POSITA would understand that transparent means permitting an electromagnetic radiation to pass through in as

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unimpeded manner as possible, as any partial absorption or blocking would not be "at least partially opaque" and not "transparent."

92. Additionally, a POSITA would understand that "at least partially opaque" is not transparent, as transparent means that the filter must pass the entire first wavelength spectrum through the filter in as unimpeded manner as possible as the '547 patent states "***'partially' denotes a partial spectrum of a spectrum, for example of the first spectrum***. In particular, the ***partial spectrum of a spectrum can consist of a part of the spectral components of this spectrum***. Furthermore, ***'partially' can also denote a part of an intensity of a spectrum or partial spectrum***." '547 patent at 2:40-45. A POSITA would understand from these disclosures in the '547 patent that a transparent filter would not absorb or block a portion of or part of the spectral components of the first wavelength spectrum, while "at least partially opaque" would block a portion of or part of the spectral components of the wavelength spectrum.

93. For example, the '547 patent specification states that "the filter layer is designed to convert electromagnetic radiation having the third wavelength spectrum into heat or thermal radiation, while ***electromagnetic radiation having the first wavelength spectrum can pass through the filter layer preferably in as unimpeded a manner as possible***. This means, in particular, that ***the electromagnetic radiation emitted by the organic layer sequence during operation remains substantially unaffected by the filter layer***." '547 patent at 3:55-62. Similarly, the '547 patent describes transparent as "the electromagnetic radiation 15 having the first wavelength can pass through the filter layer 4 in ***an unimpeded manner and substantially without any alternation of its spectral components***. To put it another way, the filter layer 4 ***is transparent to electromagnetic radiation 15 having the first wavelength spectrum***." *Id*. at 10:36-42. A POSITA would understand from these descriptions of transparent in the '547 patent specification

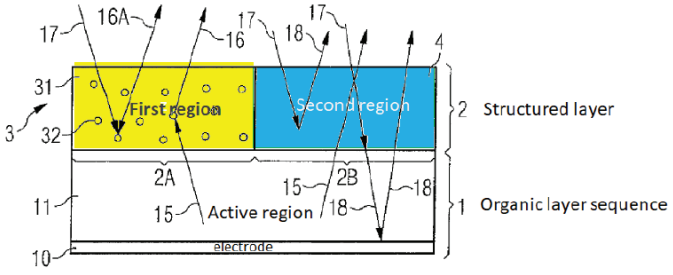
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that the filter layer is transparent to the electromagnetic radiation having the entire wavelength spectrum so the emission passes through the filter in as unimpeded manner as possible, while "at least partially opaque" would not be transparent.

94. I disagree with Pictiva's proposed construction. A POSITA would not understand "at least partially opaque to an electromagnetic radiation" means "at least partially block an electromagnetic radiation"; and "second/third wavelength spectrum" means "spectral distribution of electromagnetic radiation having second/third spectral component(s) and relative intensities." Pictiva's proposed construction fails to distinguish "at least partially opaque" from "transparent" which renders this limitation meaningless. Moreover, Pictiva's proposed construction contradicts Pictiva's statements to the U.S. Patent & Trademark Office. In its Preliminary Patent Owner Response, Pictiva described the '547 patent's disclosure of a filter layer that was partially opaque:

For instance, Figure 1A depicts an orgnaic layer sequence 1 that emits an electromangetic radiation 15 having a first wavelengh spectrum. EX1001, 10:9-12.

FIG 1A



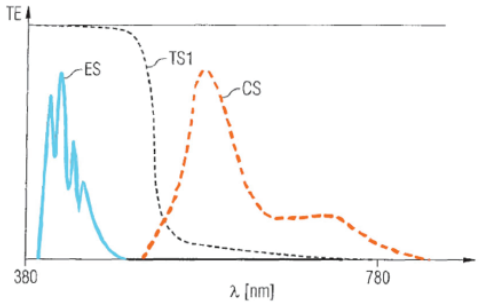
It further teache that

the electromagnetic radiation 15 having the first wavelength can pass through the filter layer 4 in an umimpeded manner and ***substanitally without any alternation of its spectral components***. To put it another way, the filter layer 4 ***is transparent to electromagnetic radiation 15 having the first wavelenght sepctrum***. EX1001, 10:36-42.

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That is, being transparent to emission having a first wavelength spectrum implies the emission would pass through the filter "substantially without any alteration of its spectral components." *Id.* Figure 2 depicts the same.

FIG 2



(Figs. 1A, 2, annotated)

In Figure 2, the blue curve depicts an "emission spectrum" of "***a spectral profile of the electromagnetic radiation 15 emitted by the organic layer sequence 1***." EX1001, 11:30-47. The orange CS curve depicts a conversion spectrum that "***represents the wavelength spectrum which is emitted by the wavelength conversion layer*** 3" (*i.e.*, emission having a second wavlength spectrum) that "comprises a yellow wavelength range and a red-green wavelength range, respectively." *Id.* "The curve designated by TS1 indicates a transmission spectrum of the filter layer 4." *Id.*

As Figure 2 shows, "the filter layer 4 is transmissive to blue light and thus to the electromagnetic radiation 15 [having a first wavelength spectrum] emitted by the organic layer sequence 1, while it is opaque to electromagnetic radiation having a yellow wavelength range and a red and green wavelength range [i.e., a third wavelenght spectrum which corresponds to at least one part of the second wavelength spectrum]." *Id.*

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IPR2024-00855 POPR at 58-60.

95. Thus, it is my opinion that a POSITA at the time of the alleged invention would understand "a filter layer which is at least partially opaque to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum," as used in the '547 patent to mean "a filter layer which is not transparent to an electromagnetic radiation having a third wavelength spectrum which corresponds to at least one part of the second wavelength spectrum."

D. "an encapsulation one of disposed upstream and disposed downstream"

Claim	Pictiva's Construction	Samsung's Construction
11	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "an encapsulation that is disposed either upstream or downstream of the structured layer in the beam path of the electromagnetic radiation emitted by the organic layer sequence	Indefinite

96. In my opinion, the '547 patent fails to inform a POSITA with reasonable certainty of the scope of the term "an encapsulation one of disposed upstream and disposed downstream," and hence the scope of the claimed invention.

97. A POSITA would not understand the scope of the term "an encapsulation one of disposed upstream and disposed downstream." This term requires an encapsulation that is both upstream and downstream. In other words, the claim language discloses "an encapsulation one of [which is] disposed upstream and [one of which is] disposed downstream." However, the specification does not provide any guidance on how such an encapsulation could meet this requirement in the claim. As the '547 patent fails to provide reasonable certainty of the scope of

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the term "an encapsulation one of disposed upstream and disposed downstream," it is my opinion the term is indefinite.

98. I also disagree with Pictiva's proposed construction. Pictiva's proposed construction simply rewrites the claim to require that "an encapsulation that is disposed either upstream or downstream of the structured layer in the beam path of the electromagnetic radiation emitted by the organic layer sequence." However, this is not what the claim states and a POSITA would understand that Pictiva's proposed construction is not the same as "an encapsulation one of disposed upstream and disposed downstream."

99. Thus, it is my opinion that the '547 patent fails to inform a POSITA with reasonable certainty of the scope of the term "an encapsulation one of disposed upstream and disposed downstream," and hence the scope of the claimed invention.

VII. '223 Patent Terms

A. "metal complex"

Claims	Pictiva's Construction	Samsung's Construction
1, 2, 10, 11	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, a compound containing one or more metal elements that coordinate to one or more non-metal elements, fragments or ions	"a metal complex that is not a compound composed of one or more metal atoms and one or more oxygen atoms"

100. During the prosecution of the '223 patent, the applicant distinguished the Ikeda prior art reference from the pending claims. Ikeda included a compound composed of one or more metal atoms and one or more oxygen atoms. '223 patent prosecution history at Nov. 1, 2012 office action. The Examiner assumed that this was a metal complex:

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Claims 1-4 and 9-15 are rejected under 35 U.S.C. 102(e) as being anticipated by Ikeda et al. (US 2008/0258610 A1).

In regard to claim 1, Ikeda e al. teach an organic electronic component, comprising: a substrate 101, a first electrode 102, a second electrode 107, an electron-conducting layer 103 which is arranged in such a way that it is electrically conductively connected to at least one of the electrodes 102/107, wherein the electron-conducting layer 103 can be obtained by joint vaporization of a metal complex, which comprises a central metal atom, with an organic compound (ABSTRACT, Figures 1A-1C, pages 2-4, paragraphs [0062]-[0082]).

101. The applicant disagreed and characterized Ikeda's alleged metal complex as a "metal oxide," after which the applicant provided its working definition of "metal oxide" ("a compound composed of one or more metal atoms and one or more oxygen atoms"). Finally, the applicant stated that its invention did not encompass metal oxides of that type. '223 patent prosecution history at Feb. 1, 2013 response to office action ("As clearly shown above, Applicants contend that Ikeda discloses a light emitting element in which a layer must have a metal oxide. Furthermore, Ikeda discloses that the layer is arranged on the anode of the light emitting element and is produced by simultaneously evaporating a metal oxide and an organic compound (See, for example, Abstract, paragraphs [0093] – [0095] and [0109]). A person of ordinary skill in the art understands that ***a metal oxide is a compound composed of one or more metal atoms and one or more oxygen atoms***. In direct contrast, Applicants assert that in the presently claimed application, the organic electronic layer is obtained by joint vaporization of a metal complex, which comprises a central metal atom, with an organic compound.") (emphasis added):

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Lastly, *Ikeda* states (emphasis added):

> The first layer 103 is a layer including a cluster in which arylamine compounds having a biphenyl skeleton form a dimolecular body by being arranged in parallel and **metal oxide** is adjacent to the dimolecular body. **As a specific example of the metal oxide included in the first layer 103, molybdenum oxide (MoO_x), vanadium oxide (VO_x), ruthenium oxide (RuO_x), tungsten oxide (WO_x), or the like is given. Moreover, indium tin oxide (ITO) or zinc oxide (ZnO) can be used**. Not only the above mentioned substances, but also other substances may be used.

Ikeda at page 3, paragraph [0066].

As clearly shown above, Applicants contend that *Ikeda* discloses a light emitting element in which a layer must have a metal oxide. Furthermore, *Ikeda* discloses that the layer is arranged on the anode of the light emitting element and is produced by simultaneously evaporating a metal oxide and an organic compound (*See*, for example, Abstract, paragraphs [0093] – [0095] and [0109]). A person of ordinary skill in the art understands that a metal oxide is a compound composed of one or more metal atoms **and** one or more oxygen atoms.

In direct contrast, Applicants assert that in the presently claimed application, the organic electronic layer is obtained by joint vaporation of a metal complex, which comprises **a** central metal **atom**, with an organic compound.

102. Following these remarks by the applicant, the examiner allowed the claims which ultimately issued. In the Notice of Allowance, the examiner specifically stated that the pending claims were allowed because the prior art failed to teach the claim limitations that included "metal complex":

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Allowable Subject Matter

Claims 1-4 and 6-15 are allowed.

The following is a statement of reasons for the indication of allowable subject matter: The prior art of record does not disclose, make obvious, or otherwise suggest the structure of the applicant's together with the other limitations of the independent claims, such as:

In claim 1, "wherein the electron-conducting layer is obtained by joint vaporization of a metal complex, which comprises a central metal atom, with an organic compound, wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C-C bond"; and

In claim 11, "wherein the electron-conducting layer is deposited by means of simultaneous vaporization of a metal complex and an organic compound, wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C-C bond".

'223 patent prosecution history at June 12, 2013 Notice of Allowability.

103. In my opinion, a POSITA reading the prosecution history (in context with the other intrinsic and extrinsic evidence) would have understood that the applicant disclaimed any metal complexes that were "a compound composed of one or more metal atoms and one or more oxygen atoms." The applicant's language is straightforward and express in this regard. There is no ambiguity that the applicant told the patent office that the scope of the claimed "metal complex" in the '223 patent expressly does not include "a compound composed of one or more metal atoms and one or more oxygen atoms." In my opinion, a POSITA would have recognized the clear and

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unmistakable disclaimer of claim scope from that applicant's remarks. For example, the applicant used the terminology "in direct contrast" to set apart its invention from the prior art, which instead used "a compound composed of one or more metal atoms and one or more oxygen atoms."

104. To the extent that Pictiva or its expert argue that the disclaimer was limited to "metal oxides," or in particular to metal oxides that contain "one or more metal atoms and one or more oxygen atoms" ***and no other atoms***, that is not what the applicant told the patent office the disclaimer was. The applicant defined its understanding of "metal oxide": "A person of ordinary skill in the art understands that ***a metal oxide is*** a compound composed of one or more metal atoms and one or more oxygen atoms." (emphasis added). In my opinion, a POSITA would have understood the applicant's language here to be definitional (*i.e.,* lexicographical). To the extent that the applicant's own interpretation of "metal oxide" differs from the understanding of that term in the general field of chemistry, a POSITA reading the relevant section of the prosecution history would have understood that the applicant clearly expressed an intention that its own interpretation should control, and thus should describe the scope of the disclaimer.

B. "wherein the organic compound coordinates to the metal complex due to the joint vaporization"

Claim	Pictiva's Construction	Samsung's Construction
2	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "wherein the organic compound coordinates to the metal complex attributable directly or indirectly to the joint vaporization"	"wherein the organic compound coordinates to the metal complex in the gas phase after the organic compound and the metal complex are jointly vaporized"

105. In my opinion, a POSITA reading claim 2 of the '223 patent in light of the specification would have recognized that the plain language of the claim requires a direct causal relationship between the joint vaporization and the coordination, because of the use of the phrase

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"due to." A POSITA would have recognized that the coordination must therefore occur ***after*** the joint vaporization. Similarly, specifying that coordination happens "due to joint vaporization" necessarily means that the reactants must first enter the gas phase via joint vaporization, and that the coordination reaction then occurs between the gaseous reactants. If the coordination occurred in the solid phase, for example, then the metal complex and organic compound would not coordinate "due to" the joint vaporization, but simply incidentally following a joint vaporization. A POSITA would have recognized that the claim language requires a stronger linkage between the joint vaporization and the coordination than simply occurring subsequently, and in particular that the coordination is the direct consequence "due to" joint vaporization, which would naturally require the coordination to occur in the gas phase where the reagents are vaporized.

106. The specification supports this interpretation. The '223 patent notes that it is possible for coordination to occur either in the gas phase or when the reactants "meet one another on the substrate surface." '223 patent at 1:60-63; *see also id.* at 11:17-23. A POSITA would have recognized that the relevant language of claim 2 ("due to the joint vaporization") explicitly selects one of these scenarios and requires the coordination to occur in the gas phase. Out of the alternative embodiments described in the specification for where the coordination occurs, claim 2 is directed specifically to the embodiment where coordination occurs in the gas phase.

107. I disagree with Pictiva's proposed construction. First, the proposed construction does not elucidate what "due to" requires because it simply replaces it with the synonym "attributable." Second, the proposed construction allows the coordination to be attributable "indirectly," which a POSITA would not consider to be within the plain and ordinary meaning of "due to," and which does not require a sufficiently causal relationship between the joint vaporization and the coordinate. In other words, Pictiva's proposed construction reads out "due

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to" from the claim language and effectively rewrites the larger phrase to "wherein the organic compound coordinates to the metal complex, and joint vaporization occurs at some point." Third, the proposed construction does not acknowledge that the coordination must occur ***after*** the joint vaporization.

C. "coordinate[s]"

Claims	Pictiva's Construction	Samsung's Construction
2, 11 14	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "have/has bonding interaction"	"form[s] a dative bond with"

108. The term "coordinate" has a well-understood and well-established meaning in the chemistry field, which is "form a dative bond with." As an initial matter, "coordinate" refers to a specific family of chemical interactions called "coordination chemistry." Coordination chemistry describes how metal ions interact with ligands. In coordination chemistry, when we say an atom or molecule "coordinates," that specifically refers to the formation of a dative bond (also called a "coordinate covalent bond"). In a dative bond, one atom (the donor) provides both electrons for the bond. The other atom (the acceptor) provides an empty orbital to accept those electrons. This is distinct from regular covalent bonds, where each atom contributes one electron. The verb "coordinate" specifically captures the unique nature of dative, or coordinate covalent, bonds, where ligands "donate" or "coordinate" their electron pairs to the metal center.

109. The plain and ordinary meaning of "coordinate" is supported by relevant extrinsic evidence. For example, The New Oxford American Dictionary, Second Edition (2005) defines "coordinate" as "Chemistry denoting a type of covalent bond in which one atom provides both the shared electrons," and it also defines "coordination" as "Chemistry the linking of atoms by coordinate bonds." PICTSAMSUNGEDTX209887. As another example, McGraw-Hill

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Dictionary of Scientific and Technical Terms, Sixth Edition (2003) defines "coordinate bond" as "See coordinate valence" and defines "coordinate valence" as "[chem] A chemical bond between two atoms in which a shared pair of electrons forms the bond and the pair has been supplied by one of the two atoms. Also known as coordinate bond; dative bond." PICTSAMSUNGEDTX209893. As a further example, Hawley's Condensed Chemical Dictionary, Fifteenth Edition (2007) defines "coordinate bond" as "(dative bond). A covalent bond consisting of a pair of electrons donated by only one of the two atoms it joins." PICTSAMSUNGEDTX209911. And Encyclopedia of Chemistry (2005) defines "coordinate covalent bond" as "A bond between two atoms in which the shared electrons are contributed by only one of the atoms," and further defines "coordination compound (coordination complex)" as "A compound containing coordinate covalent bonds." PICTSAMSUNGEDTX209916. Chemistry textbooks also agree that "coordinate" refers to a dative bond. *E.g.*, FHSST Chemistry (2008) at 71 ("A dative covalent bond (also known as a coordinate covalent bond) is a description of covalent bonding between two atoms in which both electrons shared in the bond come from the same atom. This happens when a Lewis base (an electron donor) donates a pair of electrons to a Lewis acid (an electron acceptor)."). PICTSAMSUNGEDTX210497.

110. Nothing in the intrinsic evidence calls into question this basic and well-understood meaning of "coordinate." Indeed, the specification assumes the traditional, well-understood meaning of "coordinate." *See, e.g.*, '223 patent at 2:6-12 ("By virtue of the coordination of the organic compound on the metal complexes, and the associated overlap of the orbitals, additional electrons can be transferred from the metal to the ligand via a metal complex-ligand-electron transfer (metal-ligand-charge-transfer complex). These electrons can be available for electron transportation in the organic electronic component."); 3:7-20 (similar).

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111. Thus, specific coordination interactions are an integral part of the invention: they are required to achieve the invention's goals of more efficient electron transport. *Id.* at 2:13-16 ("By increasing the 'free' electrons, the electron conductivity in the component is significantly improved. This leads to an increase in efficiency and serviceable life of the organic electronic component."); 3:7-20 (similar).

112. I note further that the specification explicitly describes nitrogen as suitable for coordination because of a "free electron pair," which indicates that the applicant understood that coordination requires a donation of two free electrons. *Id.* at 3:65-67 ("Here, N is a preferred heteroatom. Due to the mostly free electron pair, N has very good coordination properties with respect to metal complexes."); *see also id.* at 10:55-59 ("Each of these compounds comprises a nitrogen heterocycle and in addition a further nitrogen heterocycle or a homoaromatic compound which is formed from C-atoms. Each of these compounds thus has several coordination sites for metal complexes.").

113. Moreover, the specification notes that coordination may occur "via the aromatic system (π-electrons)," which is encompassed by Samsung's construction. *Id.* at 3:54-64. In coordination chemistry, aromatic π-electrons can serve as electron donors just like lone pairs can. The π-electrons occupy bonding molecular orbitals in the aromatic ring. These electrons can donate into empty d-orbitals on metals. The interaction creates a delocalized bonding network between the metal and the aromatic ring. The π-system donates both electrons to the metal, just like a lone pair would. In traditional lone pair dative bonds, two electrons move from a donor atom to an acceptor. In π-dative bonds, two electrons move from a π-orbital to an acceptor. The source of the electron pair (single atom vs. molecular orbital) does not change the fundamental

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dative nature of the interaction. Thus, a POSITA would understand that Samsung's proposed construction does not exclude any embodiments described in the specification.

114. I disagree with Pictiva's proposed construction. First, it is not clear what Pictiva's intended meaning of "bonding interaction" is, and that language does not occur in the specification. Second, Pictiva's proposed construction encompasses types of bonds which are not even covalent. Some examples include ionic bonds and metallic bonds. *See* FHSST Chemistry (2008) at 65 (PICTSAMSUNGEDTX210491) ("A chemical bond is formed when atoms are held together by attractive forces."), 74 (PICTSAMSUNGEDTX210500) ("In covalent bonding, electrons are shared between the atoms. There is another type of bonding, where electrons are transferred from one atom to another. This is called ionic bonding."), 76 (PICTSAMSUNGEDTX210502) ("The structure of a metallic bond is quite different from covalent and ionic bonds."). Third, Pictiva's proposed construction encompasses regular, non-coordinate/dative covalent bonds, which are distinct from the normal meaning of "coordinate." *See, e.g.*, Dictionary of Science and Technology, Second Edition (2007) (PICTSAMSUNGEDTX209899), which defines "coordinate bond" as "a chemical bond in which a pair of electrons is shared by two atoms, both of which are supplied by one atom (NOTE: a coordinate bond is a type of covalent bond.)" Fourth, Pictiva's construction is not congruent with the technical principles of the invention, which requires dative bonds in order to achieve its efficiency and increased component lifetime goals. '223 patent at 2:13-16; 3:7-20. In my opinion, allowing additional types of non-dative "bonding interactions" would not achieve the goals of the invention and would not make technical sense.

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D. "chain-like structure"

Claim	Pictiva's Construction	Samsung's Construction
12	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "a structure that resembles a chain"	"a structure where two metal complexes are linked by an organic compound or a structure where two organic compounds are linked by a metal complex"

115. The term "chain-like structure" does not have a well-understood or plain and ordinary meaning in chemistry. In my opinion, a POSITA would therefore have looked to the specification for guidance on the appropriate definition. The specification gives a definition of a "chain-like structure." '223 patent at 2:33-38 ("It is described that the coordination of the aromatic system can lead to a chain formation, wherein two metal complexes are linked by an organic compound. In this case, the aromatic compound is positioned perpendicularly or almost perpendicularly between adjacent, bridged metal complexes."); 7:48-53 ("These compounds I to XIII allow not only for the formation of two-dimensional chains, but, by virtue of their multiplicity of coordination sites, they also allow for the formation of three-dimensional networks. In this case, an organic compound coordinates to more than two metal complexes."); 11:11-16 ("In an embodiment of the organic electronic component, at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure is formed and/or at least parts of the organic compounds bridge more than two metal complexes together, so that a network-like structure is formed."); *see also id*. at 2:42-67; 11:48-52 ("By means of the corresponding selection of the metal complexes, more than one organic compound can coordinate to a metal complex, whereby chain-like and/or network-like structures are formed in the electron-conducting layer.").

116. Samsung's proposed construction encompasses both types of examples in the specification: 1) where two metal complexes are linked by an organic compound (*cf. id.* at 7:48-53); and 2) where two organic compounds are linked by a metal complex (*cf. id.* at 11:48-52).

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Therefore, a POSITA would have understood that Samsung's proposed construction does not exclude any embodiments discussed in the specification.

117. Samsung's proposed construction is further supported by the language of claim 8, which reads: "The organic electronic component according to claim 1, wherein at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure of the metal complexes is formed and/or at least parts of the organic compounds bridge more than two metal complexes together, so that a network-like structure of the metal complexes is formed."

118. I disagree with Pictiva's proposed construction. First, it is not clear what "a structure that resembles a chain" means. This is not terminology that is commonly used in the chemistry field, and the scope is ambiguous. Second, Pictiva's proposed construction could encompass types of structures that are not described as "chain-like" in the specification. Third, the additional types of structures that Pictiva appears to attempt to include in the claim scope would not achieve the technical goals of the invention. *Id.* at 11:29-33 ("The formation of chain-like or network-like structures enables additional electrons to be able to be transferred from the metal complexes to the organic compounds, said electrons are then available for charge transport in the electron-conducting layer.").

E. "network-like structure"

Claim	Pictiva's Construction	Samsung's Construction
12	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "a structure that resembles a network"	"a structure where more than two metal complexes are linked by an organic compound or a structure where more than two organic compounds are linked by a metal complex"

119. As with "chain-like structure," there is no commonly-accepted meaning of "network-like structure" in chemistry. A POSITA would therefore have turned to the specification and its definition of "network-like structure." I reviewed the supporting portions of the

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specification above in the context of "chain-like structure." Those same parts of the specification describe the patentee's understanding of "network-like structure." According to the specification, a "network-like structure" involves more than two metal complexes that are linked by an organic compound or more than two organic compounds that are linked by a metal complex. *E.g.*, '223 patent at 7:48-53 ("[T]hey also allow for the formation of three-dimensional networks. In this case, an organic compound coordinates to more than two metal complexes."); 10:62-64 ("[T]hey also allow for the formation of three-dimensional networks. In this case, the organic compound coordinates to more than two metal complexes."); 11:11-16 ("[A]t least parts of the organic compounds bridge more than two metal complexes together, so that a network-like structure is formed."). And as with "chain-like structure," the language of claim 8 supports Samsung's construction.

120. I disagree with Pictiva's proposed construction. As with "chain-like structure," it is not clear what "a structure that resembles a network" is, and there is no commonly-accepted concept of that in the chemistry field. Pictiva's construction would improperly encompass types of structures that are not described as "network-like" in the specification. Moreover, Pictiva's proposed construction does not make technical sense in the context of the invention and would not achieve the electron-conducting benefits that the specification ascribes to "network-like structures."

F. "degree of cross-linking of the electron-conducting layer"

Claims	Pictiva's Construction	Samsung's Construction
13	plain and ordinary to a person of ordinary skill in the art in light of the specification, that is, "the extent of crosslinking in the electron-conducting layer"	Indefinite

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121. In my opinion, the ’223 patent fails to inform a POSITA with reasonable certainty of the scope of the term “degree of cross-linking of the electron-conducting layer,” and hence the scope of the claimed invention.

122. First, the sub-phrase “cross-linking of the electron-conducting layer” does not have an antecedent basis. No cross-linking is explicitly required by the base claims 10 or 12. To the extent that the “cross-linking” in the term would be considered to implicitly refer to cross-linking of a “chain-like or network-like structure,” (*cf.* ’223 patent at 13:61-64) it is not clear what the “cross-linking” is in those structures. And, it is not a given that the “cross-linking” refers to only those structures and not to the coordination of the claimed metal complex with the claimed organic compound.

123. Second, the ’223 patent fails to provide a standard or metric for measuring the “degree” of cross-linking. In this term, “degree” is, by definition, a “term of degree” standing alone, which does not have any objective standard for measurement. Among various options, the degree could be measured by 1) the absolute number of separate “chain-like or network-like structures”; 2) the percentage of “chain-like or network-like structures” as measured against the total number of coordination complexes between the metal complex and the organic compound; 3) the size (*e.g.*, molecular weight) of the “chain-like or network-like structures”; 4) the number of coordination bond or other bonds formed in the “chain-like or network-like structures”; or even 5) the number of coordination complexes formed between the claimed metal complex and the claimed organic compound. The specification does not provide sufficient guidance.

124. Third, the term “cross-linking” standing alone has a well-established meaning in chemistry, and refers to the formation of chemical bonds that connect one polymer chain to another. *See, e.g.*, McGraw-Hill Dictionary of Scientific and Technical Terms, Sixth Edition

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(2003) (PICTSAMSUNGEDTX209894) ("crosslinking": "[org chem] The setting up of chemical links between the molecular chains of polymers."); Chambers Dictionary of Science and Technology (2007) (PICTSAMSUNGEDTX209903) ("cross-linking": "(Chem) The formation of side bonds between different chains in a polymer, thus increasing its rigidity. Usually achieved in rubbers with sulphur to give disulphidic or polysulphidic links between vicinal carbon atoms. Physical cross-links are used in thermoplastic elastomers to provide elastomeric properties. See panels on elastomers and thermosets."); A Dictionary of Chemistry, Fifth Edition (2004) (PICTSAMSUNGEDTX209908) ("cross linkage": "A short side chain of atoms linking two longer chains in a polymeric material."); Hawley's Condensed Chemical Dictionary, Fifteenth Edition (2007) (PICTSAMSUNGEDTX209912) ("cross-linking": "Attachment of two chains of polymer molecules by bridges . . . ."); Academic Press Dictionary of Science and Technology (1992) (PICTSAMSUNGEDTX209921) ("cross-linking": "Organic Chemistry. The attachment of chains of a polymer to one another to make the polymer into a single network with increased strength and resistance to solvents."); Academic Press Dictionary of Science and Technology (1992) (PICTSAMSUNGEDTX209921) ("cross-link density": "Materials Science. the density or extensiveness of chemical links that form between two polymers or between polymers and other substances.").

125. Thus, "cross-linking" is very specific to polymer chemistry. But the technology described and claimed in the '223 patent instead pertains to small molecules, which are not polymers. *E.g.*, '223 patent at cl. 1 ("joint vaporization of a metal complex, which comprises a central metal atom, with an organic compound, wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond."). More broadly, the types of cross-linkages that occur between polymers are significantly different

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from the chain-like or network-like structures described in the '223 patent specification. The cross-linkages between polymers are in the form of "bridges" or "side bonds," while the chain-like or network-like structures contemplated by the '223 patent do not use those structures. *E.g.*, '223 patent at 2:33-67; 7:48-53; 11:11-16; 11:48-52. In my opinion, a POSITA would not be able to identify any parallel "cross-link" structure in the small molecules that are covered by the '223 patent. In other words, "cross-linking" has no meaning in the context of the '223 patent, and certainly no parallel meaning implied by the usage of that term in polymer chemistry.

126. I also disagree with Pictiva's proposed construction. First, it is not clear what "the extent of crosslinking in the electron-conducting layer" means, or how it would be measured. Second, Pictiva's proposed construction simply replaces "degree" with "extent" without providing any clarity on the scope of the term. Third, the same measurement problems that are present with "degree" that I listed above would also apply to "extent."

VIII. '164 Patent Terms

A. "matrix"

Claims	Pictiva's Construction	Samsung's Construction
1-6, 10, 13-16	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification	"a continuous phase of the mixture of matrix materials"

127. In my opinion, "matrix" in the '164 patent claims should be construed as "a continuous phase of the mixture of matrix materials."

128. The specification consistently describes the matrix as a mixture of the three constituent matrix materials. *E.g.*, '164 patent at 3:20-21 ("Thus, the concentration of a matrix material in the mixture of several matrix materials plays a role."); 3:31-33 ("the mobility of electrons and holes in the matrix, which has at least three matrix materials"); 4:24-26 ("Each of these layers can have a matrix, which has at least a first, a second, and a third matrix material.");

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4:39-41 ("Depending on which charge carrier type is to have a higher mobility, the matrix can contain a higher concentration of the individual matrix material."); 6:54-56 ("Both the emission layer 30 and also the electron transport layer 32 and the hole transport layer 31 can have matrices which are composed of three or more matrix materials."); 8:52-55 ("the compilation of the first, second, and third matrix material for the matrix"). Thus, the specification is consistent in describing each matrix material as being mixed throughout the matrix.

129. A POSITA would understand that one of the main functions of a matrix as described in the '164 patent is to facilitate light emission from the emitter material housed in the matrix. To be effective, a matrix needs to be in a continuous phase to not only encourage the efficient transport of electrons and holes through, *e.g.*, the electron transporting material and hole transporting material in the matrix, but to also ensure the desired distribution and stable housing of the emitter material. Given that the claimed matrix is composed of a "mixture of matrix materials," the mixture needs to form a continuous phase. That is, the multiple matrix materials would together form a mixed matrix—a connected structure that holds, e.g., the emitter material. The advantage of a mixed matrix is that some of the matrix materials can function as charge transport materials to improve the ability of the emitter material to produce light.

130. The extrinsic evidence also supports Samsung's construction. As one example, A Dictionary of Chemistry, Fifth Edition (2004) defines "matrix" as "(in chemistry) A continuous solid phase in which particles (atoms, ions, etc.) are embedded."). PICTSAMSUNGEDTX209934. Similarly, Chambers Dictionary of Science and Technology (2007) defines "matrix" as "(BioSci) More or less continuous matter in which something is embedded . . . ."). PICTSAMSUNGEDTX209937; *see also* Pictiva's Patent Owner Preliminary Response in IPR2024-01093, at 2-3 (citing these definitions); *see also id.* at 9.

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131. I additionally understand that Pictiva's expert in IPR2024-01093, Dr. Sims, made the following statement: "In the context of the '164 patent, a matrix material would be part of the continuous phase in a given organic layer . . . ." Declaration of Dr. Marc Sims in IPR2024-01093, Ex. 2001, ¶ 37.

B. "matrix material"

Claims	Pictiva's Construction	Samsung's Construction
1-6, 10, 13-16	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification	The first, second, and third matrix materials are different materials and are part of the same matrix.

132. In my opinion, "matrix material" should be construed to require that the claimed first, second, and third matrix materials are different materials and are part of the same matrix.

133. The claimed matrix materials must be different materials. Each matrix material is described as performing a particular role—*e.g.*, hole transport, electron transport, or high band gap. *E.g.*, '164 patent at 2:32-36 ("The first matrix material can be an Ultra Wide Band Gap (UGH) material, which has a band gap that is large in comparison to the other matrix materials."); 2:50-52 ("Thus, the second matrix material, which has a higher HOMO than the third matrix material, is more suitable as the hole transport material than the third matrix material."); 2:55-57 ("Thus, the third matrix material, which has a lower LUMO than the second matrix material, is suitable as the electron transport material."); 3:21-26 ("The first matrix material, which in comparison to the second and third matrix material has the largest band gap and the smallest charge carrier mobility, can be used to adjust the concentration of the second and the third matrix material separately from one another."). The listed goals of the invention rely on the three matrix materials working in concert, but having particular electrical properties, in order to improve charge carrier transport. *E.g.*, '164 patent at 1:33-36 ("One object of the invention is to provide an electronic device with an improved charge carrier transport and an improved charge carrier balance in the

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organic layers and thus an increased efficiency."); 8:52-55 ("The relative ratio of the LUMOs and HOMOs of the three combined materials and their position to one another is important in the compilation of the first, second, and third matrix material for the matrix.").

134. The electrical properties of the three matrix materials are reflected in the claim limitations requiring a specific relationship of HOMO and LUMO levels between the three matrix materials. The claims require HOMO and LUMO levels "energetically lower than" and "energetically higher than" other levels.

135. Moreover, the specification explicitly describes the three matrix materials as different. '164 patent at 1:55-59 ("Thus, an electronic device is made available which comprises more than two different matrix materials in an organic functional layer. Three different matrix materials can be present thereby, and depending on the need, more than three also."). I further note that the specification's reference to selecting matrix materials "similarly or differently" in 4:26-28 is referring to whether different layers (with their own matrices and matrix materials) can use the same materials as ***other layers***, not whether the three matrix materials present in a single given layer can be the same.

136. The claimed matrix materials must be part of the same matrix. A POSITA would have recognized that the claim itself requires this via the language "wherein the at least one organic functional layer has at least a first matrix material, a second matrix material, and a third matrix material." Thus, all three matrix materials are part of the same organic functional layer (which has a matrix). *Cf.* '164 patent at 4:24-26 ("Each of these layers can have a matrix, which has at least a first, a second, and a third matrix material."). Additionally, the specification describes the three matrix materials as being part of (and forming) the same matrix. *E.g.*, *id.* at 3:31-33 ("the mobility of electrons and holes in the matrix, which has at least three matrix materials"); 4:39-41

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("Depending on which charge carrier type is to have a higher mobility, the matrix can contain a higher concentration of the individual matrix material."); 6:54-56 ("Both the emission layer 30 and also the electron transport layer 32 and the hole transport layer 31 can have matrices which are composed of three or more matrix materials."); 8:52-55 ("the compilation of the first, second, and third matrix material for the matrix").

137. Additionally, a POSITA would have recognized that the invention does not make technical sense unless the three matrix materials are present in the same matrix such that they may electrically interact. The three matrix materials are chosen based on specific HOMO and LUMO values ***in relation to each other***. These HOMO and LUMO criteria would not make sense if one of the matrix materials could be in a different matrix, such that it was physically separate from the other matrix materials and therefore could not interact electrically with them. *E.g.*, *id.* at 5:3-6 ("By the adjustment of the charge carrier mobility with the aid of the three matrix materials, it is possible to purposefully influence the position of the recombination zone in an emission layer.").

C. "charge carrier mobility"

Claims	Pictiva's Construction	Samsung's Construction
4, 16	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, hole mobility (for a hole transport material) and/or electron mobility (for an electron transport material)	Indefinite

138. In my opinion, the '164 patent fails to inform a POSITA with reasonable certainty of the scope of the term "charge carrier mobility," and hence the scope of the claimed invention. The principal reason for this is that the charge carrier mobility is highly dependent on the surrounding environment and is not an intrinsic property of a material. But the '164 patent claims treat it as such. *E.g.*, '164 patent at cl. 4 ("the first matrix material has a charge carrier mobility

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which is lower than the charge carrier mobilities of the second and third materials."). This is not true for several reasons.

139. First, environmental factors like temperature and humidity can alter the molecular packing of the organic semiconducting materials. As one example, humidity can cause swelling of the organic layers. As another example, temperature fluctuations can lead to thermal expansion or contraction. These structural changes affect the intermolecular distances of the claimed matrix materials. The intermolecular spacing directly affects the overlap of π-orbitals. In turn, changes in orbital overlap influence the hopping transport mechanism that carriers use to move through the material. Better orbital overlap generally leads to higher mobility. Indeed, the '164 patent specification concedes that the molecular spacing directly influences charge carrier mobility. '164 patent at 3:17-21 ("The mobility of electrons and holes can depend on the molecule distance—that is, the average distance between charge carrier-transporting molecules in the individual matrix material. Thus, the concentration of a matrix material in the mixture of several matrix materials plays a role.").

140. Second, the presence of dopant/guest molecules changes the electronic structure around the matrix molecules. This affects the overlap between molecular orbitals in the transport pathway. Importantly, energy levels of the matrix material can shift due to these interactions. The degree of electronic coupling impacts how easily charges can move. Some dopants may create new pathways for charge transport. Other dopants may block existing transport channels.

141. Third, the relative HOMO/LUMO levels of surrounding materials influence charge transfer. For example, energy barriers at interfaces affect injection and transport of holes and electrons. Furthermore, local polarization effects from nearby molecules modify energy landscapes. These energetic factors directly impact carrier mobility.

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142. Last, the phenomenon known as "charge trapping" confirms that charge carrier mobilities are not intrinsic to particular types of matrix materials. Surrounding molecules can act as trap sites. Trap sites are locations with lower energy states than the normal transport path. The distribution and depth of these traps affects overall mobility. Charge carriers (electrons/holes) normally move through the material by hopping between molecules. When a charge encounters a trap, it falls into this lower energy state—extra energy is needed for the charge to escape and continue moving. This reduces the overall mobility since carriers spend time stuck in traps. The traps can be shallow, requiring only small amounts of energy to release carriers, or they can be deep, needing significant energy to free the trapped charge.

143. For at least these reasons, a POSITA would not be able to accurately assess whether a given material in isolation has a greater or lesser charge carrier mobility than another given material. Because claims 4 and 6 treat the charge carrier mobility as an immutable parameter of a material, the '164 patent fails to apprise a POSITA with reasonable certainty of the scope of those claims.

144. I have considered the part of the specification that states "the individual mobilities of the charge carriers are indicated in m2/Vs for the various line forms; they fluctuate between 10-8 to 10-12." '164 patent at 7:7-10. Various terms in that excerpt appear to be incorrectly formatted because they are not presented in superscript. Even if the excerpt had been correctly formatted, it would not have informed a POSITA of the scope of a "charge carrier mobility" with reasonable certainty.

145. I have further considered the specification's statement at 3:35-52 that "the mobility can be determined in the following manner" according to a formula from "Miller and Abraham." '164 patent at 3:35-52. The formula reproduced in the specification is particular to the "mobility"

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at "a localized state" and "between places i and j." The formula confirms that a "charge carrier mobility" is not an intrinsic property of a material. I additionally note that the mobility formula fails to account for several circumstances (as I described above) that could affect the ultimate mobility, and is therefore not accurate.

146. Other than these sections, the specification does not explain the nature of a "charge carrier mobility," or purport to provide a custom definition. The defects in the claimed usage of "charge carrier mobility" are not corrected or addressed by the specification.

147. I additionally note that Pictiva appears to agree that the "charge carrier mobility" is not a property intrinsic to a material, although it confuses "charge transport" and "charge carrier mobility." *See, e.g.*, Pictiva's Patent Owner Preliminary Response in IPR2024-01093, at 1 ("[C]harge transport depends on both charge carrier mobility and the number of charge carriers present . . . ."); Declaration of Dr. Marc Sims in IPR2024-01093, Ex. 2001, at ¶ 44 ("There are indeed many factors that influence charge carrier mobilities in organic semiconductors . . . .").

148. I conclude that "charge carrier mobility" and the claims that specify it are indefinite.

D. "A method for the production of an electronic device according to claim 1, comprising the steps of:"

Claims	Pictiva's Construction	Samsung's Construction
13	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is "a method for producing an electronic device that has the properties according to claim 1, the method of production includes, but is not limited to, the steps of …."	Indefinite

149. In my opinion, a POSITA reading claim 13 would not be able to understand the intended scope of the claim, and in particular whether the claim is directed to both method steps and apparatus limitations. Asserted claim 1 is an apparatus claim and includes limitations about

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the structure and components of a claimed electronic device. *E.g.*, '164 patent at cl. 1 ("a first electrode"). Asserted claim 13, which purports to depend from claim 1, is a method claim that contains method steps. *E.g.*, *id.* at cl. 13 ("C) placement of at least one organic functional layer between the first electrode and the second electrode, wherein ***in method step C*** . . . .") (emphasis added). It would not have been clear to a POSITA whether each structural limitation must be present in the device, in addition to requiring the method steps to be performed, in order to practice claim 13. Because the type classification of the claim is unclear, a POSITA would not be informed, with reasonable certainty, about the scope of the invention.

150. I disagree with Pictiva's proposed construction because it materially rewrites the claim language in a way that does not follow from the language itself. For example, it replaces "an electronic device according to claim 1" with "an electronic device that has the properties according to claim 1." But claim 1 includes structures that are not "properties," such as "a substrate" and "a first electrode." To the extent that Pictiva's proposed construction attempts to eliminate or read out requirements present in claim 1, the construction is inappropriate. Additionally, Pictiva's proposed construction does not address the mixing of apparatus and method claim types.

IX. '492 Patent Terms

A. "applied in a structured fashion" and "applying . . . in a structured fashion"

Term	Pictiva's Construction	Samsung's Construction
"applied in a structured fashion" (cls. 9, 10, 16)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification. For example, the '492 patent discloses"[t]he fact that the dielectric and/or the electrode layer and/or subsequently further layers or materials are 'applied in a structured fashion' means, in various embodiments, that the desired structure	"applied such that the desired structure is already formed during the application of the corresponding layer, in contrast to planar application of the corresponding layers and subsequent structuring of the layers, as is the case for

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	is already formed during the application of the corresponding layer. The area to be coated is thus coated only in partial regions dependent on the desired structure." '492, 1:66-2:4.	example in a photolithographic method."
"applying . . . in a structured fashion" (cls. 1, 10)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification. For example, the '492 patent discloses"[t]he fact that the dielectric and/or the electrode layer and/or subsequently further layers or materials are 'applied in a structured fashion' means, in various embodiments, that the desired structure is already formed during the application of the corresponding layer. The area to be coated is thus coated only in partial regions dependent on the desired structure." '492, 1:66-2:4.	"applying such that the desired structure is already formed during the application of the corresponding layer, in contrast to planar application of the corresponding layers and subsequent structuring of the layers, as is the case for example in a photolithographic method."

151. I understand that a patentee can act as his own lexicographer, that is, the patentee can set out a definition of a claim term in the patent itself. The patentee did so for the term "applied in a structured fashion"; the patentee set out in detail the meaning of that term in the context of the patent. Specifically, the patent specification states:

> "The fact that the dielectric and/or the electrode layer and/or subsequently further layers or materials are 'applied in a structured fashion' means, in various embodiments, that ***the desired structure is already formed during the application of the corresponding layer. The area to be coated is thus coated only in partial regions dependent on the desired structure.***
>
> ***This is in contrast to planar application of the corresponding layers and subsequent structuring of the layers, as is the case for example in a photolithographic method.*** The structured application of the layers makes it possible to be able to dispense with the firstly planar application of the corresponding layers and the subsequent complex structuring of the layers, for example the photolithographic method, and/or an expensive photoresist for the photolithographic method. This contributes to simple and/or cost-effective production of the passive electronic component."

'492 patent at 1:65-2:14 (emphasis added).

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152. Therefore, in my opinion, a POSITA would understand the term "applied in a structured fashion" to mean what the patent says it means. In the context of the term "applying . . . in a structured fashion," used in claims 1 and 10, I can discern no substantive difference, in the context of the intrinsic record, between the claim term "applied in a structured fashion" and the claim term "applying . . . in a structured fashion." Thus, I understand them to mean the same thing (other than the grammatical difference).

B. "optoelectronic component"

Claim	Pictiva's Construction	Samsung's Construction
10	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, an electrical or electronic component for detecting, sensing, generating, interconverting, modulating, transmitting, responding to, controlling or otherwise interacting with light or optical signals.	"An electrical or electronic component that converts optical energy into electrical energy, converts electrical energy into optical energy, or both"

153. In my opinion, at the time of the claimed invention, and in light of the intrinsic record as a whole, a POSITA would understand the term "optoelectronic component" in claim 10 of the '492 patent to mean: "An electrical or electronic component that converts optical energy into electrical energy, converts electrical energy into optical energy, or both." This understanding is consistent with the intrinsic record, as discussed further below, and with the general understanding of a POSITA of the term at the time of the claimed invention.

154. In order to understand the scope of the claims in the '492 patent, a POSITA would have to consider how to interpret the term "optoelectronic component," as well as how to interpret the term "passive electronic component," and how the two terms are different from one another. For example, claim 14 requires "the passive electronic component and the optoelectronic

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component are connected in series via the second contact region." Further, claim 10 of the '492 patent requires a "passive electronic component" and it separately requires that a certain "dielectric demarcates a component region for forming an optoelectronic component." In the specification of the patent, an overview of potential embodiments specifically references the embodiments' separate use of "optoelectronic components" and "passive electronic components." *See* '492 patent at 20:5-15 ("The disclosure is not restricted to the embodiments indicated. By way of example, it is possible to produce more than one, for example two, three or more passive electronic components and/or optoelectronic components, for example connected in series or in parallel, in particular without carrying out a photolithographic process and/or with only one etching process. Furthermore, it is possible to combine one, two or more passive electronic components with the optoelectronic component or the optoelectronic components, for example electrically in series one after the other and/or in parallel with one another.").

155. Thus, a POSITA would understand the patent to characterize "optoelectronic components" and "passive electronic components" in contradistinction to one another, and the patent claims require these two types of components separately. Therefore, in my opinion, a POSITA's understanding of the scope of the claims of the '492 patent, including claim 10, depends on a POSITA's understanding of the meaning of the term "optoelectronic component" and of the term "passive electronic component" (discussed separately below).

156. The term "optoelectronic component" is a well-understood term in the art. A number of technical dictionaries contain definitions of the term (or related terms). *See, e.g.*, Wiley Electrical And Electronics Engineering Dictionary; Steve M. Kaplan; John Wiley & Sons, Inc., 2004 ("optoelectronic device Also spelled opto-electronic device. 1. A device which converts optical energy into electrical energy. Also, a device which converts an optical signal into an

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electrical signal. An example is a photodiode. 2. A device which converts electrical energy into optical energy. Also, a device which converts on electrical signal into an optical signal. An example is an LED. 3. A device, such as a laser, which combines optics and electronics."). A POSITA would understand the term "optoelectronic component" to have this definition. In my opinion, the first definition is the most representative of how the term is used in the claims of the '492 patent. Other dictionary definitions around the time contain similar definitions. *See* McGraw-Hill Dictionary Of Scientific And Technical Terms, Sixth Edition, The McGraw-Hill Companies, Inc., 2003 ("optoelectronics [ELECTR] 1. The branch of electronics that deals with solid-state and other electronic devices for generating, modulating, transmitting, and sensing electromagnetic radiation in the ultraviolet, visible-light, and infrared portions of the spectrum."); A Dictionary of Physics, Fifth Edition, Oxford University Press, 2005 ("optoelectronics The branch of *electronics concerned with electronic devices (frequently solid-state devices) for generating, transmitting, modulating, and detecting *electromagnetic radiation, especially at optical, ultraviolet, and infrared frequencies."); A Dictionary of Electronics and Electrical Engineering (Oxford Quick Reference) by Andrew Butterfield, John Szymanski ("optoelectronics[:] The study and design of electronic devices that manipulate light in some way. These range from photodetectors that convert light into electricity to semiconductor lasers and *light-emitting diodes. The underlying theory is largely based on the principles of quantum physics. See also optical electronics.").

157. In my opinion, when reading the claim term "optoelectronic component" in the '492 patent, in light of the '492 patent and the intrinsic record as a whole, a POSITA would understand the patent to use the term in a way consistent with its generally accepted usage among people of ordinary skill in the art at the time of the claimed invention. Although the patent does

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not expressly define the term "optoelectronic component," the patent's many references to examples of optoelectronic components, and its references to functions of or structures of optoelectronic components, are consistent with how a POSITA would understand the term "optoelectronic component" at the time of the claimed invention.

158. Claim 13 describes, to some degree, steps for forming an "optoelectronic component" as contemplated by the '492 patent. *See* '492 patent at cl. 13 ("The method as claimed in claim 11, wherein a first electrode of an optoelectronic component is formed by the first electrically conductive layer between the optically functional layer and the substrate and a second electrode of the optoelectronic component is formed by the electrode layer on a side of the optically functional layer facing away from the first electrode, wherein the optoelectronic component comprises the organically functional layer between the first and second electrodes of the first optoelectronic component."). Embodiments addressed in the specification disclose similar contemplated optoelectronic devices. *See, e.g.*, '492 patent at 6:23-31.

159. The specification of the '492 patent also discloses a number of examples of optoelectronic devices. *See, e.g.*, '492 patent at 4:46-63 ("An optoelectronic component can be for example a component which absorbs or emits electromagnetic radiation. A component which absorbs electromagnetic radiation can be a solar cell, for example. In various embodiments, a component which emits electromagnetic radiation can be a semiconductor component which emits electromagnetic radiation and/or can be embodied as a diode which emits electromagnetic radiation, as an organic diode which emits electromagnetic radiation, as a transistor which emits electromagnetic radiation or as an organic transistor which emits electromagnetic radiation. The radiation can be for example light in the visible range, UV light and/or infrared light. In this connection, the component which emits electromagnetic radiation can be embodied for example

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as a light emitting diode (LED) as an organic light emitting diode (OLED), as a light emitting transistor or as an organic light emitting transistor. In various embodiments, the light emitting component can be part of an integrated circuit."); 8:31-48; *id.* 15:9-12 ("The optoelectronic component can be for example a component which emits electromagnetic radiation, for example a light emitting component **100**, for example in the form of an organic light emitting diode.").

160. In my opinion, understanding the term "optoelectronic component" to mean, "an electrical or electronic component that converts optical energy into electrical energy, converts electrical energy into optical energy, or both," reflects the full, broad scope of the term as it is used in the '492 patent.

C. "passive electronic component"

Claims	Pictiva's Construction	Samsung's Construction
1, 10, 16	For claims 1 and 16, the preamble is not limiting; For claim 10, plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, "an electronic component that is not active"	"an electronic component, such as a capacitor or a resistor, that is neither active nor an optoelectronic component"; phrase is limiting to the extent it is in a preamble.

161. Based on the parties' proposed constructions, there appears to be no dispute that a "passive electronic component" is not an active component. Further, the '492 patent clearly states that a capacitor or a resistor is an example of a "passive electronic component" and I do not understand there to be any dispute about that. *See* '492 patent at 2:20-21 ("A passive electronic component can be for example a capacitor and/or a resistor or a combination. . . .").

162. Thus, I understand that the only issue in dispute is whether a passive electronic component can be an optoelectronic component.

163. In my opinion, a POSITA would understand the term "passive electronic component" in claims 1, 10, and 16 of the '492 patent to not encompass an optoelectronic

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component. In my opinion, the claim term "passive electronic component" in claims 1, 10, and 16 of the '492 patent would mean, to a POSITA, "an electronic component, such as a capacitor or a resistor, that is neither active nor an optoelectronic component."

164. Throughout the intrinsic record, including in the claims and the specification, the '492 patent distinguishes between a "passive electronic component" and an "optoelectronic component." For example, the '492 patent is titled, "Method for producing a passive electronic component, method for producing an optoelectronic assembly and passive electronic component"; the specification, in turn, states: "An optoelectronic assembly may include for example a passive electronic component and one, two or more optoelectronic components." '492 patent at 8:29-31. S*ee* discussion of the term "optoelectronic component" (above); *see also id.* at 20:5-15; 4:35-41.

165. The claims in the '492 patent recognize the patent's distinction between passive electronic components and optoelectronic components. For example, claim 1 is directed to a "method for producing a passive electronic component," while claim 13 is directed to a method for forming an "optoelectronic component," and claim 14 covers "The method as claimed in claim 13, wherein the passive electronic component and the optoelectronic component are connected in series via the second contact region." Allowing a passive electronic component to be an optoelectronic component would render claim 14 unintelligible because it would not distinguish between the passive electronic component and the optoelectronic component. I understand that claims should be interpreted to avoid rendering them unclear to a POSITA.

166. The '492 patent discloses details about what passive electronic components are and how they are formed; it similarly discloses details about what optoelectronic devices are and how they are formed. *See, e.g.,* '492 patent at 8:31-34 ("An optoelectronic component may include for example a component which absorbs electromagnetic radiation and/or a component which emits

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electromagnetic radiation."); cl. 13 ("the optoelectronic component comprises the organically functional layer between the first and second electrodes of the first optoelectronic component"). Despite the patent's detail about passive electronic components and optoelectronic components, there is no disclosure, or suggestion, in the patent of any passive electronic component that could be an optoelectronic component. Interpreting "passive electronic component" to include at least some "optoelectronic devices" would render the claim language, including for claims 1, 10, and 16, indefinite, because the claims, read in light of the patent as a whole, relies on a distinct understanding of "passive electronic component" and "optoelectronic component."

167. The language of claim 10 clearly indicates that a passive electronic component cannot be an optoelectronic component. Claim 10 requires a "passive electronic component," comprising several enumerated substructures. Claim 10 also requires "applying the dielectric in a structured fashion to the second layer such that the dielectric demarcates a component region for forming an optoelectronic component." By referencing a "region for forming ***an*** optoelectronic component," the claim language implies that no optoelectronic component had been referenced so far in the claim (otherwise the claim would have referenced "***the*** optoelectronic component" or "***another***" optoelectronic component). However, claim 10 had already, of course, described a passive electronic component, without any indication that the passive electronic component could also be the later-referenced "optoelectronic device." Therefore, the language of claim 10 implies that a passive electronic component cannot be an optoelectronic component.

D. "plurality of capacitors and/or resistors"

Claim	Pictiva's Construction	Samsung's Construction
6	plain and ordinary meaning to a person of ordinary skill in the art in light of specifications, that is, "more than one capacitor and/or resistor"	Indefinite

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168. In my opinion, the term "plurality of capacitors and/or resistors," read in the context of the patent and its prosecution history, fails to provide a POSITA with reasonable certainty of the scope of the invention in claim 6. The language of claim 6, read together with the claim it depends from (claim 2) is, on its face, not comprehensible by a POSITA and thus fails to apprise a POSITA with reasonable certainty of the scope of the claim. Claim 6 states: "The method as claimed in claim 2, wherein a plurality of capacitors and/or resistors are formed electrically in parallel with one another and/or electrically in series one after another." Thus, claim 6 requires carrying out the method in claim 2 in a way that capacitors or resistors (or both) are formed in parallel with one another or in series one after another. Claim 2, in turn, addresses a method to form a capacitor, but it does not address a method to form a resistor (nor does the claim it depends from—claim 1). Thus, a POSITA has no way of discerning, based on the claim language, how claim 2 could possibly be carried out such that resistors are formed in parallel with or in series with other components, because claim 1, claim 2, and claim 6 nowhere disclose how resistors are to be formed under the "method as claimed in claim 2" at all. Thus, the language in claim 6 is unclear on its face and fails to apprise a POSITA of the scope of the claim (or how the claim can be carried out at all).

169. Reading claim 6 in connection with the prosecution history confirms that the language in claim 6 fails to provide reasonable certainty about the scope of the claim, and the prosecution history makes clear why the claim cannot be understood in its present form. In a March 25, 2015 preliminary amendment from the applicants of the '492 patent, the applicants stated that "Claims 3, 6-10, 13, and 15 have been amended to remove multiple dependence." Preliminary Amendment at 10. The content of the amendment shows that claim 6 previously stated: "The method as claimed in any of the preceding claims wherein two, three or more

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capacitors and/or resistors are formed electrically in parallel with one another and/or electrically in series with one another." *Id.* at 5. Prior to the amendment, claim 2 addressed a method for forming a capacitor, and claims 3-5, together, addressed methods for forming a resistor. In this pre-amendment context, claim 6 depended on a set of claims that disclosed a method for forming a capacitor and a method for forming a resistor; thus, performing those methods "wherein two, three or more capacitors and/or resistors are formed in parallel with one another and/or electrically in series with one another" was comprehensible by a POSITA. However, in its amended form, claim 6 depends on a method for forming a resistor, but no such method for forming a resistor is referenced in any of the relevant claim language.

170. Thus, the applicants for the '492 patent rendered claim 6 unclear and ambiguous when they revised the claim to make it depend only on claim 2 (which concerns a method for forming a capacitor) instead of claim 6 depending on claims 1-6 (which, together, concern methods for forming a capacitor and for forming a resistor). In my opinion, a POSITA cannot make sense of the scope of the asserted claim 6, nor could a POSITA understand what the above-discussed amendment to claim 6 accomplished (or was meant to accomplish).

E. "a resistance region . . . which has a taper in a direction parallel to the electrically conductive layers"

Claim	Pictiva's Construction	Samsung's Construction
3	plain and ordinary to a person of ordinary skill in the art in light of the specification, that is, "a resistance region which has a shape that gradually narrows in a direction parallel to the electrically conductive layers"	Indefinite

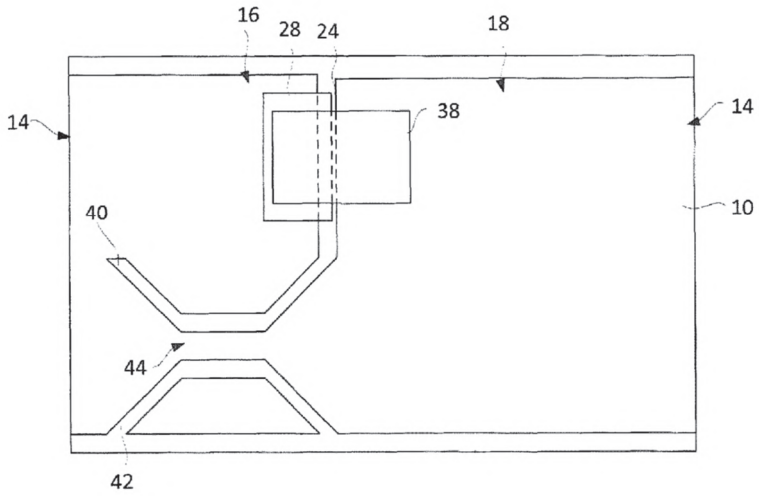
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171. Claim 3 requires: "The method as claimed in claim 1, wherein, before the dielectric is applied, a second trench and at least one third trench are formed, which delimit a resistance region, which comprises a part of the first and second electrically conductive layers and which has a taper in a direction parallel to the electrically conductive layers. . . ."

172. For purposes of the claim term at issue, the "resistance region" is required to have "a direction parallel to the electrically conductive layers." As a POSITA, reading this claim term in light of the patent as a whole, together with the prosecution history, it is my opinion that this claim does not provide reasonable certainty to a POSITA of the scope of the invention. While the crux of the claim limitation at issue is that the taper of the resistance region must be oriented in a certain direction, it is impossible to discern what direction is within versus not within the scope of the claimed invention.

173. Figure 10 depicts one orientation of the taper:

Fig. 10



174. The associated explanation in the specification states: "FIG. 10 shows a plan view of one embodiment of a passive electronic component which includes for example the capacitor explained above. The passive electronic component includes for example the second trench **40** and

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the third trench **42**, in which the substrate **10** is exposed. The second and third trenches **40**, **42** can demarcate the resistance region **44**, for example, which has the taper. The resistance region **44** can lead for example into the first contact region **16**, on the one hand, and into the second contact region **18**, on the other hand." '492 patent at 13:1-14.

175. The "resistance region" is a region of the electrically conductive layers, as described in the language of claim 3. Thus, the resistance region is both a part of the electrically conductive layers ***and*** it must contain a taper that is parallel to those layers. The patent and prosecution history nowhere clarify how it can be determined whether the taper is "parallel" to the layers or not, nor is it comprehensible to a POSITA how such a determination can be made, in the context of the patent. Because the resistance region is formed from the electrically conductive layers, it must be in the same plane as the electrically conductive layers. Further, because the resistance region is in the same plane as the electrically conductive layers, the line that forms the direction of the resistance region's taper must be part of the plane that forms the electrically conductive layers. Thus, the claim limitation that the resistance region's taper must be parallel to the electrically conductive layers means that the line defining the taper's direction (which is in the electrically conductive layers) must be parallel to the plane of the electrically conductive layers. There is no understood concept in the art that would allow a POSITA to discern what direction would satisfy the claim limitation of the taper being "parallel" to the electrically conductive layers versus not "parallel" to the electrically conductive layers in this context. When a line lies in a plane, whether that line is parallel to or not parallel to that plane is not a meaningful distinction.

176. To make an analogy, if a circular pizza is sliced twice, once vertically and once horizontally, the top-right slice will be made of the pizza layers (like the resistance region is made of the electrically conductive layers) and it will have a taper (from the crust of the pizza in to the

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center). However, requiring that the taper of the pizza slice be in a direction "parallel" to the layers of the pizza does not make sense. The pizza slice can be rotated in any direction and the direction of the slice's taper is still equally "parallel to" (or "not parallel to") the layers of the pizza.

177. Thus, there is no way for a POSITA to determine with reasonable certainty the scope of claim 3.

178. More specifically, there are two ways to look at whether the line of the taper's direction is parallel to the plane of the electrically conductive layers, of which that line is a part. First, geometrically, a line that is part of a plane is not typically considered "parallel" to that plane because the line instead lies within the plane. According to this understanding, there is no way for the taper to have a direction that is parallel to the electrically conductive layers because that direction is in the layers rather than parallel to the layers, and thus there is no way for the relevant claim limitation to be satisfied. Second, one could argue that the line of the taper's direction is parallel to the electrically conductive layers because, for example, the direction can be indicated by a line above those layers (like how a minute hand on a clock indicates a direction on the clockface, while being parallel to and above the clockface). Under this understanding, the claim limitation does not make sense because any direction of the taper would be equally parallel to (or not parallel to) the electrically conductive layers, and thus the substance of the claim limitation cannot be resolved.

179. I wish to note that it is common to define mathematical planes by their surface-normal vector. Accordingly, the direction of the vector associated with the plane is directed along the direction normal (perpendicular) to the plane. Applying this principle to a layer would associate a surface-normal direction with the layer. This creates ambiguity when determining the direction of a layer in this context.

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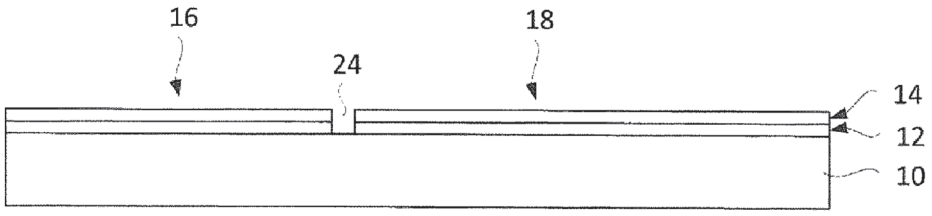
F. "second trench" and "third trench"

Term	Pictiva's Construction	Samsung's Construction
"second trench" (cl. 3)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, where the recited first/second/third trench need not be different in properties	"second trench in the first or second electrically conductive layer, or in both such layers."
"third trench" (cl. 3)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, where the recited first/second/third trench need not be different in properties	"third trench in the first or second electrically conductive layer, or in both such layers."

180. Claim 1 contains the term "first trench," and the claim language specifies, to some degree, in what material and where that "first trench" is to be formed. Specifically, claim 1 requires: "forming a ***first trench*** in the first and second electrically conductive layers such that the substrate is exposed in the ***first trench***, wherein the ***first trench*** separates a first contact region from a second contact region." '492 patent at cl. 1 (emphasis added).

181. Further, the specification sets forth how the first trench can "delimit" one region of the disclosed structure from another: "The first trench 24 separates a first contact region 16 from a second contact region 18. The first trench 24 can be part of a trench structure, which partly or completely delimit for example the first and/or second contact region 16, 18 in the planes of the two electrically conductive layers 12, 14." '492 patent at 11:40-44 (referring to Figure 4, below).

Fig. 4



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182. Claim 3 states: "The method as claimed in claim 1, wherein, before the dielectric is applied, a ***second trench*** and at least one ***third trench*** are formed, which delimit a resistance region, which comprises a part of the first and second electrically conductive layers." '492 patent at cl. 3 (emphasis added). In my opinion, the language of claim 1 and claim 3, read in the context of the rest of the intrinsic record, requires that the second and third trench each be in either first electrically conductive layer, the second electrically conductive layer, or both. This is in contrast to the second and third trench being in some material other than the first or second electrically conductive layers; I do not understand this to be possible under the language of the specification and the claims.

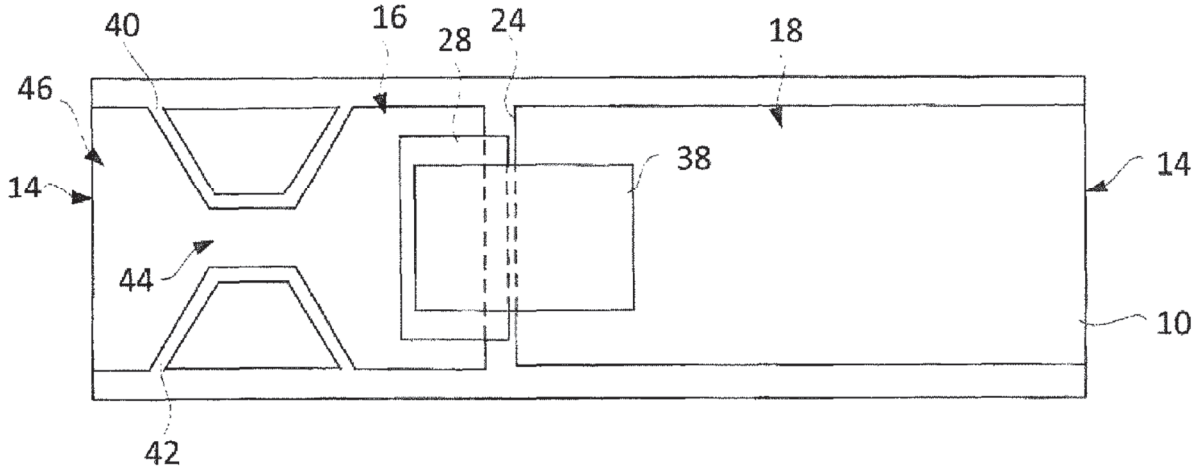
183. First, the language at the beginning of claim 3 requires the second and third trench to be in the first and second electrically conductive layers (or both). The second and third trench are to be formed "before the dielectric is applied" in claim 1. Claim 1, in turn, refers to only three structures or materials "before the dielectric is applied": (1) a first electrically conductive layer; (2) a second electrically conductive layer; and (3) a substrate. Thus, these three materials are the only disclosed materials in which the second trench and third trench could possibly be formed. According to the disclosures in the patent, the second and third trenches are to be formed in the first and second electrically conductive layers, and not in the substrate. The patent and prosecution history nowhere suggest that any trenches would (or could) be made in the substrate, and indeed, making the second or third trench in the substrate would be contrary to the understanding of a POSITA in the context of the patent and the prosecution history. The purpose of the trenches, in the claimed invention, is to create electrical separation between portions of the first and second electrically conductive layers (*see* Figure 4, and associated discussion, above), and all disclosed embodiments in the '492 patent achieve this purpose. Making trenches in the substrate (but not in

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the first or second electrically conductive layers) would serve no purpose discernable from the patent (but such a trench in the substrate could destroy the structural integrity of the claimed invention by breaking it apart).

184. For example, Figure 4 (above) and Figure 9 (below) show the second trench (40) and third trench (42) as akin to the first trench (24), and all three are shown as trenches in the first electrically conductive layer (12) and second electrically conductive layer (14); none of the three trenches are shown in the substrate (10).

Fig. 9



185. Second, according to language in claim 3, the second and third trench "delimit a resistance region, ***which comprises a part of the first and second electrically conductive layers***." '492 patent at cl. 3 (emphasis added). For the second and third trenches to delimit a region in the first and second electrically conductive layers, those trenches must be in those electrically conductive layers. The only form of "delimiting" disclosed in the patent or the prosecution history is the separation of two portions of the first and second electrically conductive layers with a trench. *See* Figure 4 and preceding language from the specification, above. Thus, for the first and second

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trenches to delimit a resistance region in the first and second electrically conductive layers, those two trenches must be formed in the first and second electrically conductive layers.

186. In my opinion as a POSITA, a POSITA who reads claim 3 of the '492 patent in the context of the patent as a whole and the prosecution history would understand the "second trench" and "third trench" to be made in either the first electrically conductive layer, the second electrically conductive layer, or both, because the claim language implies that understanding and there is no other disclosed material in which it would be feasible or practically possible to form those trenches.

G. "applying an electrically conductive electrode layer in a structured fashion to the dielectric above the first contact region and to the second contact region"; "an electrically conductive electrode layer, which is applied in a structured fashion to the dielectric above the first contact region and to the second contact region"; "an electrically conductive electrode layer, which is applied in a structured fashion on the dielectric above the first contact region and at least partly on the second contact region"

Term	Pictiva's Construction	Samsung's Construction
"applying an electrically conductive electrode layer in a structured fashion to the dielectric above the first contact region and to the second contact region" (cl. 1)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, with "applying … in a structured fashion" as construed above; no other parts require construction	"applying an electrically conductive electrode layer in a structured fashion to the dielectric above, ***and insulated from,*** the first contact region, and to the second contact region." (emphasis added)
"an electrically conductive electrode layer, which is applied in a structured fashion to the dielectric above the first contact region and to the second contact region" (cl. 10)	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, with "applied … in a structured fashion" as construed above; no other parts require construction	"an electrically conductive electrode layer, which is applied in a structured fashion to the dielectric above***, and insulated from***, the first contact region, and to the second contact region" (emphasis added)
"an electrically conductive electrode layer, which is applied in a structured fashion on the dielectric above the	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, with "applied … in a structured fashion" as	"an electrically conductive electrode layer, which is applied in a structured fashion on the dielectric above***, and insulated from,*** the first

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first contact region and at least partly on the second contact region" (cl. 16)	construed above; no other parts require construction	contact region, and at least partly on the second contact region" (emphasis added)

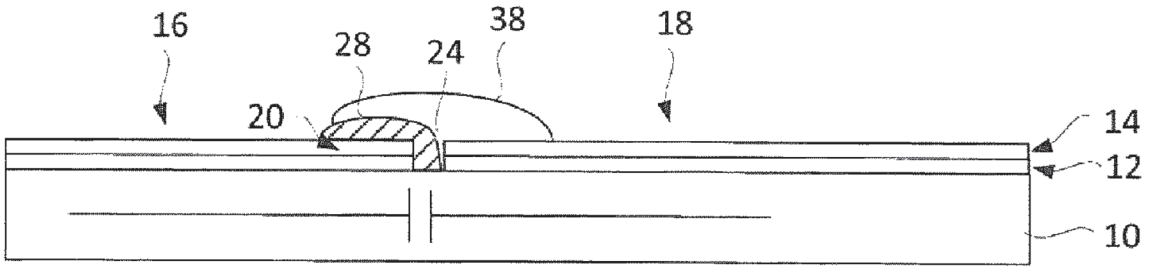
187. The above claim elements, in claims 1, 10, and 16, all require that an "electrically conductive electrode layer" be applied "in a structured fashion" on or to "the dielectric above the first contact region." In my opinion, in isolation, this claim language is unclear and ambiguous to a POSITA because it does not indicate where the electrically conductive electrode layer is to be applied with respect to the other claimed structures. While the claim language states that the application of the electrically conductive electrode layer is to be "in a structured fashion," "in a structured fashion" means (in part) that "[t]he area to be coated is thus coated only in partial regions dependent on the desired structure." '492 patent at 2:3-4. Thus, the claim language at issue leaves unclear ***which*** "partial regions" are to be coated, and ***what*** the desired structure is. In other words, the claim language at issue requires that the electrically conductive layer be applied in a particular place, to create a particular structure, but the claim language does not specify where that place is or what that structure is.

188. However, in my opinion, reading this claim language in the context of the patent as a whole makes clear that this claim language requires that the electrically conductive electrode layer be applied to the dielectric material such that the electrically conductive electrode material is not in electrical contact with the underlying first contact region—that is, the claim language requires that the electrically conductive electrode layer be ***insulated from*** the first contact region.

189. Figure 7 is generally illustrative:

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Fig. 7



190. In this figure, 16 is the "first contact region"; 18 is the "second contact region"; 28 is the dielectric, and "an electrode layer 38 is applied in a structured fashion on the dielectric 28 and a part of the second contact region 18." '492 patent at 12:29-31. The specification further explains: "The first contact region 16 between the substrate 10 and the electrode layer 38 serves as a first electrode, for example as an anode, of the passive electronic component. The electrode layer 38 on a side of the dielectric 28 facing away from the substrate 10 serves as a second electrode, for example as a cathode, of the passive electronic component." *Id.* at 12:31-36. Thus, in this figure, the first contact region 16 and electrode layer 38 are different electrical contact points for an electronic component, and they are separated by a dielectric (i.e., insulating) material, 28. While I do not understand the claims to be limited to the structure depicted in Figure 7, this figure helps explain the structures referenced in the claim language.

191. The claims at issue all expressly require that the "dielectric electrically insulates the first contact region from the second contact region." '492 patent at cls. 1, 10, 16. Such insulation is only possible if the electrode layer is insulated from the first contact region (as in Samsung's proposed constructions) because, if the electrode layer is in electrical contact with the first contract region, then the first contact region and second contact region will be in electrical contact with one another via the electrode layer (and the dielectric would not "insulate" "the first contact region from the second contact region").

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192. More specifically, the claim language at issue requires the electrically conductive electrode layer be applied (in a structured fashion) (1) on or to the dielectric, above the first contact region, and (2) to the second contact region. Because the electrode layer is "electrically conductive" (under the claim language), it will electrically connect the materials that the electrode layer touches. Thus, in understanding how the application of the electrode layer "in a structured fashion" is to be performed under the claim language, a POSITA would seek to resolve one fundamental question: which of the claimed structures does the electrode touch, and which of the claim structures does it not touch? The claim language is explicit that the electrode layer touches the dielectric (i.e., the insulator) and it touches the second contact region. The only remaining question, then, is: does the electrode layer touch the other structure present, that is, the first contact region? The claim language that the "dielectric electrically insulates the first contact region from the second contact region" resolves that question: the electrode layer cannot touch the first contact region, because if it did, the dielectric would not insulate the first contact region from the second contact region; the electrode layer would electrically connect those two regions. In my opinion, a POSITA would understand the claim language to require that the electrically conductive electrode layer be insulated from the first contact region because if it were not, then the claim language requiring the dielectric to insulate the first contact region from the second contact region would not be satisfied. Further, an interpretation of the claim term that allows the electrically conductive electrode layer to be in electrical contact with the first contract region would render meaningless, from a technical perspective, the claim requirement that the "dielectrically insulates the first contact region from the second contact region" because the dielectric cannot insulate those two regions if another material electrically connects them. I understand that claim language should generally not be interpreted to be superfluous or meaningless.

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193. The dielectric claimed in claims 1, 10, and 16 fundamentally serves to insulate the first contact region and the second contact region (as required explicitly by the claim language), and to do so, the electrode layer must be insulated from the first contact region, as described above. Therefore, application of the electrode layer "in a structured fashion," as required by the relevant claim language, means that the electrode layer will be applied such that it remains insulated from the first contact region.

194. Disclosures throughout the patent confirm that the first contact region is to remain insulated from the second contact region (and thus, the electrode layer must be insulated from the first contact region), and the patent nowhere indicates or suggests that the electrode layer can be in contact with the first contact region. *See, e.g.*, '492 patent at 1:58-65 ("A dielectric is applied in a structured fashion to the second electrically conductive layer in the first contact region and the substrate in the trench such that the dielectric electrically insulates the first contact region from the second contact region. An electrically conductive electrode layer is applied in a structured fashion to the dielectric above the first contact region and to the second contact region."); *id.* 6:60-7:1 ("A dielectric is applied in a structured fashion on the second electrically conductive layer in the first contact region and at least partly on the substrate in the first trench such that said dielectric electrically insulates the first contact region from the second contact region. An electrically conductive electrode layer is applied in a structured fashion on the dielectric above the first contact region and on the second contact region."); *id.* 3:38-47 ("In various embodiments, a first electrode of a capacitor is formed by the first contact region between the dielectric and the substrate and a second electrode of the capacitor is formed by the electrode layer on a side of the dielectric facing away from the first contact region. When an electrical voltage is applied to the first and second contact regions, the capacitor is charged, in particular the electrodes are charged, and an electric

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field forms between the electrodes. The electrical energy in the electric field existing between the charged electrodes is stored in the charged capacitor."); *id.* 11:47-56 ("FIG. 5 shows the substrate 10 and the first and second electrically conductive layers 12, 14, wherein one embodiment of a dielectric 28 is applied in a structured fashion to the second electrically conductive layer 14 in a manner adjoining the trench 24. The dielectric 28 can be an electrically insulating substance, for example, which can subsequently prevent a direct current flow between the first or second electrically conductive layer 12, 14 in the first contact region 16 and the first or second electrically conductive layer 12, 14 in the second contact region 18.").

X. '425 Patent Terms

A. "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation"

Claim	Pictiva's Construction	Samsung's Construction
1	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, where "a spectral range from infrared radiation to UV radiation" refers to spectral range from a wavelength in the infrared radiation range (e.g., between about 730 n.m. to about 300 micrometer) to a wavelength in the UV radiation (e.g., between about 400 nm to about 40 nm). No other terms require construction.	"the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range that includes the full spectrum from infrared radiation to UV radiation during operation"

195. In my opinion, the term "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation," as used in the '425 patent and as understood by a POSITA at the time of the alleged invention, refers to "the organic layer sequence comprises

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at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range that includes the full spectrum from infrared radiation to UV radiation during operation."

196. A POSITA at the time of the alleged invention would understand that "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation" is "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range that includes the full spectrum from infrared radiation to UV radiation during operation." The organic layer sequence must generate electromagnetic radiation in the spectral range from infrared radiation to UV radiation during operation. This claim term states that the radiation-emitting region is configured to generate electromagnetic radiation in the spectral range during operation. A POSITA would understand that configuring the radiation region to generate electromagnetic radiation in the spectral range from infrared radiation to UV radiation during operation means that the radiation is this full range during operation. By stating "during operation," a POSITA would understand that the spectral range emitted during operation is the full spectral range—not a subrange.

197. My opinion that "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation" is "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range that includes the full spectrum from infrared radiation to UV radiation during operation" is confirmed by the '425 patent specification. For example, the '425 patent is directed to light devices for broad use that would need broad spectrum spectral ranges that include the entire range from infrared radiation to UV radiation during operation. For example, the '425 patent is directed to "luminaires

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[that] can be, for example, luminaires which are used as an alarm clock, which form part of a shower cubicle, which form part of a shower head, which serve as solar protection, which serve as rain protection, which are provided for general lighting which can be used in mobile fashion and/or which inherently combine a plurality of these functions." '425 patent at 1:43-49. Given the broad applications for the '425 patent luminaires and they "inherently combine a plurality" of the broad functions, a POSITA would understand that the full spectrum from infrared radiation to UV radiation would be emitted during operation.

198. Additionally, the '425 patent states that "[d]uring the operation of the organic light-emitting diode 1, electromagnetic radiation is generated in the radiation-emitting region. Therefore, the emission 108 of electromagnetic radiation occurs in the radiation-emitting region. ***Preferably, electromagnetic radiation in the spectral range of infrared radiation to UV radiation is generated in this case***." '425 patent at 24:46-54. A POSITA would understand from the '425 patent's description of the spectral range that it is the full spectrum from infrared radiation to UV radiation emitted during operation. I further note that the emission spectrum is specified to reach from the IR (infrared) to the UV, yet does not require to include IR and / or UV radiation. This means that the emission spectrum must include, at a minimum, the entire visible spectral range.

199. I disagree with Pictiva's proposed construction. A POSITA would not understand "a spectral range from infrared radiation to UV radiation" to refer to spectral range from a wavelength in the infrared radiation range (e.g., between about 730 n.m. to about 300 micrometer) to a wavelength in the UV radiation range (e.g., between about 400 nm to about 40 nm). Pictiva's proposed construction would render this limitation meaningless as it merely states that the spectral range could be any wavelength or wavelengths within the range from infrared radiation to UV radiation. A POSITA would not understand "a spectral range from infrared radiation to UV

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radiation" to refer to spectral range from a wavelength in the infrared radiation range (e.g., between about 730 n.m. to about 300 micrometer) to a wavelength in the UV radiation (e.g., between about 400 nm to about 40 nm) as it is not consistent with the '425 patent's specification or the plain language of the claims.

200. Thus, it is my opinion that a POSITA at the time of the alleged invention would understand the term "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation," as used in the '425 patent means "the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range that includes the full spectrum from infrared radiation to UV radiation during operation."

B. "encapsulation"

Claims	Pictiva's Construction	Samsung's Construction
1, 3-4, 18	plain and ordinary meaning to a person of ordinary skill in the art in light of the specification, that is, a material for surrounding or sealing something else	"a seal of the organic layer sequence against environmental influences"

201. In my opinion, "encapsulation" should be construed as "a seal of the organic layer sequence against environmental influences."

202. A POSITA at the time of the alleged invention would understand that "encapsulation" means "a seal of the organic layer sequence against environmental influences." The organic layer sequence in the claims must be protected from environmental influences. A POSITA would understand that "encapsulation" is the sealing of the organic layer sequence against environmental influences.

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203. My opinion that "encapsulation" means "a seal of the organic layer sequence against environmental influences" is confirmed by the '425 patent specification. The '425 patent specification states "[t]he encapsulation forms a seal of the organic layer sequence against environmental influences." '425 patent at 1:28-38. A POSITA would understand from this disclosure in the '425 patent that "encapsulation" means "a seal of the organic layer sequence against environmental influences."

204. I disagree with Pictiva's proposed construction that "encapsulation" means "a material for surrounding or sealing something else." Pictiva's proposed construction is not how a POSITA understands encapsulation. Pictiva's proposed construction would cover any material that surrounds another material or layer and would render the limitation meaningless. Additionally, Pictiva's construction is not supported by the '425 patent.

***

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct to the best of my knowledge and belief.

Executed this 12th day of November, 2024, at Troy, New York.



E. Fred Schubert

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Citizenship

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Naturalized United States Citizen (1995)

Education

University of Stuttgart	Electrical Engineering	Vordiplom	(U. S. equivalent BSEE)	1978
University of Stuttgart	Electrical Engineering	Diplom Ingenieur (Honors)	(U. S. equivalent MSEE)	1981
Oregon State University	Electrical Engineering	Exchange Student		1977–1978
University of Stuttgart	Electrical Engineering	Doktor Ingenieur (Honors)	(U. S. equivalent Ph.D.)	1986

Current appointment

2002 – present: Professor, Department of Electrical, Computer, and Systems Engineering; Rensselaer Polytechnic Institute, Troy NY

Previous appointments

2002 – 2015: Head and Founder of the Future Chips Constellation; Rensselaer Polytechnic Institute
2002 – 2015: Wellfleet Senior Constellation Professor, Future Chips (Chaired Professor); Rensselaer Polytechnic Institute
2002 – 2012: Professor Department of Physics, Applied Physics, and Astronomy; Rensselaer Polytechnic Institute
2008 – 2009: Director, Founding Director, and Principal Investigator, NSF Engineering Center for Smart Lighting, Rensselaer Polytechnic Institute
2002 – 2003: Adjunct Professor, Boston University
1995 – 2002: Professor, Boston University, Department of Electrical and Computer Engineering; Director of the Semiconductor Devices Research Laboratory; Affiliated Faculty of the Photonics Center.
1988 – 1995: Member of Technical Staff; Principal Investigator; and Member of Management at AT&T Bell Laboratories in Murray Hill, New Jersey
1985 – 1987: Post-Doctoral Member of Technical Staff at AT&T Bell Laboratories in Holmdel, New Jersey.
1981 – 1985: Scientific Member of Staff in the Department of Solid-State Chemistry at the Max Planck Institute for Solid-State Research in Stuttgart, Germany. Ph.D. Dissertation title: “Modern Schottky gate field-effect transistors based on III–V semiconductors”

Fields of Technical Expertise, Hands-on Experience, and Teaching

- Expertise, hands-on experience, and teaching in semiconductor opto-electronics including the following devices: LED, semiconductor laser, vertical cavity surface-emitting laser (VCSEL), solar cell, photo-detector, LED displays, micro-LED displays, and LCD displays. The activities include the design, fabrication, processing, and packaging of the devices, and the use of the devices in circuits and systems. (1981 to present)
- Expertise, hands-on experience, and teaching in semiconductor electronics including the following devices: MESFET, HFET, MOSFET, CMOS-FET, LDD MOSFET, LD MOS FET, FinFET, GAA FET, Vertical MOSFET (high-power MOSFET), thyristor, GTO thyristor, and IGBT. The activities include the design, fabrication, processing, and packaging of the devices, and the use of the devices in discrete and integrated circuits. (1979 to present)
- Expertise, hands-on experience, and teaching in thin-film deposition of metal, semiconductor, and insulator films by PVD (physical vapor deposition) and CVD (chemical vapor deposition) including PECVD (plasma enhanced CVD), MOCVD (metal-organic CVD), ALE (atomic layer epitaxy), ALD (atomic layer deposition), and bulk crystal growth (AlN, GaN, and sapphire). Epitaxial growth of silicon, III-V arsenide, phosphide and nitride epitaxial layers on GaAs, sapphire, Si, and GaN substrates by epitaxy including molecular beam epitaxy (MBE),

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metal-organic chemical vapor deposition (MOCVD), and vapor-phase epitaxy (VPE). High-k materials, low-k-materials, phosphors, resins, polymers, encapsulants, alloy semiconductors and their deposition technologies such as epitaxy, CVD, and PVD. Doping of semiconductors by various means including delta doping and atomic monolayer doping. (1981 to present)

- Expertise, hands-on experience, and teaching in the design, operation, and usage of semiconductor devices in lighting systems, communication systems, and power-supply systems and in the analysis and development of LED power supplies using Boost and Buck Converters. (1993 to present)

Technical Research Activities

- Design, development and fabrication of a Si pressure sensor based on the piezo-resistivity of Si using a bridge configuration of four thin-film Si resistors (1979 – 1980)
- Design of a electro-optic Mach-Zehnder Interference Modulator based on Lithium niobate ($LiNbO_3$) operating at a wavelength of 1300 nm (1980 – 1981)
- First study of hot electron effects in selectively doped $Al_xGa_{1-x}As/GaAs$ heterostructures (1983)
- Demonstration and elimination of parallel conduction in $Al_xGa_{1-x}As/GaAs$ heterostructures (1984)
- First analysis of semiconductors doped with simultaneously shallow and deep donors (1984).
- Development and use of thyristor circuits (including GTO thyristor circuits) for the control of a lamp heating system (1984 – 1985)
- Proposal and demonstration of the δ-doped field-effect transistor. Short-channel effects in sub-micron field-effect transistors can be reduced to their theoretical minimum by using δ-doped structures (1985)
- Development of the theory of alloy broadening in luminescence spectra of alloy semiconductors such as $Al_xGa_{1-x}As$. The current understanding of the low-temperature spectral linewidths of ternary and quaternary alloy semiconductors is based on this theoretical model. The publication analyzing the phenomenon of alloy broadening has been referenced far in excess of 100 times (1984)
- First demonstration of a light-emitting diode with a doping superlattice active region (1985)
- Application of δ-doping to selectively doped heterostructures; Demonstration of high-electron-mobility transistors (HEMTs) with highest free electron concentrations; Analysis of structures by SEM, TEM, and SIMS (1986).
- Demonstration of delta-doped non-alloyed ohmic contacts with very low contact resistance and subsequent demonstration of self-aligned field-effect transistor with delta-doped non-alloyed ohmic contacts (1986)
- Demonstration of the spatial localization of dopants within 20 Å for a number of doping elements in delta-doped semiconductors including GaAs and Si for MESFET and lightly-doped drain (LDD) MOSFET applications and the analysis of delta-doped structures by SIMS (secondary ion mass spectrometry) (with colleague Henry S. Luftman, 1983-1995)
- Significant improvement of the optical properties of doping superlattices by employment of delta doping. Improvement is demonstrated by the first observation of quantized interband transitions in the absorption (1988) and in the emission spectra (1989)
- First demonstration of tunable doping superlattice laser (1989)
- First quantitative analysis of the capacitance-voltage (CV) profiling technique in semiconductors with quantum-confined carriers. Demonstration that resolution of CV profiles in quantum-confined semiconductors is not limited to the Debye screening length (1990)
- Invention and demonstration a new concept by which heterojunction band discontinuities occurring between two different semiconductors are eliminated. The *elimination of heterojunction barriers* is based on parabolic compositional grading of doped heterojunctions. This concept is widely used in the fabrication of vertical cavity surface emitting lasers and other heterojunction devices (1991)
- Invention and first demonstration of resonant cavity light-emitting diode (RCLED) which uses photon quantization in microcavities to enhance the spontaneous emission properties (1992)
- Demonstration of giant enhancement of luminescence intensity in Er-doped Si-SiO_2 microcavities (1992)
- First demonstration of a resonant-cavity detector which is useful for wavelength-selective detection (1993)
- Demonstration of resonant-cavity light-emitting diode (RCLED) with very high brightness. The experimental brightness of the RCLED is five times higher than that of conventional LEDs. Based on calculations, the brightness of RCLEDs is expected to exceed that of conventional LEDs by more than a factor of ten (1994)
- Demonstration of delta doping in silicon for the fabrication of shallow junctions in scaled-down Si lightly-doped drain (LDD) MOSFETs for integrated circuits (Si ICs) (with colleague Dr. H. J. Gossmann, 1990 – 1995)
- Invention of a new concept, *superlattice doping*, for enhanced p-type doping of GaN. All acceptors in GaN are deep, resulting in a low electrical acceptor activation of only 5 %. The new concept of superlattice doping is expected to increase the electrical activation of acceptors by more than a factor of ten (with post-doctoral associate Dr. W. Grieshaber, 1995)

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- Investigation of yellow luminescence in GaN and the use of microcavity effects in Ag / GaN / sapphire structures to determine the refractive index of GaN (with post-doctoral associate Dr. W. Grieshaber, 1996)
- Demonstration of the first GaN / GaInN double heterostructure laser. The laser has cleaved facets and was optically pumped. Laser action was demonstrated by (*i*) a threshold in the light-versus-current characteristic, (*ii*) spectral narrowing below *kT* above threshold, (*iii*) a TE / TM polarization ratio greater than one hundred above threshold, and (*iv*) increased slope efficiency with increasing back-side facet reflectivity (with graduate student D. A. Stocker, 1997)
- Co-inventor of photonic-crystal light-emitting diode, PC-LED, jointly with group of Prof. John D. Joannopoulos at MIT (publication by Shanhui Fan *et al*. appeared in *Physical Review Letters* in 1997; US patent 5,955,749 was issued in 1999)
- First demonstration of crystallographic etching of GaN (with graduate student D. A. Stocker, 1998). The discovery, crystallographic etching, can be implemented by wet chemical etching, including photo-enhanced electrochemical (PEC) wet etching. The discovery is widely used in the LED industry to strongly enhance light extraction from LED chips and is found in LED light bulbs.
- Experimental demonstration of a ten-fold enhancement of p-type doping activation in $Al_xGa_{1-x}N$/GaN doped superlattices as compared to bulk GaN and $Al_xGa_{1-x}N$ (with graduate students D. A. Stocker and I. D. Goepfert, 1999)
- Invention and demonstration of the photon-recycling semiconductor light-emitting diode (PRS-LED) which emits *white* light and many other colors with very high luminous performance of > 300 lm/W (with graduate students X. Guo and J. W. Graff, 1999). Invention of the monolithically integrated GaInN/GaN PRS-LED (with graduate students X. Guo and J. W. Graff, 2000)
- Invention and demonstration of polarization-enhanced ohmic contacts in p-type and n-type GaN (with graduate students Y.-L. Li and J. W. Graff 2000)
- Invention and demonstration of AlGaInP light-emitting diode with omni-directional reflector (ODR) for high light extraction efficiency (with post-doctoral associate Th. Gessmann and graduate student J. W. Graff, 2001)
- Developed novel model for high diodes ideality factors ($n >> 2.0$) in UV LEDs based on multiple rectifying elements (with graduate student J. M. Shah and Prof. Th. Gessmann, 2003)
- Developed new class of materials, low-refractive index materials, or low-*n* materials, with an unprecedented low refractive index of $n < 1.10$; use of these materials as low-*k* materials for inter-metal-layer dielectrics in Si lightly-doped drain (LDD) MOSFETs in conjunction with ALD-deposited high-*k* gate dielectric MOSFETs for integrated circuits (Si ICs) (with Dr. Jong Kyu Kim, "JQ" Xi, Professors Joel Plawsky, Bill Gill, starting in 2003)
- Developed theory for temperature coefficient of forward voltage in light-emitting diodes, particularly UV light-emitting diodes (with graduate student Yangang "Andrew" Xi, Dr. Jong Kyu Kim, and collaborators at Sandia National Laboratories, 2004, 2005)
- Invented highly efficient "remote phosphor configurations" in white light-emitting diodes (with Jong Kyu Kim, Hong Luo, and collaborators at SAIT-Samsung) (2004, 2005)
- Discovered whispering gallery modes in white LEDs with remote phosphors (with graduate student Hong Luo, Jong Kyu Kim, Yangang "Andrew" Xi, and collaborators at SAIT-Samsung, 2005)
- Developed graded-index antireflection coatings that, unlike conventional anti-reflection coatings, have broadband omni-directional characteristics; the graded-index antireflection coatings use novel low-*n* materials (with Jingqun "JQ" Xi, Jong Kyu Kim, 2007)
- Developed efficiency-droop reducing GaInN / GaInN and GaInN / AlGaInN LED active regions grown by MOCVD and ALE that were demonstrated to reduce the efficiency droop by as much as 40% (with Jong Kyu Kim, Martin F. Schubert, Di Zhu, Jiuru Xu, Mary Crawford, and Dan Koleske, starting in 2007)
- Developed analytic model for efficiency droop based on drift-induced reduction of the carrier-injection efficiency (with Guan Bo Lin, Jaehee Cho, and others, 2012)

Honors and awards

- Google Scholar profile, including the Hirsch-index (h-index) can be found at < http://scholar.google.com > under profile "E. Fred Schubert"
- Elected to *Senior Member* of the *IEEE* "in recognition of professional standing" (1993)
- Recipient of the Literature Prize of the *Verein Deutscher Elektrotechniker* (*VDE*) for "Doping in III–V semiconductors" (Cambridge University Press, Cambridge, 1993). Citation: "The book concerns all aspects of doping in III–V semiconductors. Fundamental, practical, and technological issues of doping are addressed. The book covers the basic theory of shallow donors, shallow acceptors, deep levels, and their influence on the free carrier concentration. It also discusses doping during growth, epitaxy, diffusion, and ion implantation. In the field of semiconductor devices, the book emphasizes applications requiring highly controlled doping distributions. It is an excellent monograph equally suited for study, research, and industry" (1994)

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- Elected as a member of the *Bohemian Physical Society* (Cornell University, Ithaca, NY). Citation: "For seminal contributions to the control of spontaneous emission by use of wavelength-size optical cavities, specifically the first demonstration in a glass host using rare earth implanted Si/SiO_2 resonant microcavities" (1994)
- Listed in "Who's Who In Science And Engineering" and "Who's Who in America" published by *Marquis Who's Who*, publishers of the original *Who's Who in America*. (*Marquis Who's Who*, New Providence, NJ) ISBN 0-8379-5755-9 (1996 – present)
- Elected Fellow *of the SPIE* "For pioneering research in semiconductor doping and sustained contributions to the development of high-efficiency light-emitting diodes and lasers". According to the Society's bylaws, a Fellow "shall be distinguished through his achievements and shall have made outstanding contributions in the field of optics, or optoelectronics, or in a related scientific, technical, or engineering field" (1999)
- Recipient of the *Alexander von Humboldt Senior Research Award* of the Alexander von Humboldt Foundation, a Bonn-based non-profit organization promoting the exchange of scientific knowledge between German and highly qualified foreign scholars. According to the Alexander von Humboldt Foundation, academic qualification is the only selection criterion for the award. The award resulted in two extended visits with the Microoptics Laboratory of Professor Jürgen Jahns at the University of Hagen, Germany (1999)
- Elected to *Fellow of the IEEE* "for contributions to semiconductor doping and resonant-cavity devices". According to the IEEE definition "the grade of Fellow is one of unusual professional distinction conferred by the Board of Directors only upon a person of extraordinary qualifications and experience" (1999)
- Listed in the "Dictionary of International Biography, 29th Edition" published by the *International Biography Center*, Cambridge, United Kingdom (2000)
- Recipient of the 2000 *Discover Magazine Award for Technological Innovation* presented by the *Christopher Columbus Foundation* in the category "Energy". The prize was awarded "for the invention and demonstration of the photon recycling semiconductor light-emitting diode", an all-semiconductor LED capable of emitting white light with very high efficiency, see < www.discover.com/awards > (2000)
- Recipient of the *RD100 Award* of the R&D Magazine that honors the "100 most technologically significant products of the year" (with Klaus Streubel of Osram-Sylvania Corp. and Rickard Marcks von Wurtemberg of Mitel Corp.). The prize was awarded for the "*Resonant-cavity light-emitting diode*" that uses enhanced spontaneous emission occurring in resonant cavities. The device is used in plastic optical fiber communication links, in telescopes for rifles, and many other applications (2000).
- Elected to *Fellow of the OSA* "for the invention and demonstration of the resonant-cavity LED and the photon-recycling semiconductor LED". OSA Fellows are elected by the OSA Board of Directors (2001)
- Recipient of the Boston University Provost Innovation Fund Award (Provost Dennis D. Berkey) valued at $ 25,000 for research and development of promising technologies (2001)
- Elected to *Fellow of the APS* "for pioneering contributions to the doping of semiconductors including delta doping, doping of compositionally graded structures resulting in the elimination of band discontinuities, and superlattice doping to enhance acceptor activation" (2001)
- Honored with RPI Medal as Senior Constellation Chair during Investiture Ceremony (2002)
- Received "2002 Rensselaer Polytechnic Institute Trustee Faculty Achievement Award" (2002)
- Inducted as Wellfleet Senior Constellation Professor, Future Chips, Rensselaer Polytechnic Institute, November 21 (November 2003)
- Distinguished Lecturer of the IEEE Electron Devices Society (2003–2006)
- Elected member in Eta Kappa Nu (2004)
- "Best Oral Presentation Award" was won by Ph. D. student Hong Luo (who was the presenter), J. K. Kim, Y. A. Xi, J. M. Shah, Th. Gessmann and E. F. Schubert "Improvement of extraction efficiency of GaInN light-emitting diodes by employment diffuse omni-directional reflectors" *Connecticut Microelectronics & Optoelectronics Consortium (CMOC)*, 14th annual symposium, New Haven CT, March 17 (March 2005).
- "Best Student Poster Award" of the *International Semiconductor Device Research Symposium (ISDRS)* was won by Ph. D. student J.Q. Xi (presenter), Jong Kyu Kim, Dexian Ye, Jasbir S. Juneja, T.-M. Lu, Shawn-Yu Lin, and E. Fred Schubert "Optical Thin Films with Very Low Refractive Index and Their Application in Photonic Devices", *International Semiconductor Device Research Symposium (ISDRS)*, Dec. 7 – 9, Bethesda, MD (December 2005)
- "MRS Silver Award" of the Materials Research Society was won by Ph. D. student Yangang Andrew Xi (who was the presenter), K. X. Chen, F. Mont, J. K. Kim, C. Wetzel, E. F. Schubert, W. Liu, X. Li, J. A. Smart "Extremely high quality AlN grown on (0001) sapphire by using metal-organic vapor-phase epitaxy" *Materials Research Society (MRS) Fall Meeting*, Boston MA, November 27 – December 1 (2006) Boston MA (December 2006)
- "25 Most Innovative Micro- and Nano-Products of 2007 Award" in July 2007 issue of *R&D Magazine* and *Micro/Nano Newsletter*. This recognition was given for the "Non-Reflective Coating" product that was published in *Nature Photonics* in 2007; full citation: Xi, J.-Q., Martin F. Schubert, J. K. Kim, E. F. Schubert,

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Minfeng Chen, Shawn-Yu Lin, Wayne Liu, and Joe A. Smart "Optical thin-film materials with low refractive index for broadband elimination of Fresnel reflection" *Nature Photonics* **1**, 176, March 2007 (July 2007)

- "Scientific American 50 Award" of 2007, as published in the January 2008 issue of *Scientific American*. According to the *Scientific American Magazine*, this award "celebrates visionaries from the worlds of research, industry and politics whose recent accomplishments point toward a brighter technological future for everyone" (January 2008)
- "Editors' Choice" of *Science Magazine*, *Science*, Volume **319**, page 1163, February 29 (February 2008). This distinction was awarded for the publication: Jong Kyu Kim et al., "Light-extraction enhancement of GaInN light-emitting diodes by graded-refractive-index indium tin oxide anti-reflection contact" that appeared in *Advanced Materials* **20**, 801, 2008 (February / March 2008)
- Received "2008 Rensselaer Polytechnic Institute Trustee Faculty Achievement Award" (2008)
- "Best Oral Presentation Award" won by David J. Poxson (who was the presenter), Frank W. Mont, Jong Kyu Kim, and E. Fred Schubert "Multilayer nano-structured anti-reflection coating with broad-band omni-directional characteristics" *Connecticut Microelectronics and Optoelectronics Conference* (*CMOC*), University of Connecticut, Storrs, Connecticut, April 9 (April 2008)
- "Best Oral Presentation Award" for presentation: David Meyaard, Sameer Chhajed, Jaehee Cho, E. Fred Schubert, Jong Kyu Kim, Daniel D. Koleske, and Mary H. Crawford "Temperature-dependent light-output characteristics of GaInN light-emitting diodes with different dislocation densities" *Connecticut Microelectronics and Optoelectronics Consortium* (CMOC) Symposium, New Haven CT, March 2 (March 2011)
- Identified as top 1% of patentees in the field of optoelectronics by study conducted by Professor Erica Fuchs of Carnegie Mellon University under a study supported by the US National Science Foundation (July 2011)
- Received "2012 Rensselaer Polytechnic Institute Trustee Faculty Achievement Award" (November 2012)
- My "LinkedIn" profile was one of the top 10% most viewed "LinkedIn" profiles during 2012 (January 2013)
- My graduate student, Mr. Ming Ma, received the $ 30,000.00 Lemelson-Rensselaer Student Prize for the invention entitled "Graded-refractive-index (GRIN) structures for brighter and smarter light-emitting diodes"; The Prize is awarded annually by the Lemelson Foundation (March 2013)
- Received the IEEE Life Fellow Award (2022)

Service to the technical community

- Current or former member of the *American Physical Society* (Member of the *Division of Materials Physics*, Member of the *Division of Condensed Matter Physics*), *Institute of Electrical and Electronics Engineers*, *Materials Research Society*, *Optical Society of America*, *Society for Optical Engineering* (*SPIE*), and the *Verein Deutscher Elektrotechniker*
- Co-author of hundreds of research articles, co-inventor of more than 30 United States patents, and numerous foreign patents (1981 – present)
- Gave many invited talks at scientific conferences organized by the *American Physical Society*, *Institute of Electrical and Electronic Engineers*, *Materials Research Society*, *SPIE* (*The International Society for Optical Engineering*), *Electrochemical Society*, *American Vacuum Society*, *Engineering Foundation*, and other professional societies (1985 – present).
- Co-editor (with A. M. Glass) of a Special Issue of the *Journal of Optical and Quantum Electronics* (Vol. **22**, 1990) on "Charge-transport assisted optical non-linearities in semiconductors" (1990)
- Symposium chair of the *American Vacuum Society Greater New York and New Jersey Chapter* on "Epitaxially grown semiconductors with atomic level control" (1991).
- Moderator of MRS Internet discussion on "Doping and Dopants in GaN" (MRS Internet Journal, 1995 – 1997)
- Member of review panels of the National Science Foundation (1995 – present)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose, CA (1997)
- Technical work has been featured in popular journals, magazines and newspapers including the New Scientist, Discover Magazine, Wall Street Journal, Boston Globe, Focus, and on National Public Radio (1996 – present)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose, CA (1998)
- Program Committee Member: IEEE IEDM, International Electron Devices Meeting (1999 and 2000)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose, CA (1999)
- Program Committee Member: ISBLLED, International Symposium on Blue Laser and Light-Emitting Diodes, Berlin, Germany, March 5 – 10 (2000)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose, CA (2000)

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- Conference Chair and Co-Organizer of the TMS- and ONR-sponsored conference on "Doping, Dopants, and Low Field Carrier Dynamics in Wide Gap Semiconductors", Copper Mountain, Colorado, April 2 - 6 (2000)
- Chair, IEEE LEOS, Central New England Chapter. During my tenure as Chair, the Central New England Chapter won the IEEE LEOS Chapter award for the highest membership growth (1999 – 2000)
- Expert Witness involving semiconductor materials, devices, and packaging including elemental and compound semiconductors such as Si, SiGe, SiC, as well as III–V arsenides, phosphides and nitrides (1998 – present)
- Member of the Board of Governors, IEEE Laser and Electro-Optics Society (LEOS) (1999 – 2000)
- Member of the Optoelectronics Industry Development Association (OIDA) Roadmap Panel on Solid-State Lighting, Albuquerque NM Oct. 26 – 28 (2000)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose, CA (2001)
- Panel Member of National Research Council meeting on "Solid-State Lighting:" held at NAS and NAE, Washington DC, March 26 (2001)
- Program Committee Member of SPIE Photonics West conference on "Laser and LED Applications" chaired by Dr. Kurt Linden, San Jose CA Jan (2002)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose, CA (2002)
- Program Committee Member: ISBLLED, International Symposium on Blue Laser and Light-Emitting Diodes, Cordoba, Spain, March 11–15 (2002)
- Program Committee Member for subcommittee on "Semiconductor lasers and LEDs" for OSA Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science Conference (CLEO / QELS) (2002 – 2003) Baltimore MD June 1–6 (2003)
- Reviewer for the National Research Council of report entitled "Partnerships for Solid-State Lighting: Report of a Workshop" authored by the Board on Science, Technology, and Economic Policy. This report is forwarded to the US Congress for the initiation of a national Solid-State Lighting Initiative. (2002)
- Program Committee Member "Lester Eastman conference on high performance devices" University of Delaware, Newark, Delaware, August 6 – 8 (2002)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose CA (2003)
- OIDA Next Generation Lighting (NGL) Consortium. Member of "Light-Emitting Diode" Committee (2003)
- Program Committee Member, International Semiconductor Device Research Symposium (ISDRS) Washington DC, Dec. 8 – 12 (2003)
- Program Committee Member of "Display and Solid-State Lighting Devices" conference for OSA/IEEE Conference on Lasers and Electro-Optics (CLEO) (2003 – 2004)
- Elected Member of the IEEE Electron Device Society Administration Committee (IEEE AdCom) (2003 – 2008)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose CA (2004)
- Program Committee Member "Fourth International Conference on Solid-State Lighting" August 2 – 6 Denver, CO (2004)
- Program Committee Member for the "Blue 2004: Advanced LEDs and Lasers Conference" Hsinchu, Taiwan, May 10 – 12 (2004)
- Conference Chair of SPIE Photonics West conference on "Light-emitting diodes: Research, Manufacturing, and Applications" San Jose CA (2005)
- Program Committee Member "International Semiconductor Device Research Symposium" December 7 – 9 Washington, DC (2005)
- Chair of "Display and Solid-State Lighting Devices" conference of OSA/IEEE Conference on Lasers and Electro-Optics (CLEO) (2005)
- Best Oral Presentation Award (Presenter: Hong Luo) at *Connecticut Microelectronics & Optoelectronics Consortium* (CMOC), 14th annual symposium, New Haven CT, March 17 (March 2005)
- Conference Chair of MRS Spring meeting "Symposium DD: Solid-State Lighting Materials and Devices" San Francisco, April 17 – 21 (April 2006)
- Member on the International Advisory Committee of *First International Conference on Display LEDs* (ICDL 2007), Seoul, Korea, January 31 to February 2 (2007)
- Member, Program Committee of *SPIE Photonics West* conference "Light-Emitting Diodes: Research, Manufacturing, and Applications XI" San Jose, CA, January 20 – 25 (2007)
- Program Chair of *SPIE Photonics West* conference "Semiconductor Lasers and LEDs" San Jose, CA, January 20 – 25 (2007)
- Member, Executive Organizing Committee *SPIE Photonics West* conference "LASE 2007" San Jose, CA, January

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20 – 25 (2007)

- Opto Track Chair of *SPIE Photonics West* conference "Semiconductor Lasers and LEDs" San Jose, CA, January 21 – 24 (January 2008)
- Member, Program Committee, Light-emitting diodes: Research, Manufacturing, and Applications, SPIE Photonics West 2008, San Jose, California, January 19 – 24 (January 2008)
- Program Committee Member of the 7th International Symposium on Semiconductor Light Emitting Devices (ISSLED-2008) held in Phoenix, Arizona (USA), April 27 – May 2 (April 2008)
- Member, Program Committee, China SSL 2008, Shenzhen Convention & Exhibition Center, China, July 24 – 26 (July 2008)
- Member, Program Committee, International Workshop on Nitride Semiconductors, IWN 2008, Montreux, Switzerland, October 6 – 10 (October 2008)
- Opto Track Chair of *SPIE Photonics West* conference "Semiconductor Lasers and LEDs" San Jose, CA, January 25 – 29 (January 2009)
- Guest Editor of Special Issue on *Solid-State Lighting* published in the *IEEE Journal of Selected Topic in Quantum Electronics*, July / August edition (August 2009)
- Honorable Conference Chair, 6th China International Forum on Solid-State Lighting (China SSL), Shenzhen Convention & Exhibition Center, China, October 14 – 16 (October 2009)
- Program Committee Member, International Conference on Nitride Semiconductors (ICNS), Jeju, South Korea, October 18 – 23 (October 2009)
- Program Committee Member, The Second International Conference on White LEDs and Solid-State Lighting, Taipei, Taiwan, December 13 – 16 (December 2009)
- Editor, *Compound Semiconductors and Energy Applications and Environmental Sustainability*, Materials Research Society (MRS) Symposium Proceedings Volume 1167 (MRS, Warrendale PA, 2009)
- Conference Chair, OPTO, *SPIE Photonics West 2010*, San Francisco, California, January 23 – 27 (January 2010)
- Guest Editor of Special Issue on *Light-Emitting Diodes* published in the *IEEE Transactions on Electron Devices* (January 2010)
- Program Committee Member, *8th International Symposium on Semiconductor Light Emitting Devices* (ISSLED), Beijing, China, May 16 – 21 (May 2010)
- International Advisory Committee Member of the 16th *Microoptics Conference* (MOC'10) held in Hsinchu, Taiwan, sponsored and endorsed by OSA and IEEE/Photonics Society and organized by National Chiao Tung University, Oct. 31 to Nov. 3 (October 2010)
- Member of Academic Committee of *China Solid-State Lighting Conference* (CHINA SSL 2010) Shenzhen, China, October 14 – 16 (October 2010)
- Conference Co-Chair, OPTO, *SPIE Photonics West 2011*, San Francisco, California, January 22 – 27 (January 2011)
- Executive Organizing Committee OPTO, *SPIE Photonics West 2011*, San Francisco, California, January 22 – 27 (January 2011)
- Program Committee Member of conference entitled: "Light-Emitting Diodes: Materials, Devices, and Applications for Solid-State Lighting XV *SPIE Photonics West 2011*, San Francisco, California, January 22 – 27 (January 2011)
- Member of CLEO Subcommittee 15, entitled "LEDs, Photovoltaics and Energy-Efficient ("Green") Photonics" for the 2011 Conference on Lasers and Electro-Optics (CLEO), Baltimore, Maryland May 1 – 6 (May 2011)
- Member of the Academic Committee of the 8th China International Forum on Solid-State Lighting (CHINA-SSL-2011) Guangzhou November 8 – 10 (November 2011)
- Program Committee Member of conference entitled: "Light-Emitting Diodes: Materials, Devices, and Applications for Solid-State Lighting XV *SPIE Photonics West 2012*, San Francisco, California, January 21 – 26 (January 2012)
- Member of CLEO Subcommittee 15, entitled "LEDs, Photovoltaics and Energy-Efficient ("Green") Photonics" for the 2012 Conference on Lasers and Electro-Optics (CLEO), San Jose, California, May 6 – 11 (May 2012)
- Member of Academic Committee of the 9th China International Forum on Solid-State Lighting (CHINA SSL 2012), Guangzhou, China, November 5 – 7, 2012 (November 2012)
- Program Committee Member of conference entitled: "Light-Emitting Diodes: Materials, Devices, and Applications for Solid-State Lighting XVI *SPIE Photonics West 2013*, San Francisco, California, 2 – 7 February 2013 (February 2013)
- Member of CLEO Subcommittee in the topic area: "Science & Innovation 15: LEDS, Photovoltaics and Energy-Efficient ("Green") Photonics" for the CLEO 2013 conference, April 28 – May 3, 2013 in Baltimore, Maryland (May 2013)
- Member, International Advisory Committee of the International Conference on Advanced Electromaterials (ICAE 2013) held on Jeju Island, Korea, from November 12 – 15, 2013 (November 2013)

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- Program Committee Member, *Solid-State and Organic Lighting* (*SOLED*), OSA Topical Meeting, 3 – 7 November 2013, Marriott Tucson Star Pass, Tucson, Arizona, USA (November 2013)
- Co-Chair, OPTIC International Conference, Chung Li, Taiwan, National Central University, December 5 – 7, 2013 (December 2013)
- Program Committee Member of conference entitled: "Light-Emitting Diodes: Materials, Devices, and Applications for Solid-State Lighting XVII" *SPIE Photonics West* 2013, San Francisco, California, 1 – 8 February (2014)
- Publication Committee Member, *5th International Conference on White LEDs and Solid-State Lighting* (White LEDs), Jeju Island, Korea, May 25 – 28, 2014 (May 2014)
- Sub-Committee Chair of Track 6: Displays, Solid-State Lighting, Photovoltaics, and Energy-Efficient Photonics of *Asia Communications and Photonics Conference 2014* (ACP 2014). ACP is the largest and the most influential conference in Asia and Pacific Rim for communications and photonics technologies. ACP 2014, Shanghai International Convention Center, Shanghai, China, November 11 – 14 (2014)
- International Consultant of technical seminar of the 11th China International Forum on Solid-State Lighting (SSL-China 2014) Guangzhou, China, November 6 – 8 (2014)
- Member of the International Advisory Committee of the 11th International Symposium on Semiconductor Light Emitting Devices (ISSLED 2017) held in Banff, Canada on October 8 – 13 (2017)
- Assisting the US Judicial Government Branch (various US District Courts), the USPTO (US Patent and Trademark Office) and the ITC (International Trade Commission) by serving as an independent Technical Expert Witness (1997 to present)

Books

- ***Doping in III-V semiconductors*** (author) Hardback and paperback, 628 pages (Cambridge University Press, Cambridge, UK, 1993). The following excerpt is from a book review by D. L. Miller, *University of Pennsylvania*, University Park PA, which appeared in *Physics Today*, Oct. 1994, p. 71: "[...] Fred Schubert has written a book that very nicely fills two roles: It serves as a reference volume for those of us who use III-V materials, and it provides enlightening explanations of interesting and important problems in semiconductor physics. [...] Schubert, who is employed by AT&T Bell Laboratories, brings his extensive research involvement with III-V materials physics straight to this book. His lucid explanations of some of the important physics of doped semiconductors is a major strength. For example, the chapter on deep centers provides the clearest treatment of the DX center I can remember reading, and it uses the large lattice distortion model and configurational coordinates introduced for the DX center to describe the EL2 deep level. This book can also serve as an excellent reference volume, because it briefly describes epitaxial growth techniques and the doping methods used with them, catalogs dopant-related phenomena, describes characterization techniques and provides 45 pages of citations to published articles and books. [...] I will use it to help my graduate students in the physics of semiconductors. [...] It will certainly be available on my bookshelf, in part to remind me what the Burstein-Moss shift is and in part for the literally hundreds of references that it provides on nearly every topic related to III-V semiconductor doping. Because of its clarity in treating some interesting phenomena of modern semiconductor physics, you too might want to get a copy of this book, even if you believe that Ga and As are just poor alternatives for doping silicon"
- ***Delta doping in semiconductors*** (editor) Hardback and paperback, 616 pages (Cambridge University Press, Cambridge, U. K., 1996)
- ***Light-emitting diodes*** (author) Hardback and paperback, 328 pages (Cambridge University Press, Cambridge, UK, 2003). The following excerpt is from a book review by David Bour, *Agilent Laboratories*, Palo Alto CA, which appeared in *Physics Today*, Nov. 2004, p. 66: "[...] In "*Light-emitting diodes*", E. Fred Schubert provides an excellent review of the physics and technology of semiconductor LEDs. […] Interesting anecdotes like [the first demonstration of electroluminescence], clearly written by someone with a broad perspective and expertise, appear throughout the book, making it enjoyable to read. […] Schubert provides an excellent description of the undesirable [non-radiative] recombination pathway. […] Schubert has made pioneering contributions to those devices, and this variety of LEDs may become more widely used in the future. […] Overall, "*Light-emitting diodes*" is an excellent examination of the physics and technology of semiconductor LEDs. The narration is simple and direct, and the book is well referenced for those seeking a deeper understanding of the topic. Written for the graduate level, the text will appeal to a broad audience; and for specialists who make semiconductor LEDs and laser diodes, it will serve as a useful connection to the scientific literature."
- ***Light-emitting diodes, second edition*** (author) Hardback, 422 pages (Cambridge University Press, Cambridge, UK, 2006)
- ***Physical Foundations of Solid-State Devices*** (author) eBook, 275 pages, ISBN-13: 978-0-9863826-2-8 (Google Books, Mountain View CA, 2015)

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- ***Light-emitting diodes, 3rd edition*** (author) eBook, 672 pages with hundreds of colored illustrations, ISBN: 978-0-9 863826-6-6 (Google Books, Mountain View CA, 2018) "The 1st edition of the book "Light-Emitting Diodes" was published in 2003. The 2nd edition was published in 2006. The current 3rd edition of the book is a substantial expansion of the second edition and has 37 chapters. The book includes a thorough discussion of white light-emitting diodes (LEDs), phosphor materials used in white LEDs, packaging technology, and the various efficiencies and efficacies encountered in the context of LEDs. The background of light, color science, and human vision is provided as well. The fully colored illustrations of the 3rd edition are undoubtedly beneficial given the prominent role of light and color in the field of LEDs. The book is a comprehensive discussion of the LED, particularly its semiconductor physics, electrical, optical, material science, thermal, mechanical, and chemical foundations. The 3rd edition is published in electronic format in order to make the book affordable and easily accessible to a wide readership."

Courses and laboratories developed at Boston University

- Developed first laboratory for "Physics of semiconductor devices" (SC-471) Fall (1998)
- Developed course "Quantum mechanics applied to semiconductor devices" (SC-574) Fall (1999)
- Developed course "Semiconductor light emitters" (SC-760) Fall (2000)
- Developed distance-learning course and NTU course on "Light-emitting diodes – Device physics and applications" Fall (2000)

Courses taught at Boston University

- Undergraduate Course "Physics of semiconductor devices" (SC-471)
- Graduate course "Fiber optic communication systems" (SC-563)
- Graduate course "Quantum mechanics applied to semiconductor devices" (SC-574)
- Graduate course "Introduction to solid-state physics of devices" (SC-577)
- Graduate course "Quantum electronics" (SC-700)
- Graduate course "Integrated optoelectronics" (SC-770)
- Graduate course "Compound semiconductor devices" (SC-771)
- Graduate course "Light-emitting diodes" (SC-760)
- Graduate course "Research seminar" (SC-860, SC-892)
- Other courses "Research", "Guided Study", "Master Thesis", and "Dissertation" (SC-900)

Courses taught at Rensselaer Polytechnic Institute

- Graduate Course "Semiconductor devices and models II" (ECSE-6290)
- Undergraduate course "Microelectronics technology" (ECSE-2210)
- Undergraduate course "Fields and Waves 1" (ECSE-2100)
- Graduate course "Quantum mechanics applied to semiconductor devices" (ECSE-6968)
- Graduate course "Physical foundations of solid-state devices" (SC-6960)
- Graduate course "Light-emitting diodes and solid-state lighting" (SC-6961)
- Undergraduate course "Introduction to Electronics" (ECSE-2050)
- Other courses "Research", "Guided Study", "Master Thesis", and "Dissertation"

Teaching evaluations and students' comments

1997 – Students made the following comments: "Clear … organized … excellent explanations … I've never had a professor like him – I wish all were like him … very clear and concise presentations … strong response to students' questions and concerns … Professor provided excellent notes … laid out lectures in a clear and precise manner which worked out wonderfully … well organized and confident … responsive to students' concerns … excellent for students going into the semiconductor industry … excellent hand-outs and course materials … well prepared … clear lectures … I was strongly encouraged … materials are very interesting … hand-outs were excellent … material is very important … the presentation of materials was very clear … hand-outs were excellent support to the class … efforts made by Prof. Schubert in keeping everyone at the same pace was remarkable …"

1998 – Students made the following comments: "Professor was always well prepared … excellent content … very relevant for the field of solid-state devices … excellent preparation for the class … handouts were very good … very well-organized teacher … excellent knowledge of material … provided a complete background of all material … easy to talk to … excellent overall teaching skills … really enjoyed coming to class … his choice of topics and homework helped me a lot … enthusiastic in teaching and helpful during the office hours … one of the best professors I have had at BU … course gave a very good overview of the different solid-state physics principles … the course was very well organized … relevant examples and homework were given … good explanations were

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given … presented clearly … presentation was clear … communicated effectively … very knowledgeable … good demonstrations in class … gives clear descriptions … asks questions of class … grades homework fairly … good at answering questions … no weak points … excellent instructor and scientist … inspiring professor … thorough … the instructor is very precise and well prepared … his knowledge of the material is exact … very responsive to feedback … encourages student questions, class participation and discussion … the instructor cared about whether students understood material … the instructor used applications immediately after showing theory … handouts were excellent … guest lecture and lab tour excellent idea … excellent class notes … presented topics neatly … well prepared … review of ongoing research topics was great … Professor Schubert is undoubtedly an expert in his area …"

1999 – Students made the following comments: "He enjoyed teaching the material and was very clear … the presentation of the material in class was excellent … he helped me to understand a lot about semiconductors … Prof. Schubert always tried to make sure that we would all have a clear understanding of the material … manuscripts were very helpful … encouraged lots of class participation and was always readily available for help … presentation was excellent … the instructor was always willing to help me … very helpful … Clearly, Prof. Schubert is *more* than just extremely knowledgeable about this material … very thorough and exact communication of points … excellent course packet written by the instructor … he was very well prepared for class … He is extremely fair and encourages participation … he is also very accessible … excellent instructor … very approachable and easy to ask questions of … handouts were very effective and helpful … Prof. Schubert is very prepared and concepts are well explained … materials will be very useful for my future … very open to questions"

2000 – Students made the following comments: "He did a lot of experiments which really helped … the material is very interesting and cutting edge … clear presentations … good in-class demonstrations … very clear lectures … the material really does challenge you … takes the time to answer your questions … very interesting material … relevant to today's world of communication … the field trip was fun … in-class demonstrations really added to class … good understanding of course material … excellent details, willing to help, good explanations … in-depth details on quantum mechanics … the instructor was extremely accessible to students … he encouraged participation in class … he gave intuitive arguments and explained concepts in a very physical way … I very much enjoyed Professor Schubert and would like to take more classes with him … material was very beautiful … I *very much* enjoyed the papers that were discussed … everything is well organized … hand-out material is very complete and clear … lectures are clear … the professor prepared an excellent manuscript … explained things very clearly … he has strong enthusiasm to solve students' questions … it's a very important course … Professor follows the course notes exactly, so one can concentrate on material without having to focus on details … clearly presented material … the course is great preparation for future courses in solid-state physics … I greatly admire Professor Schubert …"

2001 – Students made the following comments: "He has a thorough understanding of the subject … I like the fact that he shows us examples in class demonstrations … the manuscript was good … instructor provides good notes … materials are presented clearly … in this course you learn a lot … very illustrative and in depth … very interesting course … Professor presented the material well … Professor seemed to have a strong grasp on what he was teaching … the basics were presented correctly … smooth transition into more complex materials … presented basics well … Professor's strong points are knowledge, organization and class materials … clear conception … very important and useful class … Professor knew what was going on … manuscript and his notes were very helpful … responded to suggestions … notes were comprehensive … just fine … manuscript was good … knows the material very well … notes handed out are good … expert knowledge of material … developed lectures logically and straightforward … lecture notes were prepared for us - very nice touch … Professor has deep knowledge of the materials … Professor is always prepared for lectures … he emphasizes principles and the concepts … good preparation … good stuff and clear presentation … good research and industry experience … excellent handout notes and materials … excellent teaching skills … inspires the interest of students … great knowledge of material … well organized course notes … Professor Schubert gave very clear instructions … listening to his presentation is a true enjoyment of an excellent art of lecture style … the manuscript has the quality of an excellent book … the manuscript was an excellent reference source book … the instructor was very clear and well organized and encouraged participation … text [written by Schubert] was extremely good … expert knowledge of materials … class demonstrations were very beneficial … can clearly relate complex ideas – very good … has a high amount of patience … excellent understanding of material … very enthusiastic in teaching … always available for discussion … very knowledgeable … I don't see any weak points … he explains the theory very clearly …"

2002 – Students made the following comments: "Always prepared … presented difficult material in a manner that was easy to understand … presented everything neatly … very helpful and organized … presents subjects in a very easy and friendly format … very well qualified … great experience … very detailed notes … well organized … very useful … very good diagrams and explanations … he knows the material extremely well … notes given to us

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are extremely helpful … professor was very knowledgeable … was able to answer any of our questions … very informative course … very knowledgeable and a great teacher … the instructor is enthusiastic to teach students … the instructor can explain the theory very clearly …"

2003 – Students made the following comments: "Great overall knowledge … good organization skills … demonstrations were very interesting and useful … effective instructor … handouts were extremely useful and organized … good course for completely understanding many points of fiber optics …"

2004 – SPIE short course: "Encouraged questions and handled them well … excellent short course … I really appreciated and enjoyed this course … good course – covered very broad matters … the instructor was very knowledgeable on the topic … excellent! …"; RPI Semiconductor devices and models II (ECSE 6290): Overall excellence of teacher: 4.8 out of 5.0. Student comments: "course was very well prepared … [course] was very organized … this is an excellent course … I learned a lot from this course … the course was very good … thanks Prof. Schubert for a wonderful course … it's been a great course … thank you …" RPI Microelectronics Technology (ECSE 2210): Overall excellence of teacher: 4.7 (average 4.2). Overall excellence of course: 4.3 (average 3.9). Student comments: "Understandable presentation … great job [of] Prof. Schubert … very nicely done class … very helpful throughout the entire course … provided timely explanations to complicated material … very informative … course was fun and interesting … very interesting lecturer … very down to earth and easy to ask for help … [instructor] did a good job in presenting [material] … good course … fun course … excellent instructor … he is a great guy and very knowledgeable … I would definitely take a class from him again" **Book review** by Neal Oldham (San Jose, CA, USA) on "Doping in III–V semiconductors" (E. F. Schubert, Cambridge University Press, Cambridge UK, 1993) on amazon.com (May 17, 2002): "[This is the] best book I've encountered in the semiconductor field. This is, no question, the best book that I've encountered in the entire field of semiconductor physics. It is expertly organized and indexed, easy to follow, complete in its treatment of electrical and materials-science aspects of III-V semiconductor production and measurement, well-written … worth every penny if you even have the most remote interest in the subject." **Book review** by Debdeep Jena (Santa Barbara, CA, United States) on "Doping in III–V semiconductors" (E. F. Schubert, Cambridge University Press, Cambridge UK, 1993) on amazon.com (July 6, 2001): "Very useful text for semiconductor crystal growers. Doping is a big, big issue in semiconductors; this text does appreciable justice in its treatment of the issue. In addition, Schubert treats heterostructure physics appreciably well (in fact better than many textbooks on semiconductor physics!). Perusal of this book has proved very rewarding for me, and I expect it will do the same wonder for you too."

2005 – SPIE Photonics West short course student comments: "Very good instructor! … very knowledgeable … clear on complex subjects … good job fielding questions … (numerical score 4.3 out of 5.0). Educational materials on the web: … I have greatly enjoyed your LED slideshow. CLEO short course: … very good and well-organized course!" ECSE 6968: "Class presentations were very helpful in learning … very useful in learning *the details* of fundamental concepts … the course is very good … the course is excellent for engineers … your […] treatment brought about a much better understanding … examples were great and helpful … [discussion of] history and photons […] helped increase interest … After your course now, I can actually approach a quantum mechanics text book without fear … overall, I just wanted to say – *thank you* … excellent course … the instructor made it interesting and taught very effectively … the manuscript provided was also very well written … class was excellently structured … will benefit my studies in the future … especially liked the term paper requirement … Prof. Schubert is an excellent instructor, who is well prepared …" (excellence of instructor: 4.8 out of 5.0). SPIE Photonics North short course: "Very good and clear in presentation …" (numerical score 4.4 out of 5.0). ECSE 6960 mid-course and final feedback by students: "Professor has provided all course materials … I really appreciate it … well presented … technical support was great … my learning experience has been good … responses to my homework questions have been very timely … I have enjoyed the course and found it interesting and useful … homework assignments have been extremely beneficial … the set of notes is very comprehensive … good class structure …" (numerical scores of students' course and instructor evaluation: 5.0 out of 5.0). Comment on web educational materials: "Notes look very thorough and clear …"

2006 – SPIE Photonics West short course student feedback: "Excellent, knowledgeable … excellent presentation …" (numerical score 3.91 out of 5.0). ECSE 6961 (Light-emitting diodes and solid-state lighting): "excellent … Informative, comprehensive and interesting … the best part of this course, in terms of my learning experience, has been the course materials … just an outstanding class … so much is newly discovered and so much is current on-going research and commercially relevant … Dr. Schubert is obviously a leading researcher and did a great job of conveying his experience and understanding to the class … a highly technical topic that still makes a good general conversational topic … I liked the course material … I liked the fact that Prof. Schubert lectured directly from the textbook … I liked the structure of the course … I learned a lot about lasers and LEDs and other optical devices … it is a basic and fundamental class … the instructor gives ideas, concepts, and samples very clearly … very good course … students interested in LEDs and solid-state lighting are strongly recommended to take it … liked the overall coverage … the teaching pace was good … he covered a lot of material that is

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important for the subject, but it was clearly always related to the topic … the manuscript that he let us use was excellent in my opinion … the most important thing I liked about the course was the course material and the structure of the course … right amount of homework and the two exams and the term paper presentation … it was great to learn this course from someone who is a world leader in this field … well-organized material … liked the course format … organization was good … allowed me to know exactly what we were covering so I could look through the material prior to the lecture … course content was good, starting with LED basics and covering materials through modern technologies, and then a look at solid-state lighting and sort of an intro to communication devices … good fundamentals in LEDs … GREAT Professor … awesome course … informative course … ability to view course materials online was helpful … very fruitful course … covering a lot of materials … very good and very important for graduate students to take this one … for people in industry it's also useful … for the instructor, this course is thought through very clearly … the text book is also very good … great course … excellent instructor … cute instructor … course is very good … I benefited a lot from it …" (numerical scores: 4.7 out of 5.0). ECSE 2210 (Microelectronics Technology) student comments "Excellent teaching method … I like that the Professor asks random questions at the end of class – it helped me understand the subject better … I thought Prof. Schubert was fabulous … his organization of the class encouraged learning … I highly recommend this class to everyone … a devoted and involved teacher … displayed more enthusiasm in teaching than other Professors I had … he also seemed to have a philosophy about teaching that was beyond helping students get good grades … he emphasized real-world applications of material and had general advice about working in the real world after leaving academia … helpful … although he was harder in grading and exams, Prof. Schubert challenged us more and made the course more interesting … the many class activities provide lots of practice of materials just learned … provided good back-up information … made sure students understand concepts …thank you for asking students questions during class to reinforce concepts … thank you for allowing open book exams …" (numerical scores: excellence of teacher 4.4 out of 5.0; excellence of course 4.3 out of 5.0; overall average of ratings 4.4 out of 5.0)

2007 – Book review by Steven J. Wojtczuk (Lexington, MA, USA) on "Light-Emitting Diodes" (E.F. Schubert, Cambridge University Press, Cambridge UK, 2003) on amazon.com (March 14, 2006): "Schubert (RPI) has written an excellent book on LEDs that manages to explain and derive simple quantitative models for many phenomena of current interest … many monographs are a compendium of results in the field with hundreds of references … in contrast, Schubert, while giving copious references, is the sole author, leading to a coherent presentation well suited to learning … there are plentiful and good figures and drawings, as well as many exercises and solutions integrated into the text …" SPIE photonics West Short Course: "Excellent talk …" ECSE 2210 (Microelectronics Technology) "Thank you … great course … excellent instructor … interesting course … appreciated that you did not lecture completely from the slides and that you probed the class to ensure that we were understanding the key points … course is fine … good professor … Professor Schubert is one of the best lecturers I had … the pace at which he moves the topic, the way he explains things, and the manner in which he asks students questions all came together to help me learn much more form his lectures than I could on my own … instructors are absolutely very intelligent … Professor Schubert was a good professor … I actually learned things when Professor Schubert taught …" ECSE 6968 (Physical Foundations of Solid-State Devices) "The instructor explained every concept in a very simple and effective manner … I really enjoyed taking this course …" (numerical scores: 4.5 out of 5.0)

2008 – SPIE Photonics West short course feedback: "Very good … clear … very nice … answered questions readily …" (numerical score 4.3 out of 5.0) … ECSE 6961 (Light-emitting diodes and solid-state lighting) feedback: "It was great for me to have the opportunities to take two consecutive classes, *Physical Foundation* and *LEDs*, from you … both these classes have taught me a lot … they were very well organized … thank you for all the help … I have really enjoyed your classes … relevant material … very good professor …" (numerical scores: 4.3 out of 5.0) … Internet educational materials feedback: "I recently came across your course notes while trying to get a basic understanding about semiconductors and I wanted to thank you. Your notes for course "ECSE-2210 Microelectronics Technology" are the most useful and informative thing I have found on semiconductors on the Internet. I'm a chemist by trade and this is a great introduction for me …" 2007 Chautauqua Short Course and High School Teacher Summer Course, held at RPI June 26 and July 12, 2007 (numerical average of scores: 9 out of 10) … ECSE 6968 (Physical Foundations of Solid-State Devices) feedback: "Prof. Schubert is one of the best professors I've ever had … his ability to explain difficult and complex materials in a clear and concise manner is unmatched … the presentations, although time consuming, I felt were a great idea … thanks for your efforts professor! … I have really enjoyed taking this course …" By email: "Thank you professor … it has been a pleasure taking this course with you …" (numerical scores: 4.4 out of 5.0)

2009 – SPIE Photonics West short course feedback by students: "One of the best short courses I have taken … it was very nice to hear about the history of LEDs … very interesting but also very theoretical …" (numerical score 4.1 out of 5.0). ECSE 2210 (Microelectronics Technology) "Great course … instructors were excellent … encourages students to stay up to date with the subject matter … Thanks for this well-organized class … [the instructor] tries

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to get students to come out with the best grade possible … this was a good class …" ECSE 6968 (Physical Foundations of Solid-State Devices) feedback by students: "It is really an excellent course … clear hand script … great professor! …" (numerical scores: 4.7 out of 5.0)

2010 – SPIE Photonics West short course feedback by students: "Good to get the latest data and charts … very good … very broad course and well organized … it was great …" (numerical score 4.04 out of 5.0) … ECSE 6961 (Light-emitting diodes and solid-state lighting) feedback by students: "A good course … this was a wonderful course … it has given me a lot of understanding … the course has inspired me to take up LED research … useful … straight forward … very good advisor … good course …" (numerical scores: 4.3 out of 5.0) … ECSE 6220 (Physical Foundations of Solid-State Devices) feedback by students: "Overall excellent course … Professor Schubert is a good teacher … he can explain every discipline very clearly and relate them to practical applications … I like his teaching style very much … overall, it was a nice course … material explained in a clear organized manner …" (numerical scores: 4.7 out of 5.0)

2011 – SPIE Photonics West short course feedback: "Very nice overview … instructor was excellent! … very good instructor … I would recommend lengthening to 6 hours … excellent presentation, materials and text … thanks … very clear and easy to follow … to be recommended … excellent presentation … good compromise for a person with a busy schedule …" (numerical score 4.45 out of 5.0); … ECSE 2210 (Microelectronics Technology) "This was a great course … I enjoyed Professor Schubert's views … I was successful … this course was taught very well … this subject I now find quite interesting and am no longer intimidated by it … I liked the material of this course … thank you …" (numerical scores: 3.3 out of 5.0); Feedback on book *Light-Emitting Diodes*: "I am a graduate student from National Chiao Tung University, Taiwan … your wonderful book *Light-Emitting Diodes*, both first- and second-edition, gave me a lot of information and help … I would like to ask when can the third of the masterpiece be published? I wish I can get it as soon as possible and study more about the lighting devices; Feedback on Internet pages: I found your website and information […] quite enlightening and provides a great start … I simply wish to quickly express my thanks and gratitude." Feedback on book *Physical Foundations of Solid-State Devices*: "Dear Prof. Schubert, I have read your book Physical Foundations of Solid-State Devices and I must say it is amazing the explanations are really good and I am most thankful that you have decided to put the book online thank you." Itamar Jade Balla, The Israel Institute Of Technology. Feedback on book *Light-Emitting Diodes* by Trung Nguyen (San Jose, California): "It is a good book about Light Emitting Diodes (LEDs). It provides very good info and it is a good reference for engineers who work in the LED field"; … ECSE 6220 (Physical Foundations of Solid-State Devices) feedback: "Amazing course … great instructor … very good course … The text and lectures were very useful and informative … I definitely learned a lot from taking this course … I liked the course materials! …" (numerical scores: 4.6 out of 5.0)

2012 – Feedback on Internet-based materials: "I'm Cheng Liu [Wuhan National Laboratory for Optoelectronics, China], currently a graduate student major in Physical Electronics … I deeply admire your profound knowledge on this field and your unselfish sharing of it …"; … SPIE Photonics West short course feedback: "Dr. Schubert was very clear and very patient with people who had questions … the materials were comprehensive …"; Feedback on Internet-based materials: "Supremely-rich course contents posted on your website. Thank you very much for showing such awesome materials for the world to see …" (Prof. Natee Tangtrakarn, Thailand) … ECSE 6962 (Light-Emitting Diodes and Solid-State Lighting) feedback: "… very interesting course … Professor Schubert did a great job explaining the material … his textbook is very clear and understandable … nice course … I learned a lot of new things by taking it …" (numerical scores: 4.7 out of 5.0)

2013 – ***SPIE Photonics West short course*** feedback (SC-052, Light-Emitting Diodes): "Great instructor with admirable combination of knowledge in academic and commercial knowledge … I appreciated the depth of his knowledge and experience … the length of the course was good … Overall this was an excellent course … Thank you … course is very easy and I understand it easily … Excellent course! … Instructor was fantastic -- clear, explicit, took questions as we went and answered well … One of the best SPIE courses I've taken (and I've taken lots)! … Great course -- thanks! … I was happy that the slides were updated with 2012 data". ***RPI course numerical scores (ECSE-6962, Light-Emitting Diodes and Solid-State Lighting)***: Numerical score of students' evaluations: 4.67 out of 5.0; Verbatim comments: "The course is pretty good … needs no improvement … I can appreciate the more wide-angle approach from the course … These areas are very important and previously I had no knowledge of them … It was a pleasure attending your class …" ***RPI course numerical scores (ECSE-6968, Physical Foundations of Solid-State Devices)***; Verbatim comments: "It has been an awesome experience of learning for me in this course … Thank you for everything … Thank you for the great semester … Have a good break … Thank you for the great semester … Have a good break … Professor, thank you for an engaging and interesting class this semester … I enjoyed the subject of my paper and learned quite a bit particularly about GaN, which I had not had a chance to really do any research into before … Very good and interactive class … I liked the style of the class … I thought the topics covered were very interesting … I think I got much more out of the class this way than if we would have followed the manuscript chapter by chapter …" Numerical score of students' evaluations: 4.83 out of 5.0

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2014 – *SPIE Photonics West short course* verbatim feedback (SC-052, Light-Emitting Diodes): "Very knowledgeable instructor ... the course was packed with information ... handouts are excellent ... Excellent presentation and contents ... the color rendering section which was interesting and fun ..." Numerical score of students' evaluations: 4.36 out of 5.0; ***RPI Course ECSE-2210 Microelectronics Technology***; Verbatim comments: "Instructor is clearly very knowledgeable about the topics ... Very clear and comprehensive ... This is the best class ever ... I'm quite enjoying this course ... I don't really have any recommendations on things to change ... The homework and lectures being sent out at the beginning was very helpful ... Both the TA and the professor were able to explain things very well ... I think he is a good lecturer ... I think the homework each was very, very good at teaching me the material, and the exam was fairly graded and easy to understand ... I definitely like the professor and I would have him again ... A good class ... I enjoyed Prof. Schubert's style of teaching ... I would still recommend Prof. Schubert as a professor ... Microelectronics is a good class ... Prof. Schubert keeps it interesting though ... he's a great professor ... The two TAs are also great ..." Numerical score of students' evaluations of instructor: 4.25 out of 5.0. ***RPI Course ECSE-6220 Physical Foundations of Solid-State Devices***; Verbatim comments: "The book and lectures seem to be entirely in sync with one another ... it really enforces the material covered in the book ... the material is covered thoroughly and improves students' understanding of quantum physics ... The class was interesting with excellent learning materials ... I loved how the course was so well organized ... The lectures were very well put together ..." Numerical score of students' evaluations of instructor: 4.75 out of 5.0.

2015 – *SPIE Photonics West Short Course SC-052 titled Light Emitting Diodes*, Verbatim comments: "I was very satisfied with this short course" Numerical score of students' evaluations: 4.53 out of 5.0; ***RPI Course ECSE-6960 Light-Emitting Diodes***; Verbatim comments: "the class has been excellent! ... I've learned a good amount about LEDs ... Also I'd like to thank you for a great semester and say that you've peaked my interest in the LED field! ... I would like to add that the course was an excellent experience for me and that I really enjoyed learning about LED technology! ... Thank you very much for teaching such a wonderful class ... It was a great learning course" Numerical score of students' evaluations: 5.0 out of 5.0. ***RPI Course ECSE-2100 Fields and Waves 1***; Verbatim comments: "This class is going perfectly and I love the way it's run ... The material is great and understandable ... the pace is perfect ... I like the pacing of the course and the fact that we spend time really developing an understanding of the theory and concepts that we will be using ... I like the Professor ... The lectures are great ... I really enjoy this professor and he is very understanding of the students' levels of learning and focused on that ... Professor Schubert is clear and easy to understand ... Overall a very good professor ... very knowledgeable and helpful ... I thought the professor was very knowledgeable and was an excellent instructor ..." Numerical score of students' evaluations of instructor: 4.17 out of 5.0.

2016 – *SPIE Photonics West Short Course SC-052 titled Light Emitting Diodes*, Verbatim comments: "This has been my favorite course (over 3 years) ... Well-structured presentation, and well given ... I was surprised by how much I didn't know. I learned a lot ... Explained difficult concepts in a clear and simple manner ... Able to go "off script" to clarify during questions." Numerical score of students' evaluations: 4.56 out of 5.0; ***RPI Course ECSE-2100 Fields and Waves 1***; Verbatim comments: "This is cool material ... This class was one of the most well put together I have ever taken in terms of lecture pace, lecture clarity, TA support, and quality of teaching and communication ... The lectures never felt too long or too short, the pace was good, I never felt lost or without an option to turn for help ... The homework was neither too long nor too short, and was well balanced with conceptual and quantitative questions ... Prof. Schubert's lecture style was very clear, concise, and to the point, with many useful examples in real life scenarios which made the material more interesting ... Very well done ... Great class ... I liked the pace of the class ... it helps with understanding the material a lot ... The labs [...] were fun and very educational ... Overall, I learned a lot from this course ... The speed of the class is perfect ... I really got a chance to learn ... This professor is very good ... Also, [in] the lab section I was able to really break down what I learned in class ... Schubert has the neatest handwriting of any professor I've ever had in my 3 years here ... His diagrams are extremely neat and he is easy to understand verbally too ... Lots of conceptual knowledge covered ... Overall [...] it was an enjoyable class ..." Numerical score of students' evaluations: 5.0 out of 5.0. ***RPI Course ECSE-2210 Microelectronics Technology***; Verbatim comments: "So far, this has been one of my favorite courses at RPI … I'm a huge fan of Prof. Schubert's ability to clearly describe concepts both conceptually and mathematically … Class activities […] were really helpful! … Otherwise the class is great! … Prof Schubert knows his stuff … Best professor I have had … This course was well taught … Professor Schubert's explanations were very clear and understandable … he took time to address student questions with in-depth answers … I feel as though I gained a lot from this course, especially with regards to explanations of why certain things in ECSE-2050 (Intro to Electronics) occur the way they do like where the diode property comes from and how material properties of electronic components give rise to the very real circuit characteristics we see in ECSE-2050 labs … In this sense, Microelectronics Tech is a very good companion class to Intro to Electronics, and I highly recommend future students take them at the same time … this was a quite good class … Best MET instructor … I was so actively engaged during the lectures that it was kind of scary ... The lecture notes and lectures were mostly great … The material covered in it was succinct and interesting,

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yet still covered the knowledge needed to tackle engineering problems in semiconductors …" Numerical score of students' evaluations: 4.64 out of 5.0.

2017 – *RPI Course ECSE-2100 Fields and Waves 1*; Verbatim comments: "I thoroughly enjoy this class … Schubert is awesome! … Enjoyed the class … He is a good teacher … Most teachers talk really fast making it hard to follow … Schubert talks slow and explains things really well … Professor Schubert is an excellent professor, and has been one of my favorites at RPI so far … He made a difficult topic approachable, interesting and understandable … I hope I have him as a professor in the future … Thank you … I enjoyed this class, especially the labs … Lectures were good too … great class! … The professor does a great job of engaging the students by asking questions and making students ask questions to make them think about the labs … This course is overall excellent in that the professor does know the pace of class and gives feedback appropriately …"; Numerical score of students' evaluations: 4.63 out of 5.0. ***SPIE Photonics West Short Course SC-052 titled Light Emitting Diodes***, Verbatim comments: "the course covered a wide variety of concepts …" Numerical score of students' evaluations: 4.03 out of 5.0.

2018 – *RPI Course ECSE-2100 Fields and Waves 1*; Verbatim comments: "Professor Schubert is great and very entertaining to listen to in the lab and in lecture … Really appreciate how Prof. Schubert structures lectures … Schubert is great! … The professor is excellent at relaying concepts … This course is very interesting and it goes at a good pace … One of the better professors here at RPI … He cares about his students and helps them to learn the most through lectures and labs … Fantastic course that goes into great detail into not only knowing the material but also understanding the material … [the course] has been clarified and allowed for a greater learning process." Numerical score of students' evaluations of instructor: 4.17 out of 5.0. ***RPI Course ECSE-6220 Physical Foundations of Solid-State Devices***; Verbatim comments: "Perfect professor, no complaints." Numerical score of students' evaluations (median): 5.0 out of 5.0.

2019 – *RPI Course ECSE-2100 Fields and Waves 1*; Verbatim comments by students: "Schubert is excellent in relating information in a practical manner especially in the lab … Overall, both the professor and TAs prioritize if students understand material over semantics in reports and homework, which is really helping me in the course, and feedback given is incredibly helpful in both … Schubert is a mystery. He speaks very slowly and clearly, but you somehow learn everything at a very fast rate … Class […] being just the right amount focused and adequately paced … Overall great class … Labs were educational and we were allowed to have fun with it … Otherwise great lectures, notes were available and understandable … this was one of my favorite classes … Very well run by Schubert … lectures were informative and easy … labs were fun … The TA's were allowed to have personalities and interact with the students … 10/10 would take again … Schubert was okay … The best parts about the course for me were everything was online and I could copy the notes at my leisure with my busy schedule … I also liked that exams were open book and we had a lot of opportunities for practice … I have nothing but good things to say about both TAs and Professor Schubert – this has been my favorite class this semester … Though challenging, I have found the course material very interesting and all teachers have been excellent … Course was good … I like Professor Schubert's class notes online. They're super well written and helpful." Numerical score of students' evaluations of instructor: 4.63 out of 5.0 (average) and 5.0 out of 5.0 (median).

2019 – *RPI Course ECSE-6280 Light Emitting Diodes*; Verbatim comments by students: "This was a great course … I learned a lot during the semester … Great class … Really enjoyed Professor Schubert's expertise on the subject … Gives both in-depth technical knowledge as well as high level background to better understand the driving factors of the LED industry … Would highly recommend it to anyone in ECSE." Numerical score of students' evaluations: 4.83 out of 5.0 (average) 5.0 out of 5.0 (median).

2020 – *RPI Course ECSE-2100 Fields and Waves 1*; Verbatim comments by students: "I really enjoyed this class … the cool labs with good help and good lectures made me really enjoy this class and help the information stick in my head better … The labs provided a great use to show theory in practice and how certain concepts are applied to real-life applications … The laboratory session was also a great time to ask questions and have in-depth talks about the material … I would have already commended this professor for class organization and material availability prior to online courses (course material easily available, organized well, and easy to understand; interactive lectures; interactive labs better than most other ECSE courses), Prof. Schubert handled the change to online coursework best of all of my professors and maintained the quality of lecture almost perfectly … The 'live' online classes were interactive and courteous by students and the professor, organized, and just as in-depth as before, even including miniature homemade demonstrations and experiments … The course was taught very fundamentally which allowed me to think and learn more … Thank you, Professor Schubert … I really missed your live lectures and labs! … Professor Schubert made the best of the situation of online learning … Great class … I learn a lot from this class … I enjoy lab sessions and try never to miss any class … Prof. Schubert is really good!" Numerical score of students' evaluations: 4.75 out of 5.0 (average) 5.0 out of 5.0 (median).

2020 – *RPI Course ECSE-2050 Introduction to Electronics*; Verbatim comments by students: "I really enjoyed how easy it was to follow along with the lecture … I really enjoyed the content of this course, and I feel that the

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applications of this content in the lab were extremely effective to help students understand the content … the concepts in general were extremely interesting … I liked how the lecture sessions for this class provided much more room for discussion and examples than nearly any other ECSE course I have taken at RPI so far … Schubert was very aware of the students ability to fully comprehend the topic … He was very patient with the students that needed extra explaining … I learned a lot about the course material … I liked the one-on-one attention we received in the in-person lab … I enjoyed the in person laboratory sessions, they were a good place to get all my questions answered … I really like the lecture notes and the detailed diagrams / graphs that help explain the concepts … Professor Schubert does a great job of breaking down the material, he always tries to engage the students in every lecture … Very clear notes, responded quickly, answered any confusing questions really well, and very nice and accommodating towards the current COVID situation everyone is going through … He had very organized notes that helped especially with the difficulties of online learning … I loved the explanation of diodes, it's never been so clear to me before! … Examples were excellent … The course was great! … I learned a lot and this course stimulated my interest … Very engaging … stimulates participation … Professor Schubert was a refreshing exception … the professor was very knowledgeable in the subject area … explanations were clear and easy to understand … I really like the format of this class compared to my other classes … I really enjoyed the format … Very detailed lecture, very helpful with students, made very complex material easy to understand … Prof is really understanding and cares about his students … He is really willing to work with us which I found is really rare at RPI … He is easily one of the best professors I have had … He cares most about whether we are learning and understanding, rather than following his desired schedule perfectly … Cannot say anything bad about Prof Schubert … Class is great" Overall instructor rating: 4 out of 5. Overall course rating: 4 out of 5.

2021 – *RPI Course ECSE-2050 Introduction to Electronics*; Verbatim comments by students: "Class has been going smoothly … Professor Schubert includes real world-examples of devices in his lectures, showing the importance of our course materials … He is always very considerate of students, trying to adapt to what would help people most … He engages students in lectures." Overall instructor rating: 4.8 out of 5.0. Overall course rating: 4.6 out of 5.0.

2021 – *RPI Course ECSE-2050 Introduction to Electronics*; Verbatim comments by students: "Professor is always able to conceptually answer our questions, and run through circuit analysis with us if the results we're measuring don't match up … I tried taking this class once before, and I failed it. This time around, I feel like I know everything about everything. I had never imagined just what a difference teaching style could make in my ability to learn information, but this class is so much more welcoming to me this time around. It was with a different professor the first time. I much prefer Professor Schubert and the way he conveys information so effortlessly. He also seems like he's passionate about teaching the information and his handwritten notes are astonishingly detailed … Great professor! I appreciate Professor Schubert taking the time to clarify different topics and always checking in with the students. He seems to genuinely care about our education. He is strict about deadlines, more so than other professors at least, but I think he has earned that … Professor Schubert is very friendly to his students … He was very helpful and one of the few professors who actually stays and talks to students all throughout the lab period. It was very helpful because often I would think that I fully understood a concept and then he would ask a question that would either stump me or reinforce information. Additionally he kept lectures short and to-the-point, which I appreciate." Overall instructor rating: 4.3 out of 5.0. Overall course rating: 4.3 out of 5.0.

2022 – *RPI Course ECSE-2050 Introduction to Electronics*; Verbatim comments by students: "Great professor! … Handwriting is amazing … His notes are flawless and easy to understand … This course covers much more than most other EE courses I've taken, and yet I feel as though this has been the easiest EE course due to his teaching abilities … Professor Schubert is a very knowledgeable professor … It's clear that he wants his students to learn …" Overall instructor rating: 4.3 out of 5.0. Overall course rating: 4.4 out of 5.0.

2022 – *RPI Course ECSE-2210 Microelectronics Technology*; Verbatim comments by students: "I think Schubert does a great job of teaching … He makes the pn junctions as interesting as he can … I also love the chalk-board! So great, every professor should be forced to use it, because you can follow the work so smoothly (not like powerpoints) … I would not change the class … I also like how Prof. Schubert asks for feedback from everyone after class … Course was at a great pace and the level of difficulty … Professor Fred Schubert is one of my most favorite professors at RPI … I am sad to see in the course schedule for Spring 2023 that he is not teaching any 4000 level ECSE courses … I think that the department and students are missing out by not having someone as knowledgeable as him teaching more conceptually hard topics because Professor Schubert does that exceptionally … Best ever lecture experience, clear structure of lecture notes, comprehensive homework that helps to improve students' understandings, and always eager to solve students' questions … Thanks for another great course Professor!"

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Post-doctoral & visiting personnel for which I served as Major Research Advisor

Dr. Li-Wei Tu	Post-Doctoral Fellow	1988–1990
Dr. Neil Hunt	Post-Doctoral Fellow	1991–1993
Dr. Matthias Passlack	Post-Doctoral Fellow	1993–1995
Dr. Wolf Grieshaber	Post-Doctoral Fellow	1995–1997
Dr. Thomas Gessmann	Post-Doctoral Fellow	2000–2002
Dr. Jong Kyu Kim	Post-Doctoral Fellow	2003–2005
Dr. Min Ho Kim, SEMCo	Visiting Engineer	2007–2008
Prof. Ji-Myon Lee, Sunchon Univ.	Visiting Professor	2007–2008
Dr. Jaehee Cho	Post-Doctoral Fellow	2008–2009
Dr. Yongjo Park, Samsung LED	Visiting Vice President	2010–2012
Dr. Yangang Andrew Xi	Visiting Scientist	2013–2014
Dr. Guan-Bo Lin	Post-Doctoral Fellow	2014–2015

Graduate students for which I served as Major Research Advisor

Dr. Dean A. Stocker	Ph.D. Dissertation	Ph. D. completed in 1999
Xiaoyun (Jane) Guo	Master Thesis	M.S.E.E. completed in 1999
John W. Graff	Master Thesis	M.S.E.E. completed in 1999
Dr. Ian D. Goepfert	Ph.D. Dissertation	Ph. D. completed in 2000
Yun-Li Li	Master Thesis	M.S.E.E. completed in 2000
Dr. Xiaoyun (Jane) Guo	Ph.D. Dissertation	Ph. D. completed in 2001
Dr. John W. Graff	Ph.D. Dissertation	Ph. D. completed in 2002
Dr. Erik L. Waldron	Ph.D. Dissertation	Ph. D. completed in 2002
Jay M. Shah	Master Thesis	M.S.E.E. completed in 2002
Dr. Yun-Li Li	Ph.D. Dissertation	Ph. D. completed in 2003
Jingqun (“JQ”) Xi	Master Thesis	M.S. completed in 2003
Yangang Andrew Xi	Master Thesis	M.S. completed in 2003
Ronald Jackson	Master Thesis	M.S. completed in 2004
Sameer Chhajed	Master Thesis	M.S. completed in 2004
Hong Luo	Master Thesis	M.S. completed in 2005
Xiaolu Li	Master Thesis	M.S. completed in 2005
Kaixuan Chen	Master Thesis	M.S. completed in 2005
Dr. Jay M. Shah	Ph.D. Dissertation	Ph. D. completed in 2006
Frank Mont	Master Thesis	M.S.E.E. completed in 2006
Dr. Hong Luo	Ph.D. Dissertation	Ph. D. completed in 2006
Dr. Jingqun (“JQ”) Xi	Ph.D. Dissertation	Ph. D. completed in 2006
Dr. Yangang Andrew Xi	Ph.D. Dissertation	Ph. D. completed in 2006
Won Seok Lee	Master Thesis	M.S. completed in 2007
Qi Dai	Master Thesis	M.S. completed in 2007
Di Zhu	Master Thesis	M.S. completed in 2007
Jiuru Xu	Master Thesis	M.S. completed in 2007
Ahmed Noemaun	Master Thesis	M.S. completed in 2007
Roya Mirhosseini	Master Thesis	M.S. completed in 2008
David Poxson	Master Thesis	M.S. completed in 2008
Qifeng Shan	Master Thesis	M.S. completed in 2009
Ming Ma	Master Thesis	M.S. completed in 2010
Xing Yan	Master Thesis	M.S. completed in 2010
Dr. Roya Mirhosseini	Ph.D. Dissertation	Ph. D. completed in 2010
Dr. Sameer Chhajed	Ph.D. Dissertation	Ph. D. completed in 2010
Dr. Jiuru Xu	Ph.D. Dissertation	Ph. D. completed in 2011
Dr. Frank Mont	Ph.D. Dissertation	Ph. D. completed in 2011

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Dr. Wonseok Lee	Ph.D. Dissertation	Ph. D. completed in 2011
Dr. Di Zhu	Ph.D. Dissertation	Ph. D. completed in 2011
Dr. Qi Dai	Ph.D. Dissertation	Ph. D. completed in 2011
Dr. Ahmed Noemaun	Ph.D. Dissertation	Ph. D. completed in 2011
Dr. David Poxson	Ph.D. Dissertation	Ph. D. completed in 2011
Dr. Qifeng Shan	Ph.D. Dissertation	Ph. D. completed in 2012
Dr. Ann Mao	Ph.D. Dissertation	Ph. D. completed in 2013
Dr. Xing Yan	Ph.D. Dissertation	Ph. D. completed in 2013
Dr. Ming Ma	Ph.D. Dissertation	Ph. D. completed in 2013
Dr. David Meyaard	Ph.D. Dissertation	Ph. D. completed in 2013
Dr. Guan-Bo Lin	Ph.D. Dissertation	Ph. D. completed in 2013

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Expert Witness Consulting Service

1997 ***Case***: Hewlett-Packard Company versus CEO of United Epitaxy Company (Taiwan)
Nature: Trade secret misappropriation
Venue: U.S. District Court.
Law firm: Morrison & Foerster LLP, Washington DC.
Role: I served as technical expert witness on behalf of United Epitaxy (Defendant). I wrote one or more expert reports.

1998 ***Case***: Hewlett-Packard Company versus United Epitaxy Company (Taiwan)
Nature: Patent infringement.
Venue: U.S. District Court for the Northern District of California.
Law firm: Quinn Emanuel Urquhart Oliver and Hedges LLP
Role: I served as technical expert witness on behalf of United Epitaxy (Defendant). I wrote one or more expert reports.

2006 ***Case***: Kerr Company versus 3M and Dentsply International Company.
Nature: Patent infringement.
Venue: U.S. District Court for the Western District of Wisconsin.
Law Firm: Woodcock Washburn LLP, Philadelphia, Pennsylvania.
Role: I served as technical expert witness on behalf of Dentsply (Defendant). I wrote one or more expert reports.

2006 ***Case***: Nichia Corporation (Japan) versus Seoul Semiconductor Company (Korea).
Nature: Design patent infringement.
Venue: U.S. District Court for Northern District of California, San Francisco Division.
Law firm: Foley & Lardner LLP Washington DC.
Role: I served as technical expert witness on behalf of Nichia (Plaintiff). I wrote one or more expert reports; I was deposed.

2008 ***Case***: Seoul Semiconductor (SSC) Company LTD (Korea) versus Nichia Corporation (Japan).
Nature: Patent infringement.
Venue: U.S. District Court for the Eastern District of Texas, Beaumont Division.
Law firm: Morrison & Foerster LLP, Palo Alto, California.
Role: I served as technical expert witness on behalf of Nichia (Defendant). I wrote one or more expert reports; I testified in District Court during the claim construction / Markman hearing.

2008 ***Case***: Professor Gertrude Rothschild versus Toshiba Company (Japan).
Nature: Patent infringement.
Venue: U.S. International Trade Commission (ITC), Washington DC.
Law firm: DLA Piper LLP, San Francisco California.
Role: I served as technical expert witness on behalf of Toshiba (Defendant). I wrote one or more expert reports; I was deposed.

2008 ***Case***: Honeywell Company versus Cree Company and Lumileds Company.
Nature: Patent infringement and Reexamination of patent.
Venue: U.S. District Court for the Eastern District of Texas, Marshall Division. Reexamination before the USPTO's Patent Trial and Appeal Board.
Law firms: Paul Hastings LLP, Washington DC and Ingrassia, Fisher & Lorenz PC, Washington DC.
Role: I served as technical expert witness on behalf of Honeywell (Plaintiff). I wrote one or more expert reports. I testified at the USPTO during a re-examination hearing.

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2010 ***Case***: Landmark Screens Company versus MLB Company and Kohler.
Nature: Mishandling of a patent application.
Venue: U.S. District Court for the Northern District of California, San Jose Division.
Law firm: Keker & Van Nest LLP, San Francisco, California.
Role: I served as technical expert witness on behalf of MLB and Kohler (Defendant). Negligence in conjunction with a patent application; I wrote one or more expert reports.

2011 ***Case***: Koninklijke Philips Electronics N.V. versus Seoul Semiconductor (SSC) Company LTD.
Nature: Patent infringement.
Venue: U.S. District Court for the Central District of California Southern Division
Law firm: Latham & Watkins LLP, Washington DC.
Role: I served as technical expert witness on behalf of SSC (Defendant). I wrote one or more expert reports.

2011 ***Case***: Jeou-Nan Tseng versus Home Depot USA Inc. and Guangde LEDup Enterprise Inc.
Nature: Patent infringement.
Venue: U.S. District Court for the Western District of Washington at Seattle.
Law firm: DLA Piper, Philadelphia, Pennsylvania.
Role: I served as technical expert witness on behalf of Home Depot (Defendant). I wrote one or more expert reports.

2011 ***Case***: Lightpanels Ltd. Company versus Fuzhou F&V Photographic Company.
Nature: Patent infringement.
Venue: U.S. International Trade Commission (ITC), Washington DC.
Law firm: Locke Lord LLP, New York, New York.
Role: I served as technical expert witness on behalf of Fuzhou F&V and Nanguang Photographic (Defendant). I wrote one or more expert reports; I was deposed.

2012 ***Case***: Osram Company versus LG Company.
Nature: Patent infringement.
Venue: U.S. International Trade Commission (ITC), Washington DC.
Law firm: Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Washington DC.
Role: I served as technical expert witness on behalf of LG (Defendant). I wrote one or more expert reports; I was deposed; I testified at the ITC Hearing.

2012 ***Case***: Osram Company versus LG Company and Samsung Company.
Nature: Patent infringement.
Venue: U.S. International Trade Commission (ITC), Washington DC.
Law firm: Covington & Burling LLP, Washington DC.
Role: I served as technical expert witness on behalf of LG and Samsung (Defendant). I wrote one or more expert reports; I was deposed; I testified at the ITC Hearing.

2013 ***Case***: Chao Tai Electron Co. LTD. versus LEDup Enterprise Inc. and others.
Nature: Patent infringement.
Venue: U.S. District Court for the Central District of California.
Law firm: Hunton & Williams LLP, Washington DC.
Role: I served as technical expert witness on behalf of LEDup Enterprise Inc. and others (Defendants). I wrote one or more expert reports.

2013 ***Case***: Nichia Corporation versus Everlight Company and Emcore Company.
Nature: Inter Partes Review (IPR).
Venue: USPTO Patent Trial and Appeal Board.

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Law firm: Foley & Lardner LLP, Washington DC.
Role: I served as technical expert witness on behalf of Nichia Corporation (Petitioner). I wrote one or more expert reports; I was deposed.

2014 ***Case***: Everlight Electronics Co. LTD. versus Nichia Corporation.
Nature: Patent infringement.
Venue: U.S. District Court for the Eastern District of Michigan, Southern Division.
Law firm: Foley & Lardner LLP, Washington DC.
Role: I served as technical expert witness on behalf of Nichia Corporation (Defendant). I wrote one or more expert reports; I was deposed; I testified at Phase 1 of trial (jury trial) and I testified at Phase 2 of trial (bench trial).

2014 ***Case***: LEDup Company versus Nicolas Holiday Company.
Nature: Patent infringement.
Venue: U.S. District Court for the Central District of California.
Law firm: Pendleton, Wilson, Hennessey, and Crow PC, Denver, Colorado.
Role: I served as technical expert witness on behalf of LEDup (Plaintiff). I wrote one or more expert reports.

2014 ***Case***: Nichia Corporation versus Everlight Electronics Co. LTD.
Nature: Patent infringement.
Venue: U.S. District Court for the Eastern District of Texas, Marshall Division.
Case number: 02:13-cv-702-JRG (E.D. Texas).
Law firm: Rothwell, Figg, Ernst & Manbeck PC, Washington DC.
Role: I served as technical expert witness on behalf of Nichia (Plaintiff). I wrote one or more expert reports; I was deposed; I testified at trial (bench trial).

2015 ***Case***: Cree Company versus Unity Opto, Unity Microelectronics, and Feit Electric Company
Nature: Patent infringement.
Venue: U.S. International Trade Commission (ITC), Washington DC.
Law firm: Alston & Bird LLP, Silicon Valley, East Palo Alto, California.
Role: I served as expert witness on behalf of Unity Opto Technology *et al*. (Defendants). I wrote one or more expert reports; I was deposed; I testified at trial (ITC Hearing).

2015 ***Case***: Honeywell International Inc. versus Cree Inc.
Nature: Inter Partes Review (IPR).
Venue: USPTO Patent Trial and Appeal Board.
Law firm: Arnold & Porter LLP, San Francisco, California.
Role: I served as expert witness on behalf of Honeywell International Inc. (Plaintiff). I wrote one or more expert reports.

2015 ***Case***: Honeywell International Inc. versus Cree Inc.
Nature: Patent infringement.
Venue: U.S. District Court for the District of New Jersey.
Law firm: Arnold & Porter LLP, San Francisco, California.
Role: I served as expert witness on behalf of Honeywell International Inc. (Plaintiff).

2015 ***Case***: Cree Inc. versus Kingbright Electronic Co. LTD and SunLED Corporation.
Nature: Patent infringement.
Venue: U.S. District Court for the Western District of Wisconsin.
Law firm: Hansen Reynolds Dickinson Crueger LLC, Milwaukee, Wisconsin.
Role: I served as technical expert witness on behalf of Kingbright and SunLED (Defendants). I wrote one or more expert reports; I was deposed.

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2016 ***Case***: Acuity Brands Lighting Inc. versus Lynk Labs Inc.
Nature: Inter Partes Review (IPR).
Venue: USPTO Patent Trial and Appeal Board.
Law firm: Haynes Boone LLP, Chicago, Illinois.
Role: I served as technical expert witness on behalf of Lynk Labs (Plaintiff). I wrote one or more expert reports.

2016 ***Case***: Godo Kaisha IP Bridge 1 Company versus Broadcom Company and others.
Nature: Patent infringement.
Venue: U.S. District Court for the Eastern District of Texas, Marshall Division.
Law firm: Ropes and Gray LLP, New York City, New York.
Role: I served as technical expert witness on behalf of IP Bridge 1 (Plaintiff). I wrote one or more expert reports; I was deposed.

2016 ***Case***: TSMC Company versus Godo Kaisha IP Bridge 1 Company.
Nature: Inter Partes Review (IPR).
Venue: USPTO Patent Trial and Appeal Board.
Law firm: Greenblum & Bernstein, P.L.C., Reston, Virginia.
Role: I served as technical expert witness on behalf of IP Bridge (Patent Owner). I wrote one or more expert reports; I was deposed.

2017 ***Case***: Harvard University versus Micron Technology Company.
Nature: Patent infringement.
Venue: U.S. District Court for MA, Boston; U.S. District Court for Delaware, Wilmington.
Law firm: Weil Gotshal & Manges LLP, Redwood Shores, California.
Role: I served as technical expert witness on behalf of Micron Technology Company (Defendant). I wrote one or more expert reports; I was deposed.

2017 ***Case***: Seoul Viosys Company versus P3 Company.
Nature: Patent infringement.
Venue: U.S. District Court, Southern District of New York, New York City.
Law firm: Holland & Knight LLP, New York City, New York.
Role: I served as technical expert witness on behalf of Seoul Viosys (Plaintiff). I wrote one or more expert reports.

2017 ***Case***: Nitride Semiconductor Company versus Rayvio Company.
Nature: Patent infringement.
Venue: US District Court for the Northern District of California.
Law firm: Dentons LLP, Palo Alto, California.
Role: I served as technical expert witness on behalf of Rayvio (Defendant).

2018 ***Case***: CRX Tech LLC versus Samsung Electronics Co. LTD.
Nature: Patent infringement.
Venue: U.S. District Court for the Eastern District of Texas, Marshall Division.
Law firm: Arnold & Porter LLP, Los Angeles, California.
Role: I served as technical expert witness on behalf of Samsung (Defendant).

2018 ***Case***: Macom Technology Solutions Holdings Inc. versus Infineon Technologies AG.
Nature: Patent infringement.
Venue: U.S. District Court Central District of California Western Division, Los Angeles.
Law firm: Perkins Coie LLP, Denver, Colorado.

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Role: I served as technical expert witness on behalf of Macom (Plaintiff). I wrote one or more expert reports; I was deposed.

2018 ***Case***: Vizio Inc. versus Nichia Corporation.
Nature: Inter Partes Review (IPR).
Venue: USPTO Patent Trial and Appeal Board.
Case number: Case No. IPR-2017-01608 and IPR-2017-01623 (PTAB).
Law firm: Rothwell, Figg, Ernst & Manbeck, P.C., Washington DC.
Role: I served as technical expert witness on behalf of Nichia Corporation (Patent Owner). I wrote one or more expert declarations.

2018 ***Case***: Lowe's Companies Inc. versus Nichia Corporation.
Nature: Inter Partes Review (IPR).
Venue: USPTO Patent Trial and Appeal Board.
Case number: Case No. IPR2017-02014 (PTAB).
Law firm: Rothwell, Figg, Ernst & Manbeck, P.C., Washington DC.
Role: I served as technical expert witness on behalf of Nichia Corporation (Patent Owner). I wrote one or more expert declarations.

2018 ***Case***: Ultravision Technologies LLC versus Prismaflex USA Inc.
Nature: Patent infringement.
Venue: US International Trade Commission (ITC), Washington DC.
Case number: Investigation No. 337-TA-1114 (ITC)
Law firm: Womble Bond Dickinson LLP, Winston-Salem, NC
Role: I served as technical expert witness on behalf of Prismaflex USA (Defendant). I wrote one or more expert reports. I was deposed.

2019 ***Case***: Carl Zeiss AG versus Nikon USA Inc.
Nature: Patent infringement.
Venue: US International Trade Commission (ITC), Washington DC.
Case number: Investigation No. 337-TA-1129 (US ITC)
Law firm: Morrison & Foerster LLP, Los Angeles CA.
Role: I served as technical expert witness on behalf of Nikon USA (Defendant). I wrote one or more expert reports. I was deposed.

2019 ***Case***: ASM IP Holding B.V. versus Hitachi Kokusai Electric Inc.
Nature: Arbitration related to IP licensing dispute.
Venue: ICDR (International Center for Dispute Resolution), Palo Alto CA.
Case number: Case No. ICDR 01-17-0005-1963 (Palo Alto CA)
Law firm: Quinn Emanuel Urquhart & Sullivan LLP, San Francisco CA.
Role: I served as technical expert witness on behalf of ASM IP Holding B.V. (Complainant). I authored multiple witness statements. I testified at the Arbitration Hearing.

2019 ***Case***: Power Integrations Inc. versus C. W. Park.
Nature: Breach of employment contract.
Venue: US District Court, Northern District of California, San Jose Division.
Case number: 5:16-cv-02366-BLF (Northern District of California)
Law firm: Miclean Gleason LLP, San Mateo CA.
Role: I served as technical expert witness on behalf of Power Integrations Inc. (Complainant). I performed analyses relating to switched-mode power supplies (SMPS) including flyback transformers. The matter ended in settlement.

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2019 ***Case***: Omni MedSci Inc. versus Apple Inc.
Nature: Patent infringement.
Venue: US District Court, Eastern District of Texas, Marshall Division.
Case number: Civil Action No. 2:18-cv-134-RWS (E.D. Texas)
Law firm: Sidley Austin LLP, Washington DC.
Role: I served as technical expert witness on behalf of Apple Inc. (Defendant). I performed a non-infringement analysis relating to the heart rate monitor of the Apple Watch, authored an expert report, and testified at a deposition.

2019 ***Case***: Fluxwerx Illumination Inc., versus OKT Lighting USA LLC
Nature: Design patent infringement.
Venue: US District Court, Southern District of Texas, Houston Division.
Case number: Civil Action No. 4:19-CV-01113 (S.D. Texas)
Law firm: Burns & Levinson LLP, Boston MA.
Role: I served as technical expert witness on behalf of Fluxwerx Illumination, Inc. (Plaintiff). I performed an infringement analysis.

2020 ***Case***: Lighting Science Group Corporation versus Nichia Corporation and others
Nature: Patent infringement.
Venue: US ITC, Office for Unfair Import Investigations, Washington DC
Case number: Investigation No. 337-TA-1168
Law firm: Shearman & Sterling LLP, New York, NY.
Role: I served as technical expert witness on behalf of Nichia Corporation. I performed a non-infringement analysis, authored an expert report, was deposed, and testified at the ITC hearing as key technical witness on behalf of Nichia and Respondents (6 hours live testimony).

2020 ***Case***: Regents of the University of California versus Amazon, Walmart, Ikea, Target, and others
Nature: Patent infringement.
Venue: US ITC, Office for Unfair Import Investigations, Washington DC
Case number: Investigation No. 337-TA-1172
Law firm: Nixon Peabody LLP, Los Angeles CA.
Role: I served as technical expert witness on behalf of the Regents of the University of California. I performed an infringement analysis, authored an expert report, and was deposed.

2020 ***Case***: Samsung Electronics Company versus Acorn Technologies Company.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case numbers: IPR-2020-01183 ('261), IPR-2020-01182 ('423), IPR-2020-01204 ('336), IPR-2020-01264 ('336), IPR-2020-01205 (‘167), IPR-2020-01241 (‘167), IPR-2020-01206 (‘691), IPR-2020-01279 (‘691), IPR-2020-01207 ('395), and IPR-2020-01282 ('395)
Law firm: Desmarais LLP, New York NY.
Role: I served as technical expert witness on behalf of Samsung Electronics Company. I authored several expert declarations and was deposed multiple times.

2020 ***Case***: Satco Company versus The Regents of the University of California.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case number: IPR-2020-00579, IPR-2020-00695, IPR-2020-00780, and IPR-2020-00813.
Law firm: Nixon Peabody LLP, Los Angeles CA.
Role: I served as technical expert witness on behalf of The Regents of the University of California. I authored several expert declarations and was deposed.

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2020 ***Case***: Godo Kaisha IP Bridge 1 Company versus Micron Technology Company.
Nature: Patent infringement.
Venue: US District Court for the Western District of Texas, Waco Division.
Case number: C.A. No. 6:20-cv-178-ADA.
Law firm: Orrick Herrington & Sutcliffe LLP, Menlo Park CA.
Role: I served as technical expert witness on behalf of Micron Technology Company. I authored multiple expert reports and was deposed.

2020 ***Case***: Nichia Company versus Healthe Company and Lighting Science Group Company.
Nature: Patent infringement.
Venue: US District Court for the Middle District of Florida, Orlando Division.
Case number: 6:19-cv-1332-RBD-EJK and 6:19-cv-1333-RBD-EJK.
Law firm: Rothwell, Figg, Ernst & Manbeck, PC, Washington DC.
Role: I served as technical expert witness on behalf of Nichia Company. I authored one or more expert reports.

2020 ***Case***: Semiconductor Energy Laboratory (SEL) Co., Ltd. versus BOE Technology Group Co., Ltd.
Nature: Patent infringement.
Venue: US District Court for the Northern District of California.
Case number: 3:20-cv-04297-EMC, N.D. Cal.
Law firm: Fish and Richardson, P.C., Redwood City CA.
Role: I served as technical expert witness on behalf of SEL.

2021 ***Case***: The University of California versus General Electric, Ikea, Home Depot and others
Nature: Patent infringement.
Venue: US ITC, Office for Unfair Import Investigations, Washington DC
Case number: Investigation No. 337-TA-1220
Law firm: Nixon Peabody LLP, Los Angeles CA.
Role: I served as technical expert witness on behalf of the University of California. I performed multiple analyses, authored several expert reports, was deposed multiple times, and testified at trial.

2021 ***Case***: Tianma Microelectronics Co., Ltd. versus Japan Display Inc. (JDI)
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA
Case numbers: IPR-2021-01029, IPR-2021-01057 and IPR-2021-01058
Law firm: Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Washington DC.
Role: I served as technical expert witness on behalf of Tianma. I performed multiple analyses and authored several declarations.

2021 ***Case***: Japan Display Inc. (JDI) versus Tianma Microelectronics Co., Ltd.
Nature: Patent infringement.
Venue: US District Court for the Eastern District of Texas, Marshall Division.
Case numbers: Civil Action No. 2:20-cv-00283-JRG; 2:20-cv-00284-JRG; and 2:20-cv-00285-JRG
Law firm: Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Washington DC.
Role: I served as technical expert witness on behalf of Tianma. I performed multiple analyses, authored several expert reports, and was deposed multiple times.

2022 ***Case***: Satco Products Inc. versus The Regents of the University of California.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case number: IPR-2021-00662.
Law firm: Nixon Peabody LLP, Los Angeles CA.

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Role: I served as technical expert witness on behalf of The Regents of the University of California, authored one expert declaration, and was deposed.

2022 ***Case***: Samsung Electronics Co. Ltd. versus Bishop Display Tech LLC.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case numbers: IPR-2022-00500 and IPR-2022-00502.
Law firm: Baker Botts LLP, New York City NY.
Role: I served as technical expert witness on behalf of Samsung Electronics and have authored two expert declarations.

2022 ***Case***: Semiconductor Energy Laboratory (SEL) Co. Ltd. versus TCL China Star Optoelectronics Technology Co., Ltd.
Nature: Patent infringement.
Venue: US District Court for the Central District of California, Southern Division.
Case number: 8:21−cv−00554−JAK−ADS.
Law firm: Fish and Richardson, P.C., Redwood City CA.
Role: I served as technical expert witness on behalf of SEL, authored two expert reports, and was deposed.

2022 ***Case***: Nvidia Corporation versus Ocean Semiconductors LLC.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case number: IPR2022-01288.
Law firm: Sheppard Mullin LLP, Menlo Park CA.
Role: I served as technical expert witness on behalf of Nvidia and authored one expert declaration.

2022 ***Case***: Nicor, Inc. versus SourceBlue LLC and InfiniLux Corporation.
Nature: Patent infringement.
Venue: US District Court for the Central District of California.
Case number: 2:21-cv-05876-AB(PDx) (C.D. Cal.).
Law firm: Loza & Loza IP LLP, Upland CA.
Role: I served as technical expert witness on behalf of Nicor, Inc., authored three expert reports, and was deposed.

2023 ***Case***: Dr. Shimon Maimon versus Lockheed Martin Corporation.
Nature: Dispute relating to a License Agreement.
Venue: JAMS ADR (Alternative Dispute Resolution).
Case number: JAMS Ref. No. 1460005932.
Law firm: Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Washington DC.
Role: I served as technical expert witness on behalf of Lockheed Martin Corporation, authored three expert reports, was deposed, and testified at the Hearing.

2023 ***Case***: Samsung Electronics Co. Ltd. versus Daedalus Prime LLC.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case number: IPR2023-00536 and IPR2023-00653.
Law firm: Fish & Richardson PC, Minneapolis MN.
Role: I served as technical expert witness on behalf of Samsung Electronics and authored two expert declarations.

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2023 ***Case***: Seoul Semiconductor Co. Ltd., et al. versus GE Healthcare Inc.
Nature: Patent infringement.
Venue: United States District Court for the District of Delaware.
Case number: Civil Action No. 1:22-cv-01455.
Law firm: Shearman & Sterling LLP, New York, NY.
Role: I served as technical expert witness on behalf of GE Healthcare.

2023 ***Case***: Efficient Power Conversion Corp. versus Innoscience (Zhuhai) Technology Company.
Nature: Patent infringement.
Venue: US International Trade Commission (ITC), Washington DC.
Case number: Investigation No. 337-TA-1366.
Law firm: Blank Rome LLP, Washington DC
Role: I served as technical expert witness on behalf of EPC, authored multiple expert reports, was deposed, and testified at the ITC Hearing.

2023 ***Case***: Xu Peicheng (Hong Kong) Optoelectronic Technol. Co. versus SemiSilicon Technol. Corp.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case number: IPR2024-00156 (US Patent 8,124,988 and US 8,884,546)
Law firm: Rimon La PC, McLean VA.
Role: I served as technical expert witness on behalf of Xu Peicheng and authored two expert declarations.

2024 ***Case***: Seasonal Specialties, LLC versus LEDUP Manufacturing Group LTD.
Nature: Patent infringement.
Venue: US District Court, Central District of California, Western Division.
Case number: 2:23-cv-06318-SB-AS.
Law firm: Fairfield & Woods PC, Denver CO.
Role: I served as technical expert witness on behalf of LEDUP Manufacturing Group and composed multiple Invalidity Claim Charts.

2024 ***Case***: Wuxi Autowell Technology Co. Ltd. versus Teamtechnik Maschinen und Anlagen GmbH.
Nature: USPTO Inter Partes Review.
Venue: USPTO, Patent Trial and Appeal Board, Alexandria VA.
Case number: US patent numbers 8,247,681 and 8,253,009.
Law firm: Novick, Kim & Lee, PLLC, (NKL Law), Fairfax VA.
Role: I served as technical expert witness on behalf of Wuxi Autowell Technology and composed one expert declaration.

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United States Patents

1. A. Fischer, Y. Horikoshi, K. Ploog, and E. F. Schubert “Semiconductor devices with at least one monoatomic layer of doping atoms” European Patent No. 0183 146 A2; US Patent No. 4,882,609; issued on November 15 (1985)
2. J. E. Cunningham, E. F. Schubert, and W. T. Tsang “Delta doped ohmic metal to semiconductor contacts” US Patent No. 4,772,934; issued on September 20 (1988)
3. J. E. Cunningham, E. F. Schubert, and W. T. Tsang “Field-effect transistor having a delta-doped ohmic contact” US Patent No. 4,780,748; issued on October 25 (1988)
4. J. E. Cunningham, E. F. Schubert, and W. T. Tsang “Method for fabricating a field-effect transistor with a self-aligned gate” US Patent No. 4,784,967; issued on November 15 (1988)
5. E. Fred Schubert “Optical communications modulator device” US Patent No. 4,929,064; filed on July 21 (1988) issued on May 29 (1990)
6. J. E. Cunningham, A. M. Glass, and E. F. Schubert “Devices having asymmetric delta-doping” US Patent No. 4,974,044; issued on November 27 (1990)
7. J. E. Cunningham, A. M. Glass, and E. F. Schubert “Devices having asymmetric delta-doping” US Patent No. 5,031,012; issued on July 9 (1991)
8. J. E. Cunningham, T. D. Harris, E. F. Schubert, and J. P. van der Ziel “Optical system including wavelength tunable semiconductor laser” US Patent No. 4,980,892; issued on December 25 (1990)
9. R. F. Kopf, J. M. Kuo, H. S. Luftman, and E. F. Schubert “Doping procedures for semiconductor devices” US Patent No. 5,024,967; issued on June 18 (1991)
10. D. G. Deppe, R. D. Dupuis, and E. F. Schubert “Vertical cavity semiconductor lasers” US Patent No. 5,018,157; issued on May 21 (1991)
11. D. G. Deppe, L. C. Feldman, R. F. Kopf, E. F. Schubert, L.-W. Tu, and G. J. Zydzik “Vertical cavity surface emitting lasers with electrically conducting mirrors” US Patent No. 5,068,868; issued on November 26 (1991)
12. D. G. Deppe, E. F. Schubert, L.-W. Tu, and G. D. Zydzik “Optical devices with electron-beam evaporated multilayer mirror” US Patent No. 5,206,871; issued on April 27 (1993)
13. R. F. Kopf, E. F. Schubert, H. O’Brian, L.-W. Tu, Y. H. Wang, and G. J. Zydzik “Vertical cavity surface emitting lasers with transparent electrodes” US Patent No. 5,115,441; issued on May 19 (1992)
14. E. F. Schubert, L.-W. Tu, and G. J. Zydzik “Elimination of heterojunction band discontinuities” US Patent No. 5,170,407; issued on December 8 (1992)
15. S. W. Downey, A. B. Emerson, R. F. Kopf, and E. F. Schubert “Devices having repetitive layers” US Patent No. 5,226,055; issued on July 6 (1993)
16. A. Y. Cho, E. F. Schubert, L.-W. Tu, and G. J. Zydzik “Resonant cavity light emitting diode” US Patent No. 5,226,053; issued on July 6 (1993)
17. L. C. Feldman, N. E. J. Hunt, D. C. Jacobson, J. M. Poate, E. F. Schubert, A. M. Vredenberg, Y. H. Wong, and G. J. Zydzik “Erbium-doped optical devices” US Patent No. 5,249,195; issued on September 28 (1993)

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18. R. F. Kopf and E. F. Schubert “PN junction devices with group IV element-doped group III-V compound semiconductors” US Patent No. 5,268,582; issued on December 7 (1993)

19. N. E. J. Hunt and E. F. Schubert “Single mirror light-emitting diodes with enhanced intensity” US Patent No. 5,362,977; issued on November 8 (1994)

20. N. E. J. Hunt, E. F. Schubert, and G. J. Zydzik “Photodetector with a resonant cavity” US Patent No. 5,315,128; issued on May 24 (1994)

21. A. M. Glass, N. E. J. Hunt, J. M. Poate, E. F. Schubert, and G. J. Zydzik “Absorption resonant rare-earth-doped microcavities” US Patent No. 5,363,398; issued on November 8 (1994)

22. N. E. J. Hunt, M. Passlack, E. F. Schubert, and G. J. Zydzik “Electron beam deposition of gallium oxide thin films using a single high purity crystal source” US Patent No. 5,451,548; issued on September 19 (1995)

23. N. K. Dutta, R. J. Fischer, N. E. J. Hunt, M. Passlack, E. F. Schubert, and G. J. Zydzik “Gallium oxide coatings for optoelectronic devices using electron beam evaporation of a high purity single crystal $Gd_3Ga_5O_{12}$ source” US Patent No. 5,550,089; issued on August 27 (1996)

24. U. K. Chakrabarti, J. de Jong, E. F. Schubert, J. Wynn, and G. J. Zydzik “Mechanical fixture and procedure for in-vacuum coating of semiconductor laser facets” US Patent No. 5,719,077; issued on February 17 (1998)

25. E. F. Schubert “Enhanced p-type doping of wide-gap semiconductors” US Patent No. 5,932,899; issued on August 3 (1999)

26. J. D. Joannopoulos, S. Fan, P. R. Villeneuve, and E. F. Schubert “Light emitting device utilizing a periodic dielectric structure” US Patent No. 5,955,749; issued on September 21 (1999)

27. E. F. Schubert and D. A. Stocker “Crystallographic wet chemical etching on GaN” US Patent No. 6,294,475; issued on September 25 (2001)

28. E. F. Schubert “Light-emitting diode with omni-directional reflector” US Patent No. 6,784,462; issued on August 31 (2004)

29. Jaehee Cho, Hong Luo, Jong Kyu Kim, Yong Jo Park, Cheolsoo Sone, and E. Fred Schubert “Light emitting device having protection element and method of manufacturing the light emitting device” US Patent No. 7,411,221 B2; issued on August 12 (2008)

30. Jaehee Cho, Frank Wilhelm Mont, Cheolsoo Sone, Jong-kyu Kim, June-o Song, E. Fred Schubert “Optical thin film, semiconductor light emitting device having the same and methods of fabricating the same” US Patent No. 7,483,212; issued on January 27 (2009)

31. Jaehee Cho, Martin F. Schubert, E. Fred Schubert, Jong Kyu Kim, Cheolsoo Sone “Light emitting diodes and display apparatuses using the same” US Patent No. 7,560,746; issued on July 14 (2009)

32. Martin F. Schubert, Sameer Chhajed, Jong Kyu Kim, E. Fred Schubert, and Jaehee Cho “Reflector shapes for light-emitting diode-polarized light sources” US Patent No. 7,766,495; filed on June 24 (2008); issued on August 3 (2010)

33. Martin F. Schubert, Ahmed Noemaun, Sameer Chhajed, Jong Kyu Kim, E. F. Schubert, Cheolsoo Sone “Encapsulant shapes for light emitting devices lacking rotational symmetry designed to enhance extraction of light with a particular linear polarization” US Patent No. 7,819,557; filed on June 24 (2008); issued on October 6 (2010)

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34. Jaehee Cho, Jong-Kyu Kim, Cheolsoo Sone, and E. F. Schubert “LED device having diffuse reflective surface” US Patent No. 7,816,855; filed on December 28 (2005); issued on October 19 (2010)

35. Jaehee Cho, E. Fred Schubert, and Xing Yan “Liquid crystal display with refractive index matched electrodes” US Patent No. 8,164,727; filed on April 28, 2010; issued on April 24 (2012)

36. Mary H. Crawford, Daniel Koleske, Jaehee Cho, Di Zhu, Ahmed Noemaun, Martin F. Schubert, and E. Fred Schubert “High efficiency III-Nitride light-emitting diodes” US Patent No. 8,451,877; filed on March 17, 2011; issued on May 28 (2013)

37. Min-ho Kim, Martin F. Schubert, Jong Kyu Kim, E. Fred Schubert, Yongjo Park, Cheolsoo Sone, and Sukho Yoon “Nitride semiconductor light-emitting device” US Patent No. 8,502,266; filed on September 8 (2010); issued on August 6 (2013)

38. David J. Poxson, Frank W. Mont, E. Fred Schubert, and Richard W. Siegel “Tunable nanoporous film on polymer substrates, and method for their manufacture” US Patent No. 9,732,427; filed on April 23 (2013); issued on August 15 (2017)

39. Sameer Chhajed, Jong Kyu Kim, Shawn-Yu Lin, Mei-Ling Kuo, Frank W Mont, David J Poxson, E Fred Schubert, Martin F Schubert “Ultra-low reflectance broadband omni-directional anti-reflection coating” US Patent No. 11,088,291; filed on July 22 (2016); issued on August 10 (2021)

Patent Licensing: Several patents listed above have been licensed to companies, including the Luminus Devices Company, Samsung Company, Epistar Company, Cree Company, Osram Company, and Lumileds Company.

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Journal Publications

1982

1. H. Künzel, H. Jung, E. F. Schubert, and K. Ploog "Influence of growth conditions and of alloy composition on electrical and optical properties of MBE AlGaAs" *Journal Physique Colloque C5*, **C5/175**, 42 (1982)

1984

2. E. F. Schubert, K. Ploog, H. Dämbkes, and K. Heime "Selectively doped n-AlGaAs/ GaAs heterostructures with high-mobility two-dimensional electron gas for field-effect transistors. Part I: Effect of parallel conductance" *Applied Physics* **A33**, 63 (1984)
3. E. F. Schubert, K. Ploog, H Dämbkes., and K. Heime "Selectively doped n-AlGaAs/ GaAs heterostructures with high-mobility two-dimensional electron gas for field-effect transistors. Part II: Hot electron effects" *Applied Physics* **A33**, 183 (1984)
4. E. F. Schubert and K. Ploog "Transient photoconductivity in selectively doped n-type AlGaAs/GaAs heterostructures" *Physical Review* **B29**, 4562 (1984)
5. E. F. Schubert, E. O. Göbel, Y. Horikoshi, K. Ploog, and H. J. Queisser "Alloy broadening in photoluminescence spectra of AlGaAs" *Physical Review* **B30**, 813 (1984)
6. E. F. Schubert and K. Ploog "Shallow and deep donors in direct-gap n-AlGaAs:Si grown by molecular-beam epitaxy" *Physical Review* **B30**, 7021 (1984)

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7. E. F. Schubert, J. Knecht, and K. Ploog "Transient and persistent photoconductivity in n-AlGaAs and selectively doped n-AlGaAs/GaAs heterostructures*" Journal of Physics C: Solid-State Physics* **18**, L215 (1985)
8. E. F. Schubert, A. Fischer, and K. Ploog "GaAs sawtooth superlattice light-emitting diode operating monochromatically at $\lambda > 0.9$ μm" *Electronics Letters* **21**, 411 (1985)
9. E. F. Schubert, A. Fischer, Y. Horikoshi, and K. Ploog "GaAs sawtooth superlattice laser emitting at wavelengths $\lambda > 0.9$ μm" *Applied Physics Letters* **47**, 219 (1985)
10. E. F. Schubert, A. Fischer, and K. Ploog "Electron-impurity tunneling in selectively doped n-type AlGaAs/GaAs heterostructures" *Physical Review* **B31**, 7937 (1985)
11. E. F. Schubert, Y. Horikoshi, and K. Ploog "Radiative electron-hole recombination in a new sawtooth semiconductor superlattice grown by molecular-beam epitaxy" *Physical Review* **B32**, 1085 (1985)
12. E. F. Schubert and K. Ploog "The delta-doped field-effect transistor" *Japanese Journal Applied Physics Letters* **24**, L608 (1985)
13. K. Ploog, A. Fischer, E. F. Schubert "Preparation and properties of a new GaAs sawtooth doping superlattice" *Proceedings of the Second International Conference (Yamada Conference) on Modulated Semiconductor Structures*; September 9-13 (1985), Kyoto, Japan
14. E. F. Schubert and K. Ploog "Electron subband structure in selectively doped n-AlGaAs/ GaAs heterostructures*" IEEE Transactions on Electron Devices*, **ED-32**, 1868 (1985)
15. E. F. Schubert and K. Ploog "Optical properties of a new sawtooth superlattice grown by molecular beam epitaxy" *Journal de Physique* (Paris), **46**, 147 (1985)

1986

16. E. F. Schubert, A. Fischer, and K. Ploog "The delta-doped field-effect transistor" *IEEE Transactions on Electron Devices,* **ED-33**, 625 (1986)
17. E. F. Schubert and K. Ploog "Interpretation of capacitance-voltage profiles from delta-doped GaAs grown by molecular-beam epitaxy" *Japanese Journal of Applied Physics* **25**, 966 (1986)
18. E. F. Schubert and W. T. Tsang "Photoluminescence line shape of excitons in alloy semiconductors" *Physical Review B, Rapid Communications*, **B34**, 2991 (1986)
19. E. F. Schubert, J. E. Cunningham, W. T. Tsang, and T. H. Chiu "Delta-doped ohmic contacts to n-GaAs" *Applied Physics Letters* **49**, 292 (1986) and *Applied Physics Letters* **49**, 984 (1986)
20. K. Ploog, A. Fischer, and E. F. Schubert "Preparation and properties of a new GaAs sawtooth doping superlattice" *Surface Science* **174**, 120 (1986)
21. B. I. Miller, E. F. Schubert, U. Koren, A. Ourmazd, A. H. Dayem, and R. J. Capik "High quality narrow GaInAs/InP quantum wells grown by atmospheric organometallic vapor phase epitaxy" *Applied Physics Letters* **49**, 1384 (1986)
22. E. F. Schubert, Cunningham J. E., and Tsang W. T. "Self-aligned enhancement and depletion-mode GaAs field-effect transistors employing the delta-doping technique" *Applied Physics Letters* **49**, 1729 (1986)

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CERTIFICATE OF TRANSLATION ACCURACY

I am a professional reviewer and coordinator specializing in translating Japanese, Korean, and Chinese to English and vice versa.

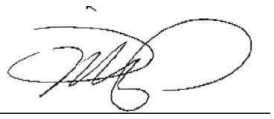
I served as Chief Examiner of the certified court interpreter test for the State of California and as a contract translator and interpreter for various federal agencies through the U.S. Department of State for more than a decade. I served as an instructor at the University of California at Berkeley and the Middlebury Institute of International Studies at Monterey (MIIS) Graduate Program in Translation.

I have more than 30 years of experience reviewing thousands of technical, legal, and business documents from Japanese to English submitted to, among others, Japanese judicial authorities, U.S. federal courts, the U.S. International Trade Commission (ITC), and the USPTO Patent Trial and Appeal Board (PTAB).

I certify that the following document translated from Japanese to English is a true, correct, and complete translation of the corresponding source text to the best of my knowledge and ability.

I certify under penalty of perjury that the foregoing is true and correct.

Executed this 17th day of May 2024 in Contra Costa County of the State of California.

By: 

Alex N. Jo
Member, ATA

Exhibit
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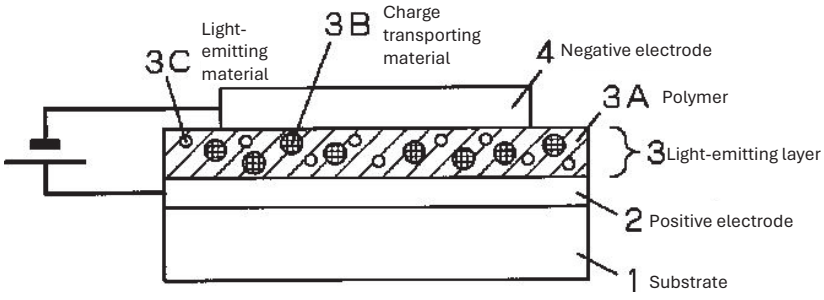
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54) [Title of the Invention] ORGANIC LIGHT-EMITTING DEVICE

(57) ABSTRACT
[PROBLEM]
To provide a polymer-dispersed organic light-emitting device that has high light-emitting efficiency.

[RESOLUTION MEANS]
A polymer-dispersed organic light-emitting device having high light-emitting efficiency can be provided by a light-emitting layer containing a charge transporting polymer 3A having a specific hole transporting capacity, a charge transporting material 3B having a specific electron transporting capacity, and a light-emitting material 3C.



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SCOPE OF PATENT CLAIMS

[Claim 1]
An organic light-emitting device, comprising:
at least one light-emitting layer between a positive electrode and a negative electrode, the light-emitting layer including a charge transporting material, a light-emitting material, and a polymer for dispersing these materials.

[Claim 2]
The organic light-emitting device according to claim 1, wherein the polymer is a charge transporting polymer.

[Claim 3]
The organic light-emitting device according to claim 1, wherein the polymer is a hole transporting polymer.

[Claim 4]
The organic light-emitting device according to claim 3, wherein the charge transporting material is an electron transporting material.

[Claim 5]
The organic light-emitting device according to claim 3 or 4, wherein a carrier mobility of the hole transporting polymer is $1x10^{-7}cm^2/V \cdot s$ or more.

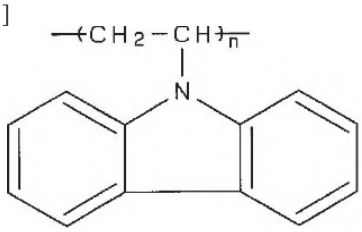
[Claim 6]
The organic light-emitting device according to claim 4 or 5, wherein the carrier mobility of the electron transporting material is $5x10^{-8}cm^2/V \cdot s$ or more.

[Claim 7]
The organic light-emitting device according to any one of claims 4 to 6, wherein the content of the electron transporting material is 30 to 120 wt% based on the polymer.

[Claim 8]
The organic light-emitting device according to any of claims 4 to 7, wherein an ionization potential of the hole transporting polymer is greater than an ionization potential of the light-emitting material, and an electron affinity of the electron transporting material is less than an electron affinity of the light-emitting material.

[Claim 9]
The organic light-emitting device according to any of claims 3 to 8, wherein the polymer is poly-N-vinylcarbazole having repeating units expressed by the following general formula (Chem. Fig. 1).

[Chem. Fig. 1]



[Claim 10]
The organic light-emitting device according to any of claims 4 to 9, wherein the electron transporting material includes at least one type selected from oxazole derivatives, oxadiazole derivatives, triazole derivatives, pyrazine derivatives, and aldazine derivatives.

[Claim 11]
The organic light-emitting device according to any of claims 4 to 9, wherein the electron transporting material includes a quinolinol complex or a derivative thereof.

[Claim 12]
The organic light-emitting device according to claim 11, wherein the electron transporting material includes tris(8-quinolinolato)aluminum or a derivative thereof.

[Claim 13]
The organic light-emitting device according to any of claims 1 to 12, comprising, a hole injecting layer between the positive electrode and the light-emitting layer.

[Claim 14]
The organic light-emitting device according to claim 13, wherein the relationship between an ionization potential of the hole injecting layer (Ip(h)), an ionization potential of the polymer (Ip(p)), and an ionization potential or work function of the positive electrode (Ip(a)) is expressed by the following formula.
$Ip(a) < Ip(h) < Ip(p)$

[Claim 15]
The organic light-emitting device according to claim 13 or 14, wherein the hole injecting layer includes at least one type selected from polyaniline derivatives, polythiophene derivatives, and amorphous carbon.

[Claim 16]
The organic light-emitting device according to any of claims 1 to 15, comprising: an electron injecting layer between the negative electrode and the light-emitting layer.

[Claim 17]
The organic light-emitting device according to claim 16, wherein an electron affinity or work function of the electron injecting layer is less than a work function of the negative electrode.

[Claim 18]
The organic light-emitting device according to claim 17, wherein the electron injecting layer includes at least one type selected from dilithium phthalocyanine, disodium phthalocyanine, and organic boron complex compounds.

[Claim 19]
The organic light-emitting device according to claim 18, wherein the electron injecting layer contains 4,4,8,8-tetrakis(1H-pyrazol-1-yl)pyrazabole.

[Claim 20]
The organic light-emitting device according to any of claims 1 to 19, wherein the charge transporting material contains at least one or more each of a hole transporting material and an electron transporting material.

[Claim 21]
The organic light-emitting device according to claim 20, wherein an ionization potential of the hole transporting material is less than an ionization potential of the polymer.

[Claim 22]
The organic light-emitting device according to claim 20 or 21, wherein the content of the hole transporting material is 10 to 120 wt% based on the polymer.

DETAILED DESCRIPTION OF THE INVENTION

[0001]
TECHNOLOGICAL FIELD OF THE PRESENT INVENTION
The present invention relates to an organic light-emitting device used in a flat light source or a flat display.

[0002]
CONVENTIONAL TECHNOLOGY
Electroluminescent devices are attracting attention as display devices for flat displays and the like due to being self-luminous, and therefore highly visible, as well as their ability to be made thin. Among these, organic EL devices, in which an organic compound forms a light-emitting body, and which have features such as the ability to be driven at a lower voltage than inorganic EL devices, easy surface area enlargement, and easy acquisition of a desired color at which light is emitted via the selection of an appropriate dye, are being actively developed for next-generation displays.

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[0003] As an example of an EL device that uses an organic light-emitting body, a blue emitted light is obtained by applying a voltage of 30 V to an anthracene-deposited film that is 1 μm or thinner (Thin Solid Films, 94 (1982) 171). However, even when this device has a high voltage applied thereto, sufficient luminance cannot be obtained, and there is a need for the light-emitting efficiency to be further improved.

[0004] In response to this, Tang et al. attempted to improve the light-emitting efficiency by laminating a transparent electrode (anode), a hole transporting layer, a light-emitting layer having electron transference, and a cathode that utilizes a metal having a low work function, and thereby achieved a luminance of 1,000 cd/m^2 at an applied voltage of 10 V or less (Appl. Phys. Lett., 51 (1987) 913).

[0005] Furthermore, there are reports of a three-layer-structured device having a light-emitting layer interposed between a hole transporting layer and an electron transporting layer (Jpn. J. Appl. Phys., 27 (1988) L269) and an device in which light-emission from a dye-doped light-emitting layer is obtained (J. Appl. Phys., 65 (1989) 3610).

[0006] On the other hand, whereas for every device having the above configuration, each film is formed by a dry process such as a vacuum deposition method, there are methods for forming devices by so-called wet film formation methods such as spin coating methods and casting methods (for example, Japanese Unexamined Patent Application No. H3-790 and Japanese Unexamined Patent Application No. H3-171590).

[0007] In other words, an device is formed by: dissolving at least one or more types of a material forming the hole transporting layer, electron transporting layer, and light-emitting layer, along with a polymer binder, in an appropriate solvent, coating this onto an electrode surface to form a light-emitting layer, and then further forming an electrode on the light-emitting layer using a vapor deposition method or the like. Hereinafter, an organic light-emitting device fabricated in this manner will be referred to as a polymer-dispersed light-emitting device, in contrast to conventional laminated light-emitting devices.

[0008] Examples of advantages of polymer-dispersed light-emitting devices over organic light-emitting devices fabricated by a dry process include the following points:

(1) Materials can be used that are difficult to form into a film by a dry process such as deposition.

(2) A trace amount of doping, which is difficult to control in a dry process, can also be easily achieved.

(3) Surface area enlargement is easy.

(4) Fabrication can be carried out at a low cost.

(5) Simultaneous light emission from a plurality of light-emitting materials can be easily obtained by introducing the respective light-emitting materials (emission of white light is possible).

(6) Polymer-dispersed light-emitting devices are thermally stable because respective materials are dispersed in a polymer binder, in contrast to conventional laminated light-emitting devices in which respective layers are in an amorphous state.

[0009] Configurations of the light-emitting layer of conventional polymer-dispersed light-emitting devices include those in which a perinone derivative or tris(8-quinolinolato)aluminum is dispersed as a light-emitting material in polyvinylcarbazole, those in which tris(8-quinolinolato)aluminum and tetraphenylbenzidine are dispersed as light-emitting materials in polycarbonate, and the like (for example, Japanese Unexamined Patent Application H3-790, Japanese Unexamined Patent Application H3-171590, and the like).

[0010]

PROBLEMS TO BE SOLVED BY THE INVENTION

Although polymer-dispersed light-emitting devices have the advantages described above, a problem exists in that light-emitting efficiency thereof is low compared to the conventional laminated light-emitting devices.

[0011] In other words, in a laminated light-emitting device, holes are injected from an anode into a hole transporting layer, and electrons are injected from a cathode into an electron transporting light-emitting layer or an electron transporting layer. Furthermore, when these holes and electrons are recombined inside the light-emitting layer, excitons are formed, and light is emitted when these excitons transition to their ground state. Here, since electron transport and hole transport are functionally separate, recombination of electrons and holes occurs only near an interface of each layer. Therefore, excitons are generated efficiently, and light-emitting efficiency is also improved.

[0012] Furthermore, regarding the injection of holes and electrons, if the materials of layers in contact with each electrode are selected such that an injection barrier is reduced between the anode and cathode, injection can be easily performed, which allows for driving at a low voltage.

[0013] In contrast, in the case of polymer-dispersed light-emitting devices, since they are mainly configured of a single layer, the recombination of holes and electrons / the generation of excitons does not occur locally as in the laminated light-emitting devices described above, and the injection barrier for the holes / electrons from the electrodes is also large, making it difficult to improve light-emitting efficiency.

[0014] The present invention solves the problems described above, realizing a high light-emitting efficiency and low driving voltage even in a polymer-dispersed organic light-emitting device.

[0015]

MEANS FOR SOLVING THE PROBLEM

As a result of intensive research into achieving the above object, the present inventors have found that current-luminance efficiency can be improved in a polymer-dispersed light-emitting device by including a charge transporting material having a specific carrier mobility in the polymer, or by using a charge transporting polymer having a specific carrier mobility. Furthermore, the present inventors found that the driving voltage can be reduced by inserting a hole injecting layer having a specific ionization potential between a positive electrode and a light-emitting layer, or by including a hole transporting material having a specific ionization potential inside the light-emitting layer.

[0016] Specifically, the organic light-emitting device of the invention of claim 1 of the present application is an organic light-emitting device containing at least one of a light-emitting layer between a positive electrode and a negative electrode, containing the light-emitting layer, a charge transporting material, a light-emitting material, and a polymer for dispersing materials.

[0017] In addition, the invention of claim 2 of the present application is an organic light-emitting device wherein the polymer according to claim 1 is a charge transporting polymer.

[0018] In addition, the invention of claim 3 of the present application is an organic light-emitting device wherein the polymer according to claim 1 is a hole transporting polymer.

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[0019] In addition, the invention of claim 4 of the present application is an organic light-emitting device wherein, in the organic light-emitting device according to claim 3, the charge transporting material is an electron transporting material.
[0020] In addition, the invention according to claim 5 of the present application is an organic light-emitting device wherein a carrier mobility of the hole transporting polymer according to claim 3 or 4 is $1x10^{-7}cm^2/V \cdot s$ or more.
[0021] In addition, the invention according to claim 6 of the present application is an organic light-emitting device wherein the carrier mobility of the electron transporting material according to claim 4 or 5 is $5 \times 10^{-8}cm^2/V \cdot s$ or more.
[0022] In addition, the invention of claim 7 of the present application is an organic light-emitting device wherein the content of the electron transporting material according to claims 4 to 6 is 30 to 120% by weight based on the polymer.
[0023] In addition, the invention of claim 8 of the present application is an organic light-emitting device wherein an ionization potential of the hole transporting polymer according to claims 4 to 7 is greater than an ionization potential of the light-emitting material, and an electron affinity of the electron transporting material is less than an electron affinity of the light-emitting material.
[0024] In addition, the invention of claim 9 of the present application is an organic light-emitting device wherein the polymer according to claims 3 to 8 is a poly-N-vinylcarbazole having the repeating unit expressed by the general formula (Chem. Fig. 1).
[0025] In addition, the invention of claim 10 of the present application is an organic light-emitting device wherein the electron transporting material according to one of claims 4 to 9 contains at least one type from among oxazole derivatives, oxadiazole derivatives, triazole derivatives, pyrazine derivatives, and aldazine derivatives.
[0026] In addition, the invention of claim 11 of the present application is an organic light-emitting device wherein the electron transporting material according to one of claims 4 to 9 contains a quinolinol complex or a derivative thereof.
[0027] In addition, the invention of claim 12 of the present application is an organic light-emitting device wherein the electron transporting material according to claim 11 contains tris(8-quinolinolato)aluminum or a derivative thereof.
[0028] In addition, the invention of claim 13 of the present application is an organic light-emitting device having, in the organic light-emitting device according to claims 1 to 12, a hole injecting layer between the positive electrode and the light-emitting layer.
[0029] In addition, the invention of claim 14 of the present application is an organic light-emitting device wherein the relationship between an ionization potential of the hole injecting layer according to claim 13 (Ip(h)), an ionization potential of the polymer (Ip(p)), and an ionization potential or work function of the positive electrode (Ip(a)) is expressed by the following formula.
[0030] $Ip(a) < Ip(h) < Ip(p)$
In addition, the invention of claim 15 of the present application is an organic light-emitting device wherein the hole injecting layer according to claim 13 or 14 contains at least one type selected from polyaniline derivatives, polythiophene derivatives, and amorphous carbon.

[0031] In addition, the invention of claim 16 of the present application is an organic light-emitting device having, in the organic light-emitting device according to one of claims 1 to 15, an electron injecting layer between the negative electrode and the light-emitting layer.
[0032] In addition, the invention of claim 17 of the present application is an organic light-emitting device wherein an electron affinity or work function of the electron injecting layer according to claim 16 is less than a work function of the negative electrode.
[0033] In addition, the invention of claim 18 of the present application is an organic light-emitting device wherein the electron injecting layer according to claim 17 contains at least one type selected from dilithium phthalocyanine, disodium phthalocyanine, and organic boron complex compounds.
[0034] In addition, the invention of claim 19 of the present application is an organic light-emitting device wherein the electron injecting layer according to claim 18 contains 4,4,8,8-tetrakis(1H-pyrazol-1-yl)pyrazabole.
[0035] In addition, the invention of claim 20 of the present application is an organic light-emitting device wherein, in the organic light-emitting device according to any one of claims 1 to 19, the charge transporting material contains at least one or more type of a hole transporting material and an electron transporting material.
[0036] In addition, the invention of claim 21 of the present application is an organic light-emitting device wherein the ionization potential of the hole transporting material according to claim 20 is less than the ionization potential of the polymer.
[0037] In addition, the invention of claim 22 of the present application is an organic light-emitting device wherein the amount of hole transporting material according to claims 20 or 21 is 10 to 120 wt% based on the polymer.
[0038]
EMBODIMENTS OF THE INVENTION
Embodiments of the present invention will be described below. FIG. 1 is a cross-sectional view depicting one example of the organic light-emitting device of the present invention. In FIG. 1, 1 is substrate, 2 is a positive electrode, 3 is a light-emitting layer, and 4 is a negative electrode.
[0039] The substrate 1 may be any substrate capable of carrying the organic light-emitting device of the present invention, and may be a transparent substrate such as glass or a resin film such as polycarbonate, polymethyl methacrylate, or polyethylene terephthalate, or a non-transparent substrate such as silicon.
[0040] At least one of the positive electrode 2 and the negative electrode 4 must be transparent or semi-transparent, and light emitted from the light-emitting layer is ejected to the outside through one or both of these electrodes. The positive electrode 2 typically is a transparent electrode such as indium tin oxide (ITO) or tin oxide, however, a metal electrode such as Ni, Au, Pt, or Pd may be used. For the purpose of improving transparency or reducing resistivity of the ITO film, a film forming method such as sputtering, electron beam deposition, or ion plating is used. In addition, film thickness is determined based on a required sheet resistance value and visible light transmittance, but since the driving current density of an organic light-emitting device is relatively high, a thickness of 1,000 Å or more is often used to reduce sheet resistance value.

The negative electrode 4 can be a metal such as Al, Ag, or Au, an alloy of a metal having a low work function and a metal having a relatively large and stable work function, such as an MgAg alloy or an AlLi alloy, or a laminated electrode of a metal having a low work function and a metal having a high work function, such as Li/Al or LiF/Al. Vapor deposition methods and sputtering methods are preferable for forming these negative electrodes. Note that in FIG. 1, the order of configuration from the bottom is: substrate / positive electrode / light-emitting layer / negative electrode. However, it is not necessarily required that lamination be done in this order, and the order from the bottom may be: substrate / negative electrode / light-emitting layer / positive electrode. In addition, in FIG. 1, when only the electrode on the substrate 1 side, that is, only the positive electrode 2, is transparent, and the negative electrode 4 is non-transparent, the substrate 1 must also be a transparent substrate in order for emitted light to be ejected to the outside.

[0041] The light-emitting layer includes a charge transporting material 3B, a light-emitting material 3C, and a polymer 3A for dispersing these. For the polymer material, charge transporting polymers are preferable, among which, hole transporting polymers are preferred. The hole transporting polymer preferably has a carrier mobility of $1\times10^{-7}cm^2/V\cdot s$ or more, where a poly-N-vinylcarbazole having the repeating unit expressed by the general formula (Chem. Fig. 1) is particularly preferable. When a hole transporting polymer is used, it is preferable that an electron transporting material be used as the charge transporting material. Furthermore, it is preferable that the carrier mobility of the electron transporting material be $5x10^{-8}cm^2/V\cdot s$ or more. In particular, oxazole derivatives, oxadiazole derivatives, triazole derivatives, pyrazine derivatives, aldazine derivatives, quinolinol complexes, and derivatives thereof are preferred. In addition, the content of the electron transporting material is preferably 30 to 120 wt% based on the polymer. In other words, with a content at less than 30%, electron transporting capacity is insufficient, and if greater than 120 wt%, dispersibility in the polymer worsens. For the light-emitting material, a fluorescent substance or a phosphorescent substance that exhibits light emission in response to hole/electron recombination may be used, and as for a substance that exhibits particularly strong fluorescence or phosphorescence, a dye such as a cyanine dye, merocyanine dye, styryl dye, anthracene derivative, porphyrin derivative, phthalocyanine derivative, coumarin, DCM, and Nile Red, and a laser dye may be used. In addition, for the light-emitting material, a substance having an ionization potential of the light-emitting material less than an ionization potential of the hole transporting polymer, and an electron affinity of the light-emitting material greater than an electron affinity of the electron transporting material is preferable.

[0042] The light-emitting mechanism of the organic light-emitting device of the present invention is as follows. That is, in an organic light-emitting device of the configuration in FIG. 1, when a voltage is applied between the positive electrode 2 and the negative electrode 4 in the direction depicted in the drawing, holes injected from the positive electrode 2 and electrons from the negative electrode 4 are injected into the light-emitting layer 3. Furthermore, the injected holes flow toward the negative electrode 4, and the electrons flow toward the positive electrode 2. The holes and electrons recombine inside the light-emitting layer, and in response to this, fluorescence or phosphorescence is emitted from the light-emitting material inside the light-emitting layer. Here, examples of primary factors determining the current efficiency of light emission (efficiency of light emission relative to injected current) include the following.

(1) Recombination efficiency of holes and electrons relative to the injected current
(2) Efficiency of exciton generation in a light-emitting material accompanying recombination
(3) Quantum efficiency of light-emission from excitons in the light-emitting material

Of the above, (2) and (3) are determined almost entirely by the properties of the light-emitting material itself. On the other hand, the recombination efficiency of holes and electrons in (1) is most affected by the balance between holes and electrons. In other words, if the balance between holes and electrons is poor, even if an excess of carriers is injected from an electrode, the excess of carriers will reach the opposite electrode with no recombination inside the light-emitting layer, resulting in wasted current that does not contribute to light emission. Therefore, if the mobility of each carrier inside the light-emitting layer is increased, the holes and electrons will flow in a balanced manner, and the light-emitting efficiency will also improve. Specifically, it is preferable that the hole mobility be $1\times10^{-7}cm^2/V\cdot s$ or more, and that the electron mobility be $5\times10^{-8}cm^2/V\cdot s$ or more.

[0043] FIGS. 2 to 4 are cross-sectional views depicting separate examples of the organic light-emitting device of the present invention. In FIGS. 2 to 4, 5 is a hole injecting layer, 6 is an electron injecting layer, 3D is a hole transporting material, and 3E is an electron transporting material.

[0044] The hole injecting layer 5 is inserted for the purpose of assisting hole injection from the positive electrode 2 to the light-emitting layer 3. For the hole injecting layer 5, it is preferable that a material be used wherein the relationship between an ionization potential (Ip(h)) thereof, an ionization potential of the polymer (Ip(p)), and an ionization potential or work function of the positive electrode (Ip(a)) satisfies: $Ip(a)<Ip(h)<Ip(p)$. In particular, it is preferable that the material includes at least one type from among polyaniline derivatives, polythiophene derivatives, and amorphous carbon.

[0045] The electron injecting layer 6 is inserted for the purpose of assisting electron injection from the negative electrode 4 to the light-emitting layer 3. For the electron injecting layer 6, it is desirable that a material be used wherein an electron affinity or work function thereof is less than a work function of the negative electrode. In particular, it is preferable that the electron injecting layer contains at least one type from among dilithium phthalocyanine, disodium phthalocyanine, and organic boron complex compounds. The hole transporting material 3D is introduced for the purpose of assisting hole injection from the positive electrode 2 to the light-emitting layer 3, as with the hole injecting layer. However, unlike the hole injecting layer 5, the hole transporting material is not inserted as a film between the positive electrode 2 and the light-emitting layer 3, but is directly dispersed inside the light-emitting layer. For the hole transporting material 3D, it is preferable that an ionization potential thereof be less than an ionization potential of the polymer. In addition, the content of the hole transporting material is preferably 10 to 120% by weight based on the polymer. In other words, at less than 10% by weight, sufficient hole injection cannot be obtained, and if greater than 120% by weight, dispersibility in the polymer worsens.

[0046] The effects of introducing the hole injecting layer 5, the electron injecting layer 6, and the hole transporting material 3D will be described with reference to the drawings.

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FIGS. 5 to 8 are energy diagrams of the organic light-emitting device of the present invention.

[0047] FIG. 5, being of an organic light-emitting device configured of a positive electrode / light-emitting layer (hole transporting polymer + electron transporting material + light-emitting material) / negative electrode, and FIG. 6, being of an organic light-emitting device configured of a positive electrode / hole injecting layer / light-emitting layer (hole transporting polymer + electron transporting material + light-emitting material) / negative electrode, represent energy diagrams and operating mechanisms thereof. As described above, when a voltage is applied to an organic light-emitting device, holes from the positive electrode and electrons from the negative electrode are injected into the light-emitting layer. More specifically, as depicted in FIG. 5, both carriers are injected into substances having a lower injection barrier, that is, holes are injected into the hole transporting polymer inside the light-emitting layer, and electrons are injected into the electron transporting material inside the light-emitting layer. Here, the lower the injection barrier for both carriers (holes and electrons), the more easily injection occurs, and the lower the driving voltage. Therefore, even if current efficiencies are the same, the power efficiency of light emission (efficiency of light emission relative to input power) can be improved by reducing the driving voltage. Therefore, for example, when a hole injecting layer having an ionization potential between the positive electrode and the hole transporting polymer–is inserted, the hole injection barrier is relaxed, as depicted in FIG. 6, and the driving voltage can also be reduced. Furthermore, when the hole injection barrier is large compared to the electron injection barrier, as depicted in FIG. 5, by reducing the hole injection barrier, the balance between hole injection quantity and electron injection quantity improves, and as a result of effects such as those described above, current efficiency improvement can also be expected.

[0048] In addition, FIG. 7 is an energy diagram of an organic light-emitting device having the configuration: positive electrode / light-emitting layer (hole transporting polymer + electron transporting material + light-emitting material) / electron injecting layer / negative electrode. As with the hole injection barrier, the electron injection barrier can also be decreased, as depicted in FIG. 7, by inserting an electron injecting layer having a small electron affinity compared to the negative electrode, the driving voltage can be reduced, and light-emitting efficiency can be improved.

[0049] On the other hand, FIG. 8 is an energy diagram of an organic light-emitting device having the configuration: positive electrode / light-emitting layer (hole transporting polymer + hole transporting material + electron transporting material + light-emitting material) / negative electrode. In this case, since the ionization potential of the hole transporting material is less than that of the hole transporting polymer, holes are injected directly from the positive electrode into the hole transporting material inside the light-emitting layer, as depicted in the drawing, and the injection barrier decreases compared to when injected into the hole transporting polymer. Therefore, as in the case where a hole injecting layer is inserted, the driving voltage can be reduced, while at the same time, current efficiency improvement can also be expected.

[0050] Of course, configurations may also include incorporation of a configuration described above, that is, insertion of both a hole injecting layer and an electron injecting layer, further insertion of an electron injecting layer, with the light-emitting layer as: hole transporting polymer + hole transporting material + electron transporting material + light-emitting material, or the like.

[0051] Next, a more detailed description will be given based on a specific embodiment.

[0052] (Example 1) An organic light-emitting device having the configuration in FIG. 1 was fabricated as follows. For the substrate 1, a glass substrate having a thickness of 0.7 mm was used, and for the positive electrode 2 thereon, ITO was formed into a film by a sputtering method. The ITO film thickness was approximately 1,000 Å, with a sheet resistance of approximately 15 Ω/□, and was patterned into a desired shape by photolithography. For the light-emitting layer 3, poly-N-vinylcarbazole (PVK) (molecular weight of approximately 28,000) was used for the polymer 3A, tris(8-quinolinolato)aluminum (Alq_3) was used for the charge transporting material 3B, and Nile Red, a laser dye, was used for the light-emitting material 3C. PVK is a hole transporting polymer with a carrier mobility of approximately $2\times10^{-6}cm^2/V\cdot s$. In addition, Alq_3 is an electron transporting material with a carrier mobility of approximately $2\times10^{-6}cm^2/V\cdot s$. The mixing ratio of each material was: PVK:Alq_3:Nile Red = 100:60:0.2 (weight ratio). The light-emitting layer was formed by performing the following method. 300 mg of PVK, 180 mg of Alq_3, and 0.6 mg of Nile Red were dissolved in 30 mL of a 1:1 mixed solvent of toluene and chloroform, and the solution was stirred for one day. This solution was spin-coated onto the ITO-affixed glass substrate described above, which was cleaned and treated with oxygen plasma in advance, to obtain the light-emitting layer 3. The spin coating was performed using a spinner, in a sealed state, and under the conditions: 500 rpm for 10 seconds and 1,000 rpm for 30 seconds, then heat treatment was performed at 110° C for 1 minute using a hot plate. The film thickness of the light-emitting layer 3 was approximately 1,000 Å. Next, for the negative electrode 4, a Li/Al laminated electrode was formed into a film by a vacuum deposition method. The film was formed under a vacuum of approximately 5×10^{-6} Torr, where first, Li was deposited over 10 Å at a rate of approximately 0.5 Å/sec, then Al was deposited over 1,500 Å at approximately 30 Å/sec. For the shape of the negative electrode, a desired pattern was obtained using a mask.

[0053] On the other hand, with regard to the energy level of each material, the ionization potential of ITO is 4.9 eV, the ionization potential of PVK is 5.6 eV and the electron affinity is 2.0 eV, the ionization potential of Alq3 is 5.7 eV and the electron affinity is 3.0 eV, the ionization potential of Nile Red is 5.3 eV and the electron affinity is 3.5 eV, the work function of Li is 2.9 eV, and the work function of Al is 4.3 eV.

[0054] When a voltage was applied to the organic light-emitting device fabricated in this manner in the direction depicted in FIG. 1, the device emitted orange light. The current efficiency (cd/A), driving voltage at a luminance of 100 cd/m^2, and power efficiency (lm/W) at a luminance of 100 cd/m^2 at this time are shown in Table 1.

[0055]

[Table 1]

	Current Efficiency (cd/A)	Driving Voltage (at 100 cd/m^2) (V)	Power Efficiency (at 100 cd/m^2) (lm/W)
Example 1	**3.0**	**10.0**	**0.9**
Example 2	**4.0**	**8.0**	**1.6**
Example 3	**3.8**	**8.0**	**1.5**
Example 4	**4.0**	**7.6**	**1.7**
Example 5	**3.0**	**9.0**	**1.0**
Example 6	**3.1**	**9.0**	**1.1**
Example 7	**3.1**	**9.0**	**1.1**
Example 8	**4.0**	**8.0**	**1.6**
Example 9	**4.0**	**7.6**	**1.7**
Comparative Example 1	**0.4**	**20.0**	**0.06**
Comparative Example 2	**0.4**	**18.0**	**0.07**

[0056] (Example 2) An organic light-emitting device having the configuration in FIG. 2 was fabricated and evaluated. The substrate 1, the positive electrode 2, the light-emitting layer 3, and the negative electrode 4 had the same configuration and thickness as in Example 1, and a commercially available polythiophene derivative was inserted as the hole injecting layer 5. The film of the hole injecting layer was formed using a spin coating method, as with the light-emitting layer, and made to a film thickness of 150 Å. The ionization potential of the polythiophene derivative used here is 5.3 eV. The evaluation results of this device are presented in Table 1.

[0057] (Example 3) For the hole injecting layer 5, in place of the polythiophene derivative in Example 2, a commercially available polyaniline derivative exhibiting an ionization potential equivalent to that of the polythiophene derivative was used. A film of the polyaniline derivative was formed in the same manner as in Example 2, and made to a film thickness of 150 Å. The evaluation results of this device are presented in Table 1.

[0058] (Example 4) For the hole injecting layer 5, in place of the polythiophene derivative in Example 2, an amorphous carbon was used. The amorphous carbon was formed by a sputtering method, and made to a film thickness of 100 Å. The ionization potential of amorphous carbon is 5.2 eV. The evaluation results of this device are presented in Table 1.

[0059] (Example 5) An organic light-emitting device having the configuration in FIG. 3 was fabricated and evaluated. The substrate 1, the positive electrode 2, and the light-emitting layer 3 had the same configuration and film thickness as in Example 1, and for the electron injecting layer 6 on the light-emitting layer, a film of dilithium phthalocyanine was formed, and furthermore, for the negative electrode 4, a film of Al was formed. The dilithium phthalocyanine and Al were formed by a vacuum deposition method, wherein a film of the dilithium phthalocyanine was formed on the light-emitting layer 3 over 10 Å at a rate of approximately 0.3 Å/sec, after which a film of the Al was formed over 1,500 Å at approximately 30 Å/sec. The electron affinity of the dilithium phthalocyanine is 3.0 eV. The evaluation results of this device are presented in Table 1.

[0060] (Example 6) For the electron injecting layer 6, in place of the dilithium phthalocyanine in Example 5, disodium phthalocyanine, which exhibits an equivalent electron affinity as dilithium phthalocyanine, was used. A film of the disodium phthalocyanine was formed in the same manner as in Example 5, and made to a film thickness of 10 Å. The evaluation results of this device are presented in Table 1.

[0061] (Example 7) For the electron injecting layer 6, in place of the dilithium phthalocyanine in Example 5, 4,4,8,8-tetrakis(1H-pyrazol-1-yl)pyrazabole was used. A film of the 4,4,8,8-tetrakis(1H-pyrazol-1-yl)pyrazabol was formed in the same manner as in Example 5, and was made to a film thickness of 10 Å. The electron affinity of 4,4,8,8-tetrakis(1H-pyrazol-1-yl)pyrazabol is 2.3 eV. The evaluation results of this device are presented in Table 1.

[0062] (Example 8) An organic light-emitting device having the configuration in FIG. 4 was fabricated and evaluated. The substrate 1, the positive electrode 2, and the negative electrode 4 had the same configuration and thickness as in Example 1. For the light-emitting layer 3, PVK was used for the polymer 3A, N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD) was used for the hole transporting material 3D, Alq_3 was used for the electron transporting material 3E, and Nile Red was used for the light-emitting material 3C. The ionization potential of the TPD is 5.4 eV. The mixing ratio of each material was: PVK:Alq_3:TPD:Nile Red = 100:60:80:0.2 (weight ratio).

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The light-emitting layer was formed by dissolving 300 mg of PVK, 180 mg of Alq_3, 240 mg of TPD, and 0.6 mg of Nile Red in 50 mL of a 1:1 mixed solvent of toluene and chloroform, stirring the solution for one day, then spin-coating the solution onto the ITO-affixed glass substrate in the same manner as in Example 1. The film thickness of the light-emitting layer 3 was approximately 1,000 Å. Furthermore, a Li/Al-laminated electrode was vacuum-deposited thereon as the negative electrode 4 in the same manner as in (Example 1). The evaluation results of this device are presented in Table 1.

[0063] (Example 9) An device was fabricated in which both a hole injecting layer and an electron injecting layer were inserted. In other words, formation from the bottom was: substrate / positive electrode / hole injecting layer / light-emitting layer / electron injecting layer / negative electrode, wherein, the hole injecting layer was formed of the polythiophene derivative, and the electron injecting layer was formed of the dilithium phthalocyanine, each using the same fabrication methods and film thicknesses as in Example 2 and Example 5. The light-emitting layer had the same configuration as in Example 1, and for the negative electrode, Al was formed over 1,500 Å. The evaluation results of this device are presented in Table 1.

[0064] (Comparative Example 1) An organic light-emitting device similar to that of Example 1 was fabricated, differing from the configuration in FIG. 1 in that the light-emitting layer was configured only of PVK and Nile Red, and otherwise being the same. The evaluation results of this device are presented in Table 1.

[0065] (Comparative Example 2) An organic light-emitting device similar to that of Example 1 was fabricated, differing from the configuration in FIG. 1 in that the light-emitting layer was configured of PVK, TPD, and Nile Red, and otherwise being the same. TPD exhibits hole transporting properties, but extremely low electron transporting properties. The evaluation results of this device are presented in Table 1.

[0066] In contrast to Comparative Examples 1 and 2, in which a charge transporting material having a high electron transporting capacity was not included, when Alq_3, which has a high electron mobility of approximately 2×10^{-6} $cm^2/V\cdot s$, was included, current efficiency was able to be significantly improved, as depicted in Example 1. In addition, as depicted in Examples 2 to 9, by inserting a hole injecting layer or an electron injecting layer, or by introducing a hole transporting material inside the light-emitting layer to assist in hole injection, further driving voltage reduction and power efficiency improvement were able to be achieved.

[0067]

EFFECTS OF THE INVENTION

As described above, according the organic light-emitting device of the present invention, the light-emitting layer includes a charge transporting material, a light-emitting material, and a polymer for dispersing these materials, and by having specific carrier transporting properties or ionization potentials, these materials allowing holes and electrons to flow inside the light-emitting layer in a balanced manner, is therefore capable of improving light-emitting efficiency.

[0068] In addition, by inserting a hole injecting layer or an electron injecting layer, or by introducing a hole transporting material into the light-emitting layer to assist in hole injection, the hole or electron injection barrier is relaxed, and further driving voltage reduction and light-emitting efficiency improvement can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[FIG. 1] A cross-sectional view of an organic light-emitting device according to the first example of the present invention.

[FIG. 2] A cross-sectional view of an organic light-emitting device according to the second example of the present invention.

[FIG. 3] A cross-sectional view of an organic light-emitting device according to the third example of the present invention.

[FIG. 4] A cross-sectional view of an organic light-emitting device according to the fourth example of the present invention.

[FIG. 5] A figure depicting an energy diagram of the organic light-emitting device of the first example of the present invention.

[FIG. 6] A figure depicting an energy diagram of the organic light-emitting device of the second example of the present invention.

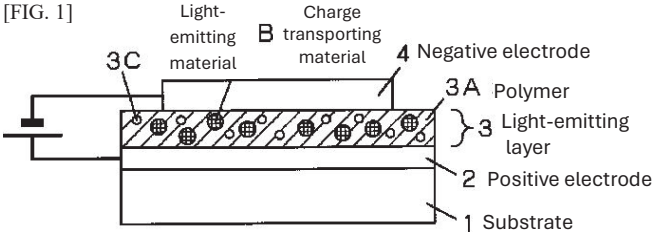
[FIG. 7] A figure depicting an energy diagram of the organic light-emitting device of the third example of the present invention.

[FIG. 8] A figure depicting an energy diagram of the organic light-emitting device of the fourth example of the present invention.

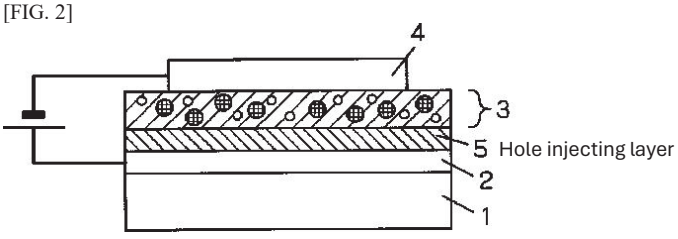
DESCRIPTION OF REFERENTIAL NUMERICALS

1. Substrate
2. Positive electrode
3. Light-emitting layer
3A. Polymer
3B. Charge transporting material
3C. Light-emitting material
3D. Hole transporting material
3E. Electron transporting material
4. Negative electrode
5. Hole injecting layer
6. Electron injecting layer

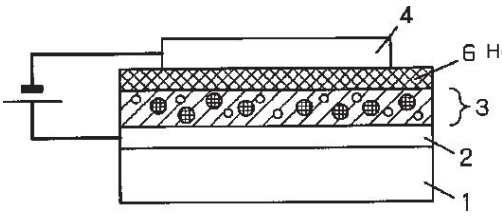
[FIG. 1]



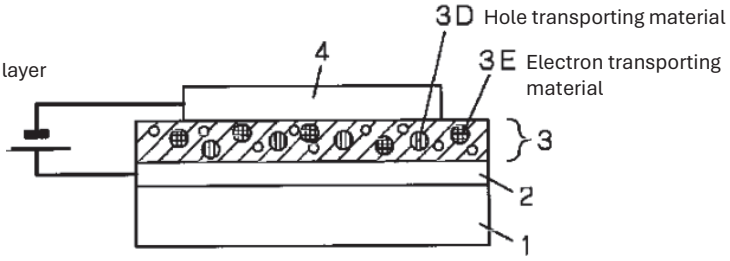
[FIG. 2]



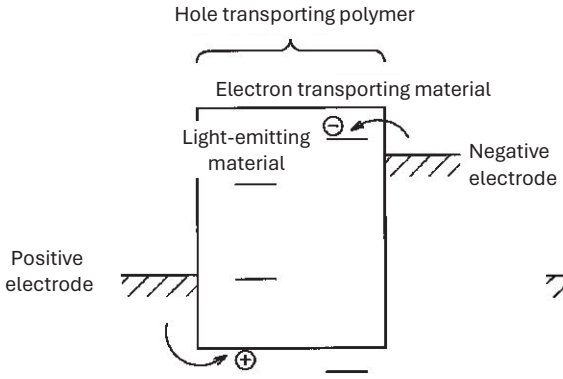
[FIG. 3]



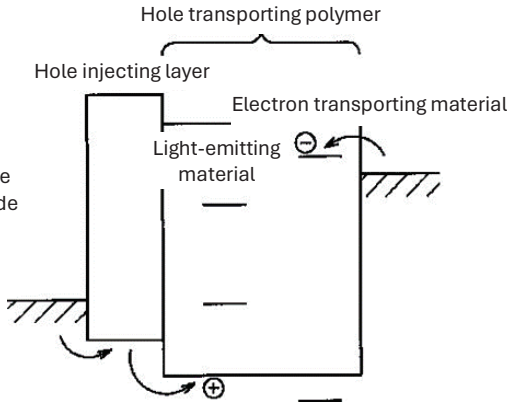
[FIG. 4]



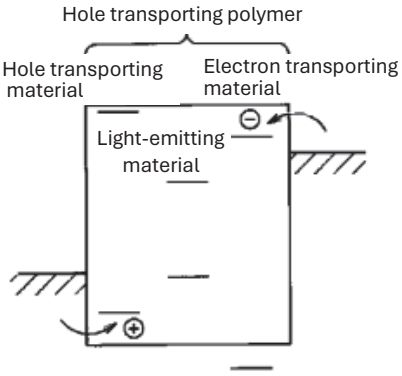
[FIG. 5]



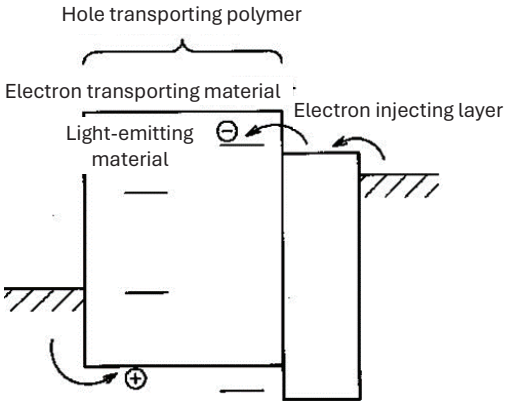
[FIG. 6]



[FIG. 8]



[FIG. 7]



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FA01

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