

Samsung Display Co., Ltd.
v.
Pictiva Displays International Ltd.

Case No. IPR2024-01093
U.S. Patent No. 8,723,164

Petitioner's Demonstratives

October 24, 2025 Oral Hearing

COVINGTON

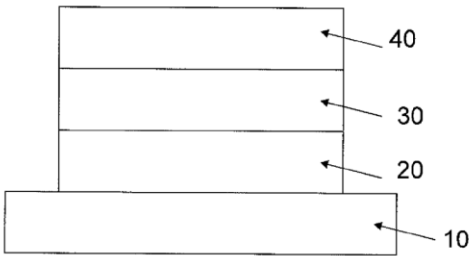
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SDC EX. 1045

The Challenged '164 Patent

(12) United States Patent Schmid et al.		(10) Patent No.: US 8,723,164 B2
		(45) Date of Patent: May 13, 2014
(54) ELECTRONIC DEVICE		(58) Field of Classification Search USPC 257/40, E51.001 See application file for complete search history.
(75) Inventors: Guenter Schmid , Hemhofen (DE); Ralf Krause , Erlangen (DE); Stefan Seidel , Nittendorf (DE); Oliver Weiss , Dossenheim (DE); Christoph Gaerditz , Regensburg (DE); Riikka Suhonen , Oulu (FI); Ulrich Niedermeier , Leibliling (DE); Fryderyk Kozlowski , Erlangen (DE)		(56) References Cited U.S. PATENT DOCUMENTS 2002/0101154 A1 8/2002 Seo et al. 2006/0068223 A1 3/2006 Nariyuki et al. 2008/0074038 A1 3/2008 Kim et al. 2008/0116536 A1 5/2008 Forrest et al. 2009/0039294 A1 2/2009 Choong et al.
(73) Assignee: OSRAM Opto Semiconductors GmbH , Regensburg (DE)		FOREIGN PATENT DOCUMENTS DE 10207053396 2/2009 JP 2002-260861 9/2002 JP 2002-305085 10/2002 JP 2002-313583 10/2002 JP 2004-536284 8/2004 JP 2005-108726 4/2005 JP 2005-108727 4/2005 JP 2005-514754 5/2005 JP 2006-128636 5/2006 JP 2006-165525 6/2006
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 319 days.		(Continued) OTHER PUBLICATIONS Manning, Bert, "Organische p-i-n Solarzellen" (English translation of relevant pages), Dissertation, Dresden 2004. (Continued)
(21) Appl. No.: 12/995,457		Primary Examiner — Anthony Ho
(22) PCT Filed: May 18, 2009		(74) Attorney, Agent, or Firm — Cozen O'Connor
(86) PCT No.: PCT/DE2009/000701		(57) ABSTRACT An electronic device comprising a substrate, a first electrode, at least one organic functional layer, and a second electrode is indicated. The organic functional layer comprises a first, a second, and a third matrix material, wherein the first matrix material has a larger band gap than the second and the third matrix materials.
§ 371 (c)(1), (2), (4) Date: Feb. 18, 2011		16 Claims, 5 Drawing Sheets
(87) PCT Pub. No.: WO2009/143807 PCT Pub. Date: Dec. 3, 2009		
(65) Prior Publication Data US 2011/0291080 A1 Dec. 1, 2011		
(30) Foreign Application Priority Data May 30, 2008 (DE) 10 2008 025 920 Aug. 22, 2008 (DE) 10 2008 039 361		
(51) Int. Cl. H01L 35/24 (2006.01)		
(52) U.S. Cl. USPC 257/40; 257/E51.001		



- U.S. Patent No. 8,723,164
- Directed to an OLED device
- Allegedly improves charge carrier transport and charge carrier balance in OLEDs

Ex. 1001 ('164 patent)

The Challenged '164 Patent

■ The alleged invention

BACKGROUND OF THE INVENTION

Electronic devices, such as organic light-emitting diodes (OLEDs), consist of a sequence of several functional organic layers. Emission layers thereby have a matrix material, which is doped with emitter molecules. In the emission layer, excitons are formed by a recombination of electrons and “holes,” which lead to light emission. In order to obtain a high efficiency of the electronic device, the ratio between electrons and “holes” which are transported in the emission layer is decisive. A nonbalanced ratio between hole and electron transport results in a low radiation efficiency of the device.

Ex. 1001 ('164 patent) at 1:20–29

SUMMARY OF THE INVENTION

tional layer. The at least one organic functional layer has at least a first matrix material, a second matrix material, and a third matrix material, wherein the third matrix material has a Lowest Unoccupied Molecular Orbital (LUMO), which is energetically lower than the LUMO of the second matrix material and the LUMO of the first matrix material, and wherein the second matrix material has a Highest Occupied Molecular Orbital (HOMO), which is energetically higher than the HOMO of the first matrix material and the HOMO of the third matrix material. 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.

Ex. 1001 ('164 patent) at 1:46–57

Overview of Challenge

- The petition proposed four grounds of unpatentability:
 - Ground I: Claims 1–8 and 10–16 are anticipated or at a minimum rendered obvious by Choulis;
 - Ground II: Claim 9 is obvious over Choulis in view of Yong;
 - Ground III: Claims 1, 3, 5–8, and 10–13 are anticipated or at a minimum rendered obvious by Sugiura; and
 - Ground IV: Claims 15–16 are anticipated by or at a minimum rendered obvious by Thompson.

Agenda: Primary Issues in Dispute

■ Claim Construction

- Whether the claimed matrix materials should be limited to exclude dopants and dispersed agglomerations (all grounds)

■ Ground I

- Whether Choulis teaches or suggests the claimed matrix materials (claims 1–8 and 10–16)
- Whether Choulis teaches or suggests various dependent claims (claims 2, 4, 10, 13–16)

Agenda: Primary Issues in Dispute

■ Ground II

- Whether it would have been obvious to combine Choulis and Yong (claim 9)

■ Ground III

- Whether Sugiura teaches or suggests the claimed matrix materials (claims 1, 3, 5–8, and 10–13)

■ Ground IV

- Whether Thompson teaches or suggests the claimed matrix materials (claims 15–16)

Construction of Matrix Materials

All Grounds

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- Petitioner does not believe any specialized construction is necessary

1. An electronic device, comprising:
a substrate;
a first electrode;
at least one organic functional layer; and
a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and wherein the at least one organic functional layer has at least a first matrix material, a second matrix material, and a third matrix material, and the third matrix material has a Lowest Unoccupied Molecular Orbital (LUMO), which is energetically lower than the LUMO of the second matrix material and the LUMO of the first matrix material, and wherein the second matrix material has a Highest Occupied Molecular Orbital (HOMO), which is energetically higher than the HOMO of the first matrix material and the HOMO of the third matrix material,
wherein the organic functional layer is an emission layer and is doped with at least one emitter material.

Ex. 1001 ('164 patent), claim 1

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- Patent Owner asserts that dopants and dispersed agglomerations cannot be matrix materials
- The Board's institution decision correctly rejected this assertion

to the meaning of particular claim terms.”). Claim 1 recites first, second, and third matrix materials but, aside from reciting relationships between the LUMOs and HOMOs of the matrix material, does not require any particular composition or any particular amount for any of the three matrix materials. Ex. 1001, 9:4–22. Nor does claim 1 recite that any of the matrix materials must be present in a continuous phase. *Id.* Claim 1 does recite that the organic functional layer, which includes the three matrix materials, is doped with at least one emitter material. *Id.* at 9:21–22. On this record, no words in claim 1 limit a “matrix material” to the meaning advanced by Patent Owner.

Decision to Institute at 24

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- Similarly, Judge Gilstrap rejected Patent Owner’s construction that a matrix material must form a continuous phase (and thus, supposedly excludes dopants and dispersed agglomerations)

M. “matrix” / “matrix material” (’164 Patent, Claims 1–6, 10, 13–16)	
Pictiva’s Construction	Samsung’s Construction
“matrix material”: plain and ordinary meaning, i.e., a material that forms a continuous phase	matrix: “a continuous phase of the mixture of matrix materials” matrix material: “The first, second, and third matrix materials are different materials and are part of the same matrix”

Ex. 1030 (Claim Construction Order, June 27, 2025) at 32

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- The specification supports the Board's and Judge Gilstrap's interpretation of the term matrix material

It is also possible for several organic functional layers to be present in an electronic device, wherein the layers can have different functions or the same functions. For example, an electronic device can have a sequence of several functional, organic layers, which, for example, is composed of a hole injection layer, a hole transport layer, a first emission layer, an intermediate layer, a second emission layer, an electron transport layer, and an electron injection layer. Each of these layers can have a matrix, which has at least a first, a second, and a third matrix material. The matrix materials in the various organic functional layers can be selected similarly or differently in all layers.

Ex. 1001 ('164 patent) at 4:17–28

The device can have, for example, mCP (m-bis(N-carbazolylbenzene)), as the first matrix material in an organic functional layer; as a second matrix material, which can be a hole transport material, TCTA (9H-carbazole, 9,9',9''-(1,3,5-benzenetriyl)tris-(9Cl)); and as a third matrix material, which can be an electron transport material, for example, TPBi (1,3,5-tris(N-phenylbenzylimidazol-2-yl)). If a matrix is to be pre-

Ex. 1001 ('164 patent) at 5:32–37

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- Patent Owner argues that dopants cannot be matrix materials
- But the term dopant merely refers to a component that has been added to a film or functional layer

6. Contrary to Dr. Sims's assertion, the fact that the specification also describes an emitter material as a dopant does not imply that a matrix material cannot also be a dopant. The specification explicitly describes a matrix material, such as BCP, as a *dopant* within a matrix composed of BCP, NPB, and UGH4. Ex.1001, 8:56-65; Ex.2020, 23:5-26:7. During his deposition, Dr. Sims agreed that the specification disclosed a matrix comprised of matrix materials BCP, NPB, and UGH4, and that BCP was a dopant. Ex.1043, 42:10-43:24. The term "dopant" merely refers to a component that has been added to a film or functional layer. Ex.2020, 327:17-328:4. As the Board explained, to the extent the '164 patent suggests a distinction between a matrix material and a dopant, any such suggestion is not definitional. DI 24 (citing Ex.1001, 7:12-15).

Ex. 1044 (Holmes) at ¶ 6

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- Thus, the specification describes an electron transport matrix material, such as BCP, as a dopant

The matrix cannot be selected arbitrarily for phosphorescent emitters because of chemical compatibility. The red emitter iridium (III) bis(2-methyldibenzo[f,h]quinoxaline) acetylacetonate) is only efficient in an NBP matrix. NPB, however, is a hole transport material. If on the anode side, there is also another emitter layer, then this is not sufficiently supplied with electrons. By doping in an electron transport material, for example, BCP, the relative transport characteristics can be adjusted. The fine coordination of the transport characteristics takes place with UGH4.

Ex. 1001 ('164 patent) at 8:56–65

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

Patent Owner's expert agreed

10 Q. So you agree that the '164 patent describes
11 BCP as a dopant; correct?
12 MS. ZHONG: Objection; form.
13 THE WITNESS: Well, BCP is certainly a matrix
14 material in this case, and NPB is, as well as UGH4.

Ex. 1043 (Sims) at 43:10–14

20 Q. So you agree that the '164 patent describes
21 BCP as a dopant; yes?
22 MS. ZHONG: Objection; form.
23 THE WITNESS: Yes. I mean, that's what it's --
24 according to the language that was used, yes.

Ex. 1043 (Sims) at 43:20–24

On redirect, he tried to change his testimony

16 Q. So why do you consider that to be a matrix
17 material?
18 A. I think that when we were discussing this,
19 my mind just fixed on the -- other aspects of the
20 '164 patents. So the table, the example table of
21 mCP, TCTA, TBPI, they are more or less evaporated to
22 a -- sort of in an even proportion of one another.
23 So that's where -- that's what I was thinking at
24 the time, that you had a sort of similar percentage
25 of each of those within the -- within the matrix in

1 that case.
2 So that formed a, you know, a continuous or a
3 more or less continuous phase of those materials,
4 and that -- in this case, it actually does not state
5 any kind of evaporation rates or any kind of
6 compositional ratios of these various materials.
7 So that was a -- the reasoning why I thought it
8 was a matrix material, which is erroneous.

Ex. 1043 (Sims) at 89:16–90:8

The Claimed Matrix Materials Encompass Dopants/Dispersed Agglomerations

- But, the attempt to change his testimony came after Patent Owner's expert discussed his testimony with counsel during a one-and-a-half-hour break

3 MR. BYUN: For the record, after I passed the
4 witness after my initial questions, Counsel asked
5 for a 30- to 45-minute break and then ended up
6 taking about one and a half hours.
7 EXAMINATION
8 BY MR. BYUN:
9 Q. Dr. Sims, during the break, did you discuss
10 with Counsel anything relating to the substance of
11 your testimony?
12 MS. ZHONG: It's a yes-or-no question.
13 THE WITNESS: Oh, yes.
14 BY MR. BYUN:
15 Q. What did you discuss?
16 MS. ZHONG: I instruct you not to answer the
17 question.

Ex. 1043 (Sims) at 102:3–17

4 Q. Did you discuss with Counsel any questions
5 that Counsel was going to ask you?
6 A. Discuss any questions that Counsel was
7 going to ask --
8 MS. ZHONG: Objection; form.
9 THE WITNESS: We discussed my answers, some of
10 my answers to earlier parts of the discussion and
11 some -- yeah -- aspects of --
12 BY MS. ZHONG:
13 Q. Can you tell me what aspects you discussed
14 with Counsel?
15 MS. ZHONG: I instruct you not to answer.
16 THE WITNESS: Yeah, okay.

Ex. 1043 (Sims) at 103:4–16

Matrix Materials in Choulis

Claim 1–8 and 10–16

Choulis Teaches or Suggests the Claimed Matrix Materials

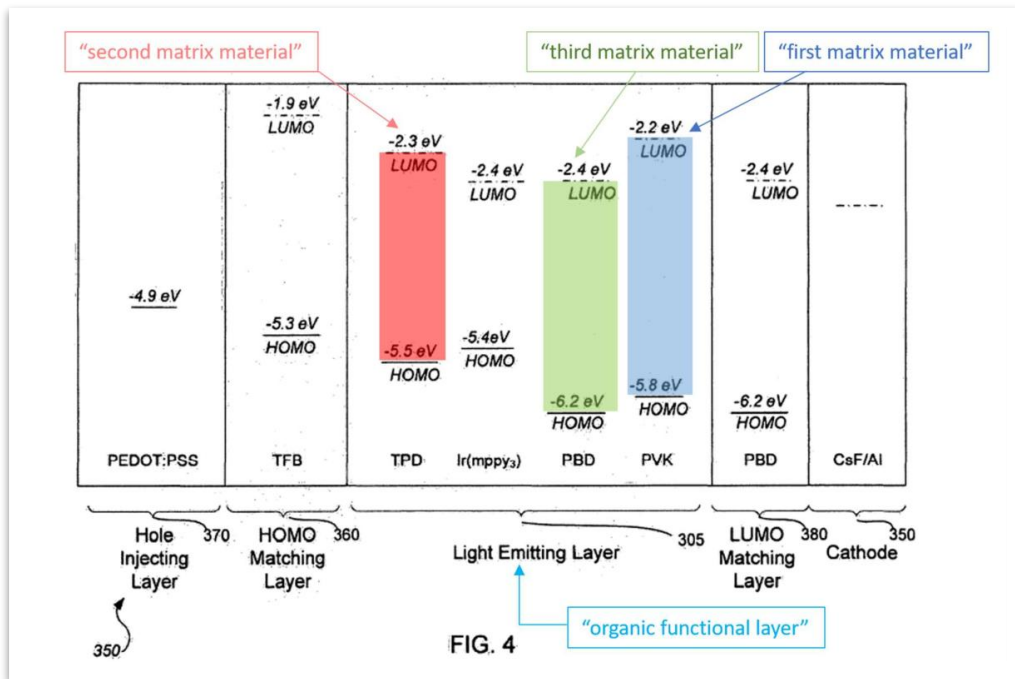
- Patent Owner argues that TPD and PBD are not matrix materials because they are dopants
- But as discussed for claim construction, the '164 specification confirms that dopants can be matrix materials

The matrix cannot be selected arbitrarily for phosphorescent emitters because of chemical compatibility. The red emitter iridium (III) bis(2-methyldibenzo[f,h]quinoxaline) acetylacetonate) is only efficient in an NBP matrix. NPB, however, is a hole transport material. If on the anode side, there is also another emitter layer, then this is not sufficiently supplied with electrons. By doping in an electron transport material, for example, BCP, the relative transport characteristics can be adjusted. The fine coordination of the transport characteristics takes place with UGH4.

Ex. 1001 ('164 patent) at 8:56–65

Choulis Teaches or Suggests the Claimed Matrix Materials

- In addition to PVK, Choulis's light emitting layer contains *hole transport material* (TPD) and *electron transport material* (PBD), similar to the matrix materials in the '164 patent



Ex. 1004 (Choulis), Fig. 4 (annotated)

The device can have, for example, mCP (m-bis(N-carbazolyl)benzene)), as the first matrix material in an organic functional layer; as a second matrix material, which can be a hole transport material, TCTA (9H-carbazole, 9,9',9''-(1,3,5-benzenetriyl)tris-(9Cl)); and as a third matrix material, which can be an electron transport material, for example, TPBi (1,3,5-tris(N-phenylbenzylimidazol-2-yl)). If a matrix is to be pre-

Ex. 1001 ('164 patent) at 5:32–37

Choulis Teaches or Suggests the Claimed Matrix Materials

- Elsewhere, Patent Owner equates the second and third matrix materials to hole/electron transport materials (which is what Choulis's TPB and PBD are)

PBD, TPB and Ir(mppy)₃. Specifically, paragraph 30 of EX1003 describes the preferred properties of hole and electron transport materials (*i.e.*, second and third matrix materials). Paragraph 31 mentions the use of “ultra-wide energy gap” (UGH)

POR at 38

Choulis's Disclosure of Dependent Claims

Claims 2, 4, 10, 13–16

Using PMMA in Place of PVK (claims 2, 4, and 15–16)

- **Anticipation:** Contrary to Patent Owner's argument, Choulis expressly discloses that PMMA can be used instead of PVK in some embodiments of its light emitting layer

[0030] Referring to FIG. 4, organic moieties (which can include functional groups or whole molecules) can be mixed in with the light emitting layer 305 and a matching layer can be used to improve efficiencies of injecting of holes into the light emitting layer. The light emitting layer 305 includes a host material 310, poly(9-vinylcarbazole) (PVK), a light emitting material 320, Ir(mppy)₃, a first organic moiety 330, triphenyldiamine (TPD) and a second organic moiety 335, PBD. The HOMO and LUMO energy levels of PVK are =2.2 eV and -5.8 eV, respectively. Thus, the PVK has a large band gap and can confine the triplet excited state of the Ir(mppy)₃ phosphorescent molecule, preventing luminescence quenching.

Ex. 1004 (Choulis) at [0030]

[0044] The light emitting layer can include a host material. The hole material can be PVK, as described above, which is a non-conjugated polymer having mostly hole transporting properties. The host can be also a electron, hole or bipolar transporting material, can have a high band gap (have a large difference between their HOMO and LUMO levels), can be a polymer, small molecules or a mixture of a polymer with small molecules. In some embodiments, the phosphorescent compounds are used without a host, that is, the light emitting layer does not include a host. In some embodiments, the light emitting layer includes materials that are insulated matrices, that is, the host does not have transport properties, such as polycarbonate (PC), polymethyl methacrylate (PMMA) or polystyrene sulphonate (PSS).

Ex. 1004 (Choulis) at [0044]

Using PMMA in Place of PVK (claims 2, 4, and 15–16)

- Moreover, it would have been obvious to use PMMA in Choulis's light emitting layer

23. To the extent Choulis does not disclose substituting PMMA for PVK (although it does), it would have been obvious to do so, as discussed in my Opening Declaration. Ex.1003, ¶100. A POSITA would understand that the wide energy gap of PMMA beneficially minimizes interference with charge transport on the other matrix materials, simplifying device design and optimization. Ex.1003, ¶100. Specifically, a POSITA interested in minimizing or preventing charge transport on the first matrix material would select a wider energy gap insulating material, such as PMMA, in place of PVK, which is a known hole transporter with a narrower energy gap.

Ex. 1044 (Holmes) at ¶ 23

Using PMMA in Place of PVK (claims 2, 4, and 15–16)

- Patent Owner’s assertion that PMMA could not be used (or would not work due to quenching) is contradicted by prior work showing successful use of PMMA for light emission

24. Dr. Sims’s argument that substituting PMMA for PVK would “upset the hole and electron balance,” “affect hole-charge recombination,” and “degrade the performance of the resulting OLED system,” Ex.2019, ¶80, overlooks the fact that it would have been a routine task for a POSITA to optimize the composition of each component in the light-emitting layer to attain proper charge balance. A POSITA

Ex. 1044 (Holmes) at ¶ 24

25. For example, prior seminal work by Kido et al. in 1992, demonstrates an OLED with a light-emitting layer consisting of PMMA, TPD and the archetypical electron transporting material Alq₃. Ex.1034, 763. Kido notes that its approach “enables easy fabrication of EL devices in which carriers are injected through the dopants to the polymer layer resulting in electroluminescence.” Ex.1034, 763. Figure 1 of Kido depicts such an OLED device.

Ex. 1044 (Holmes) at ¶ 25

Using PMMA in Place of PVK (claims 2, 4, and 15–16)

■ Indeed, numerous sources show successful use of PMMA for light emission

28. Moreover, there is also supporting prior work demonstrating the integration of Ir phosphors into PMMA, and the use of PMMA as a non-quenching host. A non-quenching host is one that permits excitons to be confined to the emitter molecules. In energetic terms, this requires the host to have singlet (in the case of a fluorophore) or singlet and triplet (in the case of a phosphor) energy levels that exceed those of the emitter. This configuration allows excitons to be confined to the emitter, enabling luminescence from the emitter. Indeed, PMMA is a frequently used non-quenching host for studies of luminescence from Ir-phosphors. A prior art example is work by Goushi in which the archetypical green-emitting Ir-phosphor Ir(ppy)₃ is included in films with PMMA. Ex.1036, L937. Goushi notes that their results “lead us

Ex. 1044 (Holmes) at ¶ 28

30. These results confirm that PMMA does not quench triplet excitons, making it suitable for use in an emissive layer with an Ir-phosphor. Consequently, a POSITA would understand that PMMA together with TPD, PBD, and Ir(mppy)₃ forms an effective emission layer, and further based on Kido’s and Ma’s prior work, would know how to optimize the relative composition of PMMA, TPD, and PBD to tune performance. Thus, contrary to Dr. Sims’s assertions, I am not suggesting “simply swap[ping] out PVK with PMMA and hop[ing] that the resulting system would work,” nor is PMMA a “random host material.” Ex.2019, ¶¶78-79. Rather, in my opinion, a POSITA would know how to use PMMA in place of PVK with any necessary optimizations.

Ex. 1044 (Holmes) at ¶ 30

Using Rubrene in Place of Ir(mppy)₃ (claim 10)

- **Anticipation:** Contrary to Patent Owner's argument, Choulis expressly discloses that light emitting material rubrene can be used instead of Ir(mppy)₃

[0030] Referring to FIG. 4, organic moieties (which can include functional groups or whole molecules) can be mixed in with the light emitting layer 305 and a matching layer can be used to improve efficiencies of injecting of holes into the light emitting layer. The light emitting layer 305 includes a host material 310, poly(9-vinylcarbazole) (PVK), a light emitting material 320, Ir(mppy)₃, a first organic moiety 330, triphenyldiamine (TPD) and a second organic moiety 335, PBD. The HOMO and LUMO energy levels of PVK are =2.2 eV and -5.8 eV, respectively. Thus, the PVK has a large band gap and can confine the triplet excited state of the Ir(mppy)₃ phosphorescent molecule, preventing luminescence quenching.

Ex. 1004 (Choulis) at [0030]

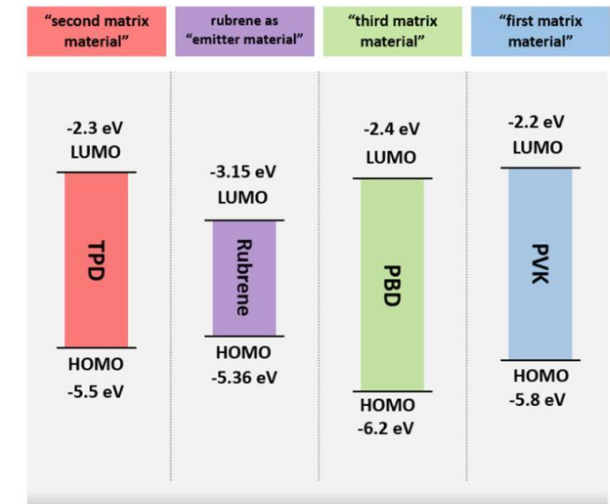
[0043] In accordance with embodiments of the invention, small organic molecules that emit by fluorescence or by phosphorescence can serve as a light emitting material residing in the light emitting layer. Unlike polymeric materials that are applied as solutions or suspensions, small-molecule light emitting materials are preferably deposited through evaporation, sublimation, or organic vapor phase deposition methods. There are also small molecule materials that can be applied by solution methods too. Combinations of PLED materials and smaller organic molecules can also serve as an active electronic layer thereby forming a hybrid device. For example, a PLED may be chemically derivatized with a small organic molecule or simply mixed with a small organic molecule to form the light emitting layer. Examples of electroluminescent small molecule materials include chelates, such as tris(8-hydroxyquinolate) aluminum (Alq₃) and tris(2-phenylpyridine) iridium (Ir(ppy)₃), organic materials, such as anthracene, rubrene or triazine, or any metal-chelate compounds or derivatives of any of the organic materials or small molecule materials.

Ex. 1004 (Choulis) at [0043]

Using Rubrene in Place of Ir(mppy)₃ (claim 10)

- Moreover, it would have been obvious to use rubrene in place of Ir(mppy)₃

40. To the extent Choulis does not disclose the substitution of rubrene for Ir(mppy)₃ (although it does), such substitution, as well as the use of PQIr or DCM2 in place of Ir(mppy)₃, would have been obvious, as discussed in my Opening Declaration. Ex.1003, ¶¶27, 30, 31, 115. Electrons tend to lower their energy by traveling “downhill” to LUMO levels that are lower, and in contrast, holes tend to lower their energy by traveling “uphill” to HOMO levels that are higher. Ex.1003, ¶¶27, 115. To ensure that all charges efficiently travel to the emitter material to form excitons, the LUMO level of the emitter material is preferably lower than those of other materials in the light emitting layer, and the HOMO level of the emitter material is preferably higher than those of other materials in the light emitting layer. Ex.1003, ¶115. As for the choice of the specific emitter material, it would depend at least in part on the desired emission color.



Ex. 1003 (Holmes) at ¶ 115

Ex. 1044 (Holmes) at ¶ 40

Using Rubrene in Place of Ir(mppy)₃ (claim 10)

- Contrary to Patent Owner's argument that using rubrene would not work, rubrene has long been used in OLEDs and would work in Choulis's devices

39. Rubrene is an archetypical fluorescent emitter that has been long used in OLEDs and was well-known to a POSITA at the time of the '164 patent. Dr. Sims's suggestion to the contrary based on the assertion that Kang and Hamada do not suggest using rubrene as an emitter material is incorrect. These references are distinct and unrelated to Choulis, and hence do not detract from Choulis's disclosure concerning the use of rubrene. I referenced Kang and Hamada in my Opening Declaration merely to show the HOMO and LUMO levels of rubrene. Ex.1003, ¶115.

Ex. 1044 (Holmes) at ¶ 39

41. Contrary to Dr. Sims's assertions, Choulis's alleged "operating principle" accommodates LUMO levels that are 0.3 eV or 0.7 eV lower than the LUMO of the LUMO matching layer material. In its simplest form, Choulis requires light emission

Ex. 1044 (Holmes) at ¶ 41

Simultaneous Application (claim 13)

- No dispute that Choulis's disclosure of using spin-coating involves a simultaneous application

13. A method for the production of an electronic device according to claim 1, comprising the steps of:

- A) preparation of a substrate;
- B) preparation of a first electrode and a second electrode; and
- C) placement of at least one organic functional layer between the first electrode and the second electrode, wherein in method step C), at least the first matrix material, the second matrix material, and the third matrix material are simultaneously applied.

Ex. 1001 ('164 patent), claim 13

layer.”). The process of spin-coating a mix of the first, second, and third matrix materials (polymer PVK and small molecules TPD and PBD) would involve dissolving PVK, TPD, and PBD in a solution, placing that solution on a substrate, and then spinning the substrate at high speed so that the solution spreads to form a thin layer. A POSITA would recognize that this process of spin-coating PVK, TPD, and PBD involves simultaneously applying the first, second, and third matrix materials to form a single emissive layer. A POSITA would also appreciate that spin-coating a mix of PVK, TPD, and PBD was well-known in the art before 2008. *See, e.g.,* Ex. 1017 (Neher), 2476 (“A blend of PVK, PBD, TPD and Ir(mppy)₃ in chlorobenzene solution was spin coated on top of indium tin oxide substrates....”).

Ex. 1003 (Holmes) at ¶ 131

Evaporation Coating (claim 14)

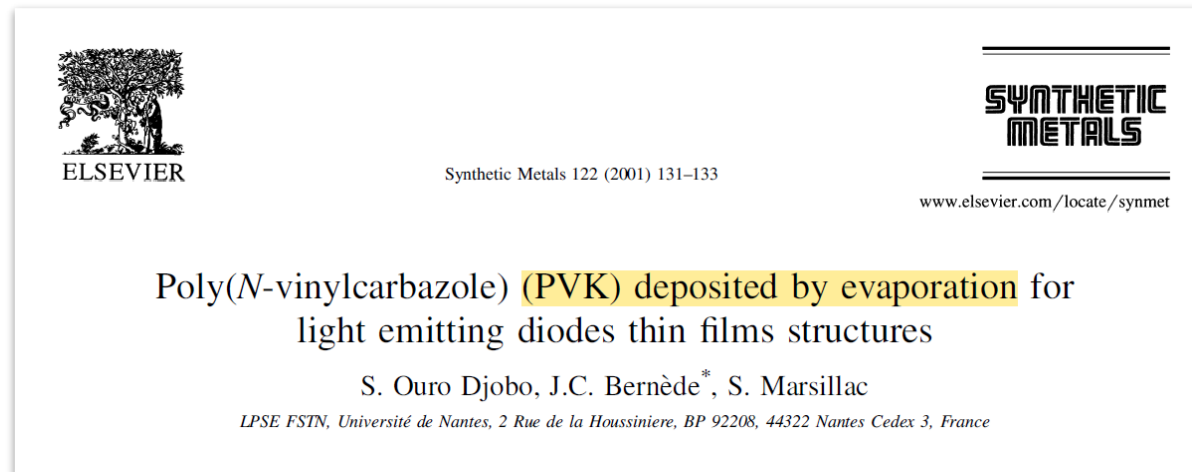
14. A method according to claim 13, wherein in the method step C), the first matrix material, the second matrix material, and the third matrix material are applied by evaporation coating.

Ex. 1001 ('164 patent), claim 14

- Choulis teaches that small organic molecules in its devices (such as TPD and PBD) are “preferably deposited through evaporation.” Ex. 1004 at [0043].

Obvious to Deposit PVK Through Evaporation

- It was known that PVK could be successfully deposited through evaporation and it would have been obvious to do so in light of the well-known benefits of this technique



Ex. 1023 (Djobo) at 1

134. It would have been obvious to a POSITA to apply the first matrix material (PVK) using evaporation coating, along with second matrix material (TPD) and third matrix material (PBD). A POSITA would have been motivated to apply the materials simultaneously via evaporation, as the approach would enable forming layers with increased control over film thickness and composition, and enable a broader variety of device architectures. These would allow higher yield and improved performance, when compared to other techniques such as spin-coating. A POSITA would have had a reasonable expectation of success in applying PVK, TPD, and PBD via evaporation coating, and doing so would be well within a POSITA's ability. Indeed, Choulis explains that "the techniques described herein," including evaporation coating, can be readily applied to OLED display manufacturing. Choulis, [0059].

Ex. 1003 (Holmes) ¶ 134

Evaporation Coating (claim 14)

- Moreover, Choulis also expressly discloses replacing PVK with other small molecules (that are preferably evaporated) that have similar properties as PVK

[0044] The light emitting layer can include a host material. The hole material can be PVK, as described above, which is a non-conjugated polymer having mostly hole transporting properties. The host can be also a electron, hole or bipolar transporting material, can have a high band gap (have a large difference between their HOMO and LUMO levels), can be a polymer, small molecules or a mixture of a polymer with small molecules. In some embodiments, the phosphorescent

Ex. 1004 (Choulis) at [0044]

materials are discussed herein. Additional suitable materials than those described for the host material 310, the light emitting material 320, the first organic moiety 335 and the second organic moiety 335, can also be selected according to the properties described herein.

Ex. 1004 (Choulis) at [0031]

Combination of Choulis and Yong

Claim 9

Obvious to Combine Choulis and Yong

- There is no dispute that Yong discloses the claimed gradient in the concentration of the emitter material, as well as its benefits

forming a construction with gradient doping. In the organic light emitting layer of the device, phosphorescent dyes are doped into the host material in a gradient doping manner, expanding the luminescent region of the device, improving the utilization rate of the phosphorescent dyes, and facilitating the combination of electrons and holes to form excitons, thereby improving the device's luminescence efficiency and brightness, improving its stability, and overcoming the disadvantages of low luminescence efficiency and poor stability under high current.

Ex. 1009 (Yong) Abstract

9. The electronic device according claim 1, wherein the concentration of the emitter material in the emission layer has a gradient.

Ex. 1001 ('164 patent), claim 9

In OLEDs, the concentration distribution of electrons generally decreases nonlinearly from the electron transporting layer to the hole transporting layer. The gradient distribution of the doping concentration of phosphorescent dyes in the organic light emitting layer in the host material in the above technical solution is to make the distribution trend of phosphorescent dyes in the host material conform to the distribution trend of electrons in the host material, and such concentration distribution expands the luminescent region of the device, improves the utilization rate of phosphorescent dyes, and is also conducive to the combination of electrons and holes to form excitons.

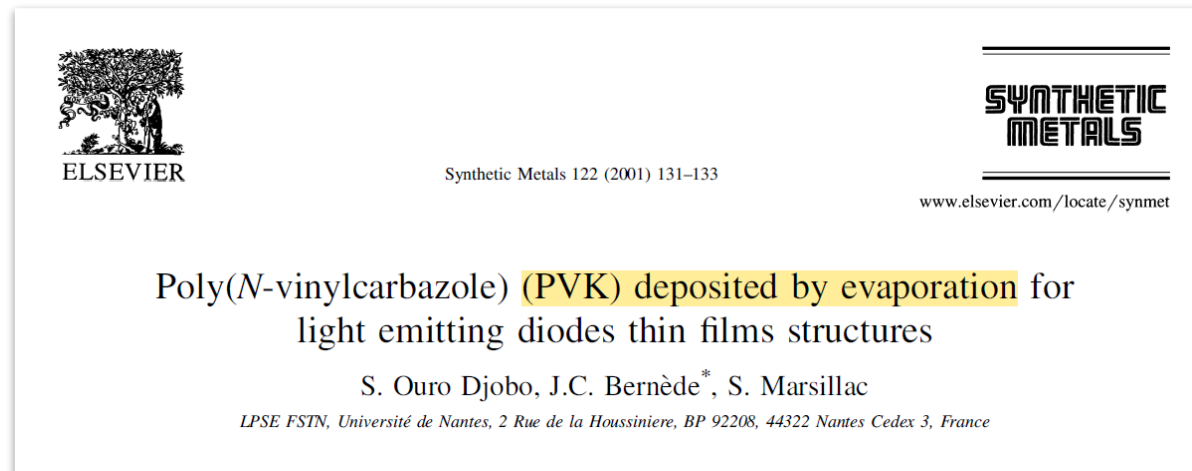
Ex. 1009 (Yong) Description at 3

Obvious to Combine Choulis and Yong

- Patent Owner argues that Choulis and Yong cannot be combined because Choulis discloses applying PVK via *solution processing* while Yong discloses using *evaporation* to create gradients
- As previously discussed, it was known that Choulis's PVK could be successfully deposited through evaporation

Obvious to Deposit PVK Through Evaporation

- It was known that PVK could be successfully deposited through evaporation and it would have been obvious to do so in light of the well-known benefits of this technique



Ex. 1023 (Djobo) at 1

134. It would have been obvious to a POSITA to apply the first matrix material (PVK) using evaporation coating, along with second matrix material (TPD) and third matrix material (PBD). A POSITA would have been motivated to apply the materials simultaneously via evaporation, as the approach would enable forming layers with increased control over film thickness and composition, and enable a broader variety of device architectures. These would allow higher yield and improved performance, when compared to other techniques such as spin-coating. A POSITA would have had a reasonable expectation of success in applying PVK, TPD, and PBD via evaporation coating, and doing so would be well within a POSITA's ability. Indeed, Choulis explains that "the techniques described herein," including evaporation coating, can be readily applied to OLED display manufacturing. Choulis, [0059].

Ex. 1003 (Holmes) ¶ 134

Obvious to Combine Choulis and Yong

- Moreover, using solution processing to form gradients was well known (which Patent Owner's expert does not dispute)

54. *Second*, OLEDs relying on solution-processed layers with a gradient in the emitter composition were well known. For example, work by Chang and co-workers in 2001 utilized an emissive layer consisting of PVK, just as is done in Choulis, with a graded composition profile of the fluorescent dopant coumarin 6 (C6), where the C6 composition decreases through the thickness of the film. Ex.1039, 574-76. Chang realizes this graded emitter profile through a process known as finite-source

Ex. 1044 (Holmes) at ¶ 54

574. Chang's work demonstrates clearly the ability to use solution processing as a means to realize gradients in emitter concentration, here showing the result even for PVK, a material applied in Choulis. This is contrary to Dr. Sims's assertion that "controlled concentration gradients cannot be achieved via spin-coating" and that "[t]he ability to grow concentration gradients through a multicomponent layer is a unique capability of physical vapor deposition." Ex.2019, ¶104.

Ex. 1044 (Holmes) at ¶ 55

Matrix Materials in Sugiura

Claims 1, 3, 5–8, and 10–13

Sugiura Teaches or Suggests the Claimed Matrix Materials

- Patent Owner argues that Sugiura's hole and electron transport materials are not matrix materials because they are dispersed agglomerations or dopants
- But as discussed for claim construction, dispersed agglomerations or dopants can be matrix materials

The matrix cannot be selected arbitrarily for phosphorescent emitters because of chemical compatibility. The red emitter iridium (III) bis(2-methyldibenzo[f,h]quinoxaline) acetylacetonate) is only efficient in an NBP matrix. NPB, however, is a hole transport material. If on the anode side, there is also another emitter layer, then this is not sufficiently supplied with electrons. By doping in an electron transport material, for example, BCP, the relative transport characteristics can be adjusted. The fine coordination of the transport characteristics takes place with UGH4.

Ex. 1001 ('164 patent) at 8:56–65

Sugiura Teaches or Suggests the Claimed Matrix Materials

- In addition to PVK, Sugiura's light emitting layer contains *hole transport material* (TPD) and *electron transport material* (Alq₃), similar to the matrix materials in the '164 patent

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, Alq₃ 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

Ex. 1006 (Sugiura) at [0062]

The device can have, for example, mCP (m-bis(N-carbazolylbenzene)), as the first matrix material in an organic functional layer; as a second matrix material, which can be a hole transport material, TCTA (9H-carbazole, 9,9',9''-(1,3,5-benzotriyl)tris-(9Cl)); and as a third matrix material, which can be an electron transport material, for example, TPBi (1,3,5-tris(N-phenylbenzylimidazol-2-yl). If a matrix is to be pre-

Ex. 1001 ('164 patent) at 5:32–37

Sugiura Teaches or Suggests the Claimed Matrix Materials

- Moreover, Sugiura's hole and electron transport materials are not dispersed agglomerations

60. Furthermore, a POSITA would recognize that Sugiura's hole and electron transport materials are not in dispersed agglomerations, as such agglomerations would hinder the functionality of Sugiura's devices as described. In describing the operation

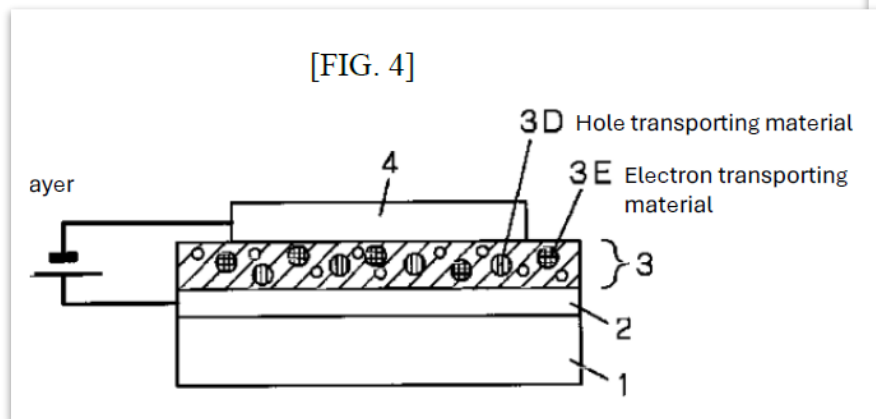
Ex. 1044 (Holmes) at ¶ 60

Sugiura Teaches or Suggests the Claimed Matrix Materials

- Patent Owner argues that the circles in Sugiura's Figure 4 represent dispersed agglomerations
- But Figure 4 is a simplified illustration

Ex. 1044 (Holmes) at ¶ 63

63. Notably, the term “dispersed agglomerations” is introduced by Dr. Sims and is not a concept taught by Sugiura. Dr. Sims erroneously argues by interpreting the circles in Sugiura's figures as dispersed agglomerations. However, these figures are simplified illustrations demonstrating that Sugiura's light-emitting layer comprises multiple materials, aligning with the requirements of claim 1. During his deposition,



Ex. 1006 (Sugiura), Fig. 4

22 Q. Do you agree that Figure 4 of Sugiura is
23 not drawn to scale?
24 A. Of course. It's a schematic.

Ex. 1043 (Sims) at 62:22–24

Sugiura Teaches or Suggests the Claimed Matrix Materials

- Patent Owner's expert's admissions confirm that Sugiura's hole and electron transport materials cannot be dispersed agglomerations

Ex. 1043 (Sims) at 65:18-66:9

18 Q. Do you agree that Sugiura's hole
19 transporting material transports holes?
20 A. Just checking.
21 TPD? I agree.
22 Q. So you agree that the molecules of
23 Sugiura's hole transporting material are
24 sufficiently close to each other to be able to
25 transport holes; correct?

1 MS. ZHONG: Objection; form, misstated the
2 testimony.
3 THE WITNESS: It is difficult to say, but, you
4 know, they've given the weight ratio here, which is
5 not really the critical thing. We need to know what
6 the equivalent molar ratio is for this. But I
7 believe the direction you would go is such that TPD
8 would be able to transport holes in that system, and
9 that's from an ability point of view.

Sugiura Teaches or Suggests the Claimed Matrix Materials

- Patent Owner's expert's admissions confirm that Sugiura's hole and electron transport materials cannot be dispersed agglomerations

Ex. 1043 (Sims) at 66:16–67:5

16 Q. Do you agree Sugiura's electron
17 transporting material transports electrons?

18 A. That is ALq3. Yes, that's what it is
19 intended to do.

20 Q. So you agree that the molecules of
21 Sugiura's electron transporting material are
22 sufficiently close to each other to be able to
23 transport electrons; correct?

24 MS. ZHONG: Objection; form.

25 THE WITNESS: So there's -- we don't know how --

1 to be able to transport electrons is one thing, but
2 how effectively it does is another thing. And I
3 don't know, but if there is anything that is going
4 to be transporting electrons in that system, it
5 would be designed to do that with ALq3.

Matrix Materials in Thompson

Claims 15–16

Thompson Teaches or Suggests the Claimed Matrix Materials

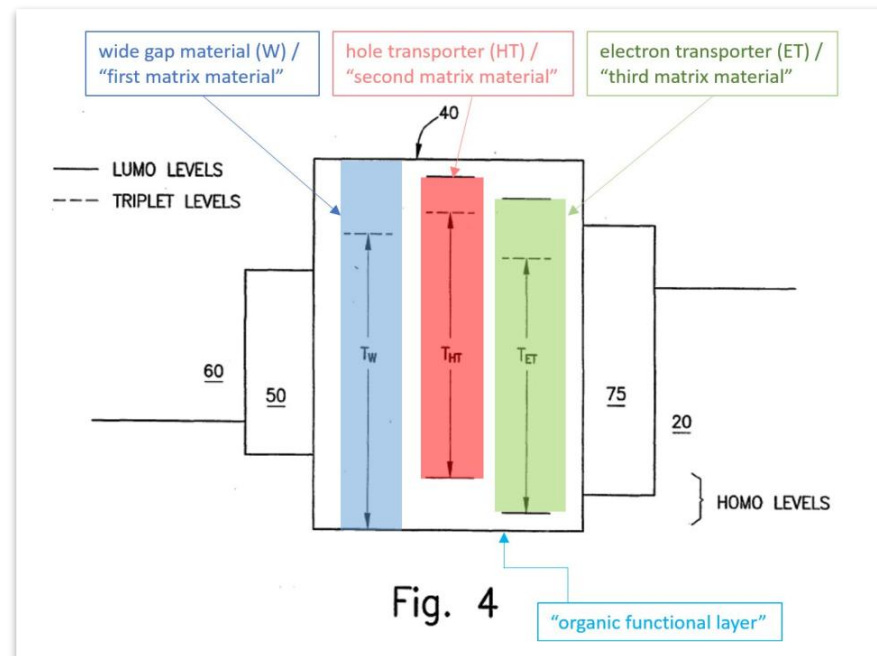
- Patent Owner argues that Thompson's hole transporter and electron transporter are not matrix materials because they are dopants
- But as discussed for claim construction, dopants can be matrix materials

The matrix cannot be selected arbitrarily for phosphorescent emitters because of chemical compatibility. The red emitter iridium (III) bis(2-methyldibenzo[f,h]quinoxaline) acetylacetonate) is only efficient in an NBP matrix. NPB, however, is a hole transport material. If on the anode side, there is also another emitter layer, then this is not sufficiently supplied with electrons. By doping in an electron transport material, for example, BCP, the relative transport characteristics can be adjusted. The fine coordination of the transport characteristics takes place with UGH4.

Ex. 1001 ('164 patent) at 8:56–65

Thompson Teaches or Suggests the Claimed Matrix Materials

- In addition to the wide gap material (W), Thompson's organic functional layer contains the *hole transporter* (HT) and the *electron transporter* (ET), similar to the matrix materials in the '164 patent



The device can have, for example, mCP (m-bis(N-carbazolyl)benzene)), as the first matrix material in an organic functional layer; as a second matrix material, which can be a hole transport material, TCTA (9H-carbazole, 9,9',9''-(1,3,5-benzenetriyl)tris-(9Cl)); and as a third matrix material, which can be an electron transport material, for example, TPBi (1,3,5-tris(N-phenylbenzylimidazol-2-yl)). If a matrix is to be pre-

Ex. 1001 ('164 patent) at 5:32–37

Ex. 1007 (Thompson) at Fig. 4 (annotated)