

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG DISPLAY CO., LTD.,
Petitioner,

v.

PICTIVA DISPLAYS INTERNATIONAL LTD.,
Patent Owner.

Case No. IPR2024-01093

Patent No. 8,723,164

**PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO.
8,723,164 UNDER 35 U.S.C. §§ 311–319 AND 37 C.F.R. § 42.100 *et seq.***

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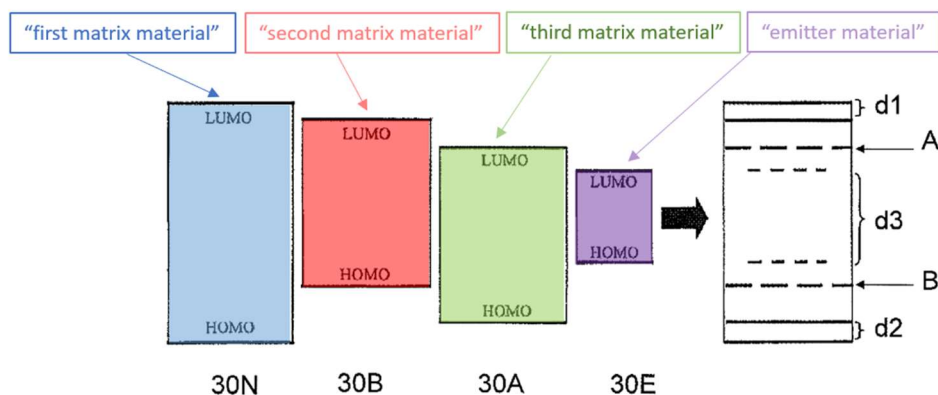
Exhibit No.	Description
1001	U.S. Patent No. 8,723,164
1002	File History for U.S. Patent No. 8,723,164
1003	Declaration of Dr. Russell Holmes
1004	U.S. Patent Application Publication No. 2007/0069636 (Choulis)
1005	Japanese Published Application No. 2001/110568 (Sugiura)
1006	Certified English Translation of Japanese Published Application No. 2001/110568 (Sugiura)
1007	U.S. Patent Application Publication No. 2004/0155238 (Thompson)
1008	Chinese Published Application No. 1,582,073 (Yong)
1009	Certified English Translation of Chinese Published Application No. 1,582,073 (Yong)
1010	H.Y. Kang and C.H. Lee, <i>Electroluminescence Properties of Organic Light-Emitting Diodes with a Red Dye Doped into Alq3: Rubrene Mixed Host</i> , 45(3) J. Korean Physical Soc’y 756–760 (Sept. 2004) (Kang)
1011	Wenbo Li et al., <i>Organic Long-Persistent Luminescence from a Thermally Activated Delayed Fluorescence Compound</i> , 32 Adv. Mater. 2003911 (2020) (Li)
1012	Chaoxing Wu et al., <i>Efficient tristable resistive memory based on single layer graphene/insulating polymer multi-stacking layer</i> , 104 Appl. Phys. Lett. 183105 (2014) (Wu)
1013	U.S. Patent Publication No. 2008/0116536 (Forrest)
1014	INTENTIONALLY LEFT BLANK
1015	Sung Hyun Kim et al., <i>Relationship between host energy levels and device performances of phosphorescent organic light-emitting diodes with triplet mixed host emitting structure</i> , 91 Appl. Phys. Lett. 083511 (2007)
1016	R.J. Holmes et al., <i>Efficient, deep-blue organic electrophosphorescence by guest charge trapping</i> , 83 Appl. Phys. Lett. 3818–3820 (2003)

Exhibit No.	Description
1017	X.H. Yang and D. Neher, <i>Polymer electrophosphorescence devices with high power conversion efficiencies</i> , 84 Appl. Phys. Lett. 2476–2478 (2004)
1018	Stelios A. Choulis et al., <i>The effect of interfacial layer on the performance of organic light-emitting diodes</i> , 87 Appl. Phys. Lett. 113503 (2005)
1019	INTENTIONALLY LEFT BLANK
1020	INTENTIONALLY LEFT BLANK
1021	Zoran D. Popovic and Hany Aziz et al., <i>Reliability and Degradation of Small Molecule-Based Organic Light-Emitting Devices (OLEDs)</i> , VOL. 8, NO. 2 IEEE Journal on Selected Topics in Quantum Electronics 362 (2002)
1022	Stelios A. Choulis et al., <i>Highly efficient organic electroluminescent device with modified cathode</i> , 88 Appl. Phys. Lett. 203502 (2006)
1023	S. Ouro Djobo et al., <i>Poly(N-vinylcarbazole) (PVK) deposited by evaporation for light emitting diodes thin films structures</i> , 122 Metals 131–133 (2001)
1024	Yuji Hamada et al., <i>Red organic light-emitting diodes using an emitting assist dopant</i> , 75 Appl. Phys. Lett. 1682–1684 (1999)
1025	Hiroshi Kanno et al., <i>White Stacked Electrophosphorescent Organic Light-Emitting Devices Employing MoO₃ as a Charge-Generation Layer</i> , 18 Adv. Mater. 339–342 (2006)
1026	Docket Control Order, <i>Pictiva Displays International Ltd. v. Samsung Electronics Co., Ltd., et al.</i> , Case No. 2:23-cv-00495, Dkt. #40 (E.D. Tex. Apr. 17, 2024)

I. INTRODUCTION

Samsung Display Co., Ltd. (“Petitioner”) petitions for *inter partes* review (“IPR”) seeking cancellation of claims 1-16 (the “Challenged Claims”) of U.S. Patent No. 8,723,164 (Ex.1001, “the ’164 patent”), assigned to Pictiva Displays International Ltd.

The ’164 patent relates to an organic light-emitting diode (“OLED”) display with a light-emitting layer composed of three matrix materials, as well as an emitter material. ’164 patent, 6:19-21, 6:34-37. Annotated Figure 2 below is an energy diagram that depicts the energy levels of each material in the light-emitting layer:



’164 patent, Fig. 2 (annotated); *see also* Ex.1003, ¶¶32-42. As in typical energy diagrams, the top of each rectangle in the above energy diagram represents the Lowest Unoccupied Molecular Orbital (LUMO) energy level of the corresponding material, and the bottom of each rectangle represents the Highest Occupied Molecular Orbital (HOMO) energy level of the corresponding material. Ex.1003, ¶¶26-29.

The independent claims of the '164 patent require the LUMO of the third matrix material to be energetically lower than the LUMOs of the first and second matrix materials, and the HOMO of the second matrix material to be energetically higher than the HOMOs of the first and third matrix materials. One of the purported benefits of such a structure is to improve charge carrier transport. *See* '164 patent, 2:1-4; Ex.1003, ¶¶35-39.

This display structure was not novel. *See, e.g.*, Ex.1003, ¶¶22-31. Rather, it was specifically disclosed by the prior art Choulis reference (Ex.1004). As shown in Choulis's energy diagram below, Choulis likewise discloses an OLED light emitting layer containing PVK, TPD, and PBD ("first matrix material," "second matrix material," and "third matrix material," respectively), as well as an emitter material Ir(mppy)₃.

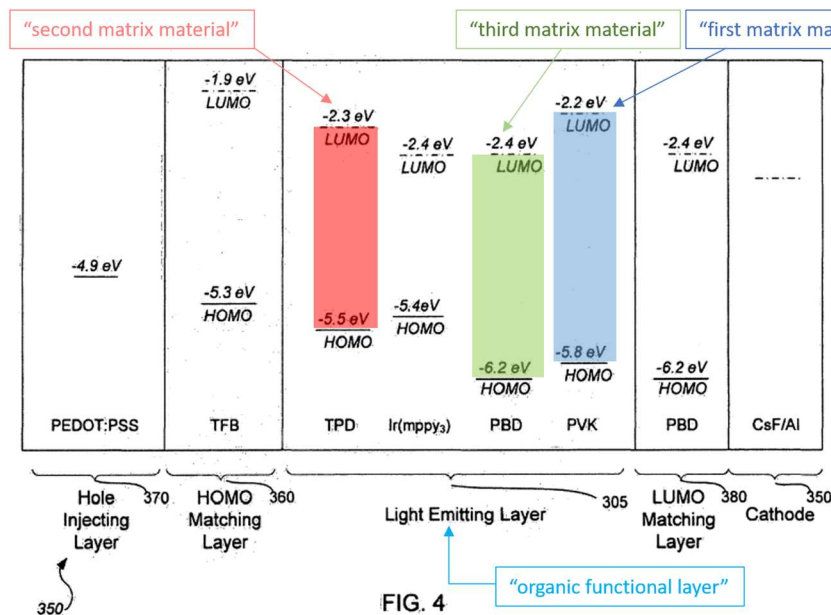
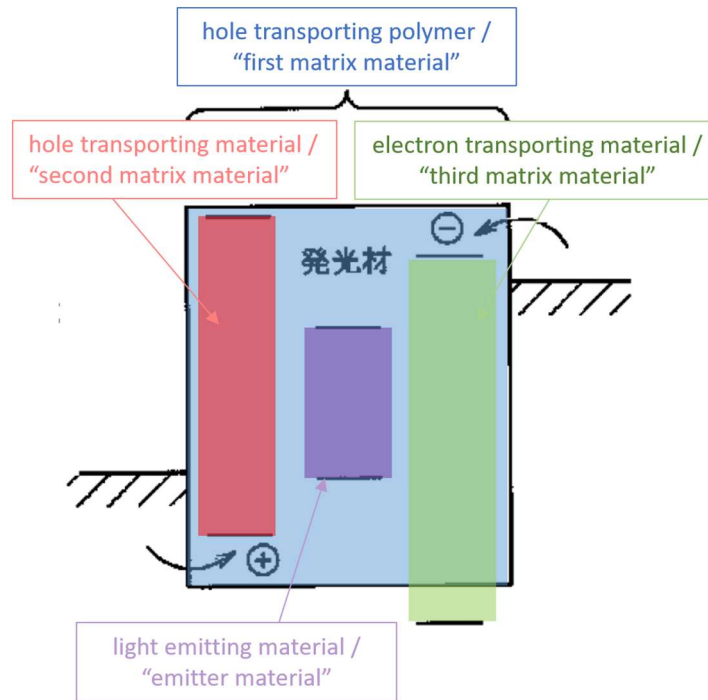


FIG. 4

Choulis, Fig. 4 (annotated). As shown above, the LUMO of the third matrix material (top of the green region) is energetically lower than the LUMOs of the first and second matrix materials (tops of the blue and red regions, respectively), and the HOMO of the second matrix material (bottom of the red region) is energetically higher than the HOMOs of the first and third matrix materials (bottoms of the blue and green regions, respectively). Ex.1003, ¶¶89-96. Choulis thus discloses all the limitations of claims 1-8 and 10-16, and therefore anticipates these claims or at a minimum renders them obvious, as shown below in Ground I.

This same structure was also disclosed by the prior art Sugiura reference (Ex.1005). As shown in Sugiura's energy diagram below, Sugiura likewise discloses an OLED light emitting layer containing a first matrix material ("hole transporting polymer"), second matrix material ("hole transporting material"), and a third matrix material ("electron transporting material"), as well as an emitter material Nile Red. *See, e.g.*, Ex.1003, ¶¶183-191; Sugiura, [0049].



Sugiura, Fig. 8 (annotated). As shown above, the LUMO of the third matrix material (top of the green region) is energetically lower than the LUMOs of the first and second matrix materials (tops of the blue and red regions, respectively), and the HOMO of the second matrix material (bottom of the red region) is energetically higher than the HOMOs of the first and the third matrix materials (bottoms of the blue and green regions, respectively). Ex.1003, ¶¶183-188. Sugiura thus discloses all the limitations of claims 1, 3, 5-8, and 10-13, and therefore anticipates these claims or at a minimum renders them obvious, as shown below in Ground III.

And, as shown below in Ground IV, Thompson (Ex.1007) also discloses an OLED light emitting layer with the first, second, and third matrix materials, anticipating claims 15-16 or at a minimum rendering them obvious.

As for dependent claim 9, which requires the concentration of the emitter material in the emission layer to have a gradient, it would have been obvious over the combination of Choulis and Yong (Ex.1009), as shown below in Ground II.

II. STANDING, MANDATORY NOTICES AND FEE AUTHORIZATION

Grounds for Standing: Pursuant to 37 C.F.R. § 42.104(a), Petitioner certifies that the '164 patent is available for IPR and that Petitioner is not barred or estopped from requesting an IPR challenging the '164 patent on the ground identified in this petition.

Real Party-in-Interest: Petitioner identifies Samsung Display Co., Ltd., Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. as real parties-in-interest.

Related Matters: Patent Owner has asserted the '164 patent in litigation against Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. in *Pictiva Displays International Ltd. v. Samsung Electronics Co., Ltd.*, Case No. 2:23-cv-00495 (E.D. Tex.).

Lead and Back-Up Counsel: Petitioner designates Scott C. Weidenfeller (Reg. No. 54,531) as lead counsel, of Covington & Burling LLP, One CityCenter, 850 Tenth Street, NW, Washington, DC 20001 (postal and hand delivery), telephone: (202) 662-6000, facsimile: (202) 662-6291

Petitioner designates David A. Garr (Reg. No. 74,932, dgarr@cov.com) as back-up counsel, of Covington & Burling LLP, One CityCenter, 850 Tenth Street, NW, Washington, DC 20001 (postal and hand delivery), telephone: (202) 662-6000, facsimile: (202) 662-6291.

Service Information: Service information is provided in the designation of counsel above. Petitioner consents to service of all documents via electronic mail at the email addresses above and at SDC-Pictiva-IPR@cov.com.

Fee Authorization: The Office is authorized to charge all fees due in connection with this proceeding to Deposit Account No. 60-3160.

III. SUMMARY OF CHALLENGE

Petitioner requests IPR of claims 1-16 of the '164 patent based on the following grounds:

- ***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.

Petition for *Inter Partes* Review of U.S. Patent No. 8,723,164

The '164 patent issued based on an international application filed on May 18, 2009 and claims priority to foreign applications filed on May 30, 2008 and August 22, 2008. Petitioner's challenge is based on the following references, which are available as prior art under 35 U.S.C. § 102 (pre-AIA)¹ as shown in the following table:

Exhibit	Reference	Date(s)	Availability as Prior Art
Ex.1004 (Choulis)	U.S. Patent Application Publication No. 2007/0069636	Filed Sep. 28, 2005 Published Mar. 29, 2007	§§ 102(a), (b), (e)
Ex.1005 (Sugiura) (certified translation provided as Ex.1006)	Japanese Published Application No. 2001/110568	Published Apr. 20, 2001	§§ 102(a), (b)
Ex.1007 (Thompson)	U.S. Patent Application Publication No. 2004/0155238	Filed Mar. 13, 2002 Published Aug. 12, 2004	§§ 102(a), (b), (e)
Ex.1008 (Yong) (certified translation provided as Ex.1009)	Chinese Published Application No. 1582073 A	Published Feb. 16, 2005	§§ 102(a), (b)

¹ Because the application for the '164 patent was filed prior to March 16, 2013, the pre-AIA conditions for patentability apply.

IV. OVERVIEW OF THE '164 PATENT

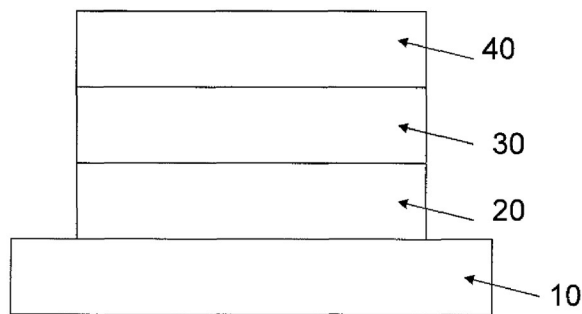
The '164 patent is directed to “an electronic device with an improved charge carrier transport and an improved charge carrier balance in the organic layers,” and a method for preparing the same. '164 patent, 1:33-35; Ex.1003, ¶¶32-42.

In its “Background of the Invention,” the '164 patent states that:

[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.

'164 patent, 1:22-28. A purported “object of the invention” is to increase efficiency through consideration of Lowest Unoccupied Molecular Orbital (LUMO) and Highest Occupied Molecular Orbital (HOMO) of the various materials in the organic layer of an OLED. '164 patent, 1:36, 1:46-2:57.

For example, as shown in Figure 1, the '164 patent's electronic device can have “a substrate 10, a first electrode 20, an emission layer 30, and a second electrode 40. The first electrode can, for example, be an anode and the second electrode, a cathode....The emission layer 30 can have a first, a second, and a third matrix material and be doped with an emitter material.” '164 patent, 6:6-16.



'164 patent, Fig. 1. The emission layer 30 is also referred to as an organic layer. '164 patent, 1:38-59.

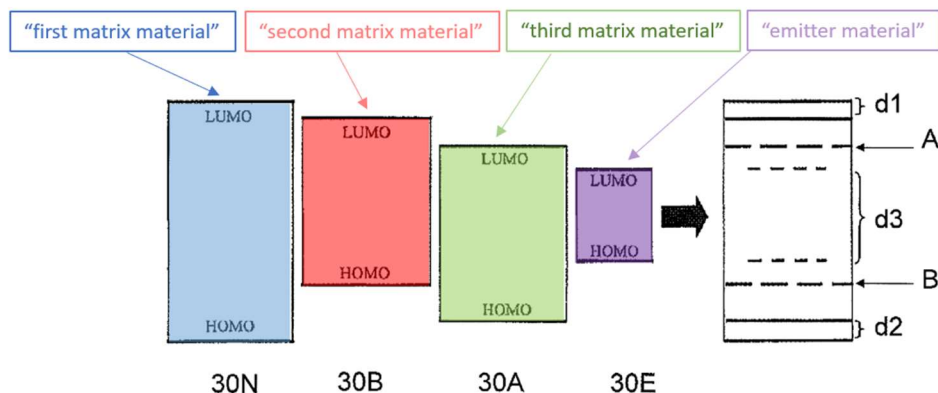
In the emission layer, “the third matrix material has a [LUMO], which is energetically lower than the LUMO of the second matrix material and the LUMO of the first matrix material,” and “the second matrix material has a [HOMO], which is energetically higher than the HOMO of the first matrix material and the HOMO of the third matrix material.” '164 patent, 1:48-55. This exact structure was already disclosed in the art, as shown in the references discussed throughout this petition (*e.g.*, Choulis, Sugiura, Thompson). *See, e.g.*, Ex.1003, ¶¶56-68.

Additionally, in some embodiments, the first matrix material is selected such that “it has a large band gap that is, the difference between HOMO and LUMO, for example, so that its HOMO is energetically below the HOMO of the other two matrix materials, and its LUMO is energetically above the LUMO of the other two matrix materials.” '164 patent, 2:4-9. Indeed, “the first matrix material can have the largest band gap between the HOMO and the LUMO, in comparison to the second and the

third matrix material, and...can have a charge carrier mobility in the electronic device which is less than the charge carrier mobility of the second and the third matrix material.” ’164 patent, 2:20-35. “Thus, it cannot have a share in the charge carrier transport.” ’164 patent, 2:35-36. On the other hand, “the second matrix material has a band gap which is shifted energetically to the band gap of the third matrix material. In this way, electrons can be transported on the LUMO of the third matrix material, and holes can be transported on the HOMO of the second matrix material.” ’164 patent, 2:22-27.

If one or more emitter materials are present, in one embodiment, “the LUMO of the emitter material can be energetically lower than the LUMO of the first, second, and third matrix material, and the HOMO of the emitter material can be energetically higher than the HOMO of the first, second, and third matrix material.” ’164 patent, 4:44-49. “Thus, the band gap between the HOMO and LUMO of the emitter material is smaller than the band gaps of the three matrix materials and, moreover, energetically is between all band gaps of all matrix materials.” ’164 patent, 4:49-52.

The energy levels of the foregoing structure are shown in Figure 2.



'164 patent, Fig. 2 (annotated). In energy diagrams such as annotated Figure 2 above, the top and bottom of a rectangle or vertically separated pair of horizontal lines represent the energy levels of each organic material, with the bottom of a rectangle or a bottom line representing the position of the HOMO level and the top of a rectangle or a top line representing the position of the LUMO level. Ex.1003, ¶¶26-27.

The '164 patent includes three independent claim (claims 1, 15, 16) and thirteen dependent claims (claims 2-14).

A. Prosecution History

During prosecution, the Examiner rejected the pending independent claims as anticipated by Forrest (US 2008/0116536) (Ex.1013). Ex.1002 (File History) at 233, 236; *see also* Ex.1003, ¶¶44-51. The claims of the '164 patent were only allowed after the independent claims were amended to require that “wherein the organic functional layer is an emission layer and is doped with at least one emitter material” (allowed claim 1), “wherein the first matrix material has a LUMO which is

energetically higher than the LUMO of the second matrix material and the LUMO of the third matrix material, and a HOMO which is energetically lower than the HOMO of the second matrix material and the HOMO of the third matrix material” (allowed claim 15), and “wherein the first matrix material has a charge carrier mobility which is lower than the charge carrier mobilities of the second and third matrix materials” (allowed claim 16). As explained below, none of these limitations is novel.

V. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art (“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.

VI. CLAIM CONSTRUCTION

Petitioner does not believe that any specialized constructions are necessary for this petition.

VII. OVERVIEW OF PRIOR ART

A. Choulis (Ex.1004)

Choulis, which serves as the primary reference for Grounds I-II, “is directed to improving the efficiency of an OLED by adding organic moieties to the light

emitting layer.” Choulis, [0007]. Figure 4 of Choulis illustrates an embodiment of the invention where “[t]he 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.” Choulis, [0030].

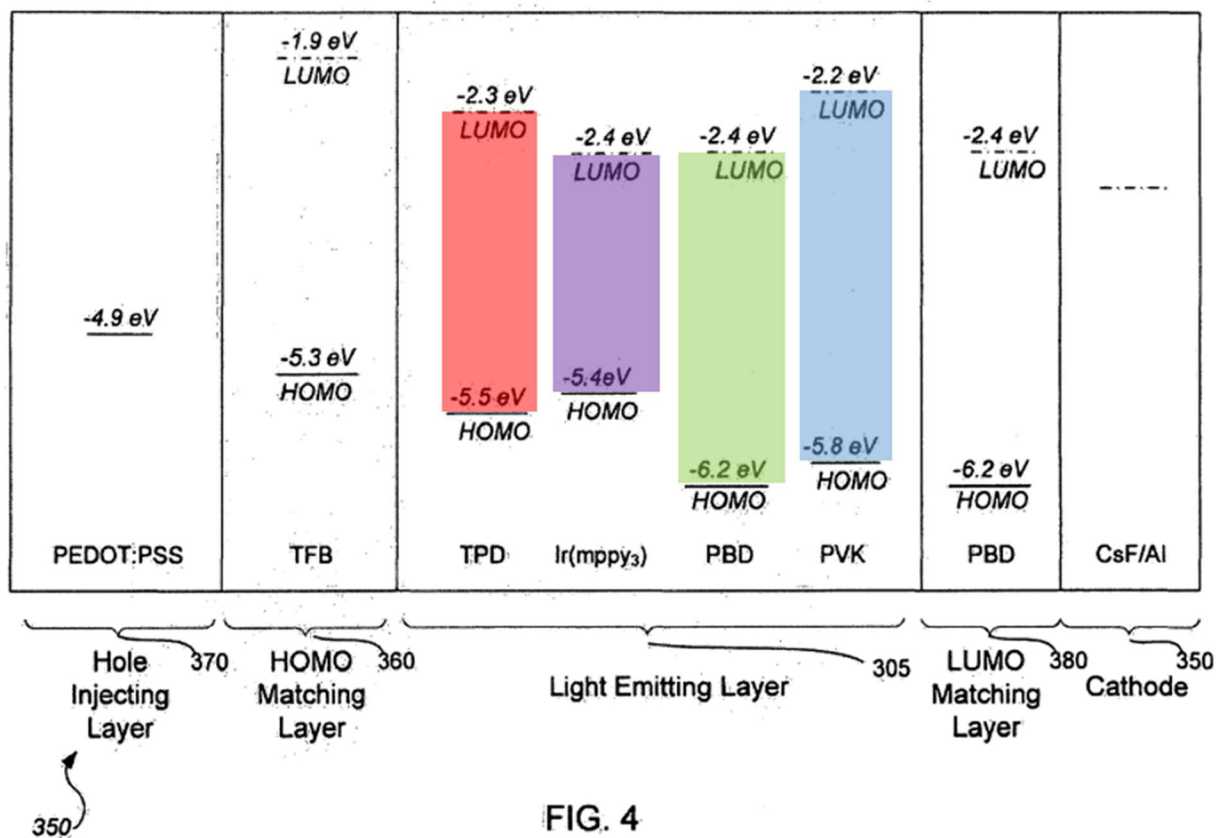


FIG. 4

Choulis, Fig. 4 (annotated to show the HOMO-LUMO gap of each light emitting layer material); Ex.1003, ¶¶56-60.

However, “[t]he materials described in [Figure 4] are only examples of possible materials for use in an OLED” and “[a]dditional 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.” Choulis, [0031]; Ex.1003, ¶58. Choulis also discloses that its emission layer can be doped to increase its efficiency and include materials with other properties:

[T]he light emitting layer can be co-doped with organic moieties...[to] increase the recombination zone within the light emitting layer, allowing for more recombination to occur and more light to be emitted...When organic moieties are mixed in with the light emitting material and host, the moieties can move the holes and electrons throughout the layer, as well as inject them to the light emitting material. The holes and electrons can therefore be transferred into the core of the light emitting layer, where combination and exciton formation can occur. Thus, the organic moieties in the light emitting layer expand the recombination zone, and thus increase the efficiency of the light emitting layer over other light emitting layers in OLED devices without such moieties.

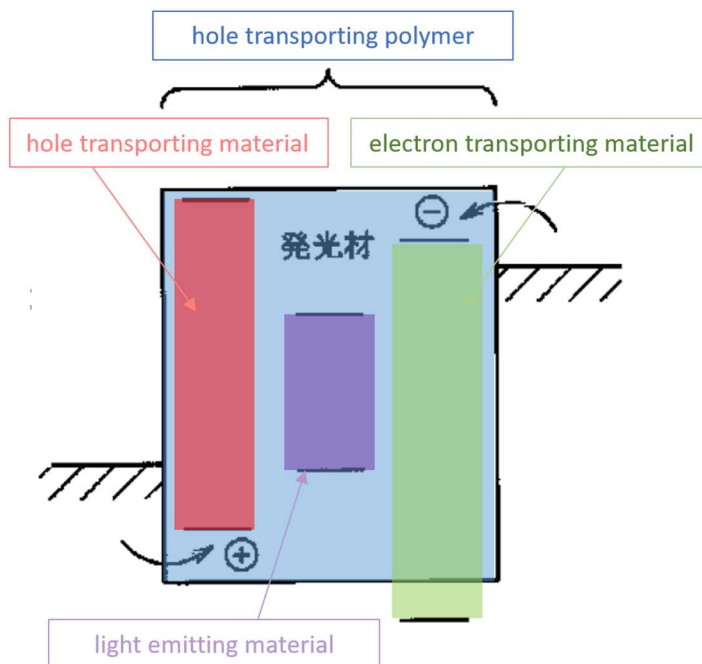
Choulis, [0032]. For example, the “organic material that emits light” “may be organic or organo-metallic in nature” with the “[l]ight-emission in these materials ...occur[ing] as a result of fluorescence or phosphorescence or both,” and “[e]xamples of electroluminescent small molecule materials include chelates, such as...(Ir(ppy)₃), organic materials, such as...rubrene or triazine, or any metal-chelate compounds or derivatives of any of the organic materials or small molecule materials.” Choulis, [0041]-[0043]. See Ex.1003, ¶59. Choulis also discloses that its “host material” in the “light emitting layer” can be “a polymer, small molecules, or a mixture of a polymer with small molecules.” Choulis, [0044].

Choulis also discloses that the light emitting layer can be formed either by the materials being “spun (spin-coated) onto the device, although other deposition methods...are possible too” such as being “deposited through evaporation, sublimation, or organic vapor phase deposition methods.” Choulis, [0042]-[0043]; Ex.1003, ¶60.

B. Sugiura (Exs.1005/1006)

Sugiura, which serves as the primary reference for Ground III, “relates to an organic light-emitting device used in a flat light source or a flat display,” Sugiura, [0001], that “reali[zes] a high light-emitting efficiency and low driving voltage even in a polymer-dispersed organic light-emitting device.” Sugiura, [0014].

Figure 8 of Sugiura illustrates “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.” Sugiura, [0049].



Sugiura, Fig. 8 (annotated); *see* Ex.1003, ¶¶61-64.

Sugiura discloses an embodiment, where “[f]or the light-emitting layer...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.” Sugiura, [0062]; *see also* Sugiura, Figs. 1, 4. Sugiura discloses manufacturing the light emitting layer in this embodiment by using “[t]he mixing ratio of each material [] PVK:Alq3:TPD:Nile red=100:60:80:0.2 (weight ratio),” with the layer “formed by dissolving 300 mg of PVK, 180 mg of Alq3, 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.” Sugiura, [0062].

C. Thompson (Ex.1007)

Thompson, which serves as the primary reference for Ground IV, “relates to highly efficient organic light emitting devices (OLEDs) that are, for example, capable of emitting blue light, and in particular to OLEDs that have an emitting layer comprising a phosphorescent dopant material and a charge carrying dopant material that are doped in an inert host material.” Thompson, [0001]; Ex.1003, ¶66. In one embodiment, Thompson explains that “the emissive layer comprises a wide gap host material doped with both a charge carrying dopant material and a phosphorescent dopant material” where “[e]ach dopant material...carries charge...of opposite polarity.” Thompson, [0008].

Figure 4 illustrates the energy levels of the materials for one embodiment of the OLED disclosed in Thompson:

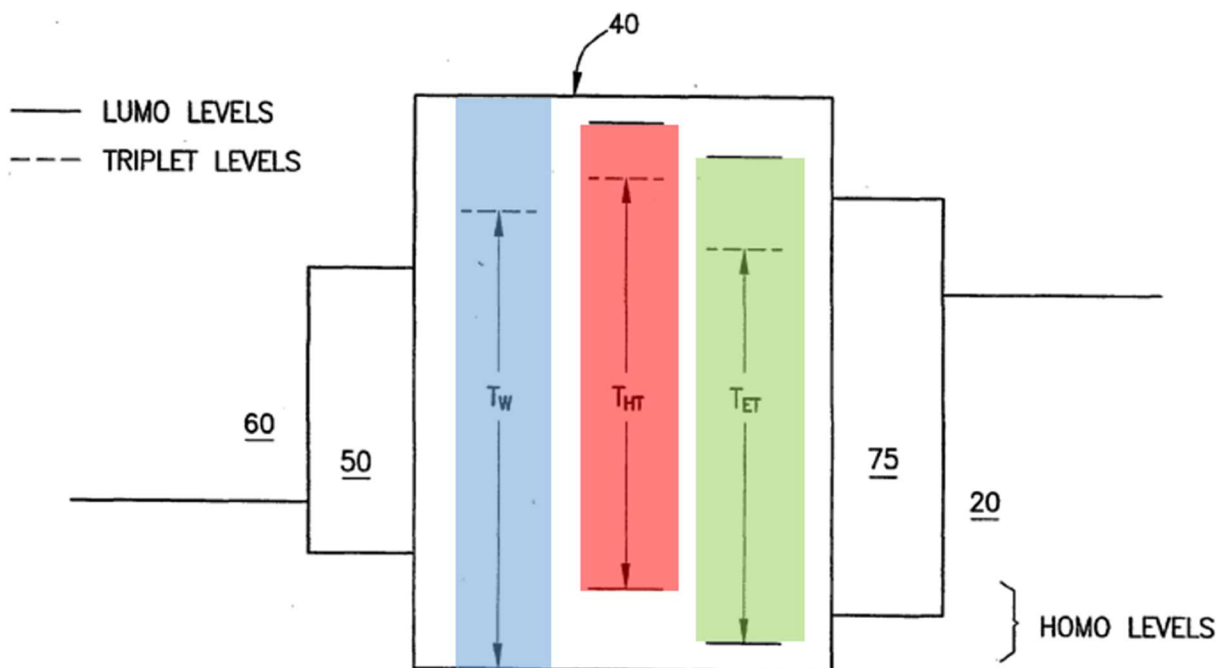


Fig. 4

Thompson, Fig. 4 (annotated); Ex.1003, ¶¶65-68. Thompson explains that, “[p]referably, the HOMO level of the inert host material is lower than the HOMO level of any of the dopant materials....In addition, the LUMO level of the inert host material is [sic] higher than the LUMO level of any of the dopant materials.” Thompson, [0042]; Ex.1003, ¶68.

International Patent Application No. WO02/074015 to Thompson et al. (“Thompson WO”), which shares the same specification as Thompson (Ex.1007), was line-listed in an IDS during prosecution of the ’164 patent. Ex.1002 (File History) at 48-49. The Examiner never cited Thompson WO in any rejection during prosecution, though.

D. Yong (Exs.1008/1009)

Yong relates to “to a phosphorescent organic light emitting device and the preparation method thereof” where the emission layer “comprises a host material and a phosphorescent dye, and the doping concentration of the phosphorescent dye gradually increases or decreases along the direction from the anode layer to the cathode layer with the increase of the thickness of the organic light emitting layer, forming a construction with gradient doping.” Yong, Abstract; Ex.1003, ¶¶69-71.

Yong explains that gradient doping is a “solution...to make the distribution trend of phosphorescent dyes in the host material conform to the distribution trend of electrons in the host material,” such that “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.” Yong, Description at 3. This helps “improv[e] the luminescent efficiency and brightness of the device, improv[e] its stability, and overcom[e] the disadvantages of low luminescent efficiency and poor stability of the device under high current.” Yong, Description at 3.

VIII. APPLICATION OF PRIOR ART TO THE CHALLENGED CLAIMS

A. Ground I: Claims 1-8 and 10-16 Are Anticipated By Or At A Minimum Rendered Obvious By Choulis

Choulis anticipates all of the elements of claims 1-8 and 10-16 of the '164 patent, as discussed below. Ex.1003, ¶¶72-159. Moreover, to the extent there is any

question whether Choulis anticipates any element of claims 1-8 and 10-16 of the '164 patent, the element or claim would have been obvious based on Choulis for substantially similar reasons. Ex.1003, ¶¶72-166. That is, to the extent any limitation is not disclosed by Choulis, it would have been strongly suggested to a POSITA for the same reasons discussed in Ground I below for that limitation. *See also Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1373 (Fed. Cir. 2019) (“It is well settled that a disclosure that anticipates under § 102 also renders the claim invalid under § 103, for anticipation is the epitome of obviousness.” (cleaned up)). Further, given the identical arrangement in Choulis of each disclosed or suggested element, as articulated in Ground I below, a POSITA would have been motivated to arrive at the claims as a whole based on Choulis’s disclosures and the knowledge of a POSITA.

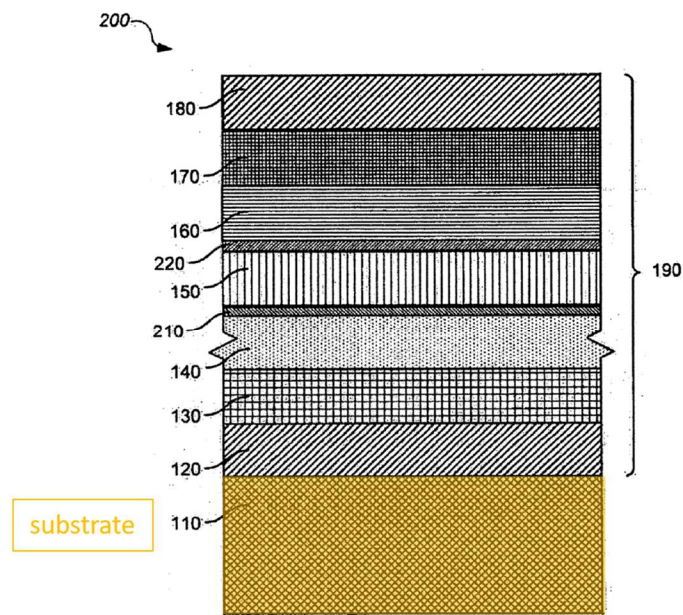
1. Independent Claim 1

a. Preamble: An electronic device, comprising:

To the extent the preamble is limiting, Choulis discloses it. Ex.1003, ¶¶72-74. Choulis states that its “invention relates to optoelectronic devices.” Choulis, [0014]. Choulis describes “[t]echniques...forming an organic light emitting diode device with improved device efficiency,” Choulis, Abstract, where the OLEDs of the invention “have at least one organic layer between two electrodes.” Choulis, [0002]. Choulis therefore discloses an electronic device.

b. Element 1[a]: a substrate;

Choulis discloses this element. Ex.1003, ¶¶75-76. Choulis discloses a substrate: “[f]or example, referring to FIG. 1, OLED 100 includes a substrate 110, such as a transparent layer, for example, glass or plastic.” Choulis, [0003] (emphasis added). Choulis’s Figure 2 (reproduced below with annotations) likewise discloses a substrate 110.



Choulis, Fig. 2 (annotated).

c. Element 1[b]: a first electrode;

Choulis discloses this element. Ex.1003, ¶¶77-79. Choulis discloses that, in its “optoelectronic devices[,]” a “light emitting diode has a first electrode, a light emitting layer coupled to the first electrode and second electrode coupled to the light

emitting layer.” Choulis, [0014]; *see also* Choulis, [0024] (disclosing anode 120, i.e., “first electrode”). *See* Ex.1003, ¶78.

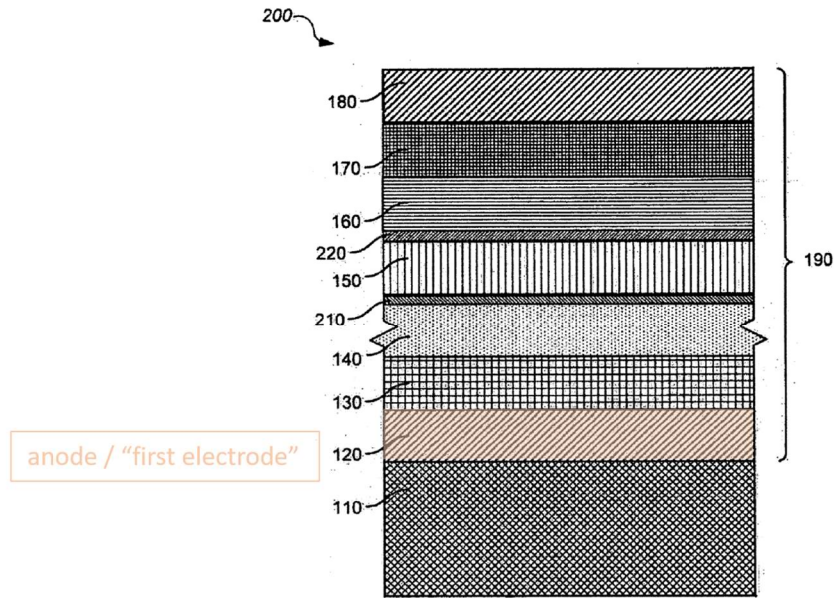


FIG. 2

Choulis, Fig. 2 (annotated).

d. Element 1[c]: at least one organic functional layer; and

Choulis discloses this element. Ex.1003, ¶¶80-82. Choulis discloses that its OLED device has a “light emitting layer,” which includes “a phosphorescent organic material.” Choulis, [0014]; *see also* Choulis, [0024] (disclosing light emitting layer 150); Figs. 2, 4.

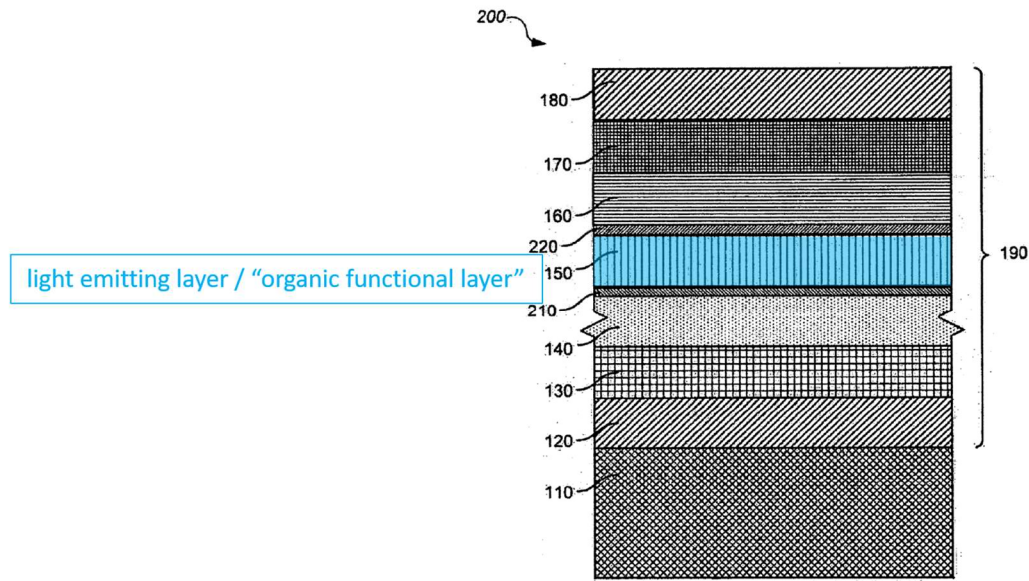


FIG. 2

Choulis, Fig. 2 (annotated).

Choulis's light emitting layer is an "organic functional layer." Ex.1003, ¶81; *see also* '164 patent at 3:61-63 ("The organic functional layer can be an emission layer and be doped with at least one emitter material.").

- e. **Element 1[d]: a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and**

Choulis discloses this element. Ex.1003, ¶¶83-84. Choulis discloses a prior art OLED device, where an "upper electrode, such as cathode 180, sandwiches the organic layers with the lower electrode." Choulis, [0003]. Similarly, as depicted in annotated Figure 2 below, Choulis's OLED device has a light emitting layer (i.e., "organic functional layer") located between an anode (i.e., "first electrode") and a cathode (i.e., "second electrode"). Choulis, [0024]; *see also* Choulis, [0014]

(disclosing “a light emitting layer coupled to the first electrode and second electrode coupled to the light emitting layer”). See Ex.1003, ¶83.

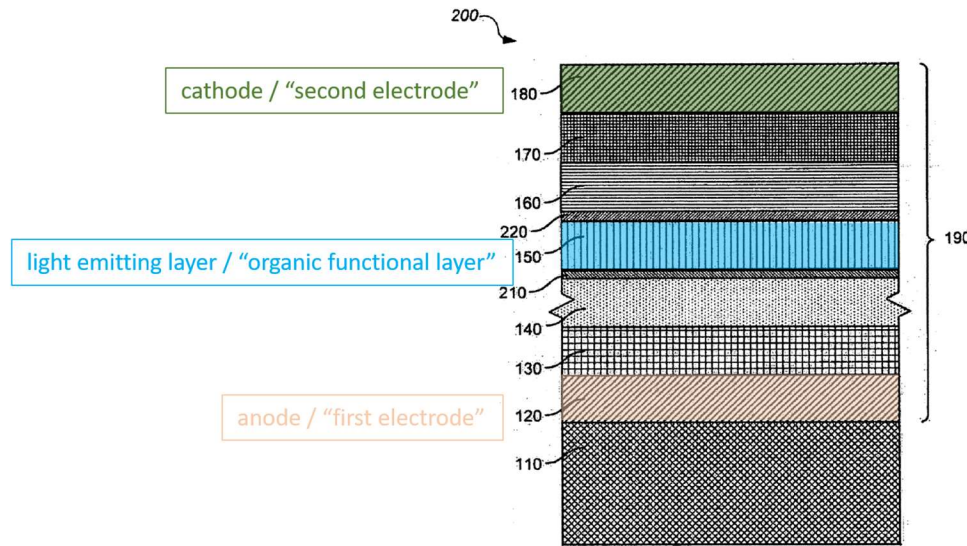


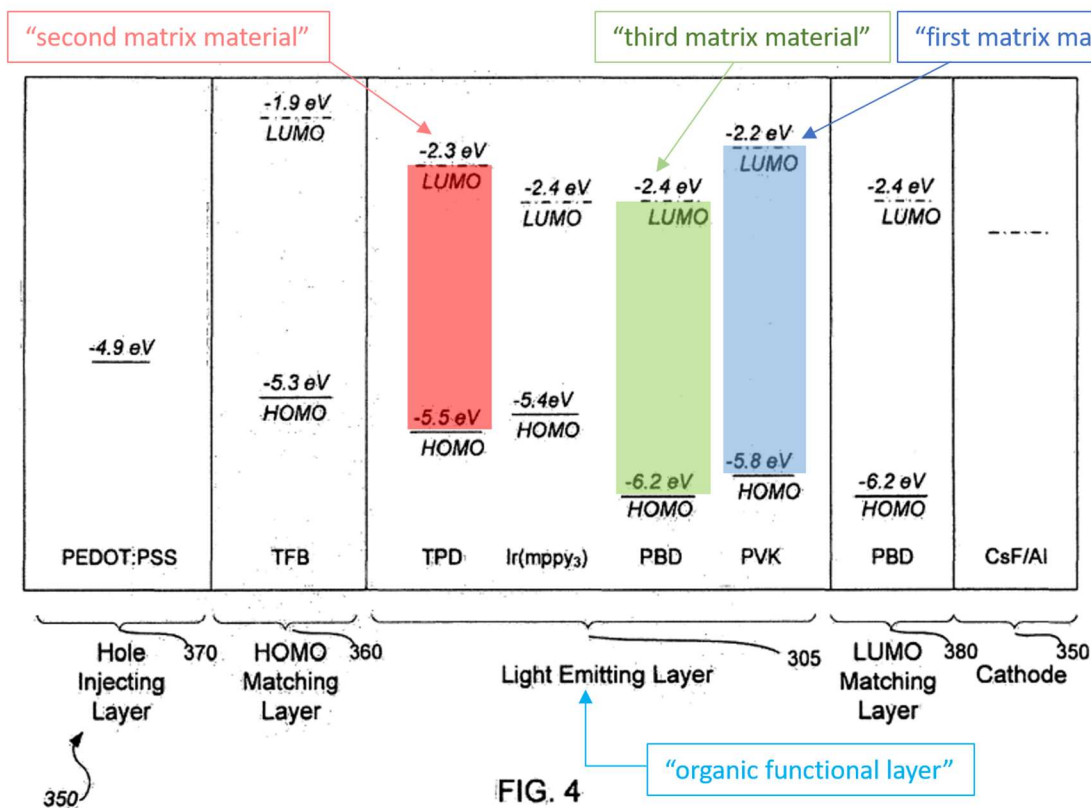
FIG. 2

Choulis, Fig. 2 (annotated).

- f. **Element 1[e]: 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**

Choulis discloses this element. Ex.1003, ¶¶85-88. Choulis discloses an organic layer, i.e., “light emitting layer 305,” which 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.” Choulis, [0030]. According to Choulis, “PVK has a large band cap and can confine the triplet excited state of the Ir(mppy)_3 phosphorescent molecule, preventing luminescence quenching.” Choulis, [0030]. Here, PVK is the “first

matrix material,” TPD is the “second matrix material,” and PBD is the “third matrix material,” which are all located in Choulis’s light emitting layer (*i.e.* “organic functional layer”). Ex.1003, ¶¶86-87. This is illustrated in Figure 4:



Choulis, Fig. 4 (annotated).

- g. **Element 1[f]: 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**

Choulis discloses this element. Ex.1003, ¶¶89-91. As shown in Choulis’s energy diagram (annotated Figure 4), the top line for the third matrix material PBD (green), with a LUMO value of -2.4 eV, is located below both the top line for the

second matrix material TPD (red) and the top line for the first matrix material PVK (blue), with LUMO values of -2.3 eV and -2.2 eV, respectively. Ex.1003, ¶¶90. Thus, Choulis discloses that the third matrix material PBD has a LUMO value that is energetically lower than those of the second matrix material TPD and the first matrix material PVK.

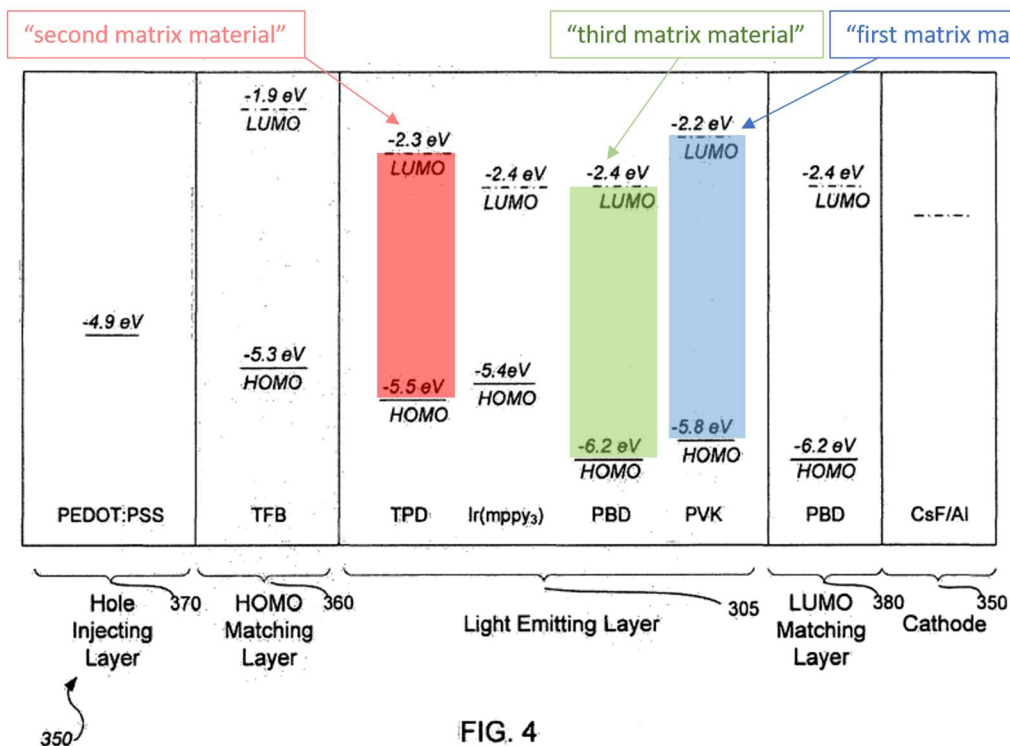


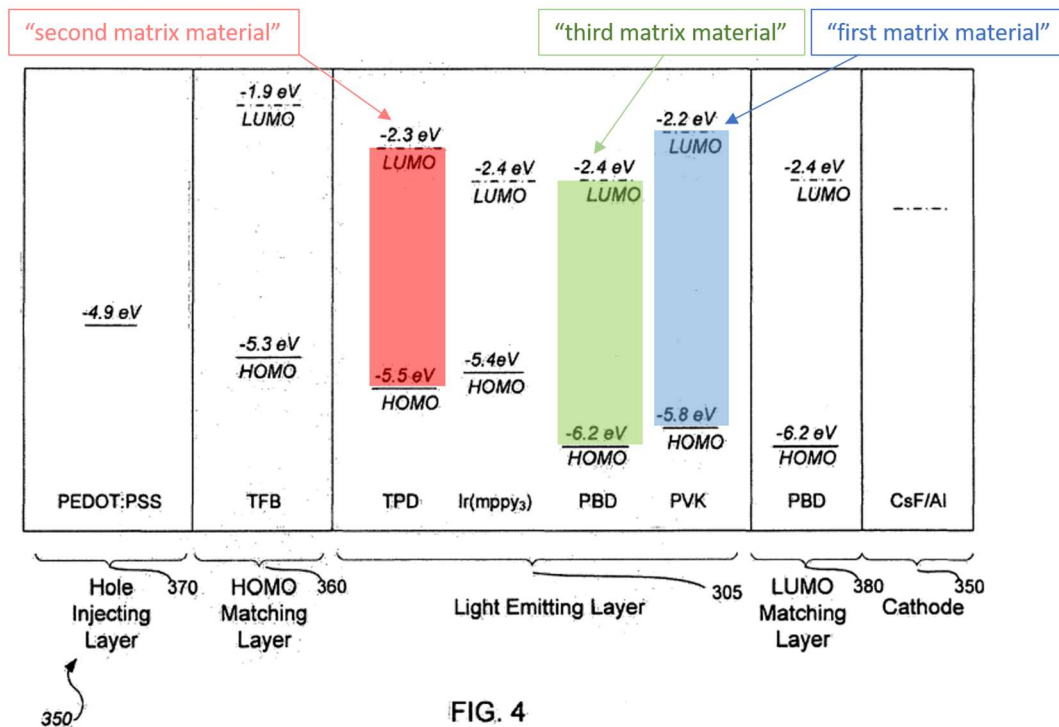
FIG. 4

Choulis, Fig. 4 (annotated).

- h. **Element 1[g]: 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,**

Choulis discloses this element. Ex.1003, ¶¶92-94. As shown in Choulis's energy diagram (annotated Figure 4), the bottom line for the second matrix material

TPD (red), with a HOMO value of -5.5 eV, is located above both the bottom line for the first matrix material PVK (blue) and the bottom line for the third matrix material PBD (green), with HOMO values of -5.8 eV and -6.2 eV, respectively. Thus, Choulis discloses that the second matrix material TPD has a HOMO value that is energetically higher than those of the first matrix material PVK and the third matrix material PBD.

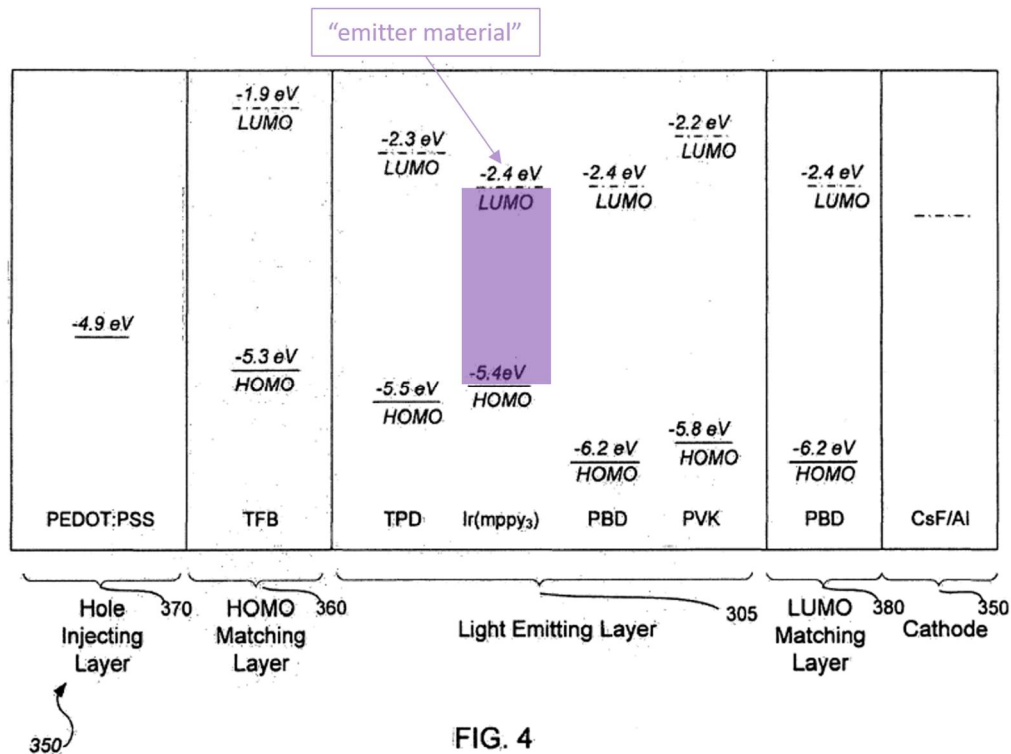


Choulis, Fig. 4 (annotated).

- i. **Element 1[h]: wherein the organic functional layer is an emission layer and is doped with at least one emitter material.**

Choulis discloses this element. Ex.1003, ¶¶95-96. As discussed in §VIII.A.1.d above regarding element 1[c], Choulis's light emitting layer is an "organic functional

layer.” Choulis, [0014]. Choulis further discloses doping the light emitting layer with an emitter material: “small organic molecules that emit by fluorescence or by phosphorescence can serve as a light emitting material residing in the light emitting layer.” Choulis, [0043]; Ex.1003, ¶95. Annotated Figure 4 below depicts the use of a light emitting material $\text{Ir}(\text{mppy})_3$ in the light emitting layer. Choulis, [0030].

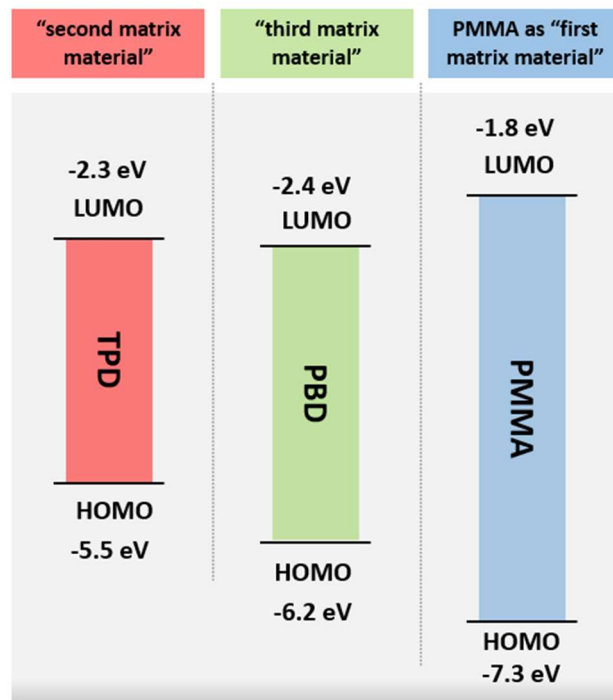


Choulis, Fig. 4 (annotated). Choulis also discloses applying rubrene to form the light emitting layer. Choulis, [0043]. Therefore, Choulis discloses that its light emitting layer is doped with, e.g., $\text{Ir}(\text{mppy})_3$ or rubrene (i.e., “emitter material”). Ex.1003, ¶95.

2. **Dependent Claim 2: The electronic device according to claim 1, wherein the first matrix material has a LUMO which is energetically higher than the LUMO of the second matrix material and the LUMO of the third matrix material, and a HOMO which is energetically lower than the HOMO of the second matrix material and the HOMO of the third matrix material.**

Choulis discloses or at a minimum renders obvious this claim. Ex.1003, ¶¶97-101. Choulis discloses that its “light emitting layer can include a host material” with a “high band gap (have a large difference between their HOMO and LUMO levels).” Choulis, [0044]. Choulis also discloses that “the light emitting layer [can] include[] materials that are insulated matrices, that is, the host does not have transport properties, such as...polymethyl methacrylate (PMMA)[.]” Choulis, [0044] (emphasis added). Ex.1003, ¶97.

The HOMO and LUMO levels of PMMA have been characterized and reported as -7.3 eV and -1.8 eV, respectively. *See, e.g.*, Ex.1011 (Li), Fig. 2; Ex.1012 (Wu), Fig. 4. Thus, when PMMA is used as the host material (as taught by Choulis, [0044]), the LUMO level of Choulis’s “first matrix material” (-1.8 eV) is “energetically higher” than the LUMO levels of Choulis’s second and third matrix materials (-2.3 eV and -2.4 eV, respectively) and the HOMO level of Choulis’s “first matrix material” (-7.3 eV) is “energetically lower” than the HOMO levels of Choulis’s second and third matrix materials (-5.5 eV and -6.2 eV, respectively). Ex.1003, ¶98. This is illustrated below:



Ex.1003, ¶98.

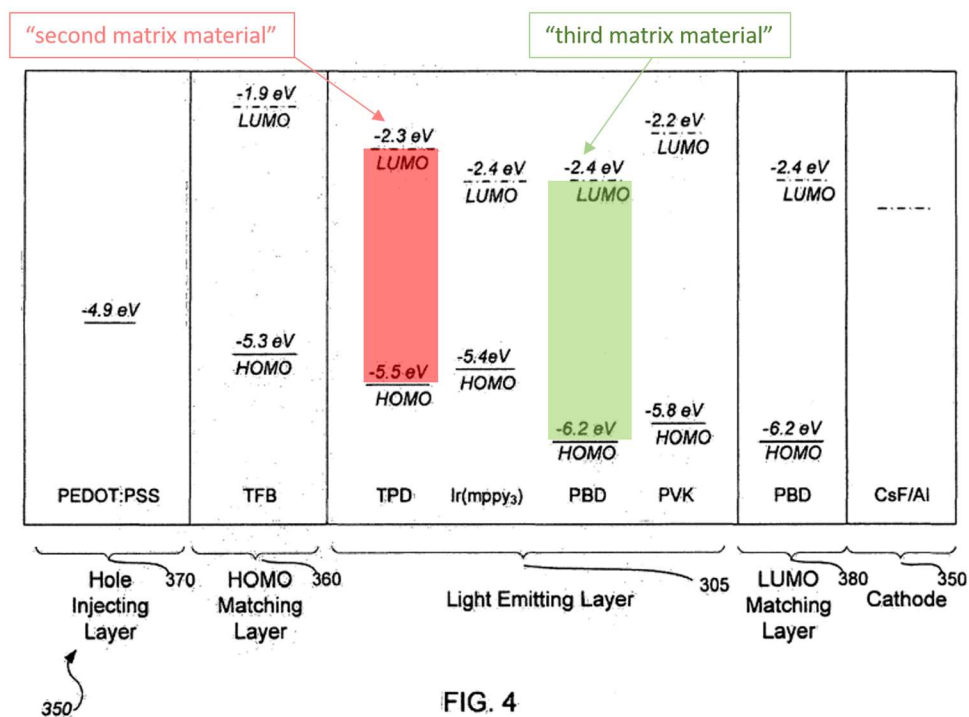
With PMMA as the “first matrix material,” Choulis discloses all of the limitations of claim 1 (from which claim 2 depends). As shown in the illustration above (which shows the HOMO/LUMO levels of PMMA), Choulis’s third matrix material (PBD) has a LUMO (-2.4 eV) which is energetically lower than the LUMO (-2.3 eV) of the second matrix material (TPD) and the LUMO (-1.8 eV) of the first matrix material (PMMA), satisfying element 1[f]; and Choulis’s second matrix material (TPD) has a HOMO (-5.5 eV) which is energetically higher than the HOMO (-7.3 eV) of the first matrix material (PMMA) and the HOMO (-6.2 eV) of the third matrix material (PBD), satisfying element 1[g]. Ex.1003, ¶99. As for the other

elements of claim 1 (elements 1[a]-1[e] and 1[h]) Choulis discloses them for the reasons explained in §VIII.A.1.

To the extent Choulis does not expressly disclose this claim, it would have been obvious to a POSITA to use a material such as PMMA with a LUMO level energetically higher than the LUMO levels of TPD (i.e., the “second matrix material”) and PBD (i.e., the “third matrix material”), and a HOMO level energetically lower than the HOMO levels of TPD and PBD, as the host material (i.e., the “first matrix material”) in Choulis’s OLED. Ex.1003, ¶100. A POSITA would have understood that the host material, which serves as a matrix in which guest materials are dispersed, preferably would have a wide energy gap so as not to interfere with the charge transport of the second and third matrix materials. Ex.1003, ¶100; Choulis, [0031], [0041]. A POSITA would have had a reasonable expectation of success in using such a material as the host material. Choulis, [0031], [0041]. Such use was well-known around 2008 and implementing it in Choulis’s OLED would have been a routine matter well within the ability of a POSITA. *See, e.g.*, Thompson, Abstract (“An OLED includes a wide gap inert host material doped with two dopants.”); Ex.1003, ¶100.

3. Dependent Claim 3: The electronic device according to claim 1, wherein the second matrix material has a LUMO which is energetically higher than the LUMO of the third matrix material and a HOMO which is energetically higher than the HOMO of the third matrix material.

Choulis discloses this claim. Ex.1003, ¶¶102-103. As shown in the annotated version of Figure 4 below, TPD as the “second matrix material” has a LUMO of -2.3 eV, “which is energetically higher than the LUMO of the third matrix material” PBD (-2.4 eV). TPD also has a HOMO of -5.5 eV, “which is energetically higher than the HOMO of the third matrix material” PBD (-6.2 eV). See Ex.1003, ¶102.



Choulis, Fig. 4 (annotated).

4. Dependent Claim 4: The electronic device according to claim 1, wherein the first matrix material has a charge carrier mobility which is lower than the charge carrier mobilities of the second and third matrix materials.

Choulis discloses or at a minimum renders obvious this claim. Ex.1003, ¶¶104-106. As discussed with respect to dependent claim 2, Choulis, with PMMA as the “first matrix material,” discloses the limitations of claim 1. *See* §VIII.A.2 above. Choulis discloses that “insulated matrices” such as PMMA “do[] not have transport properties,” Choulis, [0044], i.e., the ability for charge carriers such as electrons or holes to traverse the material under an applied voltage, Ex.1003, ¶105. This ability is generally quantified in terms of the “charge carrier mobility,” where a higher mobility reflects a greater ease of transport. Ex.1003, ¶105. Because PMMA does not have transport properties, the charge carrier mobility of this material is lower than that of the second and third matrix materials that do transport holes or electrons as discussed in §VIII.A.5 below regarding the second matrix material and §VIII.A.6 regarding the third matrix material. Ex.1003, ¶105.

5. Dependent Claim 5: The electronic device according to claim 1, wherein the second matrix material comprises a hole transport material.

Choulis discloses this claim. Ex.1003, ¶¶107-108. As discussed above with respect to claim 1, Choulis discloses TPD as the “second matrix material.” *See* §VIII.A.1.f above. In addition to explaining that its “light emitting layer can include a material capable of charge transport,” Choulis explains that TPD is a “hole

transporting material.” Choulis, [0046] (explaining that “a hole transporting material” may include “TPD”); Ex.1003, ¶107. Choulis therefore discloses a second matrix material that comprises a hole transport material.

6. Dependent Claim 6: The electronic device according to claim 1 wherein the third matrix material comprises an electron transport material.

Choulis discloses this claim. Ex.1003, ¶¶109-110. As discussed above with respect to claim 1, Choulis discloses PBD as the “third matrix material.” *See* §VIII.A.1.f above. In addition to explaining that its “light emitting layer can include a material capable of charge transport,” Choulis describes PBD as a material that performs “electron...transport.” Choulis, [0047]; *see also* Ex.1003, ¶109. Choulis therefore discloses a third matrix material that comprises an electron transport material.

7. Dependent Claim 7: The electronic device according to claim 1, wherein the organic functional layer is selected from a group which comprises emission layers, electron transport layers, hole transport layers, electron blocking layers, hole blocking layers, hole injection layers, electron injection layers, and intermediate layers.

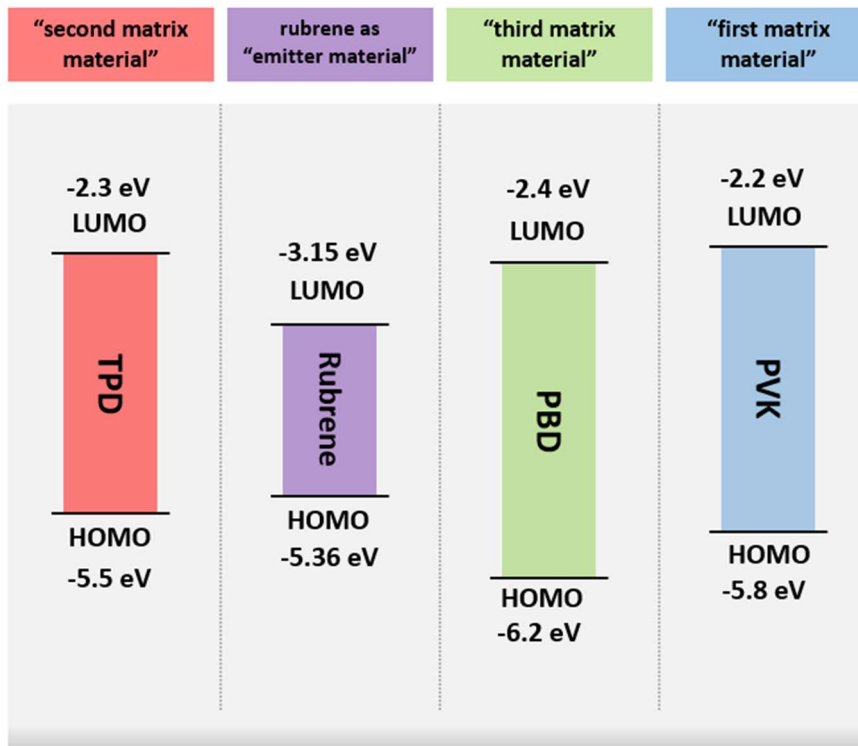
Choulis discloses this claim. Ex.1003, ¶¶111-112. As discussed in §VIII.A.1.d above regarding element 1[c], Choulis discloses a light emitting layer (i.e., “emission layer”), which is an “organic functional layer.” Choulis, [0014], [0024].

8. Dependent Claim 8: The electronic device according to claim 1, wherein the emitter material in the emission layer has a concentration of ≤ 10 wt %.

Choulis discloses this claim. Ex.1003, ¶¶113-114. Choulis discloses in one example that a “light emitting layer includes 61% PVK, 24% PBD, 9% TPD and 6% Ir(mppy)₃.” Choulis, [0054] (emphasis added). Choulis discloses that “Ir(mppy)₃” is a “light emitting material.” Choulis, [0028]. Choulis therefore discloses an emitter material in the emission layer with a concentration of “ ≤ 10 wt %.” Ex.1003, ¶113.

9. Dependent Claim 10: The electronic device according to claim 1, wherein the LUMO of the emitter material is energetically lower than the LUMO of the first, second, and third matrix materials, and the HOMO of the emitter material is energetically higher than the HOMO of the first, second, and third matrix materials.

Choulis discloses or at a minimum renders obvious this claim. Ex.1003, ¶¶115-116. As discussed in §VIII.A.1.i regarding element 1[h], Choulis discloses applying rubrene (i.e., “emitter material”) to form the light emitting layer. The HOMO and LUMO levels of rubrene are -5.36 eV and -3.15 eV, respectively. *See, e.g.,* Kang (Ex.1010), 756-57; Hamada (Ex.1024), Fig. 5. As illustrated below, the LUMO of rubrene (-3.15 eV) is energetically lower than the LUMOs of the exemplary first, second, and third matrix materials taught by Choulis (-2.2 eV, -2.3 eV, and -2.4 eV, respectively), and the HOMO of rubrene (-5.36 eV) is energetically higher than the HOMO of the exemplary first, second, and third matrix materials (-5.8 eV, -5.5 eV, and -6.2 eV, respectively). Ex.1003, ¶115.



Ex.1003, ¶115.

To the extent Choulis does not expressly disclose this claim, it would have been obvious to a POSITA to use an emitter material in Choulis's OLED which has a LUMO level energetically lower than the LUMO levels of PVK (i.e., the "first matrix material"), TPD (i.e., the "second matrix material") and PBD (i.e., the "third matrix material"), and a HOMO level energetically higher than the HOMO levels of PVK, TPD and PBD. Ex.1003, ¶115. A POSITA would have known that examples of such emitter materials include PQIr and DCM2. *See, e.g.*, Kanno (Ex.1025), Fig. 2 caption; Hamada (Ex.1024), Fig. 5. Ex.1003, ¶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 guest emitter material to form excitons, the LUMO level of the guest emitter material is preferably lower than those of other materials in the light emitting layer, and the HOMO level of the guest emitter material is preferably higher than those of other materials in the light emitting layer. Ex.1003, ¶115. A POSITA would have had a reasonable expectation of success in using such an emitter material; such use was well-known around 2008 and implementing it in Choulis’s OLED would have been a routine matter well within the ability of a POSITA. *See, e.g.*, Sugiura, Fig. 8; Ex.1003, ¶¶115, 30-31.

10. Dependent Claim 11: The electronic device according to claim 1, which is constructed as a radiation-emitting device.

Choulis discloses this claim. Ex.1003, ¶¶117-118. For example, Choulis discloses that an OLED device “emit[s] light via radiative decay.” Choulis, [0003] (emphasis added). As discussed in §VIII.A.1.d above regarding element 1[c], Choulis discloses that its OLED device has a light emitting layer. Choulis, [0024]. Light is a form of radiation. Ex.1003, ¶117. Choulis therefore discloses that its OLED device is constructed as a radiation-emitting device. Ex.1003, ¶117.

- 11. Dependent Claim 12: The electronic device according to claim 1 wherein the device is selected from a group which comprises an organic light-emitting device, a solar cell, and a transistor.**

Choulis discloses this claim. Ex.1003, ¶¶119-120. For example, Choulis is directed towards “[t]echniques...for forming an organic light emitting diode device with improved device efficiency.” Choulis, at Abstract (emphasis added).

12. Dependent Claim 13

- a. Preamble: A method for the production of an electronic device according to claim 1, comprising the steps of:**

To the extent the preamble is limiting, Choulis discloses it. Choulis discloses “[a] method of fabricating a light emitting diode.” Choulis, [0019]; Ex.1003, ¶¶121-123.

- b. Element 13[a]: A) preparation of a substrate;**

Choulis discloses this element. Ex.1003, ¶¶124-125. Choulis states that “[a] method of fabricating a light emitting diode can include the following steps. A substrate with an electrode formed thereon is provided.” Choulis, [0019] (emphasis added); *see also* Choulis, [0003], Fig. 2.

- c. Element 13[b]: B) preparation of a first electrode and a second electrode; and**

Choulis discloses this element. Ex.1003, ¶¶126-127. Choulis discloses an OLED device with “the first electrode and second electrode.” Choulis, [0014]; *see also* Choulis, [0024], Fig. 2. Choulis further discloses “[a] method of fabricating a

light emitting diode” where “[a] substrate with an electrode formed thereon is provided.” Choulis, [0019].

d. Element 13[c]: C) placement of at least one organic functional layer between the first electrode and the second electrode,

Choulis discloses this element. Ex.1003, ¶¶128-129. Choulis discloses that a prior art OLED device, where “[a]n upper electrode, such as cathode 180, sandwiches the organic layers with the lower electrode.” Choulis, [0003]. As discussed in §VIII.A.1.d above regarding element 1[c], Choulis discloses an OLED device with a light emitting layer, which is the “organic functional layer.” Choulis, [0014], [0024]. Choulis discloses that the light emitting layer is “coupled to the first electrode and second electrode,” as shown in annotated Figure 2 below. Choulis, [0014]; *see also* Choulis, [0024].

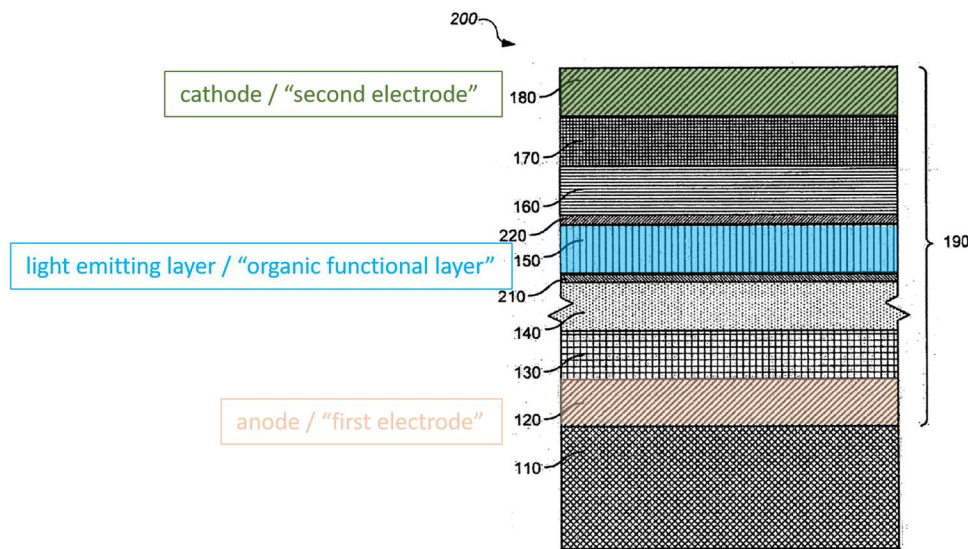


FIG. 2

Choulis, Fig. 2 (annotated); Ex.1003, ¶128.

- e. **Element 13[d]: wherein in method step C), at least the first matrix material, the second matrix material, and the third matrix material are simultaneously applied.**

Choulis discloses or at a minimum renders obvious this element. Ex.1003, ¶¶130-137. As discussed in §VIII.A.1.f above regarding element 1[e], Choulis discloses a light emitting layer containing a first matrix material PVK, a second matrix material TPD, and a third matrix material PBD. Choulis, [0030], Fig. 4; *see also* Choulis, [0020] (“Forming the light emitting layer can include applying a layer including an organo-metallic phosphorescent compound and organic moieties”). PVK is a polymer while TPD and PBD are small molecules. Ex.1003, ¶130; Choulis, [0044] (“PVK...is a non-conjugated polymer”); Ex.1021, Fig. 1 (explaining that TPD is a material “commonly used in small molecule based OLEDs”); Ex.1022, 203502-2 (noting “PBD” as a “small molecule”).

Spin-coating. Choulis discloses depositing its materials via spin-coating. Choulis, [0042] (“Polymers can be solvated in an organic solvent...and spun (spin-coated) onto the device”), [0043] (“[S]mall molecule materials...can be applied by solution methods too.”). Spin-coating a mix of PVK, TPD, and PBD involves dissolving PVK, TPD, and PBD in a solution, placing the solution on a substrate, and spinning the substrate at high speed so that the solution spreads to form a thin layer. Ex.1003, ¶131. As such, this process involves a simultaneous application of PVK, TPD, and PBD. Ex.1003, ¶131. Spin-coating a mix of PVK, TPD, and PBD

was well-known 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...”).

Evaporation Coating. Choulis also discloses depositing its materials “through evaporation.” Choulis, [0048]. The evaporation process involves heating materials so that their molecules are released and subsequently travel through a vacuum chamber to be deposited simultaneously on a target substrate. Ex.1003, ¶132. Therefore, the materials are “simultaneously applied.” Ex.1003, ¶132.

PVK can be deposited via evaporation when manufacturing OLED devices. *See, e.g.*, Ex.1023 at 1 (“Poly(*N*-viylcarbazole) (PVK) deposited by evaporation for light emitting diodes thin films structures”); Ex.1003, ¶133. TPD and PBD are both small organic molecules. *See, e.g.*, Ex.1021, Fig. 1 (showing TPD as “material[] commonly used in small molecule based OLEDs”); Ex.1022 at 203502-2 (“PBD small molecule...”); Ex.1003, ¶133. Choulis discloses that such “small organic molecules...are preferably deposited through evaporation.” Choulis, [0043]. A POSITA would have, at a minimum, found it obvious to apply PVK via evaporation coating, along with TPD and PBD, as it would improve manufacturability, display quality, and yield, particularly when compared to other manufacturing methods such as spin-coating. Ex.1003, ¶134. A POSITA would have had a reasonable expectation of success; Choulis explains that “the techniques described herein,” including

evaporation coating, can be readily applied to OLED display manufacturing. Choulis, [0059]; Ex.1003, ¶134.

Alternatively, Choulis discloses that the “host material...can be...small molecules,” instead of a polymer such as PVK. Choulis, [0044]; *see also* Choulis, [0031] (“Additional suitable materials than those described for the host material...can also be selected according to the properties described herein.”). A POSITA would have found it obvious to simultaneously apply the substitute small molecule-based host material (i.e., the “first matrix material”), TPD (i.e., the “second matrix material”), and PBD (i.e., the “third matrix material”) via evaporation coating to achieve the manufacturing process benefits described above. Ex.1003, ¶135.

With a small molecule material as the “first matrix material,” Choulis still discloses all of the limitations of claim 1 (from which claim 13 depends) because Choulis discloses that any material that replaces the exemplary materials (including the host material PVK) is preferably “selected according to the properties described herein,” i.e.,, among other things, the third matrix material would preferably have a LUMO, which is energetically lower than the LUMO of the second matrix material and the LUMO of the first matrix material (element 1[f]), and the second matrix material would preferably have a HOMO, which is energetically higher than the HOMO of the first matrix material and the HOMO of the third matrix material (element 1[g]), as is the case for PVK relative to the second matrix material TPD

and the third matrix material PBD. Choulis, [0031]; *see also* §§VIII.A.1.g & h regarding elements 1[f] and 1[g]. As for the remaining elements of claim 1—elements 1[a]-1[e] and 1[h]—Choulis discloses them for the reasons explained in §VIII.A.1.

13. Dependent Claim 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.

Choulis discloses or at a minimum renders obvious this claim. Ex.1003, ¶¶138-139. As discussed in §VIII.A.12.e above regarding element 13[d], Choulis discloses or at a minimum renders obvious applying the first matrix material (e.g., PVK, substitute small molecule host material), the second matrix material TPD, and the third matrix material PBD by evaporation.

14. Independent Claim 15

a. Preamble: An electronic device, comprising:

To the extent the preamble is limiting, Choulis discloses it. Ex.1003, ¶¶140-141. This element is the same as the preamble for independent claim 1, and Choulis discloses it for the same reasons. *See* §VIII.A.1.a above.

b. Element 15[a]: a substrate;

Choulis discloses this element. Ex.1003, ¶142. This element is the same as independent claim 1[a], and Choulis discloses it for the same reasons. *See* §VIII.A.1.b above.

c. Element 15[b]: a first electrode;

Choulis discloses this element. Ex.1003, ¶143. This element is the same as independent claim 1[b], and Choulis discloses it for the same reasons. *See* §VIII.A.1.c above.

**d. Element 15[c]: at least one organic functional layer;
and**

Choulis discloses this element. Ex.1003, ¶144. This element is the same as independent claim 1[c], and Choulis discloses it for the same reasons. *See* §VIII.A.1.d above.

e. Element 15[d]: a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and

Choulis discloses this element. Ex.1003, ¶145. This element is the same as independent claim 1[d], and Choulis discloses it for the same reasons. *See* §VIII.A.1.e above.

**f. Element 15[e]: 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**

Choulis discloses this element. Ex.1003, ¶146. This element is the same as independent claim 1[e], and Choulis discloses it for the same reasons. *See* §VIII.A.1.f above.

- g. Element 15[f]: 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**

Choulis discloses this element. Ex.1003, ¶147. This element is the same as independent claim 1[f], and Choulis discloses it for the same reasons. *See* §VIII.A.1.g above.

- h. Element 15[g]: 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,**

Choulis discloses this element. Ex.1003, ¶148. This element is the same as independent claim 1[g], and Choulis discloses it for the same reasons. *See* §VIII.A.1.h above.

- i. Element 15[h]: wherein the first matrix material [sic] has a LUMO which is energetically higher than the LUMO of the second matrix material and the LUMO of the third matrix material, and a HOMO which is energetically lower than the HOMO of the second matrix material and the HOMO of the third matrix material.**

Choulis discloses or at a minimum renders obvious this element. Ex.1003, ¶149. This element is substantively the same as dependent claim 2, and Choulis discloses it for the same reasons. *See* §VIII.A.2 above.

15. Independent Claim 16

a. Preamble: An electronic device, comprising:

To the extent the preamble is limiting, Choulis discloses it. Ex.1003, ¶¶150-151. This element is the same as the preamble of independent claim 1, and Choulis discloses it for the same reasons. *See* §VIII.A.1.a above.

b. Element 16[a]: a substrate;

Choulis discloses this element. Ex.1003, ¶152. This element is the same as independent claim 1[a], and Choulis discloses it for the same reasons. *See* §VIII.A.1.b above.

c. Element 16[b]: a first electrode;

Choulis discloses this element. Ex.1003, ¶153. This element is the same as independent claim 1[b], and Choulis discloses it for the same reasons. *See* §VIII.A.1.c above.

**d. Element 16[c]: at least one organic functional layer;
and**

Choulis discloses this element. Ex.1003, ¶154. This element is the same as independent claim 1[c], and Choulis discloses it for the same reasons. *See* §VIII.A.1.d above.

- e. **Element 16[d]: a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and**

Choulis discloses this element. Ex.1003, ¶155. This element is the same as independent claim 1[d], and Choulis discloses it for the same reasons. *See* §VIII.A.1.e above.

- f. **Element 16[e]: 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**

Choulis discloses this element. Ex.1003, ¶156. This element is the same as independent claim 1[e], and Choulis discloses it for the same reasons. *See* §VIII.A.1.f above.

- g. **Element 16[f]: 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**

Choulis discloses this element. Ex.1003, ¶157. This element is the same as independent claim 1[f], and Choulis discloses it for the same reasons. *See* §VIII.A.1.g above.

- h. Element 16[g]: 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,**

Choulis discloses this element. Ex.1003, ¶158. This element is the same as independent claim 1[g], and Choulis discloses it for the same reasons. *See* §VIII.A.1.h above.

- i. Element 16[h]: wherein the first matrix material has a charge carrier mobility which is lower than the charge carrier mobilities of the second and third matrix materials.**

Choulis discloses or at a minimum renders obvious this element. Ex.1003, ¶159. This element is the same as dependent claim 4, and Choulis discloses it for the same reasons. *See* §VIII.A.4 above.

B. Ground II: Claim 9 Is Rendered Obvious By Choulis and Yong

- 1. Dependent Claim 9: The electronic device according [sic] claim 1, wherein the concentration of the emitter material in the emission layer has a gradient.**

Claim 9 would have been obvious to a POSITA based on Choulis and Yong. Ex.1003, ¶¶160-166. As discussed in §§VIII.A.1.d & i above regarding elements 1[c] & 1[h], Choulis discloses that its OLED device has a “light emitting layer,” which includes “a phosphorescent organic material,” such as Ir(mppy)₃. Choulis, [0014], [0030]. Choulis explains in its “Background” that “[t]he recombination current in any of the layers...can be controlled...by adjusting dopant

concentrations.” Choulis, [0002] (emphasis added). It would have been obvious to a POSITA to apply the emitter material in Choulis’s emission layer such that the concentration of the emitter has a gradient. Ex.1003, ¶160.

Prior to the ’164 patent, forming a gradient with an emitter material was well known. Ex.1003, ¶161. For example, the OLED disclosed in Yong has an organic light emitting layer where “the doping concentration of the phosphorescent dye gradually increases or decreases along the direction from the anode layer to the cathode layer with the increase of the thickness of the organic light emitting layer, forming a construction with gradient doping.” Yong, Abstract.

Yong further explains that the benefit of gradient distribution comes from the gradient “mak[ing] the distribution trend of phosphorescent dyes in the host material conform to the distribution trend of electrons in the host material,” and thus “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.” Yong, Description at 3; *see* Ex.1003, ¶¶162-163. Yong teaches that this results in benefits including “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.” Yong, Description at 3.

It would have been obvious to a POSITA to dope the emission layer in the device disclosed in Choulis such that “the concentration of the emitter material in the emission layer has a gradient.” Ex.1003, ¶164. A POSITA would have been motivated to use a gradient for the emitter concentration in the emission layer to achieve the advantages discussed in Yong, including improving the device’s luminescence efficiency and stability. Ex.1003, ¶164.

A POSITA also would have reasonably expected success forming a gradient for the emitter concentration in Choulis’ OLED display device. Gradient doping was a well-known alternative to uniform doping of materials, and a POSITA would be familiar with the manufacturing techniques for producing a gradient composition for the emitter concentration. Ex.1003, ¶165. Indeed, Yong describes methods for forming its gradient using evaporation, a method also disclosed in Choulis. Yong, Description at 4 (discussing “vapor depositing” in a “vacuum chamber” using “evaporation sources”); Choulis, [0048] (discussing “deposit[ion] through evaporation”). Specifically, as discussed in §VIII.A.12.e above regarding element 13[d], Choulis discloses applying the first, second, and third matrix materials using evaporation. *See* Choulis, [0044], [0048]; Ex.1003, ¶165.

Yong also describes a similar OLED structure and emitter material as disclosed in Choulis, including “a phosphorescent organic light emitting device” comprising a “substrate, an anode layer, an organic functional layer, and a cathode

layer,” with the organic functional layer formed from “an organic light emitting layer, selective of one or more layers of hole injection layer, hole transporting layer, electron transporting layer, and electron injection layer,” and “the organic light emitting layer comprises a host material and a phosphorescent dye” where the phosphorescent emitter is Ir(mppy)₃. Yong, Description at 3, 11; Ex.1003, ¶166.

C. Ground III: Claims 1, 3, 5-8, and 10-13 Are Anticipated By Or At A Minimum Rendered Obvious By Sugiura

Sugiura anticipates all of the elements of claims 1, 3, 5-8, and 10-13 of the '164 patent, as discussed below. Ex.1003, ¶¶167-219. Moreover, to the extent there is any question whether Sugiura anticipates any element of claims 1, 3, 5-8, and 10-13 of the '164 patent, the element or claim would have been obvious based on Sugiura for substantially similar reasons. Ex.1003, ¶¶167-219. That is, to the extent any limitation is not disclosed by Sugiura, it would have been strongly suggested to a POSITA for the same reasons discussed in Ground III below for that limitation. Further, given the identical arrangement in Sugiura of each disclosed or suggested element, as articulated in Ground III below, a POSITA would have been motivated to arrive at the claims as a whole based on Sugiura's disclosure and the knowledge of a POSITA.

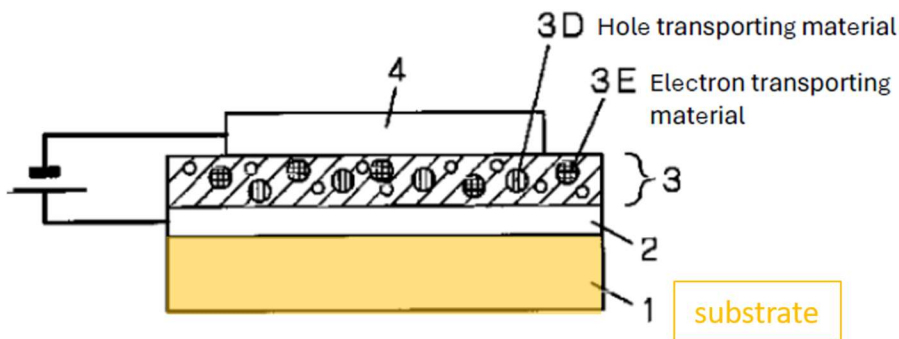
1. Independent Claim 1

a. Preamble: An electronic device, comprising:

To the extent the preamble is limiting, Sugiura discloses it. Ex.1003, ¶¶167-169. For example, Sugiura “relates to an organic light-emitting device used in a flat light source or a flat display,” Sugiura, [0001], where an “organic compound forms a light-emitting body, and...[has] features such as the ability to be driven at a lower voltage.” Sugiura, [0002]. Sugiura thus discloses an electronic device. Ex.1003, ¶168.

b. Element 1[a]: a substrate;

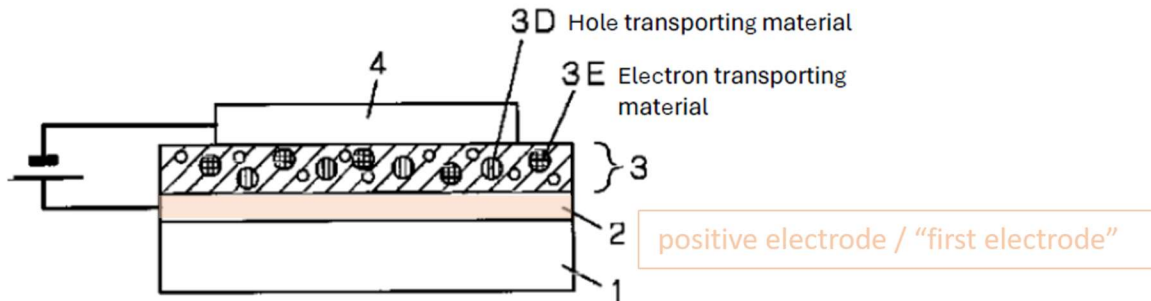
Sugiura discloses this element. Ex.1003, ¶¶170-171. As depicted in annotated Figure 4 below, Sugiura discloses a “substrate 1.” Sugiura, [0062].



Sugiura, Fig. 4 (annotated). *See* Ex.1003, ¶170.

c. Element 1[b]: a first electrode;

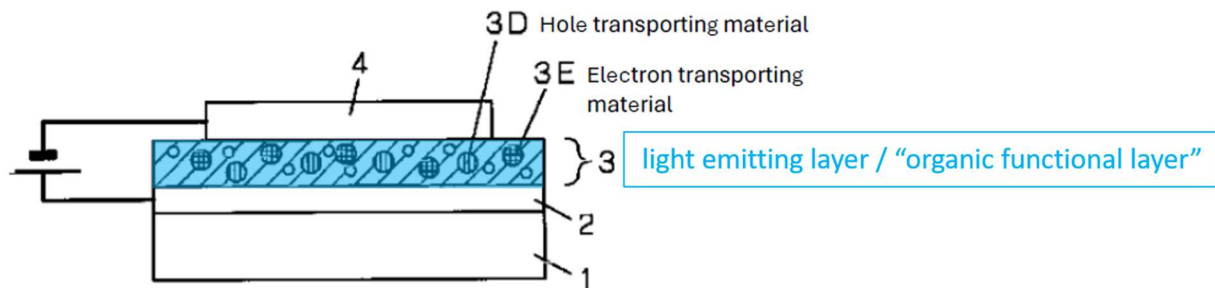
Sugiura discloses this element. Ex.1003, ¶¶172-173. In reference to its Figure 4, Sugiura discloses a “positive electrode 2,” which is the claimed “first electrode.” Sugiura, [0062].



Sugiura, Fig. 4 (annotated). See Ex.1003, ¶172.

d. Element 1[c]: at least one organic functional layer; and

Sugiura discloses this element. Ex.1003, ¶¶174-176. The OLED shown in Figure 4 contains a “light-emitting layer 3.” Sugiura, [0062].

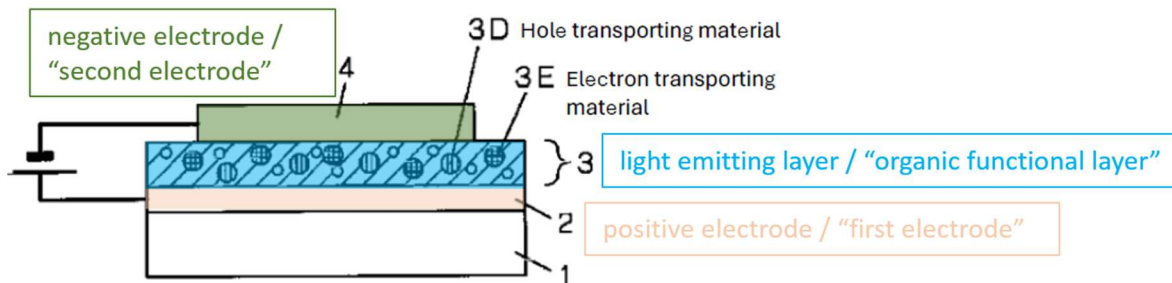


Sugiura, Fig. 4 (annotated). See Ex.1003, ¶174.

Sugiura's light-emitting layer is an "organic functional layer." Ex.1003, ¶175; '164 patent at 3:61-63 ("The organic functional layer can be an emission layer and be doped with at least one emitter material.").

- e. **Element 1[d]: a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and**

Sugiura discloses this element. Ex.1003, ¶177. As shown in annotated Figure 4 below, Sugiura discloses that the light emitting layer (i.e., "organic functional layer") is located between the positive electrode (i.e., "first electrode") and a negative electrode (i.e., "second electrode"). Sugiura, [0062].



Sugiura, Fig. 4 (annotated).

- f. **Element 1[e]: 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**

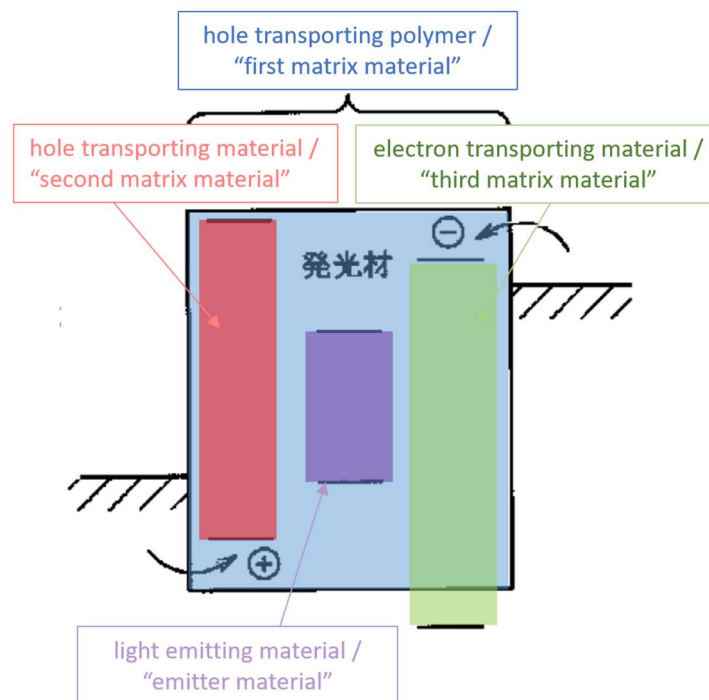
Sugiura discloses this element. Ex.1003, ¶¶178-182. For example, Sugiura discloses the following regarding the OLED shown in Figure 4:

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 5.4 eV. The mixing ratio of each material was: PVK:Alq₃:TPD:Nile Red = 100:60:80:0.2 (weight ratio).

Sugiura, [0062] (emphasis added) (referring to Figure 4 above). Here, polymer PVK is the claimed “first matrix material,” the hole transport material TPD is the claimed “second matrix material,” and the electron transport material Alq₃ is the claimed “third matrix material.” Ex.1003, ¶179.

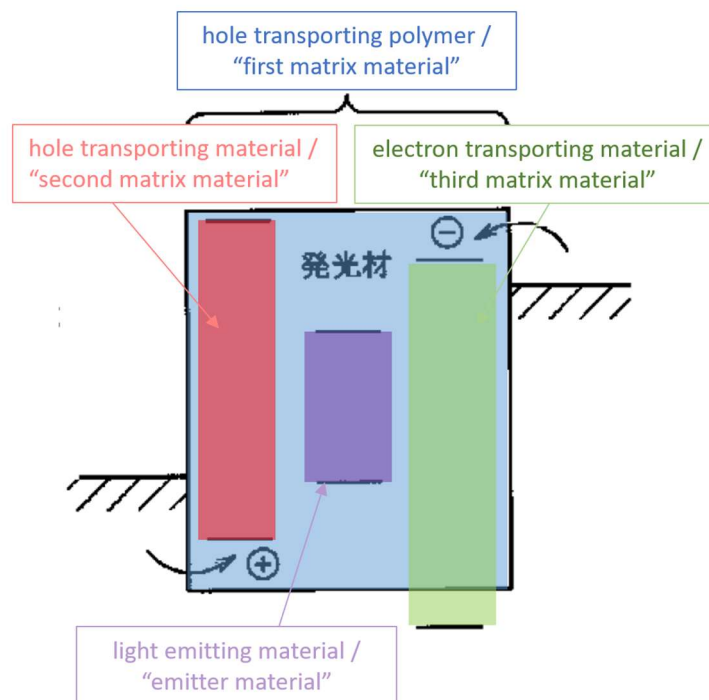
Sugiura further discloses “FIG. 8[,] [which] is an energy diagram of an organic light-emitting device having the configuration: positive electrode / light-emitting layer (hole transporting polymer + hole transporting material + electron transporting material + light-emitting material) / negative electrode.” Sugiura, [0049] (emphasis added).



Sugiura, Fig. 8 (annotated). *See* Ex.1003, ¶180. Sugiura's light-emitting layer (i.e., "organic functional layer") has a hole transporting polymer (i.e., "first matrix material"), a hole transporting material (i.e., "second matrix material"), and an electron transporting material (i.e., "third matrix material"). Sugiura, [0049].

- g. Element 1[f]: 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**

Sugiura discloses this element. Ex.1003, ¶¶183-185. For example, Sugiura discloses "FIG. 8[,] [which] 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." Sugiura, [0049] (emphasis added).

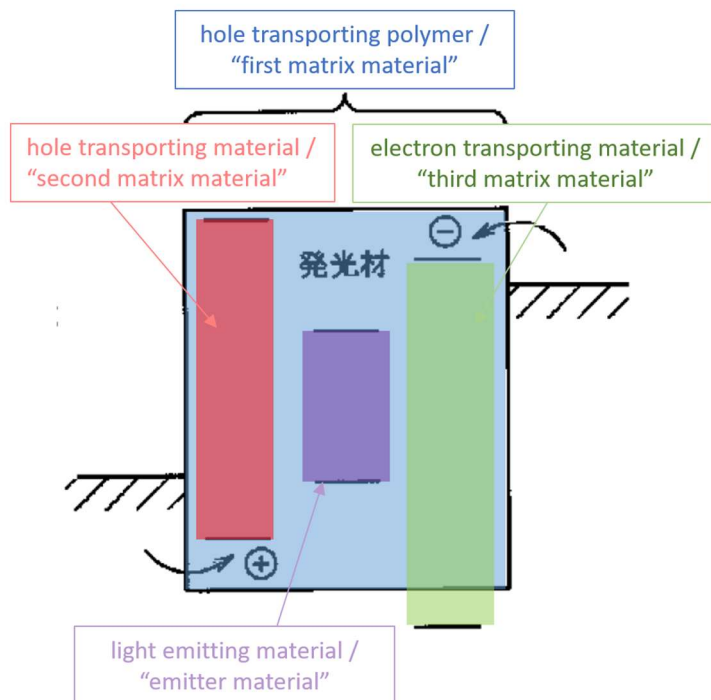


Sugiura, Fig. 8 (annotated). As seen in annotated Figure 8, the top line representing the LUMO for the third matrix material (green) is located below both the top line for the second matrix material (red) and the top of the rectangle for the first matrix material (blue). See Ex.1003, ¶184. Thus, Sugiura discloses that the third matrix material has a LUMO value that is energetically lower than those of the second matrix material and the first matrix material.

- h. **Element 1[g]: 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,**

Sugiura discloses this element. Ex.1003, ¶¶186-188. As seen in annotated Figure 8, the bottom line representing the HOMO for the second matrix material

(red) is located above both the bottom of the rectangle for the first matrix material (blue) and the bottom line for the third matrix material (green). Ex.1003, ¶187. Thus, Sugiura discloses that the second matrix material has a HOMO value that is energetically higher than those of the first matrix material and the third matrix material.

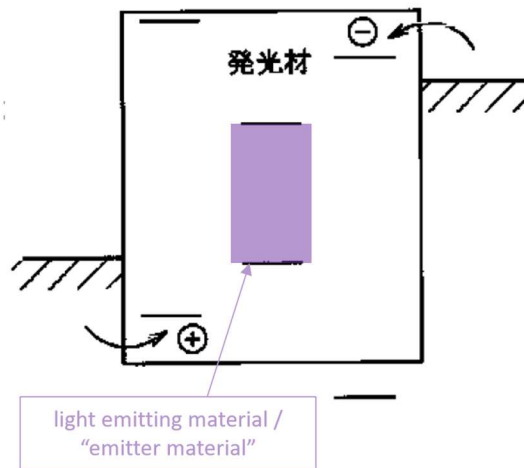


Sugiura, Fig. 8 (annotated).

- i. **Element 1[h]: wherein the organic functional layer is an emission layer and is doped with at least one emitter material.**

Sugiura discloses this element. Ex.1003, ¶¶189-191. As discussed in §VIII.C.1.d above regarding element 1[c], Sugiura's light emitting layer is an "organic functional layer." Sugiura further discloses that that this light emitting layer

includes a “light-emitting material.” Sugiura, [0049]. Sugiura further discloses that “[f]or 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 “Nile Red” may be used. Sugiura, [0041]. The energy diagram shown in Figure 8 (annotated) below illustrates the energy levels of the light-emitting material.

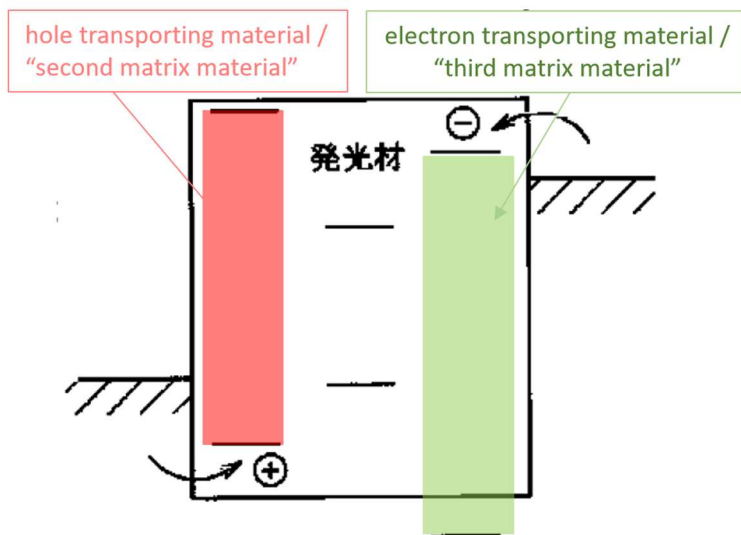


Sugiura, Fig. 8 (annotated).

Sugiura discloses doping the light-emitting layer with the light-emitting material Nile Red. Sugiura, [0062] (“light emitting layer was formed by dissolving PVK 300 mg, Alq3 180 mg, TPD 240 mg, and Nile Red 0.6 mg in 50 ml of a mixed solvent of toluene and chloroform 1:1 and stirring for 1 day.”) (emphasis added). Thus, Sugiura’s light-emitting layer is doped with at least one light-emitting material. *See* Ex.1003, ¶190.

- 2. Dependent Claim 3: The electronic device according to claim 1, wherein the second matrix material has a LUMO which is energetically higher than the LUMO of the third matrix material and a HOMO which is energetically higher than the HOMO of the third matrix material.**

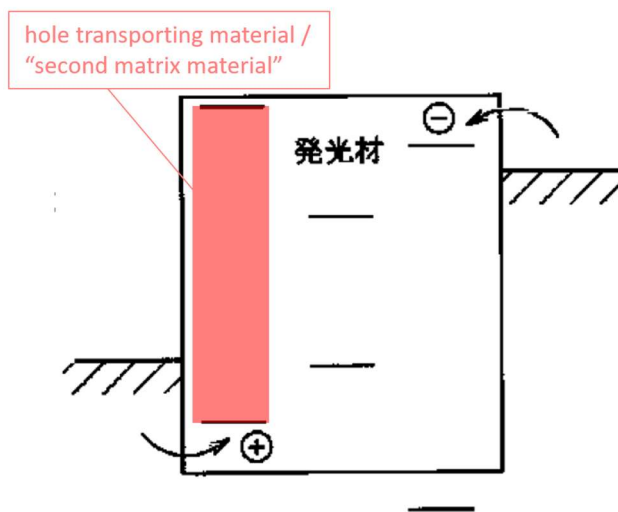
Sugiura discloses this claim. Ex.1003, ¶¶192-193. As seen in annotated Figure 8 below, the top line representing the LUMO for the second matrix material (red) is located above the top line for the third matrix material (green), and the bottom line representing the HOMO for the second matrix material (red) is also located above the bottom line for the third matrix material (green). Ex.1003, ¶192. Thus, Sugiura discloses that the second matrix material has a LUMO value that is energetically higher than that of the third matrix material, and a HOMO value that is energetically higher than that of the third matrix material.



Sugiura, Fig. 8 (annotated).

3. Dependent Claim 5: The electronic device according to claim 1, wherein the second matrix material comprises a hole transport material.

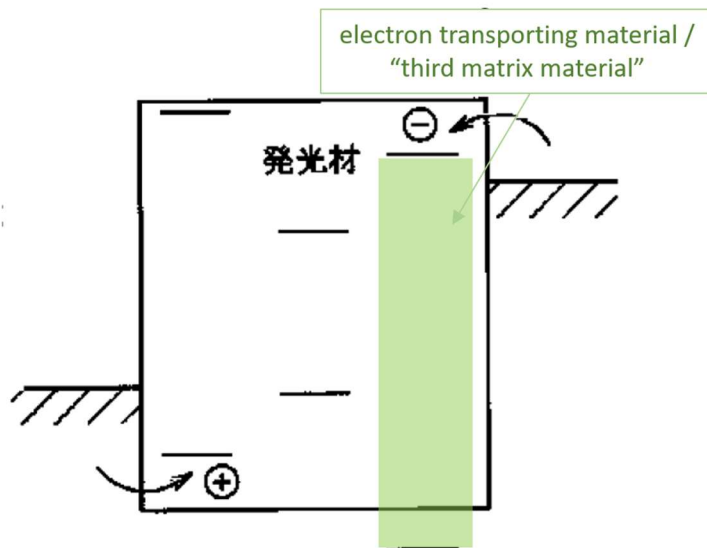
Sugiura discloses this claim. Ex.1003, ¶¶194-195. For example, as shown in the annotated Figure 8 below, Sugiura's second matrix material is a hole transporting material.



Sugiura, Fig. 8 (annotated); *see also* Sugiura, [0049] (“FIG. 8[,] [which] is an energy diagram of an organic light-emitting device having...[a] light-emitting layer (hole transporting polymer + hole transporting material + electron transporting material + light-emitting material)”) (emphasis added). *See* Ex.1003, ¶194. The plus sign represents a hole and the arrow next to it represents transport. Ex.1003, ¶194. In an embodiment, “N,N’-diphenyl-N,N’-bis(3-methylphenyl)-1,1’-biphenyl-4,4’-diamine (TPD) was used for the hole transporting material 3D.” Sugiura, [0062].

4. Dependent Claim 6: The electronic device according to claim 1 wherein the third matrix material comprises an electron transport material.

Sugiura discloses this claim. Ex.1003, ¶¶196-197. As shown in the annotated Figure 8 below, Sugiura's third matrix material is an electron transporting material.



Sugiura, Fig. 8 (annotated); *see also* Sugiura, [0049] (“FIG. 8[,] [which] is an energy diagram of an organic light-emitting device having...[an] electron transporting material”) (emphasis added). *See* Ex.1003, ¶196. The minus sign represents an electron and the arrow next to it represents transport. Ex.1003, ¶196. In an embodiment, “Alq3 was used for the electron transporting material 3E.” Sugiura, [0062].

- 5. Dependent Claim 7: The electronic device according to claim 1, wherein the organic functional layer is selected from a group which comprises emission layers, electron transport layers, hole transport layers, electron blocking layers, hole blocking layers, hole injection layers, electron injection layers, and intermediate layers.**

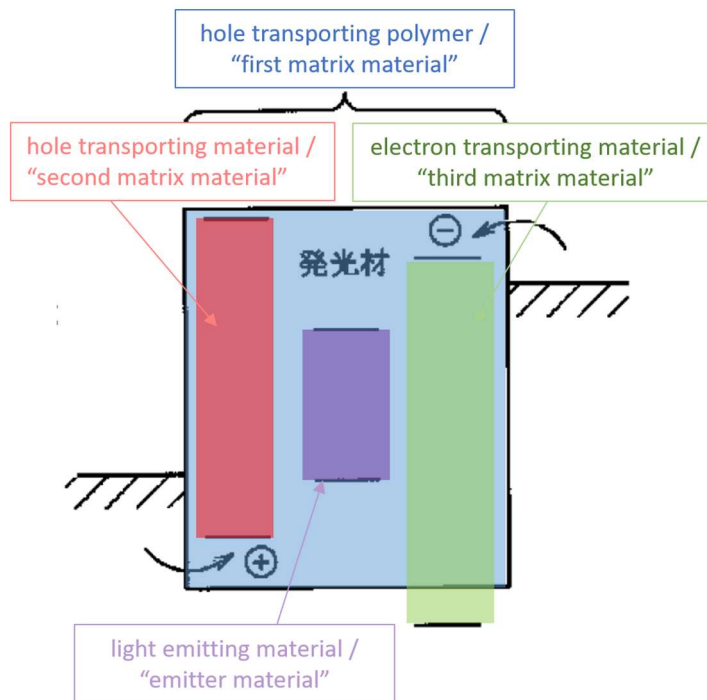
Sugiura discloses this claim. Ex.1003, ¶¶198-199. As discussed in §VIII.C.1.d regarding element 1[c], Sugiura discloses a light emitting layer, which is the “organic functional layer.” Sugiura, [0062]. Sugiura therefore discloses that its “organic functional layer” can be selected from a group comprising, *inter alia*, “emission layers” (i.e., Sugiura’s “light-emitting layer”).

- 6. Dependent Claim 8: The electronic device according to claim 1, wherein the emitter material in the emission layer has a concentration of ≤ 10 wt %.**

Sugiura discloses this claim. Ex.1003, ¶¶200-201. For example, Sugiura discloses that its “light-emitting layer” can include “PVK...[as] the polymer 3A, N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD)...[as] the hole transporting material 3D, Alq3...[as] the electron transporting material 3E, and Nile Red...[as] the light-emitting material 3C.” Sugiura, [0062]. Sugiura discloses that “[t]he mixing ratio of each material was: PVK:Alq3:TPD:Nile Red = 100:60:80:0.2 (weight ratio),” where Nile Red is the emitter material in the emission layer. Sugiura, [0062] (emphasis added). Thus, Sugiura’s emitter material (Nile Red) concentration in the emission layer is $0.2/(100+60+80+0.2)*100$, which is 0.08 wt% and less than 10 wt%. Ex.1003, ¶200

- 7. Dependent Claim 10: The electronic device according to claim 1, wherein the LUMO of the emitter material is energetically lower than the LUMO of the first, second, and third matrix materials, and the HOMO of the emitter material is energetically higher than the HOMO of the first, second, and third matrix materials.**

Sugiura discloses this claim. Ex.1003, ¶¶202-204. As seen in annotated Figure 8 below, the top line representing the LUMO for the emitter material (purple) is located below the top of the rectangle for the first matrix material (blue) and below the top lines for the second and third matrix materials (red and green). Ex.1003, ¶202. In addition, the bottom line representing the HOMO for the emitter material (purple) is located above the bottom of the rectangle for the first matrix material (blue) and above the bottom lines for the second and third matrix materials (red and green, respectively). Ex.1003, ¶202. Thus, Sugiura discloses that the emitter material has a LUMO value that is energetically lower than those of the first, second, and third matrix materials, and a HOMO value that is energetically higher than those of the first, second, and third matrix materials. *See* Ex.1003, ¶203.



Sugiura, Fig. 8 (annotated).

8. Dependent Claim 11: The electronic device according to claim 1, which is constructed as a radiation-emitting device.

Sugiura discloses this claim. Ex.1003, ¶¶205-206. For example, Sugiura discloses an “organic light emitting device” wherein “[h]oles and electrons are recombined in the light emitting layer, and in response to this, fluorescence or phosphorescence is emitted.” Sugiura, [0042]. The OLED device disclosed in Sugiura is therefore “a radiation-emitting device.” Ex.1003, ¶205.

- 9. Dependent Claim 12: The electronic device according to claim 1 wherein the device is selected from a group which comprises an organic light-emitting device, a solar cell, and a transistor.**

Sugiura discloses this claim. Ex.1003, ¶¶207-208. Sugiura's "present invention relates to an organic light emitting device used for a flat light source or a flat panel display." Sugiura, [0001] (emphasis added).

10. Dependent Claim 13

- a. Preamble: A method for the production of an electronic device according to claim 1, comprising the steps of:**

To the extent the preamble is limiting, Sugiura discloses it. Ex.1003, ¶¶209-211. For example, Sugiura explains how an "organic light-emitting device having the configuration in FIG. 4 was fabricated and evaluated." Sugiura, [0062] (emphasis added).

- b. Element 13[a]: A) preparation of a substrate;**

Sugiura discloses this element. Ex.1003, ¶¶212-213. For example, Sugiura discloses that an "organic light-emitting device having the configuration in FIG. 4 was fabricated and evaluated" such that "substrate 1, the positive electrode 2, and the negative electrode 4 had the same configuration and thickness as in Example 1." Sugiura, [0062] (emphasis added). Sugiura also discloses that "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

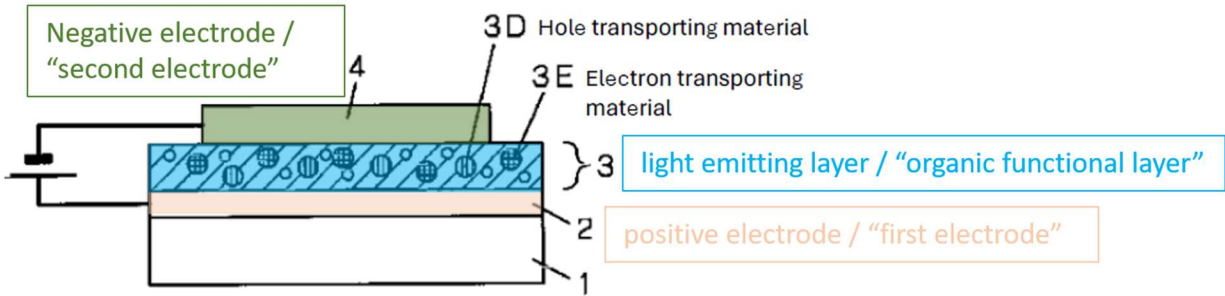
polycarbonate, polymethyl methacrylate, or polyethylene terephthalate, or a non-transparent substrate such as silicon.” Sugiura, [0039]; Ex.1003, ¶212.

c. Element 13[b]: B) preparation of a first electrode and a second electrode; and

Sugiura discloses this element. Ex.1003, ¶¶214-215. For example Sugiura discloses that an “organic light-emitting device having the configuration in FIG. 4 was fabricated and evaluated” such that “substrate 1, the positive electrode 2, and the negative electrode 4 had the same configuration and thickness as in Example 1.” Sugiura, [0062] (emphasis added). Sugiura further discloses that “[a]t least one of the positive electrode 2 and the negative electrode 4 must be transparent or semi-transparent.” Sugiura, [0040].

d. Element 13[c]: C) placement of at least one organic functional layer between the first electrode and the second electrode,

Sugiura discloses this element. Ex.1003, ¶¶216-217. As discussed in §VIII.C.1.d regarding element 1[c], Sugiura discloses a light emitting layer, which is the “organic functional layer.” Sugiura, [0062]. As depicted in annotated Figure 4 below, Sugiura discloses that the light emitting layer (i.e., “organic functional layer”) is located between the positive electrode (i.e., “first electrode”) and a negative electrode (i.e., “second electrode”). Sugiura, [0062].



Sugiura, Fig. 4 (annotated).

- e. **Element 13[d]: wherein in method step C), at least the first matrix material, the second matrix material, and the third matrix material are simultaneously applied.**

Sugiura discloses this element. Ex.1003, ¶¶218-219. For example, Sugiura discloses that “[t]he light-emitting layer was formed by dissolving 300 mg of PVK, 180 mg of Alq3, 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” Sugiura, [0062]. A POSITA would understand that when the matrix materials in the emissive layer are “formed by dissolving” the materials in “a mixed solvent” which is applied via “spin-coating,” the matrix materials are “simultaneously applied.” Ex.1003, ¶218. The solution resulting from dissolving the matrix materials contains all three matrix materials, and spin-coating using the solution deposits the three materials simultaneously. Ex.1003, ¶218.

D. Ground IV: Claims 15-16 Are Anticipated By Or At A Minimum Rendered Obvious By Thompson

Thompson anticipates all of the elements of claims 15-16 of the '164 patent, as discussed below. Ex.1003, ¶¶220-258. Moreover, to the extent there is any question whether Thompson anticipates any element of claims 15-16 of the '164 patent, the element or claim would have been obvious based on Thompson for substantially similar reasons. Ex.1003, ¶¶220-258. That is, to the extent any limitation is not disclosed by Thompson, it would have been strongly suggested to a POSITA for the same reasons discussed in Ground IV below for that limitation. Further, given the identical arrangement in Thompson of each disclosed or suggested element, as articulated in Ground IV below, a POSITA would have been motivated to arrive at the claims as a whole based on Thompson's disclosure and the knowledge of a POSITA.

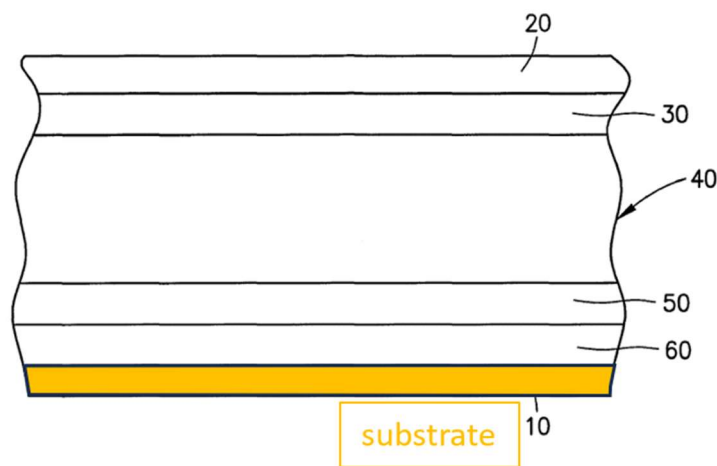
1. Independent Claim 15

a. Preamble: An electronic device, comprising:

To the extent the preamble is limiting, Thompson discloses it. Ex.1003, ¶¶221-223. For example, Thompson discusses "[o]rganic light emitting devices (OLEDs), which make use of thin film materials that emit light when excited by electric current." Thompson, [0002]; Ex.1003, ¶222.

b. Element 15[a]: a substrate;

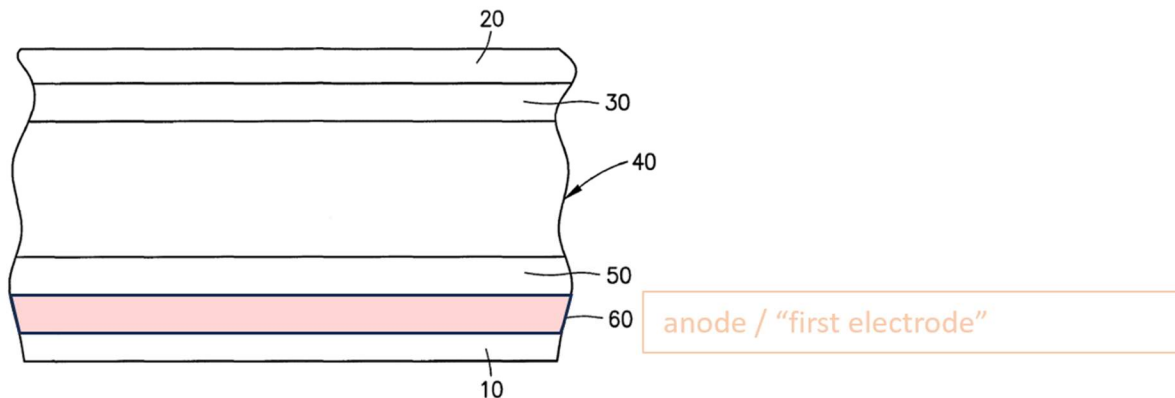
Thompson discloses this element. Ex.1003, ¶¶224-225. Thompson discloses an electronic device possessing a substrate: “An embodiment of an OLED structure according to the invention is described with reference to Figure 1. The device can be manufactured, for example, by forming the various layers on a substrate 10....” Thompson, [0033] (emphasis added).



Thompson, Fig. 1 (annotated).

c. Element 15[b]: a first electrode;

Thompson discloses this element. Ex.1003, ¶¶226-227. Thompson discloses that “[a] substrate 10 is first formed, on which an anode layer 60 connected to a positive power supply is formed,” Thompson, [0034] (emphasis added) (referring to Figure 1 below), where the anode can function as “a first electrode.”



Thompson, Fig. 1 (annotated).

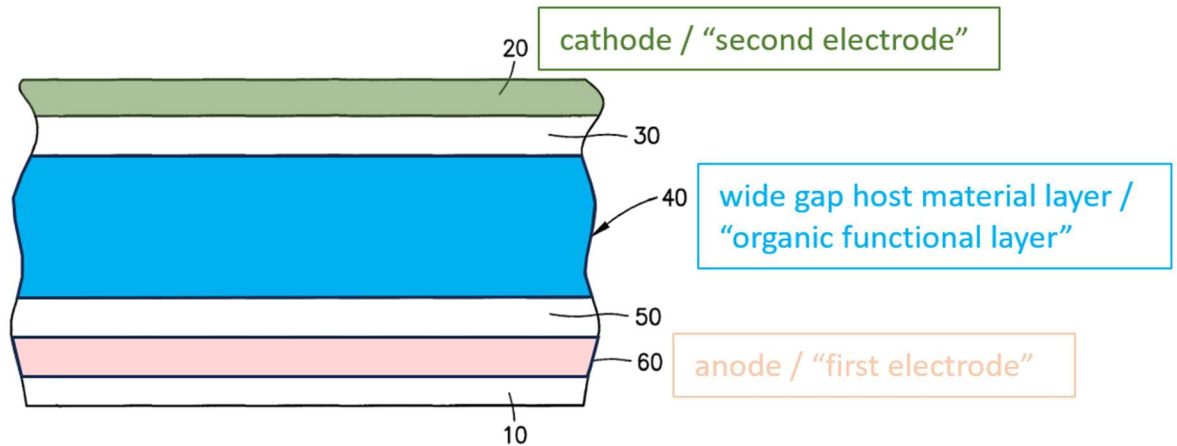
**d. Element 15[c]: at least one organic functional layer;
and**

Thompson discloses this element. Ex.1003, ¶¶228-229. Thompson discloses that its “preferred embodiments of the present invention are directed toward OLEDs containing a single, emissive, organic layer.” Thompson, [0032] (emphasis added). Thompson’s emissive layer is an “organic functional layer.” Ex.1003, ¶228; ’164 patent at 3:61-63 (“The organic functional layer can be an emission layer and be doped with at least one emitter material.”).

e. Element 15[d]: a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and

Thompson discloses this element. Ex.1003, ¶¶230-231. Thompson discloses embodiments where its “OLEDs contain[] a single, emissive, organic layer...with one interface in direct contact with an anode and the opposite interface in direct contact with a cathode.” Thompson, [0032] (emphasis added). As further illustrated in Figure 1: “A substrate 10 is first formed, on which an anode layer 60 [i.e., “first

electrode”] connected to a positive power supply is formed....A wide gap host material layer 40 [i.e., “organic functional layer”] is formed...[which] defines the emissive region of the OLED...followed by a conventional cathode layer 20 [i.e., “second electrode”] connected to a negative power supply.” Thompson, [0034].



Thompson, Fig. 1 (annotated). See Ex.1003, ¶230.

- f. **Element 15[e]: 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**

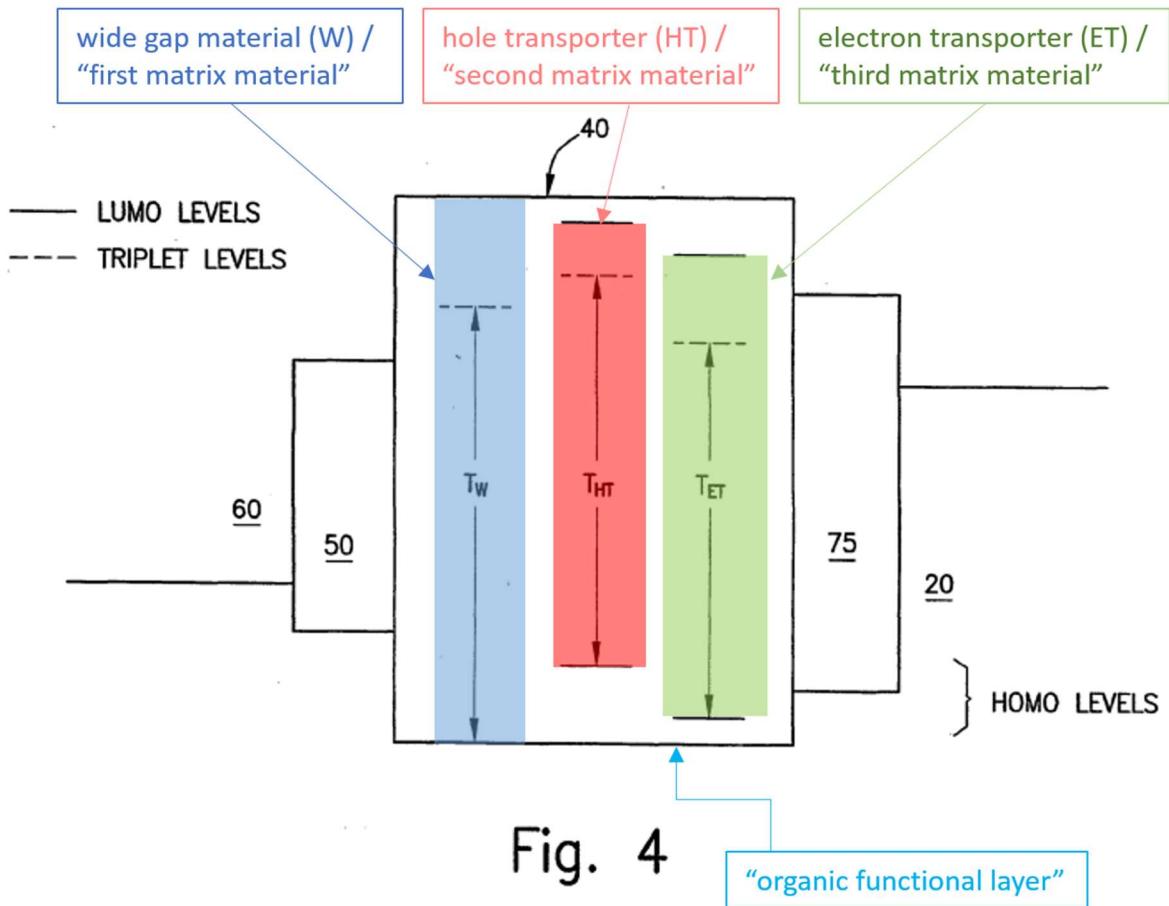
Thompson discloses this element. Ex.1003, ¶¶232-235. The invention in

Thompson is directed to:

[A]n OLED, and to methods of preparing the same, in which the he emissive layer comprises a wide gap host material doped with both a charge carrying dopant material and a phosphorescent dopant material. The charge carrying dopant material is capable of transporting a hole or an electron, and the phosphorescent dopant material is capable of transporting a charge opposite to the charge carried by the charge carrying dopant material. Each dopant material, thus, carries charge, though of opposite polarity. The charge carrying phosphorescent

material also performs the function of emitting the phosphorescent radiation.

Thompson, [0008] (emphasis added). Thompson's "wide gap host material" is the claimed "first matrix material." Each of Thompson's "charge carrying dopant material [that] is capable of transporting a hole or an electron" and "phosphorescent dopant material [that] is capable of transporting a charge opposite to the charge carried by the charge carrying dopant material" can be the claimed "second matrix material" or "third matrix material." Ex.1003, ¶234. Thompson's Figure 4 illustrates the energy levels of the first, second, and third matrix materials taught by Thompson, where "T indicates triplet energy, and the subscripts indicate the wide gap material (W) the electron transporter (ET) and hole transporter (HT)." Thompson, [0040]. Thompson also adds that the "HOMO-LUMO energy gap of the inert host material layer 40...is greater than the energy gap of both the hole and electron transporters." Thompson, [0042]. Thompson's Figure 4 is reproduced below with annotations identifying the first matrix material (wide gap host material "W"), second matrix material (hole transporter "HT"), and third matrix material (electron transporter "ET").



Thompson, Fig. 4 (annotated).

- g. **Element 15[f]: 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**

Thompson discloses this element. Ex.1003, ¶¶236-238. For example, in Thompson, "Figure 4 shows the energy levels of the materials forming an OLED device according to the invention." Thompson, [0039].

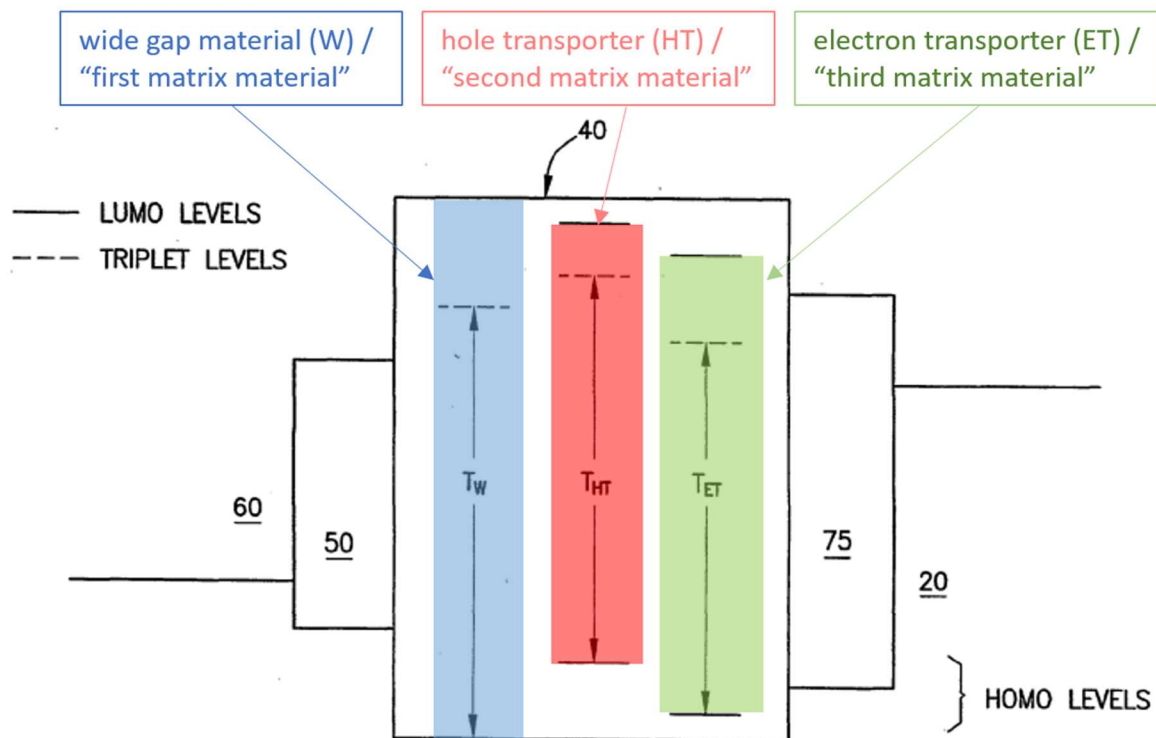


Fig. 4

Thompson, Fig. 4 (annotated). As seen in annotated Figure 4, the top line representing the LUMO for the third matrix material (green) is located below both the top line for the second matrix material (red) and the top of the rectangle for the first matrix material (blue). Ex.1003, ¶237. As such, Thompson's third matrix material (electron transporter "ET") has a LUMO which is energetically lower than the LUMO of the second matrix material (hole transporter "HT") and the LUMO of the first matrix material (wide gap host material "W").

- h. Element 15[g]: 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,**

Thompson discloses this element. Ex.1003, ¶¶239-241. As seen in annotated Figure 4, the bottom line representing the HOMO for the second matrix material (red) is located above both the bottom of the rectangle for the first matrix material (blue) and the bottom line for the third matrix material (green). As such, Thompson's second matrix material (hole transporting "HT") has a HOMO that is energetically higher than the HOMOs of the first matrix material (wide gap host material "W") and the third matrix material (electron transporting "ET"). *See* Ex.1003, ¶240.

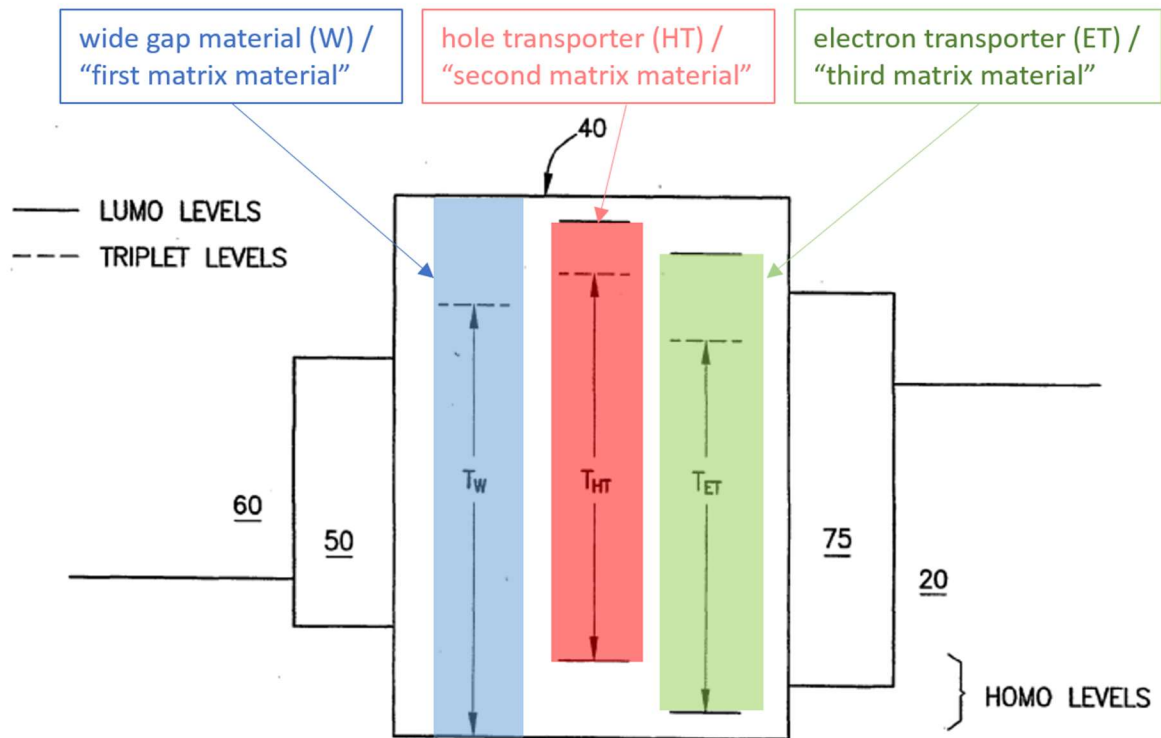


Fig. 4

Thompson, Fig. 4 (annotated).

- i. **Element 15[h]:** wherein the first matrix material [sic] has a LUMO which is energetically higher than the LUMO of the second matrix material and the LUMO of the third matrix material, and a HOMO which is energetically lower than the HOMO of the second matrix material and the HOMO of the third matrix material.

Thompson discloses this element. Ex.1003, ¶¶242-246. As seen in annotated Figure 4, the top of the rectangle representing the LUMO for the first matrix material (blue) is located above the top lines for the second and third matrix materials (red and green, respectively), and the bottom of the rectangle representing the HOMO

for the first matrix material (blue) is located below the bottom lines for the second and third matrix materials (red and green, respectively). Ex.1003, ¶243.

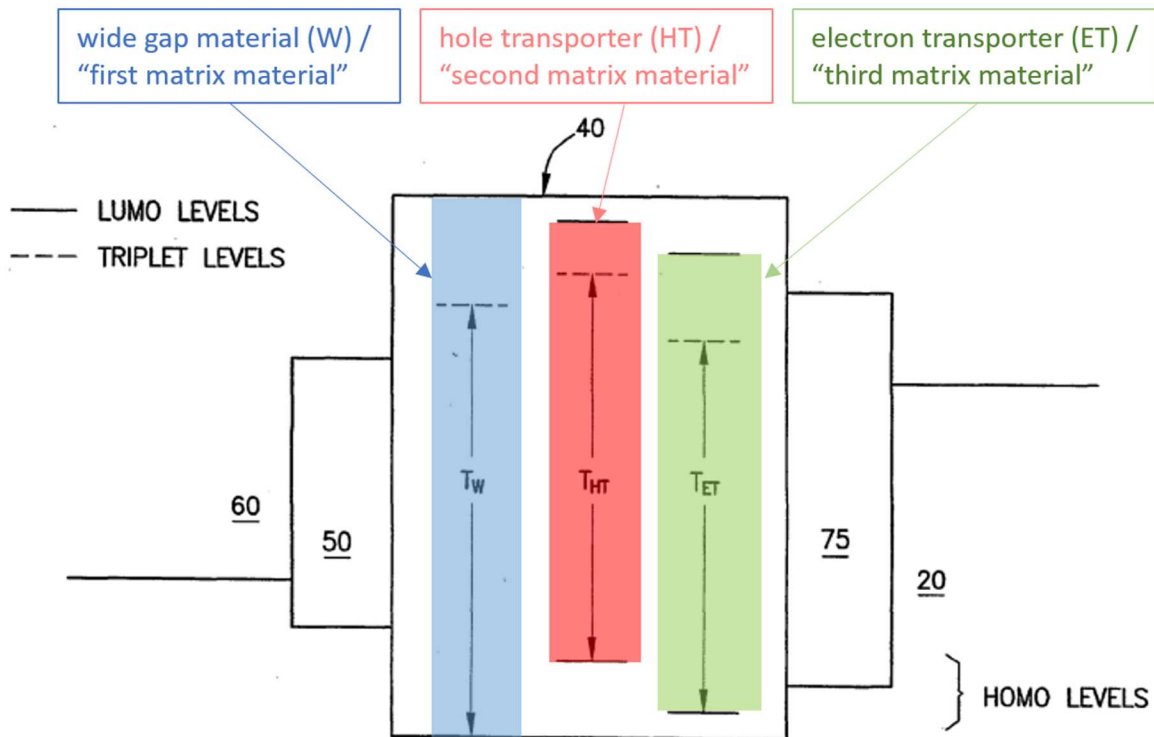


Fig. 4

Thompson, Fig. 4 (annotated).

Thompson further explains that “the HOMO level of the inert host material is lower than the HOMO level of any of the dopant materials” and “the LUMO level of the inert host material is higher than the LUMO level of any of the dopant materials.” Thompson, [0042] (emphasis added). Thompson adds that “the constraints on the HOMO and LUMO levels of the inert host material layer 40 relative to the levels of the electron and hole transporter dopants typically result in

an inert host material layer having a wide energy gap between the HOMO and the LUMO energy levels.” Thompson, [0043].

2. Independent Claim 16

a. Preamble: An electronic device, comprising:

To the extent the preamble is limiting, Thompson discloses it. Ex.1003, ¶¶247-248. This element is the same as the preamble of independent claim 15, and Thompson discloses it for the same reasons. *See* §VIII.D.1.a above.

b. Element 16[a]: a substrate;

Thompson discloses this element. Ex.1003, ¶249. This element is the same as independent claim 15[a], and Thompson discloses it for the same reasons. *See* §VIII.D.1.b above.

c. Element 16[b]: a first electrode;

Thompson discloses this element. Ex.1003, ¶250. This element is the same as independent claim 15[b], and Thompson discloses it for the same reasons. *See* §VIII.D.1.c above.

**d. Element 16[c]: at least one organic functional layer;
and**

Thompson discloses this element. Ex.1003, ¶251. This element is the same as independent claim 15[c], and Thompson discloses it for the same reasons. *See* §VIII.D.1.d above.

- e. **Element 16[d]: a second electrode, wherein the at least one organic functional layer is located between the first electrode and the second electrode, and**

Thompson discloses this element. Ex.1003, ¶252. This element is the same as independent claim 15[d], and Thompson discloses it for the same reasons. *See* §VIII.D.1.e above.

- f. **Element 16[e]: 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**

Thompson discloses this element. Ex.1003, ¶253. This element is the same as independent claim 15[e], and Thompson discloses it for the same reasons. *See* §VIII.D.1.f above.

- g. **Element 16[f]: 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**

Thompson discloses this element. Ex.1003, ¶254. This element is the same as independent claim 15[f], and Thompson discloses it for the same reasons. *See* §VIII.D.1.g above.

- h. Element 16[g]: 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,**

Thompson discloses this element. Ex.1003, ¶255. This element is the same as independent claim 15[g], and Thompson discloses it for the same reasons. *See* §VIII.D.1.h above.

- i. Element 16[h]: wherein the first matrix material has a charge carrier mobility which is lower than the charge carrier mobilities of the second and third matrix materials.**

Thompson discloses this element. Ex.1003, ¶¶256-258. Thompson discloses the use of an “inert” host material in an OLED’s emissive layer with “such a large energy gap between the HOMO and LUMO levels of the material that the inert host matrix does not participate in hole or electron transport.” Thompson, [0028] (emphasis added). Indeed, Thompson also discloses that “inert host material layer” typically has “a wide energy gap between the HOMO and the LUMO energy levels.” Thompson, [0043]. Thompson further discloses that the “[w]ide gap host material layer 40 is preferably inert, that is, it preferably does not carry a charge within the structure of the OLED. Accordingly, charge is preferably carried only by the dopants, and not by the wide gap host material layer 40.” Thompson, [0035].

As discussed with respect to claim 15, the inert host material acts as “the first matrix material,” while the hole transporting dopant and electron transporting dopant

act as second and third matrix materials, respectively. *See* §VIII.D.1.f above; *see also* Ex.1003, ¶¶220-245. Thus, the first matrix material, which is “inert,” “does not participate in hole or electron transport,” and “does not function as a charge carrying material” (*see* above), would have a lower charge carrier mobility than that of second matrix material, which acts as a hole transporter, and that of the third matrix material, which acts as an electron transporter. Ex.1003, ¶257.

IX. DISCRETIONARY DENIAL IS INAPPROPRIATE

A. Section 314(a)

The Board should decline to exercise its discretion to deny institution under 35 U.S.C. § 314(a) and *Apple Inc. v. Fintiv, Inc.*, IPR2020-0019, Paper 11 (P.T.A.B. Mar. 20, 2020) (precedential). While the ’164 patent has been asserted in *Pictiva Displays International Ltd. v. Samsung Electronics Co., Ltd., et al.*, Case No. 2:23-cv-00495 (E.D. Texas), that case remains in a very early stage. The ’164 patent was first asserted on March 1, 2024. Ex.1028. Infringement contentions were served on March 11, 2024. Invalidity contentions were served on June 10, 2024. The court issued its initial scheduling order on April 17, 2024, scheduling a trial for August 2025. *See* Ex.1026.

Accordingly, the parties have made no material investments in the parallel litigation. Discovery is still in its early stages (with the deadline for fact discovery being March 10, 2025), and the claim construction process has not even begun (the

parties will not exchange their proposed claim terms for construction until October 1, 2024). Additionally, this Petition is being filed just three and a half months after service of infringement contentions, demonstrating that Petitioner has acted with diligence in preparing its patent challenge. Finally, Patent Owner will need to narrow the asserted claims in advance of any trial, *see* Ex.1026 at 1, so a trial could not resolve all of Petitioner’s claim challenges. Discretionary denial is further inappropriate because this Petition presents compelling evidence of unpatentability, for the reasons discussed in Section VIII, above.

B. Section 325(d)

The Board should likewise not deny institution under §325(d) and *Advanced Bionics, LLC v. Med-El Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 at 8 (P.T.A.B. Feb. 13, 2020) (precedential).

In applying *Advanced Bionics*, the Board considers the “*Becton, Dickinson*” factors, *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 (P.T.A.B. Dec. 15, 2017) (precedential as to § III.C.5, first paragraph). “[I]f the record of the Office’s previous consideration of the art is not well developed or silent, then a petitioner may show the Office erred by overlooking something persuasive.” *Advanced Bionics*, IPR2019-01469 at 10. “An example of a material error may include misapprehending or overlooking specific teachings of the relevant

prior art where those teachings impact patentability of the challenged claims.” *Id.* at 8, n.9.

Here, none of the prior art references asserted in this Petition were substantively considered by the Examiner during prosecution. Choulis, Sugiura, and Yong were not of record during prosecution. Thompson (“Thompson WO”) (and not Thompson (Ex.1007)) was cited in an IDS during prosecution, but the Examiner did not rely on Thompson WO to reject any claims and thus did not meaningfully address Thompson WO. Furthermore, the Examiner erred by overlooking or not appreciating Thompson WO’s materiality to the challenged claims, as described above. *See STMicroelectronics, Inc. v. Trustees of Purdue Univ.*, IPR2022-00309, Paper 14 at 12-13 (P.T.A.B. July 6, 2022) (finding that petitioner demonstrated examiner erred by not appreciating that IDS reference disclosed features recited in the challenged claims). Discretionary denial under §325(d) is not warranted here.

X. CONCLUSION

Petitioner respectfully requests *inter partes* review and cancellation of claims 1-16 of the ’164 patent.

Date: June 28, 2024

Respectfully submitted,

By /Scott C. Weidenfeller/
Scott C. Weidenfeller
Registration No.: 54,531

Petition for *Inter Partes* Review of U.S. Patent No. 8,723,164

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CERTIFICATION UNDER 37 C.F.R. § 42.24(D)

I certify that the foregoing complies with the type-volume limitation of 37 C.F.R. § 42.24 and contains 13,559 words based on the word count indicated by the word-processing system used to prepare the paper, and excluding those portions exempted by § 42.24(a).

Date: June 28, 2024

/ Scott C. Weidenfeller /
Scott C. Weidenfeller (Reg. No. 54,531)

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6 and 42.105, I hereby certify that on June 28, 2024, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No.8,723,164, supporting exhibits, and Power of Attorney to be served via Priority Mail Express on the Patent Owner at the following correspondence address of record as listed on the USPTO Patent Center:

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A courtesy copy was also served via electronic mail on Patent Owner's counsel of record in District Court matter:

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Date: June 28, 2024

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