

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

PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE

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EXHIBIT LIST

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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)
1027	Stipulation made by Defendants in <i>Pictiva Displays Int’l Ltd. v. Samsung Elecs. Co.</i> , No. 2:23-cv-0495 (E.D. Tex.)
1028	Curriculum Vitae of Dr. Russell J. Holmes
1029	Hyun S. Byun Declaration
1030	Memorandum Claim Construction Opinion And Order, in <i>Pictiva Displays Int’l Ltd. v. Samsung Elecs. Co.</i> , No. 2:23-cv-0495 (ECF 397) (E.D. Tex. June 27, 2025)
1031	Yuichiro Kawamura et al., <i>Intermolecular Interaction and a Concentrations-Quenching Mechanism of Phosphorescent Ir(III) Complexes in a Solid Film</i> , 96 Physical Rev. Letters 017404 (2006)

Exhibit No.	Description
1032	Sebastian Reinecke, <i>Highly Phosphorescent Organic Mixed Films: The Effect of Aggregation on Triplet-Triplet Annihilation</i> , 94 Appl. Phys. Lett. 163305 (2009)
1033	Zhenzhen Li et al., <i>Pure-blue Fluorescent Organic Light-Emitting Diodes by Co-Doping a Supplementary Host Material Into a Light-Emitting Layer as an Electron Transport Ladder</i> , 8 J. Mater. Chem. C 3438 (2020)
1034	Junji Kido et al., <i>Organic Electroluminescent Devices Based on Molecularly Doped Polymers</i> , 61 Appl. Phys. Lett. 761 (1992)
1035	Dongge Ma et al., <i>Bright Blue Electroluminescent Devices Utilizing Poly (N-vinylcarbazole) Doped With Fluorescent Dye</i> , 91 Synthetic Metals 331 (1997)
1036	Kenichi Goushi et al., <i>Unusual Phosphorescence Characteristics of Ir(ppy)₃ in a Solid Matrix at Low Temperatures</i> , 43 Jap. J. Appl. Phys. L937 (2004)
1037	Y. Kawabe and J. Abe, <i>Electron Mobility Measurement Using Exciplex-Type Organic Light-Emitting Diodes</i> , 81 Appl. Phys. Lett. 493 (2002)
1038	Tsung-Syun Huang et al., <i>Study of Organic Thin Film Transistor with Polymethylmethacrylate as a Dielectric Layer</i> , 91 Appl. Phys. Lett. 092116 (2007)
1039	Hsin-Hua Chang et al., <i>Graded Doping Profiles for Reduction of Carrier Trapping in Organic Light-Emitting Devices Incorporating Dropped Polymers</i> , 78 Appl. Phys. Lett. 574 (2001)
1040	Chung-Chih Wu et al., <i>Finite-Source Dye-Diffusion Thermal Transfer for Doping and Color Integration of Organic Light-Emitting Devices</i> , 77 Appl. Phys. Lett. 794 (2000)
1041	E.H. Martin and J. Hirsch, <i>Determination of Carrier Mobility in Plastics by a Time-Of-Flight Method</i> , 7 Solid State Communications 783 (1969)
1042	Noriyuki Matsusue et al., <i>Charge Carrier Transport in Neat Thin Films of Phosphorescent Iridium Complexes</i> , 44 Jap. J. Appl. Phys. 3691 (2005)
1043	Deposition Transcript of Dr. Marc Sims, taken July 31, 2025
1044	Reply Declaration of Dr. Russell Holmes

I. Introduction

The Board should dismiss Patent Owner's (PO) arguments, as they largely reiterate arguments that have already been rejected by the Board.

II. Claim Construction

The Board appropriately interpreted the term “matrix material” to include “not only materials that form a continuous phase but also materials embedded within such a matrix.” Paper 11 (“DI”), page 29. In doing so, the Board rejected the PO's argument that “matrix material” must be present “in sufficient amounts to form a continuous phase in which other materials can be embedded” and that “materials described as doped or embedded into another material are not matrix materials.” DI 22. Despite this, PO maintains that a “dopant” or “dispersed agglomerations”¹ do not qualify as “matrix materials.” POR 8-25. The Board should reject these arguments for the same reasons outlined in its DI, and as further discussed below. Ex.1044, ¶2.

A. Intrinsic evidence contradicts PO's arguments

As noted by the Board, “no words in claim 1 limit a ‘matrix material’ to the meaning advanced by Patent Owner.” DI at 24. “Claim 1 recites first, second, and third matrix materials but, aside from reciting relationships between the LUMOs and HOMOs of the matrix material, does not require any particular composition or any

¹ PO uses the term “dispersed agglomerations” to refer to dopants. POR 5.

particular amount for any of the three matrix materials.” DI 24. “Nor does claim 1 recite that any of the matrix materials must be present in a continuous phase.” DI 24. Rather, claim 1 simply requires that the same organic functional layer contains first, second, and third matrix materials with a specific relative alignment of the HOMO and LUMO levels.² Ex.1001, 9:8-20; Ex.1044, ¶3.

Consistent with this understanding, Judge Gilstrap, in a co-pending district court case, denied the Patent Owner’s request to define the term “matrix material” as “a material that forms a continuous phase.” Ex.1030, 32-35. Instead, Judge Gilstrap construed “matrix material” as “The first, second, and third matrix materials are different materials and are part of the same matrix.” Ex.1030, 50.

The specification supports the Board’s and Judge Gilstrap’s interpretation of the term “matrix material.” Ex.1044, ¶5. The Summary of the Invention indicates that each organic functional layer includes a matrix with a first, second, and third matrix materials but does not mandate that each matrix material exists in a continuous phase, nor does it exclude dopants or dispersed agglomerations from being regarded as matrix materials. Ex.1001, 4:24-26 (“Each of these layers can have

² In this regard, other independent claims resemble claim 1, sharing similar requirements.

a matrix, which has at least a first, a second, and a third matrix material”),³ 2:46-47; *see also id.*, 1:46-48, 4:35-36. During his deposition, PO’s expert, Dr. Sims, affirmed that “BCP [as described in the specification] is *certainly a matrix material*” although he was unable to confirm whether BCP exists in a continuous phase or even a “more or less” continuous phase.⁴ Ex.1043, 43:10-14, 44:2-10; *see also* Ex.1043, 39:16-40:1 (acknowledging that a passage of the specification mentioning BCP provides examples of matrix materials).

Contrary to PO’s assertion, the specification’s description of an emitter material as a dopant does not imply that a matrix material cannot also be a dopant. Ex.1044, ¶6. The specification explicitly describes a matrix material, such as BCP, as a dopant within a matrix composed of BCP, NPB, and UGH4. Ex.1001, 8:56-65; Ex.2020, 23:5-26:7. In his deposition, Dr. Sims concurred that the specification disclosed a matrix composed of matrix materials BCP, NPB, and UGH4, with BCP identified as a dopant. Ex.1043, 42:10-43:24. The term “dopant” simply refers to a component added to a film or functional layer. Ex.1044, ¶6; Ex.2020, 327:17-328:4.

³ All emphasis has been added unless otherwise noted.

⁴ Although Dr. Sims attempted to modify certain elements of his testimony during redirect, this occurred after he had discussed the substance of his testimony with the patent owner’s counsel for nearly an hour and a half. Ex.1044, 102:3-104:24.

As the Board noted, to the extent the '164 patent suggests a distinction between a matrix material and a dopant, any such suggestion is not definitional. DI 24 (citing Ex.1001, 7:12-15).

Without any intrinsic evidence to support its claims, PO incorrectly accuses Petitioner of “treat[ing] any material that happened to be in an emission layer as a matrix material,” effectively reading “matrix” out of “matrix materials,” and giving inconsistent meanings to “matrix” in “matrix materials.” POR 8, 17-19, 23-25. PO’s assertions are meritless. Ex.1044, ¶7. Consistent with the claims and the specification, Petitioner accurately aligned host materials and charge transport materials located within the same matrix to the claimed matrix materials, in accordance with the claims and specification. Paper 1 (“Pet.”) 24-25, 54-56, 72-74. The term “matrix” in “matrix material” indicates that the material is part of the same matrix. *See, e.g.*, Ex.1001, 4:24-26, 2:46-47, Ex.1030, 33, 50.

Contrary to PO’s argument, a POSITA would understand that the claimed organic functional layer comprises “a matrix, which has at least a first, a second, and a third matrix material.” Ex.1001, 4:24-26; Ex.1044, ¶8. During his deposition, Dr. Sims concurred with this understanding. Ex.1043, 38:3-25. PO mistakenly suggests that this statement from the Summary of the Invention is restricted to specific embodiments. The only intrinsic evidence PO cites is from the specification at 1:22-

23, but this passage from the Background of the Invention section merely addresses prior art.

PO improperly claims that the concurrent evaporation of the first, second, and third matrix materials necessarily leads to each material forming a continuous phase, thus implying that the matrix materials described in the claims must be continuous. POR 20. This assertion is flawed, as none of the independent claims require the evaporation method. Only dependent claim 14 requires it. Furthermore, the simultaneous evaporation of various materials does not necessarily cause each to form a continuous phase. Ex.1044, ¶¶9-10 (citing Ex.1001, 7:12-35; Ex.1031, 017404-4; Ex.1032, 163305-1, 163305-3). In his deposition, Dr. Sims conceded that “just because a material was jointly evaporated doesn’t mean that it’s in continuous phase.” Ex.1043, 49:15-19; *see also* Ex.1043, 27:4-9. He further admitted that he is unable to determine whether any of the jointly evaporated matrix materials are in a continuous phase, as he lacks knowledge of the molecular distances of the material. Ex.1043, 33:4-20.

B. Extrinsic evidence cannot be used to contradict the clear meaning derived from intrinsic evidence

PO argues that extrinsic evidence suggests a dopant or dispersed agglomerations do not qualify as matrix materials. However, such extrinsic evidence cannot override the clear interpretation established by intrinsic evidence. *See, e.g., Seabed Geosolutions (US) Inc. v. Magseis FF LLC*, 8 F.4th 1285, 1290 (Fed. Cir.

2021). This principle is particularly relevant in this context, as the term “matrix material” lacks a broadly accepted definition in the OLED field. Ex.1044, ¶11 (citing Ex.2025, 164:16-19).

Moreover, the extrinsic evidence cited by PO does not support the claim that a matrix material cannot encompass a dopant or dispersed agglomerations. Ex.1044, ¶12. PO asserts that the extrinsic evidence indicates the term *matrix* refers to a continuous phase, thereby concluding that the claimed *matrix material* must also be a continuous phase. POR 17. However, as previously discussed, both the claim and the specification demonstrate that the term matrix material refers to a component of a matrix, which need not itself be continuous. Ex.1001, 4:24-26, 2:46-47.

Contrary to PO’s contention, the presence of extrinsic evidence referring to emitters and conductivity materials as dopants does not exclude a dopant from being the claimed matrix material. Ex.1044, ¶13. As previously noted, the term “dopant” merely refers to a component that has been added to a film or functional layer. Ex.1044, ¶13; Ex.2020, 327:17-328:4. Therefore, the ’164 patent also identifies a charge transport matrix material as a dopant. Ex.1001, 8:62-64. Thompson’s mention of a “charge carrying dopant material” is consistent with this usage. Ex.1007, [0025].

The use of the term “host” material in certain references for “matrix” material aligns with the ’164 patent’s use of “matrix material” to encompass host materials.

Ex.1044, ¶14. Additionally, host materials can also be dopants, which further refutes PO's claim that the term matrix material excludes dopants.⁵ Ex.1044, ¶14 (citing Ex.1033, 3438-39, 3444).

Therefore, the Board should dismiss PO's interpretations of "matrix material," as they mistakenly exclude dopants or dispersed agglomerations.

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

As demonstrated in the Petition, Choulis anticipates or at a minimum renders obvious claims 1-8 and 10-16.⁶ Ex.1003, ¶¶72-159; Ex.1044, ¶15.

A. Choulis's TPD and PBD are the claimed matrix materials, along with PVK

As demonstrated in the Petition, and as the Board agreed, Choulis discloses that PVK, TPD, and PBD correspond to the claimed first, second, and third matrix

⁵ Therefore, PO's claim that hosts and dopants are "mutually exclusive terms" is erroneous. POR 16.

⁶ Contrary to PO's assertion, a reference that discloses each limitation of a claim can indeed render it obvious. *See Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1376 (Fed. Cir. 2019); *see also Unification Techs. LLC v. Micron Tech. Inc.*, No. 2023-1348, 2024 WL 3738401, at *6 (Fed. Cir. Aug. 9, 2024). None of the cases cited by PO support a different conclusion.

materials, respectively. Pet. 24-25; DI 32-33; Ex.1044, ¶16. PO does not dispute that PVK is a host material, TPD is a hole transporting material, and PBD is an electron transport material, all residing in the same light emitting layer.⁷ Pet. 24-25, 33-34; POR 26-29. PO also does not dispute that PVK, TPD, and PBD have the HOMO/LUMO levels required by claim 1. The '164 patent explicitly characterizes a hole transport material and an electron transport material, such as those disclosed by Choulis, as matrix materials. Ex.1001, cls. 5-6, 5:34-37. Elsewhere, PO even equates hole and electron transport materials to the second and third matrix materials. POR 38 (“hole and electron transport materials (*i.e.*, second and third matrix materials)”).

While PO argues that TPD and PBD are not matrix materials due to their potential status as dopants, the term “matrix material” indeed includes dopants, as discussed above in Section II. Ex.1044, ¶17. Therefore, contrary to PO’s assertion, Choulis’s description of PVK as a host and TPD and PBD as organic moieties that can be co-doped does not preclude TPD and PBD from being considered matrix materials. In fact, PO itself recognizes that PBD can operate as a matrix material. POR 27-28 (highlighting the use of PBD as a matrix material).

⁷ Contrary to PO’s assertion, Petitioner’s use of the term “matrix” in “matrix material” consistently refers to the matrix of which each matrix material is a part.

PO claims, without substantiation, that TPD cannot qualify as the claimed matrix material because its concentration is 9 wt%. POR 31. However, the '164 patent specification explicitly cites TPD as an exemplary “matrix material.” Ex. 1001, 8:38-50. The '164 patent does not specify any concentration or concentration threshold for TPD, nor does it imply that TPD would no longer be considered a matrix material if its concentration were 9 wt%. Ex.1044, ¶18. As the Board noted, claim 1—and indeed any other independent claim—“does not require any particular composition or any particular amount for any of the three matrix materials.” DI 24 (citing Ex.1001, 9:4-22). Moreover, contrary to PO’s suggestion, Choulis’s teaching regarding TPD is not limited to the singular exemplary embodiment detailed in the “EXAMPLE” section, where TPD is noted as having roughly 9% concentration within the mixture. Ex.1004, [0054]; Ex.1044, ¶19.

Furthermore, since PO does not indicate “the threshold at which a material would have been recognized as, and considered, a matrix material by an ordinarily skilled artisan or how that artisan would determine such a threshold,” accepting PO’s argument could result in indefiniteness concerns. DI 25.

B. Choulis anticipates or at a minimum renders obvious claims 2, 4, and 15-16

As demonstrated in the Petition, Choulis anticipates or at a minimum renders obvious claims 2, 4, and 15-16. Pet. 29-31, 33, 43-48; Ex.1044, ¶21.

Choulis discloses that the light emitting layer can include PVK or, alternatively, PMMA. Ex.1004, [0044]; Ex.1044, ¶22. Specifically, Choulis states, “The light emitting layer can include a host material” and further notes, “The hole [sic] material can be PVK, as described above.” Ex.1004, [0044]. Choulis’s earlier description shows that PVK is a host material in the Figure 4 embodiment. Ex.1004, [0030]. Choulis further teaches that insulated hosts such as PMMA may be used as an alternative. Ex.1004, [0044]. This is a clear teaching of substituting PMMA for PVK. Ex.1044, ¶22; Ex.1003, ¶97. Contrary to PO’s argument, the distinction between PVK being non-insulating and PMMA being insulating does not undermine Choulis’s explicit teaching to use PMMA. Ex.1004, [0044].

Even if Choulis did not explicitly disclose substituting PMMA for PVK (although it indeed does), it would have been obvious to make such a substitution, as shown in the Petition. Pet. 31 (citing Ex.1003, ¶100); Ex.1044, ¶23. A POSITA would recognize that PMMA’s wide energy gap is advantageous for minimizing interference with charge transport in other matrix materials, thereby simplifying device design and optimization. Ex.1044, ¶23; Ex.1003, ¶100. Specifically, a POSITA aiming to minimize or prevent charge transport in the first matrix material would choose a wider energy gap insulating material, like PMMA, in place of PVK, which is a known hole transporter with a narrower energy gap. Ex.1044, ¶23.

PO's assertion that substituting PMMA for PVK would "upset the hole and electron balance," "affect hole-charge recombination," and "degrade the performance of the resulting OLED system," POR 37, overlooks that it would have been a routine task for a POSITA to optimize the composition of each component within the light-emitting layer to achieve the desired charge balance. Ex.1044, ¶24. A POSITA would reasonably expect success in constructing an OLED system based on PMMA, and further in combining PMMA with additional charge transport materials such as TPD. Ex.1044, ¶¶24-30 (citing Ex.1034, 762-63, Fig. 1; Ex.1035, 331-32; Ex.1036, L937-38, Fig. 2; Ex.1017, Fig. 2b).

PO's assertion that some ultra-wide energy gap hosts (UGHs) may participate in charge transport under specific conditions is irrelevant, considering the advantage of *PMMA* in minimizing interference with charge transport.⁸ Ex.1044, ¶31. Similarly, PO's argument concerning the HOMO and LUMO levels of certain UGHs is immaterial, as it is undisputed that PMMA's HOMO and LUMO levels meet the claim requirements.

Faced with Choulis's teachings, PO attempts to shift attention by highlighting *Yang's* focus on PVK. However, Yang's emphasis on PVK does not undermine

⁸ Moreover, contrary to PO's assertion, UGH2 in Ex.1016 "act[s] as an inert host matrix" when in the presence of the emitter. Ex.1016, 3820.

Choulis's teaching to use PMMA. Ex.1044, ¶32. Yang was co-authored by X. H. Yang and D. Neher, neither of whom are inventors of Choulis. Ex.1017. Additionally, Yang does not teach against the use of PMMA. If anything, Yang illustrates how tuning the composition of the hole transporting material TPD in PVK is a standard practice for optimizing device performance (Ex.1017, Table I), and this same approach would be applicable for a device utilizing PMMA. Ex.1044, ¶32.

Furthermore, Petitioner's argument that Choulis does not anticipate or render obvious claims 4 and 16 is incorrect, as it is based on the allegation that Petitioner has not demonstrated PMMA to have a lower charge carrier mobility than TPD and PBD. Ex.1044, ¶33. As discussed in the Petition, Choulis discloses that "insulated matrices" such as PMMA "do[] not have transport properties." Ex.1004, [0044]. PMMA has a lower charge carrier mobility compared to TPD or PBD. Ex.1044, ¶34. TPD and PBD are well-known, frequently used materials for hole and electron transport, with high mobilities of approximately $10^{-3} \text{ cm}^2/\text{Vs}$ and 10^{-5} to $10^{-4} \text{ cm}^2/\text{Vs}$, respectively. Ex.1034, 761; Ex.1037, Fig. 4. Conversely, PMMA is an insulator and dielectric, commonly employed in organic thin-film transistors as an insulating dielectric—an application suitable for a material characterized by high resistivity and low charge carrier mobility. Ex.1044, ¶34 (citing Ex.1038, 092116-1).

C. Choulis anticipates or at a minimum renders obvious claim 10

As demonstrated in the Petition, Choulis anticipates or at a minimum renders obvious claim 10. Pet. 35-37; Ex.1044, ¶35.

Contrary to PO's argument, Choulis discloses that, "[i]n accordance with embodiments of the invention," the light emitting layer may incorporate other electroluminescent small molecules like Ir(ppy)₃ or, alternatively, rubrene. Ex.1004, [0043]. This explicitly teaches the substitution of rubrene for Ir(mppy)₃. Ex.1044, ¶36; Ex.1003, ¶95. A POSITA would recognize that Ir(ppy)₃ and Ir(mppy)₃ possess virtually identical triplet energies. Ex.1044, ¶36 (citing Ex.1036, Fig. 2; Ex.1017, Fig. 2b).

PO's assertion that Choulis's statement—"The first interfacial layer *can* have a LUMO level that is within 0.2 eV ... of a LUMO level ... of the phosphorescent organic material"—undermines this disclosure is incorrect. Ex.1004, [0015]; Ex.1044, ¶37. Choulis merely suggests that the first interfacial layer "can" have a LUMO level difference of 0.2 eV, indicating it is not a mandatory requirement.⁹

⁹ Consistent with this understanding, only Choulis's dependent claim 10 specifies that "the first interfacial layer has a LUMO level that is within 0.2 eV," while Choulis's independent claims 1 and 7, from which claim 10 depends, do not impose this limitation.

Indeed, an interfacial matching layer itself is an optional feature in OLED design. Ex.1004, [0054] (“Referring to FIG. 5, a light emitting device having a phosphorescent light emitting compound is formed *with and without matching layers*.”); Ex.1044, ¶37 (citing Ex.1034, Fig. 1). Additionally, claim 10 of the ’164 patent does not require an interfacial layer.

PO’s assertion that a POSITA would avoid using rubrene in Choulis as a substitute for Ir(mppy)₃ due to its potential impact on trapping and electron transport is flawed. Ex.1044, ¶38. Optimized OLEDs employing fluorescent emitters, such as rubrene, typically adopt low emitter concentrations. Ex.1044, ¶38. A POSITA would understand that the impact of rubrene on electron transport is minimal due to its low concentration. Ex.1044, ¶38.

Rubrene is a classic fluorescent emitter that has been extensively utilized in OLEDs and was well-known to a POSITA at the time of the ’164 patent. Ex.1044, ¶39. PO’s contrary suggestion, which is based on the assertion that Kang and Hamada do not propose using rubrene as an emitter material is incorrect. These references are distinct and unrelated to Choulis, and therefore do not diminish Choulis’s disclosure regarding the use of rubrene. Ex.1044, ¶39.

Even if Choulis does not explicitly disclose the substitution of rubrene for Ir(mppy)₃ (which it actually does), such substitutions, as well as the use of PQIr or DCM2 in place of Ir(mppy)₃, would have been obvious, as demonstrated in the

Petition. Pet. 36-37 (citing Ex.1003, ¶¶27, 30, 31, 115); Ex.1044, ¶40. Electrons tend to lower their energy by traveling “downhill” to lower LUMO levels, whereas holes tend to lower their energy by moving “uphill” to higher HOMO levels. Ex.1003, ¶¶27, 115. To ensure that all charges efficiently travel to the emitter material to form excitons, it is preferable that the LUMO level of the emitter material be lower than those of other materials in the light emitting layer, and the HOMO level be higher than those of other materials in the layer. Ex.1003, ¶115. The choice of the specific emitter material would depend, at least in part, on the desired emission color. Ex.1044, ¶40.

Contrary to PO’s assertions, Choulis’s alleged “operating principle” accommodates LUMO levels that are 0.3 eV or 0.7 eV lower than the LUMO of the LUMO matching layer material. Ex.1044, ¶41. As noted in the discussion regarding the disclosed emitter rubrene, Choulis merely proposes that the first interfacial layer “can” have a LUMO level difference of 0.2 eV, indicating it is not a mandatory requirement. Furthermore, the interfacial matching layer is an optional feature in OLED design. Consequently, a POSITA would not interpret these aspects of Choulis as restrictive when selecting other emitter materials. Ex.1044, ¶41.

Contrary to PO’s argument, the fact that Kanno uses PQIr with CBP and Hamada uses DCM2 with Alq₃ and rubrene does not limit PQIr and DCM2 to exclusively pair with those specific materials. Ex.1044, ¶42. Furthermore, contrary

to PO's argument, Kanno and Thompson's use of materials with specific energy levels does not dictate those levels as a standard for all OLED devices. Ex.1044, ¶43. Kanno's research is specifically focused on constructing a white OLED, where emission needs to be balanced among three light-emitting molecules. Ex.1044, ¶43 (citing Ex.1025, 340, 342). Regarding the emitter in Thompson, it fulfills a more comprehensive role than what would typically be encountered in a simple OLED. Ex.1044, ¶44 (citing Ex.1007, [0008]).

D. Choulis anticipates or at a minimum renders obvious claims 13 and 14

As demonstrated in the Petition, Choulis anticipates or at a minimum renders obvious claims 13 and 14. Pet. 38-43; Ex.1044, ¶45.

As an initial matter, Petitioner has established that Choulis anticipates or at a minimum renders obvious claim 13 due to Choulis's disclosure of using spin-coating as a method for depositing materials, which involves a simultaneous application process. Pet. 40-41; Ex.1044, ¶46. PO has not contested this point. POR 48. Therefore, there is no genuine dispute regarding the unpatentability of claim 13, notwithstanding PO's arguments concerning evaporation, which is a distinct process from spin-coating.

Petitioner has demonstrated that Choulis anticipates or at a minimum renders obvious claim 14. Claim 14 depends on claim 13 and includes the requirement of applying matrix materials via evaporation coating. *First*, Petitioner has shown that

Choulis discloses evaporation coating as a method, and that PVK can be deposited using this technique. Pet. 41-42; Ex.1044, ¶47. Contrary to PO's argument that evaporating PVK would not lead to acceptable performance, this method allows the evaporated PVK layer to transport charge and emit light. Ex.2020, 156:16-157:10 (discussing Djobo (Ex.1023)); Ex.1044, ¶47 (citing Ex.1023, 133). PO's claim that Dr. Holmes "is not aware of any literature or anyone who has used evaporation to process PVK" (POR 48) is incorrect, as Dr. Holmes was aware of Djobo and addressed it in both his declaration and during his deposition. Ex.1003, ¶133; Ex.2020, 162:17-163:3.

Second, Choulis discloses that small molecules can be used as alternatives to PVK. Ex.1004, [0044]; *see also id.*, [0031]. It would have been obvious to apply small molecules, TPD, and PBD via evaporation coating because Choulis teaches that "small-molecule light emitting materials are preferably deposited through evaporation." Ex.1004, [0043]; Ex.1044, ¶48. There would have been a reasonable expectation of success, applying small molecules via evaporation coating was a well-established and routine process. Ex.1044, ¶48 (citing Ex.1004, [0043]).

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

As demonstrated in the Petition, Choulis in view of Yong renders claim 9 obvious. Pet. 48-51; Ex.1044, ¶49.

PO does not contest that Yong discloses the claimed emission layer with a gradient. Instead, PO merely criticizes Yong for being “a single Chinese patent.” POR 49. The fact that Yong is a Chinese patent does not disqualify it from being considered prior art. A single exemplary reference can serve as evidence of knowledge in the art, and Yong indicates that the use of gradients was indeed known. Ex.1044, ¶50. Moreover, contrary to PO’s argument, the use of gradients was well established in the art. Ex.1044, ¶51. Yong specifically describes the prior application of gradients in OLEDs. Ex.1009, Description at 2; Ex.2020, 196:5-13.

Contrary to PO’s assertion, the combination of Choulis and Yong would have been obvious, as Yong demonstrates the benefits of an emission layer with a gradient in an OLED structure similar to that disclosed by Choulis. Ex.1003, ¶¶160-66; Ex.1044, ¶52. PO’s claim that Choulis has “already solved” the charge balance issue lacks a credible basis, as Choulis does not imply that its device is without imperfections. Indeed, Choulis and Yong share the common objective of improving charge balance in the emissive layer. Ex.1004, [0058]; Ex.1009, Abstract. Therefore, it would have been obvious to combine the teachings of Choulis and Yong. *See Maxell, Ltd. v. Amperex Tech. Ltd.*, No. 2023-2256, 2025 WL 271614, at *4 (Fed. Cir. Jan. 23, 2025) (holding that it would have been obvious to combine two references that teach discrete means to achieve the same goal); *Intel Corp. v. PACT XPP Schweiz AG*, 61 F.4th 1373, 1380 (“That Kabemoto and Bauman address the

same problem ... is precisely the reason that there's a motivation to combine under *KSR* and our precedent.") (Fed. Cir. 2023); Ex.1044, ¶52.

A POSITA would have a reasonable expectation of success in integrating the graded composition from Yong with Choulis to achieve enhanced control over charge balance and further performance improvements. Ex.1044, ¶53. PO's assertion that there would not be a reasonable expectation of success due to Yong disclosing evaporation while Choulis discloses solution processing lacks merit. *First*, as discussed above in Section III.D, Choulis discloses evaporation coating as a viable method, and a POSITA would understand that PVK can be deposited using this technique. *Second*, OLEDs utilizing solution-processed layers with a gradient in the emitter composition were well established in the field. Ex.1044, ¶¶54-55 (citing Ex.1039, 574-76; Ex.1040, 795; Ex.1009, Description at 3).

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

As demonstrated in the Petition, Sugiura anticipates or at a minimum renders obvious claims 1, 3, 5-8, and 10-13. Pet. 51-69. Ex.1044, ¶56.

A. Sugiura's hole and electron transport materials are the claimed matrix materials

As demonstrated in the Petition, Sugiura discloses that polymer PVK, hole transport material TPD, and electron transport material Alq₃ correspond to the claimed first, second, and third matrix materials, respectively. Pet. 54-55; Ex.1044,

¶57. The '164 patent explicitly describes a hole transport material and an electron transport material, such as those identified by Sugiura, as matrix materials. Ex.1001, cls. 5-6, 5:34-37.

PO mistakenly argues that Sugiura's hole and electron transport materials do not meet the criteria for the claimed matrix materials because they are "dispersed agglomerations." POR 54. However, PO's assertion is incorrect, as the term "matrix material" does not exclude "dispersed agglomerations," as discussed above in Section II. Ex.1044, ¶58. Furthermore, while PO asserts that Sugiura's hole and electron transport materials cannot be considered matrix materials because they may be dopants, the term "matrix material" indeed includes dopants, as discussed above in Section II.

Moreover, Sugiura's hole and electron transport materials are not dispersed agglomerations. Ex.1044, ¶59. PO overlooks Sugiura's explicit teaching that PVK (an exemplary "first matrix material"), Alq₃ (an exemplary "third matrix material"), TPD (an exemplary "second matrix material"), and Nile Red (an exemplary "emitter material") can be mixed in a ratio of 100:60:80:0.2.¹⁰ Ex.1006, [0062]. A POSITA would recognize that Sugiura's hole and electron transport materials are not in

¹⁰ In addition to TPD, the '164 patent explicitly identifies Alq₃ as another matrix material. Ex. 1001, 8:3-9.

dispersed agglomerations because such agglomerations would impede the functionality of Sugiura's devices as described. Ex.1044, ¶¶60-62 (citing Ex.1006, [0042], [0064], [0066], [Table 1]). In his deposition, Dr. Sims testified that the molecules in Sugiura's hole transport material are sufficiently proximate to enable hole transport. Ex.1043, 65:18-66:14. Similarly, Dr. Sims confirmed that the molecules in Sugiura's electron transport material are adequately close to facilitate electron transport. Ex.1043, 66:16-67:5. These admissions suggest that Sugiura's hole and electron transport materials are not dispersed in agglomerations.

Importantly, the term "dispersed agglomerations" is introduced by PO and is not a concept taught by Sugiura. PO's argument is flawed, as it is based on an interpretation of the circles in Sugiura's figures as representing dispersed agglomerations. However, these figures are merely simplified illustrations designed to demonstrate that Sugiura's light-emitting layer comprises multiple materials, consistent with the requirements of claim 1. Ex.1044, ¶63. In his deposition, Dr. Sims acknowledged that Sugiura's figure is not drawn to scale. Ex.1043, 62:22-24.

Contrary to PO's argument, forming dispersed agglomerations is not advantageous, as they hinder hole and electron transport and would prevent Sugiura from achieving its stated objectives. Ex.1044, ¶64. In his deposition, Dr. Sims examined the processing details of Sugiura's device and conceded that Sugiura "made an attempt to get a good mixture of the materials." Ex.1043, 64:22-23. PO's

assertion that dispersed agglomerations are beneficial for preventing exciplex formation is unfounded, especially considering that it was already well-known at the time that Sugiura's hole transport material, TPD, and electron transport material, Alq₃, do not form exciplexes. Ex.1044, ¶64 (citing Ex.1034, 763).

B. Sugiura discloses the claimed HOMO and LUMO levels

As demonstrated in the Petition, Sugiura discloses the claimed HOMO and LUMO levels. Pet. 56-58, 60, 64-65; Ex.1044, ¶65.

Sugiura's energy diagrams illustrate the relative HOMO and LUMO levels of the materials within the light-emitting layer. Ex.1044, ¶66. PO's contention that Sugiura does not disclose the claimed HOMO and LUMO levels because it uses the terms "ionization potential" and "electron affinity" is unfounded. These terms "can be used interchangeably [with HOMO and LUMO] in interpreting an energy level diagram for an OLED." Ex.2020, 127:7-128:14; *see also* Ex.1044, ¶¶66-67 (citing Ex.1007, [0042]; Ex.2029, [0011]). During his deposition, Dr. Sims concurred. Ex.1043, 99:18-19 ("Those terms are often used interchangeably, and it is not a big deal to do that."); *see also* Ex.1043, 79:18-80:14, 78:1-12.

The slight differences between the ionization potential and electron affinity for Alq₃ disclosed by Sugiura and the HOMO and LUMO levels reported by Manninen and Kang do not detract from Sugiura's disclosure regarding relative energy levels. Ex.1044, ¶68. According to Forrest, due to potential discrepancies in

measuring HOMOs and LUMOs, it is recommended to measure them “under the same conditions on the same equipment to minimize experimental error.” Ex.2029, [0103]. In his deposition, Dr. Sims expressed agreement with Forrest’s teachings. Ex.1043, 78:15-79:1. In the absence of such data, a POSITA would recognize that relying on energy levels provided within the same reference is the most consistent approach. Ex.1044, ¶68. As discussed in the Petition, Sugiura discloses the claimed relative energy levels. Pet. 56-58, 60, 64-65.

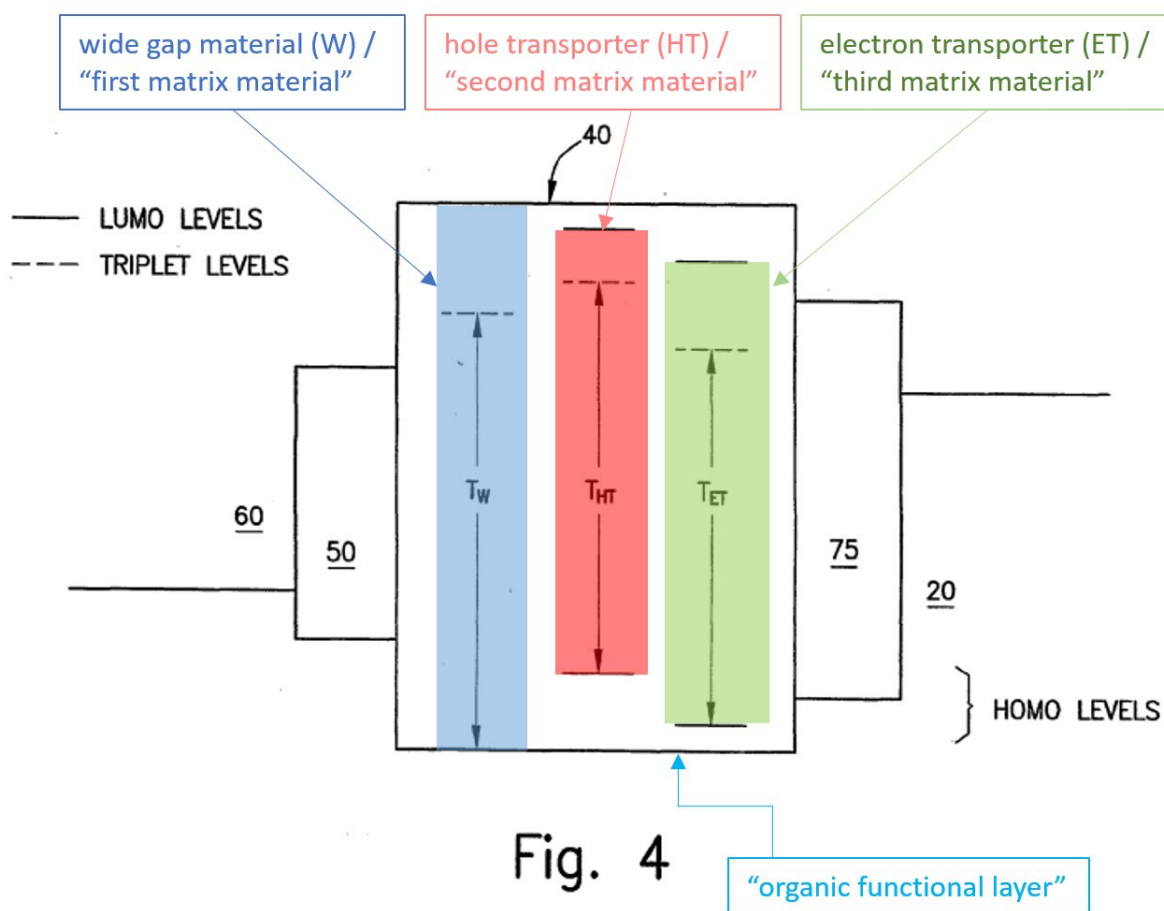
PO’s assertion that Sugiura does not disclose the claimed relative energy levels is misguided, as PO selectively chooses energy levels from various references rather than considering Sugiura’s own disclosure of these levels. Ex.1044, ¶69; Ex.1003, ¶¶202-04. Contrary to PO’s argument, a POSITA would recognize that energy diagrams, such as Figure 8 in Sugiura, depict the relative HOMO and LUMO levels of different materials. Ex.1044, ¶69. During his deposition, Dr. Sims acknowledged that Figure 8 from Sugiura’s energy diagram illustrates the relative HOMO and LUMO levels of various materials. Ex.1043, 98:1-14.

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

As demonstrated in the Petition, Thompson anticipates or at a minimum renders obvious claims 15-16. Pet. 69-82. Ex.1044, ¶70.

A. Thompson discloses the claimed matrix materials

The Petition accurately identified the wide gap material (W), the hole transporter (HT), and the electron transporter (ET) as the claimed matrix materials. Pet. 72-74. These components—wide gap material (W), hole transporter (HT), and electron transporter (ET)—are integral parts of the same matrix, as illustrated in Figure 4 below. Ex.1044, ¶71.



Thompson, Fig. 4 (annotated).

PO does not dispute that the wide gap material (W), the hole transporter (HT), and the electron transporter (ET) are components of the same matrix or that they

satisfy the claimed HOMO and LUMO levels. While PO argues that Thompson's hole transporter and electron transporter do not qualify as matrix materials because they are dopants, the term "matrix material" indeed encompasses dopants, as discussed above in Section II. Ex.1044, ¶72.

Without any supporting evidence, PO incorrectly claims that Thompson teaches away from the claimed arrangement because one of the charge transporters may function as an emitter. As discussed above in Section II.A, claims 15 and 16 recite first, second, and third matrix materials but do not specify any particular composition for these matrix materials. Notably, claims 15 and 16 do not mention emitters, nor do they inhibit any matrix materials from functioning as emitters. The fact that Thompson indicates one of its charge transporters may also emit light does not exclude it from being part of the matrix. Ex.1044, ¶73. It merely shows that one of its matrix materials has the additional property of emitting light. Ex.1007, [0008].

The '164 patent explicitly identifies both a hole transport material and an electron transport material, such as those described by Thompson, as matrix materials. Ex.1001, cls. 5-6, 5:34-37. The fact that one of Thompson's charge transporters may also function as an emitter does not negate its role as a charge transporter, akin to the charge transporters characterized as matrix materials in the patent specification. Ex.1044, ¶74. Although the specification discusses

embodiments with separate emitters and charge transporters, it does not preclude a charge transporter from also serving as an emitter.

B. Thompson's host material has a lower charge carrier mobility than those of the charge transporters

As demonstrated in the Petition, Thompson discloses an "inert" host material. Ex.1007, [0028]. A POSITA would interpret Thompson's inert host material as possessing a lower charge carrier mobility relative to the charge transporters. Ex.1044, ¶75.

Although PO cites an article by Martin and Hirsch reporting a mobility value of $5 \times 10^{-5} \text{ cm}^2 \text{ s}^{-1} \text{ V}^{-1}$ at 80°C and under an electric field of 1.2 MV/cm for polystyrene, this value may not be applicable to OLEDs due to the atypical conditions under which it was obtained. Ex.1044, ¶76. Even if we consider the charge carrier mobilities reported by Martin and Hirsch to be relevant, these mobilities are substantially lower than those of the materials described by Thompson for charge transport. Ex.1044, ¶¶77-79 (citing Ex.1007, [0055], [0056]; Ex.1041, Fig. 3; Ex.2009, Fig. 1, 135; Ex.1037, 494, Fig. 4; Ex.1042, Fig. 5, 3693).

The Board should determine that the challenged claims are unpatentable.

Date: August 11, 2025

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CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), I certify that the foregoing Petitioner's Reply contains 5585 words based on the word count indicated by the word-processing program used to generate the paper and excluding those portions exempted by 37 C.F.R. § 42.24(a).

Date: August 11, 2025

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.6, I hereby certify that the foregoing Petitioner's Reply to Patent Owner's Response and accompanying exhibits were served by electronic mail today on the following counsel of record for Patent Owner:

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