

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. IPR2024-01095
Patent No. 11,828,425

**DECLARATION OF RUSSELL J. HOLMES, PH.D.
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 11,828,425**

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I. INTRODUCTION

I, Russell J. Holmes, Ph.D., declare and state, to the best of my knowledge, understanding, and belief, as follows:

1. I have been retained by counsel for Petitioner Samsung Display Co, Ltd. to provide my expert opinions concerning the validity of certain claims of U.S. Patent No. 8,828,425 (“the ’425 patent”). For the reasons discussed below, it is my opinion that claims 1–19 of the ’425 patent would have been anticipated by the prior art or obvious to a person of ordinary skill in the art.

2. I am being compensated at my standard hourly consulting rate for my time. My compensation is in no way contingent on the content of my testimony or the outcome of these or any other proceedings relating to the ’425 patent.

II. BACKGROUND AND QUALIFICATIONS

3. In this section, I summarize my qualifications for forming the opinions set forth in this declaration. Additional information is provided in my *curriculum vitae*, which is attached as Appendix A. My *curriculum vitae* also includes a list of my publications, presentations, and patents, as well as previous patent proceedings in which I have served as an expert. Appendix A at 4–25.

4. I have extensive experience in the research of organic electronic materials and devices, and more broadly in the areas of semiconductor physics and

materials science. Since earning my Ph.D. in 2006, I have operated an independent research group in the Department of Chemical Engineering and Materials Science at the University of Minnesota. My group has consistently focused on the study of organic semiconductor materials and optoelectronic devices, with heavy emphasis on organic light-emitting devices (OLEDs), organic solar cells, and the study of excitonic phenomena in organic thin films. Specific to the areas of OLEDs and excitonic phenomena, my research group has demonstrated novel architectures for phosphorescent OLEDs, elucidated mechanisms governing device efficiency and degradation, and worked to demonstrate methods to engineer exciton formation, recombination, and migration. My research group has been funded by federal funding agencies including the National Science Foundation, the Department of Energy, and the Department of Defense, in addition to several sponsored projects with industry.

5. In my capacity as an expert in semiconductor physics and materials science, I have taught courses in Introductory Materials Science, Electronic and Magnetic Properties of Materials, Thermodynamics, Transport and Kinetics, Solar Cell Physics, and Engineering Design.

6. I earned my Ph.D. in 2006 and Masters degree in 2002, both in Electrical Engineering, from Princeton University, and a Bachelor of Science (Honours) in Physics degree in 2000 from the University of Manitoba. The focus of

my graduate study in Electrical Engineering was in understanding the luminescent properties of organic semiconductor thin films under optical and electrical excitation, with particular emphasis on applications in phosphorescent OLEDs. In particular, I carried out work in the design, fabrication, characterization, and analysis of phosphorescent blue OLEDs, realizing record efficiencies, as well as the first phosphorescent blue OLEDs with exothermic host-guest energy alignment, and some of the earliest phosphorescent blue OLEDs capable of high efficiency and deep blue color purity. Realization of the latter required the development of the first OLEDs based on ultra-wide energy gap host (UGH) materials. I separately carried out spectroscopic studies of exciton energy transfer and quenching behavior in organic semiconductor materials and devices to elucidate device operating mechanisms and the interaction of molecular excited states with other excitons and electronic charges, especially under high current excitation. Finally, I led efforts to investigate the behavior of excitons in optical microcavities, leading to the first observations of microcavity polaritons in polycrystalline organic thin films, hybridization of vibronic transitions, and hybrid Wannier-Mott-Frenkel polaritons. I also contributed to work in the areas of white phosphorescent OLEDs, the elucidation of singlet-triplet exciton spin formation statistics, and the integration of phosphorescent OLEDs with flexible transistors to form display pixels. My graduate

work led to numerous publications and granted patents, which are listed in my *curriculum vitae*.

7. I am currently an active tenured full professor in the Department of Chemical Engineering and Materials Science (CEMS) at the University of Minnesota located in Minneapolis, MN. I am also a member of the Graduate Faculty in the Department of Electrical and Computer Engineering and in the Chemical Physics Program in the Department of Chemistry. I have received several competitive academic appointments at the University of Minnesota; including the Distinguished McKnight University Professorship (2021), which is a university-wide honor recognizing outstanding faculty members who have recently achieved full professor status; the Ronald L. and Janet A. Christenson Chair in Renewable Energy (2020), an endowed Chair in the College of Science and Engineering; and a Distinguished University Teaching Professorship (2016), which comes with the Horace T. Morse-Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education, representing the highest award offered by the University of Minnesota for excellence in undergraduate instruction.

8. I also hold additional positions at the University of Minnesota. For example, since 2014 I have served as Program Leader for the Optoelectronics and Metamaterials (formerly Flexible Electronics and Photovoltaics) program of the University of Minnesota Industrial Partnership for Research in Interfacial and

Materials Engineering (IPRIME). I will also begin an appointment as the Department Executive Officer for Materials Science in July 2024. Also notable is my recently concluded service as Chair of the Department Head Search Committee (2023-2024) and prior appointment as Director of Graduate Studies for Materials Science program (2013-2020). Finally, since 2017, I have served as an Editor for the Elsevier journal Synthetic Metals, which focuses on research on the physics, chemistry, and applications of organic and carbon electronic materials.

9. I have advised a number of graduate and undergraduate students in the Departments of Chemical Engineering and Materials Science, Electrical and Computer Engineering, and Chemistry at the University of Minnesota. This includes 18 completed Ph.D. graduate advisees (and an additional 7 current graduate advisees), 5 completed master's degree advisees, and 30 undergraduate advisees. Of my graduated Ph.D. students, several now work in the display and electronics industries.

10. Over the past 22 years, I have been an author on over 115 peer-reviewed publications, and given over 120 presentations, on topics in the general areas of semiconductors and materials science, with emphasis on organic semiconductor materials and devices. A long-term focus of my research, publications, and presentations has been on organic optoelectronic devices such as organic light-emitting devices (OLEDs), including the engineering of device

architecture to manipulate exciton behavior, and the study of singlet and triplet exciton phenomena in organic semiconductors and in OLEDs. A complete list of my publications and presentations can be found in my *curriculum vitae*.

11. My research career has led to the filing of several patent applications. As listed in my *curriculum vitae*, there are currently six issued U.S. patents on which I am an inventor. An additional five applications are listed that while published did not lead to issued patents. All of the listed patents and patent applications pertain to organic semiconductor materials and devices.

12. Additional details about my employment history, publications, and presentations can be found in my *curriculum vitae*.

13. In summary, I have extensive familiarity with organic light-emitting devices. At the time the '425 patent was filed, I was already leading an independent research group focused on organic semiconductor materials and devices. I am familiar with the development and state of this field around the time that the '425 patent was filed.

III. MATERIALS CONSIDERED

14. In forming my opinions, I have reviewed the '425 patent, as well as the prosecution history of the '425 patent and its related U.S. applications. I have also reviewed a number of prior art and background references from the time of the alleged invention of the '425 patent. Specifically, I have reviewed the materials cited

throughout my declaration and each of the documents in the following table. I have also relied on my education, knowledge, and experience gained by working in the field for more than 20 years.

Exhibit	Description
1001	U.S. Patent No. 11,828,425 (“’425 patent”)
1002	File History for U.S. Patent No. 11,828,425
1003	INTENTIONALLY LEFT BLANK
1004	Certified Translation of International Patent Application Publication No. WO 2008/040323 A2 (“Diekmann”)
1005	International Patent Application Publication No. WO 2008/040323 A2
1006	Certified Translation of Japanese Patent Application Publication No. JP 2007-277631 A (“Suzuki”)
1007	Japanese Patent Application Publication No. JP 2007-277631 A
1008	U.S. Patent Application Publication No. 2005/0146267 (“Lee”)
1009	U.S. Patent Application Publication No. 2006/0214892 (“Harada”)
1010	Ma et al., <i>Organic light-emitting diodes based on new n-doped electron transport layer</i> , Synthetic Metals 158 (2008) (“Ma”)
1011	U.S. Patent Application Publication No. 2003/0159910 (“Caldwell”)
1012	U.S. Patent Application Publication No. 2008/0211395 (“Koshihara”)

Exhibit	Description
1013	Baldo et al., <i>Highly efficient phosphorescent emission from organic electroluminescent devices</i> , 395 Nature 151 (1998).
1014	Baldo et al., <i>Very high-efficiency green organic light-emitting devices based on electrophosphorescence</i> 75 Appl. Phys. Lett. 4–6 (1999)
1015	Adachi et al., <i>Confinement of charge carriers and molecular excitons within 5-nm-thick emitter layer in organic electroluminescent devices with a double heterostructure</i> , 57 Appl. Phys. Lett. 531–533 (1990)
1016	Pfeiffer et al., <i>Electrophosphorescent p-i-n organic light-emitting devices for very-high-efficiency flat-panel displays</i> , 22 Adv. Mater. 14 (2002)
1017	Hung et al., <i>Enhanced electron injection in organic electroluminescence devices using an Al/LiF electrode</i> , 70 Appl. Phys. Lett., 152–154 (1997)
1018	Liu et al., <i>Improved electron injection in organic LED with lithium quinolate/aluminium cathode</i> , 128 Synthetic Metals 211–214 (2002)
1019	He et al., <i>Very high-efficiency and low voltage phosphorescent organic light-emitting diodes based on a p-i-n junction</i> , 95 J. Appl. Phys., 5773–5777 (2004) (“He”).
1020	Moro et al., <i>Process and design of a multilayer thin film encapsulation of passive matrix OLED displays</i> , Proceedings of SPIE Vol. 5214 (2004)
1021	Chwang et al., <i>Thin film encapsulated flexible organic electroluminescent displays</i> , 83 Appl. Phys. Lett. 413–415 (2003)
1022	Bulovic et al., <i>Transparent light-emitting devices</i> , 29 Nature 380 (1996)

Exhibit	Description
1023	INTENTIONALLY LEFT BLANK
1024	U.S. Patent No. 6,879,319 (“Cok”)
1025	File History for U.S. Patent Application No. 13/139,514
1026	File History for U.S. Patent Application No. 15/651,508
1027	File History for U.S. Patent Application No. 16/790,198
1028	U.S. Patent Application Publication No. 2011/0260201 (“Klein”)
1029	Gross et al., <i>High Power Efficiencies at Record Lifetimes: NOVALED’S PIN-OLEDs</i> , FPD Yokohama 2005
1030	He et al., <i>High-efficiency and low-voltage p-i-n electrophosphorescent organic light-emitting diodes with double-emission layers</i> , 85 Appl. Phys. Lett. 3911–3913 (2004)
1031	Werner et al., <i>Pyronin B as a donor for n-type doping of organic thin films</i> , 82 Appl. Phys. Lett. 4495–4497 (2003)
1032	U.S. Patent No. 5,594,469 (“Freeman”)
1033	Lu et al., <i>High-efficiency top-emitting organic light-emitting devices</i> , 81 Appl. Phys. Lett. 3921–3923 (2002)
1034	First Amended Complaint, <i>Pictiva Displays International Ltd. v. Samsung Electronics Co., Ltd., et al.</i> , Case No. 2:23-cv-00495, Dkt. #17 (E.D. Tex. Mar. 1, 2024)
1035	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)

IV. RELEVANT LEGAL STANDARDS

15. I am not an attorney. For the purposes of this declaration, I have been informed about certain aspects of the law that are relevant to forming my opinions. I have applied the following understanding of the law:

16. Petitioner's counsel has informed me that a patent claim may be "anticipated" if each element of that claim is present either explicitly or inherently in a single prior art reference, and that the elements should be arranged in the reference as in the claim. Petitioner's counsel has informed me that for a claimed limitation to be inherently present, the prior art need not expressly disclose the limitation, so long as the claimed limitation necessarily flows from a disclosure in the prior art.

17. Petitioner's counsel has informed me that a patent claim can be considered to have been obvious to a person of ordinary skill in the art at the time the application was filed. This means that, even if all of the requirements of a claim are not found in a single prior art reference, the claim is not patentable if the differences between the subject matter in the prior art and the subject matter in the claim would have been obvious to a person of ordinary skill in the art at the time the application was filed.

18. Petitioner's counsel has informed me that a determination of whether a claim would have been obvious should be based upon several factors, including, among others:

- the level of ordinary skill in the art at the time the application was filed;
- the scope and content of the prior art; and
- what differences, if any, existed between the claimed invention and the prior art.

19. Petitioner's counsel has informed me that a single reference can render a patent claim obvious if any differences between that reference and the claims would have been obvious to a person of ordinary skill in the art. Alternatively, the teachings of two or more references may be combined in the same way as disclosed in the claims, if such a combination would have been obvious to one having ordinary skill in the art. In determining whether a combination based on either a single reference or multiple references would have been obvious, it is appropriate to consider, among other factors:

- whether the teachings of the prior art references disclose known concepts combined in familiar ways, and when combined, would yield predictable results;
- whether a person of ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so;

- whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by those skilled in the art;
- whether a person of ordinary skill would have recognized a reason to combine known elements in the manner described in the claim;
- whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and
- whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way.

20. Petitioner's counsel has informed me that one of ordinary skill in the art has ordinary creativity and is not an automaton. Petitioner's counsel has informed me that in considering obviousness, it is important not to determine obviousness using the benefit of hindsight derived from the patent being considered.

21. Petitioner's counsel has informed me that under specific circumstances whereby a secondary reference is not being used to teach a limitation but rather to explain the teachings of a primary reference, a specific motivation to combine need not be identified; however, in the case of the combination of art discussed in this declaration, a specific motivation to combine is present and I have identified it.

22. I further understand that certain objective indicia can be important evidence regarding whether a patent is obvious or nonobvious, including the existence of a long-felt but unsolved need, unexpected results, commercial success, copying, and industry acceptance or praise. Evidence of such objective indicia must be considered when present.

V. TECHNOLOGY BACKGROUND

A. Technology Overview

1. Organic light emitting diodes (OLEDs)

23. Organic light-emitting diodes (OLEDs) are an important component in mobile displays (phones, watches, tablets) and also in televisions, virtual reality headsets, and lighting applications. Unlike their liquid crystal display (LCD) counterparts, OLEDs are electroluminescent, meaning they emit light in response to an electrical current. Conventional LCD displays require a backlight, essentially a source of light that passes through an array of liquid crystal elements. The liquid crystal elements do not themselves emit light, but instead act as gates either blocking or passing light to the external viewer depending on the applied voltage. Displays based on OLEDs are attractive for a variety of reasons including reduced power consumption, increased contrast, and suitability for flexible display applications. There are now several consumer products that incorporate mechanical flexible OLED displays, enabling an entirely new end-user experience.

24. An OLED display comprises a large assembly of individual microscopic OLED pixels that are each designed to produce red, green, or blue light, for example. Each individual OLED consists of a sequential stack of layers, where each layer is a collection of organic semiconductor molecules. The term organic semiconductor generally refers to carbon-containing molecules that exhibit some significant bond conjugation (i.e., alternating single and double bonds) in order to enable charge transport across the molecule. The function of light-emission is carried out by a particular layer known as the emissive layer (EML) of the device. The organic layers are placed between two conducting electrodes, a positive electrode (anode) and a negative electrode (cathode), which permit the injection of electrical current through the device. One of the two electrodes (i.e., either the anode or the cathode) is generally transparent or semi-transparent so as to enable the light generated in the emissive layer to leave the device; this is generally achieved by making either the cathode or anode thin enough that it is transparent or semi-transparent to the light generated in the organic layer stack or, alternatively, by using a transparent material such as indium tin oxide.

25. In order to make a cathode or anode which is transparent or semi-transparent, a thin metal layer is often utilized to ensure light can pass through the cathode or anode. For example, the first fully transparent OLEDs utilized a cathode of 5-40 nm of a silver-magnesium alloy, a metal which is commonly used as a

cathode in OLEDs, followed by a 40-nm-thick layer of indium tin oxide. *See* Ex. 1022 (Bulovic), 29; *see also* Ex. 1033, 3921-3923. It was found that the transmission of light through the cathode was sharply reduced as the thickness of the cathode increased: with a cathode comprising a 7.5 nm thick layer of silver-magnesium alloy, the transmission of light was 81% and sharply fell to 10% at a thickness of 20 nm and fell all the way to 1% at a cathode thickness of 40 nm. *See* Ex. 1022 (Bulovic), 29; *see also* Ex. 1033, 3921-3923. As such, it has long been understood that for metals, a thin film needs to be used in order for the cathode of the OLED to realize an appreciable level of light transmission. However, the subsequent layer of indium tin oxide can be thicker since it is a more transparent and less strongly absorbing material. *See* Ex. 1022 (Bulovic), 29; *see also* Ex. 1033, 3921-3923.

2. OLED layer structure

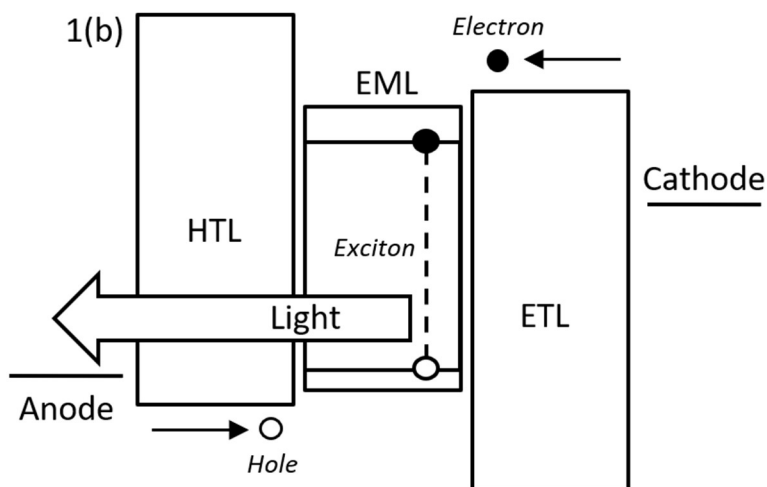
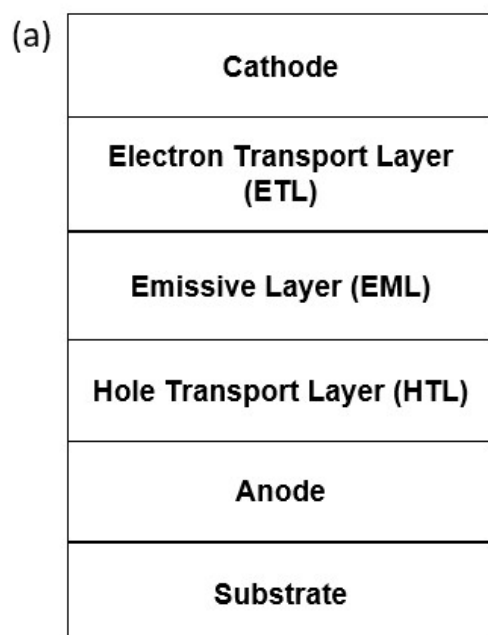
26. A typical layer structure for an OLED is shown in Figure 1(a) below. This structure reflects the need for an OLED to efficiently convert injected electrons and holes into light. In the fields of solid-state and semiconductor physics, the “hole” is considered as an analog to the electron but with positive charge. In the structure of Fig. 1(a) an applied voltage leads to electrons being injected into the OLED from the cathode while holes are injected into the OLED from the anode, as shown in Fig. 1(b). The structure shown in Figs. 1(a) and 1(b) is what is known as a “bottom-emitting” OLED, wherein the light generated by the OLED exits via the

anode on the bottom of the OLED. Alternatively, one could design an OLED to be “top-emitting,” such as the OLED illustrated in Figs. 2(a) and 2(b). In a “top-emitting” OLED, light exits the device through the cathode on top of the OLED rather than via the anode.

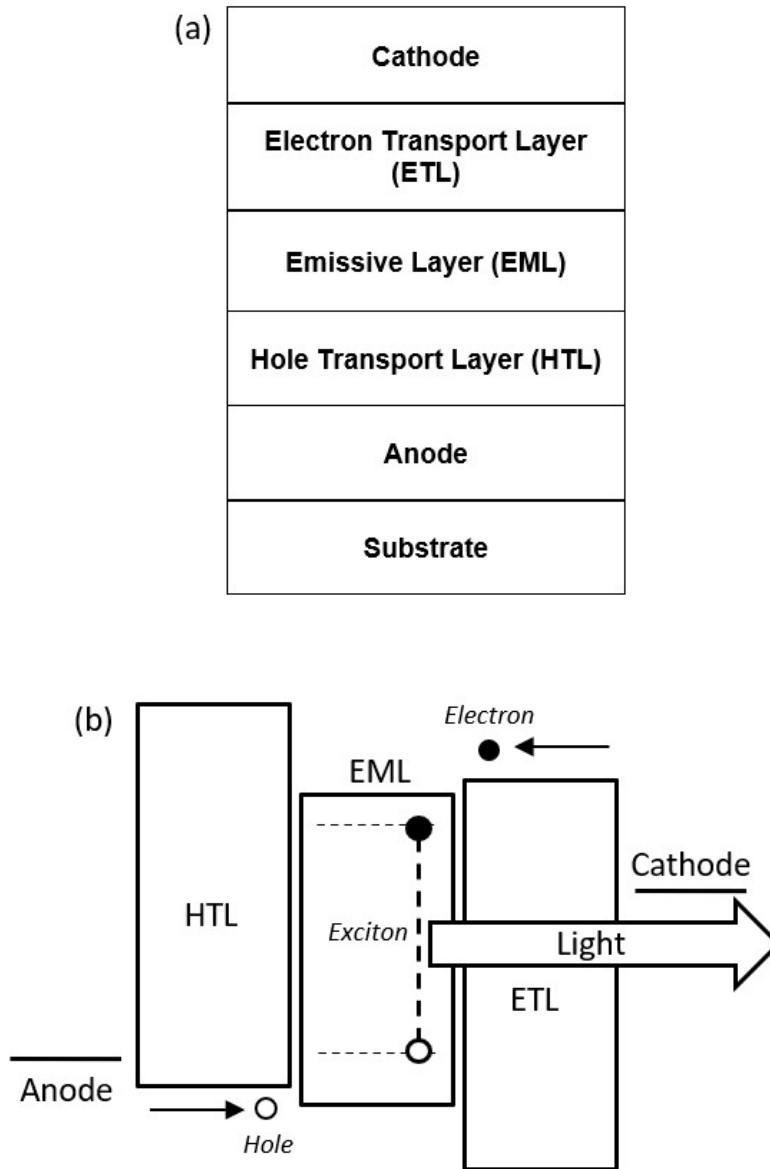
27. Electrons travel from the cathode through a specifically designed sequence of layers permitting efficient arrival into to the emissive layer (EML) of the device. For electrons, this sequence typically includes an electron transport layer (ETL) before reaching the EML. In some OLEDs, an electron injection layer (EIL) may also be used in addition to an ETL. Similarly, holes travel from the anode through a specifically designed sequence of layers permitting efficient arrival into the EML of the device. For holes, this sequence typically includes a hole transport layer (HTL) before reaching the EML. In some OLEDs, a hole injection layer (HIL) may also be used in addition to an HTL. An OLED which contains electron and hole injection layers, in addition to the electron and hole transport layers, is illustrated below in Figures 3(a) and 3(b).

28. In the EML, electrons and holes meet to form a bound electron-hole pair known as an exciton, an energetically excited molecule. Ideally, this process should lead to light emission and electroluminescence from the OLED. The EML generally consists of at least two different types of molecules, referred to as

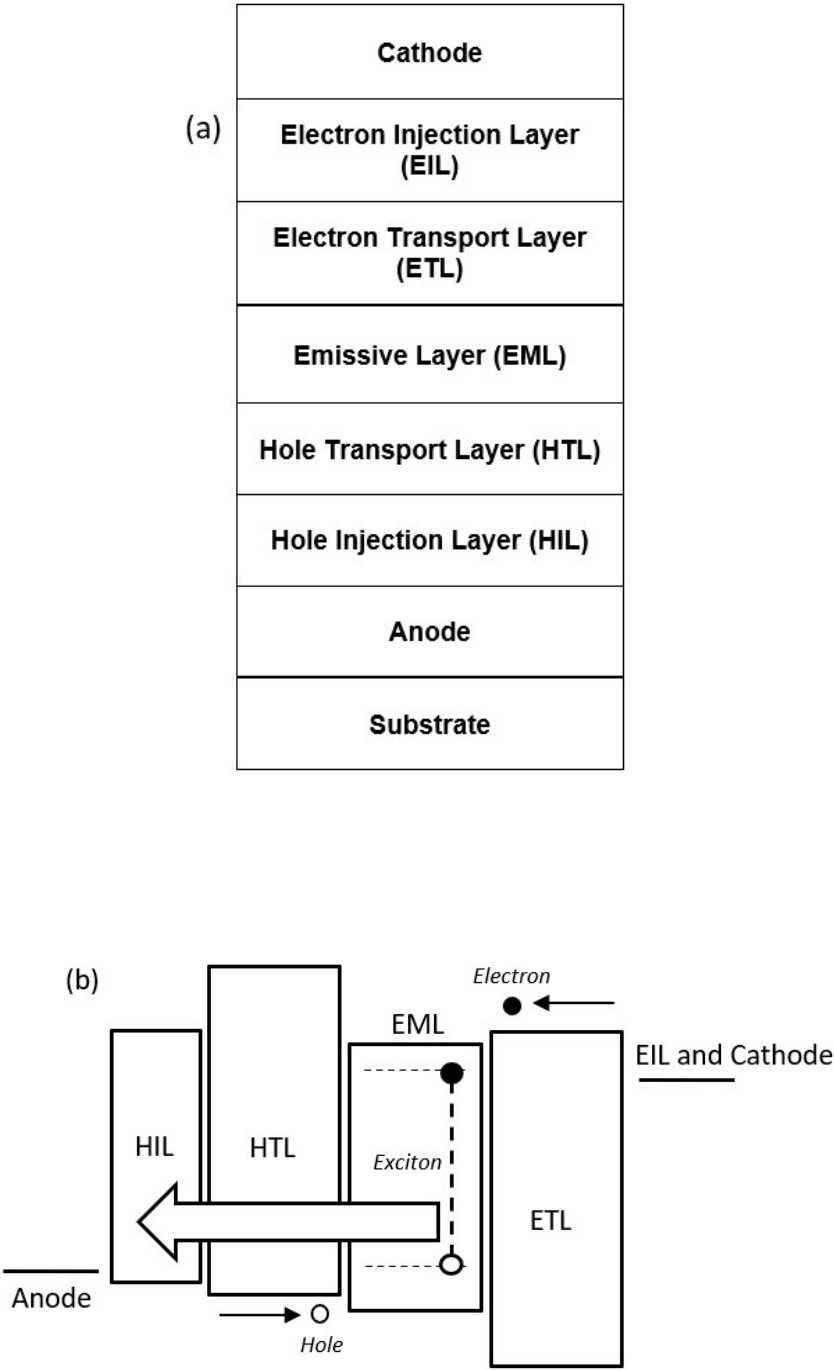
host and guest, with the host encompassing roughly 90% of the film, but with the guest ultimately responsible for light emission.



Figs. 1(a) and 1(b).



Figs. 2(a) and 2(b).



Figs. 3(a) and 3(b).

3. Emission layer (EML)

29. The selection of the materials that are included in the EML of the OLED strongly determines the light-emitting efficiency of the device. The efficiency of an OLED can be defined using several metrics. Most relevant for display applications are efficiency units that account for the photopic response of the human eye. These include the current efficiency, in units of Candelas per Ampere (Cd/A) and the power efficiency, in units of Lumens per electrical Watt (lm/W). The latter is useful in that by expressing the light emitted per unit of power consumed, both the *drive current* and *drive voltage* of the device are properly accounted for. In order to maximize the light emitted by an OLED, it is important to utilize a guest material in the EML capable of efficiently converting injected electrons and holes into excitons which decay radiatively to emit light. In order to maximize the power efficiency, it is important to also minimize the OLED driving voltage.

30. At the time of the '425 patent, two different classes of guest emitter material had been applied in the construction of OLEDs. Molecules in these classes are denoted as either fluorescent or phosphorescent depending on their light-emitting mechanism. While fluorescent emitter materials were applied in initial demonstrations of thin film OLEDs, they were limited in the efficiency they could realize. When excitons are formed in the EML of an OLED, they can become either “triplet” or “singlet” excitons; these are formed at a ratio of 3:1 (meaning for every

three triplet excitons, there will be one singlet exciton). Although singlet excitons are capable of undergoing rapid recombination to emit light (termed fluorescence), triplet excitons, in contrast, are unable to relax radiatively in a fluorescent material, and tend to decay non-radiatively. Since under electrical excitation the triplet to singlet ratio is 3:1, electroluminescence from simple fluorescent materials can be at best 25% efficient. This limitation presented a significant obstacle to the commercialization of OLEDs until the advent of electroluminescence from phosphorescent guest emitter molecules.

31. A phosphorescent emitter differs from a fluorescent emitter in that light emission originates from the recombination of the excitons in the triplet state rather than those in the singlet state. Additionally, any electrically generated singlet excitons can be rapidly converted into triplet excitons, increasing the maximum possible efficiency of the OLED to 100%. The conversion from singlets to triplets, as well as efficient light emission via phosphorescence from the triplet state is made possible through the heavy atom effect which increases the coupling between singlet and triplet exciton states. At the time of the '425 patent, phosphorescent emitters were being widely utilized to demonstrate OLEDs with high efficiency, with the requisite heavy atom effect enabled by including an element like platinum (Pt) or iridium (Ir) in the molecular structure. Initial demonstrations of electroluminescence from OLEDs relying on phosphorescence were by Baldo et al.

using a platinum-containing phosphor, Ex. 1013 (Baldo 1998), and Baldo et al. using an iridium-based phosphor, Ex. 1014 (Baldo 1999). These early demonstrations led to significant commercialization efforts for the use of phosphorescence in displays by Universal Display Corporation. As such, the OLED community as a whole was well-aware of iridium-phosphors as a means to maximize OLED efficiency, and there was vigorous effort to further develop these materials toward commercial applications in the early 2000s.

4. Injection and Transport layers

32. Equally important to the ability of an emitter molecule to convert electrons and holes injected into the EML into excitons capable of radiative recombination (i.e., capable of emitting light) is the ease with which electrons and holes are injected into the OLED from their respective electrodes (the cathode and anode, respectively) and transported to the EML. Efficient carrier injection from the electrodes and between organic layers depends on the relative energy level alignment between adjacent layers of the organic stack, as well as the electrical conductivity of each layer. Fig. 1(b) below illustrates a schematic energy diagram for the OLED structure depicted in Fig. 1(a). In this diagram, energy levels are defined relative to vacuum (i.e. the case of a free electron outside of the material). The anode and cathode are characterized by a single energy level defined by the respective work function of each electrode. What is relevant for injection is the

alignment of the electrode (i.e., anode and cathode) work function with the energy levels of the layer adjacent to that electrode, since the objective is to inject an electron (in the case of the cathode) or hole (in the case of the anode) into the layers of the OLED stack.

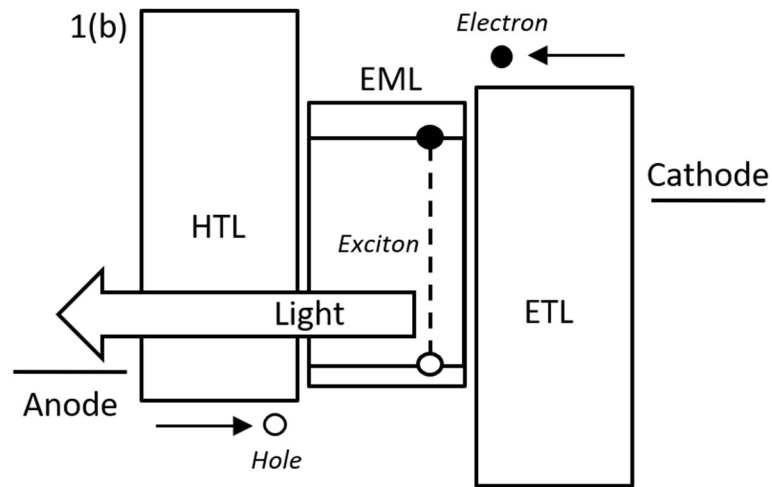
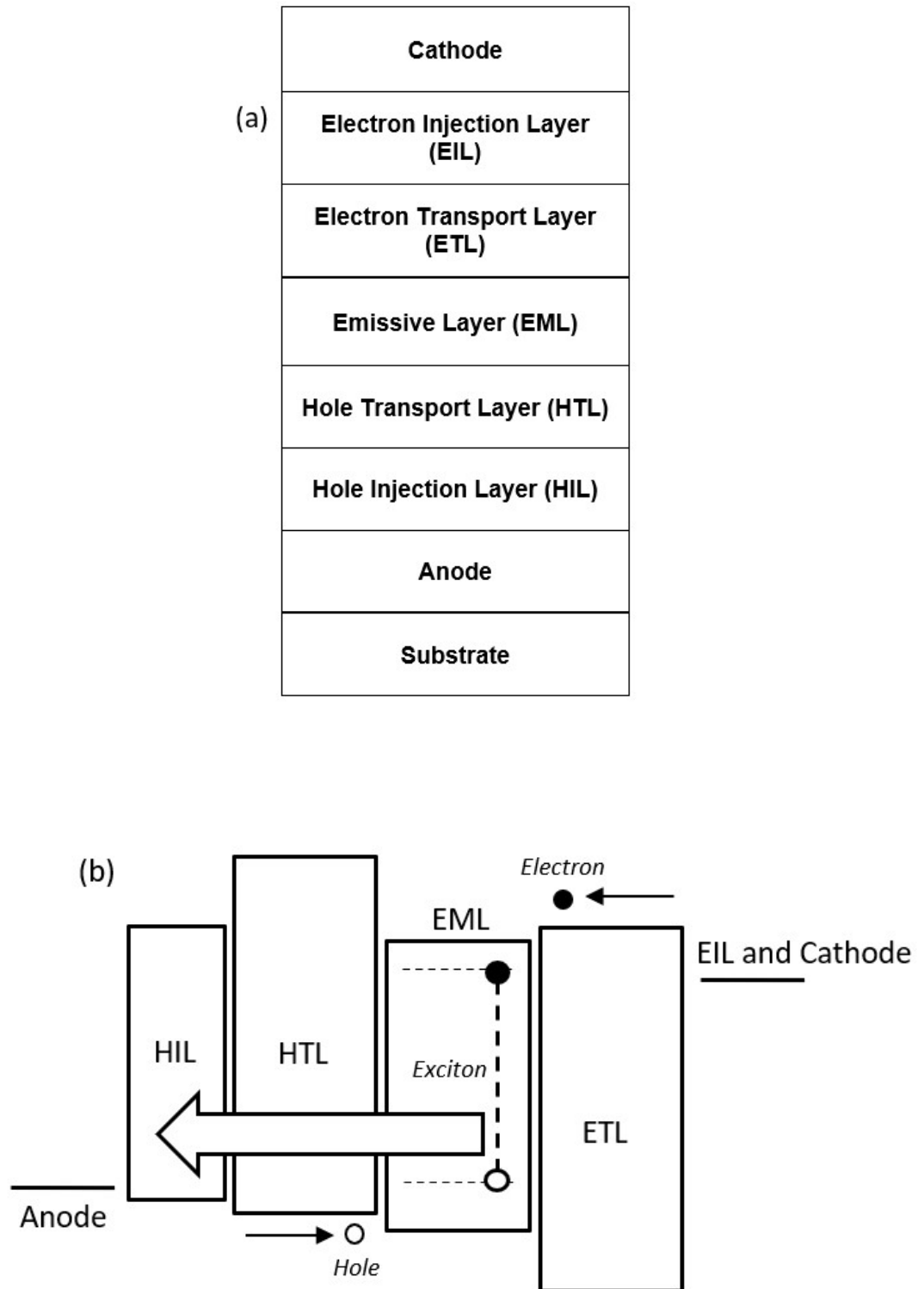


Fig. 1(b).

33. Whether or not an injection layer is present between the transport layers and their respective electrodes, an OLED will generally contain hole- and electron- transport layers. *See, e.g.,* Ex. 1016; Ex. 1019. Transport layers are responsible for carrying charge carriers to the EML. As such, a transport layer must be able to both accept a charge carrier from the electrode or if present, an adjacent injection layer, and move carriers to the EML so that exciton formation and electroluminescence may occur. Transport layers may be doped or undoped, and in some very early OLEDs were even responsible for light-emission.

a. Injection layers

34. Prior to the '425 patent, it was understood that improving the ability to inject charges from the cathode into the adjacent organic stack was important for reducing the voltage needed to realize a particular brightness from the OLED. Reducing the OLED driving voltage in turn also reduces the power consumed by the OLED. In practice this can be accomplished by inserting an electron injection layer or, alternatively, an electron transport layer that has been doped to increase conductivity (as I explain further below) between the cathode and the organic layer stack. An OLED which contains an electron injection layer between the cathode and organic layer stack, and a hole injection layer between the anode and organic layer stack, is illustrated below in Figures 3(a) and 3(b).



Figs. 3(a) and 3(b).

35. By the late 1990s, the inclusion of lithium-containing compounds like LiF and Liq in the organic layer stack had been shown to be an effective means to realize a reduced injection barrier for electrons, and a practical means to reduce the driving voltage of the OLED. In 1997, Hung et al. found that the inclusion of a thin LiF electron injection layer below an aluminum cathode significantly reduced device driving voltage compared to either magnesium-silver alloy or aluminum-only cathodes. Ex. 1017 (Hung).

36. In 2002, Liu et al. found a similar result for the use of Liq as an electron injection layer paired with, and directly below, an aluminum cathode. Ex. 1018 (Liu). Specifically, devices containing a thin layer of Liq as the electron injection layer showed improved current and luminance output compared to devices using a layer of calcium followed by aluminum. The performance of devices containing Liq was found to be similar to devices using LiF in a similar capacity. As such, by the time of the late 90s and early 2000s it was well known in the OLED community that the inclusion of an electron injection layer of LiF or Liq could favorably improve device performance by reducing the barriers for electron injection into the organic stack.

b. Transport layers

37. Transport layers are a core unit of OLED architecture and are ubiquitous for their presence across devices found in the literature. Many of the most

prominent papers in OLEDs utilize this terminology (i.e., “electron transport layer” and “hole transport layer”) in describing the layer responsible for charge transport from the electrode. In 1990, Adachi et al. introduced the advantage of sandwiching a purpose-designed EML between hole- and electron-transport layers. Ex. 1015 (Adachi). The relevant device structure comprised, in order: an anode of ITO, followed by a hole-transport layer of TAD, an EML, an electron-transport layer of PBD, and a cathode. In this work, the transport layers are noted for their role in moving electrons and holes from the electrodes to the EML, and also to prevent quenching of excitons in the EML by the electrodes.

38. Another prominent example is in the first demonstration of efficient electroluminescence from an Ir-containing phosphorescent guest by Baldo et al. who constructed a device comprising an anode, followed by a hole-transport layer of α -NPD, an emissive layer consisting of CBP and Ir(ppy)₃, a barrier layer of BCP, an electron transport layer of Alq₃, and finally a cathode consisting of magnesium and silver. Ex. 1014 (Baldo 1999). Notably, even with the inclusion of a barrier layer of BCP, Alq₃ is designated as the electron transport layer, sitting between the barrier layer and the cathode.

39. In OLEDs where both a doped transport layer and injection layer are present, a distinction is made between the “injection” and “transport” layers. Ma demonstrates a device in which the EML is followed by an Liq-doped layer of BPhen

followed by LiF and an aluminum cathode. Ex. 1010 (Ma). The doped layer of BPhen is referred to as the electron transport layer, while the LiF layer is referred to as the electron injection layer. Ex. 1010 (Ma).

40. A relevant issue being considered by those in the art at the time was the potentially low conductivity of the electron- and hole- transport layers which, as explained above, serve to bring charge carriers from the OLED electrodes to the EML to generate light. By 2008, it was well-understood that the conductivity of transport layers could be improved through doping the transport layer. For example, it was understood at the time that one way to increase the conductivity of the hole transport layer was to dope the hole transport layer with a p-type dopant (this practice being referred to as “p-doping”). A p-type dopant is an atomic or molecular species that when added to the HTL increases the conductivity for holes in the layer. Similarly, it was well known that one way to increase the conductivity of the electron transport layer in an OLED was to dope the electron transport layer with an n-type dopant (also known as “n-doping”). An n-type dopant is an atomic or molecular species that when added to the ETL increases the conductivity for electrons in the layer.

41. A notable example of this conductivity doping approach applied to OLEDs based on iridium-containing phosphorescent emitters is described in an article published by Pfeiffer et al. in 2002. Ex. 1016. In the Pfeiffer paper, a hole

transport layer of MTDATA is doped with the p-dopant F₄-TCNQ and an electron transport layer is doped with the n-dopant lithium. The OLED disclosed in the Pfeiffer paper also utilizes electron- and hole-blocking layers of Ir(ppz)₃ and BPhen, respectively and has an EML consisting of a CBP host doped with the iridium-containing compound Ir(ppy)₃. Pfeiffer et al. found that the inclusion of conductivity doping in the transport layers, and specifically n-doping the electron transport layer and p-doping the hole transport layer, reduced the OLED operating voltage and increased its power efficiency under display-relevant brightness conditions. This OLED configuration (with an n-doped electron transport layer and a p-doped hole transport layer) is often referred to as a “*p-i-n*” OLED. Pfeiffer et al.’s work was also notable in that it demonstrated how an OLED with an n-doped electron transport layer does not require a separate electron injection layer. Pfeiffer et al. note that the “[t]wo principle reasons for the low operation voltage ... are the *efficient injection from contacts into doped transport layers*, and the low ohmic losses in these high conductivity layers.” Ex. 1016, 1635 (emphasis added). Pfeiffer et al.’s work is an early demonstration of the dual impact of electron transport layer doping on conductivity and injection. Thus, while an OLED need contain hole- and electron-transport layers, it need not necessarily contain injection layers. Pfeiffer et al.’s work led to further investigation into n- and p- doping of transport layers to realize

improved performance in phosphorescent devices, and also led to commercialization efforts by Novaled.

42. Other OLEDs with doped electron and hole transport layers had also been successfully demonstrated by 2008. For example, in a 2004 paper He et al. demonstrated high performance phosphorescent OLEDs achieved by using a p-i-n OLED including a p-doped hole transport layer (doped with p-dopant F₄-TCNQ) and an n-doped electron transport layer (doped with n-dopant cesium). Ex. 1019 (He). Like the devices of Pfeiffer et al., those of He et al. did not require a separate electron injection layer when using a doped electron transport layer of BPhen, as the n-doped electron transport layer can itself serve to improve electron injection into the device. In a 2008 paper, Ma et al. similarly used doped transport layers to improve the performance of an OLED, by using a p-doped hole transport layer (doped with p-dopant F₄-TCNQ) and an n-doped electron transport layer (doped with n-dopant Liq). Ex. 1010 (Ma). Ma et al.'s work shows that the community was also actively working on molecular dopants containing lithium (for example, Liq) to increase the conductivity of electron transporting layers in OLEDs.

5. Encapsulation

43. At the same time that those in the art were working to improve device performance via the use of iridium-containing emission layers and n- and p-doped transport layers, there was simultaneously a significant effort directed at

developing the means to encapsulate OLEDs from the ambient environment and specifically to protect them from oxygen and water vapor to increase the device operational lifetime. There was a particular interest in developing flexible encapsulation solutions that could protect the OLED from the environment while maintaining sufficient mechanical flexibility to enable applications of OLEDs in flexible displays. It was also desirable for these solutions to be processed at low temperature (so as not to damage the OLED) and for the encapsulation to be optically transparent (so that light generated within the OLED could escape the device).

44. One such solution known in the art at the time was the use of a multilayer barrier coating consisting of alternating organic and inorganic layers as described, for example, in a 2004 publication by Moro et al. Ex. 1020 (Moro). Specifically, Moro et al. fabricated an OLED in which an organic layer was deposited onto the OLED followed by polymerization with ultraviolet light to form an insulation layer comprising an insulating acrylic polymer film. Ex. 1020 (Moro). The polymer layer is then followed by the deposition of an inorganic metal oxide layer. In this structure, the inorganic layer serves as the moisture/oxygen permeation barrier while the polymer layer serves to planarize the layer and enable the smooth deposition of the inorganic layer, minimizing the presence of defects. This structure serves to decouple the propagation of defects between these layers, removing continuous channels for moisture and oxygen diffusion. Multi-layer encapsulations

such as this create a tortured path for diffusion, improving the encapsulation ability of the structure and in doing so, better protecting the OLED and extending its life. This encapsulation approach was also applied to phosphorescent OLED displays by Chwang et al. in order to realize flexible devices on plastic substrates. Ex. 1021 (Chwang). At the time, this approach was already being developed commercially by Vitex Systems, reflecting the understanding in the art at the time that stacks of dissimilarly structured materials could serve as effective encapsulation layers for phosphorescent OLEDs.

VI. OVERVIEW OF U.S. PATENT NO. 11,828,425

A. Summary

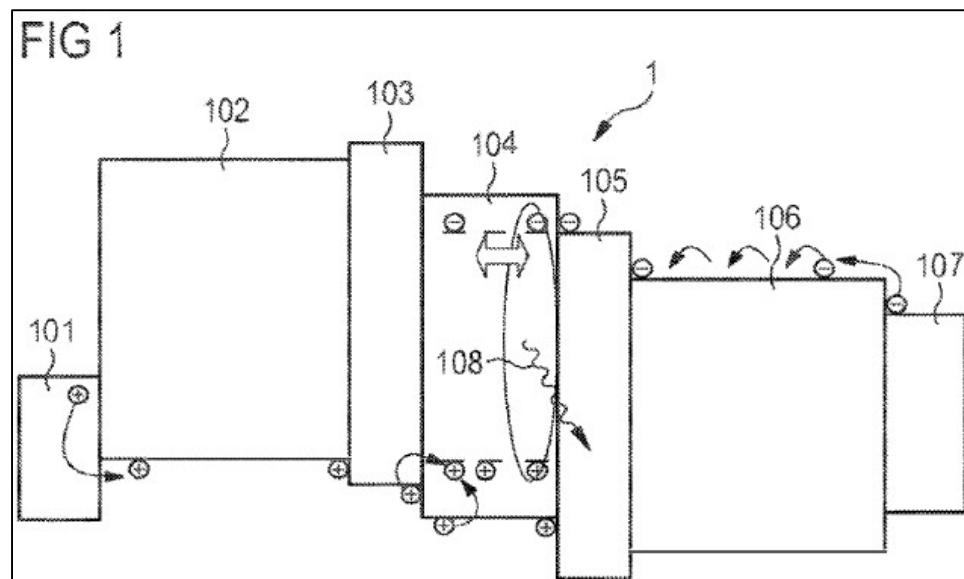
45. The '425 patent is entitled "Organic-Light Emitting Diode" and name as inventors Ulrich Kastner-Jung, Markus Klein, Stan Maes, Romana Sigl, Annette Haid, Stephan Lintner, Julian Herget, and Gregor Matjan. The '425 patent is generally directed to "to an organic light-emitting diode comprising an organic layer sequence, a radiation exit area and an encapsulation." '425 patent, 1:29–31.

46. A stated object of the patent is "to provide organic light-emitting diodes which can be used particularly diversely." '425 patent, 1:26–27. For example, the patent describes "organic light-emitting diodes which are transparent, emit on both sides, emit white light, emit colored light, emit infrared radiation, emit light

diffusely, are rigid, are flexible and/or emit directional radiation.” ’425 patent, 1:39–43.

47. The patent explains that its stated objective may be achieved by an OLED with an organic layer sequence that “comprises at least one radiation-emitting region which generates electromagnetic radiation in the spectral range from infrared radiation to UV radiation during operation.” ’425 patent, 1:28–38. The patent further explains that the radiation exit area (*i.e.* where light leaves the device) “is structured, so that the electromagnetic radiation has a directional emission profile.” ’425 patent, 1:28–38. There is also an encapsulation which “forms a seal of the organic layer sequence against environmental influences.” ’425 patent, 1:28–38.

48. Figure 1, below, depicts an exemplary “organic light-emitting diode 1” according to the ’425 patent.



'425 patent, Fig. 1.

49. This exemplary organic light emitting diode comprises a “first electrode 101” as an anode, a “hole transport layer 102 adjoin[ing] the first electrode 101” for “transport[ing] the positive charge carriers toward the radiation-emitting region 104 of the organic light-emitting diode 1,” ’425 patent, 24:37–40, and “an electron barrier layer 103, which prevents the penetration of electrons from the radiation-emitting region 104 into the hole transport layer 102,” ’425 patent, 24:41–46. Within the organic layer sequence of the OLED can be seen the radiation-emitting region 104 which “[d]uring the operation of the organic light-emitting diode 1, [generates] electromagnetic radiation” preferably “in the spectral range of infrared radiation to [U]V radiation.” ’425 patent, 24:46–54. The radiation-emitting region 104 adjoins “a hole barrier layer 105, which prevents the penetration of positive charge carriers into the adjoining electron transport layer 106.” ’425 patent, 24:55–58. The OLED also contains an electron transport layer 106 which “adjoins the hole barrier layer 105 and transports negative charge carriers—electrons—from the second electrode 107, embodied as a cathode, to the radiation-emitting region 104.” ’425 patent, 24:59–62. As was typical at the time, the hole transport layer 102 and electron transport layer 106 “comprise, for example, a matrix material that is p- and n-doped, respectively.” ’425 patent, 24:63–67.

50. The '425 patent includes one independent claim (claim 1) and eighteen dependent claims (claims 2–19).

B. Priority Date of the '425 Patent

51. I have been asked to assume that the earliest possible priority date for the '425 patent is December 11, 2008, the earliest Foreign Application Priority Date listed on the face of the '425 patent. I have therefore analyzed the prior art as of that date or somewhat before that date.

C. Prosecution History

52. I have reviewed the prosecution history of the '425 patent (Ex. 1002).

53. I understand that '425 patent is a continuation of Application No. 16/790,198 (“’198 Application”), which is a continuation of Application No. 15/651,508 (“’508 Application”), which is a continuation of Application No. 13/139,514 (“’514 Application”), filed as PCT Application No. PCT/DE2009/001741 on December 9, 2009.

54. During prosecution of the '514 Application, the then-pending claims were subject to numerous rejections, Ex. 1025, 1050–1080; 1154–1192; 1269–1293; 1326–1357, including a rejection of some claims as anticipated by, or obvious over, Diekmann in view of other references. Ex. 1025, 1406–1413. Specifically, the Examiner determined that Diekmann teaches an “organic light-

emitting diode” comprising a “plurality of functional layers” with “at least one radiation-emitting region in which electromagnetic radiation is generated . . . in the spectral range from infrared radiation to UV radiation during operation,” an “encapsulation” with layers having “unique volume structure,” comprising “silicon oxide and silicon nitride,” and formed by a “PECVD method.” Ex. 1025, 1406–1411.

55. The Examiner also indicated that some claims were allowable because they included particular features not taught by the references of record. The allowed claims, as seen below, included highly specific, narrow limitations relating to the device’s encapsulation and pre-encapsulation layers.

- “the volume structure of the first encapsulation layer being in crystalline or poly-crystalline form and having lattice defects which form a permeation path for moisture and/or oxygen and the second encapsulation layer being arranged directly on the first encapsulation layer and in direct contact with the first encapsulation layer and having a common interface with the first encapsulation layer, wherein the second encapsulation layer is amorphous and does not continue the lattice defects of the first encapsulation layer”
- “on the side facing away from the functional layers the encapsulation being covered by a pre-encapsulation layer which serves for encapsulating the organic layer sequence and as a planarization layer for the encapsulation, wherein the pre-

encapsulation layer comprises a transparent epoxide or a radiation-transmissive adhesive and a second carrier is applied to the pre-encapsulation layer on a side of the pre-encapsulation layer facing away from the encapsulation.”

Ex. 1025, 1413–1414.

56. Applicants did not dispute the Examiner’s findings. Rather, applicants filed an amendment in which they cancelled prosecution claims 9–21 and amended dependent claims 22 and 23 by rewriting them in independent claim form and importing all of the limitations from the now-cancelled independent claim 9 on which they had previously been dependent. Ex. 1025, 2038–2042, 2050–2056. Thus, the ’514 Application claims were only allowed over Diekmann because they included the highly specific limitations about encapsulation or pre-encapsulation layers shown above.

57. During prosecution of the ’514 Application, in order to overcome the numerous rejections issued by the Examiner, Applicants repeatedly sought to explain the meaning of the terms “volume structure” and “amorphicity.” These same terms also appear in claim 4 of the ’425 Patent. Specifically, Applicants argued that “volume structure” is “a term of art to a person of ordinary skill in the pertinent art,” and that it is distinct from “surface structure”:

Thus, in solids there is a well-ordered molecular, atomic or ionic arrangement. Part of the atoms or molecules of the solid are ordered at

the surface of the solid and is called surface structure. Part of the atoms or molecules of the solid are ordered inside the solid, wherein every atom or molecule has neighbors. This part is called a “volume structure.”

Ex.1025, 1386; *see also id.*, 1241, 1313.

58. Regarding these same terms, Applicants also argued that “[i]n the present application, the term ‘volume structure’ was chosen to comprise any structure ranging from polycrystalline to polyamorphous.” Ex.1025, 1241; *see also* Ex. 1025, 1313-1314, 1386–1387. Applicants further stated that “examples of volume structures” include “crystalline, partly crystalline and/or polycrystalline or completely amorphous.” Ex.1025, 1241; *see also* Ex. 1025, 1313–1314, 1386–1387. Applicants further explained that a crystal structure has “long range order and symmetry,” whereas in an amorphous structure, “atoms or molecules do not have a long range order, but a short range order.” Ex.1025, 1314.

59. The prosecution claims of the ’508 and ’198 Applications were also rejected numerous times. However, during the prosecution histories of these patents, Diekmann was not cited by the Examiner and was not substantively discussed. *See generally* Exs. 1026, 1027.

60. Notably, during prosecution, the ’198 Application was reassigned to a different Examiner who withdrew all rejections and allowed the

claims to issue. Ex. 1027, 420–424, 449–456. This same Examiner also allowed '425

Patent to issue without any rejections, and in the Notice of Allowance identified the following limitations as containing allowable subject matter:

wherein the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation, wherein the organic layer sequence comprises an electron transport layer that is n- doped; and wherein the organic layer sequence comprises an emission layer comprising an iridium-containing compound.

Ex. 1002, 267–268.

61. Diekmann was not listed among the prior art references considered by the '425 Examiner during prosecution of the '425 patent, and it remains unclear whether the '425 Examiner considered Diekmann in allowing the claims to issue. The '514 Examiner considered Diekmann to be highly relevant to the claims of the '514 Application, which had substantively identical limitations to those in the '425 Patent. As noted above, Applicants obtained allowance over Diekmann only by incorporating highly specific limitations that are not present in any of the claims of the '425 Patent.

D. The Claims at Issue

62. I have been asked to consider the patentability of claims 1–19 of the '425 patent (“Challenged Claims”). Those claims are reproduced below for reference:

1. A device comprising:
an organic light-emitting diode comprising:
an organic layer sequence,
a radiation exit area, and
an encapsulation,
wherein the organic layer sequence and the encapsulation are disposed on a carrier,
wherein the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation,
wherein the organic layer sequence comprises an electron transport layer that is n-doped; and
wherein the organic layer sequence comprises an emission layer comprising an iridium-containing compound.

2. The device of claim 1,
wherein the electron transport layer comprises 8-hydroxyquinolinolato-lithium.

3. The device of claim 1,

wherein at least one part of the encapsulation is formed by an insulation layer, and

wherein the insulation layer comprises at least one of: resin, silicon oxide, silicon nitride.

4. The device of claim 1,

wherein the encapsulation comprises a first encapsulation layer and a second encapsulation layer,

the first and the second encapsulation layer each having a respective volume structure,

wherein the volume structure of the second encapsulation layer is independent of the volume structure of the first encapsulation layer, and the volume structure of the second encapsulation layer has a higher amorphicity than the volume structure of the first encapsulation layer.

5. The device according to claim 1,

wherein the organic light-emitting diode comprises a hole transport layer that is p-doped.

6. The device according to claim 1,

wherein a color filter is arranged between the emission layer and the radiation exit area, and

wherein the color filter is configured to be highly transmissive for a first spectral subrange of the generated electromagnetic radiation and highly absorbant for a second spectral subrange of the generated electromagnetic radiation.

7. The device according to claim 1,
wherein the encapsulation is flexible.

8. The device according to claim 7,
wherein the carrier comprises a film, a plastic film or a laminate.

9. The device according to claim 1,
wherein the device comprises at least one touch-sensitive operating
element, and
wherein the at least one touch-sensitive operating element comprises at
least one touch sensor.

10. The device according to claim 9,
wherein the at least one touch sensor is integrated into the organic light-
emitting diode.

11. The device according to claim 10,
wherein the touch-sensitive operating element is arranged at the
radiation exit area of the device.

12. The device according to claim 1,
wherein the device is drivable by means of a gesture control.

13. The device according to claim 1,

wherein the organic light-emitting layer sequence comprises a cathode having a thickness of at least 1 nm and at most 50 nm.

14. The device according to claim 13, wherein the cathode comprises one of: silver, magnesium, or an alloy comprising silver and magnesium.

15. The device according to claim 13, wherein the cathode is in direct contact with a lithium containing layer.

16. The device according to claim 13, wherein the cathode comprises silver, magnesium, or alloy consisting of at least one of the abovementioned materials.

17. The device according to claim 1, wherein the electron transport layer comprises at least 8-hydroxyquinolinolato-lithium.

18. The device according to claim 1, wherein at least one part of the encapsulation is formed by an insulation layer, which can contain at least one of the following electrically insulating materials: resin, silicon oxide, silicon nitride, and wherein at least one part of the encapsulation is formed by a PECVD method.

19. The device according to claim 1, wherein the organic light-emitting diode is configured for installation in a vehicle.

VII. LEVEL OF ORDINARY SKILL IN THE ART

63. I have been informed by counsel that there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including the educational level of active workers in the field at the time of the alleged invention, the sophistication of the technology, the type of problems encountered in the art, and the prior art solutions to those problems.

64. Considering these factors, it is my opinion a person of ordinary skill in the art (POSITA) at the time of the alleged inventions 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.

65. At the time of the alleged invention of the '425 patent, I would have qualified as at least a POSITA. As discussed above, I was actively working in the field at that time. My opinions herein are informed by my own knowledge and personal experience, as well as my observations of others of various skill levels working in the field.

VIII. CLAIM CONSTRUCTION

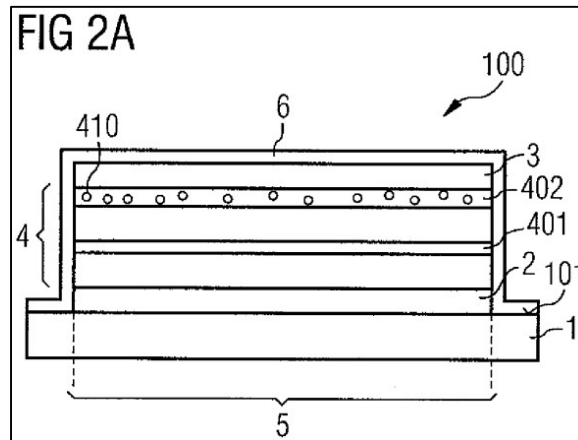
66. I understand that in IPR proceedings, claims are construed in accordance with their ordinary and customary meaning in light of the specification. For the purposes of my opinions, I have been asked to assume that the claim terms should be given their plain and ordinary meaning. I have therefore applied the terms' plain and ordinary meaning in my analysis.

IX. OVERVIEW OF THE PRIOR ART REFERENCES

A. Diekmann (Ex. 1004)

67. Diekmann is an international patent application publication filed on September 26, 2007 and published on April 10, 2008. Diekmann, 1. I am informed that Diekmann is therefore prior art to the '425 patent.

68. Similar to the '425 patent, Diekmann relates to “an organic lighting device and lighting equipment with such a lighting device” Diekmann, 1. Figure 2A of Diekmann, seen below, illustrates an embodiment of the OLED disclosed by Diekmann:



Diekmann, Fig. 2A.

69. Diekmann explains that the OLED seen above in Figure 2A comprises a “substrate 1 having a first main surface 101, to which the first electrode 2 is applied within an active region 5 of the substrate 1.” Diekmann, 91. In addition, “[a]n organic layer stack 4 with at least one layer 401 suitable for generating light is arranged on the first electrode 2, to which the second electrode 3 is applied.” Diekmann, 91. Diekmann also explains that “the first electrode 2 on the substrate 1 is the anode and the second electrode 3 on the organic layer stack 4 is the cathode.” Diekmann, 91. Diekmann further explains that “[o]n its outer side facing the cathode, the organic layer stack 4 has a doped layer 402 with a dopant 410, which acts as an electron donor” which “advantageously increases the injection of electrons from the cathode into the organic layer stack.” Diekmann, 91. Diekmann similarly explains that the advantage of doping this layer is that it “advantageously increases the conductivity of the doped organic layer and, in the case of an n-doped layer

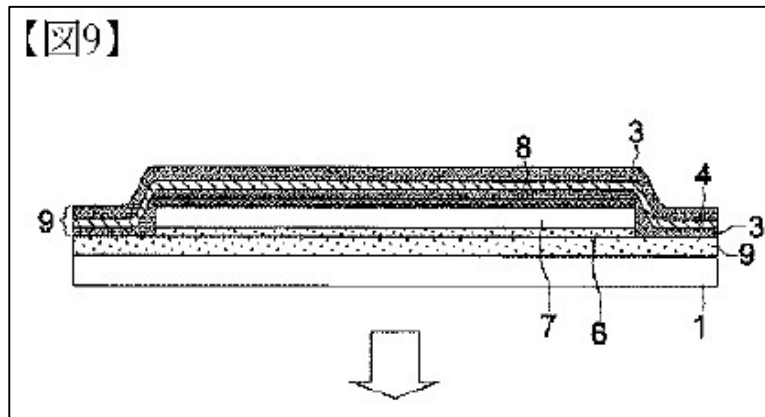
adjacent to the cathode, leads to better injection of electrons from the cathode into the organic layer stack or, in the case of a p-doped layer adjacent to the anode, to better hole injection from the anode into the organic layer stack.” Diekmann, 10. Additionally, there is a thin-film encapsulation 6 that is “applied directly to the second electrode.” Diekmann, 92.

70. Diekmann explains that its OLED is “designed to be transparent to visible light, in particular to light generated by the organic layer stack.” Diekmann, 92. To achieve this, Diekmann explains that the substrate, the first electrode, the organic material in the organic layer stack, the second electrode, and the thin-film encapsulation, are all designed to be “transparent to visible light.” Diekmann, 92, 94.

B. Suzuki (Ex. 1006)

71. Suzuki is a Japanese patent application publication published on October 25, 2007. Suzuki, 1. I am informed that Suzuki is therefore prior art to the ’425 patent.

72. Similar to the ’425 patent, Suzuki relates to “an organic electroluminescent device” using a “gas barrier resin substrate material.” Suzuki [0001]. Figure 9 of Suzuki, seen below, illustrates an embodiment of the OLED disclosed by Suzuki:



Suzuki, Fig. 9.

73. The OLED seen in Figure 9 comprises, “an anode, a light emission layer or the like, an organic layer, and a cathode is formed on the gas barrier resin substrate material of the present invention, and then a gas barrier thin film laminate comprising the buffer film and the barrier film according to the present invention is formed on the cathode and sealed.” Suzuki, [0274]. In the drawing, the organic EL element is configured by laminating, in order, an anode 6 comprising ITO, an organic layer (comprising a hole transport layer, a light emission layer, an electron transport layer, and the like) 7, and a cathode 8 on a resin substrate material 1 on which a gas barrier thin film laminate 9 is formed. Suzuki, [0274].

C. Ma (Ex. 1010)

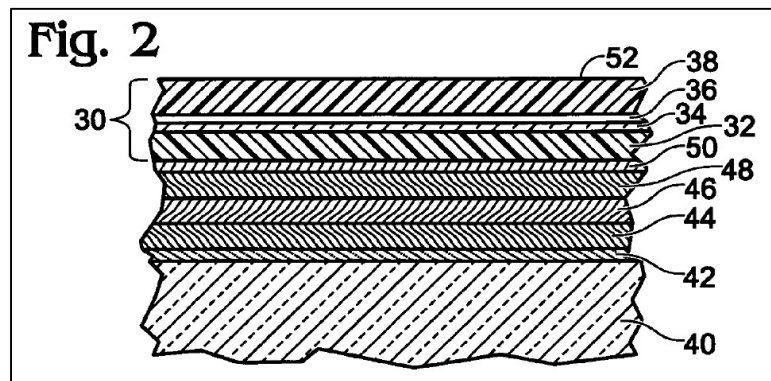
74. Ma is a research publication published on August 29, 2008. Ma, 810. I am informed that Ma is therefore prior art to the '425 patent.

75. Ma is a study of “[o]rganic light-emitting diodes with 8-hydroxy-quinolinato lithium doped 4’7-diphenyl-1,10-phenanthroline as electron transport layer.” Ma, Abstract. Ma conducted research and testing concerning the “conductivity of carrier transport layers with different doping concentration” and concluded that a “doping concentration of the Liq” (short for 8-hydroxy-quinolinato lithium) in the electron transport layer results in increased current density and reduced driving voltage compared to the undoped device. Ma, Abstract, 813. Ma also concluded that a certain doping ratio of Liq to Bphen (electron transport layer material) can “improve the electron transport ability of the co-deposited layer.” Ma, 813. Specifically, Ma attributed the improved current and power efficiency to “the improved conductivity of the transport layers and the efficient charge balance in the emission zone.” Ma, Abstract.

D. Lee (Ex. 1008)

76. Lee is a U.S. patent application publication filed on December 8, 2004 and published on July 7, 2005. Lee, 1. I am informed that Lee is therefore prior art to the ’425 patent.

77. Lee relates to “an organic light emitting device having a barrier for protection against environmental degradation.” Lee [0002]. Figure 2 of Lee, below, illustrates an embodiment of such an organic light emitting device:



Lee, Fig. 2.

78. Lee discloses an OLED with a multi-layered encapsulation, including parylene-based polymer layers 32 and 38 sandwiching an inorganic barrier layer 34. Lee, [0022]. Layer 32 is formed by depositing a “semi-crystalline parylene-based polymer,” and layer 38 is formed by depositing a semi-crystalline parylene-based polymer and then annealing it to form a “highly crystalline parylene-based polymer.” Lee, [0021]. This annealing process increases the crystallinity of the polymer film. Lee, [0024]. Thus, the layers 32 and 38 in Lee’s OLED have different levels of crystallinity: “the first semi-crystalline and second highly crystalline parylene-based polymer layers respectively have at least 10% and up to 70% of crystallinity.” Lee, [0023].

79. Lee explains that the OLED is formed on a substrate 40 and includes “a transparent anode 42, an organic hole transport layer 44, an organic light emitting layer 46, an organic electron transport layer 48, and a cathode 50.” Lee,

E. Koshihara (Ex. 1012)

second detection electrode 18, the dielectric film 15, and the detection unit 16.”

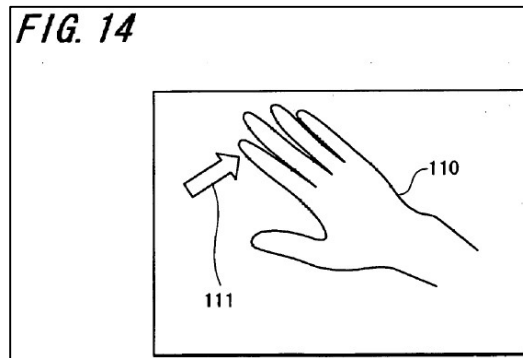
Koshihara, [0031]. These components act together as a touch panel unit to detect touch inputs. Koshihara, [0031]. The “first detection electrode 14” is located “on the inner surface of the counter sealing substrate 12.” Koshihara, [0031].

F. Harada (Ex. 1009)

83. Harada is a U.S. patent application publication filed on March 24, 2006 and published on September 28, 2006. Harada, 1. I am informed that Harada is therefore prior art to the ’425 patent.

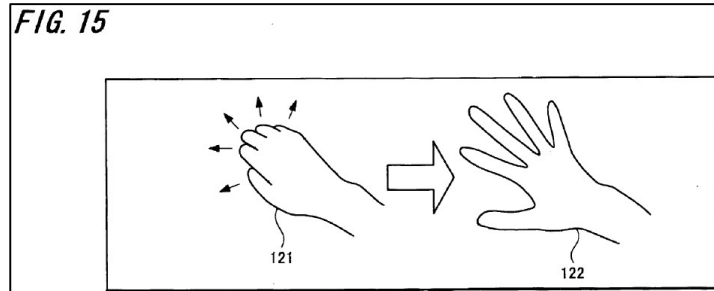
84. Harada relates to “a display technology capable of receiving light in parallel with emitting light,” which can be applied to an “organic EL (Electro-Luminance) display.” Harada, [0003]. Harada refers to this as an “I/O” display. This I/O display device is capable of gesture recognition, “detect[ing] not only a touch that is a state of the screen being touched, but also an object approached to the screen.” Harada, [0039].

85. Figure 14, for example, “shows an example of gesture recognition using a hand shape” in which “the shape of a hand 110 touched (or approached) to a display panel is recognized, and the hand shape recognized is displayed as an image and then with a display object move 111, some processing is performed.” Harada, [0071].



Harada, Figure 14.

86. Figure 15, below, similarly “shows an example in which a hand closed 121 is changed to a hand opened 122 and the touch or approach of the hand (121, 122) in each condition is recognized as an image on the display panel and the processing based on the image-recognition is executed.” Harada, [0072].

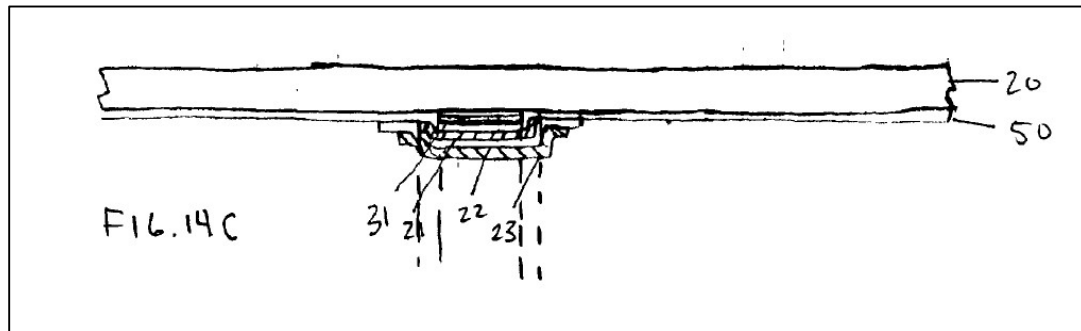


Harada, Fig. 15.

G. Caldwell (Ex. 1011)

87. Caldwell is a U.S. patent application publication filed on October 15, 2002 and published on August 28, 2003. Caldwell, 1. I am informed that Caldwell is therefore prior art to the '425 patent.

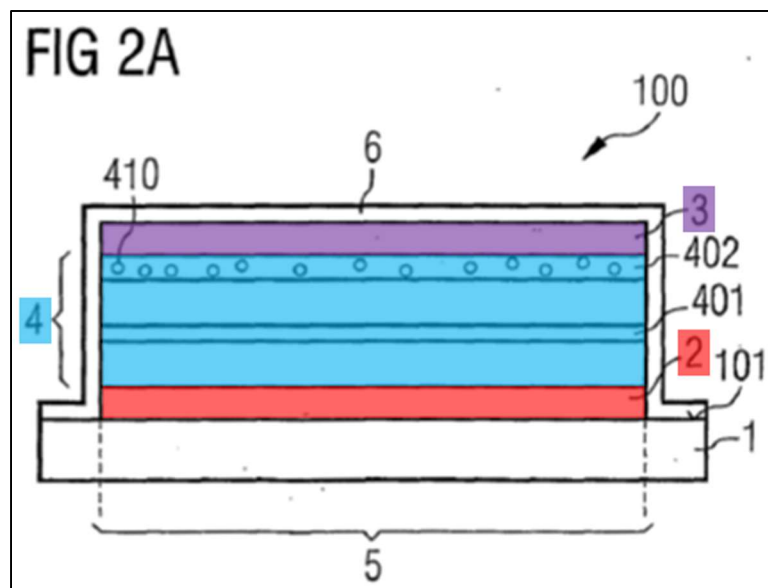
88. Caldwell relates to the “integration of touch sensors with light emitting devices,” Caldwell [0007], including OLEDs. Caldwell, [0004]–[0006]. Figure 14C depicts an embodiment of such a bottom-emitting OLED with an integrated touch sensor:



Caldwell, Fig. 14C.

89. As seen in Figure 14C, this comprises an anode 21, an emissive stack 22, and a cathode 23, as well as a touch electrode 31. Caldwell, [0074]. Touch electrode 31 can be seen overlying anode 21, “which in turn overlies emissive stack 22 and cathode 23.” Caldwell, [0074]. Additionally, there is an “insulating layer 50” which “separates electrode 31 from the layers of the light emitting device.” Caldwell, [0074]. Caldwell explains that “[i]nsulating layer 51 is preferably transparent and can be SiO₂ or any other suitable dielectric material.” Caldwell, [0074]. Caldwell also specifies that each of these components are “borne on substrate 20.” Caldwell, [0074].

Diekmann, 91. This OLED can be seen in the annotated version of Diekmann's Figure 2A, below:

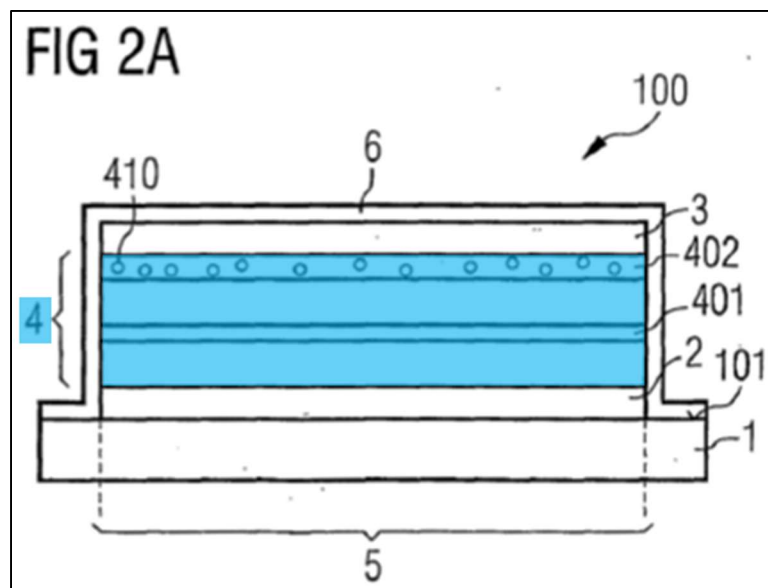


holes into the organic layer stack,” and the cathode “injects electrons into the organic layer stack.” Diekmann, 3. As I explained in §§V.A.1–V.A.3 above, this process of

recombination of holes and electrons in the organic layer stack is what generates light in an OLED. Thus, Diekmann describes an organic light-emitting diode. *See* '425 patent, Fig. 1; '425 patent, 24:30–62. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

c. Element 1[b]: an organic layer sequence,

94. Diekmann discloses this element. Diekmann discloses that the OLED, discussed above, includes an organic layer sequence (which Diekmann refers to as an “organic layer stack”). Specifically, Diekmann teaches an “organic layer stack 4 with at least one layer 401 suitable for generating light” and “a doped layer 402,” Diekmann, 91, as can be seen in the annotated Figure 2A below:

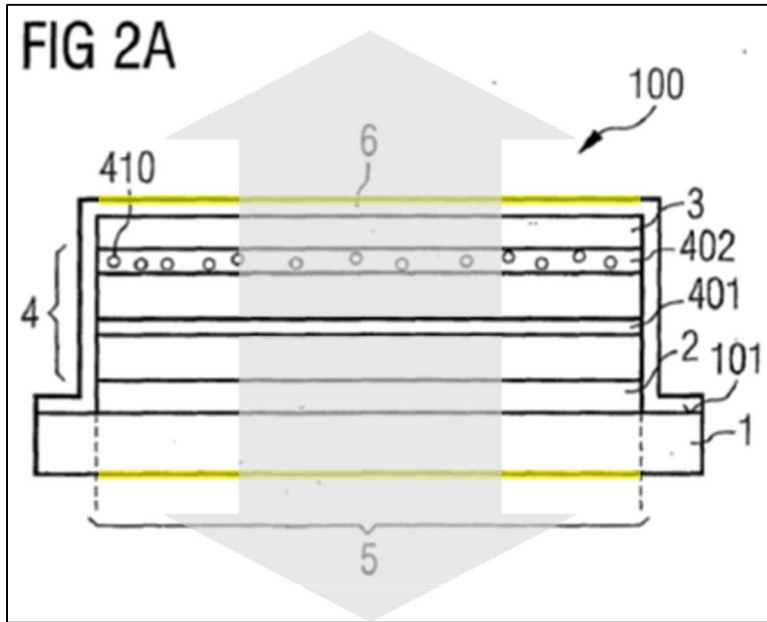


Diekmann, Fig. 2A (annotated).

95. Diekmann explains that organic layer stack 4 includes multiple layers applied in sequence to the first electrode 2. Diekmann, 91. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

d. Element 1[c]: a radiation exit area, and

96. Diekmann discloses this element. Diekmann discloses that the OLED, discussed above, further includes a radiation exit area. Diekmann teaches that “[t]he lighting device according to Figure 2A is designed to be transparent to visible light, in particular to light generated by the organic layer stack 4.” Diekmann, 92. Diekmann accomplishes this by teaching that each of substrate 1, first electrode 2, organic layer stack 4, second electrode 3, and thin-film encapsulation 6 are each designed to be “transparent to visible light” that is “generated by the organic layer stack.” Diekmann, 92, 94. The OLED disclosed by Diekmann includes radiation exit areas at the top and bottom of the OLED, as illustrated in the annotated Figure 2A below:

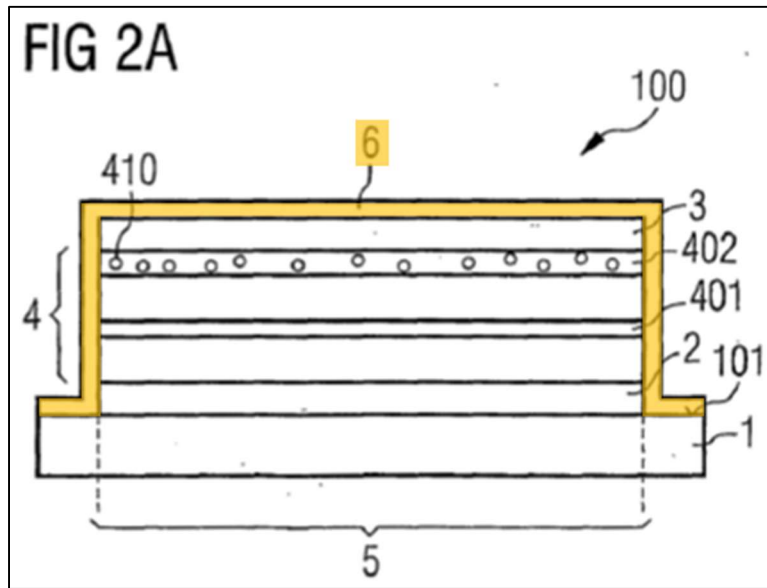


Diekmann, Fig. 2A (annotated).

97. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

e. Element 1[d]: an encapsulation,

98. Diekmann discloses this element. Diekmann discloses that the OLED, discussed above, is encapsulated within an encapsulation. Specifically, the encapsulation is a “thin-film encapsulation 6.” Diekmann, 92. The encapsulated OLED can be seen in annotated Figure 2A below:

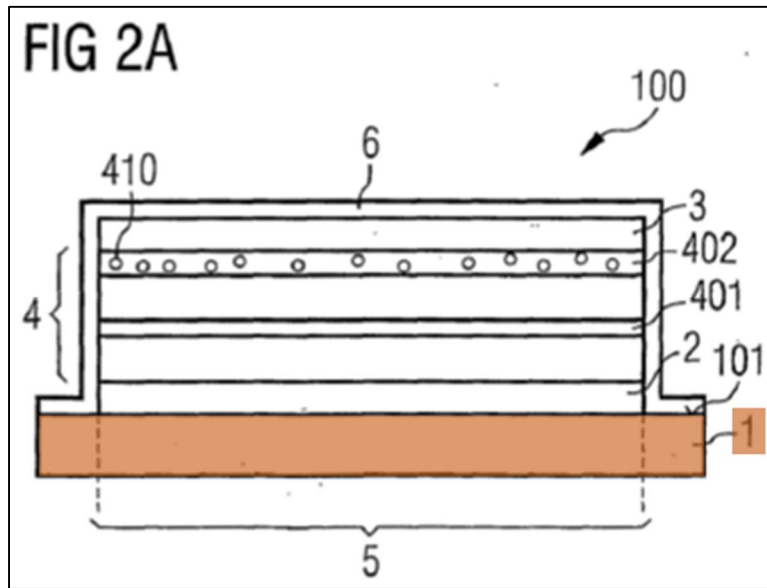


Diekmann, Fig. 2A (annotated).

99. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

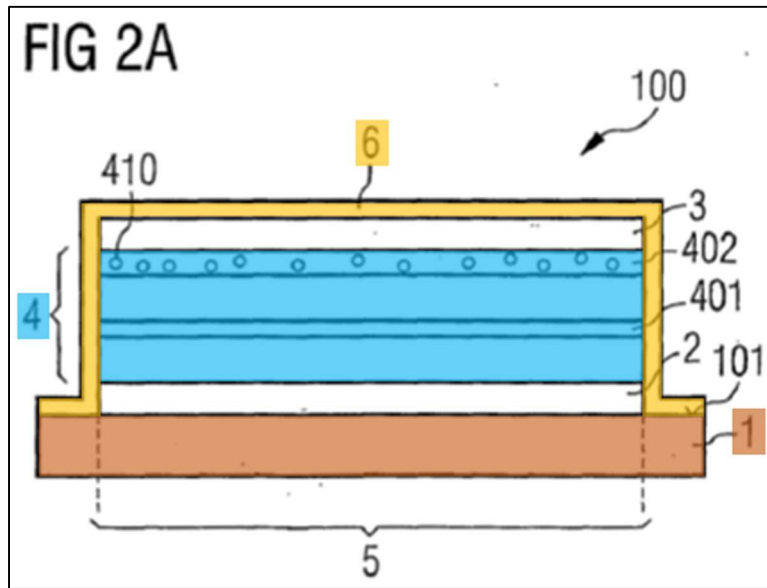
f. Element 1[e]: wherein the organic layer sequence and the encapsulation are disposed on a carrier,

100. Diekmann discloses this element. Diekmann discloses that its OLED includes a carrier, “substrate 1.” Diekmann teaches that its organic layer sequence, discussed above, is mounted on this carrier: “organic layer stack 4 . . . is arranged on the first electrode 2,” which is applied to the substrate 1. Diekmann, 91. This is illustrated in the annotated Figure 2A below.



Diekmann, Fig. 2A (annotated).

101. Diekmann further teaches the “thin-film encapsulation 6 is applied directly to the second electrode 3,” which is applied to the “organic layer stack 4.” Diekmann, 92. The encapsulation is thus also disposed on the carrier, as depicted in Figure 2A. Indeed, portions of Diekmann’s thin-film encapsulation 6 are in direct contact with portions of substrate 1, as seen below:



Diekmann, Fig. 2A (annotated).

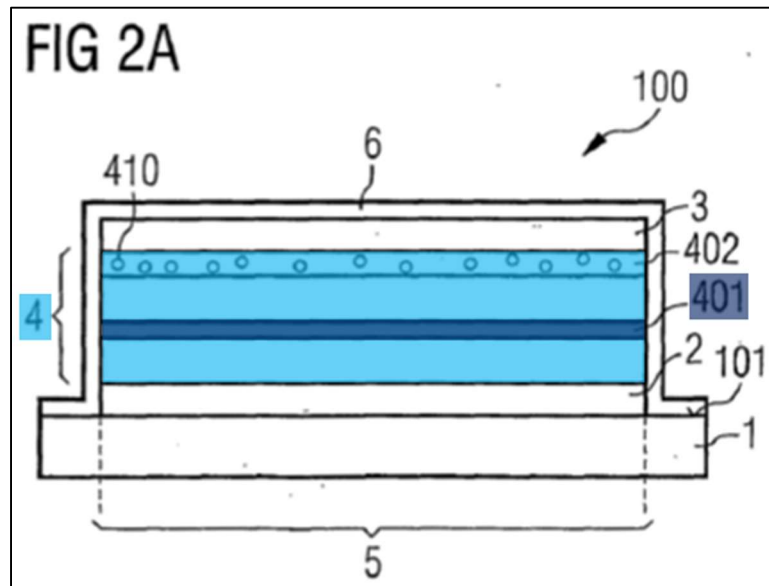
102. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

- g. Element 1[f]: wherein the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation,**

103. Diekmann discloses this element. Diekmann discloses that its organic layer sequence (organic layer stack 4) includes “at least one layer 401 suitable for generating light.” Diekmann, Fig. 2A (annotated); Diekmann, 91. Diekmann further teaches that “[t]he electromagnetic radiation generated by the active area of the radiation-emitting component may in particular have a spectrum with wavelengths *in an ultraviolet to infrared spectral range.*” Diekmann, 76

(emphasis added). The radiation-emitting region (layer 401) can be seen in annotated

Figure 2A below:



Diekmann, Fig. 2A (annotated).

104. Diekmann further explains “[t]he organic layer stack 4 can, for example, comprise the layers of the organic layer stack of Figure 1” Diekmann, 92, which includes as radiation-emitting regions “a SEB-010:SEB020 layer . . . a TMM-004:Ir(ppy)₃(15%) layer . . . and a TMM-04:TER012 layer,” Diekmann, 91. Diekmann discloses that “[t]his organic layer stack is suitable for emitting white light.” Diekmann, 91. Thus, a POSITA would recognize that these emissive layers are configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation.

105. In particular, SEB-010:SEB-020 is a blue light-emitting layer, TMM-004:Ir(ppy)₃(15%) is a green light-emitting layer, and TMM-004:TER-012 is a red light-emitting layer. *E.g.*, Ex. 1028 (Klein), [0064]. These blue, green, and red light-emitting layers will generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

h. Element 1[g]: wherein the organic layer sequence comprises an electron transport layer that is n-doped; and

106. Diekmann discloses this element. Diekmann teaches that its organic layer sequence comprises an electron transport layer (layer 402) that is n-doped: “organic layer stack 4 has a doped layer 402 with a dopant 410, which acts as an electron donor. . . . The dopant 410 can be for example cesium, barium or lithium fluoride.” Diekmann, 91. Diekmann notes that “doping advantageously increases the conductivity of the doped organic layer and, in the case of an n-doped layer adjacent to the cathode, leads to better injection of electrons from the cathode into the organic layer stack.” Diekmann 10. This description of the function of the n-doped layer is consistent with prior work describing the function of an n-doped electron transport layer (see my discussion of Pfeiffer et al. (Ex. 1016) above in §V.A.4.b). It would be clear to a POSITA that doped layer 402 is an electron

transport layer, and that an electron transport layer containing electron donating dopants would be considered an n-doped layer.

107. Diekmann teaches that its doped layer 402 is situated between the cathode 3 and radiation-emitting region 401. This layer thus plays an central role in transporting electrons from the cathode to the emissive layer of the OLED (401) and is an electron transport layer, as I explained above in §V.A.4.b. This is also recognized in '425 patent itself, which explains that the “electron transport layer” serves the function of “transport[ing] negative charge carriers—electrons—from the . . . cathode, to the radiation-emitting region.” '425 patent, 24:59–62.

108. Diekmann also teaches exemplary materials to use in its electron-conducting layer, such as Alq3, BALq, and TPBi. Each of these exemplary materials were well-known materials for electron transport layers at the time. *See, e.g.*, Ex. 1014. Indeed, the '425 patent itself lists Balq and TPBi as exemplary electron transport layer materials. '425 patent, 26:32–43. It would be clear to a POSITA that doped layer 402 in Diekmann's OLED is an electron transport layer.

109. Diekmann further discloses that this electron transport layer (doped layer 402) is n-doped: Diekmann teaches that doped layer 402 “is generally an n-doped layer” in which “[p]referred n-dopants are cesium, barium and lithium fluoride.” Diekmann, 10; Diekmann, 91 (“[T]he organic layer stack 4 has a doped layer 402 with a dopant 410, which acts as an electron donor.”); Diekmann, 119

(“the dopant 410 of the doped layer comprises . . . atoms or molecules which . . . are suitable for emitting electrons - n-dopant.”).

110. Even had Diekmann not disclosed that its doped layer is an n-doped electron transport layer, it would have been obvious to a POSITA to include an n-doped electron transport layer in the organic stack 4 of Diekmann’s OLED. At the time of the ’425 patent, using n-doped electron transport layers was well known in the art. *See, e.g.*, Exs. 1016 (Pfeiffer); 1019 (He); 1029; 1030. A POSITA would have known that n-doping the electron transport layer would have clear benefits, including promoting injection of electrons from the cathode and improving transportation of electrons to the light-emitting region. Diekmann, 10. A POSITA would have understood that this would also lead to improved device characteristics, such as lower driving voltage and better power efficiency. *See, e.g.*, Ma, 810; Ex. 1016 (Pfeiffer); Ex. 1019 (He); Ex. 1029; Ex. 1030.

111. In light of these well-known benefits, a POSITA would have been motivated to include an n-doped electron transport layer in Diekmann’s OLED. Indeed, as I explained in §V.A.4.b above, n-doped electron transport layers were widely used at the time in OLEDs to achieve these known benefits, and n-doping the electron transport layer of Diekmann’s OLED so would be a routine, well-known process that would be simple to execute for a POSITA. Thus, it would at least have been obvious to a POSITA to include in Diekmann’s organic stack 4 an n-doped

electron transport layer. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

i. Element 1[h]: wherein the organic layer sequence comprises an emission layer comprising an iridium-containing compound.

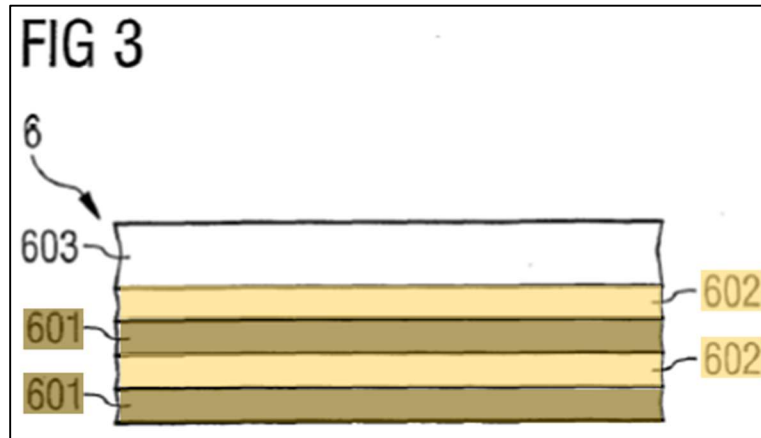
112. Diekmann discloses this element. Diekmann teaches that its organic layer sequence (organic layer stack 4) comprises a layer containing Ir(ppy)₃, which is an iridium-containing compound. Specifically, Diekmann teaches that “[t]he organic layer stack 4 can, for example, comprise the layers of the organic layer stack of Figure 1,” Diekmann, 92, which includes “a TMM-004:Ir(ppy)₃(15%) layer (Irppy = fac-tris(2-phenyl-pyridyl)iridium complex).” Diekmann, 91. The TMM-004:Ir(ppy)₃(15%) layer contains Ir(ppy)₃, which is an iridium-containing compound which functions as a green light-emitting phosphorescent dopant. Ex. 1014, 4. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

2. Dependent Claim 3

a. The device of claim 1, wherein at least one part of the encapsulation is formed by an insulation layer,

113. Diekmann discloses this element. Diekmann teaches that its encapsulation is a thin-film encapsulation (labeled 6), and explains that “[a]

schematic sectional view through a thin-film encapsulation 6, such as can be used according to Figure 2A, is shown in Figure 3.” Diekmann, 94.



Diekmann, Fig. 3 (annotated).

114. Diekmann explains “the thin-film encapsulation 6 comprises two first barrier layers 601, which comprise silicon oxide or consist of silicon oxide, and two second barrier layers 602, which comprise silicon nitride or consist of silicon nitride.” Diekmann, 94. A POSITA would recognize that both silicon oxide and silicon nitride are insulating materials. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

b. wherein the insulation layer comprises at least one of: resin, silicon oxide, silicon nitride.

115. Diekmann discloses this element. As I explained above, Diekmann’s encapsulation includes insulation layers comprised of the insulating materials silicon oxide and silicon nitride. Diekmann, 94 (“the thin-film encapsulation comprises two first barrier layers 601, which comprise *silicon oxide*

or consist of silicon oxide, and two second barrier layers 602, which comprise *silicon nitride* or consist of silicon nitride.”) (emphases added)). Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

3. Dependent Claim 5: The device according to claim 1, wherein the organic light-emitting diode comprises a hole transport layer that is p-doped.

116. Diekmann discloses this claim. Diekmann discloses that its organic layer sequence comprises a hole transport layer that is p-doped. Diekmann explains that “[t]he organic layer stack 4 can, for example, comprise the layers of the organic layer stack of Figure 1.” Diekmann, 92. Diekmann teaches that the organic layer stack of Figure 1 includes “a 1-TNATA layer” and “a sp-TAD layer.” Diekmann, 4–5. Diekmann further teaches that these materials are used in “hole-conducting” layers. Diekmann, 4–5. A POSITA would have understood that Diekmann’s “hole-conducting layer” is a hole transport layer. Indeed, the materials taught by Diekmann as examples of a hole-conducting layer such as sp-TAD were well-known materials for facilitating the transport of holes from the anode to the emissive layer. *See* §V.A.4.b above; Ex. 1016 (Pfeiffer); 1019 (He).

117. Diekmann further teaches that this hole transport layer is p-doped. Diekmann discloses that “the organic layer stack comprises a *doped organic layer* with a dopant.” Diekmann, 10 (emphasis added). Diekmann further explains that it is preferable that this doped organic layer be the “outermost layer of the

organic layer stack” such that it will “form[] a common interface with the respective electrode facing it.” Diekmann, 10. Diekmann teaches that “[t]he doped organic layer can be an n-doped layer or a p-doped layer” and further specifies that “[i]f the doped layer is arranged so that it faces the cathode or is adjacent to the cathode, it is generally an n-doped layer” whereas if the doped layer is “is arranged so that it faces the anode or is adjacent to it, it is generally a *p-doped layer*.” Diekmann, 10. (emphasis added). Thus, Diekmann discloses including a p-doped hole transport layer within its organic layer stack.

118. Even had Diekmann not explicitly disclosed p-doping its doped hole transport layer, it would have been obvious to a POSITA to dope Diekmann’s hole transport layers adjacent to the anode with p-dopants. As I explained in §V.A.4 above, p-doped hole transport layers were well-known for OLEDs at the time. In particular, it was well-known that using a p-doped hole transport layer could improve current and power efficiencies of the OLED. Ex. 1030, 3911 (“high conductive *p*- and *n*-doped layers enhance the charge injection from the contacts and reduce the ohmic losses in these layers resulting in “reduced the operating voltage for both fluorescent and phosphorescent devices.”); Ma, 810 (“[r]ecently, the p-doping of HTL has drawn a lot of attentions because of its ability to enhance hole injection and lower driving voltages in OLEDs.”); Ex. 1019 (He), 5773 (finding that a “p-i-n” OLED (i.e., an OLED with an n-doped ETL and p-doped HTL) “features

efficient carrier injection from both contacts into the doped transport layers and low ohmic losses in these highly conductive layers. Thus, low operating voltages are obtained compared to conventional undoped OLEDs.”). Indeed, Diekmann itself teaches that p-doping the hole transport layer would result in “better hole injection from the anode into the organic layer stack.” Diekmann, 10.

119. A POSITA would have further recognized that it would have been beneficial to use a p-doped hole transport layer together with an n-doped electron transport layer which, as I explained above in §X.A.1.h, Diekmann also teaches. For example, as explained by Ma, “current efficiency not only relies on the carrier injection, but also on the carrier balance.” Ma, 813. A surplus of one charge carrier could result in formation of unstable ions or “rapid device degeneration.” Ma, 814. As I explained in §V.A.4.b above, it was well-known at the time, and POSITA would recognize, that achieving a good balance of electrons and holes using a “p-i-n device” (*i.e.* a device that has both a p-doped hole transport layer and an n-doped electron transport layer) would result in “good lifetime” for an OLED such as the one taught by Diekmann. Ma, 814; *see also* Ex. 1029 at 5 (“OLEDs with doped transport layers enable... unprecedented power efficiencies [and] [the] lowest operating voltages.”), 6 (“PIN-Structures” deliver “High Efficiency at Long Lifetimes”), 6-14 (test results demonstrating the long lifetimes of p-i-n OLEDs); Ex. 1030 at 3911 (“By introducing a *p-i-n* structure to an OLED, we have successively

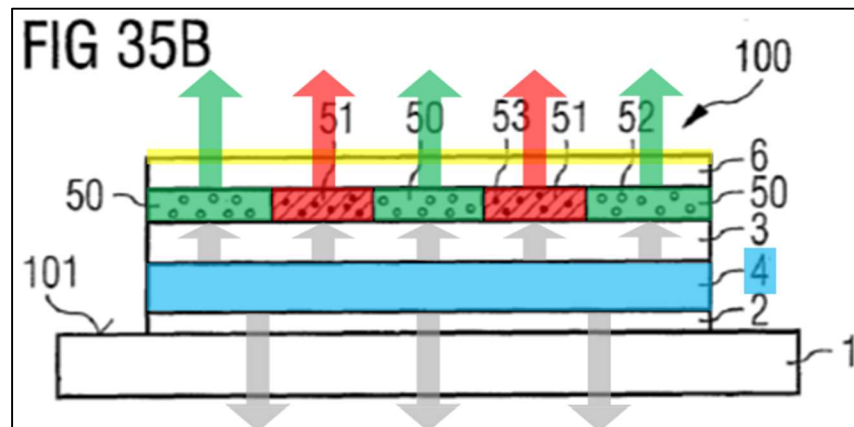
reduced the operating voltage for both fluorescent and phosphorescent devices in previous studies. The high conductive p- and n-doped layers enhance the charge injection from the contacts and reduce the ohmic losses in these layers.”), 3912 (“For *p-i-n* devices, both holes and electrons can be easily injected from anode and cathode to the organic layers so that the operating voltages are low...”). In light of these well-known benefits, a POSITA would have been motivated to include an p-doped hole transport layer in Diekmann’s OLED.

120. A POSITA would have reasonably expected success in using a p-doped hole transport layer in Diekmann’s OLED, in conjunction with the n-doped electron transport layer also taught by Diekmann (as explained above in §X.A.1.h). As discussed above, Diekmann already contemplates both an n-doped electron transport layer and a p-doped hole transport layer. Further, *p-i-n* OLEDs (OLEDs which include both an n-doped and a p-doped transport layer) were well known by the time of the ’425 patent. *See* §V.A.4 above; Ex. 1019 (He); Ex. 1029, Ex. 1030. Moreover, adding a p-dopant to a hole transport layer would be a routine matter well within a POSITA’s ability. Accordingly, a POSITA would have appreciated that Diekmann discloses this claim.

4. Dependent Claim 6

- a. The device according to claim 1, wherein a color filter is arranged between the emission layer and the radiation exit area, and**

121. Diekmann discloses this element. Diekmann discloses that the OLED may include a color filter layer to form differently colored subregions and a “multicolored” output. Diekmann, Fig. 35B; Diekmann, 37–38, 40, 128–130. The color filters are arranged between the emission layer (within organic layer stack 4), and the radiation exit area, as seen in annotated Figure 35B below:



Diekmann, Fig. 35B (annotated).

122. Diekmann teaches that “at least a majority of the electromagnetic radiation generated in the organic layer stack 4 during operation passes through this [color filter] layer.” Diekmann, 130; *see also* Diekmann, 40. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

- b. wherein the color filter is configured to be highly transmissive for a first spectral subrange of the generated electromagnetic radiation and highly absorbant for a second spectral subrange of the generated electromagnetic radiation.**

123. Diekmann discloses this element. As explained above, Diekmann discloses that the OLED may include a color filter layer to form differently colored subregions and a “multicolored” output. Diekmann further discloses that a “first color sub-region emits light of a first color” and a “second color sub-region emits light of a second color,” with the first color being different from the second color. Diekmann, 41; *see* Diekmann, 129–130. Diekmann teaches that each such “color filter is suitable for filtering light of a specific wavelength range.” Diekmann, 40. As such, light of these specific wavelength ranges is “at least partially absorbed by the color filter.” Diekmann, 40. For example, “a first color component can be filtered out of white light” while at the same time “a second color component can pass through the color filter essentially unhindered.” Diekmann, 40. As a result, “[t]he color sub-area with the color filter then essentially emits light of the second color component.” Diekmann, 40. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

5. Dependent Claim 7: The device according to claim 1, wherein the encapsulation is flexible.

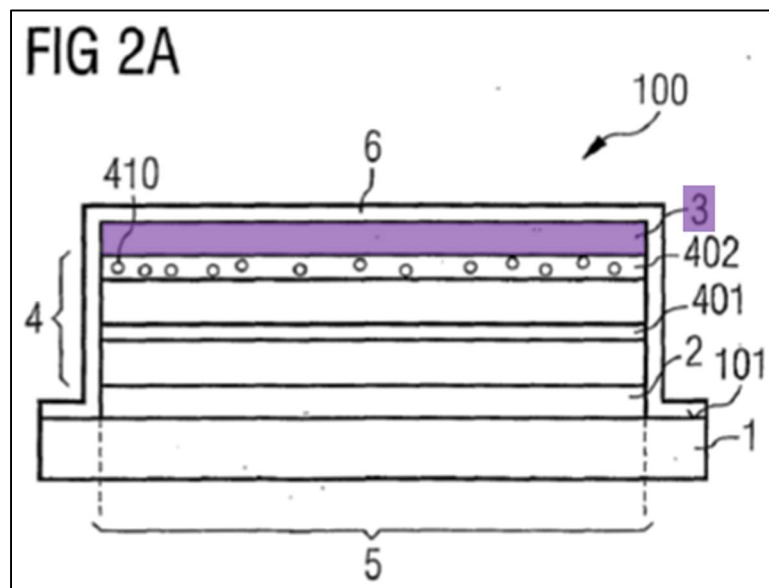
124. Diekmann discloses this claim. As discussed above, Diekmann discloses that its OLED is encapsulated within a flexible “thin film encapsulation.” Diekmann, 30–31. Diekmann teaches that “the encapsulation [that] is formed from one or more barrier layers, as described, for example, in connection with Figure 3 . . . is designed as a *flexible thin-film encapsulation*.” Diekmann, 120 (emphasis added). Accordingly, a POSITA would have appreciated that Diekmann discloses this claim.

6. Dependent Claim 8: The device according to claim 7, wherein the carrier comprises a film, a plastic film or a laminate.

125. Diekmann discloses this claim. As explained above, Diekmann discloses an OLED which is mounted on a carrier (substrate 1). Diekmann further discloses that “the substrate 1 . . . can, for example, be made of . . . a flexible *plastic film*.” Diekmann, 92. Diekmann also teaches that, in addition a plastic film, the carrier can also comprise a laminate. *See* Diekmann, 119 (“The substrate 1 is in the form of a plastic film.”); Diekmann, 121 (“The substrate 1 is a flexible laminate substrate.”). Accordingly, a POSITA would have appreciated that Diekmann discloses this claim.

7. **Dependent Claim 13: The device according to claim 1, wherein the organic light-emitting layer sequence comprises a cathode having a thickness of at least 1 nm and at most 50 nm.**

126. Diekmann discloses this claim. As explained above, Diekmann's OLED comprises an organic light-emitting layer sequence. Diekmann further teaches that this organic layer sequence includes a "second electrode 3 [which] is the cathode." Diekmann, 91. This can be seen in annotated Figure 2A below:



Diekmann, Fig. 2A (annotated).

127. Diekmann teaches that the cathode "can, for example, have a metallic layer that contains . . . silver and *has a thickness of approximately 30 nm.*" Diekmann, 92 (emphasis added). Diekmann thus discloses a cathode having a thickness of at least 1 nm and at most 50 nm.

128. Diekmann further teaches that this cathode is transparent so as to enable light to be transmitted through it: “[t]he second electrode 3 is also transparent to visible light, in particular to light generated by the organic layer stack 4.” Diekmann, 92. It was well-known in the art at the time that in order for light to be transmitted through an electrode, the electrode must be made sufficiently thin to be rendered transparent or semi-transparent. *See* §V.A.1 above; *see also, e.g.*, Ex. 1022 (Bulovic); Ex. 1033 (Lu). Diekmann teaches this as well, explaining that “to be permeable to the light emitted by the organic layer stack, the metallic layer must be sufficiently thin,” further specifying that, preferably, “the thickness of such a semi-transparent metallic layer is between 1 nm and 100 nm, inclusive.” Diekmann, 8; *see also* Diekmann, 75. Thus, Diekmann teaches an OLED with a cathode thickness of approximately 30 nm, and further teaches a range of cathode thicknesses to provide transparency such that the cathode will be made permeable to the light generated in the organic light-emitting layer. Diekmann thus teaches a range of cathode thickness that overlaps with the range of thicknesses claimed.

129. It would be clear to a POSITA that the upper bound of 50 nm in the claimed range is not critical to the claimed invention; as explained above, the reason for using a thickness in this range is to render the cathode transparent or semi-transparent. Indeed, the ’425 patent also makes this clear, as the specification merely describes the 1-50 nm range as an example thickness for a transparent metal layer.

See '425 patent, 3:1–4, 5:16–41, 32:13–22. Accordingly, a POSITA would have appreciated that Diekmann discloses this claim.

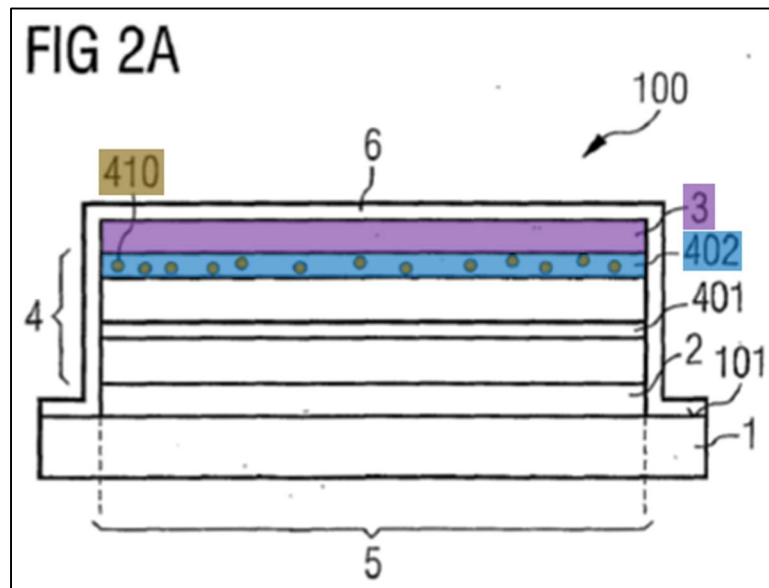
8. Dependent Claim 14: The device according to claim 13, wherein the cathode comprises one of: silver, magnesium, or an alloy comprising silver and magnesium.

130. Diekmann discloses this claim. Diekmann teaches that the cathode used in its OLED, discussed above, comprises silver or a silver and magnesium alloy. For example, Diekmann teaches that the cathode can “have a metallic layer that contains . . . silver.” Diekmann, 92; *see also* Diekmann, 91 (“The second electrode 3 serves as the cathode. It consists of aluminum or silver, for example.”); Diekmann, 3–4 (“[T]he cathode can comprise . . . silver.”).

131. Diekmann also teaches that “compounds, combinations and alloys” of silver and magnesium “can prove to be advantageous as cathode material,” allowing the cathode to be transparent for a “top emitter” OLED. Diekmann, 75. Diekmann also teaches that the cathode “preferably has a material that has a low work function for electrons.” Diekmann, 3–4. As I explained above in §V.A.1, silver-magnesium alloys were well-known in the art as a suitable cathode material for OLEDs because they have a low work function and can be made sufficiently transparent for top-emission OLEDs. *See, e.g.*, Ex. 1022 (Bulovic), 29; Ex. 1033, 3921-3923. Accordingly, a POSITA would have appreciated that Diekmann discloses this claim.

9. **Dependent Claim 15: The device according to claim 13, wherein the cathode is in direct contact with a lithium containing layer.**

132. Diekmann discloses this claim. Diekmann teaches that the cathode is in direct contact with organic layer 402 containing dopant 410. Diekmann, 91.



Diekmann, Fig. 2A (annotated).

133. As seen in annotated Figure 2A above, the “doped layer 402 with a dopant 410” is on the “outer side” of the organic layer stack “facing the cathode,” and “[t]he dopant 410 can be . . . *lithium fluoride*.” Diekmann, 91 (emphasis added); *see also* Diekmann, 10 (“[T]he doped organic layer forms an outermost layer of the organic layer stack, which particularly preferably forms a common interface with the respective electrode facing it. . . . If the doped layer is arranged so that it faces

the cathode or is adjacent to the cathode, it is generally an n-doped layer. . . . Preferred n-dopants are cesium, barium and lithium fluoride.”).

Accordingly, a POSITA would have appreciated that Diekmann discloses this claim.

10. Dependent Claim 16: The device according to claim 13, wherein the cathode comprises silver, magnesium, or alloy consisting of at least one of the abovementioned materials.

134. This claim is the same as claim 14, and Diekmann discloses it for the same reasons. *See* §X.A.8 above.

11. Dependent Claim 18

a. The device according to claim 1, wherein at least one part of the encapsulation is formed by an insulation layer, which can contain at least one of the following electrically insulating materials: resin, silicon oxide, silicon nitride,

135. Diekmann discloses this element for the same reasons discussed with regards to Claims 3[a]–3[b]. *See* §X.A.2 above.

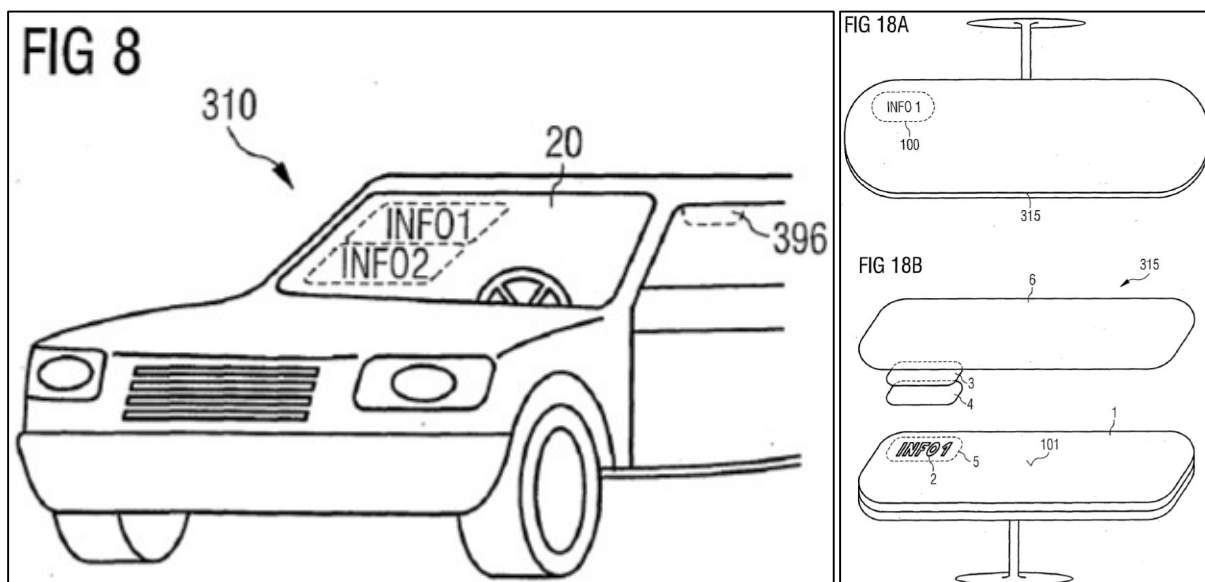
b. and wherein at least one part of the encapsulation is formed by a PECVD method.

136. Diekmann discloses this element. As discussed above, Diekmann teaches that its OLED is encapsulated by a thin film encapsulation. Diekmann teaches that “at least one thin film layer, such as the barrier layer” of this thin film encapsulation “is applied by means of a thin film process, such as . . . plasma-enhanced CVD.” Diekmann, 13; *see also* Diekmann, 94 (“The barrier layers can, for example, be vapor-deposited, sputtered or deposited on the second electrode using a

plasma-enhanced process such as chemical vapor deposition (CVD).”). A POSITA would appreciate that plasma-enhanced CVD is simply another way of referring to the PECVD method. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

12. Dependent Claim 19: The device according to claim 1, wherein the organic light-emitting diode is configured for installation in a vehicle.

137. Diekmann discloses this claim. Diekmann teaches that its OLED can be installed in a vehicle for numerous different uses. For example, Diekmann teaches that the OLED can be “integrated into a window” of a “motor vehicle” to display information to the driver. Diekmann, 102. Diekmann further teaches that the OLED can be used as “vehicle interior lighting,” Diekmann, 102, or integrated into “a motor vehicle mirror,” Diekmann, 112–113. These motor vehicle applications are illustrated in Figures 8, 18A, and 18B, below:



Diekmann, Figs. 8, 18A–18B.

138. Accordingly, a POSITA would have appreciated that Diekmann discloses this element.

B. Ground II: Claims 2, 17 are obvious over Diekmann in view of Ma

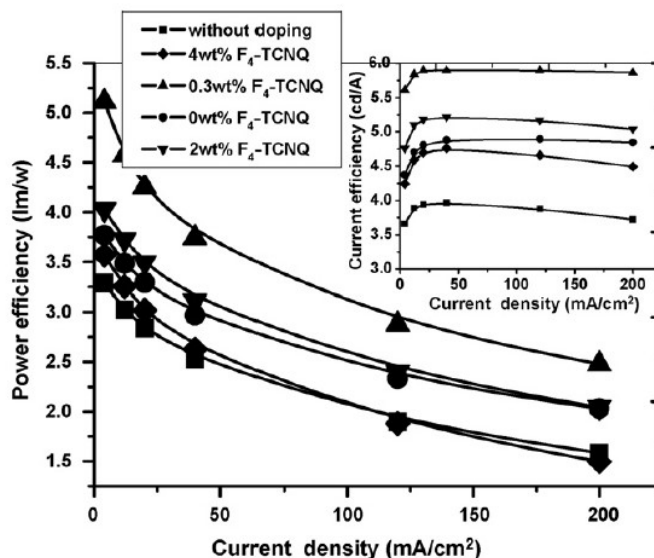
1. Dependent Claim 2: The device of claim 1, wherein the electron transport layer comprises 8-hydroxyquinolinolato-lithium.

139. This claim would have been obvious to a POSITA based on Diekmann in view of Ma. As I explained above in §X.A.1.h, Diekmann discloses, and at minimum renders obvious, an n-doped electron transport layer. It would have been obvious to a POSITA to use 8-hydroxyquinolinolato-lithium as the dopant in Diekmann’s n-doped electron transport layer, as taught by Ma. Ma teaches an OLED with an electron transport layer doped with 8-hydroxy-quinolinatolithium (“Liq”). Ma, Abstract, 810–811.

140. The use of Liq-doped electron transport layers in OLEDs was a well-known practice in the art at the time, and had well-known benefits. *See* §V.A.4 above. At the time, it was highly desirable to create OLEDs with a high level of efficiency, and it was well known that Liq-doping the electron transport layer was one way of achieving such efficiency. *See* §V.A.4 above. This understanding is reflected, for example, in Ma, which explains that “[s]ince the discovery of organic

light-emitting devices (OLEDs), there has been a considerable interest in developing OLEDs with high efficiency.” Ma, 810.

141. Ma discloses an OLED with an Liq-doped electron transport layer. Ma tests the power efficiency of four different OLEDs, one with an undoped ETL and HTL, and four others with a fixed n-doping of Liq in the ETL and a varying amount of p-doping in the HTL. As shown in Ma’s Figure 3 below, Ma finds that “the current and power efficiencies” are improved between the control device with no doping (squares) and the optimized device that has both n-type and p-type doping (up triangles).



Ma, Fig. 3.

142. Ma concludes based on this testing that “[t]his significant enhancement in the device performance is attributed to the improved transport

conductivity of both p-doped HTL and n-doped ETL at a particular doping concentration of F4-TCNQ into m-MTDATA and Liq into Bphen” and, “[a]s a result, the high carrier balance is reached in the emission zone, which leads to the enhanced current and power efficiency at low driving voltage.” Ma at 812. Therefore, Ma explicitly teaches that an the current and power efficiency of an OLED can be increased at a low driving voltage by utilizing an ETL which is doped with Liq.

143. Specifically, Ma teaches that a “doping concentration of Liq” in the electron transport layer results in increased current density and reduced driving voltage, compared to the undoped OLED. Ma, 813. Ma further teaches that “a certain doping ratio of Liq to Bphen can improve the electron transport ability of the co-deposited layer.” Ma, 813. A POSITA would have been motivated to use a Liq-doped electron transport layer in Diekmann’s OLED to achieve these benefits.

144. Indeed, Diekmann explicitly teaches that the n-dopant for its electron transport layer should be “suitable for emitting electrons,” and that “doping advantageously increases the conductivity of the doped organic layer and, in the case of an n-doped layer adjacent to the cathode, leads to better injection of electrons from the cathode into the organic layer stack.” Diekmann, 10. As I explained above, Liq was well-known in the art at the time to have good electron injection and transport properties. *See* §V.A.4; *see also* Ma; Ex. 1018 (Liu). Moreover, Diekmann

also teaches that “the dopant preferably has a low diffusion constant within the organic layer stack, as is usually the case with large atoms or molecules, for example.” Diekmann, 10. A POSITA would know that Liq has a larger molecular weight than Diekmann’s preferred n-dopants cesium, barium, and lithium fluoride and, as such, would be preferable to those alternatives. *See, e.g.*, Ex. 1031, 4495. At the time, it was well understood that dopant metal ions could readily diffuse in the OLED during film growth and operation, compromising performance. A larger, molecular dopant would be less able to diffuse in the transport layer, reducing the severity of these issues. A POSITA thus would have recognized that Liq would be an advantageous dopant for Diekmann’s doped layer.

145. Additionally, as I explained above, use of Liq as a dopant in an OLED electron transport layer was well-known in the art at the time, and was specifically taught by Ma. Doing so would be a routine practice for a POSITA to implement with a high probability of success, particularly considering that Diekmann already contemplates an analogous n-doped layer for electron transport. As such, a POSITA could readily have implemented an Liq-doped electron transport layer in Diekmann’s OLED.

146. Accordingly, a POSITA would have appreciated that Diekmann in view of Ma discloses this claim.

- 2. Dependent Claim 17: The device according to claim 1, wherein the electron transport layer comprises at least 8-hydroxyquinolinolato-lithium.**

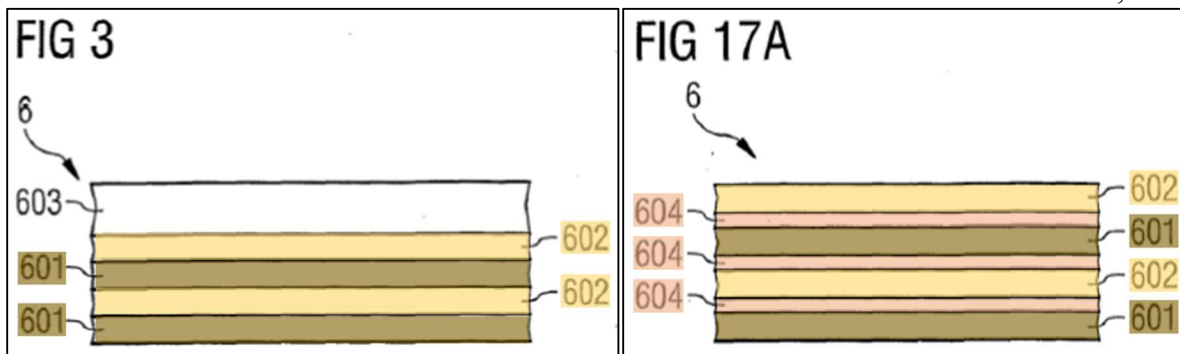
147. This claim is the same as claim 2, and would have been obvious to a POSITA based on Diekmann in view of Ma for the same reasons. *See* §X.B.1 above.

C. Ground III: Claim 4 is obvious over Diekmann in view of Lee

1. Dependent Claim 4

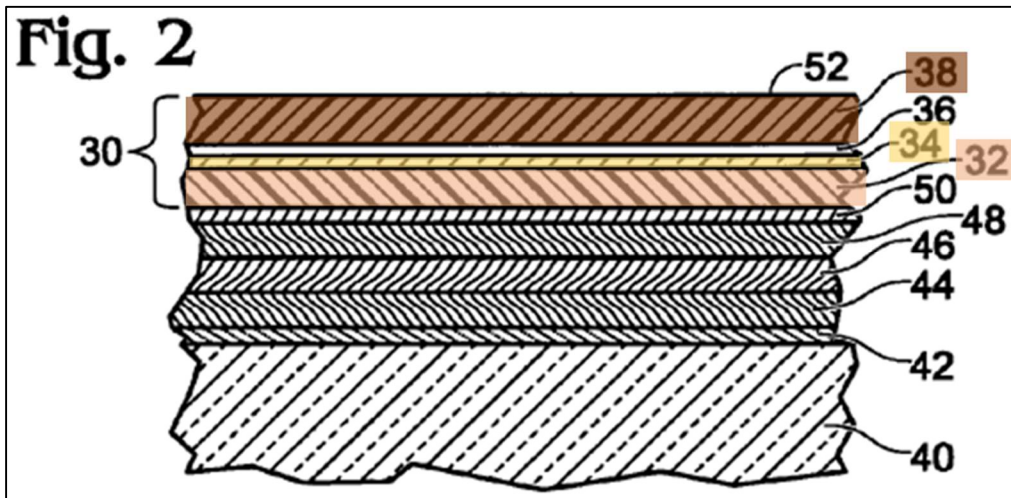
- a. The device of claim 1, wherein the encapsulation comprises a first encapsulation layer and a second encapsulation layer,**

148. This element would have been obvious to a POSITA based on Diekmann in view of Lee. As I explained above in §X.A.1.e, Diekmann discloses that its OLED is encapsulated in a thin film encapsulation. Diekmann further teaches that this thin film encapsulation comprises two encapsulation layers. Specifically, Diekmann discloses that the thin film encapsulation 6 comprises “two first barrier layers 601” (a first encapsulation layer) and “two second barrier layers 602” (a second encapsulation layer). Diekmann, 94. Diekmann further teaches that between these barrier layers are intermediate polymer layers. Diekmann, 109 (“[T]he barrier layers 601, 602 are separated from each other by intermediate polymer layers 604.”). These encapsulation layers can be seen in annotated Figures 3 and 17A below:



Diekmann, Figs. 3, 17A (annotated).

149. Like Diekmann, Lee similarly teaches an encapsulation for an OLED comprising two encapsulation layers: a first encapsulation layer (“second semi-crystalline parylene-based polymer layer 38”) and a second encapsulation layer (“first semi-crystalline parylene-based polymer layer 32.”). Lee, [0022] (“The first semi-crystalline parylene-based polymer layer is shown in FIG. 2 at 32, the inorganic barrier layer is shown at 34, . . . and the second semi-crystalline parylene-based polymer layer is shown at 38”); Lee, [0021] (“annealing . . . the second semi-crystalline parylene-based polymer layer [forms] a highly crystalline parylene-based polymer layer”). Lee’s encapsulation layers are illustrated in Lee’s annotated Figure 2 below. Lee, [0022] (“The first semi-crystalline parylene-based polymer layer is shown in FIG. 2 at 32, the inorganic barrier layer is shown at 34, . . . and the second semi-crystalline parylene-based polymer layer is shown at 38”); Lee, [0021] (“annealing . . . the second semi-crystalline parylene-based polymer layer [forms] a highly crystalline parylene-based polymer layer”).



Lee, Fig. 2 (annotated).

150. A POSITA would have been motivated to use Lee's multi-layered encapsulation as the encapsulation for Diekmann's OLED. As I explained above in §V.A.5, the use of encapsulations in OLEDs were well-known at the time, specifically to protect the OLED from the ambient environment and extend its lifetime. *See, e.g.*, Exs. 1020 (Moro), 1021 (Chwang). Indeed, Lee itself teaches the benefits of using an encapsulation in an OLED; for example, Lee explains that "the low work function metals typically used as cathodes in OLEDs are environmentally sensitive, and may be easily oxidized by moisture or oxygen from air. Therefore, it is important to protect these materials from air both during processing and during use." Lee, [0005]. Lee also teaches the specific benefits of the type of multi-layer encapsulation that it discloses: Lee explains that semi- and highly-crystalline parylene-based polymer films "have low-enough WVTR [(water vapor transport

rate)] and OTR [(oxygen transport rate)] values that they not only ‘decouple’ adjacent inorganic layers to prevent the propagation of defects between inorganic layers, but also themselves help block water vapor and oxygen permeation into the OLED.” Lee, [0020]. Thus, Lee’s encapsulation formed of semi-crystalline and highly-crystalline polymer barrier layers may provide “a significantly improved lifetime compared to prior OLEDs having polyacrylate or amorphous parylene barrier layers.” Lee, [0020]. Applying Lee’s multi-layered encapsulation to Diekmann’s OLED would require only the application of a known technique to a piece of prior art ready for improvement. Diekmann’s intermediate polymer layers are “vapor-deposited as monomers and . . . cross-linked using UV radiation.” Diekmann, 15. This is precisely the prior art structure that Lee’s encapsulation is intended to improve upon. Lee, [0008].

151. A POSITA would have reasonably expected success in combining Lee’s multi-layered encapsulation with Diekmann’s OLED. Diekmann contemplated a multi-layered encapsulation with alternating layers of inorganic barrier layers and polymer interlayers. As I explained above in §V.A.5, the use of such an OLED encapsulation comprising a multilayer barrier coating consisting of alternating organic and inorganic layers was well known in the art at the time. *See, e.g.,* Ex. 1020 (Moro); Ex. 1021 (Chwang). Applying Lee’s encapsulation merely replaces one set of alternating layers of inorganic barriers and polymers with

another, to obtain the benefits taught in Lee. This modification would have been well within the ability of a POSITA. Accordingly, a POSITA would have appreciated that Diekmann in view of Lee discloses this element.

b. the first and the second encapsulation layer each having a respective volume structure,

152. This element would have been obvious to a POSITA based on Diekmann in view of Lee.

153. As I discussed in §VI.C above, during prosecution of the '425 patent's predecessor, the '514 patent, the applicants offered two distinct explanations as to the meaning of the terms "volume structure" in order to overcome rejections. Regardless of which meaning is applied, however, Lee teaches encapsulation layers having respective, independent volume structures.

154. Specifically, the '514 applicants distinguished between the atomic and molecular arrangement inside of a solid ("volume structure") and the atomic and molecular arrangement at the solid's surface ("surface structure"). Ex. 1025, 1386. The '514 applicants also argued that "volume structure" "comprise[s] any structure ranging from polycrystalline to polyamorphous," and that "examples of volume structures" include "crystalline, partly crystalline and/or polycrystalline or completely amorphous." Ex. 1025, 1241; *see also* Ex. 1025, 1313–1314, 1386–1387.

155. Lee discloses that its encapsulation layers have distinct crystalline structures; Lee's encapsulation includes semi-crystalline parylene-based polymer layer 32 and highly crystalline parylene-based polymer layer 38. Lee, [0021]–[0023]. Lee further discloses that “the first semi-crystalline and second highly crystalline parylene-based polymer layers respectively have at least 10% and up to 70% of crystallinity.” Lee, [0023].

156. If two solids have different levels of crystallinity from one another, the interior of those two solids will necessarily also have distinct molecular and atomic arrangements from one another. A POSITA would recognize, therefore, that in disclosing encapsulation layers with differing levels of crystallinity, Lee also discloses encapsulation layers with their own respective, and distinct, molecular arrangements.

157. Accordingly, a POSITA would have appreciated that Diekmann in view of Lee discloses this element.

c. wherein the volume structure of the second encapsulation layer is independent of the volume structure of the first encapsulation layer, and

158. This element would have been obvious to a POSITA based on Diekmann in view of Lee.

159. Lee teaches a first and second encapsulation layer with independent volume structures. As I explained above regarding claim 4[b], Lee's

first (highly crystalline) encapsulation layer has “up to 70% of crystallinity” and the second (semi-crystalline) encapsulation layer has “at least 10%” of crystallinity. Lee, [0023]. Lee also explains that its polymer layers have low-enough WVTR and OTR values that they “‘decouple’ adjacent inorganic layers to prevent the propagation of defects between inorganic layers.” Lee, [0020]. Accordingly, a POSITA would have appreciated that Diekmann in view of Lee discloses this element.

d. the volume structure of the second encapsulation layer has a higher amorphicity than the volume structure of the first encapsulation layer.

160. This element would have been obvious to a POSITA based on Diekmann in view of Lee.

161. As explained above regarding claim 4[b], Lee’s encapsulation includes two encapsulation layers: semi-crystalline parylene-based polymer layer 32 (“second encapsulation layer”), and highly crystalline parylene-based polymer layer 38 (“first encapsulation layer”). Lee, [0021]–[0023]. Lee explains that the semi-crystalline polymer layer may be about 10% crystallinity as deposited, while the highly crystalline polymer layer, formed by depositing a semi-crystalline polymer film and annealing to increase its crystallinity, may be about 70% crystallinity. Lee, [0021], [0023]–[0027]. Amorphicity and crystallinity both describe the volume structure of solids, and have an inverse relationship; crystalline solids have a long-range order, meaning the atoms or molecules are arranged in a periodic pattern, while

amorphous solids have no long-range order, meaning the atoms or molecules are arranged without a periodic pattern. *See* Ex. 1025, 1313–1314, 1386–1387. In practical terms, this means that the higher a material’s crystallinity, the lower its amorphicity; if material A has higher crystallinity than material B, then material A necessarily has a lower amorphicity than material B. Therefore, a POSITA would recognize that because Lee’s second (semi-crystalline) encapsulation layer has lower crystallinity than the first (highly crystalline) encapsulation layer, the second encapsulation layer must also have a higher amorphicity than the first encapsulation layer. Accordingly, a POSITA would have appreciated that Diekmann in view of Lee discloses this element.

D. Ground IV: Claims 9–11 are obvious over Diekmann in view of Koshihara

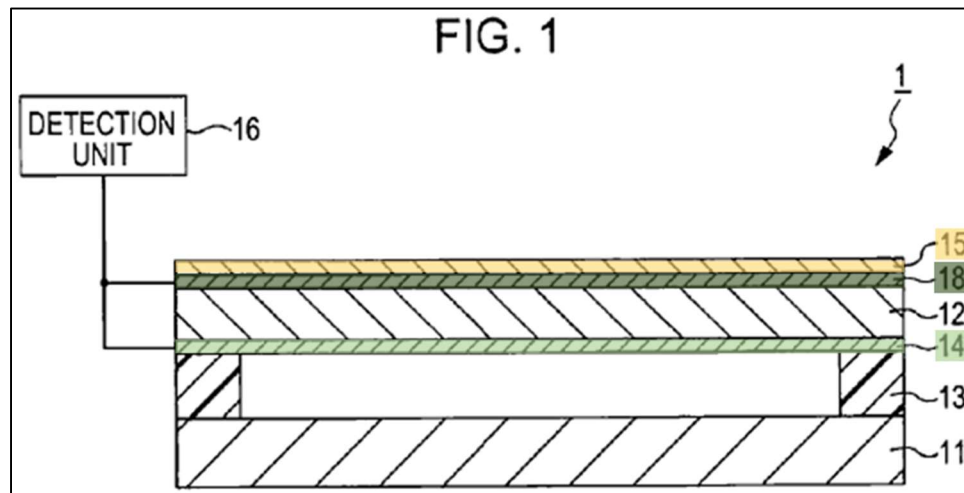
1. Dependent Claim 9

- a. The device according to claim 1, wherein the device comprises at least one touch-sensitive operating element, and**

162. This element would have been obvious to a POSITA based on Diekmann in view of Koshihara. As explained above, Diekmann teaches an OLED, as well as display devices which incorporate this OLED. *See* §X.A.1.a above. It would have been obvious to a POSITA to implement touch sensing functionality,

such as that taught by Koshihara, into the OLED taught by Diekmann by integrating touch-sensitive operating elements into the OLED.

163. Koshihara teaches a “touch-sensitive organic EL device” which detects touch via an integrated “touch panel unit.” Koshihara, [0028], [0031].



Koshihara, Fig. 1 (annotated).

164. As seen in Figure 1 above, Koshihara teaches that this includes “[a] combination of the first detection electrode 14, the second detection electrode 18, the dielectric film 15, and the detection unit 16 constitutes a so-called a [sic] touch panel unit that operates in compliance with the so-called capacitive sensing scheme.” Koshihara, [0031]. Koshihara’s touch panel unit senses touch, using a “detection unit 16” to detect a position where electrostatic capacitance is generated by a “touching object.” As Koshihara explains, the “detection unit 16 detects a position at which electrostatic capacitance is generated via the dielectric film 15 between the first detection electrode 14 and the second detection electrode 18

(generated via the dielectric film 15 between the first detection electrode 14, the second detection electrode 18, and a touching object).” Koshihara, [0031].

165. A POSITA would have been motivated to incorporate touch sensing functionality to Diekmann’s OLED. Indeed, Diekmann already contemplates that its OLED will be operable through user control including, for example, so that the device can be switched on or off, or to control the brightness or the color of light output. Diekmann, 45–50, 53, 70, 139. Diekmann additionally contemplates integrating sensors with the OLED for controlling its operation “depending on the measured values determined by the sensor.” Diekmann, 49–50, 64, 143. The use of touch sensors as input devices for controlling electronic devices was very well-known in the art before 2008. *See, e.g.*, Caldwell, [0006]–[0007]. A POSITA would have been motivated to incorporate touch sensors to “allow[] a user to manually input instructions” intuitively by touch. Koshihara, [0004].

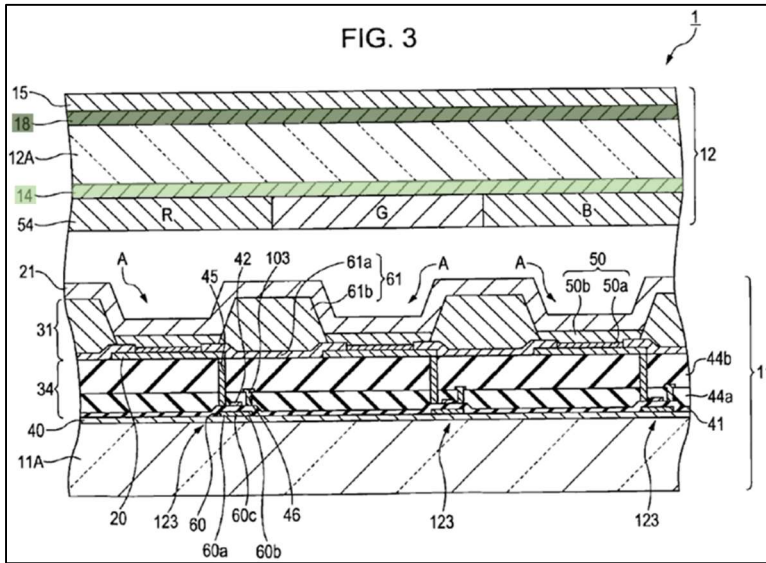
166. Further, a POSITA would have recognized the benefits of integrating Koshihara’s touch sensor directly into Diekmann’s OLED. Koshihara’s touch sensor is integrated with the sealing substrate for “preventing a light emitting layer, which is formed on a negative electrode or in a light emission element layer portion, from becoming oxidized,” Koshihara, [0030], and, as such, allows a touch-sensitive OLED to be formed without the additional material and manufacturing costs associated with connecting a separate touch panel to touch sensors formed on

another substrate. Caldwell, [0006]–[0007]. A POSITA would recognize that an integrated touch sensor would also result in a thinner profile for the device. *See* Ex. 1024, 3:2–7

167. A POSITA would have reasonably expected success in incorporating touch sensing functionality in Diekmann’s OLED. As I explained above, OLEDs with integrated touch sensors were well known prior to the ’425 patent, with applications already existing at that time for controlling the functionality of devices including OLED displays and OLED light sources. Caldwell, [0004]–[0007]. Additionally, Diekmann already contemplates using integrated sensors to control the operation of its OLED. Diekmann, 49–50, 64, 143. Implementing Koshihara’s touch sensor would thus have been a simple, routine modification to Diekmann’s OLED which would be well within the ability of a POSITA. Accordingly, a POSITA would have appreciated that Diekmann in view of Koshihara discloses this element.

b. wherein the at least one touch-sensitive operating element comprises at least one touch sensor.

168. This element would have been obvious to a POSITA based on Diekmann in view of Koshihara. Koshihara teaches that its touch panel unit includes two touch sensors, a “first detection electrode 14” and a “second detection electrode 18.” Koshihara, [0031]. These can be seen in the annotated Figure 3 below:



Koshihara, Fig. 3 (annotated).

169. Koshihara explains that “[t]he detection unit 16 detects a position at which electrostatic capacitance is generated via the dielectric film 15 between the first detection electrode 14 and the second detection electrode 18 (generated via the dielectric film 15 between the first detection electrode 14, the second detection electrode 18, and a touching object).” Koshihara, [0031]. Koshihara therefore teaches a touch-sensitive operating element that comprises at least one touch sensor. Accordingly, a POSITA would have appreciated that Diekmann in view of Koshihara discloses this element.

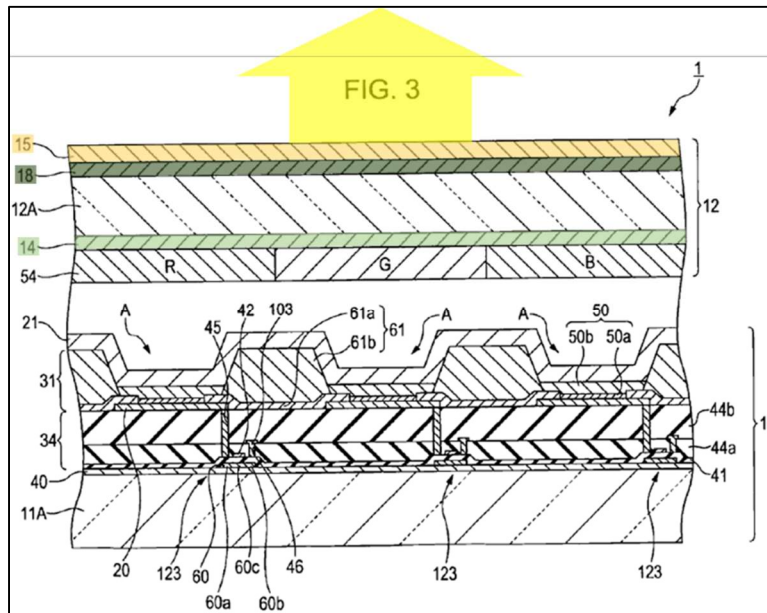
2. Dependent Claim 10: The device according to claim 9, wherein the at least one touch sensor is integrated into the organic light-emitting diode.

170. This claim would have been obvious to a POSITA based on Diekmann in view of Koshihara. Koshihara's teaches that its touch sensor is

171. Accordingly, a POSITA would have appreciated that Diekmann
Koshihara discloses this claim.

3. Dependent Claim 11: The device according to claim 10, wherein the touch-sensitive operating element is arranged at the radiation exit area of the device.

172. This claim would have been obvious to a POSITA based on Diekmann in view of Koshihara. Koshihara teaches that the touch panel unit is arranged at the radiation exit area of the OLED. Koshihara, [0031] (“The first detection electrode 14 is provided on the inner surface of the counter sealing substrate 12 . . . The second detection electrode 18 is provided on the outer surface of the counter sealing substrate 12.”); Koshihara, [0046] (“The first detection electrode 14 is formed on the inner surface of the base substrate substance 12A . . . On the other hand, the second detection electrode 18 is provided on the outer surface of the base substrate substance 12A.”). The OLED taught by Koshihara is “configured as a so-called top-emission type display device” meaning that “light emitted from a light-emitting layer formed on (i.e., in) the element substrate 11 of the top-emission type organic EL device 1 goes out through the counter sealing substrate 12 thereof.” Koshihara, [0029]. This is illustrated in Figure 3, below, which shows the light generated from the light-emitting layer exiting through the top of the OLED after passing through the touch panel unit:



Koshihara, Fig. 3 (annotated).

173. Accordingly, a POSITA would have appreciated that Diekmann in view of Koshihara discloses this claim.

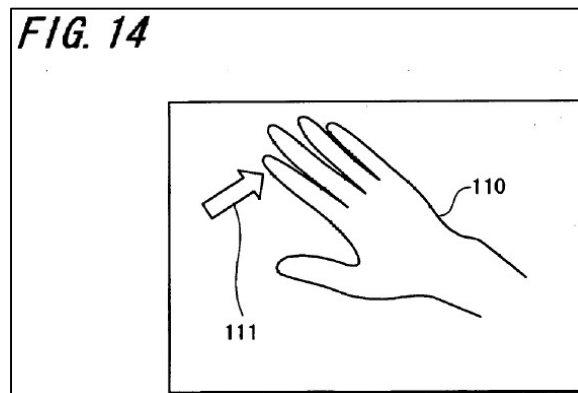
E. Ground V: Claim 12 is obvious over Diekmann in view of Harada

1. Dependent Claim 12: The device according to claim 1, wherein the device is drivable by means of a gesture control.

174. This claim would have been obvious to a POSITA based on Diekmann in view of Harada. As I explained above, Diekmann teaches an OLED and various display and lighting devices incorporating this OLED. It would have been obvious to a POSITA to implement gesture control for operating Diekmann's device, such as the gesture control taught by Harada. Harada teaches "a display technology capable of receiving light in parallel with emitting light," which can be applied to "an organic EL (Electro-Luminance) display." Harada, [0003], [0086].

Specifically, Harada's organic EL display includes an "I/O display" capable of both emitting light and receiving light. Harada, [0039], [0040]–[0044], [0076]–[0079].

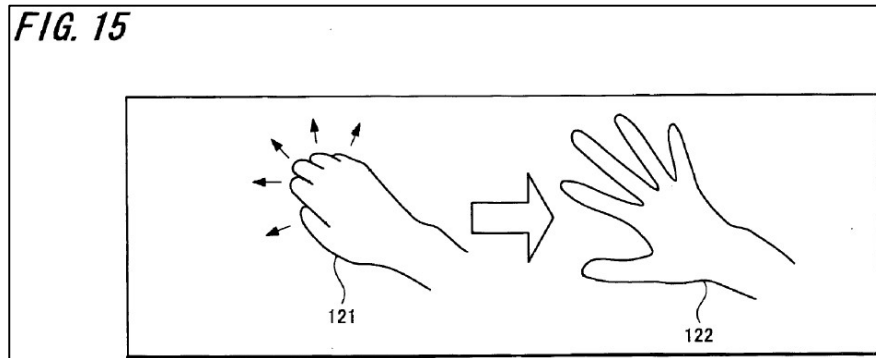
175. The I/O display device disclosed by Harada can detect both when the screen is touched and also when an object approaches the screen. Harada, [0039], [0050]–[0051], [0082]–[0085]. The display device performs "gesture recognition using a hand shape" by recognizing "the shape of a hand 110 touched (or approached) to a display panel." Harada, [0071]. For example, as seen in Figure 14, "the hand shape recognized is displayed as an image and then with a display object move 111, some processing is performed." Harada, [0071].



Harada, Fig. 14.

176. Figure 15 below depicts another example wherein "a hand closed 121 is changed to a hand opened 122 and the touch or approach of the hand (121, 122) in each condition is recognized as an image on the display panel and the processing based on the image-recognition is executed." Harada, [0072]. Harada

further explains that the device can be operated by providing instructions or commands “based on those recognitions.” Harada, [0073].



Harada, Fig. 15.

177. A POSITA would have been motivated to incorporate gesture control functionality in the OLED disclosed by Diekmann. Using gesture control input for controlling electronic devices was well known by the time of the '425 patent. *See, e.g.,* Ex. 1032 (Freeman); Harada. Moreover, Diekmann already contemplates its OLED being operable through user control, for example to be switched on or off, or to control the brightness or color of light output, Diekmann, 45–50, 53, 70, 139, as well as the use of sensors integrated with the OLED for controlling its operation “depending on the measured values determined by the sensor.” Diekmann, 49–50, 64, 143. Diekmann explicitly contemplates using a “photodiode” or “photodetector” integrated with the OLED as a sensor for detecting the brightness of light and controlling the operation of the OLED based on the value measured by the sensor. Diekmann, 49, 137–140, 142. A POSITA would have been

motivated to implement gesture control based on the received light as taught by Harada to allow a user to operate the device “in more natural ways.” Harada, [0073].

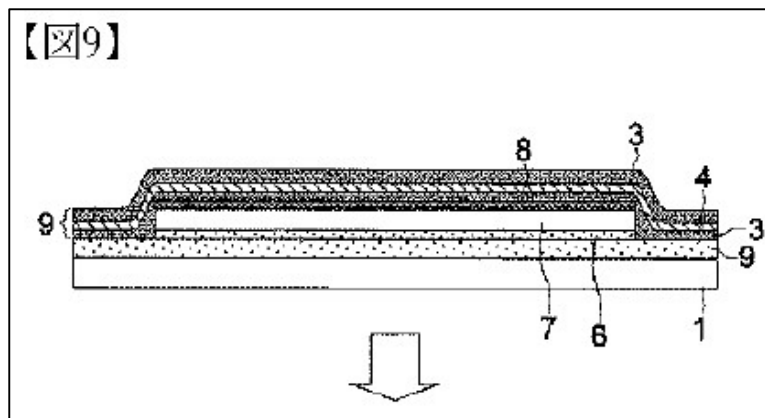
178. A POSITA would have reasonably expected success in incorporating Harada’s gesture control functionality in Diekmann’s OLED. OLEDs with integrated sensors for gesture recognition and control of the OLED were well known in the art at the time, with applications for controlling the functionality of devices including OLED displays and OLED light sources existing prior to the ’425 patent. *See, e.g.*, Harada; Ex. 1032 (Freeman). As mentioned above, Diekmann already contemplated using integrated sensors for controlling the operation of its OLED, Diekmann, 49–50, 64, 143, and contemplated a “photodiode” or “photodetector” integrated with the OLED as a sensor for detecting the brightness of light and controlling the operation of the OLED based on the measured value. Diekmann, 49, 137–140, 142. Integrating Harada’s gesture detection capability into Diekmann’s OLED would have been a simple, routine modification well within the ability of a POSITA.

F. Ground VI: Suzuki anticipates and renders obvious claims 1, 3, 5–8, 13–16, and 18–19

1. Independent Claim 1

a. Preamble: A device comprising:

179. Suzuki discloses a device. Specifically, Suzuki discloses an OLED, and devices that incorporate this OLED. An embodiment of “an organic EL device” according to Suzuki can be seen in Figure 9 below. Suzuki, [0274].



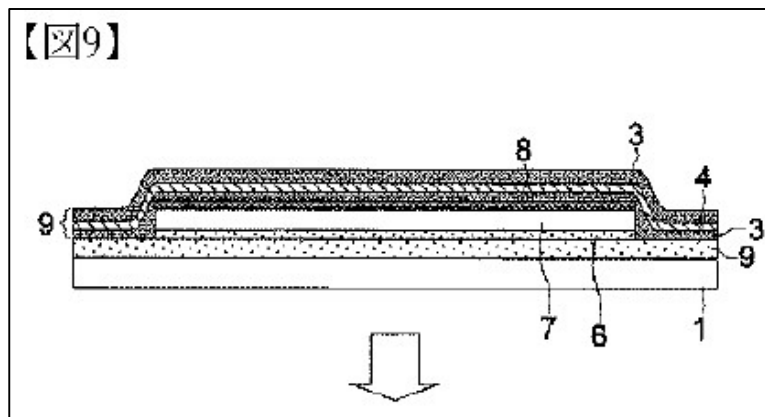
Suzuki, Fig. 9.

180. Suzuki discloses that its OLED can be incorporated into various different devices. As Suzuki explains, “the organic EL element of the present invention can be used as a display device, a display, and various light-emitting light sources” and that the “[d]isplay devices and displays include TVs, PCs, mobile devices, ... information displays in automobiles, and the like,” Suzuki, [0343] – [0344], as well as “[i]llumination devices” such as “home lighting, in-car lighting,” and other devices. Suzuki, [0345].

181. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

b. Element 1[a]: an organic light-emitting diode comprising:

182. Suzuki discloses an organic light-emitting diode. As discussed above, Suzuki discloses “an organic EL device.” Suzuki, [0274]. A POSITA would recognize that an “organic EL device” is another name for an organic light emitting diode (OLED). The organic light emitting diode taught by Suzuki can be seen in Figure 9 below.



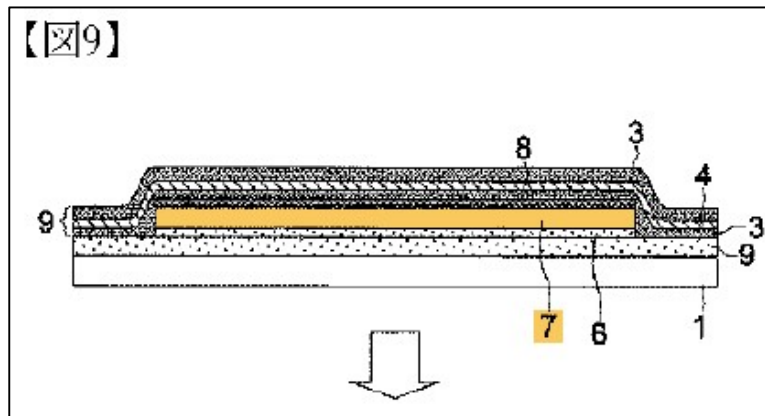
Suzuki, Fig. 9.

183. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

c. Element 1[b]: an organic layer sequence,

184. Suzuki discloses this element. As discussed above, Suzuki discloses an OLED. Suzuki teaches that this OLED includes “an organic layer

(comprising a hole transport layer, a light emission layer, an electron transport layer, and the like).” Suzuki, [0274]. Suzuki’s organic layer sequence can be seen highlighted in annotated Figure 9 below.

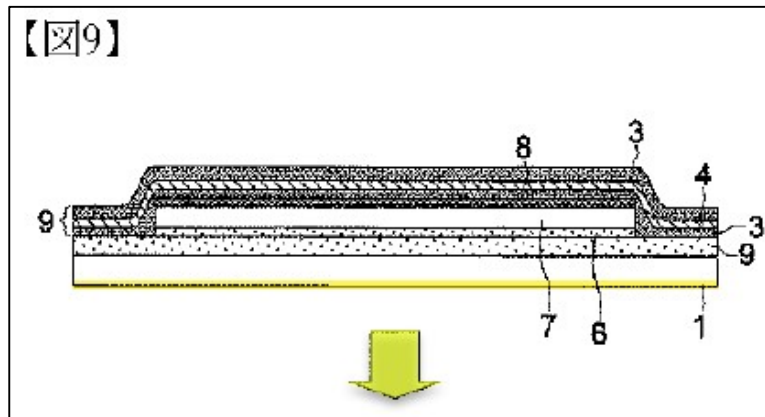


Suzuki, Fig. 9 (annotated).

185. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

d. Element 1[c]: a radiation exit area, and

186. Suzuki discloses this element. Suzuki teaches that its OLED is bottom-emitting, and the light generated by the OLED exits from the bottom after passing through the resin substrate (1). A POSITA would recognize this area where light exits the OLED to be a radiation exit area. Suzuki’s radiation exit area can be seen in annotated Figure 9 below where “[t]he arrow indicates the direction of light extraction.” Suzuki, [0274].

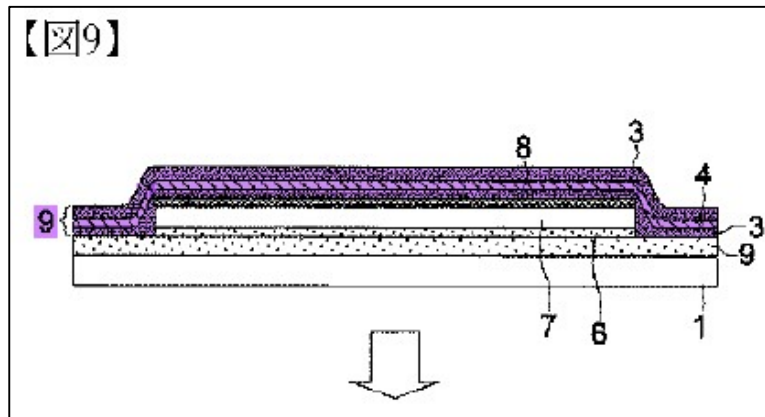


Suzuki, Fig. 9 (annotated).

187. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

e. Element 1[d]: an encapsulation,

188. Suzuki discloses this element. Suzuki teaches that its OLED includes an encapsulation, “gas barrier thin film laminate 9.” Suzuki, [0274]. Suzuki further teaches that this encapsulation comprises multiple layers: a “buffer film 3,” “a barrier film 4,” and another “buffer film 3.” Suzuki, [0274]. Suzuki explains that the “gas barrier thin film laminate 9” is “formed on the cathode and sealed,” Suzuki, [0274], creating “the sealed organic electroluminescent device[.]” Suzuki, [0273]. A POSITA would understand that the gas barrier thin film laminate 9 is therefore an encapsulation which seals the OLED.

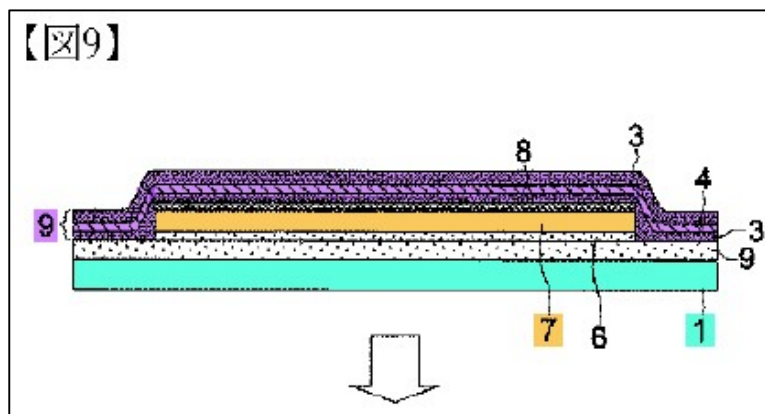


Suzuki, Fig. 9 (annotated).

189. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

f. Element 1[e]: wherein the organic layer sequence and the encapsulation are disposed on a carrier,

190. Suzuki discloses this element. As discussed above, Suzuki teaches that its OLED comprises an organic layer sequence sealed by an encapsulation. Suzuki further teaches that both the organic layer sequence and encapsulation are disposed on a carrier, “a resin substrate material 1” as see in Figure 9 below. Suzuki, [0274]

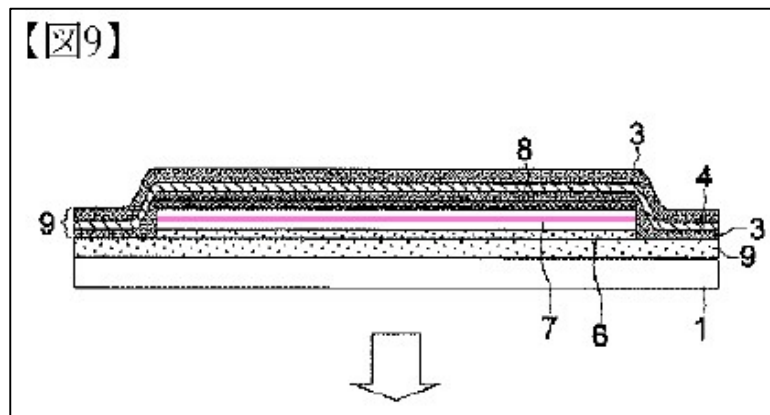


Suzuki, Fig. 9 (annotated).

191. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

- g. Element 1[f]: wherein the organic layer sequence comprises at least one radiation-emitting region configured to generate electromagnetic radiation in a spectral range from infrared radiation to UV radiation during operation,**

192. Suzuki discloses this element. Suzuki's organic layer sequence (organic layer 7) comprises "a light emission layer" that contains a light-emitting region which emits light, a form of electromagnetic radiation. Suzuki, [0274]. The radiation-emitting region of Suzuki's OLED is highlighted below in annotated Figure 9:



Suzuki, Fig. 9 (annotated).

193. Suzuki teaches that its light emission layer "emits light by recombination of electrons and holes injected from the electrode or the electron

transport layer and the hole transport layer...” Suzuki, [0299]. Suzuki further discloses using various different “light emission hosts” which Suzuki teaches “may be used in combination.” Suzuki, [0316]–[0319]. Suzuki further explains that “by using a plurality of dopant compounds, it is possible to mix different light emissions, thereby obtaining any desired light emission color.” Suzuki, [0316]–[0319]. For example, Suzuki teaches that “[w]hite light emission is possible by adjusting the type and doping amount of phosphorescent compounds, and can be applied to illumination and backlighting.” Suzuki, [0316]–[0319]. A POSITA would recognize that emitting of lights of various colors, as disclosed by Suzuki, entails generating electromagnetic radiation in a spectral range from infrared radiation to UV radiation. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

h. Element 1[g]: wherein the organic layer sequence comprises an electron transport layer that is n-doped; and

194. Suzuki discloses this element. As I explained above, Suzuki’s OLED contains an organic layer sequence (organic layer 7). This organic layer sequence includes “an electron transport layer.” Suzuki, [0274]. Suzuki discloses that the “electron transport layer comprises a material having the function of transporting electrons, and in a broad sense, electron injection layers and hole blocking layers are both included in electron transport layers” and that the “electron transport layer can be a single layer or a plurality of layers.” Suzuki, [0329]. Suzuki

specifies that “an electron transport layer with a high n nature doped with impurities can also be used.” Suzuki, [0333]. A POSITA would understand that “an electron transport layer with a high n nature doped with impurities” refers to an electron transport layer which has been n-doped. Moreover, Suzuki cites an article by Gufeng He et al., the same article I discussed above in §V.A.4.b as an “[e]xample” of such “an electron transport layer with a high n nature doped with impurities” as taught by Suzuki. *See* Ex. 1019 (He). He teaches an OLED with a “hole injection and transport layer (HTL)” which is “*p*-doped” and an “*n*-doped electron transport layer.” He, Abstract. The article further teaches that OLEDs with this “*p-i-n*” configuration (i.e., a configuration which has a *p*-doped HTL and *n*-doped ETL) feature “efficient carrier injection from both contacts into the doped transport layers and low ohmic losses in these highly conductive layers” and, as such, “low operating voltages are obtained compared to conventional undoped OLEDs.” He, Abstract. As such, a POSITA would understand that Suzuki’s reference to “an electron transport layer with a high n nature doped with impurities” is describing an electron transport layer which has been n-doped.

195. As I explained above in §V.A.4, at the time of the ’425 patent, using n-doped electron transport layers was well known in the art. *See, e.g.*, Exs. 1016, 1019, 1029, 1030. Even had Suzuki not disclosed that its doped electron transport layer was specifically n-doped, it would have been obvious to a POSITA

to n-dope the electron transport layer in Suzuki's OLED. A POSITA would have been motivated to include an n-doped electron transport layer to promote transport of electrons from the cathode and to improve electron injection and transport to the light-emitting region. *See, e.g.,* Ma, 812. A POSITA would have had a reasonable expectation of success, as n-doped electron transport layers were widely used at the time in OLEDs for this reason, and this would have been a straightforward, routine modification to Suzuki's electron transport layer for a POSITA to implement. Accordingly, a POSITA would have appreciated that Suzuki discloses or renders obvious this element.

i. Element 1[h]: wherein the organic layer sequence comprises an emission layer comprising an iridium-containing compound.

196. Suzuki discloses this element. As I discussed above, Suzuki teaches that its organic layer sequence (organic layer 7) comprises "a light emission layer." Suzuki, [0274], [0299]. Suzuki further teaches that, to achieve "even higher light emission efficiency," this light emission layer "preferably contains a host compound and a dopant compound." Suzuki, [0300]. A POSITA would know that, as Suzuki explains, there are "two major types of light emission dopants: fluorescent dopants, which emit fluorescence, and phosphorescent dopants, which emit phosphorescence." Suzuki, [0301]. Suzuki teaches that in the case of phosphorescent dopants, "iridium compounds are the most preferable." Suzuki, [0301], [0303].

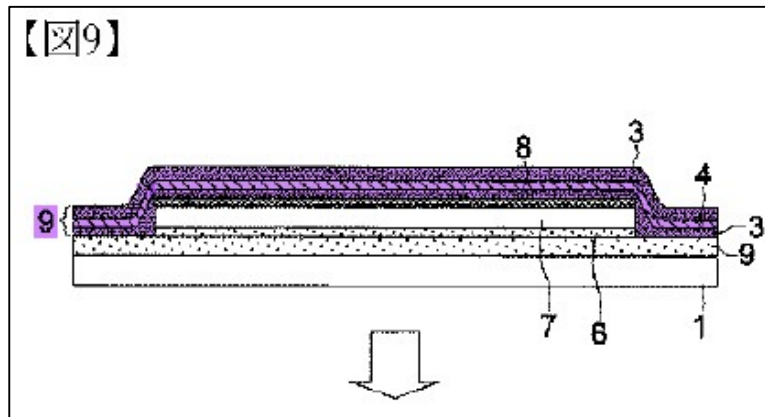
Thus, Suzuki discloses an organic layer sequence wherein the light emission layer includes an iridium-containing compound.

197. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

2. Dependent Claim 3

a. The device of claim 1, wherein at least one part of the encapsulation is formed by an insulation layer,

198. Suzuki discloses this element. Suzuki's OLED is sealed by an encapsulation, "gas barrier thin film laminate 9," which is comprised of multiple layers: "buffer film 3," "a barrier film 4," another "buffer film 3," and then a "ceramic (silicon oxide film)." Suzuki, [0274]. Suzuki defines a barrier film as "a dense film with a low water vapor transmission coefficient comprising a ceramic composition with low or no carbon content and having at least Si and O atoms" and defines a buffer film as "a flexible film with a larger water vapor transmission coefficient and a lower density than the barrier film consisting of a film with a high content of carbon atoms with Si, O, and C atoms." Suzuki, [0117]. A POSITA would recognize that barrier film 4, which comprises a dense intervening layer of insulation between the two more permeable, flexible buffer layers 3, is an insulating layer.



Suzuki, Fig. 9 (annotated).

199. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

b. wherein the insulation layer comprises at least one of: resin, silicon oxide, silicon nitride.

200. Suzuki discloses this element. As I explained above regarding claim 3[a], Suzuki teaches an encapsulation, “gas barrier thin film laminate 9,” comprises multiple layers including a buffer film and a barrier film, the latter of which is an insulation layer. Suzuki, [0068], [0274]. Suzuki further teaches that the buffer film and barrier film are preferably made from “at least one of silicon oxide, silicon oxide nitride, and silicon nitride.” Suzuki, [0069]. Suzuki thus discloses an encapsulation containing an insulation layer which includes silicon oxide or silicon nitride.

201. Moreover, even had Suzuki not disclosed including silicon oxide or silicon nitride in the insulation layer, doing so would have been obvious to a

POSITA. At the time of the '425 patent, using an insulating layer comprised of resin, silicon oxide, or silicon nitride was well known in the art. *See, e.g.*, Diekmann, 15. A POSITA would have known that it would be beneficial to include resin, silicon oxide, or silicon nitride, well-known insulating materials, in the insulation layer. Moreover, incorporating these well-known insulating materials in the insulation layer of Suzuki's OLED would have been a routine, straightforward modification with predictable results. Accordingly, a POSITA would have appreciated that Suzuki discloses or at a minimum renders obvious this element.

3. Dependent Claim 5: The device according to claim 1, wherein the organic light-emitting diode comprises a hole transport layer that is p-doped.

202. Suzuki discloses or at a minimum renders obvious this claim. As I explained above, Suzuki teaches that its OLED includes an organic layer 7 which includes a "hole transport layer." Suzuki, [0274]. Suzuki explains that "[a] single or a plurality of hole transport layers" may be included in the organic layer 7. Suzuki, [0322]–[0323]. Suzuki further teaches doping this hole transport layer, and specifically teaches that "a hole transport layer with a high p nature doped with impurities can also be used." Suzuki, [0328]. Suzuki cites an article by Gufeng He et al. as an "[e]xample" of a "hole transport layer with a high p nature doped with impurities" as taught by Suzuki. *See* Ex. 1019 (He). He et al.'s work teaches an OLED with a "hole injection and transport layer (HTL)" which is "*p*-doped" and an

“*n*-doped electron transport layer.” The article further teaches that OLEDs with this “*p-i-n*” configuration (i.e., a configuration which has a p-doped HTL and n-doped ETL) feature “efficient carrier injection from both contacts into the doped transport layers and low ohmic losses in these highly conductive layers” and, as such, “low operating voltages are obtained compared to conventional undoped OLEDs.” He, Abstract. As such, a POSITA would understand that Suzuki’s reference to “a hole transport layer with a high p nature doped with impurities” is describing a hole transport layer which has been p-doped.

203. Even had Suzuki not disclosed that its doped hole transport layer was specifically p-doped, it would have been obvious to a POSITA to p-dope the hole transport layer in Suzuki’s OLED. As I explained above in §V.A.4, p-doped hole transport layers were well-known for OLEDs at the time. In particular, it was well-known that using a p-doped hole transport layer so could improve current and power efficiencies of the OLED. Ma, 810 (“[r]ecently, the p-doping of HTL has drawn a lot of attentions because of its ability to enhance hole injection and lower driving voltages in OLEDs.”); Ma, 812 (finding that “the current and power efficiencies” of devices with an ETL n-doped with Liq and an HTL which is p-doped “are considerably improved as compared to” devices with no doping).

204. A POSITA would have further recognized that it would have been beneficial to use a p-doped hole transport layer together with an n-doped electron

transport layer which, as I explained above, Suzuki also teaches. For example, as explained by Ma, “current efficiency not only relies on the carrier injection, but also on the carrier balance.” Ma, 813. A surplus of one charge carrier could result in formation of unstable ions or “rapid device degeneration.” Ma, 814. A POSITA would recognize that a “*p-i-n*” OLED (i.e., an OLED that has both a p-doped hole transport layer and an n-doped electron transport layer) would achieve a good balance of electrons and holes and thus result in “good lifetime” for an OLED such as the one taught by Suzuki. Ma, 814; *see also* Ex. 1029. In light of these well-known benefits, a POSITA would have been motivated to include an p-doped hole transport layer in Suzuki’s OLED.

205. A POSITA would have reasonably expected success in using a p-doped hole transport layer in Suzuki’s OLED, in conjunction with the n-doped electron transport layer also taught by Suzuki. As discussed above, Suzuki already contemplates both an n-doped electron transport layer and a p-doped hole transport layer. Further, PIN-OLEDs using both n-doped and p-doped transport layers were well known by the time of the ’425 patent. *See, e.g.*, Ex. 1019 (He); Ex. 1016; Ex. 1029; Ex. 1030. Moreover, adding an p-dopant to a hole transport layer would be a routine matter well within a POSITA’s ability. Accordingly, a POSITA would have appreciated that Suzuki discloses or at a minimum renders obvious this claim.

4. Dependent Claim 6

- a. The device according to claim 1, wherein a color filter is arranged between the emission layer and the radiation exit area, and**

206. Suzuki discloses this element. As discussed above, Suzuki teaches use of a color filter in its OLED. Specifically, Suzuki teaches that “[a] color filter, some other hue improvement filter, or the like may also be used” and, additionally, that “a color conversion filter that converts the color emitted from the organic EL element to multicolor using phosphors may also be used.” Suzuki, ¶ [0336]. Suzuki further teaches that “one emission color, e.g., white emission light, can be made into BGR using a color filter to create a full-color display” and that “it is possible to convert the organic EL light emission color to other colors using color conversion filters to achieve full color.” Suzuki, [0348]. A POSITA would appreciate that the color filter taught by Suzuki necessarily must be placed between the emission layer and the radiation exit area as, in order for the device to produce this kind of colored light, light must be generated (which occurs in the emission layer), then pass through the color filter, and then, after being converted into colored light, exit the OLED (which occurs at the radiation exit area). Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

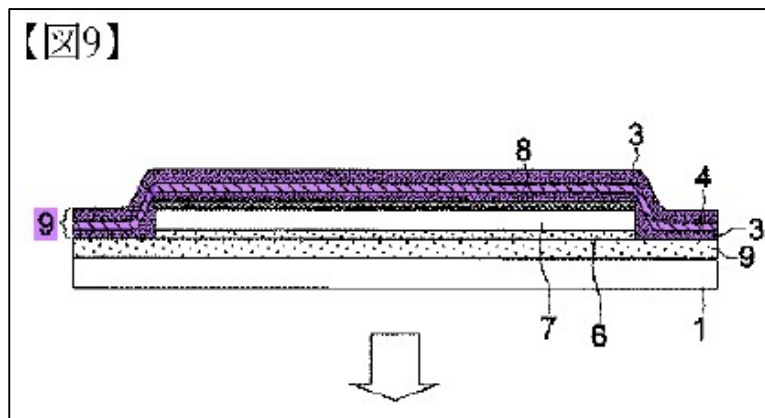
- b. wherein the color filter is configured to be highly transmissive for a first spectral subrange of the generated electromagnetic radiation and highly absorbant for a second spectral subrange of the generated electromagnetic radiation.**

207. Suzuki discloses this element. As explained above, Suzuki discloses a color filter that is arranged between the emission layer and the radiation exit area of the device and that, by doing so, Suzuki's OLED can produce different colors and achieve a "full color display." Suzuki further teaches that these color filters correspond to (i.e. are highly transmissive to) a particular wavelength range and, conversely, are relatively absorbent to wavelengths falling outside of that wavelength range. For example, Suzuki teaches that "any combination of the platinum complexes according to the present invention and other known light emitting materials can be selected, combined and whitened to *match the wavelength range corresponding to the color filter (CF) characteristics.*" Suzuki, [0373] (emphasis added). The use of color filters in lighting devices was well-known at the time and POSITA would know that, as explained by Diekmann, each "color filter is suitable for filtering light of a specific wavelength range" meaning that "light of this wavelength range is at least partially absorbed by the color filter." Diekmann, 40. For example, "a first color component can be filtered out of white light" while at the same time "a second color component can pass through the color filter essentially unhindered." Diekmann, 40. Suzuki therefore discloses color filters which are highly

transmissive to one spectral subrange of generated electromagnetic radiation while also being highly absorbent to another spectral subrange. Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

5. Dependent Claim 7: The device according to claim 1, wherein the encapsulation is flexible.

208. Suzuki discloses this claim. As discussed above, Suzuki teaches that its OLED is sealed by an encapsulation, “gas barrier thin film laminate 9,” which is comprised of a “buffer film 3,” “a barrier film 4,” another “buffer film 3,” and a “ceramic (silicon oxide film).” Suzuki, [0274]. Suzuki’s encapsulation can be seen in annotated Figure 9 below:



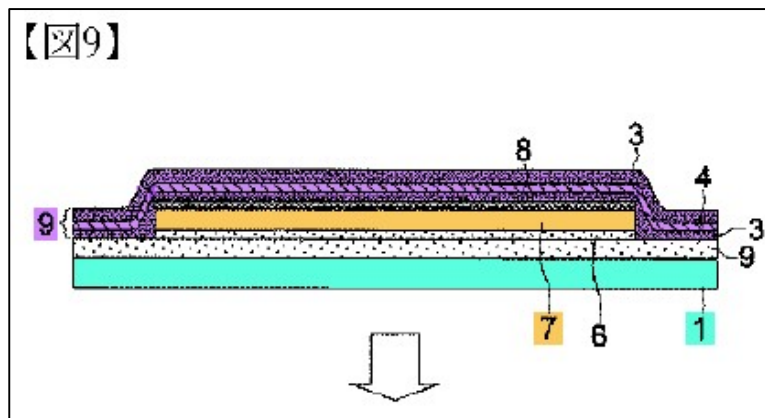
Suzuki, Fig. 9 (annotated).

209. Suzuki further teaches that the encapsulation that seals its OLED is a flexible encapsulation. Suzuki explains that “the barrier film, which has a high density and low gas and moisture vapor permeability, is a ceramic film that has a dense structure, is rigid, and breaks easily, and therefore by laminating a flexible

ceramic film with the same composition and relatively low density and flexibility compared to the gas barrier film as a buffer film to relieve stress, both flexibility and gas barrier performance are attained.” Suzuki, [0067]. A POSITA would understand this to be a flexible encapsulation. Accordingly, a POSITA would have appreciated that Suzuki discloses this claim.

6. Dependent Claim 8: The device according to claim 7, wherein the carrier comprises a film, a plastic film or a laminate.

210. Suzuki discloses this claim. Suzuki’s OLED includes a carrier, “resin substrate material 1,” which comprises a polymer (i.e., “plastic”) film, as seen in annotated Figure 9 below:



Suzuki, Fig. 9 (annotated).

211. Suzuki teaches that this carrier comprises a polymer, explaining that “a polyethylene terephthalate (PET) film is used as the resin substrate material” Suzuki, [0121]. A POSITA would recognize that polyethylene terephthalate

(PET) is a polymer. Accordingly, a POSITA would have appreciated that Suzuki discloses this claim.

7. Dependent Claim 13: The device according to claim 1, wherein the organic light-emitting layer sequence comprises a cathode having a thickness of at least 1 nm and at most 50 nm.

212. Suzuki discloses this claim. Suzuki's OLED comprises a "cathode 8," Suzuki, [0274], which "can be fabricated by forming a thin film of this electrode material with a method such as deposition or sputtering." Suzuki, [0288]. As I explained above in §V.A.1, it was well-known in the art at the time that either the cathode or anode should be made thin enough to be transparent or semi-transparent so as to allow light to leave the device after being generated. Suzuki also teaches this, explaining that in order for the emitted light to pass through, it is preferable that "either the anode or the cathode of the organic EL element is transparent or semi-transparent for improved luminance of the emitted light." Suzuki, [0288]. Specifically, Suzuki teaches that "a transparent or semi-transparent cathode can be fabricated by fabricating a film of the metal described above to 1-20 nm thick..." Suzuki, [0289].

213. Suzuki therefore teaches using a cathode of a thickness (1-20nm) within the claimed range. It would be clear to a POSITA that the upper bound of 21 nm to 50 nm in the claimed range is not critical to the claimed invention; as explained

above, the reason for using a thickness in this range is to render the cathode transparent or semi-transparent so that light can leave the device. Indeed, the '425 patent also makes this clear, as the specification merely describes the 1-50 nm range as an example thickness for a transparent metal layer. *See* '425 patent, 3:1–4, 5:16–41, 32:13–22. Moreover, Suzuki also discloses that, in general, a cathode's "film thickness is ordinarily chosen in the range of 10 nm to 5 μm ," while the 1-20 nm range is taught for a cathode which is transparent or semi-transparent. Suzuki, [0288]. Accordingly, a POSITA would have appreciated that Suzuki discloses this claim.

214. Even had Suzuki not specifically disclosed that its cathode was in the 1-50 nm range, it would have been obvious to a POSITA to select a cathode of a thickness between 1-50nm for use in Suzuki's OLED. As I explained above in §V.A.1, it was quite common to use cathodes in OLEDs with thicknesses within the 1-50nm range at the time and, indeed, this range of thicknesses was disclosed by Bulovic et al. and Lu et al. *See, e.g.*, Ex. 1022 (Bulovic); Ex. 1033 (Lu). The reason for this is that it was well-known by those in the art that the cathode in an OLED would preferably be sufficiently thin to be transparent or semi-transparent and thus enable the light generated by the OLED to exit the device. It was understood that a cathode thickness of greater than 50 nm would render the metal opaque. *See, e.g.*, Ex. 1022 (Bulovic); Ex. 1033 (Lu). A POSITA would thus have recognized that

thinning Suzuki's cathode to a thickness between 1-50 nm is needed in order for the cathode to be made transparent or semi-transparent. This, in turn, allows the light generated in the organic layer to exit the device via the transparent or semi-transparent cathode. A POSITA thus would have been motivated to use a cathode with a thickness between 1-50nm in Suzuki's OLED to achieve these benefits and would have reasonably expected success in making the well-known, routine modification of using a thin transparent or semi-transparent cathode in an OLED.

8. Dependent Claim 14: The device according to claim 13, wherein the cathode comprises one of: silver, magnesium, or an alloy comprising silver and magnesium.

215. Suzuki discloses this claim. Suzuki's OLED device contains a "cathode 8." Suzuki, [0274]. Suzuki teaches that it is preferable that this cathode be made from conductive materials with "small work functions (4 eV or lower)" such as "magnesium" and "magnesium/silver mixtures" (which a POSITA would understand to mean a magnesium and silver alloy). Suzuki, [0288]. Suzuki thus discloses a cathode comprising magnesium or an alloy comprised of silver and magnesium. Accordingly, a POSITA would have appreciated that Suzuki discloses this claim.

9. Dependent Claim 15: The device according to claim 13, wherein the cathode is in direct contact with a lithium containing layer.

216. Suzuki discloses this claim. Suzuki's OLED includes a "cathode 8." Suzuki, [0274]. Suzuki also teaches that its OLED includes an "injection layer" which is located "between the cathode and the light emission layer or electron transport layer." Suzuki, [0292].

217. Suzuki teaches, more specifically, that "[t]he injection layer is provided between an electrode and an organic layer to lower the drive voltage and improve the light emission brightness... and includes a hole injection layer (anode buffer layer) and an electron injection layer (cathode buffer layer)." Suzuki, [0293]. Suzuki makes clear that this electron injection layer, which serves as a "cathode buffer layer," is the layer immediately following the cathode, and thus is in direct contact with it. Suzuki discloses that the layers are stacked in the following order: "anode / anode buffer layer / hole transport layer / light emission layer / hole blocking layer / electron transport layer / *cathode buffer layer* / *cathode*." Suzuki, [0287] (emphasis added). As such, Suzuki discloses that the cathode is in direct contact with the electron injection layer.

218. Suzuki further teaches that this electron injection layer which is in direct contact with the cathode contains lithium. Suzuki teaches using an "alkali metal compound buffer layers typified by *lithium fluoride*..." as an electron injection

layer. Suzuki, [0295] (emphasis added). A POSITA would recognize that lithium fluoride is a compound which contains lithium. Accordingly, a POSITA would have appreciated that Suzuki discloses this claim.

10. Dependent Claim 16: The device according to claim 13, wherein the cathode comprises silver, magnesium, or alloy consisting of at least one of the abovementioned materials.

219. This claim is the same as claim 14, and Suzuki teaches it for the same reasons. *See* §X.F.8 above.

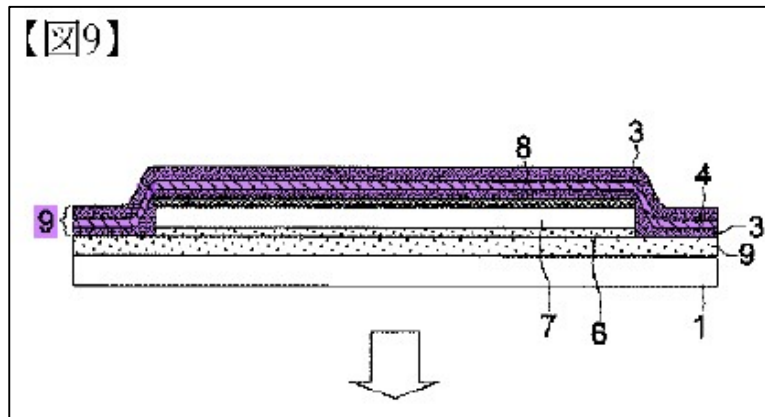
11. Dependent Claim 18

a. The device according to claim 1, wherein at least one part of the encapsulation is formed by an insulation layer, which can contain at least one of the following electrically insulating materials: resin, silicon oxide, silicon nitride,

220. Suzuki teaches this element for the same reasons discussed for Claims 3[a]–3[b]. *See* §X.F.2 above.

b. and wherein at least one part of the encapsulation is formed by a PECVD method.

221. Suzuki discloses this element. Suzuki’s OLED includes a multi-layer encapsulation, “gas barrier thin film laminate 9.” Suzuki’s encapsulation can be seen in annotated Figure 9 below:



Suzuki, Fig. 9 (annotated).

222. Suzuki teaches that it is preferable to form the layers of its encapsulation by “apply[ing] a *plasma CVD method* using plasma polymerization, and the atmospheric plasma method performed under atmospheric or near-atmospheric pressure is particularly preferable.” Suzuki, [0165] (emphasis added). A POSITA would recognize that “plasma CVD method” refers to plasma-enhanced chemical vapor deposition (PECVD). Accordingly, a POSITA would have appreciated that Suzuki discloses this element.

12. Dependent Claim 19: The device according to claim 1, wherein the organic light-emitting diode is configured for installation in a vehicle.

223. Suzuki discloses this claim. Suzuki teaches that its OLED can be used in various different display and illumination applications: “the organic EL element of the present invention can be used as a display device, a display, and various light-emitting light sources.” Suzuki, [0343]–[0344]. Suzuki further teaches

that these “[d]isplay devices and displays include TVs, PCs, mobile devices, ... *information displays in automobiles*, and the like.” Suzuki, [0343]–[0344] (emphasis added). With regards to the use of OLED in illumination devices, Suzuki teaches that that “[i]llumination devices using the organic EL element of the present invention include, but are not limited to, home lighting, *in-car lighting*,” and other devices. Suzuki, [0345] (emphasis added). Accordingly, a POSITA would have appreciated that Suzuki discloses this claim.

G. Ground VII: Claims 2, and 17 are obvious over Suzuki in view of Ma

1. Dependent Claim 2: The device of claim 1, wherein the electron transport layer comprises 8-hydroxyquinolinolato-lithium.

224. This claim would have been obvious to a POSITA based on Suzuki in view of Ma. As I explained above, Suzuki discloses, and at minimum renders obvious, an n-doped electron transport layer. *See* §X.F.1.h above. It would have been obvious to a POSITA to use 8-hydroxyquinolinolato-lithium as the dopant in Suzuki’s n-doped electron transport layer, as taught by Ma. Ma teaches an OLED with an electron transport layer doped with 8-hydroxy-quinolinatolithium (“Liq”). Ma, Abstract, 810–811.

225. The use of Liq-doped electron transport layers in OLEDs was a well-known practice in the art at the time, and had well-known benefits. At the time,

it was highly desirable to create OLEDs with a high level of efficiency, and it was well known that Liq-doping the electron transport layer was one way of achieving such efficiency. This understanding is reflected, for example, in Ma, which explains that “[s]ince the discovery of organic light-emitting devices (OLEDs), there has been a considerable interest in developing OLEDs with high efficiency.” Ma, 810. As I explained in §*V.A* above, it was understood in the art at the time, as explained in Ma, that “in order to lower driving voltage and enhance power efficiency, it is critical to enhance the carrier injection from the electrode to the transporting layer and to increase the transport conductivity.” Ma, 810.

226. Specifically, Ma teaches that a “doping concentration of Liq” in the electron transport layer results in increased current density and reduced driving voltage, compared to the undoped device. Ma, 813. Ma further teaches that “a certain doping ratio of Liq to Bphen can improve the electron transport ability of the co-deposited layer.” Ma, 813. A POSITA would have been motivated to use a Liq-doped electron transport layer in Suzuki’s OLED to achieve these benefits.

227. Indeed, Suzuki already contemplates an n-doped electron transport layer, so using an Liq-doped electron transport layer merely involves using a different dopant. As I explained above, Liq was well-known in the art at the time to have good electron injection and transport properties. A POSITA thus would have

recognized that Liq would be an advantageous dopant for Suzuki's doped electron transport layer.

228. Additionally, as I explained above, use of Liq as a dopant in an OLED's electron transport layer was well-known in the art at the time, and was specifically taught by Ma. Doing so would be a routine practice which would be easy for a POSITA to implement with a high probability of success, particularly considering that Suzuki already contemplates an analogous n-doped layer for electron transport. As such, a POSITA could readily have implemented an Liq-doped electron transport layer in Suzuki's device. Accordingly, a POSITA would have appreciated that Suzuki in view of Ma discloses this claim.

2. Dependent Claim 17: The device according to claim 1, wherein the electron transport layer comprises at least 8-hydroxyquinolinolato-lithium.

229. This claim is the same as claim 2, and would have been obvious to a POSITA based on Suzuki in view of Ma for the same reasons. *See* §X.G.1 above.

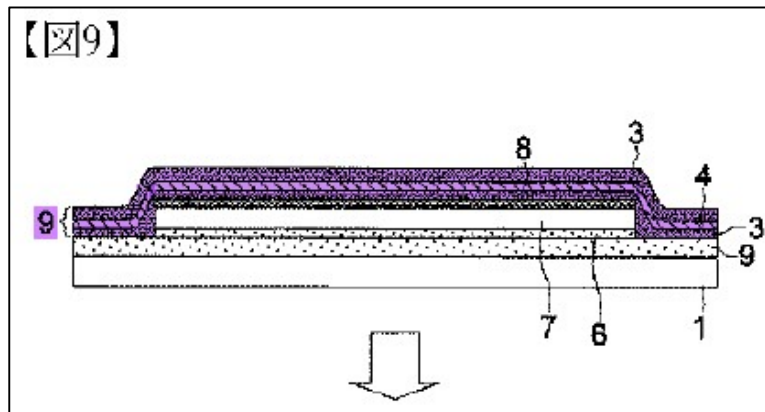
H. Ground VIII: Claim 4 is obvious over Suzuki in view of Lee

1. Dependent Claim 4

a. The device of claim 1, wherein the encapsulation comprises a first encapsulation layer and a second encapsulation layer,

230. This element would have been obvious to a POSITA based on Suzuki in view of Lee. As I explained above, Suzuki discloses that its OLED is

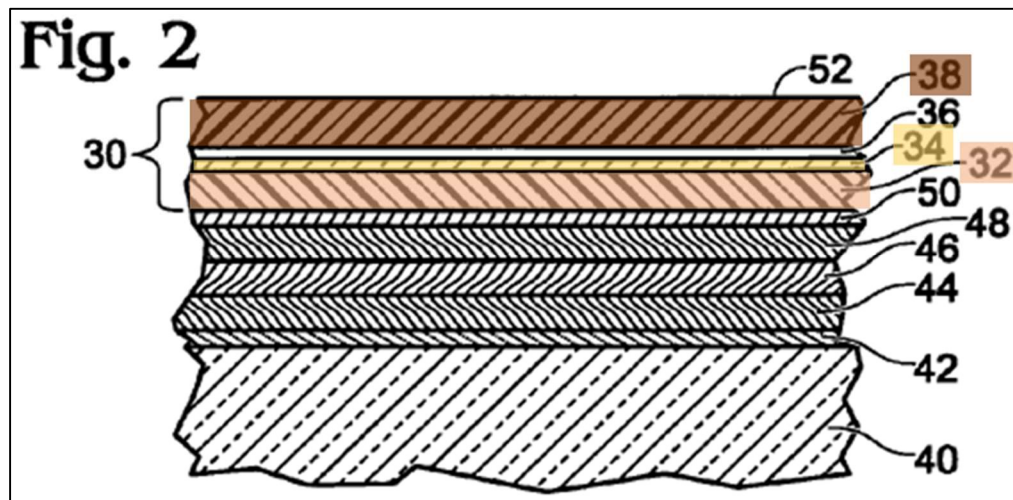
encapsulated in an encapsulation, “gas barrier thin film laminate 9,” which comprises multiple encapsulation layers, a “buffer film 3,” followed by “a barrier film 4,” followed by another “buffer film 3,” and then a “ceramic (silicon oxide film).” Suzuki, [0274]. Suzuki teaches that these encapsulation layers make the encapsulation flexible, as “the barrier film, which has a high density and low gas and moisture vapor permeability, is a ceramic film that has a dense structure, is rigid, and breaks easily, and therefore by laminating a flexible ceramic film with the same composition and relatively low density and flexibility compared to the gas barrier film as a buffer film to relieve stress, both flexibility and gas barrier performance are attained.” Suzuki, [0067]. Suzuki’s multi-layer encapsulation can be seen in annotated Figure 9, below:



Suzuki, Fig. 9 (annotated).

231. Like Suzuki, Lee similarly teaches an encapsulation for an OLED comprising multiple encapsulation layers, a first encapsulation layer (“second

semi-crystalline parylene-based polymer layer 38”) and a second encapsulation layer (“first semi-crystalline parylene-based polymer layer 32”). Lee, [0022] (“The first semi-crystalline parylene-based polymer layer is shown in FIG. 2 at 32, the inorganic barrier layer is shown at 34, . . . and the second semi-crystalline parylene-based polymer layer is shown at 38”); Lee, [0021] (“annealing . . . the second semi-crystalline parylene-based polymer layer [forms] a highly crystalline parylene-based polymer layer”). These are illustrated in Lee’s annotated Figure 2 below:



Lee, Fig. 2 (annotated).

232. A POSITA would have been motivated to use Lee’s multi-layered encapsulation as the encapsulation for Suzuki’s OLED. As I explained above in §V.A.5 and §X.C.1.a, the use of encapsulation in OLEDs was well-known at the time, specifically to protect the OLED from the ambient environment and extend its lifetime. *See, e.g.*, Exs. 1020, 1021. Indeed, Lee itself teaches the benefits of using

an encapsulation in an OLED; for example, Lee explains that “the low work function metals typically used as cathodes in OLEDs are environmentally sensitive, and may be easily oxidized by moisture or oxygen from air. Therefore, it is important to protect these materials from air both during processing and during use.” Lee, [0005]. Lee also teaches the specific benefits of the type of multi-layer encapsulation that it discloses: Lee explains that semi- and highly-crystalline parylene-based polymer films “have low-enough WVTR [(water vapor transport rate)] and OTR [(oxygen transport rate)] values that they not only ‘decouple’ adjacent inorganic layers to prevent the propagation of defects between inorganic layers, but also themselves help block water vapor and oxygen permeation into the OLED.” Lee, [0020]. Thus, Lee’s encapsulation formed of semi-crystalline and highly-crystalline polymer barrier layers may provide “a significantly improved lifetime compared to prior OLEDs having polyacrylate or amorphous parylene barrier layers.” Lee, [0020]. Applying Lee’s multi-layered encapsulation to Suzuki’s OLED is also the mere application of a known technique to a piece of prior art ready for improvement.

233. A POSITA would have reasonably expected success in combining Lee’s multi-layered encapsulation with Suzuki’s OLED. Suzuki already contemplates a multi-layered encapsulation with alternating layers of relatively flexible and permeable “buffer films” and dense, less permeable “barrier films,” and applying Lee’s encapsulation merely replaces one set of alternating layers with

another, to obtain the benefits taught in Lee. This modification would have been a routine matter well within the ability of a POSITA. Accordingly, a POSITA would have appreciated that Suzuki in view of Lee discloses this element.

b. the first and the second encapsulation layer each having a respective volume structure,

234. This element would have been obvious to a POSITA based on Suzuki in view of Lee. As explained above in §X.C.I, the encapsulation taught by Lee includes a first and second encapsulation layer which each have distinct volume structures.

235. Lee teaches that its encapsulation comprises a first “*highly crystalline*” and a second “*semi-crystalline*” “*parylene-based polymer layer.*” Lee, [0023] (emphasis added). Lee explains that the first (highly crystalline) encapsulation layer has “up to 70% of crystallinity” and the second (semi-crystalline) encapsulation layer has “at least 10%” of crystallinity. Lee, [0023]. As such, Lee teaches an encapsulation comprising a first encapsulation layer with a highly crystalline volume structure, and a second encapsulation layer with a semi-crystalline volume structures. Accordingly, a POSITA would have appreciated that Suzuki in view of Lee discloses this element.

- c. wherein the volume structure of the second encapsulation layer is independent of the volume structure of the first encapsulation layer, and**

236. This element would have been obvious to a POSITA based on Suzuki in view of Lee. As explained above in §X.C.1 and §X.H.1.b, Lee teaches a multi-layer comprising encapsulation layers with volume structures which are distinct and independent from one another: the first (highly crystalline) encapsulation layer has “up to 70% of crystallinity” and the second (semi-crystalline) encapsulation layer has “at least 10%” of crystallinity. Lee, [0023]. Lee also explains that its polymer layers have low-enough WVTR and OTR values that they “‘decouple’ adjacent inorganic layers to prevent the propagation of defects between inorganic layers.” Lee, [0020].

237. Accordingly, a POSITA would have appreciated that Suzuki in view of Lee discloses this element.

- d. the volume structure of the second encapsulation layer has a higher amorphicity than the volume structure of the first encapsulation layer.**

238. This element would have been obvious to a POSITA based on Suzuki in view of Lee. As explained above in §X.H.1.c, Lee discloses a multi-layer encapsulation wherein the first (highly crystalline) encapsulation layer has “up to 70% of crystallinity” and the second (semi-crystalline) encapsulation layer has “at least 10%” of crystallinity. Lee, [0021]–[0023]. Lee explains that the semi-

crystalline polymer layer may be about 10% crystallinity as deposited, while the highly crystalline polymer layer, formed by depositing a semi-crystalline polymer film and annealing to increase its crystallinity, may be about 70% crystallinity. Lee, [0021], [0023]–[0027]. Amorphicity and crystallinity both describe the volume structure of solids, and have an inverse relationship; crystalline solids have a long-range order, meaning the atoms or molecules are arranged in a periodic pattern, while amorphous solids have no long-range order, meaning the atoms or molecules are arranged without a periodic pattern. *See* Ex. 1025, 1313–1314, 1386–1387. In practical terms, this means that the higher a material's crystallinity, the lower its amorphicity; if material A has higher crystallinity than material B, then material A necessarily has a lower amorphicity than material B. Therefore, a POSITA would recognize that because Lee's second (semi-crystalline) encapsulation layer has lower crystallinity than the first (highly crystalline) encapsulation layer, the second encapsulation layer must also have a higher amorphicity than the first encapsulation layer.

239. Accordingly, a POSITA would have appreciated that Suzuki in view of Lee discloses this element.

I. Ground IX: Claims 9–11 are obvious over Suzuki in view of Caldwell

1. Dependent Claim 9

- a. The device according to claim 1, wherein the device comprises at least one touch-sensitive operating element,**

240. This claim would have been obvious to a POSITA based on Suzuki in view of Caldwell. As explained above in §X.F.1, Suzuki teaches an OLED, as well as display devices incorporating this OLED. It would have been obvious to a POSITA to implement touch sensing functionality in an OLED display device according to Suzuki by incorporating touch-sensitive operating elements.

241. Caldwell teaches a touch-sensitive operating element (a “bottom-emitting touch switch assembly”) comprising at least one touch sensor (electrode 31). Caldwell discloses that the electrode 31 is integrated into the bottom-emitting device which comprises an emissive stack (22), cathode (23), anode (21), wherein the touch electrode 31 “is shown overlying anode 21, which in turn overlies emissive stack 22 and cathode 23” which is “borne on substrate 20” and includes an “[i]nsulating layer 50 [which] separates electrode 31 from the layers of the light emitting device.” Caldwell, [0074].

242. A POSITA would have been motivated to incorporate touch sensing functionality to Suzuki’s OLED. Using touch sensors as input devices for

controlling electronic devices was well known by the time of the '425 patent. *See, e.g.,* Koshihara, [0030]–[0031]. Moreover, a POSITA would have recognized the benefits of integrating Caldwell's touch sensor directly into Suzuki's OLED as opposed to combining Suzuki's OLED with a separate touch sensor device. Indeed, Caldwell specifically teaches these benefits, explaining that “backlighting can be advantageously aligned with an operative touch surface” and that directly integrating a touch sensor directly into a light emitting device can “greatly reduce the cost and complexity of using backlighting with touch sensors.” Caldwell, [0006], [0007]. Caldwell further teaches that doing so can “reduce or eliminate the extra material and manufacturing cost associated with the separate touch sensor and lighting assemblies known in the art, which must be electrically coupled and aligned.” Caldwell, [0006], [0007]. Moreover, as I explained above in §X.D.1, it was known to be desirable in the art at the time to have an OLED with a thin profile, and a POSITA would have understood that an integrated touch sensor would also result in a thinner profile for the OLED. Ex. 1024, 3:2-7.

243. A POSITA would have also reasonably expected success in incorporating Caldwell's touch sensing functionality in Suzuki's OLED. OLEDs with integrated touch sensors were well known at the time, and there existed various applications for controlling the functionality of devices including OLED displays and OLED light sources. *See, e.g.,* Koshihara, [0030]–[0031]. Integrating Caldwell's

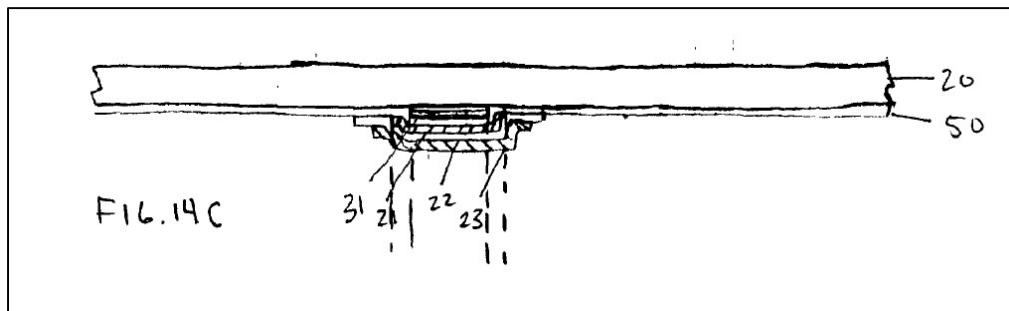
touch sensor into Suzuki's OLED would have been a simple, routine modification that would have been well within a POSITA's ability to implement. Thus, the combination of Suzuki's bottom-emitting OLED with Caldwell's integrated touch sensor discloses a touch-sensitive operating element comprising at least one touch sensor. Accordingly, a POSITA would have appreciated that Suzuki in view of Caldwell discloses this claim.

b. wherein the at least one touch-sensitive operating element comprises at least one touch sensor.

244. This claim would have been obvious to a POSITA based on Suzuki in view of Caldwell. As explained above regarding claim 9[a], Caldwell teaches a touch-sensitive operating element (a “bottom-emitting touch switch assembly”) which includes a touch sensor (electrode 31). Caldwell discloses that this touch electrode 31 is integrated into the bottom-emitting device which comprises an emissive stack (22), cathode (23), anode (21), wherein the touch electrode 31 “is shown overlying anode 21, which in turn overlies emissive stack 22 and cathode 23” which is “borne on substrate 20” and includes an “[i]nsulating layer 50 [which] separates electrode 31 from the layers of the light emitting device.” Caldwell, [0074].

2. Dependent Claim 10: The device according to claim 9, wherein the at least one touch sensor is integrated into the organic light-emitting diode.

245. This claim would have been obvious to a POSITA based on Suzuki in view of Caldwell. As explained above, Caldwell teaches that its touch sensor (electrode 31) is directly integrated into a bottom-emitting OLED. As seen in Figure 14C below, Caldwell discloses “a bottom-emitting touch switch with integrated control circuit assembly according to the present invention including a touch switch with integrated control circuit assembly.” Caldwell, [0074].



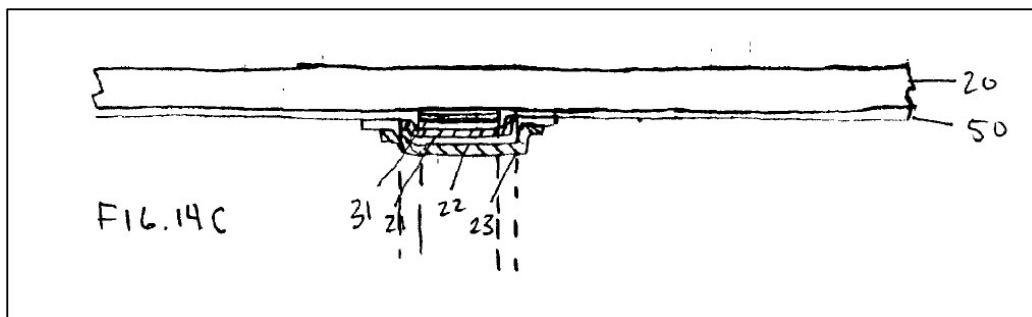
Caldwell, Fig. 14C.

246. Caldwell’s bottom-emitting touch switch assembly comprises a very similar structure to that of Suzuki’s OLED; much like the OLED taught by Suzuki, Figure 14C depicts a bottom-emitting touch switch which comprises an emissive stack (22), cathode (23), anode (21), and a touch electrode (31). Caldwell, [0074]. Further, as discussed above, Caldwell teaches that its touch sensor is directly integrated into the OLED as the touch electrode “is shown overlying anode 21, which in turn overlies emissive stack 22 and cathode 23” which is “borne on

substrate 20” and includes an “[i]nsulating layer 50 [which] separates electrode 31 from the layers of the light emitting device.” Caldwell, [0074]. Caldwell teaches that this insulating layer 51 “is preferably transparent and can be SiO₂ or any other suitable dielectric material” and, likewise, “[e]lectrode 31 and anode 21 are also preferably transparent.” Caldwell, [0074]. Thus, the combination of Suzuki’s bottom-emitting OLED with Caldwell’s integrated touch sensor discloses a touch sensor integrated into an OLED. Accordingly, a POSITA would have appreciated that Suzuki in view of Caldwell discloses this claim.

3. Dependent Claim 11: The device according to claim 10, wherein the touch-sensitive operating element is arranged at the radiation exit area of the device.

247. This claim would have been obvious to a POSITA based on Suzuki in view of Caldwell. As explained above in §X.I.2, Caldwell teaches a touch sensor which is directly integrated into a bottom-emitting OLED, as seen in Figure 14C:



Caldwell, Fig. 14C.

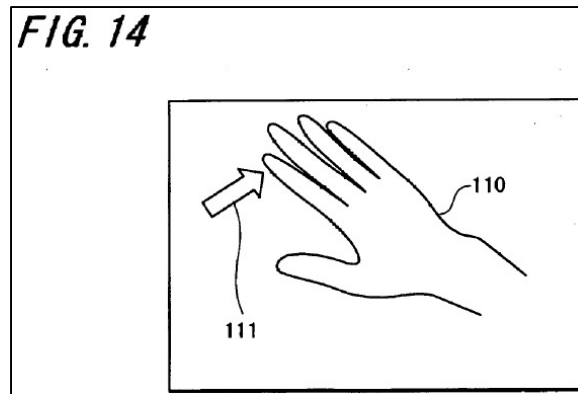
248. Figure 14C also illustrates that the transparent touch electrode (31) is arranged at the “radiation exit area” at bottom of the bottom-emitting OLED (*i.e.*, where light exits the OLED); arranging the touch sensor in this location allows light to exit the device through the transparent touch electrode. Caldwell, [0074]. Thus, combination of Suzuki’s bottom-emitting OLED with Caldwell’s integrated touch sensor discloses the touch sensor being arranged at the radiation exit area of the OLED. Accordingly, a POSITA would have appreciated that Suzuki in view of Caldwell discloses this claim.

J. Ground X: Claim 12 is obvious over Suzuki in view of Harada

1. Dependent Claim 12: The device according to claim 1, wherein the device is drivable by means of a gesture control.

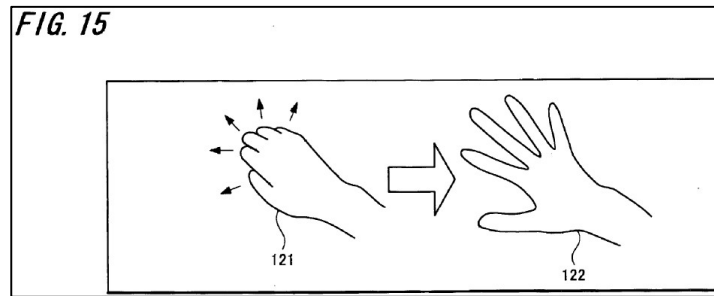
249. This claim would have been obvious to a POSITA based on Suzuki in view of Harada. As explained above in §X.F.1, Suzuki teaches an OLED and various display devices incorporating this OLED. It would have been obvious to a POSITA to implement gesture control for operating Suzuki’s OLED, such as the gesture control taught by Harada. Harada teaches “a display technology capable of receiving light in parallel with emitting light,” which can be applied to “an organic EL (Electro-Luminance) display.” Harada, [0003], [0086]. Specifically, Harada’s organic EL display includes an “I/O display” capable of both emitting light and receiving light. Harada, [0039], [0040]–[0044], [0076]–[0079]. The I/O display can

detect both when the screen is touched and also when an object approaches the screen. Harada, [0039], [0050]–[0051], [0082]–[0085]. The display device performs “gesture recognition using a hand shape” by recognizing “the shape of a hand 110 touched (or approached) to a display panel.” Harada, [0071]. For one example, shown in Figure 14, “the hand shape recognized is displayed as an image and then with a display object move 111, some processing is performed.” Harada, [0071].



Harada, Fig. 14.

250. In another example, shown in Figure 15, “a hand closed 121 is changed to a hand opened 122 and the touch or approach of the hand (121, 122) in each condition is recognized as an image on the display panel and the processing based on the image-recognition is executed.” Harada, [0072]. Harada further teaches that the device can be operated by providing instructions or commands “based on those recognitions.” Harada, [0073].



Harada, Fig. 15.

251. A POSITA would have been motivated to incorporate this gesture control functionality taught by Harada in Suzuki's OLED. Using gesture control input for controlling electronic devices, including OLEDs, was well known in the art by the time of the '425 patent. *See, e.g.,* Harada; Ex. 1032 (Freeman). Indeed, Harada specifically teaches that its gesture control functionality can be applied to OLEDs. Harada, [0003]. A POSITA would have been motivated to implement gesture control based on light detection as taught by Harada into Suzuki's OLED in order to allow a user to operate the device "in more natural ways." Harada, [0073].

252. A POSITA would have also reasonably expected success in incorporating gesture control functionality in Suzuki's OLED particularly given that OLEDs with integrated sensors for gesture recognition and control of the OLED were well known in the art, with applications for controlling the functionality of devices including OLED displays and OLED light sources. *See, e.g.,* Harada; Ex. 1032 (Freeman). Implementing gesture control functionality based on light detection

as taught by Harada to allow a user to control an OLED would not have led to unpredictable results, and would have been a routine matter well within the ability of a POSITA.

253. Accordingly, a POSITA would have appreciated that Suzuki in view of Harada discloses this claim.

XI. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

254. I understand that no secondary considerations evidence has been identified for the '425 patent at this time. I am not aware of any such evidence that would apply to the challenged claims.

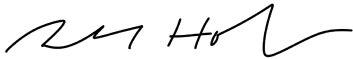
XII. CONCLUSION

255. For the reasons discussed above, claims 1–19 of the '425 patent would have been anticipated and/or obvious to a POSITA.

* * *

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on July 2, 2024, at Minneapolis, MN.

A handwritten signature in black ink, appearing to read "R. J. Holmes", is written above a horizontal line.

Russell J. Holmes, Ph.D.