

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. IPR2024-01223
Patent No. 6,949,389

DECLARATION OF MR. KURT HUMPHREY

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P.O. Box 1450
Alexandria, VA 22313-145

I, Kurt Humphrey, declare as follows:

I. Introduction

1. I have been retained as an independent expert on behalf of Pictiva Displays International Ltd. (“Patent Owner”) to provide certain technical background regarding the primary references (Kijima and Suzuki) that form the basis for the Grounds of unpatentability in the Petition for IPR2024-01223.

2. I am being compensated for my time at my normal consulting rate. My compensation does not depend on the outcome of any matter or on any of the opinions provided below. I have no financial interest in this matter.

3. My testimony herein is based on my technical background, my years of experience in the field of microelectronics, photonics, and display technologies, the associated fabrication and deposition technologies, and my review of the materials cited herein.

4. I provide my testimony from the perspective of a person of ordinary skill in the art at the time of the invention (further addressed below). I am familiar with the knowledge and skill level of these people based on my decades of experience in the display technology and frequent interactions with such people. For example, in the 2001-2002 time frame, I served as Engineering Director at TAEUS International Corporation, and was the primary technical contributor on

display technology projects including LCD, LED, plasma and OLED, as well as other photonics and optoelectronics assignments. Before then, between 1986-1989, I assisted in setting up the state-of-the-art semiconductor fab (WAX) that would become a key LCD display research and pilot production facility for the Flat Panel Display (FDC) Company consortium led by Philips.

II. Qualification and Experience

5. I am the founder and principal technologist of IP Engenuity LLC, an entity that provides engineering consulting to high-tech companies, inventors, patent holders and intellectual property professionals. I am also an Adjunct Professor in the College of Engineering at Colorado Technical University in Colorado Springs, specializing in instruction of general organic and inorganic chemistry for engineers. A copy of my CV is attached as Appendix A.

6. I obtained my Bachelor of Science and Master of Science degrees in Ceramic Engineering from the University of Missouri-Rolla (now Missouri University of Science and Technology), in Rolla, Missouri, in 1978 and 1980, respectively.

7. I worked as an engineer and engineering manager in the microelectronics industry for 20 years including positions with General Motors, AT&T Technologies, Philips Research Laboratories (Eindhoven, NL), United Technologies Microelectronics Center, and Rockwell Semiconductor Systems.

8. After serving as Director of Engineering for TAEUS International from 1999-2005, I launched IP Enginuity LLC to provide comprehensive technical expert consulting and engineering services to high-tech companies, inventors, patent holders and intellectual property professionals.

9. In addition to my extensive experience in developing microelectronics fabrication processes, materials characterization, and failure analysis methods for a variety of microelectronic products and components including CMOS digital logic and memory integrated circuits (ICs), smart power devices, complementary bipolar silicon-on-insulator (SOI) ICs, CMOS image sensors, automotive sensors and micro-electrical-mechanical systems (MEMS) gyroscopes, I have investigated and reverse-engineered several commercial OLED displays used in a variety of applications from smartphones and smart watches to medical devices.

10. I have been engaged by multiple major flat panel developers, users, OEMs and/or patent owners to investigate display IP and commercial OLED displays dating back to 2011. The OLED IP investigations required comparison of published OLED utility patents to commercially available displays in terms of their physical, material and electrical design and construction. Subsequent engagements have also involved technical investigations of sub-pixel design and construction as well as overall display layout including peripheral circuitry used to communicate touch sensor output with the specific microprocessors and microcontrollers used to

interpret and execute the various product operations and functions associated with the touchscreen.

III. Skilled Artisan

11. I understand that Samsung defines a person of ordinary skill in the art at the time of the invention as someone with “a bachelor’s degree in Electrical Engineering, Materials Science, or a related field, and at least one year of experience in display technologies.” Petition at 14-15.

12. I have degrees in Ceramic Engineering, a branch of Materials Science, and I worked on flat panel display (FPDs) technology at Philips in the 1980s. Since 2011, I have worked on many projects involving plasma, LCD, electrophoretic (E-ink) and OLED technologies.

13. I was at least a person of ordinary skill in the art, if not one with above average skills, at the time of the invention (2001), under Samsung’s definition of a person of ordinary skill in the art.

IV. Ground I

14. I am informed that in the district court action, Samsung has proposed to construe “planarization layer” as “a layer of material that planarizes such that the propagation of defects from one layer to another layer is interrupted and the topography of the underlying layer is not reproduced.” EX2003 at 6-7. I am also informed that Samsung has proposed that “selectively depositing” means

“depositing a material in only desired areas, such that no additional processing must be performed for removing unwanted material.” *Id.* at 7. I have been asked to apply those definitions in my analysis.

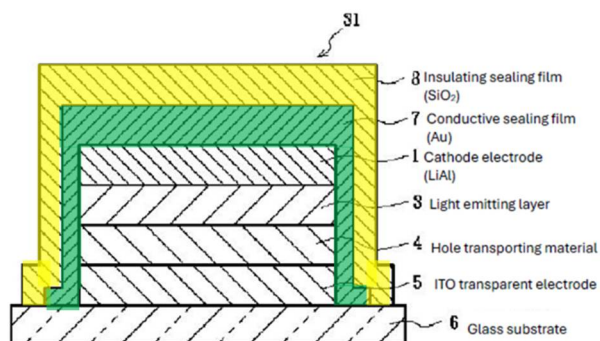
A. Kijima’s Disclosure: Kijima’s thin film encapsulation already prevents dark spot growth

15. Kijima aims “[t]o provide a method for producing an optical element which exhibits good stability even when exposed to moisture and oxygen.”

EX1010, [PROBLEM]. Kijima observes that conventional OLEDs suffer from “a major problem” of “degradation.” EX1010, [0026]. Kijima states that “the causes of this degradation are thought to include thermal degradation of the organic materials due to heat degradation accompanying light emission, the effects of moisture and oxygen contamination during production, and peeling of the organic layer due to oxidation of the cathode electrode.” *Id.*

16. Kijima’s solution is “[a] conductive sealing film 7 and an insulating sealing film 8 [that] are successively formed on a metal electrode 1 provided on a laminate body of organic layers 2, 3, and 4 including a light-emitting layer, and film formation is continuously performed in the same vacuum deposition device 11 as the organic layers 2, 3, and 4 and the metal electrode 1.” *Id.*, [RESOLUTION MEANS]; *see also* [0027] (“When organic electroluminescent elements are applied to display devices and the like, the influence of the aforementioned factors on the life span of these elements is a major problem. Therefore, there is desire to

provide a sealing film to protect the organic layer and the metal electrode, and then to continuously fabricate a sealing film structure in a vacuum.”).



(annotated figure on cover page from Kijima)

17. Kijima notes, however, “if the insulating sealing film is deposited in a vacuum deposition device, the effect of radiant heat during deposition of the insulating sealing film will be large, raising concern about the effect on organic layers such as the light emitting layer.” *Id.*, [0028]. An object of Kijima is thus “to provide a method for producing a long-life optical element that hardly experience degradation of the organic layer and exhibits favorable stability even under atmospheric conditions.” *Id.*, [0029].

18. To address the perceived issue of radiant heat during deposition of insulating sealing film 8, Kijima interposes “at least a conductive sealing film” 7 (green) on the top electrode (such as the cathode 1) “while maintaining the vacuum (and preferably further forming an insulating sealing film [8 (yellow)] thereon).” *Id.*, [0030].

19. Kijima discloses that, after depositing a 2k angstrom (*i.e.*, 0.2 μm) thick cathode made of LiAl or SrAl (*see* EX1010, [0049], [0061], [0065], [0069]), a 10k angstrom (*i.e.*, 1 μm) thick gold-based conductive sealing film 7 is deposited under vacuum (*id.*, [0031]-[0032], [0050], [0062], [0066], [0070], [0052]). Then, without breaking vacuum, a 2k angstrom (0.2 μm) thick SiO_2 or Al_2O_3 -based insulating sealing film 8 is deposited on the gold sealing film 7. *Id.*, [0031]-[0032], [0051], [0052], 32[0063], [0067], [0071]. Devices made in this manner exhibit the same performance after one month in air with “almost no dark spots [] observed.” *Id.*, [0055], [0064], [0068], [0072].

20. Kijima also provides three comparative examples to emphasize the importance of conductive sealing film 7 and the need to maintain a vacuum before completing the deposition of the insulating sealing film 8. For example, in Comparative Example 1, the conductive sealing film is omitted. *Id.*, [0073]-[0074]. The resulting OLED is non-operative because “the organic layer had degraded due to radiant heat generated during deposition of the insulating sealing film 8.” *Id.*, [0075]. This demonstrates the importance of “providing the conductive sealing film adjacent to and below the insulating sealing film[.]” *Id.* This is because being a “material with good thermal conductivity such as a metal,” “efficient dissipation of the radiant heat can be expected.” *Id.*, [0057]. Kijima

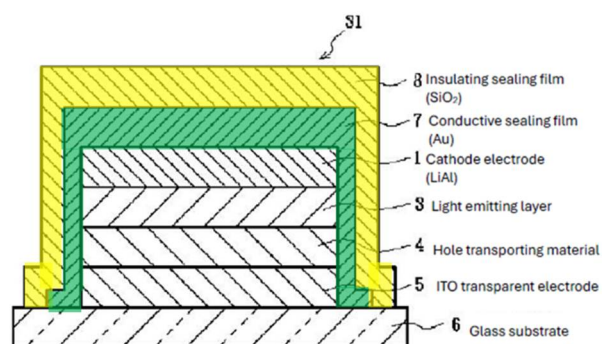
states that it is important to have a “thickly formed” conductive sealing film 7 “as a buffer layer during deposition.” *Id.*, [0056].

21. In Comparative Example 2, before depositing the conductive sealing film 7, the deposition chamber “was temporarily returned from vacuum to atmospheric pressure, and then the device was again evacuated to a vacuum.” *Id.*, [0077]-[0078]. The resulting device showed significantly reduced stability and lifetime, with “a large number of dark spots.” *Id.*, [0080]. This demonstrates the “adverse effects of exposing the elements to the atmosphere before the formation of the conductive sealing film 7,” and “the importance of ... forming the conductive sealing film 7 under vacuum conditions.” *Id.*, [0081].

22. In Comparative Example 3, before depositing the insulating sealing film 8, “the pressure inside the deposition device was temporarily returned from vacuum to atmospheric pressure, and then the device was again evacuated to a vacuum.” *Id.*, [0084]. The resulting devices also showed worse performance with “an increase in dark spots” than a device whose sealing layers 7 and 8 were both deposited under vacuum. *Id.*, [0086]. This example demonstrates “the importance of forming all of the films under vacuum conditions.” *Id.*, [0087]; *see also* [0058] (“the organic layer and above are formed continuously in the same vacuum deposition device, so productivity is high and there is no effect of oxygen in the atmosphere during production.”).

23. Thus, according to Kijima, (1) a sufficiently thick conductive sealing film such as a gold film of 1 micron and above is needed to address the radiant heat during the deposition of the inorganic sealing film 8; (2) both the conductive sealing film 7 and the inorganic sealing film 8 must be deposited under vacuum, without exposing the device to atmosphere before completing the deposition of both sealing layers.

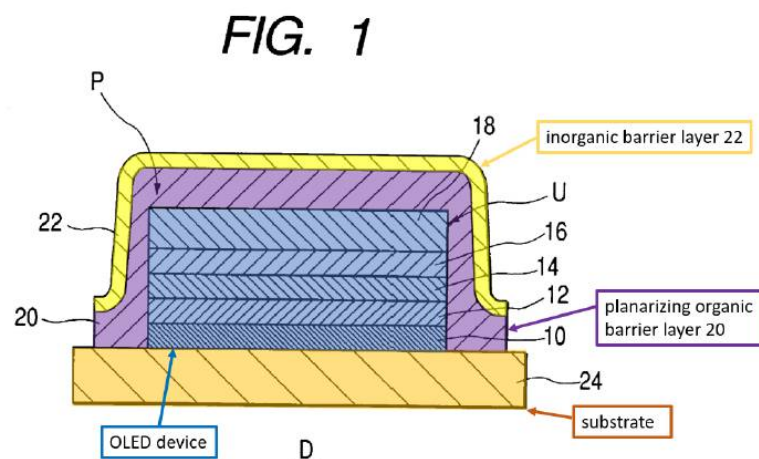
24. Of note, Kijima does not describe the inorganic sealing layer 8 as a planarization layer. This is not surprising because the sealing layer 8 generally follows the topology of the underlying conductive sealing film 7.



B. Suzuki's Disclosure: Suzuki's thin film encapsulation is no more effective against dark spot growth than Kijima

25. Suzuki also attempts to address the problem associated with “shortage of stability” and “dark spot[s]” in OLEDs. EX1012, 1:41-49. According to Suzuki, dark spots are caused by “moisture entering from defective portions” of the OLEDs. *Id.*, 1:50-52. Suzuki's solution is to provide a protective layer consisting

of “an organic barrier layer 20 and an inorganic barrier layer 22.” *Id.*, 2:26-29, 2:60-62, Fig. 1.



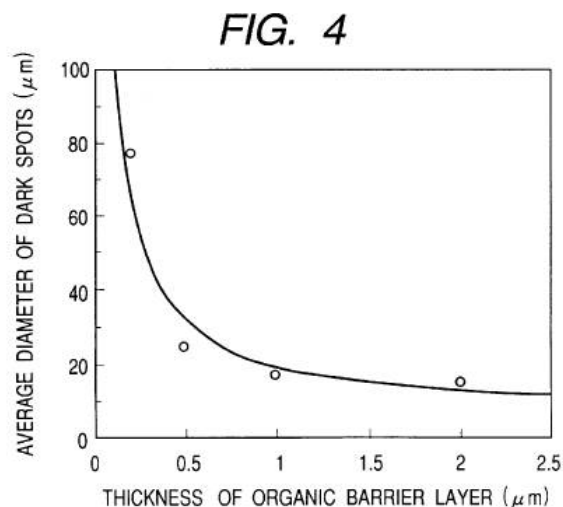
(annotated by Petitioner, Pet. 20)

26. Suzuki does not describe organic barrier layer 20 as a “planarization layer.” This is not surprising because Suzuki’s organic layer generally follows the topology of the underlying layer’s topology even though it can cover particles and other defects that are unintentionally deposited on the surface of the underlying layer that is not intended to be part of the underlying layer’s topology.

27. Suzuki also does not mention masking, patterning or selective deposition of any of its layers. For example, the various layers can be deposited over the entire substrate surface and then selectively removed using laser ablation.

28. Unlike Kijima, Suzuki’s devices still have dark spots, but the sizes of the dark spots are significantly reduced when the organic layer 20 is sufficiently thick, *e.g.*, above 1 μ m. See Fig. 4 (average diameter of dark spots approaches a

plateau of slightly below 20 microns when the thickness of the organic barrier layer is 1 μ m and above).¹



29. Suzuki describes its organic layer 20 as “exhibit[ing] good affinity for the metal or alloy cathode, cover[ing] defects in the electroluminescent unit U therewith and mak[ing] a smooth surface on the relatively irregularly surface of the cathode 18.” EX1012, 5:59-62. Suzuki notes that “defects are mainly caused by foreign matter inevitably deposited on the electroluminescent unit U during the

¹ Suzuki states that the threshold thickness is about 500 nm or 0.5 μ m. But as shown in Figure 4, when the organic layer is 500nm thick, the size of the dark spots is still on the portion of the curve that is rapidly decreasing. A person of ordinary skill in the art would therefore consider the threshold thickness to begin at when the curve starts to flatten, or around 1 μ m.

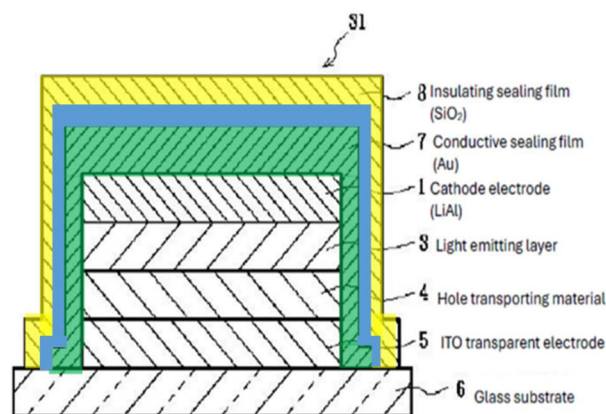
course of the fabrication thereof under very severely controlled conditions.” *Id.*, 5:54-58. According to Suzuki, forming the inorganic barrier layer 22 “on the smooth surface of the organic barrier layer 20” “ensur[es] the formation of the layer 22, which is substantially defect-free and dense.” *Id.*, 5:63-66. Suzuki uses the double-layer structure for moisture proofing and passivation. *Id.*, 5:66-67.

C. A person of ordinary skill in the art would not have incorporated an organic sealing layer between its conductive sealing layer 7 and the inorganic sealing layer 8 because there is no evidence that the added organic layer would provide any improvements in performance while introducing many unpredictable potential problems that can degrade performance

30. I understand that Samsung proposes to replace Kijima’s insulating sealing film 8 with “a ‘protective double layer made of an organic barrier layer and an inorganic barrier layer.’” Pet. 32-33. Samsung argues “that this simple modification would entail adding a new organic sealing layer on top of Kijima’s OLED in order to form a smooth surface on which to deposit Kijima’s inorganic sealing film 8.” Pet. 32. According to Samsung, such an organic layer would be desirable because Kijima’s conductive film 7 allegedly “would be vulnerable to the known problems associated with the cathode surface discussed in Suzuki.” Pet. 33. Samsung argues that “depositing such an organic sealing layer on top of Kijima’s OLED device would [allegedly] be beneficial for the same reason that Suzuki discusses for its organic barrier layer 20.” *Id.*

31. But a person of ordinary skill in the art would know that adding any new layer to a film stack is hardly simple. A person of ordinary skill in the art would wave away suggestions that adding new layers, materials and processing steps to a film stack is “simple” because anyone who had experience with display designs would understand that adding a new layer is anything but straightforward and simple. A POSITA would understand the risks and challenges of such a process change, which I explain further below in paragraph 36.

32. As a preliminary matter, even if an organic layer is interposed between Kijima’s insulating sealing film 8 and the conductive sealing film 7, that organic layer would not be regarded as a planarization layer because it would be generally following the topology of the underlying conductive sealing film 7, just like the inorganic sealing film 8 generally following the topology of the underlying conductive sealing film 7. *See below* (blue layer added to illustrate the topology of the added organic layer).

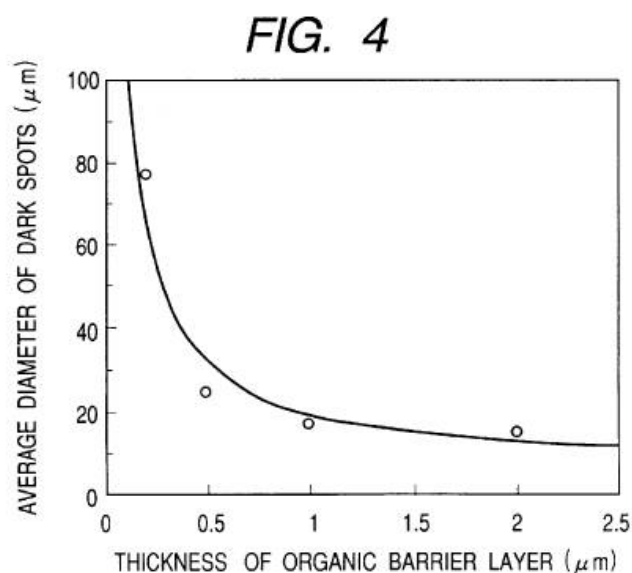


33. Even if the organic layer is sufficiently thick to cover particles and other defects, if any, on the conductive sealing film 7, those defects are created unintentionally on the surface of the underlying layer and is generally not considered to be part of the underlying layer's topology, which is a property of design. Thus, even with an added organic layer, there would not be a planarization layer in the modified Kijima device.

34. Second, the assumption that “depositing such an organic sealing layer on top of Kijima’s OLED device would be beneficial for the same reason that Suzuki discusses for its organic barrier layer 20” is incorrect. Kijima expressly discloses that with a sufficiently thick gold layer (conductive sealing film 7) on top of the cathode material 1 and an inorganic sealing film 8 on top of the gold layer, all deposited continuously under vacuum, “an organic EL element having good stability even when used in air can be obtained.” EX1010, [0058]. Kijima states that, when an organic EL element made according to Kijima’s method “was left in air for one month after production,” it had “almost the same” luminescence “as ... measured immediately after the element was produced.” *Id.*, [0054], [0064], [0068], [0072]. That is, even without an organic layer, Kijima is free from the concerns related to “shortage of stability” and “dark spot[s]” in Suzuki. Because Kijima does not suffer from the same issue as Suzuki, a person of ordinary skill in

the art would not have had a reason or motivation to add new materials and processing steps to address a problem that does not exist.

35. In fact, even though Suzuki still has observable dark spots of about 20 microns in sizes, “*almost no dark spots were observed*” in Kijima’s devices made according to Kijima’s method. Compare Kijima, [0054], [0064], [0068], [0072] with EX1012, Fig. 4 (even with the organic layer, average diameters of the dark spots remained about 20 microns). As explained in Section A, Kijima does not deposit a separate organic layer between the conductive sealing film 7 (the gold layer) and the inorganic sealing film 8. *Id.*



36. In other words, Kijima’s device without the additional organic layer is already performing better than a device made with Suzuki’s method. There is no evidence that an added organic layer would have improved Kijima device’s reliability, but a person of ordinary skill in the art would be acutely aware of the

issues associated with an added layer and additional processing steps. For example, a person of ordinary skill in the art would know that additional layers should be avoided whenever possible. This is because every time a layer is added, not only an additional processing step needs to be added, but one has to be concerned with issues such as

- Interfacial properties, including adhesions of the additional layer, to the layer immediately above and below (so it won't cause delamination)
- Stresses and associated failure caused by property mismatches between the new layer and the layers above and below, which can cause film stresses, *e.g.*, the mismatched properties can be due to mismatches in thermal coefficients of expansion
- the cohesion strength of the additional layer so it won't be the point of failure
- whether the deposition process of the additional layer is compatible with the already deposited layers and whether the deposited additional layer is compatible with the layer to be deposited, *e.g.*, whether there would be chemical reactions between layers
- how it would affect light transmission, for example, whether it is sufficiently transparent to let through the desired wavelengths, how

different or similar its refractive index is compared to the layer above or below, how thick it needs to be in order to provide the needed mechanical strength as well as resistance to moisture and oxygen, the incident light's angles and wavelengths

- added risk of contamination and defects with each additional deposition step.

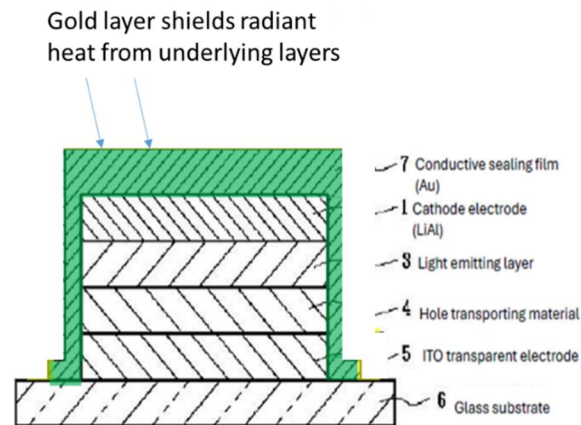
37. A person of ordinary skill in the art would not have incurred expenses for additional process steps, materials, complexities and risks, when there is no attendant added benefits. This is particularly the case when attempting to modify Kijima by adding an organic layer between Kijima's conductive film 7 and sealing film 8. This is because Kijima states:

When the conductive sealing film 7 is made of a material with good thermal conductivity such as a metal, efficient dissipation of the radiant heat can be expected, which is considered to be advantageous in preventing degradation of the organic layer.

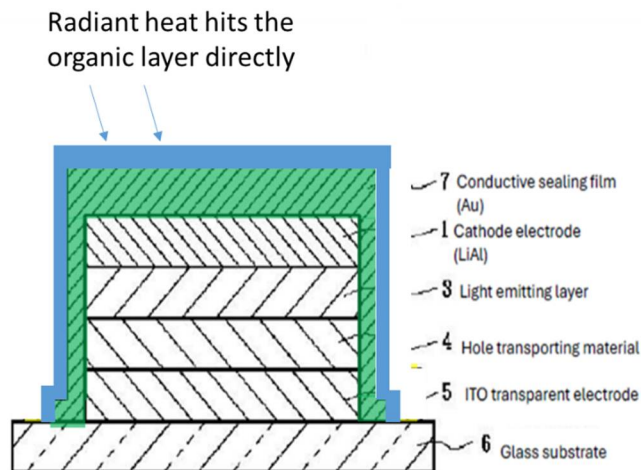
EX1010, [0057]. Kijima also states that it is the use of the sealing film 7 that prevented "degradation of the organic layer due to radiant heat during vapor deposition of the insulating sealing film 8." *Id.*, [0056].

38. Thus, a person of ordinary skill in the art—who according to Samsung is someone with a bachelor's degree and only one year of experience in display, would view it as an unnecessary and unacceptable risk to vapor deposit the

insulating sealing film 8 directly over an organic interlayer that is deposited over the conductive sealing film 7. That is because they would conclude from Kijima's teaching that without a thermally conductive layer such as gold to shield the organic layer from the radiant heat generated during deposition of the insulating sealing film, the radiant heat would degrade the organic layer that Samsung argues should be deposited between the insulating sealing film 8 and the conductive film 7.



versus



39. But there is no reason for a person of ordinary skill in the art to deposit the organic layer when they know that (1) it is unlikely to provide any improvement in device performance or stability; (2) it will introduce many unpredictable complexities as noted in paragraph 36 above; and (3) the organic layer will likely suffer degradation when the insulating sealing film is deposited on top of it and therefore will not provide the needed protection at any rate. Given these facts, a person of ordinary skill in the art would not have found it suitable to deposit an organic layer between Kijima's inorganic sealing film 8 and the conductive sealing film 7.

40. I have also reviewed other references that Samsung has cited and those other references do not support Samsung's proposed modification either. For example, Komatsu also discloses ways to suppress growth of dark spots ("DS") by reducing the device's reactions with moisture or oxygen. *See* EX1017, 2:29-58). Komatsu notes the need for "thickened protective film." EX1017, 11:21-25. Komatsu uses an organic layer in addition to the inorganic SiON layer because "SiON alone is very difficult to form a thick protective film necessary for the organic electroluminescence device." *Id.*, 11:32-36. Komatsu therefore combines SiON with "a layer of material having a lower internal stress than that of SiON, where lower moisture permeation can be attained in the protective film by the SiON layer and *thick protective film* formation *can be attained by the layer of a*

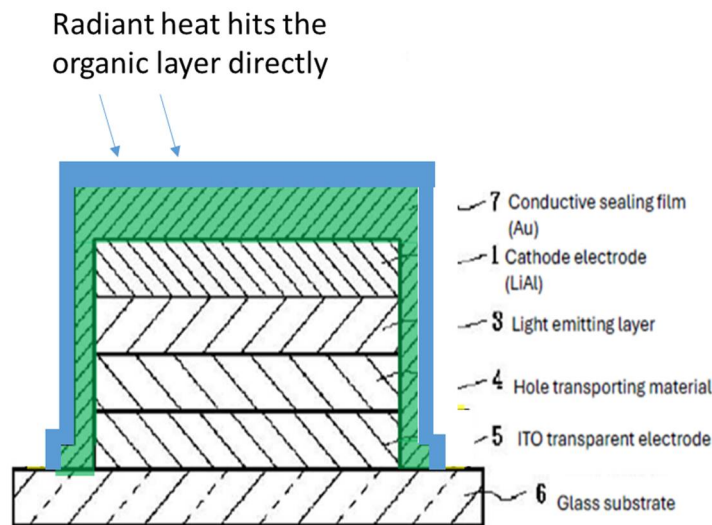
material having a lower internal stress.” Id., 11:37-45. In other words, Komatsu discloses that an inorganic layer with low moisture permeation property combined with a sufficiently thick under-layer is the key to protection against environmental elements and dark spots. In fact, Komatsu implies, and a POSITA would conclude that only an ECR sputtered SiON layer would be effective. That is because ECR sputtering in particular were used at the time of the inventions to minimize damage to substrate surface. Conventional DC sputtering subjects the substrate surfaces to greater heat, ion damage, and charging effects. ECR sputtering serves to confine high energy plasmas closer to the sputter target surface away from the substrate surface.

41. This is similar to Suzuki’s finding that a sufficiently thick organic layer in combination with an inorganic barrier layer is required for optimized protection against dark-spot growth. *See* EX1012, Fig. 4 (organic layer of 1 micron or thick needed to obtain reduction in dark spot sizes).

42. Kijima, however, already has such a thick protective film structure in the form of a gold layer 7 of 1 μ m and above and an inorganic insulating sealing layer 8 on top of the thick gold layer. *See* EX1010, [0056] (emphasizing that “the conductive sealing film 7 must be thickly formed as a buffer layer during deposition, and the above thickness (about 10 kÅ) is sufficient”); [0062] (gold of about 10 kÅ is deposited on cathode 1); [0066] (same); [0070] (same). As

discussed above, Kijima reports that devices with its double-layer protection already suppresses dark spots growth even after exposing to air. *Id.*, [0054], [0064], [0068], [0072].

43. In other words, Kijima's encapsulation can already effectively defend against oxygen and moisture to suppress dark spot growth and there is no evidence that Suzuki's organic-inorganic layer structure would have brought any additional improvement in performance. In fact, according to Kijima, depositing an inorganic insulating layer 8 directly over an organic layer (as would be the case in the proposed modification) would have unintended consequences, because the organic layer would degrade when exposed to the radiant heat generated during deposition of the inorganic sealing film 8.



44. Because of these facts and the complexities and risks caused by adding a layer in an OLED devices (as discussed in paragraph 36 above), a person

of ordinary skill in the art would not have incurred the extra cost to add the extra layer when there would be no concomitant benefit.

45. Thus, even if an OLED device without the thick gold layer could have defects on the cathode surface and could thus require a thick organic layer to attain the optimized protection against dark spots, Kijima's device—with its thick gold layer in combination with an insulating sealing film 8—does not suffer from the same problem and does not need an organic layer between the insulating sealing film 8 and the conductive film 7. Kijima, [0030], [0056]-[0057], [0062]-[0064], [0066]-[0068], [0070]-[0072]. That is, in contrast to Suzuki where depositing only an inorganic barrier layer over an electrode is insufficient to prevent dark spots, (*see* Suzuki, Fig.3), in Kijima, an inorganic layer over a cathode already coated with a gold sealing layer is sufficient to prevent dark spots (*see* Kijima, [0030], [0056]-[0057], [0062]-[0064], [0066]-[0068], [0070]-[0072]). A person of ordinary skill in the art therefore would not have had a reason to modify Kijima in order to solve a problem that does not exist in Kijima. Put another way, even if the use of an organic layer was a known solution for addressing the dark spots caused by irregularity on electrode surfaces like those in Suzuki, that solution does not apply to Kijima which does not suffer from the problem.

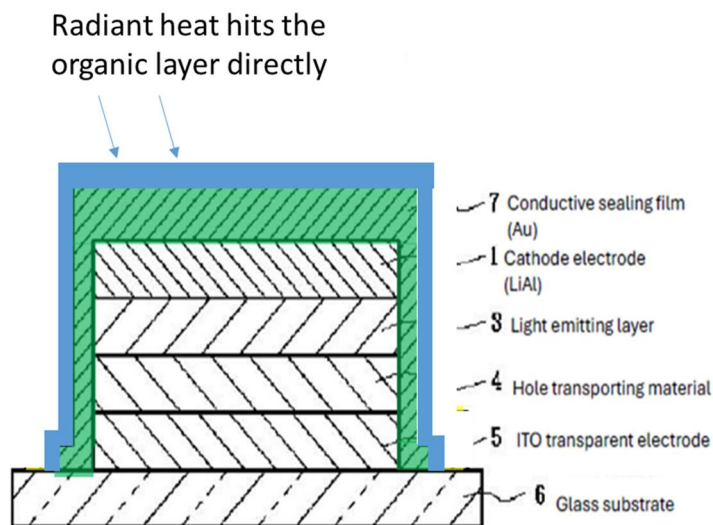
46. I was also asked whether Samsung's proposed modification would have simplified the encapsulation process. The answer is no. Including an

additional layer will always make the processes more complicated and costly.

Additionally, like the inorganic layer in Kijima, the organic layer (as well as the further inorganic layer) also needs to be deposited in vacuum such that there is no simplification in the process. *See* Suzuki, 8:48-55 (organic TPAC layer “was vacuum deposited on the anode layer” followed by vacuum deposition of an inorganic layer); 8:64-9:3 (same), 9:13-17 (same) 9:26-34 (same).

47. As I have explained above, Kijima discloses that it is critical in its system to have a thermally conductive film “adjacent to and below” the inorganic sealing film 8. EX1010, [0075]. Otherwise, the resulting device may be inoperable. *Id.* (without a conductive layer “adjacent to and below the insulating sealing film,” the resulting device had “almost no light” emission); *see also id.*, [0057] (“When the conductive sealing film 7 is made of material with good thermal conductivity such as a metal, efficient dissipation of the radiant heat can be expected.”).

48. As I have explained above, this is because of the stated concern that without this conductive protective film 7, radiant heat during deposition of Kijima’s inorganic film 8 would impinge directly on the added organic layer and thus degrade the organic layer that is to be added directly above the conductive sealing film 7.



49. Samsung has not provided any evidence that the organic sealing layer could withstand or dissipate this radiant heat to ensure the resulting device would operate. *See* Pet. 32-36. Notably, the thermal conductivity of gold is 2-3 orders of magnitude higher than that of organic materials. EX2005 (<http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/thrcn.html>) (thermal conductivity for gold is 314 W/mK versus 0.8W/mK for glass); EX2006 (https://www.engineeringtoolbox.com/thermal-conductivity-d_429.html) (common organic materials, such as paraffin, acrylic, cellulose, polyethylene, have a thermal conductivity on the order of 0.2-0.4 W/mK).

50. A person of ordinary skill in the art would therefore not consider the organic layer to be able to dissipate the radiant heat or to withstand the radiant heat. But they would also understand that in Kijima “the effect of radiant heat during deposition of the insulating sealing film will be large.” Kijima, [0028].

They would also understand the importance “of providing the conductive sealing film adjacent to and below the insulating sealing film” in Kijima. *Id.*, [0075].

51. A person of ordinary skill in the art with barely one year of experience in display would not have enough knowledge to go against Kijima’s express warning and add an organic layer directly below the inorganic sealing film 8. They would know that if they do so, the resulting device likely would not have worked, and therefore it would be unsuitable to add an organic layer between the sealing films 7 and 8 as proposed.

V. A Person of Ordinary Skill in the Art Would Not Use Ink-jetting to Deposit the Organic Layer Sequence in Kijima

52. Kijima emphasizes “the importance of forming all of the films under vacuum conditions.” EX1010, [0087]. For example, even after a thick gold layer is deposited under vacuum, exposing the device to atmospheric pressure before depositing the insulating sealing film 8 would still cause significant degradation in OLED device and increase in dark spots. *Id.*, [0082]-[0087].

53. But depositing an organic layer using Sturm’s ink-jetting method would break vacuum during Kijima’s encapsulation process. Pet. 41-45; EX1013-Sturm (no reference to using vacuum while performing ink-jetting); EX1016, 3:15-17 (contrasting “ink jet printing step” with “a printing step involving a vacuum based process”). A person of ordinary skill in the art would not ignore Kijima’s

express warning and expose the device to atmospheric pressure before completing the entire encapsulation process.

54. I note that Sturm does not address OLED barrier or encapsulation layers at all beyond a casual reference to a vacuum-deposited Ag layer over the Mg:Ag cathode. Sturm, 4:66-5:2. A person of ordinary skill in the art would not regard the deposited Ag layer as a planarization layer or a barrier layer. A person of ordinary skill in the art also would not consult Duthaler, because it relates to electrophoretic displays and addressing devices, not OLEDs.

55. Encapsulation methods used in electrophoretic displays address a different set of degradation and failure mechanisms than those of OLED displays. For example, electrophoretic displays do not share the same degree of sensitivity to moisture and oxygen as is well-known for OLED displays. More specifically, Duthaler describes encapsulated electrophetic displays as follows:

Generally, an encapsulated electrophoretic display includes a capsule with one or more species of particle that either absorb or scatter light and that are suspended in a fluid. One example is a system in which the capsules contain one or more species of electrophoretically mobile particles dispersed in a dyed suspending fluid. EX1016, p. 23

This form of encapsulation is unique to electrophoretic displays and clearly does not apply to OLED displays.

56. A person of ordinary skill in the art, even with their one year experience, would understand that deposition techniques suitable for electrophoretic displays would often not be suitable for OLEDs. A person of ordinary skill in the art therefore would not apply Sturm or Duthaler's methods to deposit the planarization layer or the barrier layer to encapsulate OLED devices.

57. Sturm and Duthaler also do suggest using ink-jetting to deposit an encapsulation layer as opposed to "form[ing] electronic components or component arrays." EX1016, 15:6-8. For example, in the figure on Sturm's cover page, layer 122 is formed by ink-jetting, with 122 being "a polymer semiconducting layer" having source/drain contacts 124/126 then formed over 122. EX1013, 6:52-67, Figs. 14(a)-(b). Likewise, Sturm's Figures 7(a)-(c) shows islands 22 and 24 deposited by inkjet, with electrodes 26, 28 then applied over 22 and 24. *Id.*, 5:39-47. Similarly, in Figures 8(a)-(c), electrodes 40, 42, 44 are deposited over ink-jetted islands 34, 36 and 38 containing red, blue and green inks. Figures 9(a)-(c) use inkjet to deposit top and bottom contacts as well as organic materials contacting the contacts. *Id.*, 5:64-6:5. Figure 10 involves ink-jetting top electrodes 60 and 62. *Id.*, 6:6-13; *see also* 6:19-51 (ink-jetting used to deposit organic red/blue/green materials as well as contacts). None of the examples, however, involved using ink-jetting to deposit an organic layer for encapsulation.

58. As Weaver explains, the concern of susceptibility to oxygen and moisture arises after the top electrode, such as a cathode is deposited:

In forming an OLED, a layer of metal is typically utilized as the cathode to ensure efficient electron injection and low operating voltages. However, metals and their interface with the organic material are susceptible to oxygen and moisture, which can severely limit the lifetime of the devices. Moreover, moisture and oxygen are also known to increase “dark spot areas” in connection with OLEDs.

EX1008-Weaver, [0004]. Hence, although inkjet may be suitable for depositing organic light emitting layers, as Kijima observed, after cathode deposition, the subsequent encapsulation steps must take place under vacuum in order to obtain a suitable and operable OLED device. *See* EX1010-Kijima, [0076]-[0081] (comparative example 2, showing the “adverse effects of exposing the element to the atmosphere before the formation of the conductive sealing film 7”).

59. I also note that in Sturm, the ink-jet printing results in non-flat surfaces. *See, e.g.,* Sturm, Figs 6B, 6C, 7B-7C, 8B-8C, 9A-9C, 10C, 11B-11C, 12B-12C, 13B, 14B. But Samsung’s reason for interposing an organic layer below the inorganic sealing film 8 is to provide a smooth surface for depositing the sealing film 8. *See* Pet. 33-34. Under that reason-to-modify theory, the non-flat surfaces yielded by Sturm’s ink-jetting process would have dissuaded a person of

ordinary skill in the art from using ink-jetting to apply the organic layer. Samsung does not address this inconsistency.

VI. A Person of Ordinary Skill in the Art Would Not Use Screen-Printing to Deposit the Organic Layer Sequence in Kijima

60. Samsung also proposes using screen-printing disclosed by Duthaler to deposit the organic layer between Kijima's conductive film 7 and inorganic sealing film 8. But Duthaler's screen-printing, like ink-jet printing, would typically break vacuum. Pet. 46-49. For example, Duthaler² distinguishes "screen printing" with "a printing step involving a vacuum based process" EX1016, 3:18-20.

Moreover, Duthaler does not teach the use of screen-printing, nor any other method, for encapsulating OLED devices. In fact, Duthaler only teaches methods for the fabrication of electrophoretic displays, not OLED displays. Therefore, it would be highly unlikely for a person of ordinary skill in the art to look toward Duthaler for OLED encapsulation methods as described above.

61. Yet, as explained below, Kijima emphasizes "the importance of forming all of the films under vacuum conditions." EX1010, [0087]. For example, even after a thick gold layer is deposited under vacuum, exposing the device to

² As noted above, Duthaler concerns electrophoretic displays and not OLEDs, and there is no evidence that printing techniques suitable for electrophoretic displays would also be suitable for OLEDs.

atmospheric pressure before depositing the insulating sealing film 8 would still cause significant degradation in OLED device and increase in dark spots. *Id.*, [0082]-[0087].

62. Given this express warning, a person of ordinary skill in the art would not have considered a deposition method, such as screen-printing, that would typically break vacuum before all encapsulation layers are deposited.

63. Samsung has also presented no evidence that using screen printing in Kijima would have improved Kijima's throughput or lowered its cost. Pet. 48. For instance, Kijima observes that its method of forming the various layers "continuously in the same vacuum deposition device" provides "high" "productivity" while precluding "effect of oxygen in the atmosphere during production." EX1010, [0058].

64. Screen-printing would require new equipment and cannot be easily integrated into Kijima's evaporative vacuum deposition chamber or conditions. Screen-printing would therefore likely disrupt Kijima's continuous use of vacuum deposition, which would negatively affect Kijima's productivity. Thus, screen-printing would not only expose the devices to air before completion of encapsulation, but would also require a new set of equipment and processing conditions. A person of ordinary skill in the art would recognize that instead of improving Kijima's productivity or lowering Kijima's cost, including screen

printing in Kijima would actually increase cost by requiring a new set of equipment beyond the vacuum deposition chambers that Kijima already has and would lower the productivity. This is because now, instead of forming films “continuously ... in the same vacuum deposition device 11,” the devices need to be removed from the vacuum deposition device to screen-print the organic layer, dry the organic layer and then put the devices back into the vacuum deposition device.

VII. A Person of Ordinary Skill in the Art Would Not Combine Kijima, Suzuki and Fujimori

65. Samsung also proposes adding an organic layer between Kijima’s conductive sealing film 7 and the insulating sealing film 8 for Ground IV (claims 41-46). For the same reasons stated for Ground 1, a person of ordinary skill in the art would not have added an organic layer between Kijima’s films 7 and 8. Thus, for the same reasons stated for Ground 1, a person of ordinary skill in the art would not combine Kijima and Suzuki to create a planarization layer.

66. A person of ordinary skill in the art also would not have used Fujimori’s mask in Kijima. The problem that Fujimori attempts to address is that the deposited material may wrap around the shadow of finely patterned masks such that deposited electrodes are not sufficiently isolated from each other and thus “cause a short in the elements and crosstalk.” EX1014, [0008].

67. Fujimori, however, does not disclose or suggest using its magnetized masks for depositing encapsulation layers, whether it is an organic layer or an

inorganic layer. *See* EX1014 *generally*. Instead, Fujimori uses the magnetized masks to deposit

- (1) electrodes, in particular the electrodes above the (OLED) organic layers, *see* EX1014, [0026], [0041]-[0042], [0044], [0047], [0048];
- (2) materials to create closely spaced blue, green and red multicolor regions, *see* EX1014, [0050]; and
- (3) non-emission regions such as the black matrix that blackens the gaps between the light-emitting region to improve contrast or pixel define layers that surround/define emission regions and insulate electrodes from one another, *see id.*, [0027].

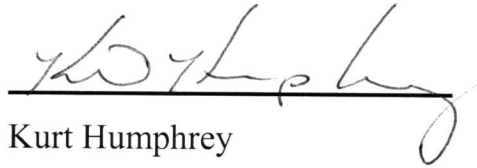
68. Notably, for the non-emission regions such as the black matrix, in the actual examples, no masks were used to develop the black matrix. *See id.*, [0049]. Instead, “spin-coating” followed by “conventional photolithography method” was used “to form a black layer ... that served as both a spacer and a black matrix.” *Id.* Moreover, for non-conductive layers used for encapsulation such as those preferred by ‘389, magnetic masks would be an unnecessary complication since conventional shadow masks would be completely adequate for OLED encapsulation applications. Thus, to the extent that Samsung suggests that a person of ordinary skill in the art would have used the same method that Fujimori

uses for forming the non-emitting region to deposit Kijima's encapsulation layer, the person would not have used a magnetic mask.

69. A person of ordinary skill in the art also would not use Fujimori's magnetized mask to deposit the proposed organic encapsulation layer because the insulating organic layers won't "cause a short in the elements" or "crosstalk," the problem that led to Fujimori's invention. EX1014, [0008]. That is, there lacks a motivation of the person of ordinary skill in the art to use Fujimori's magnetized mask for depositing the organic encapsulation layer.

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 December 11, 2024 in Colorado Springs, Colorado


Kurt Humphrey

