

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG DISPLAY CO., LTD.,
Petitioner

v.

WUHAN CHINA STAR OPTOELECTRONICS SEMICONDUCTOR DISPLAY
TECHNOLOGY CO., LTD.
Patent Owner.

Case No. IPR2026-00486
U.S. Patent No. 11,957,031

**DECLARATION OF DR. MICHAEL LEBBY
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 11,957,031**

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I. INTRODUCTION

1. I have been retained by Samsung Display Co., Ltd. (“Samsung” or “Petitioner”), as an independent expert in this proceeding before the Patent Trial and Appeal Board (“PTAB” or “Board”). I understand that Samsung is requesting that the Board institute an *inter partes* review (“IPR”) proceeding of U.S. Patent No. 11,957,031 (“the ’031 Patent”) (Ex-1001), currently assigned to Wuhan China Star Optoelectronics Semiconductor Display Technology Co., Ltd. (“Patent Owner” or “PO”).

2. I am not and have never been an employee of Samsung. I am being compensated at my usual and customary rate of \$650 per hour. No part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my independent analysis of the ’031 Patent in light of the prior art publications cited below. I have also been asked to consider the state of the art and prior art available as of May 20, 2021. Based on the prior art discussed in this declaration, it is my opinion that Claims 1–19 of the ’031 Patent are unpatentable for the reasons provided below.

A. Qualifications

4. I have summarized in this section my educational background, career, publications, and other relevant qualifications. My full curriculum vitae is attached as Ex-1003 to this Declaration.

5. I received a Bachelor of Engineering degree in Electrical and Electronic Engineering in 1984 from the University of Bradford, UK. I then took an MBA in 1985. I also received a Ph.D. in Semiconductor Physics in 1987 from the University of Bradford, UK. I was awarded a Doctor of Engineering degree with a focus in optoelectronics in 2004 from the University of Bradford, UK.

6. As described in this Section, and further detailed in my curriculum vitae (Ex-1003), over the course of my 40-year career in electronics and optoelectronics, I have worked in nearly every aspect of the electronic and optoelectronics business, ranging from epitaxial wafer growth (compound semiconductors), electrical and optoelectronic device and circuit design, using modeling and simulation, electrical and optoelectronic device and component fabrication, testing, and qualification, to the implementation of devices into packages and panels, both hermetic and non-hermetic, as well as analysis of package/panel materials such as plastics (including plastic housings such as resin-packaged lead frame housings), optical plastics, metallic-based packages, semiconductor-based packages, and ceramic-based packages. I have also designed device and display packages (through-pin, surface

mount, flip-chip, and various combinations thereof) for printed circuit board mounting. Many of the designed packages were implemented into electronic and optoelectronic modules/panels and sub-system/luminaire applications that included various electronics designs. The modules/panels have been at least fiber-optic-, display-, lighting-, imaging-, sensing-, power-, and RF-based. I have also worked in commercially based industrial research-and-development laboratories to bring new electronic, optoelectronic-, display-, and photonic- based technologies from the research proof-of-concept phase through prototyping and qualified manufacturing for volume release. This has included both transfer as well as injection molding techniques for packaging.

7. I have been both an entrepreneur (e.g., Ignis Optics Inc, One Chip Photonics, Lightwave Logic Inc.), as well as an intrapreneur (e.g., Motorola, Intel, TE Connectivity (previously Tyco Electronics), AT&T Bell Labs), creating innovative new programs, both as venture backed start-ups as well as corporate funded divisions. I have built these entities to develop electronic, optoelectronics, and photonics technology from the laboratory and fabrication clean room to production factories.

8. I received a Bachelor of Electrical Engineering degree in 1984, a Master of Business Administration in 1985, and a Doctorate degree in 1987, all from University of Bradford in the United Kingdom. My Ph.D. thesis involved the design

and fabrication of both optoelectronic and electronic compound semiconductor devices (such as GaAs, InP etc.), and their associated characterization. In 2004, I was awarded a Doctor of Engineering degree (a higher doctorate degree) from University of Bradford for my technical contributions to the field.

9. My career started in the late 1970s at the Ministry of Defense in the UK where I spent time at their R&D facility in Malvern (RSRE – Royal Signals and Radar Establishment). I worked on electronic and optoelectronic semiconductor device design, fabrication, and characterization, and especially materials using III-V compound semiconductors such as GaAs and InP. These devices included electronic transistors, optical waveguides, and optoelectronic device operation. My research work in semiconductor device design then took me to AT&T Bell Laboratories in 1985, where I pursued research in novel opto-device designs using III-V semiconductor material systems that included FETs, bipolar transistors, optical waveguides, optics, LEDs, laser diodes, and photodetectors. The devices researched became, in part, the subject of my PhD thesis that was granted in 1987.

10. I moved to Motorola in 1989 to further develop my electronic, optoelectronic, semiconductor and display engineering and development skills, and I became a Research and Development Manager in Motorola, until I left the company in 1998. During my time at Motorola, I worked on many photonic, electronic, display and optical technology projects that included optical lenses,

display, imaging, camera, fiber-optic optical interconnects, electronic circuits (both analog and digital), displays, LEDs, OLEDs, and laser devices, as well as the packaging and reliability of mobile product prototypes. At that time, I was particularly interested in miniature displays/panels and miniature optics using a number of technologies such as LEDs, lasers, LCDs, lenses, and organic LEDs which were aimed towards (at the time) pagers, mobile phones, micro-imagers/displays, holograms, and advanced prototypes of futuristic communications hardware. I was also particularly interested in miniature color displays in which LEDs/OLEDs could be utilized, and the associated drive and processing electronics for them. One interesting patent I was a co-inventor on is called an Electronic Book which was filed in 1994 (US. Patent Number 5,534,888). This invention relates, in general, to optical displays and, more particularly, to optical displays in electronic books and was an early patent in the field of electronic books.

11. In aiming for miniature full color displays and associated optics, the early 1990s, there was only red wavelength Phosphide (GaAsP and/or InGaAlP) and AlGaAs based LED technology that was advanced in technology and performance. Green wavelength Gallium Phosphide based LEDs had low emission output, and blue wavelength emission LEDs were only available using pure Silicon Carbide on Silicon Carbide substrate wafers, with very low emission output. I worked closely with Motorola's mobile divisions on new and novel display prototypes for mobile

phones etc., and optics to research and develop how best to innovate with full color red, green, and blue displays and associated electronics. A number of alternative technologies were evaluated, such as LCD (Liquid Crystal Displays), OLED (organic LEDs), and Gallium Nitride and Indium Gallium Nitride materials grown onto Sapphire. I also explored the electronic circuits that were needed to drive, operate, and signal these types of optoelectronic displays.

12. During my time at Motorola as a Research and Development Manager, I designed optical and electrical packages/panels for these displays and devices, which included standard TO- cans, over-molded plastic DIL solutions, and ceramic-based and semiconductor-based technology.

13. The compound semiconductors used in the early 1990s at Motorola corporate research, for which I was a Research and Development Manager, included the Group III-V materials system, Group IV material system, Group VI material system, and Group III-N material system. A number of these materials included: GaAs, InP, GaN, GaP, InGaAlP, and silicon, amongst other materials, all of which were intended to be designed into various light emitting sources, detectors, and electronics in their associated optical package platforms that included optics and lens design. The research work at Motorola also included work on displays and, in particular, miniature displays and optics for pagers, clam-shell phones, and head-mounted displays that included mounting onto eyeglasses (similar in concept to

Google glass™). The types of displays ranged from large arrays of visible LEDs (i.e., 10,000 LEDs on a chip) that required custom LED packaging to tiny color LCDs, where work was conducted into approaches to efficiently optically package the displays as well as OLEDs, even though the technology was not mature. At the time, I explored less corrosive metallization for OLED displays as well as approaches in the fabrication processing to improve brightness and lifetime of OLED materials. On-board integrated LED driver electronic circuits were implemented in some of the prototypes. Some of the research work at Motorola utilized phosphor technology, especially for display projects that were based on field emission (i.e., the field emission display (FED)), as well as arrays of visible LED/OLED displays and optics where a full color gamut was required by both internal and external customers. The phosphor technology performed down-conversion of light energy.

14. I also initiated Motorola's work in optical interconnect (Optobus™) technology, that incorporated both transfer and injection molded optical parts. This project involved the research and development of a multi-channel electronic IC chip for parallel optical interconnect.

15. I was one of Motorola's most prolific inventors, having over 150 issued utility patents as an inventor or a co-inventor by the late 1990s. Many of the photonics, electronics, and optical/display prototypes with which I was involved

were subject to reliability and stress testing that included humidity, temperature, optical, mechanical, and electrical evaluation. These consumer products all were driven using standard electronic ICs and electronic signaling where I had a role in design and simulation of these circuits.

16. I filed my first GaN patent, which taught techniques using GaN and InGaN LEDs, in 1996, shortly after the invention of high performance GaN/InGaN blue LEDs by Nichia in the early 1990s. My work at Motorola addressed, in part, the big issue at the time in the mid-1990s: full color display and display electronics composed of red, green and blue LEDs that could be utilized in mobile products as well as other applications. As part of this work, I was engaged in how to optically package these technologies that allowed for electrical, optical, and thermal high performance. Examples of patents on which I am a co-inventor, with respect to high heat conductivity surface emitting optical devices, include, for example, U.S. Patent No. 5,538,919, as well as U.S. Patent No. 5,818,404, U.S. Patent No. 5,739,800, and U.S. Patent No. 5,838,703, which three patents address LED packaging solutions.

17. Another of my inventions was directed to a new semiconductor laser that had the potential to be manufactured in high volume. This device was called a VCSEL (vertical cavity surface emitting laser), and the invention was to optimize the performance using an oxide process, and is now the basis for the highest volume semiconductor laser today (with its recent implementation as a structured light

sensor in facial recognition systems utilized in modern day smart mobile phones). The VCSEL is a surface emitting diode laser and operates in a similar fashion to most LED chips today. Some of the goals of the research work at Motorola was to be able to optically package VCSEL laser diodes and their associated optical lenses in a similar approach to LEDs as well as drive them using novel electronic circuits. Laser diodes require thermal issues to be addressed very carefully, as they develop significant levels of heat during operation. The optical package designs at the time (including for lasers and LED packages) took into account optical lensing, thermal heat sinking and thermal paths to take the heat away from the source. My additional patents, including during my time at Motorola, are listed in my curriculum vitae (Ex-1003).

18. Between 1998 and 1999, I worked as the Director of Technology/ BD (Fiber Optics) for Tyco Electronics (previously AMP). I joined Tyco Electronics as a member of the Global Optoelectronics Division's management team. I was responsible for growing the optoelectronics and optical business through external interactions that included mergers, acquisitions, strategic alliances, and technical strategic planning. Much of that work was laser-and LED-based, with associated optics, and included designing and characterizing laser- and LED-based optical packages and modules for customer qualification specifications.

19. In 1999, I left Tyco and started employment at Intel. At Intel, I was involved heavily in photonic technology, especially technology that supported silicon photonic device platforms. As a culmination of this work, I was one of Intel's founders of its silicon photonics division in the year 2000, and worked to set up a fabrication facility in South San Jose. The work involved integrating silicon FET electronics with optoelectronics and optics onto the same silicon semiconductor wafer. I was also part of Intel Capital's optical investment team, and participated in over 30 photonics investments into photonics, optics, and optoelectronics. Focus included optical devices, packaging and modules. Technologies investigated included lasers, LEDs, optics, and optical displays.

20. At the end of 2000, I left Intel and raised venture capital funding for a company called Ignis Optics Inc. The main goal of the company was to design and manufacture, in high volume, very high-performance fiber optic transceiver modules, and associated optics with data rates up to OC-192, or approximately 10 Gbps. The fiber optic transceiver modules have the capability of transmitting and receiving optical signals that are controlled using programmable electronics and packaged optoelectronics chips, such as laser diodes, optical lenses, and photodetectors.

21. In 2005, I took up employment for a trade association, based in Washington, D.C., called IEEE Optoelectronics Industry Development Association

(OIDA). As head of this trade association, and with photonics and optics manufacturers that included fiber optics, display, cameras, sensing, defense, aerospace, LED lighting, OLED displays (including flexible), and automotive vendors as members, I was responsible, in part, for industry-based technology roadmaps; and I implemented common industry roadmap methodologies with common features such as “Red Brick Walls” and transferred them into optoelectronics roadmaps for the industry in which displays as well as LEDs, OLEDs, fiber-optics, optics, fiber, cameras, optical sensors, projection techniques, and their associated packaging, were featured. OIDA roadmaps featured purple brick walls, to show differentiation from the semiconductor industry.

22. In 2010, I became the General Manager and CTO of Translucent, Inc., a high-tech start-up company which developed and manufactured silicon and rare earth oxide based epitaxial semiconductor wafers. One of the key drivers at Translucent was to develop a new and novel platform for the growth of GaN and InGaN onto silicon for low-cost LED, RF FET, and power FET manufacturing on larger format substrate wafers (e.g., 200mm), in order to achieve economies of scale and lower chip costs. Translucent pioneered the deposition of single crystal rare earth oxides such as Erbium Oxide (ErOx), Gadolinium Oxide (GdOx), Neodymium Oxide (NdOx), etc., that, when grown, single crystal layers of GaN/InGaN/AlN could be grown on top of them. This allows a lattice-matched, and monolithic-based,

wafer template to be manufactured for both FET and LED fabrication. While at Translucent, I researched various epitaxial semiconductor layer structures that utilized rare earth oxide technology in order to improve the performance of FETs and LEDs. Other material growth work at Translucent focused on the growth of Silicon Germanium (SiGe) compounds with rare earth oxides, and various crystal orientation wafer substrates. I patented a number of electronic FET device designs using rare earth oxides while employed at Translucent.

23. I am currently Chief Executive Officer (CEO) and Chief Technology Officer (CTO) of GenusTechnik Inc. GenusTechnik Inc. is my consulting company, through which I engage in my expert witness work.

24. I recently retired as Chairman and CEO of Lightwave Logic Inc. (NASDAQ:LWLG), where I served as a Director of the Board of Directors. Lightwave Logic is a company that is developing electro-optical polymer materials for a number of data-rich industries.

25. Throughout my career, I have also had an active role in a number of technical professional organizations, including, among others, IEEE Components, Packaging, and Manufacturing Technology (CPMT), IEEE Electronic Components and Technology Conferences (ECTC); IEEE TC-10 (Technical Committee on Optoelectronics), and IEEE Optoelectronics Industry Development Association (OIDA). Through these organizations, I have consistently been a part of committees,

events, and workshops relating to semiconductor, optoelectronics, electronics, and packaging technology. I am currently at the grade of Fellow of the IEEE, Optica and National Academy of Inventors (NAI).

26. I also serve as a Technical Expert/Consultant for the European Commission. In my work at the European Commission, I review and advise on general electronics, semiconductors, photonics, optoelectronics, imaging, sensing, display (LCD, LED, OLED, flexible displays etc.), and related ICT (Information and communications technology) technology.

27. My work has also led to over 225 USPTO utility patents in semiconductors, electronics, optics, displays, and optoelectronics, including a number of patents relating to display technology. I am the author of more than 60 publications and over 300 media events/talks etc.

B. Materials Considered

28. In forming my opinions, I reviewed the following documents, in addition to others I have cited in my declaration. I also relied on my own knowledge of and experience in electronics, photonics, semiconductors, displays, as well as materials and mechanical/back-end assembly/manufacturing of innovative products in the display sector. These include the design and/or development of display devices in consumer electronics and familiarity with OLED displays, flexible display panels, display module structures, adhesives, and/or packaging technologies:

Ex. No.	Description
Ex-1001	U.S. Patent No. 11,957,031 (“the ’031 Patent”)
Ex-1004	Prosecution History of U.S. Patent No. 11,957,031
Ex-1005	U.S. Patent Publication No. 2022/0061168 to Shin (“Shin”)
Ex-1006	PCT Patent Publication No. WO2022/051943 to Luo (“Luo”)
Ex-1007	U.S. Patent No. 12,507,538 to Lee (“Lee’538”)
Ex-1008	Korean Patent Publication No. 2019/0005703 to Lee
Ex-1009	
Ex-1010	U.S. Patent Publication No. 2019/0096975 to Park (“Park”)
Ex-1011	Korean Patent Application No. 2021/0052532 to Lee
Ex-1012	Translation of Korean Patent Application No. 2021/0052532 to Lee (“Lee’532”)
Ex-1013	INTENTIONALLY LEFT BLANK
Ex-1014	INTENTIONALLY LEFT BLANK
Ex-1015	INTENTIONALLY LEFT BLANK
Ex-1016	INTENTIONALLY LEFT BLANK
Ex-1017	INTENTIONALLY LEFT BLANK
Ex-1018	INTENTIONALLY LEFT BLANK
Ex-1019	INTENTIONALLY LEFT BLANK
Ex-1020	Claim mapping table for the ’031 Patent
Ex-1021	U.S. Patent No. 10,777,101 to Park (“Park’101”)
Ex-1022	U.S. Patent Publication No. 2024/0269956 to Kang (“Kang”)

Ex. No.	Description
Ex-1023	U.S. Patent No. 11,686,883 to Kim (“Kim’883”)
Ex-1024	Gregory P. Crawford, Flexible Flat Panel Displays, Wiley Series in Display Technology (2005) (“Crawford”)
Ex-1025	U.S. Patent Publication No. 2017/0047547 to Son (“Son”)
Ex-1026	Chinese Patent No. 112,786,807 to Zeng
Ex-1027	Chuan X. Xu et al., Foldable AMOLED Display Utilizing Novel COE Structure, 2018 Soc’y Info. Display Dig. Tech. Papers 310 (“Xu”)
Ex-1028	U.S. Patent No. 12,108,621 to Lee (“Lee’621”)
Ex-1029	U.S. Patent No. 10,826,003 to Um (“Um”)
Ex-1030	U.S. Patent No. 11,537,226 to Lee (“Lee’226”)
Ex-1031	U.S. Patent Publication No. 2020/0403039 to Park (“Park’039”)
Ex-1032	Korean Patent Publication No. 2019/0078835 to Lee
Ex-1033	U.S. Patent No. 10,651,246 to Park (“Park’246”)
Ex-1034	U.S. Patent No. 12,527,206 to Onoue (“Onoue”)
Ex-1035	U.S. Patent Publication No. 2019/0221774 to Jeon (“Jeon”)
Ex-1036	U.S. Patent Publication No. 2017/0262109 to Choi (“Choi”)
Ex-1037	U.S. Patent No. 10,840,476 to Lee (“Lee’476”)
Ex-1038	U.S. Patent No. 9,780,157 to Kwon (“Kwon”)
Ex-1039	Certified translation of Korean Patent Publication No. 2019/0078835 to Lee (“Lee’835”)
Ex-1040	Certified translation of Chinese Patent No. 112,786,807 to Zeng

II. LEGAL STANDARDS

29. In forming my opinions and considering the subject matter of the '031 Patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

30. I understand that earlier publications and patents may act to render a patent unpatentable for one of two reasons: (1) anticipation, and (2) obviousness.

A. Anticipation

31. As explained to me by counsel, it is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in the reference. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily present in the allegedly anticipating reference, and that it would have been so recognized by a person of ordinary skill in the art ("POSITA").

32. I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

33. Although anticipation typically involves the analysis of a single prior art reference, I understand that additional references may be used to show that the prior art reference has enabling disclosure (i.e., allows a POSITA to make the

invention without undue experimentation), to explain the meaning of a term used in the prior art reference, and/or to show that a characteristic is inherent in the prior art reference.

B. Obviousness

34. As explained to me by counsel, I understand that a claim is invalid as obvious if it would have been obvious to a person of ordinary skill in the art at the time the alleged invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in the art who was aware of the prior art would have been able to come up with the claimed invention. This may be the case, for example, where the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system. I understand that in an obviousness determination, the person of ordinary skill in the art is presumed to have knowledge of all material prior art.

35. I understand that an obviousness analysis requires an understanding of the scope and content of the prior art, any differences between the alleged invention and the prior art, and the level of ordinary skill in evaluating the pertinent art.

36. I understand that when a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation,

obviousness likely bars its patentability. For the same reason, if a technique has been used to improve one device and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

37. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art at the time of the alleged invention. I have been told that there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered through the knowledge of one skilled in the art. In addition, I have been told that the inferences and creative steps a person of ordinary skill in the art would employ are relevant to the determination of obviousness.

38. I understand that one may consider, e.g., whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed

innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a person of ordinary skill in the art.

39. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of those having ordinary skill in the art at the time of the invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I understand that there must be a nexus—that is, a connection—between any such secondary considerations and the alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

40. I am not aware of any allegations by the named inventors of the '031 Patent or any assignee of the '031 Patent that any secondary considerations tend to rebut the obviousness of the '031 Patent.

41. Additionally, I understand that in considering obviousness, it is important not to use the benefit of hindsight derived from the patent under consideration.

C. Level of Ordinary Skill in the Art

42. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to that patent, as well as the level of ordinary skill in that art at the time of the claimed invention. The “art” is the field of technology to which the patent is related.

43. I am informed and understand that the POSITA is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor’s skill is not determinative of the level of ordinary skill. I further understand that factors that may be considered in determining level of skill include: (i) the types of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

44. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

45. A person of ordinary skill in the art (“POSITA”) at the relevant time, which I have been told to consider as of May 20, 2021 would have had at least a bachelor’s degree in electrical engineering, materials science, mechanical engineering, or a related field, and two years of experience in the design and/or development of display devices in consumer electronics, including familiarity with OLED displays, flexible display panels, display module structures, adhesives, and/or packaging technologies. A higher level of education or skill might make up for less experience, and vice versa.

46. Based on my knowledge, skill, and experience, I have an understanding of the capabilities of a person of ordinary skill in the relevant art. For example, from my industry experience, I am familiar with what an engineer designing innovative flexible display and associated electronics, photonics, and materials technologies into a consumer product for high volume manufacturing would have known and found predictable in the art. From teaching and supervising my post-graduate students, I also have an understanding of the knowledge that a person with this academic experience possesses. Furthermore, I possessed the knowledge of a POSITA myself at least as of 1990.

D. Claim Construction

47. I understand that the United States Patent and Trademark Office interprets claim terms in an *inter partes* review proceeding under the same claim construction standard that is used in a United States federal court. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

48. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claims terms are generally not limited by the embodiments described in the specification.

49. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have been informed that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

III. SUMMARY OF GROUNDS

50. I understand that Petitioner challenges the validity of Claims 1–19 of the '031 Patent. It is my opinion that the following grounds demonstrate that the claims of the '031 Patent are invalid.

Ground	Summary
1	Claims 1–3, 5, 7, 9–15, and 17–19 are obvious over Shin (Ex-1005)
2	Claims 1–3, 5, 7–15, and 17–19 are obvious over Shin and Luo (Ex-1006)
3–4	Claim 3 is obvious over Shin and Lee’538 (Ex-1007) or Shin-Luo and Lee’538
5–6	Claims 4–6 are obvious over Shin and Lee’703 (Ex-1009) or Shin-Luo and Lee’703
7–8	Claim 16 is obvious over Shin and Park (Ex-1010) or Shin-Luo and Park

IV. TECHNOLOGY BACKGROUND

A. Display Devices Having a Flexible Screen Body Comprising a Planar Area and a Bending Area Connected to the Planar Area Were Known

51. Display devices having a flexible screen body were well known by 2021. For example, U.S. Patent No. 10,777,101 to Park (Ex-1021, “Park’101”) teaches “[a] foldable display device.” Ex-1021 (Park’101), Abstract, Figs. 4, 21. This is also taught by U.S. Patent Publication No. 2024/0269956 to Kang (Ex-1022, “Kang”). Kang teaches that the display panel of its display device “may be a flexible display panel,” which includes “a plurality of electronic elements on a flexible substrate.” Ex-1022 (Kang) ¶159; *see also, e.g.*, Ex-1023 (Kim’883), 8:22–38 (“The display panel DP may be a flexible display panel.”); Ex-1024 (Crawford), 1

(“Flexible flat panel display technologies offer many potential advantages, such as very thin profiles, lightweight and robust display systems, the ability to flex, curve, conform, roll, and fold a display for extreme portability, high-throughput manufacturing, wearable displays integrated in garments and textiles, and ultimate engineering design freedom (e.g. odd-shaped displays).”). Additionally, U.S. Patent Publication No. 2017/0047547 to Son (Ex-1025, “Son”) teaches “[a] flexible display device compris[ing] a flexible substrate including a display area and a non-display area.” Ex-1025 (Son), Abstract, Fig. 4C. Moreover, Chinese Patent No. 112,786,807 to Zeng (Ex-1040, “Zeng”) teaches that “flexible display devices” having “[f]lexible screens, as an important application technology of OLED photocurable adhesives, have seen significant development in recent years” and “[c]ompared with traditional screens, flexible screens have significant advantages, such as being thinner and lighter in volume.” Ex-1040 (Zeng) ¶¶2–4, 38, Figs. 1, 6; *see also, e.g.*, Ex-1027 (Xu), Abstract (“A 5.46inch WQHD foldable AMOLED display having thin thickness, wide color gamut, high brightness and low reflectivity was obtained.”), Fig. 1.

52. Display devices comprising a planar area and a bending area connected to the planar area were also well known by 2021. For example, Park’101 teaches that the display module of its display device “may include a main region MR and a bent region BR (or bending region) connected to one side of the main region MR”

wherein the “main region MR is a planar area located in one plane, and may include the display area DPA.” Ex-1021 (Park’101), 15:48–16:6, Fig. 4. Kang also teaches a display panel, which includes “a first area AA1, a second area AA2, and a bending area BA between the first and second areas AA1 and AA2.” Ex-1022 (Kang) ¶161, Figs. 15, 22. Moreover, Son teaches “[a] flexible display device compris[ing] a flexible substrate including a display area and a non-display area,” “a cover coat in the non-display area on the first surface of the flexible substrate,” and that “[a]t least a portion of the non-display area of the flexible substrate and the cover coat are bendable in a bending direction.” Ex-1025 (Son), Abstract, Fig. 4C.

53. *See also, e.g.*, Ex-1040 (Zeng), Cl. 9 (“the second region comprises a transition portion, a bent portion, and an extension”), Figs. 1, 6; Ex-1028 (Lee’621), 5:37–57 (“The display panel 10 may include a bending region BR. The bending region BR may be disposed in the non-display area NA between the display area DA and the pad portion PP. The bending region BR may be disposed across the display panel 10 in the first direction x. The display panel 10 may be bent at a predetermined radius of curvature about a bending axis parallel to the first direction x in the bending region BR. ... The display panel 10 may be in a bent state when a display device including the display panel 10 is applied to an electronic device. The bending region BR may be bent about one bending axis, and may be bent about two or more bending axes. In the drawing, although the bending region BR is illustrated to be disposed in

the non-display area NA, the bending region BR may be disposed over the display area DA and the non-display area NA, or may be disposed in the display area DA.”), Fig. 4; Ex-1029 (Um), 5:15–36 (“A substrate 100 included in the display panel may have a bending area BA extending in a first direction (+y direction). The bending area BA may be located between a first area 1A and a second area 2A in a second direction (+x direction) across the first direction. The substrate 100 may be bent with respect to a bending axis BAX extending in the first direction (+y direction) as shown in FIG. 1. The substrate 100 may include various materials having a flexible or bendable characteristic[s].”), Figs. 15, 16; Ex-1030 (Lee’226), 6:18–27 (“The fourth bezel area BZ4, which includes the pad area PDA, includes a bending area BD configured to be bent or folded, and the bending area GD includes a crack prevention layer 140 formed of an organic insulating material that exhibits high strain and impact resistance to alleviate bending stress. When the bezel is bent, the crack prevention layer 140 may alleviate bending stress applied to wires and insulating layers thereunder, whereby it is possible to prevent crack defects and open-circuit defects in the bending area BD.”); Ex-1031 (Park’039) ¶86 (“The display member 20 may be disposed across the main area MR, the bending region BR and the subsidiary region SR.”), Cl. 23 (“A display device, comprising: a display member comprising a substrate having a main region, a subsidiary region and a bending region located between the main region and the subsidiary region.”), Fig.

13; Ex-1039 (Lee'835) ¶¶96–97 (“in the flexible display device (200), the flexible substrate (210) is defined by a display area (201), a non-display area (203), and a bending area (202)”), Fig. 5; Ex-1023 (Kim'883), 8:22–38 (“display panel DP may have a plane defined by the first and second directions DR1 and DR2” and is “a flexible display panel”), Fig. 14 (showing a planar area and a bending area connected to the planar area).

B. Display Devices Having a Color Filter Disposed on the Flexible Screen Body and at Least Covering the Planar Area Were Known

54. Display devices having a color filter disposed on the flexible screen body and at least covering the planar area were well known by 2021. For example, Park'101 teaches that its display device includes “at least one functional layer,” which may perform “a color filtering feature” such as “a color filter.” Ex-1021 (Park'101), 8:36–47, Figs. 4 (showing the color filter covering the planar area), 21, 24–25. Moreover, U.S. Patent No. 12,108,621 to Lee (Ex-1028, “Lee'621”) teaches that “[a] color filter 230 may be disposed on the touch sensor layer TS,” which transmits “any one of red, green, and blue light,” “may include quantum dots or phosphors, and may convert light emitted from the light emitting diode LED into red or green light.” Ex-1028 (Lee'621), 16:9–21, Fig. 14 (showing color filter 230 covering the planar area). Kang also teaches that its display module DM includes “an antireflection layer RPL,” which “may include a plurality of color filters that

display the same colors as those generated from the pixels.” Ex-1022 (Kang) ¶¶158, 163, Figs. 15, 22.

55. *See also, e.g.,* Ex-1027 (Xu), 310, pt. 1 (“According to the foregoing report, we introduced the novel COE (CF on Encapsulation) structure with RGB emitter, thin film encapsulation (TFE) and low temperature color filter array directly patterned on TFE to maintain the thinness of the flexible display and ensure its flexibility and reliability.”), pt. 2 (“color filter array ... includes 5 layers (black matrix/red/green/blue/over-coat)” and “is patterned directly over the TFE layer”), §§2.1, 2.3, Fig. 1 (showing color filter covering the planar area); Ex-1029 (Um), 12:39–60 (“the reflection of external light may be reduced by using a black matrix or a color filter”); Ex-1030 (Lee’226), 4:5–17 (“The touch display panel 10 includes ... a color filter layer 500 disposed on the touch sensor unit 400, the color filter layer 500 having color realization and low reflection functions. In addition, the touch display panel 10 may further include an optical film 600 attached to the color filter layer 500, an optically clear adhesive (OCA) 700, and a cover substrate 800, and may further include a protective film.”), 5:1–27 (“The color filter layer 500, which is disposed on the touch sensor unit 400, includes a color filter overlapping an emissive area EA of each pixel, the color filter being configured to transmit red light, green light, or blue light for each pixel, and a black matrix overlapping a non-emissive area NA, the black matrix being configured to absorb external light. The

color filter layer 500 exhibits a light wavelength selection property and an external light absorption property, whereby it is possible to reduce the reflectance of external light by the touch sensor unit 400 and the display unit DP.”), Figs. 2, 8; Ex-1031 (Park’039) ¶¶215 (“color filters 161_R, 161_G and 161_B, and a light-blocking pattern BM, are disposed in (and overlap) the main region MR”), 217 (“Color filters 161_R, 161_G and 161_B may be disposed on the light-blocking pattern BM and the second sensing conductive layer TCL2 in each of the pixels,” “may include a red color filter 161_R transmitting red light and blocking green light and blue light, a green color filter 161_G transmitting green light and blocking red light and blue light, and a blue color filter 161_B transmitting blue light and blocking red light and green light,” and “the color filters 161_R, 161_G and 161_B may be in direct contact with the exposed upper surface of the second sensing insulating layer 330.”), Cl. 23 (“A display device, comprising: ... a color filter layer disposed on the sensing member and overlapping the main region”); Ex-1033 (Park’246), 8:29–36 (“the display module DM ... may further include an antireflection layer,” which “may include a color filter, a laminated structure of a conductive layer/a dielectric layer/a conductive layer, or an optical member”), Fig. 3; Ex-1034 (Onoue), 5:47–54 (“a reflection prevention layer RPP (see FIG. 5A) may be disposed between the window WP and the display module DM,” which “reduces the reflectance of external light incident from an upper side of the window WP”), 8:39–45 (“[t]he reflection

prevention layer RPP may include color filters”); Ex-1023 (Kim’883), 11:9–14 (“The anti-reflection layer RPL disposed on the display panel DP may be defined as an external light anti-reflection film.”); Ex-1024 (Crawford), 186 (“Color filers are an integral part of modern displays allowing for the production of full-color images.”), 473 (color filter is “formed on the TFT substrate), Figs. 23.12, 23.13.

C. Display Devices Having a Protective Layer Disposed on the Flexible Screen Body and at Least Covering a Part of the Bending Area Were Known

56. Display devices having a protective layer disposed on the flexible screen body and at least covering a part of the bending area were well known by 2021. For example, Park’101 teaches that a “protective layer 411 (or a bent region protective layer) may be disposed on the display module 210 in the bent region BR and the sub region SR,” which “covers and protects driving wiring,” “reinforce[s] the strength of the flexible substrate,” and “mitigate[s] stress in the bent region BR.” Ex-1021 (Park’101), 16:35–17:4, Fig. 4. Moreover, Son teaches that “[a] cover coat 240 may be disposed on the non-display area (NA) of the first surface 210a of the flexible substrate 210 to prevent moisture permeation or crack occurrence” and “may be disposed in the bend area.” Ex-1025 (Son) ¶44, Fig. 4C. Additionally, U.S. Patent Publication No. 2019/0221774 to Jeon (Ex-1035, “Jeon”) teaches that “[t]he display device DD ... may include a protection layer BL disposed on the non-display area NDA ... between the display panel DP and the connection circuit member CP ... to

protect the connection line CL disposed on the non-display area NDA.” Ex-1035 (Jeon) ¶64. Jeon further teaches that “[t]he protection layer BL may be disposed on the bending part BA of the non-display area NDA” and “may prevent fractures of the connection line CL from occurring in the bending part BA and ... moisture from permeating into the display panel DP.” Ex-1035 (Jeon) ¶65 (“Also, the protection layer BL may protect the connection line CL disposed on the bending part BA, an edge portion of the display panel DP, which is adjacent to the bending part BA, and an edge portion of the connection circuit member CP disposed on the non-display area NDA against an external impact or vibration.”), Fig. 5. Kang also teaches that its “display device DD may include a protection layer BPL ... on the bending area BA, a portion of the first area AA1 adjacent to the bending area BA, and a portion of the second area AA2 adjacent to the bending area BA.” Ex-1022 (Kang) ¶232 (“protection layer BPL may extend from the portion of the first area AA1 adjacent to the bending area BA, through the bending area BA, toward the portion of the second area AA2 adjacent to the bending area BA”), Figs. 15, 22. Kang further teaches that the protection layer BPL “may serve to protect the bending area BA,” may “cover and protect connection lines on the bending area BA,” “complement rigidity of the bending area BA” such that “when the bending area BA is bent, cracks in the bending area BA may be prevented or reduced,” and may “protect the bending area BA against external impact.” Ex-1022 (Kang) ¶233.

57. *See also, e.g.,* Ex-1036 (Choi) ¶¶112 (“[a] bending protection layer BPL 600 may be located outside the display area DA” and “may correspond to at least the bending area BA to be located above the fan-out wiring 720a”), 115 (“a portion of the BPL 600 in the direction (-x direction) toward the display area DA is in contact with the cover layer 730”), Fig. 3B; Ex-1029 (Um), 14:1–20 (“the first bending protection layer 610 may be coated on the display panel through a nozzle N” and “may be arranged in at least a part of the boundary of the area of the bending protection layer 600”), Fig. 15; Ex-1030 (Lee’226), 6:18–27 (“The fourth bezel area BZ4, which includes the pad area PDA, includes a bending area BD configured to be bent or folded, and the bending area GD includes a crack prevention layer 140 formed of an organic insulating material that exhibits high strain and impact resistance to alleviate bending stress. When the bezel is bent, the crack prevention layer 140 may alleviate bending stress applied to wires and insulating layers thereunder, whereby it is possible to prevent crack defects and open-circuit defects in the bending area BD.”); Ex-1031 (Park’039) ¶¶86 (“the display panel 10 may include ... a bending protective layer (BPL) 50”), 90 (“the bending protective layer 50 is disposed in the bending region BR”); Ex-1034 (Onoue), 8:15–18 (“The display module DM may include a bending portion protective layer BPL overlapping at least the bending region BA.”), 9:46–59 (“The display module DM is bent around the bending axis BX, and may include the bending portion protective layer BPL

disposed in the bending region BA (see FIG. 4) of the display panel DP. 70% or more of the total area of the bending portion protective layer BPL may be disposed in the bending region BA. A portion of the bending portion protective layer BPL may overlap the flat region NBA1 and the opposing region NBA2. The bending portion protective layer BPL may be disposed in the bending region BA, and perform a function of reducing stress generated as the display module DM is bent. The bending portion protective layer BPL may generate a neutral plane of the bending region BA defined during bending adjacent to a circuit layer ML-D (see FIG. 8A) of the display panel DP.”), Fig. 5A; Ex-1039 (Lee’835) ¶¶96–97 (“And wiring is formed in the bending area (202) of the flexible substrate (210), and a protective coating layer (284) is applied to protect the wiring. After applying the protective coating layer (284), a curing process is performed and then a bending process is performed.”); Ex-1023 (Kim’883), 18:20–29 (“The protection layer BPL may serve to protect the bendable area BA. The protection layer BPL may cover lines disposed on the bendable area BA to protect the lines disposed on the bendable area BA. The protection layer BPL may complement stiffness of the bendable area BA, and when the bendable area BA is bent, the bendable area BA may be prevented from being cracked. The protection layer BPL may protect the bendable area BA against an external impact. The protection layer BPL may have a thickness of about 80 micrometers (μm) in the third direction DR3.”).

D. Display Devices Having a Coverplate Disposed on the Color Filter and at Least Covering the Planar Area Were Known

58. Display devices having a coverplate disposed on the color filter and at least covering the planar area were well known by 2021. For example, Zeng teaches that “flexible screens have significant advantages, such as being thinner and lighter in volume, and their stack-up generally comprising a cover glass (CG), an optically clear adhesive layer (OCA) layer, a polarizer (Pol) layer, a display panel, a backplane (BP) layer, a composite material, and the like.” Ex-1040 (Zeng) ¶¶2–4, Figs. 1, 3. Moreover, Son teaches that a “overcoat layer 236 may be disposed on the polarizing layer 232, with an adhesive layer 234 bonding the polarizing layer 232 and the overcoat layer 236 together.” Ex-1025 (Son) ¶47, Fig. 4C. Additionally, Lee’621 teaches that “[a]n overcoat layer 240 may be disposed on the color filter 230.” Ex-1028 (Lee’621), 16:9–21, Fig. 14. Kang also teaches that its display module DM may include a “window protection layer WP ... on or above the display panel DP.” Ex-1022 (Kang) ¶158. Kang further teaches that “window protection layer WP may be on the window WIN” and “may include a flexible plastic material, such as polyimide or polyethyl-eneterephthalate.” Ex-1022 (Kang) ¶168.

59. *See also, e.g.,* Ex-1027 (Xu), 310, pt. 2 (“The function films are introduced to protect the panel from scratch and to ensure that the neutral axis of the stress could be placed around the most fragile layers of the flexible panel (the TFT,

OLED, TFE), thereby avoiding damage during bending or folding.”); Ex-1030 (Lee’226), 4:5–17 (“[T]he touch display panel 10 may further include an optical film 600 attached to the color filter layer 500, an optically clear adhesive (OCA) 700, and a cover substrate 800, and may further include a protective film.”) Ex-1035 (Jeon) ¶82 (“The display device DD-1 may further include the window member WP. The window member WP may be disposed on the polarization plate PL.”); Ex-1031 (Park’039) ¶90 (“the cover film 60 is disposed in the subsidiary region SR, thus covering and protecting the exposed second sensing conductive layer”); Ex-1033 (Park’246), 7:32–44 (“the display device DD includes a protection film PM, a window WM, a display module DM, a first adhesion member AM1, and a second adhesion member AM2” and “[t]he display module DM is disposed between the protection film PM and the window WM”; “the second adhesion member AM2 is coupled to the display module DM and the window WM”), 8:1–13 (“The window WM protects the display module DM against the external impact and provides an input surface to a user. The window WM provides a second outer surface OS-U that is exposed to the outside and an adhesion surface AS2 that adheres to the second adhesion member AM2. The display surface IS of FIGS. 1A to 1C may be the second outer surface OS-U.”), Figs. 13A-13C; Ex-1037 (Lee’476), 17:14–23 (“the cover glass CG is attached after removing the protective film PF disposed on the first adhesive layer 341” and “protects the upper surface of the organic light emitting

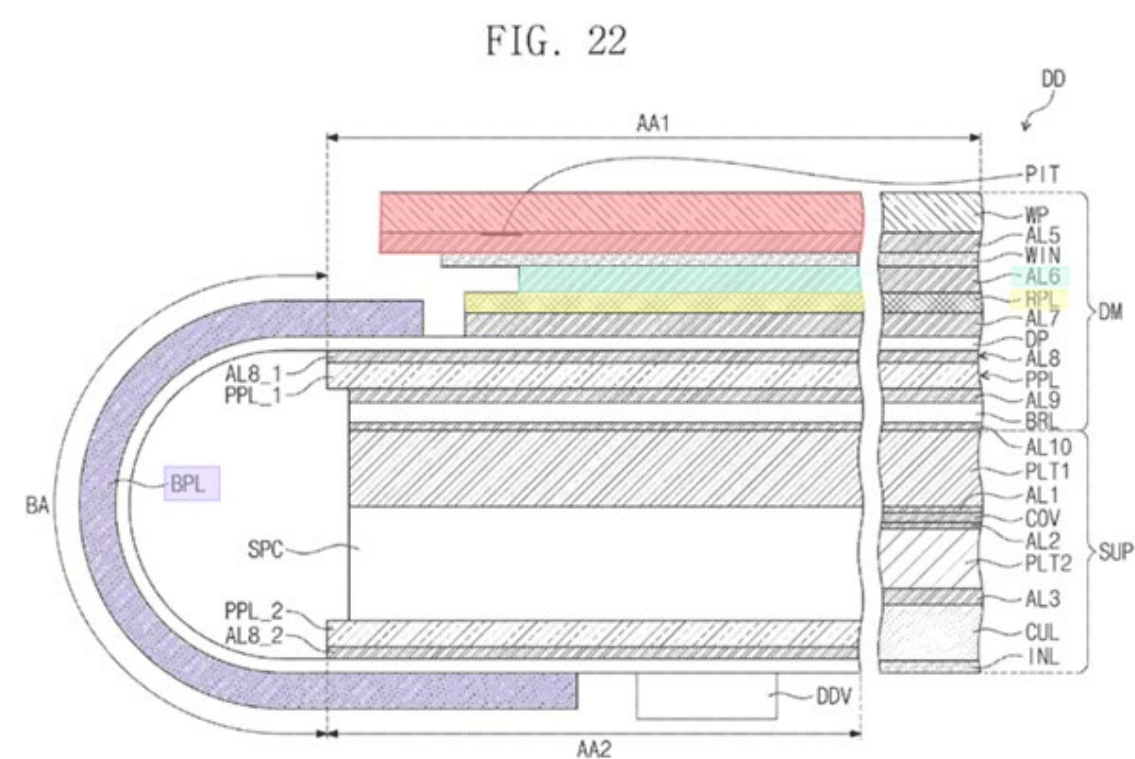
display device”; “To this end, the cover glass CG is not only disposed on the display area D/A and the first non-display area N/A1, but also disposed to outwardly protrude from the first non-display area N/A1 so as to correspond to a bezel area which is formed after bending the bending area B/A toward the rear surface.”), Fig. 4G; Ex-1034 (Onoue), 5:15–27 (“The window WP may include an optically transparent insulation material. For example, the window WP may include glass or plastic. The window WP may have a multi-layered structure or a single-layered structure. For example, the window WP may include a plurality of plastic films coupled with an adhesive, or a glass substrate and a plastic film coupled with an adhesive.”); Ex-1039 (Lee’835) ¶¶96–97 (“back plates (220A, 220B) for supporting the flexible substrate (210)), 124 (“For example, in the case where the delamination phenomenon of the protective coating layer (384) may occur relatively frequently for a relatively large flexible substrate (310), the degree of overlap or covering is implemented to be large, and in the case where the delamination phenomenon of the protective coating layer (384) occurs relatively little for a relatively small flexible substrate (310), the degree of overlap or covering may be implemented to be small. In order to use a high-modulus resin as the protective coating layer (384), it is very important to apply the protective coating layer (384) to the flexible substrate (310) and bend it without disconnection of the wiring or breakage or damage of the flexible substrate (310).”); Ex-1023 (Kim’883), 10:58–67 (“[T]he display device DD

includes a display panel DP, an anti-reflection layer RPL, an impact absorption layer ISL, a window WIN, a window protection layer WP, a first coating layer CT1, a second coating layer CT2, a panel protection layer PPL, a cover layer CYL, a plate PLT, a sub cover layer SCV, a support SUP, a heat dissipation layer RHL, an insulation layer INL, and first to eleventh adhesion layers AL1 to AL11.”), Fig. 6.

E. Display Devices Wherein in an Overlapping Area of the Protective Layer and Coverplate, a Distance Between the Protective Layer and Coverplate is Greater Than or Equal to a Default Value, Wherein the Default Value Is Greater Than 0, Were Known

60. Display devices wherein in an overlapping area of the protective layer and coverplate, a distance between the protective layer and coverplate is greater than or equal to a default value greater than 0 were well known by 2021. For example, as shown in annotated Fig. 22 below, Kang teaches that the distance (designated by the green arrow) between bending protection layer BPL (purple) and window protection layer WP (red) in an overlapping area of the two components (designated by the purple arrow) “is greater than or equal to a default value, wherein the default value is greater than 0” as depicted by the physical gap shown in the figure between BPL and WP. Ex-1022 (Kang), Fig. 22. Specifically, Kang teaches a distance that spans at least the thickness of the AL6 layer (teal) and the non-overlapping portion of the RPL layer (yellow) between the BPL and WP layers, which are greater than a distance of 0. Ex-1022 (Kang) ¶¶165 (“The window WIN may be on the

antireflection layer RPL. The window WIN may protect the display panel DP and the antireflection layer RPL against external scratches. The window WIN may have optically transparent properties.”), 171 (“The sixth adhesive layer AL6 may be between the window WIN and the antireflection layer RPL. The sixth adhesive layer AL6 may attach the window WIN to the antireflection layer RPL.”).



61. See also, e.g., Ex-1023 (Kim’883), Fig. 6 (showing the same “default value” as Kang’s Fig. 22), 10:58–67 (“[T]he display device DD includes a display panel DP, an anti-reflection layer RPL, an impact absorption layer ISL, a window WIN, a window protection layer WP, a first coating layer CT1, a second coating layer CT2, a panel protection layer PPL, a cover layer CYL, a plate PLT, a sub cover layer SCV, a support SUP, a heat dissipation layer RHL, an insulation layer INL,

and first to eleventh adhesion layers AL1 to AL11.”), 11:15–20 (“the display panel DP may have a thickness of about 30 micrometers (μm), and the anti-reflection layer RPL may have a thickness of about 31 micrometers (μm)”), 11:35–38 (“The impact absorption layer ISL may have a thickness greater than that of the anti-reflection layer RPL in the third direction DR3. For example, the impact absorption layer ISL may have a thickness of about 41 micrometers (μm)”), 11:53–57 (“The window WIN may have a thickness less than that of each of the impact absorption layer ISL and the anti-reflection layer RPL and have the same thickness as the display panel DP. For example, the window WIN may have a thickness of about 30 micrometers (μm).”), 12:6–11 (“The window protection layer WP may have a thickness greater than that of the impact absorption layer ISL in the third direction DR3. For example, the window protection layer WP may have a thickness of about 55 micrometers (μm).”), 12:21–24 (“The first adhesion layer AL1 may have a thickness less than that of the window WIN. For example, the first adhesion layer AL1 may have a thickness of about 25 micrometers (μm).”), 12:28–33 (“The second adhesion layer AL2 may have a thickness greater than that of the window WIN and less than that of the impact absorption layer ISL. For example, the second adhesion layer AL2 may have a thickness of about 35 micrometers (μm).”), 12:40–45 (“The third adhesion layer AL3 may have a thickness less than that of the anti-reflection layer RPL and have the same thickness as the first adhesion layer AL1. For example, the

third adhesion layer AL3 may have a thickness of about 25 micrometers (μm).”), 12:49–54 (“The fourth adhesion layer AL4 may have a thickness less than that of the display panel DP and have the same thickness as the first adhesion layer AL1. For example, the fourth adhesion layer AL4 may have a thickness of about 25 micrometers (μm).”), 12:64–67 (“The panel protection layer PPL may have a thickness greater than that of the display panel DP in the third direction DR3. For example, the panel protection layer PPL may have a thickness of about 50 micrometers (μm).”), 13:26–33 (“the barrier layer BRL may have a thickness of about 35 micrometers (μm)” and “the cushion layer CUL may have a thickness of about 100 micrometers (μm)”), 13:60–63 (“the plate PLT may have a thickness of about 150 micrometers (μm)”), 14:1–4 (“the fifth adhesion layer AL5 may have a thickness of about 18 micrometers (μm)”), 14:9–13 (“the sixth adhesion layer AL6 may have a thickness of about 25 micrometers (μm)”), 14:17–21 (“the seventh adhesion layer AL7 may have a thickness of about 8 micrometers (μm)”), 14:39–43 (“each of the sub cover layer SCV and the eighth adhesion layer AL8 may have a thickness of about 8 micrometers (μm)”), 15:14–17 (“the support SUP may have a thickness of about 80 micrometers (μm)”), 15:30–33 (“the ninth adhesion layer AL9 may have a thickness of about 8 micrometers (μm)”), 15:38–42 (“the heat dissipation layer RHL may have a thickness of about 17 micrometers (μm)”), 15:50–54 (“the tenth adhesion layer AL10 may have a thickness of about 5 micrometers (μm)”),

15:57–61 (“the insulation layer INL may have a thickness of about 15 micrometers (μm)”), 15:67–16:3 (“the eleventh adhesion layer AL11 may have a thickness of about 5 micrometers (μm)”), 18:28–29 (“protection layer BPL may have a thickness of about 80 micrometers (μm) in the third direction DR3”), 21:25–27 (“spacer SPC may have a thickness of about 47 micrometers (μm) in the third direction DR3”); Ex-1027 (Xu), 310, pt. 2 (“some COE structure panels were folded for 100,000 times at a radius of 3mm, and the brightness of the panels were almost unchanged”).

62. Indeed, it was well known by 2021 that a bending area is an area that can cause damage and the prior art taught that cracking and delaminating are issues that need to be addressed. Specifically, the prior art taught that the effect of intense mechanical stress, especially tensile stress on the outer bending layers in the form of stretching, as well as compressive stress on the inner bending layers in the form of squeezing and squishing. And that if the adjacent organic layers such as protective coatings, encapsulation and cushion layers, adhesive layers etc. are over compressed or improperly dimensioned, the resulting stress distribution in the layers is uneven and could lead to micro-cracking. Examples would be delamination between the glass and protective film or cracking of the glass, or even deformation, creasing or other non-linear effects of the organic layers. The prior art taught that controlling the layer thickness, stiffness, and squeezing or compression of the organic layers is important for high quality operation of the display. For example, regulating the

thickness ratios of the various layers was known to be important as well as avoiding compression over-squeeze and regulation of viscosity and flow characteristics to mitigate layer delamination. A POSITA would have understood that if layers are too thick and become over compressed during the lamination process then their performance will deteriorate. *See, e.g.*, Ex-1029 (Um) 10:35–67 (“Since hardness of the inorganic insulating layer is higher than that of the organic material layer 160, there may be a high probability that cracks occur in the inorganic insulating layer in the bending area BA. When cracks occur in the inorganic insulating layer, since cracks occur in the first conductive layer 215 c over the inorganic insulating layer, there may be a high probability that defects such as a disconnection of the first conductive layer 215 c occur. ... [C]racks may be prevented from occurring in a part of the first conductive layer 215 c located over the organic material layer 160 in the bending area BA or an occurrence rate of cracks may be minimized.”), 15:32–38 (“When the thickness of the bending protection layer 600 is not uniform, a curvature radius may not be uniform and there may be a high possibility that cracks occur in the bending area BA when the substrate 100 is bent. However, the above-formed bending protection layer 600 may have a uniform thickness in the bending area BA or the opening 170OP.”), 15:39–40 (“The bending protection layer 600 may minimize tensile stress when the bending area BA is bent.”); Ex-1034 (Onoue) 1:37–41 (“The flexible circuit board may be cracked in the repeated bending action of a

circuit pattern formed on a circuit board or in the process of coupling the circuit pattern in a bent state, or may be damaged due to tensile force generated during bending.”), 9:53–56 (“The bending portion protective layer BPL may be disposed in the bending region BA, and perform a function of reducing stress generated as the display module DM is bent.”); Ex-1021 (Park’101) 16:37–40 (“the protective layer 411 may reinforce the strength of a flexible substrate or to mitigate stress in the bent region BR”), 9:63–10:14 (describing thickness of various layers), 16:55–67 (“protective layer 411 may have a thickness relatively less than the thickness of the flexible function module 221 ... the window module 222 may be spaced apart from the protective layer 411 due to the thickness of the protective layer 411, such that the window module 222 may be bent without being supported thereby”), 17:22–30, 18:3–16, 18:50–58, 19:15–18; Ex-1036 (Choi) ¶¶109, 111, 115, 135 (“[S]ince the display apparatus ... includes a conductive layer having a multiple layer structure in the bending area BA, even if a crack occurs in a conductive layer having a single layer structure, an electrical signal may be transferred to the display area DA without a problem.”), 103 (“The organic material layer 160 may absorb tensile stress of the substrate 100 and other elements, caused by bending, to thus effectively reduce tensile stress concentrated on the fan-out wiring 720 a.”), 156–158; Ex-1030 (Lee’226), 6:18–27 (“The fourth bezel area BZ4, which includes the pad area PDA, includes a bending area BD configured to be bent or folded, and the bending area

GD includes a crack prevention layer 140 formed of an organic insulating material that exhibits high strain and impact resistance to alleviate bending stress. When the bezel is bent, the crack prevention layer 140 may alleviate bending stress applied to wires and insulating layers thereunder, whereby it is possible to prevent crack defects and open-circuit defects in the bending area BD.”); Ex-1035 (Jeon) ¶¶76 (“In an exemplary embodiment, the protection layer BL may have a mean thickness of about 80 μm to about 150 μm .”), 77 (“the protection layer BL at a portion thereof adjacent to the display panel DP or a portion thereof adjacent to the connection circuit member CP may have a thickness greater than that of the protection layer BL at a central portion thereof”), 78, 81; Ex-1037 (Lee’476) 9:21–29 (“the thickness d2 of the adhesive layer 140 may be adjusted so as to serve as a buffer enough to protect an internal configuration of the organic light emitting display device 100 from a touch pressure applied by the user on an upper portion of the cover glass or an external impact. For example, the thickness d2 of the adhesive layer 140 may be 50 μm to 200 μm , but is not limited thereto”), 11:25–27 (“the thickness of the micro coating layer 170 may be 70 μm to 130 μm , but is not limited thereto”), 15:6–8 (“the thickness d7 of the second adhesive layer 342 may be 20 μm to 80 μm , but is not limited thereto”), 15:52–62 (“a thickness d8 a of the first adhesive layer 341 a and a thickness d9 a of the second adhesive layer 342 a may be freely adjusted as needed. For example, the first adhesive layer 341 a may have a thickness of 50 μm to 200

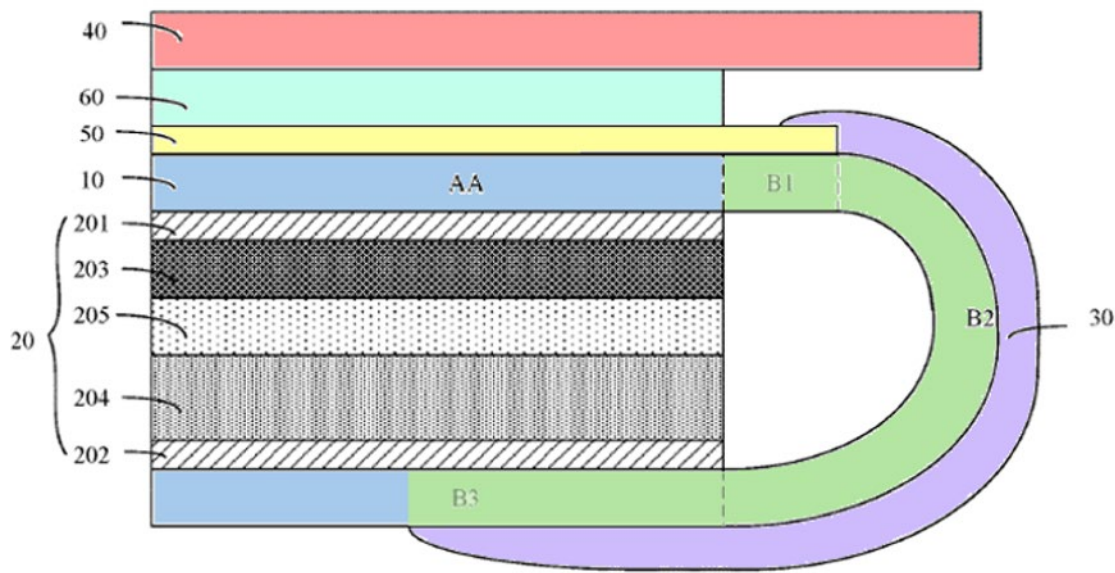
μm to bond the cover glass (not shown) and buffer an external impact and a pressure which are transmitted through the cover glass (not shown). The second adhesive layer 342 a may have a thickness of 20 μm to 80 μm enough to bond the display unit 120 and the polarization layer 130 and form a concave portion in the second adhesive layer 342 a, but the thicknesses are not limited thereto”).

V. THE '031 PATENT

A. Overview of the '031 Patent

63. The '031 Patent teaches a display device that purportedly “solve[s] a problem of current OLED display panels having the risk of cracking.” Ex-1001, 2:4–6. As shown in annotated Figure 1 below,¹ the '031 Patent teaches a display device, which includes a flexible screen body 10, a color filter 50 (yellow), a protective layer 30 (purple), a coverplate 40 (red), and an optical adhesive 60 (teal), among other components. Ex-1001, 4:32–28, Fig. 1. The '031 Patent further teaches that “flexible screen body 10 can be divided into a planar area AA [blue]” for displaying and “a bending area [green] extending from the planar area AA ... that cannot display,” which includes “a transitional bending sub-area B1, a bending sub-area B2, and an extending bending sub-area B3.” Ex-1001, 4:33–40.

¹ Throughout, emphasis and annotations are added unless otherwise specified.



64. Independent Claim 1 of the '031 Patent recites an arrangement of the components of the display device including that color filter 50 is disposed on flexible screen body 10 and at least covers the planar area; protective layer 30 is disposed on flexible screen body 10 and at least covers part of the bending area; and coverplate 40 is disposed on color filter 50 and at least covers the planar area. Ex-1001, Cl. 1, 12:10–23. The claim additionally recites that in an overlapping area of protective layer 30 and coverplate 40, a distance between protective layer 30 and coverplate 40 “is greater than or equal to a default value, wherein the default value is a value greater than 0.” *Id.* The '031 Patent teaches that the default value “may be flexibly adjusted according to actual needs” so that “coverplate 40 will not squeeze the protective layer 30, thereby preventing a risk of cracking the display device. Ex-1001, 7:1–10.

B. Prosecution History of the '031 Patent

65. I have reviewed the prosecution history of the '031 Patent. The '031 Patent was filed June 29, 2021 as the U.S. national stage entry of PCT Application No. PCT/CN2021/097527, filed on May 31, 2021. It claims priority to Chinese Application No. 202110548905.2, filed May 20, 2021. The Examiner did not issue any office actions during prosecution. Ex-1004.

66. This Declaration presents new prior-art grounds and arguments that I understand were not considered during prosecution. In my opinion, the challenged claims are invalid as obvious for the reasons explained below.

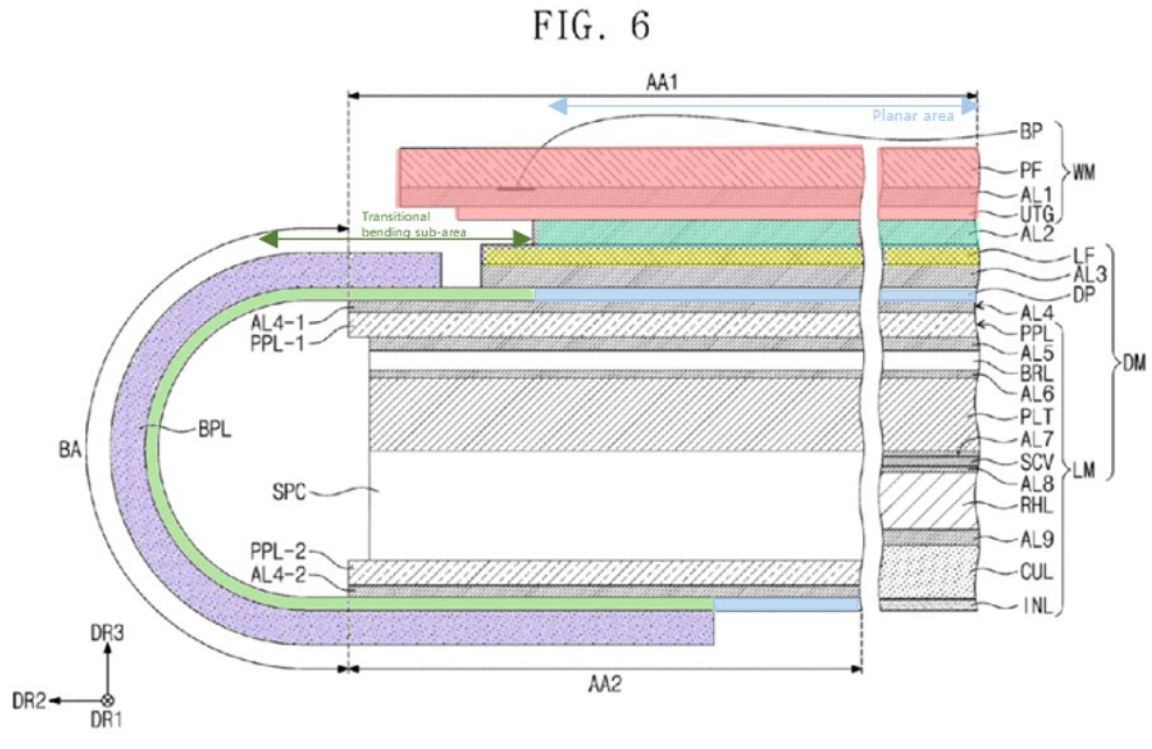
VI. DESCRIPTION OF THE APPLIED PRIOR ART

A. Shin (Ex-1005)

67. Shin (U.S. Patent Publication No. 2022/0061168) was filed April 28, 2021 and published February 24, 2022. I understand that Shin is prior art to the '031 Patent under 35 U.S.C. §102(a)(2).

68. Shin teaches a “foldable display device and an electronic device including the same.” Ex-1005 ¶2. As shown in annotated Figure 6 below, Shin teaches that its display device comprises display panel DP, which includes “a display area DP-DA [blue] and a non-display area DP-NDA” (Ex-1005 ¶69) and “a first panel area AA1, a second panel area AA2 and a bending area BA which are planar areas distinguished from each other along the second direction DR2.” Ex-1005 ¶91.

Moreover, Shin teaches that optical film LF (yellow), which includes “color filters,” is disposed in the first panel area AA1,” “covers at least the display area DP-DA,” and is “coupled ... to the display panel DP.” Ex-1005 ¶¶86, 115. Shin further teaches bending protection layer BPL (purple), which is disposed on display panel DP “in at least the bending area BA [green].” Ex-1005 ¶148. Additionally, Shin teaches “window module WM (e.g., window)” (red), which is coupled to optical film LF by second adhesive layer (teal), “provides or defines the front surface of the electronic device ED,” and includes “a thin-film glass substrate UTG, a plastic film PF disposed on the thin-film glass substrate UTG, a first adhesive layer AL1 coupling the thin-film glass substrate UTG and the plastic film PF and a bezel pattern BP.” Ex-1005 ¶¶67, 102, 115; *see also id.* ¶103 (bezel pattern BP “may be disposed on a top surface of the plastic film PF” of the device and “overlaps the non-display area NDA”). Shin also teaches that adhesive layer AL2 may “have a thickness of about 35 μm to about 65 μm , e.g., about 50 μm .” Ex-1005 ¶111.

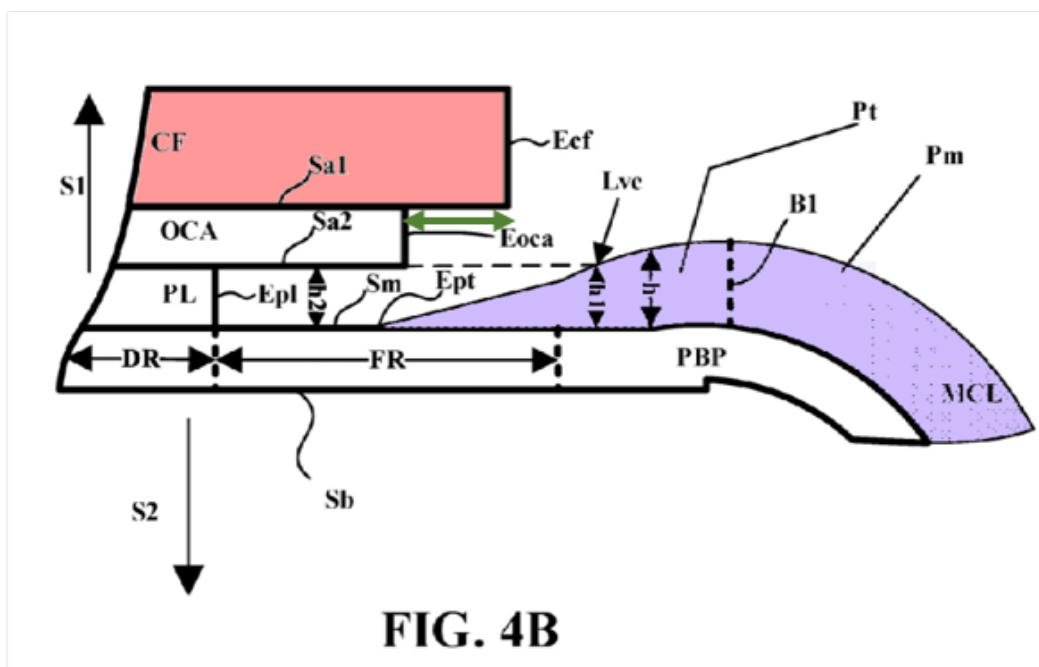


B. Luo (Ex-1006)

69. Luo (PCT Patent Publication No. WO2022/051943 to Luo) was filed September 9, 2020 and published March 17, 2022. I understand that Luo is prior art to the '031 Patent under 35 U.S.C. §102(a)(2).

70. Luo teaches a display apparatus having “an intricate structure to eliminate” interference “by defining critical parameters including at least one of the first shortest distance Ds1, the second shortest distance Ds2, the third shortest distance Ds3, or the fourth shortest distance Ds4.” Ex-1006 ¶77. Specifically, as shown in annotated Figure 4B below, Luo teaches that “a fourth shortest distance Ds4 [designated by the green arrow] between the orthographic projection of the edge

Eoca connecting the first adhering surface Sa1 and the second adhering surface Sa2 on the plane comprising the main surface Sm of the display portion DP and the orthographic projection of the edge Ecf of the cover window CF [red] adjacent to the tapered portion Pt on the plane comprising the main surface Sm of the display portion DP is equal to or greater than a second value.” Ex-1006 ¶68. Luo further teaches that “the second value is equal to a bonding tolerance of the optically clear adhesive layer OCA,” which may be “in a range of 100 μm to 200 μm , e.g., 100 μm to 125 μm , 125 μm to 150 μm , 150 μm to 175 μm , or 175 μm to 200 μm ” such that, for example, “the fourth shortest distance Ds4 is equal to or greater than 150 μm .” Ex-1006 ¶69. Luo also teaches that “not only the interference between the *cover window CF [red]* and the *coating layer MCL [purple]* can be eliminated, but also other defects such as cover window depression, bending portion cracking, and light leakage, can be effectively prevented or entirely eliminated.” Ex-1006 ¶77.



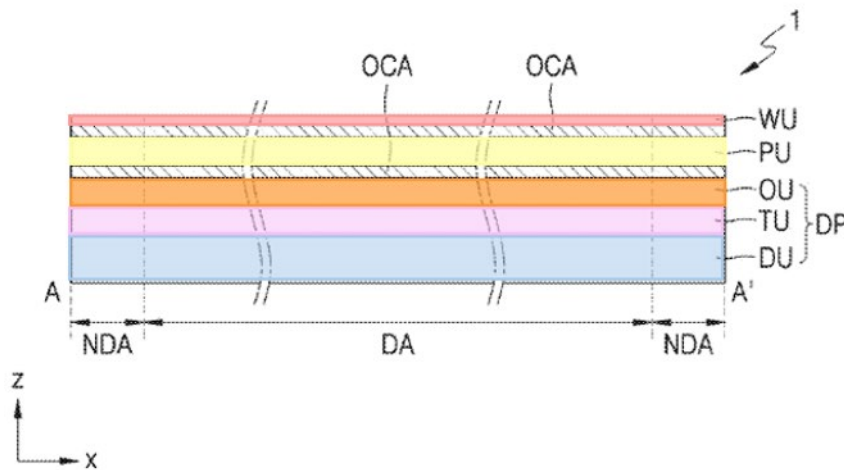
C. Lee'538 (Ex-1007)

71. Lee'538 (U.S. Patent No. 12,507,538) was filed January 24, 2022, claims priority to Korean Patent Application No. 2021/0052532 ("Lee'532") filed April 22, 2021, and issued December 23, 2025. A certified translation of Lee'532 (Ex-1011) is attached as Ex-1012. I understand that Lee'538 is prior art to the '031 Patent under 35 U.S.C. §102(a)(2).

72. Lee'538 teaches a display apparatus, which includes "display layer DU," "touch sensing layer TU," "optical functional layer OU," "polarization layer PU," and a window layer WU." Ex-1007, 6:33–36. As shown in annotated Figure 2A below, Lee'538's touch sensing layer TU (pink) is disposed between the display layer DU (blue) and the optical functional layer OU (orange). Ex-1007, Fig. 2A.

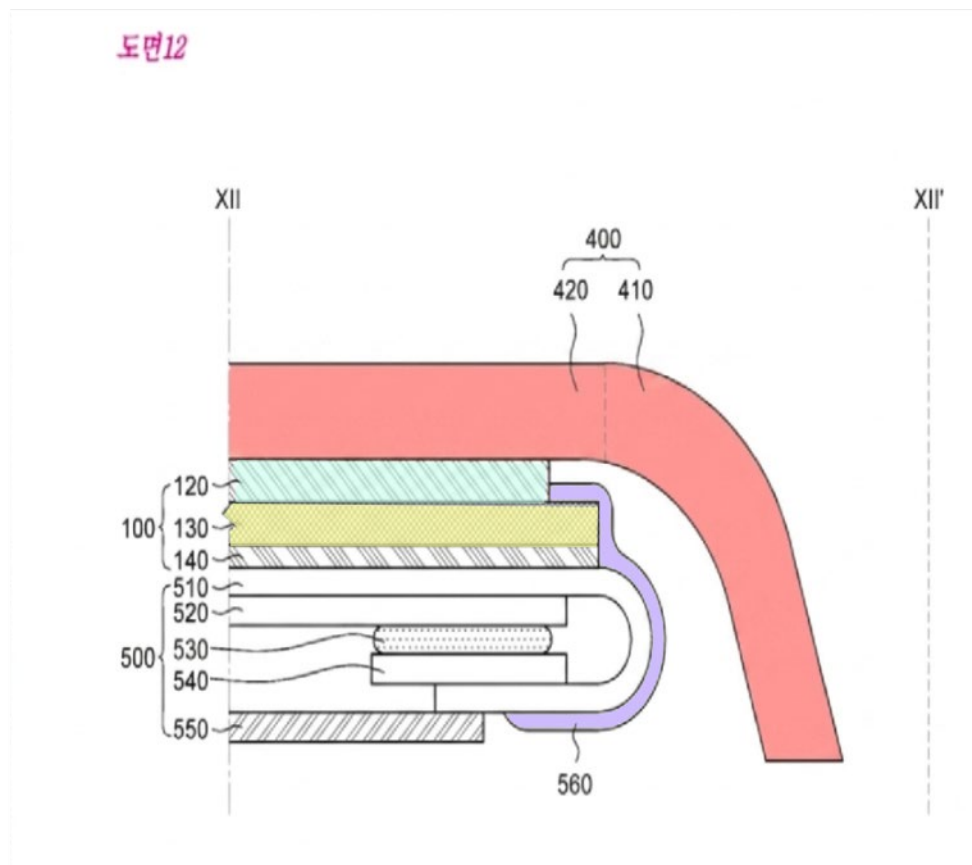
Moreover, Lee'538's polarization layer PU (yellow) is disposed between the OU and WU layers. *Id.*

FIG. 2A



73. Moreover, as shown in annotated Figure 6 below, Lee'538 teaches that “optical functional layer OU may be disposed on the touch sensing layer TU” and includes first layer 510 (orange) and second layer 520 (yellow) “arranged on the first layer 510.” Ex-1007, 15:39–44, Fig. 6. Both first layer 510 and second layer 520 include “an insulating material” and second layer 510 “extend[s] over the peripheral area NDA while covering the bending area BA.” Ex-1007, 11:40–41, 15:43–59. Lee'538 further teaches stress reduction layer 800 (purple), which is “disposed on the second layer 520 of the optical functional layer OU,” “arranged to correspond to the bending area BA,” and includes “an organic insulating material.” Ex-1007, 19:18–22.

surface portion (420) of the cover glass (400)” and “comprises a first adhesive layer (120) [teal], a polarizing layer (130) [yellow],” and a second adhesive layer (140).” Ex-1009 ¶108. Lee’703 further teaches that organic light-emitting display panel (500) includes coating layer (560) (purple), which may be disposed on a portion of the upper surface of the polarizing layer (130).” Ex-1009 ¶¶110, 117. Lee’703 also teaches that coating layer (560) “is composed of an insulating material” and “intended to prevent moisture penetration and wiring cracks, and may be disposed so as to cover at least the bent region.” Ex-1009 ¶116.

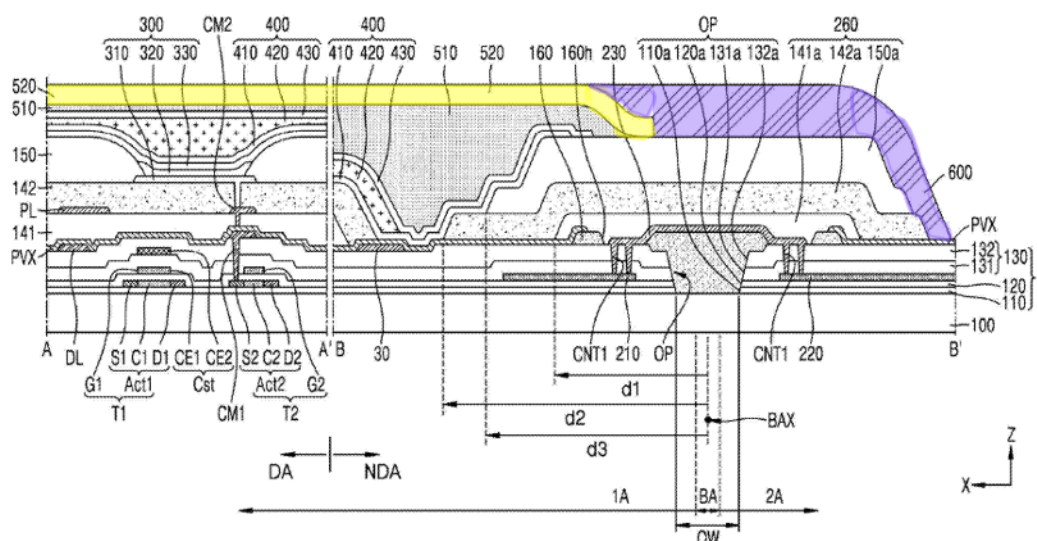


E. Park (Ex-1010)

76. Park (U.S. Patent Publication No. 2019/0096975) was January 12, 2018 and published March 28, 2019. I understand that Park is prior art to the '031 Patent under 35 U.S.C. §102(a)(1).

77. Park teaches a display apparatus comprising display area DA including pixels P, which “may emit, for example, a red light, a green light, a blue light or a white light through the OLED” and “may each be a sub-pixel that emit light of one of a red color, a green color, and a blue color as described above, or a sub-pixel that emit light of any one of a red color, a green color, a blue color, and a white color.” Ex-1010 ¶¶57–58. As shown in annotated Figure 3 below, Park also teaches a color filter 520 (yellow), which clarifies emission color and reduces “the reflection of external light due to the inclusion of a matrix of a color corresponding to the color of each pixel and a black matrix.” Ex-1010 ¶¶92–93, Fig. 3. Park further teaches a bending protection layer 600 (purple), which is disposed on the surface of the color filter 520. Ex-1010 ¶130.

FIG. 3



VII. DETAILED EXPLANATION OF THE UNPATENTABILITY GROUNDS

A. Ground 1: Claims 1–3, 5, 7, 9–15, and 17–19 Are Obvious over Shin

1. Independent Claim 1

a. 1[pre]: A display device, comprising:

78. In my opinion, Shin teaches² the preamble, to the extent it is limiting.

79. Shin teaches a “foldable *display device* and an electronic device including the same.” Ex-1005 ¶2. Figures 1A and 1B below depict “perspective views” of an embodiment of Shin’s display device. Ex-1005, Figs. 1A, 1B.

² I use the term “teaches” to include both express teachings and those that, in my opinion, are fairly suggested to a person of ordinary skill in the art. I have been informed by counsel that this approach is consistent with the test for obviousness under patent law.

FIG. 1A

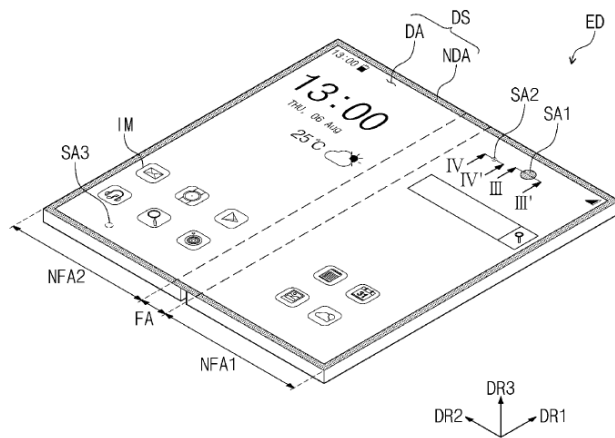
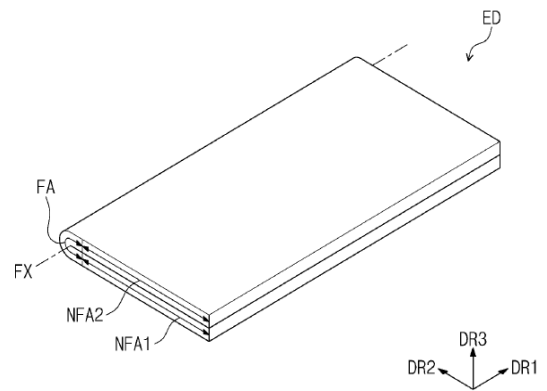


FIG. 1B

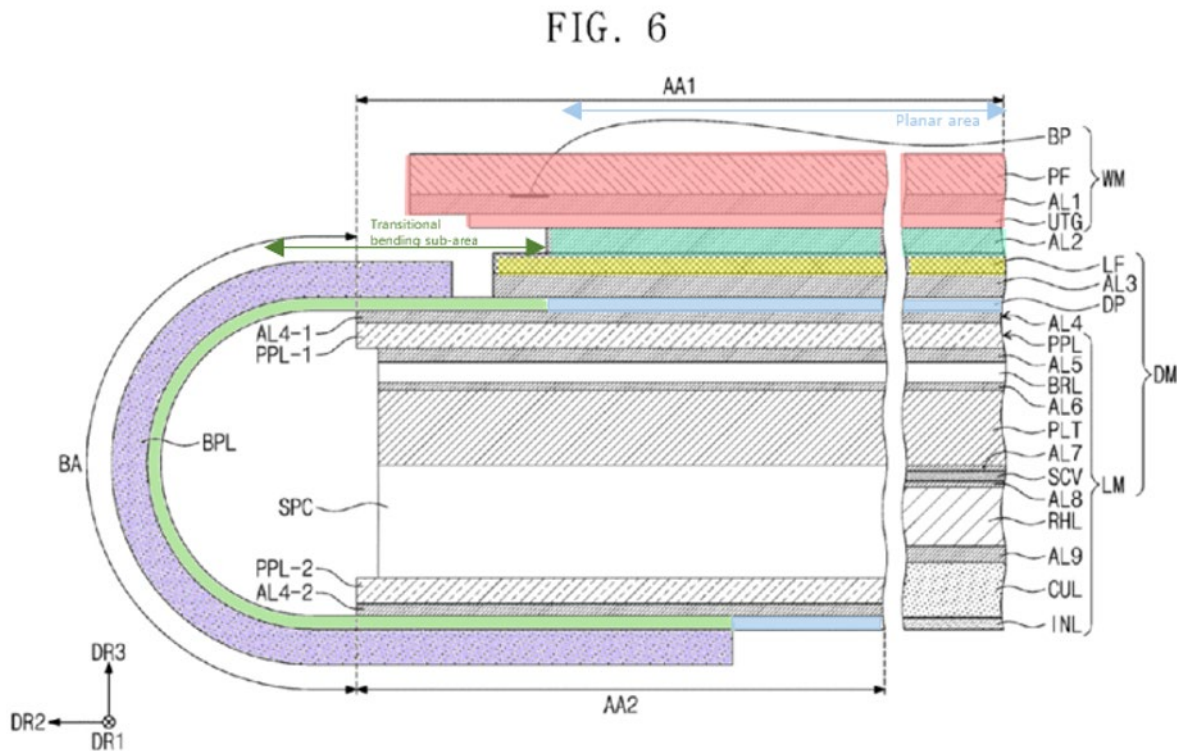


b. 1[a]: a flexible screen body comprising a planar area and a bending area connected to the planar area;

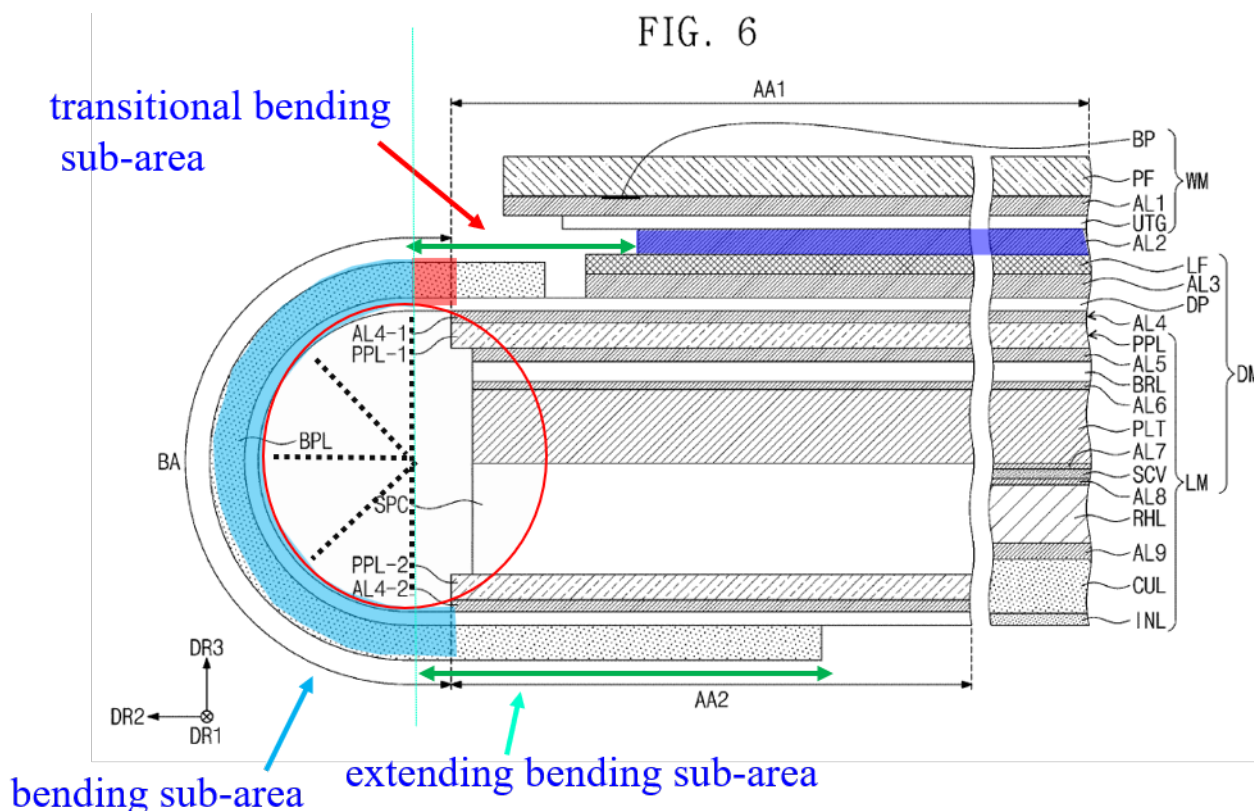
80. In my opinion, Shin teaches Element 1[a].

81. Shin's display device includes a flexible screen body comprising a planar area and a bending area connected to the planar area. Shin teaches that "electronic device ED which is flat may include a display surface DS *in a plane which is parallel to a plane* defined by a first direction DR1 and a second direction DR2 which crosses the first direction DR1." Ex-1005 ¶53. Shin also teaches that the ED "may include a display device DD," which "generates an image IM and/or senses an external input" and includes a display module DM having a display panel DP. Ex-1005 ¶68. As shown in annotated Figure 6 below, similar to the challenged patent, Shin's display panel DP includes "a display area DP-DA [blue] and a non-display area DP-NDA which is adjacent to the display area DP-DA." Ex-1005 ¶¶53–

54, 69 (display area DP-DA and non-display area DP-NDA correspond to display area DA of Fig. 1A (*see* 1[pre])), 90, Fig. 6. Shin further teaches that the display area “*may be a planar area at which the image IM is displayed,*” and the non-display area “may be a planar area at which the image IM is not displayed.” Ex-1005 ¶54. The non-display area “surround[s] the display area ... in a plan view.” Ex-1005 ¶54. Shin explains that the display area and the non-display area “together may define a front surface of the electronic device ED,” which “may have a total planar area including planar areas of both the” display area and the non-display area, “without being limited thereto.” Ex-1005 ¶54. Shin also teaches that “[t]he display panel DP may be bendable at the bending area BA along the bending axis.” Ex-1005 ¶93, 99 (Fig. 6 illustrates “a cross-sectional view of an embodiment of the display device DD which is ben[t] or folded at the bending area BA.”).



82. Moreover, as shown in the annotated Figure 6 below, there is a bend radius (red circle) and the transitional bending sub-area (green arrow) on the top of the display panel goes left from the AL2 layer (dark blue) to the transition to the bending area (red square to blue bending semicircle). Additionally, the extending bending sub-area (green arrow) on the bottom of the display panel extends to the left to the transition to the bending area (blue bending semicircle).



83. Shin teaches that “*display panel DP* further *includes a first panel area AA1*, a second panel area AA2 and a *bending area BA* [green] *which are planar areas* distinguished from each other along the second direction DR2.” Ex-1005 ¶91, Fig. 6. Moreover, Shin teaches that “*first panel area AA1 corresponds to the display surface DS in FIG. 1A*” and “[e]ach of the *bending area BA* and the second panel area AA2 *may be a partial area of the non-display area DP-NDA*” on the DS. Ex-1005 ¶¶91–92. Shin’s bezel pattern BP (red), which “may be disposed on a top surface of the plastic film PF” of the device and “*overlaps the non-display area NDA.*” Ex-1005 ¶103.

84. Shin's display panel DP corresponds to the recited "flexible screen body" because it is "foldable." Ex-1005 ¶¶3, 5; *see also* Ex-1001, 4:33–34 ("flexible screen body 10 means a highly flexible screen that can be bent and folded"). The portion of first panel AA1 designated by the blue arrow in Figure 6 (extending from the right to bezel portion BP) above corresponds to the recited "planar area" of display panel DP because this is the portion of the display that is both planar and which displays the image, as explained by the challenged patent. Ex-1005 ¶¶92, 103; *see also id.* ¶91 ("first panel area AA1" is a "planar area[]"); Ex-1001, 4:36–38 ("the planar area AA means an area for displaying, and the bending area means an area that cannot display"). Thus, the "planar area" in the cross-sectional view of Figure 6 extends from the right of Figure 6 to bezel pattern BP, but not further left to the remaining length of first panel area AA1, which is the non-display area (NDA). The planar region refers to the main flat and central active area of the display panel. This is the area that forms the primary front surface of the device that is used to display visual content across the flat front face of the housing. From a positioning standpoint in the housing, the planar region is parallel to the main flat front cover layer without curvature or structural bending. It also is a transition at its boundaries into at least one curved regions. Bending area BA in Figure 6 corresponds to the recited "bending area connected to the planar area" on the non-display side of BP because, for example, Shin teaches that "bending protection layer BPL may be disposed on one

portion of the first panel area AA1 and one portion of the second panel area AA2 in addition to the bending area BA,” meaning that they are all connected. Ex-1005 ¶148. Indeed, as shown in annotated Figure 6 above, the transitional bending sub-area designated by the green arrow (extending from the left-most edge of AA1 to BP, as described in more detail below in Section VII.A.2.b) is connected to the “planar area” of AA1 designated by the blue arrow underneath BP and extending to the right edge), at the point where there is a transition from Shin’s display area to the non-display area. Ex-1005, Fig. 6.

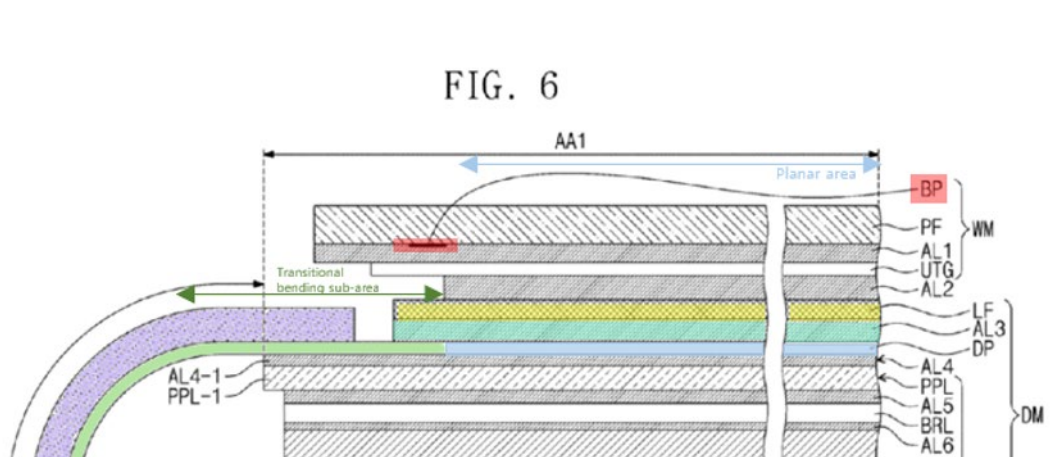
85. Moreover, as I explained in the Technology Background section (*see* Section IV.A.), display devices having a flexible screen body comprising a planar area and a bending area connected to the planar area were well known by 2021.

c. 1[b]: a color filter disposed on the flexible screen body and at least covering the planar area;

86. In my opinion, Shin teaches Element 1[b].

87. Shin teaches a color filter disposed on the flexible screen body (i.e., DP) and at least covering the planar area (i.e., the section of AA1 described in 1[a], extending from underneath BP to the right in Figure 6). Specifically, Shin teaches that “optical film LF [yellow] is disposed in the first panel area AA1” and “covers at least the display area DP-DA [blue].” Ex-1005 ¶115. As shown in annotated Figure 6 below, optical film LF at least covers this “planar area” of Shin’s first panel

AA1, designated by the blue arrow. Ex-1005 ¶¶91–92, 103, Fig. 6. Shin further teaches that “the third adhesive layer AL3 [teal] couples the optical film LF to the display panel DP,” i.e., the flexible screen body. Ex-1005 ¶115. Moreover, Shin’s “optical film LF may include color filters in a color filter layer.” Ex-1005 ¶86. Optical film LF thus corresponds to the recited “color filter disposed on the flexible screen body and at least covering the planar area” because it covers the entire planar area (DP-DA) and then some.

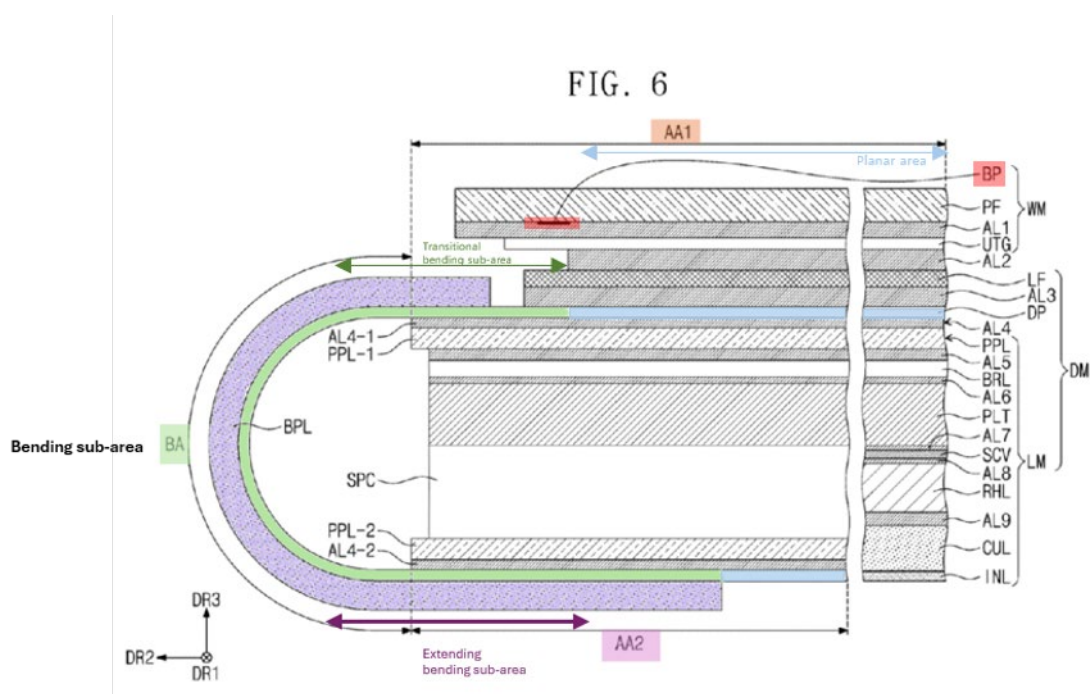


88. Moreover, as I explained in the Technology Background section (*see* Section IV.B.), display devices having a color filter disposed on the flexible screen body and at least covering the planar area were well known by 2021.

- d. **1[c]: a protective layer disposed on the flexible screen body and at least covering a part of the bending area; and**

89. In my opinion, Shin teaches Element 1[c].

90. Shin teaches a protective layer disposed on the flexible screen body (i.e., DP) and at least covering a part of the bending area (i.e., BA). As shown in annotated Figure 6 below, Shin's bending protection layer BPL (purple) is disposed on the flexible screen body (i.e., DP) and covers at least the bending area BA (green). Ex-1005 ¶148, Fig. 6.



91. Shin further teaches that “bending protection layer BPL may overlap the bending area BA, the first panel area AA1 and the second panel area AA2.” Ex-1005 ¶148. Specifically, “bending protection layer BPL may be disposed on one portion of the first panel area AA1 and one portion of the second panel area AA2 in addition to the bending area BA.” Ex-1005 ¶148. The BPL “protects the bending area BA from an external impact,” “controls a neutral plane of the bending area BA,”

and “controls a stress of the bending area BA so that the neutral plane becomes closer to signal lines disposed in the bending area BA.” Ex-1005 ¶149. Shin’s BPL is thus “a protective layer disposed on the flexible screen body and at least covering a part of the bending area” because it covers the bending sub area BA identified in annotated figure 6 above, as well as the transitional bending areas that extend into Shin’s AA1 and AA2.

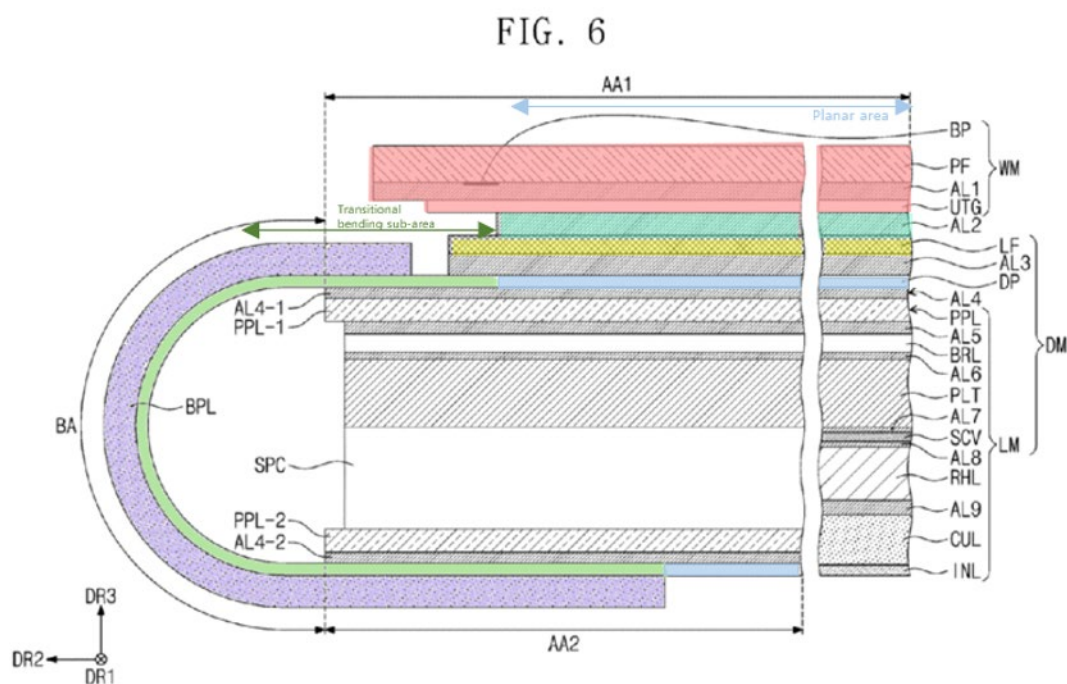
92. Moreover, as I explained in the Technology Background section (*see* Section IV.C.), display devices having a protective layer disposed on the flexible screen body and at least covering a part of the bending area were well known by 2021.

e. 1[d]: a coverplate disposed on the color filter and at least covering the planar area;

93. In my opinion, Shin teaches Element 1[d].

94. Shin teaches a coverplate disposed on the color filter (i.e., LF) and at least covering the planar area, blue (i.e., the section of AA1 described in 1[a], extending from underneath BP to the right in Figure 6). Specifically, Shin teaches “a window module WM (e.g., window),” which “provides or defines the front surface of the electronic device ED.” Ex-1005 ¶67. As shown in annotated Figure 6 below, Shin teaches that “window module WM [red] may include a thin-film glass substrate UTG, a plastic film PF disposed on the thin-film glass substrate UTG, a

first adhesive layer AL1 coupling the thin-film glass substrate UTG and the plastic film PF and a bezel pattern BP.” Ex-1005 ¶102, Fig. 6. Shin further teaches that “second adhesive layer AL2 [teal] couples the optical film LF” (i.e., color filter (yellow)) “to the window module WM” the same way that the recited coverplate is connected to the color filter in the challenged patent. Ex-1005 ¶115; *see also* Ex-1001, 2:55–58 (“the coverplate is connected to the color filter by an optical adhesive”). Shin’s window module WM is disposed on optical filter LF via optical adhesive AL2 and it at least covers the “planar area” of AA1 designated by the blue arrow. Ex-1005, Fig. 6. Shin’s WM thus corresponds to the recited coverplate because it covers the entire planar area (DP-DA) and then some.



95. Moreover, as I explained in the Technology Background section (*see* Section IV.D.), display devices having a coverplate disposed on the cover filter and at least covering the planar area were well known by 2021.

- f. **1[e]: wherein in an overlapping area of the protective layer and the coverplate, a distance between the protective layer and the coverplate is greater than or equal to a default value, wherein the default value is greater than 0.**

96. In my opinion, Shin teaches Element 1[e].

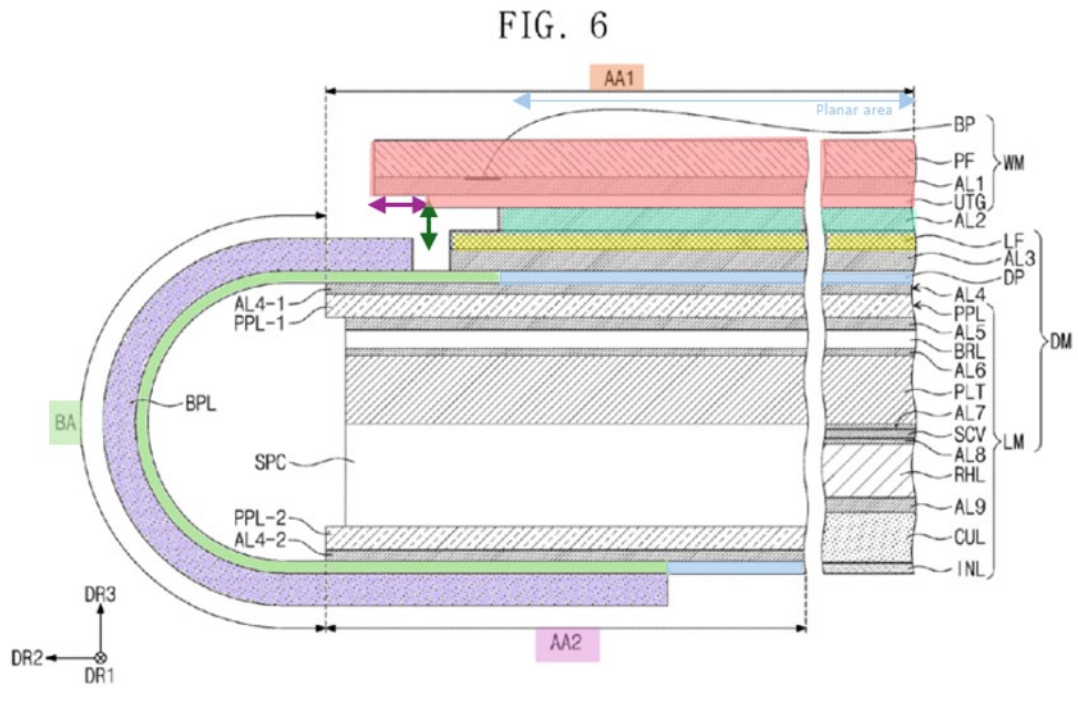
97. Shin teaches that in an overlapping area of the protective layer (i.e., BPL) and the coverplate (i.e., WM), a distance between the protective layer and the coverplate is greater than or equal to a default value,³ wherein the default value is greater than 0.⁴ As shown in annotated Figure 6 below, the distance (designated by

³ The '031 Patent does not define the term “default value” but states that “[i]n an overlapping area of the protective layer 30 and the coverplate of the display device provided by the embodiment of the present disclosure, a distance between the protective layer 30 and the coverplate 40 is greater than or equal to a default value ... greater than 0 and may be flexibly adjusted according to actual needs, and is not specifically limited in the embodiment. Therefore, the *coverplate 40 will not squeeze the protective layer 30, thereby preventing a risk of cracking the display device.*” Ex-1001, 7:1–10. Thus, while it is not clear what the criteria for the “default value” is, a POSITA would have understood that the recited distance greater than 0 between the coverplate and the protective layer must be, at least, large enough to prevent cracking or other damage to the device.

⁴ The recited “default value” appears to be an unbounded range greater than 0. The prior art teaches such a default value in a reasonable range, as explained herein. Regardless, I reserve the right to argue in another proceeding such as the Samsung litigation that the criteria for the “default value” is unclear and/or an unbounded range as recited by the challenged patent is legally improper under section 112.

the green arrow) between bending protection layer BPL (purple) and window module WM (red) in an overlapping area of the two components (designated by the purple arrow) “is greater than or equal to a default value, wherein the default value is greater than 0” as depicted by the physical gap shown in the figure between BPL and WM. Ex-1005, Fig. 6. Specifically, Shin teaches that “second adhesive layer AL2 [teal] couples the optical film LF” (yellow) “to the window module WM.” Ex-1005 ¶115. Shin further teaches that AL2 “may include a pressure sensitive adhesive or a transparent adhesive such as the optically clear adhesive” and “*have a thickness of about 35 μm to about 65 μm , e.g., about 50 μm .*” Ex-1005 ¶111. Shin thus teaches that a “default value” for the distance in an overlapping area of the BPL and WM components, which encompasses at least the entire thickness of AL2 (as shown in Figure 6) is “*about 50 μm ,*” which is greater than 0. *Id.* Additionally, similar to the ’031 Patent, Shin teaches that this distance may be adjusted as needed to encompass “*a thickness of about 35 μm to about 65 μm .*” Ex-1005 ¶111; *see also id.* ¶113 (explaining how the varied areas of AL1 and AL2 may prevent “a buckling phenomenon or a crack” in the UTG and decrease “a probability of foreign substances attached to” AL2). *See, e.g.,* Ex-1001, 7:1–10 (the default value “may be flexibly adjusted according to actual needs”). In all cases, the distance is greater than zero, whether it is Shin’s default value of about 50 μm , or anywhere within the

allowable range of about 35 μm to about 65 μm , which prevents failure of Shin's various layers.



98. A bending area is an area that can cause damage and Shin teaches that cracking and delaminating are issues that need to be addressed. Shin teaches the effect of intense mechanical stress, especially tensile stress on the outer bending layers in the form of stretching, as well as compressive stress on the inner bending layers in the form of squeezing and squishing. This is pertinent for the UTG and PF layers that are bound by OCA for the folding movement. Shin also teaches that if the adjacent organic layers such as protective coatings, encapsulation and cushion layers, adhesive layers etc. are over compressed or improperly dimensioned, the resulting stress distribution in the layers is uneven and could lead to micro-cracking.

Examples would be delamination between the glass and protective film or cracking of the UTG, or even deformation, creasing or other non-linear effects of the organic layers. Shin teaches that controlling the layer thickness, stiffness, and squeezing or compression of the organic layers is important for high quality operation of the display. Shin notes that the regions around the UTG are especially important during the bending process. For example, regulating the thickness ratios of the PF, adhesives and UTG is important. Shin also teaches that avoiding compression over-squeeze and regulation of viscosity and flow characteristics will help mitigate layer delamination. For example if layers are too thick and become over compressed during the lamination process then their performance will deteriorate. This also is important for the viscosity specifications of organic layers especially those close or adjacent to the UTG and PF interface.

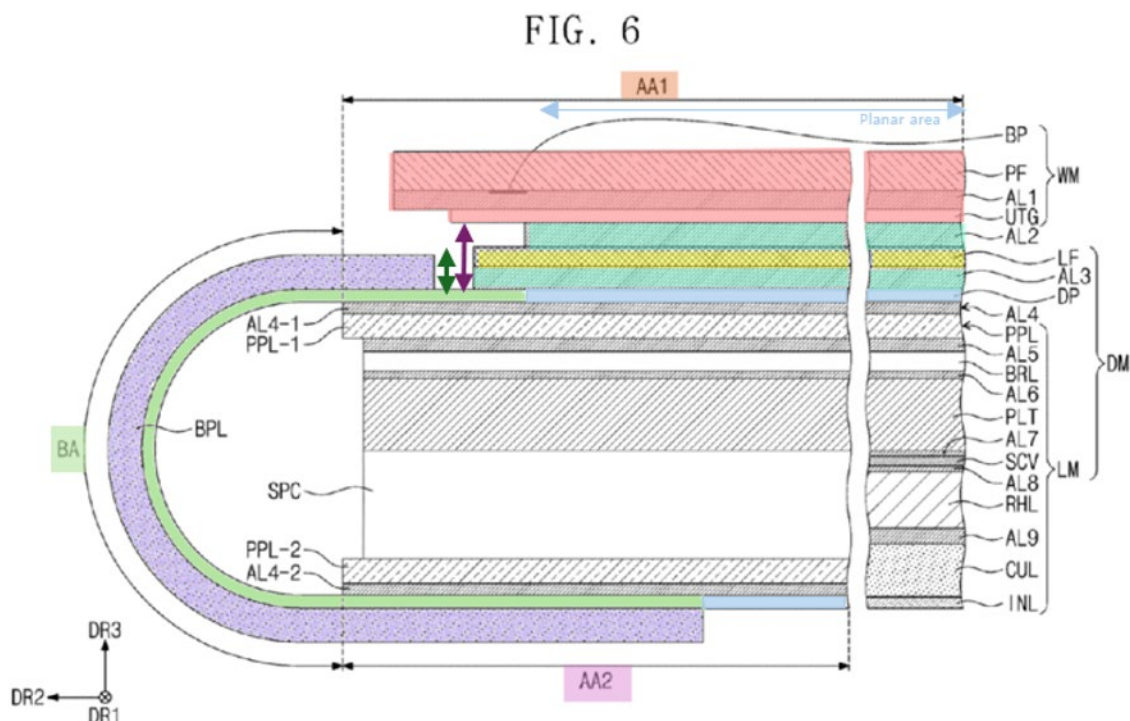
99. Moreover, as I explained in the Technology Background section (*see* Section IV.E.), display devices wherein an overlapping area of the protective layer and coverplate, a distance between the protective layer and coverplate is greater than or equal to a default value that is greater than 0 were well known by 2021.

2. Dependent Claims 2, 5, 7, 9–15, and 17–19

- a. Claim 2: The display device according to claim 1, wherein the protective layer is disposed on a surface of the flexible screen body, and a thickness of the protective layer on the surface of the flexible screen body is less than or equal to a distance between one side of the coverplate adjacent to the flexible screen body and one side of the flexible screen body adjacent to the coverplate.**

100. In my opinion, Shin teaches Claim 2.

101. Shin teaches that the protective layer (i.e., BPL) is disposed on a surface of the flexible screen body (i.e., DP), and a thickness of the protective layer on the surface of the flexible screen body is less than or equal to a distance between one side of the coverplate (i.e., WM) adjacent to the flexible screen body and one side of the flexible screen body adjacent to the coverplate. As shown in annotated Figure 6 below, the BPL (i.e., purple) is disposed on a surface of the bending portions of DP (green) and, as indicated by the green and purple arrows, the thickness of the BPL is less than the distance between the WM (red) and the DP. Ex-1005, Fig. 6.



102. While there is no scale shown in Figure 6, the BPL is depicted as having a thickness that is less than the combined thickness of the optical film LF, the second adhesive layer AL2, and the third adhesive layer AL3, which together separate the DP from the WM. *See, e.g., Ex-1005 ¶111* (“second adhesive layer AL2 may have a thickness of about 35 μm to about 65 μm , e.g., about 50 μm ”). Moreover, as shown in Figure 6, there is a physical gap between the top of BPL (purple) and the bottom of WM (red).

103. Additionally, the '031 Patent teaches that “a skilled person in the art can set a suitable thickness for the protective layer 30 according to a size and type of the flexible screen body 10, a bending radius of the bending sub-area B2,

flexibility and an ability to relieve stresses of the protective layer 30, and is not specifically limited in the embodiment.” Ex-1001, 8:3–10. Like the ’031 Patent, Shin teaches that “display device DD which is bent has a curvature and a radius of curvature at the bending area BA,” the BPL “may overlap” with and is “bendable together with the bending area BA,” and the BPL “protects the bending area BA from an external impact,” “controls a neutral plane of the bending area BA,” and “controls a stress of the bending area BA so that the neutral plane becomes closer to signal lines disposed in the bending area BA.” Ex-1005 ¶¶147–149. A POSITA would thus have understood that Shin’s BPL would be set at a suitable thickness according to a size and type of the DP, a bending radius of the bending area BA, flexibility and an ability to relieve stresses of the BPL, which would be less than the distance between the WM and the DP because this is consistent with the teachings of both Shin and the ’031 Patent. Specifically, the gap shown in Figure 6 ensures that there is adequate physical separation between BPL and WM to prevent damage to them along the bend area of the display.

104. A bending area is an area that can cause damage and Shin teaches that cracking and delaminating are issues that need to be addressed. Shin teaches the effect of intense mechanical stress, especially tensile stress on the outer bending layers in the form of stretching, as well as compressive stress on the inner bending layers in the form of squeezing and squishing. This is pertinent for the UTG and PF

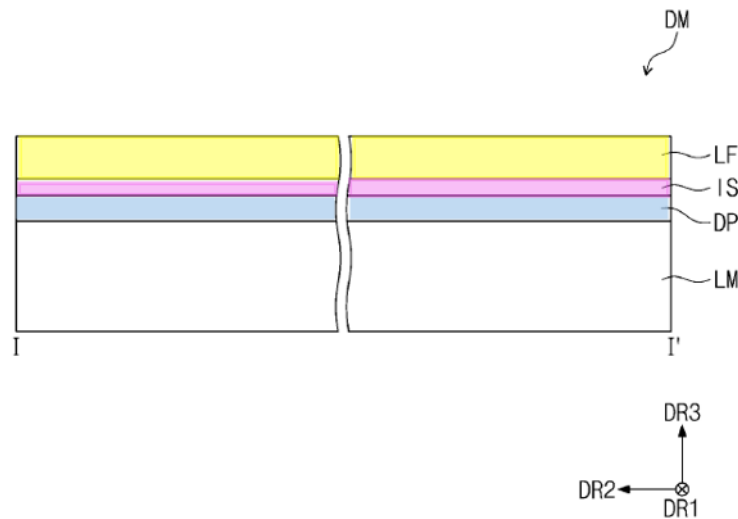
layers that are bound by OCA for the folding movement. Shin also teaches that if the adjacent organic layers such as protective coatings, encapsulation and cushion layers, adhesive layers etc are over compressed or improperly dimensioned, the resulting stress distribution in the layers is uneven and could lead to micro-cracking. Examples would be delamination between the glass and protective film or cracking of the UTG, or even deformation, creasing or other non-linear effects of the organic layers. Shin teaches that controlling the layer thickness, stiffness, and squeezing or compression of the organic layers is important for high quality operation of the display. Shin notes that the regions around the UTG are especially important during the bending process. For example, regulating the thickness ratios of the PF, adhesives and UTG is important. Shin also teaches that avoiding compression over-squeeze and regulation of viscosity and flow characteristics will help mitigate layer delamination. For example if layers are too thick and become over compressed during the lamination process then their performance will deteriorate. This also is important for the viscosity specifications of organic layers especially those close or adjacent to the UTG and PF interface.

- b. **Claim 3: The display device according to claim 1, further comprising a touch control layer disposed between the flexible screen body and the color filter and an insulating layer disposed between the touch control layer and the color filter; wherein the protective layer is disposed on a surface of the insulating layer, and a thickness of the protective layer on the surface of the insulating layer is less than or equal to a distance between one side of the coverplate adjacent to the insulating layer and one side of the insulating layer adjacent to the coverplate**

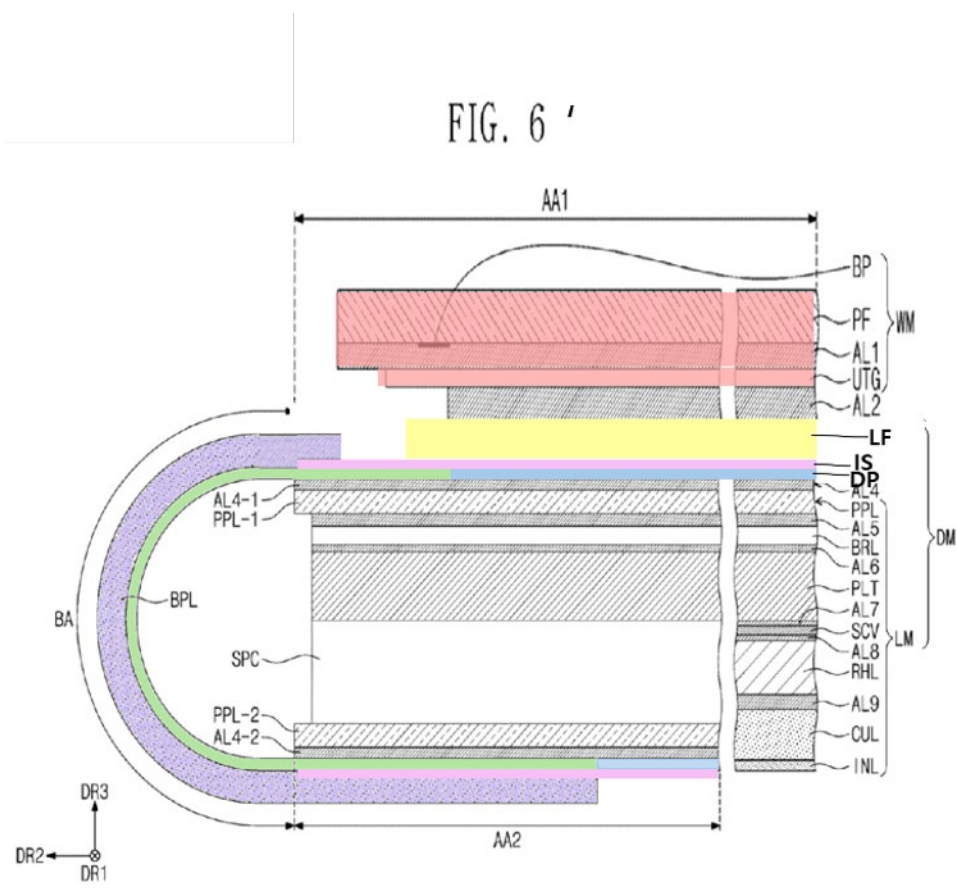
105. Shin teaches Claim 3.

106. As shown in annotated Figure 3 below, Shin teaches a touch control layer (i.e., input sensor IS (pink)) disposed between the flexible screen body (i.e., DP (blue)) and the color filter (i.e., optical film LF (yellow)). Ex-1005, Fig. 3. Specifically, Shin teaches that display module DM includes “display panel DP, an input sensor IS (e.g., input-sensing layer) disposed on the display panel DP,” and “an optical film LF disposed on the input sensor IS.” Ex-1005 ¶75. Shin further teaches that “input sensor IS may include a plurality of sensing electrodes (not shown) *for sensing an external input*” and “conductive trace lines (not shown) connected to the plurality of sensing electrodes.” Ex-1005 ¶80.

FIG. 3

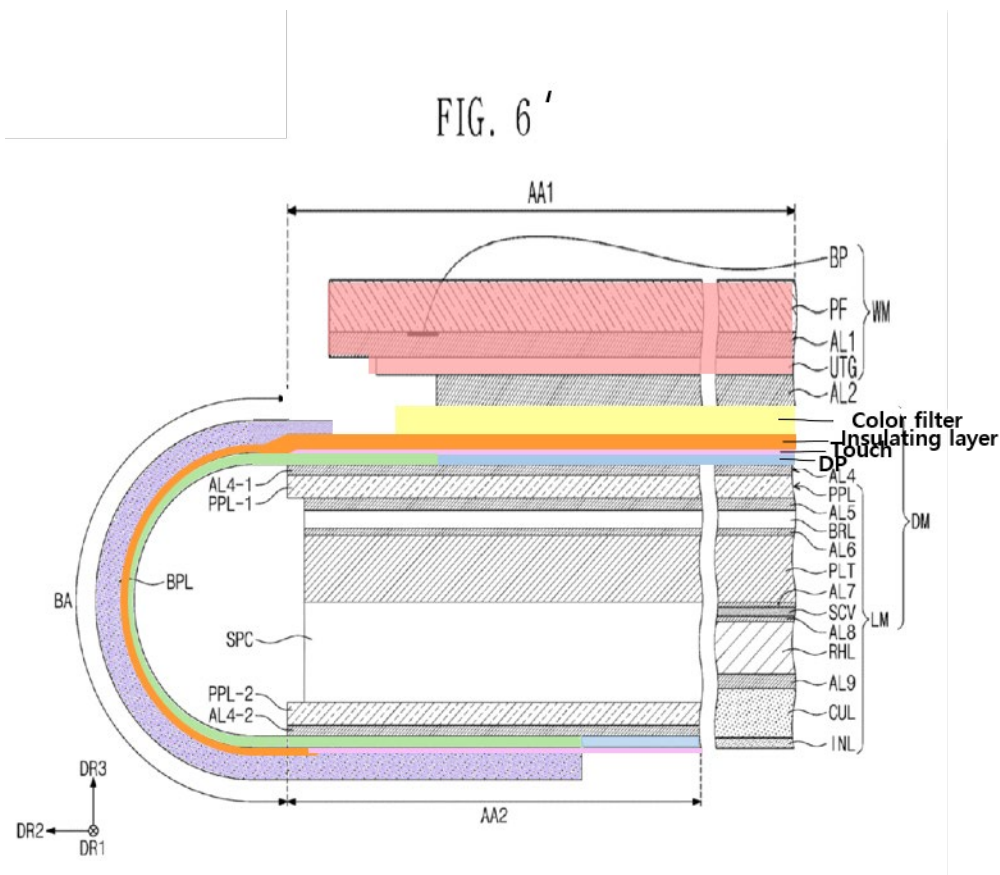


107. Shin's Figure 6 does not depict input sensor IS but Shin teaches that "input sensor IS may be directly provided or formed on the thin-film encapsulation layer of the display panel DP such as through a continuous process when the display panel DP is provided or manufactured." Ex-1005 ¶81. In that case, "input sensor IS integrated with display panel DP through the continuous process may be defined as an electronic panel." Ex-1005 ¶81. In the modified, annotated version of Shin's Figure 6 below, Shin's optical film LF (yellow) is disposed on input sensor IS (pink), as taught by Shin for Figure 3. Ex-1005, Fig. 6' (Shin).



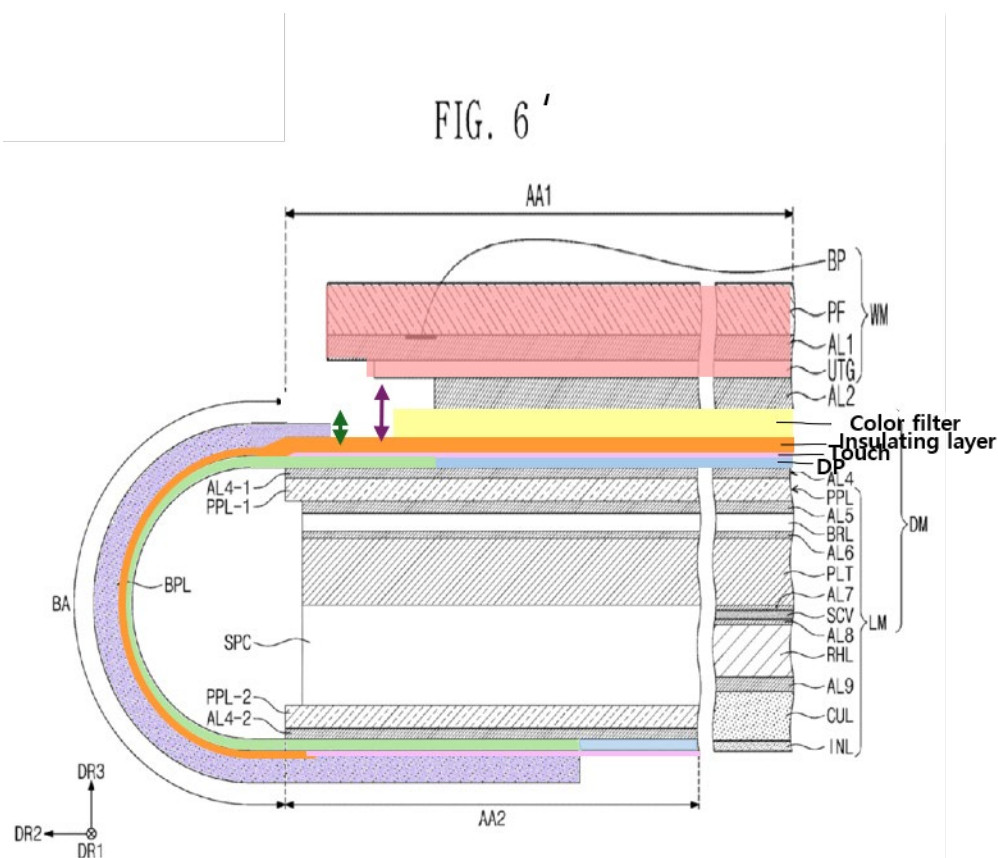
108. Shin also teaches an insulating layer disposed between the touch control layer and the color filter. Specifically, Shin teaches that “input sensor IS may include ... *an inorganic layer and/or an organic layer for insulating/protecting the plurality of sensing electrodes or the trace lines.*” Ex-1005 ¶80. While Shin does not depict the insulating layer in Figures 3 and 6, a POSITA would have been motivated to place it between the input sensor IS layer and the optical film LF layer because, for example, as shown in modified, annotated versions of Shin’s Figure 6 below, the optical film LF layer (yellow) separates the DP (blue) from the coverplate (i.e., WM (red)) where external input to the device is received and, therefore, the

insulating layer (orange) should be provided on the LF-facing-side of the input sensor IS (pink). Ex-1005, Fig. 6' (Shin). A POSITA would thus have implemented Shin's Figure 6 embodiment with the BPL disposed on a surface of the insulating layer (orange) of the input sensor IS (pink), which is, in turn, attached to the DP, as shown in Figure 6' below.



109. Shin teaches that the protective layer (i.e., BPL) is disposed on a surface of the insulating layer for the same reasons. Moreover, as shown in modified, annotated versions of Shin's Figure 6 below and explained for Claim 2, the thickness of the BPL (designated by the green arrow) on the surface of the insulating layer

(orange) is less than the distance between one side of the coverplate (i.e., WM (red)) adjacent to the insulating layer and one side of the insulating layer adjacent to the coverplate (designated by the purple arrow). Ex-1005 ¶¶111, 147–149, Fig. 6' (Shin); *see also* Ex-1001, 8:3–10.



c. Claim 5

- (1) **5[pre]: The display device according to claim 1, wherein the bending area comprises a transitional bending sub-area, a bending sub-area, and an extending bending sub-area defined in sequence, and the transitional bending sub-area is connected to and flush with the planar area;**

110. In my opinion, Shin teaches Element 5

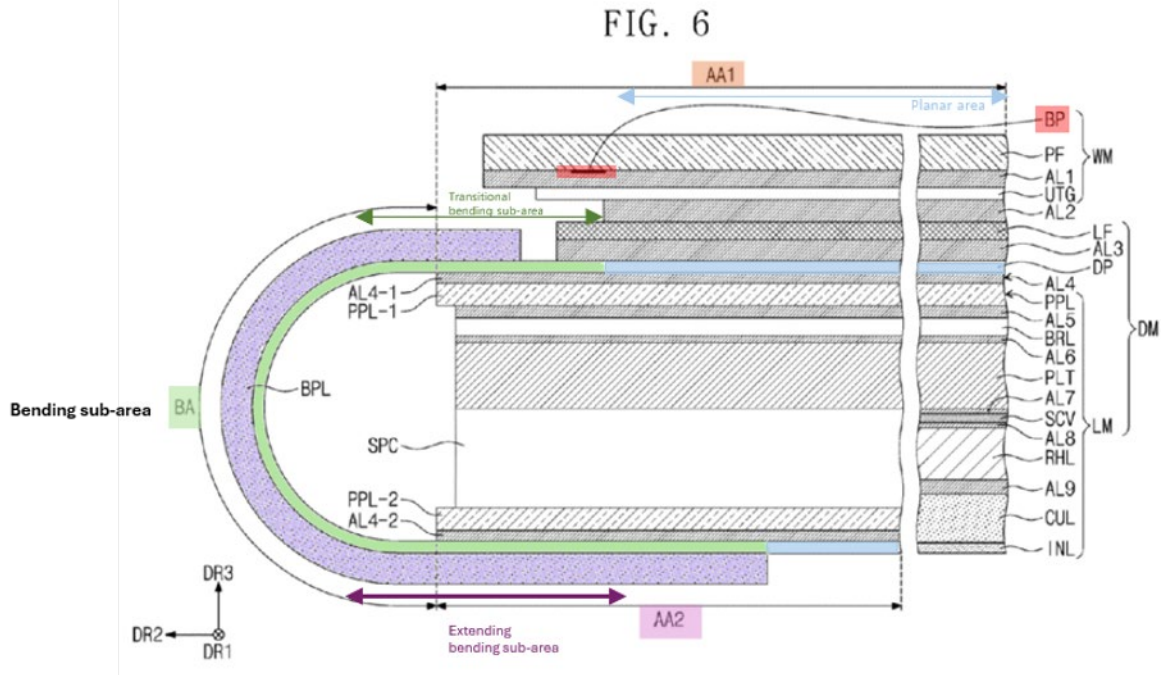
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[pre]
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111. Shin teaches that the bending area comprises a transitional bending sub-area, a bending sub-area, and an extending bending sub-area defined in sequence, and the transitional bending sub-area is connected to and flush with the planar area. Specifically, Shin teaches that display panel DP “includes a *first panel area AA1*, a *second panel area AA2* and a *bending area BA* which *are planar areas* distinguished from each other *along the second direction DR2*.” Ex-1005 ¶91. Shin further teaches that “[a]long the first direction DR1, each of the bending area BA and the second panel area AA2 may have a dimension such as a length less than a length of the first panel area AA1,” “[a] bending axis may be defined along the first direction DR1,” and “[t]he display panel DP may be bendable at the bending area BA along the bending axis.” Ex-1005 ¶93. Shin also teaches that “display device DD which is bent at the bending area BA disposes the second panel area AA2 below the first panel area AA1” such that “the first panel area AA1 and the second panel area AA2 may be disposed in different planes or on different reference surfaces from each other” and “[t]he bending area BA may be bent convexly in a transverse direction on a cross-section.” Ex-1005 ¶147. Moreover, Shin teaches that “bending area BA may define an end portion of the display device DD which is bent” and “has a curvature and a radius of curvature at the bending area BA.” Ex-1005 ¶147.

112. As shown in annotated Figure 6 below, the area designated by the green arrow corresponds to the recited “transitional bending sub-area,” the curved area

designated by the black arrow corresponds to the recited “bending sub-area,” and the area designated by the purple arrow corresponds to the recited “extending bending sub-area.” Ex-1005, Fig. 6. The transitional bending sub-area, bending sub-area, and extending bending sub-area are “defined in sequence” because, as shown in Figure 6, they follow a path in sequence starting from bezel point BP (red) in the first panel area AA1 (orange) along the radius of curvature of bending area BA (green) and ending in a location in second panel area AA2 that mirrors bezel point BP. Ex-1005 ¶91 (“[D]isplay panel DP may include the first panel area AA1, the bending area BA and the second panel area AA2 *in order along the second direction DR2*.”). As also shown in Figure 6, the transitional bending sub-area designated by the green arrow is “connected to and flush with the planar area” of first panel area AA1 (extending from BP to the right, in Figure 6), designated by the blue arrow.

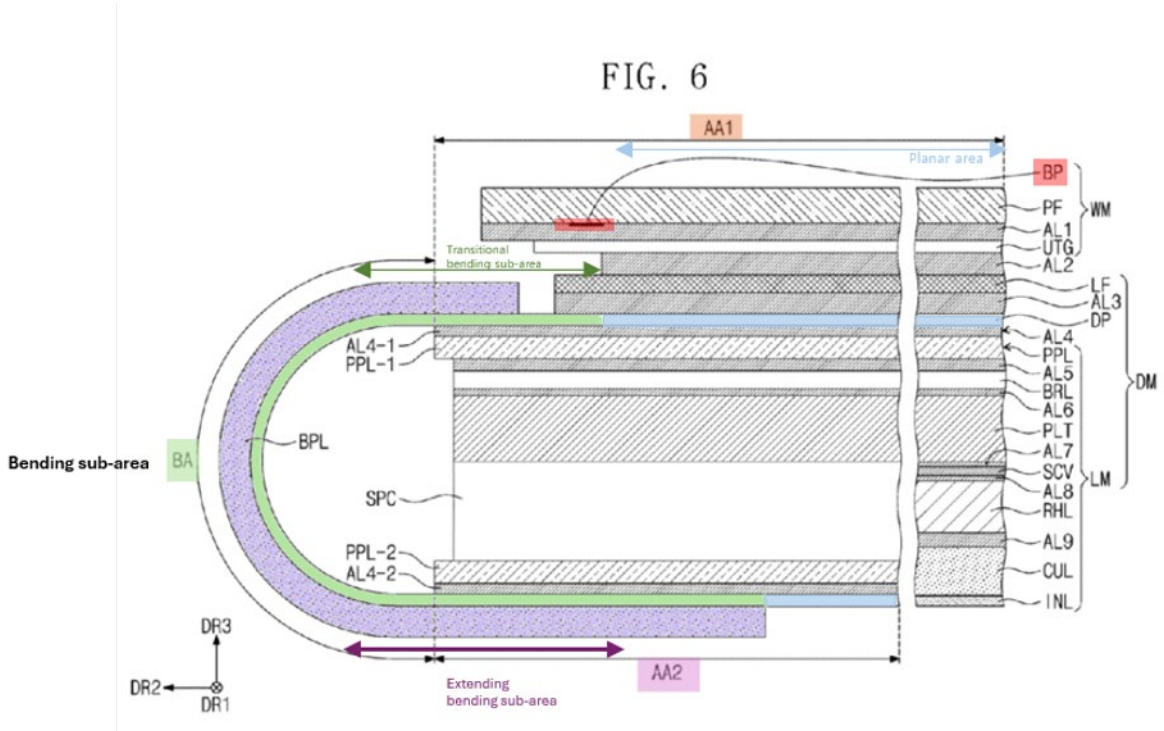


(2) **5[a]: the protective layer completely covers the bending sub-area and covers at least a part of the transitional bending sub-area; and**

113. In my opinion, Shin teaches Element 5[a].

114. As shown in annotated Figure 6 below, Shin teaches that the protective layer (i.e., BPL (purple)) completely covers the bending sub-area (designated by the black arrow) and covers at least a part of the transitional bending sub-area (designated by the green arrow). Ex-1005, Fig. 6. Specifically, Shin teaches that “bending protection layer BPL is disposed in at least the bending area BA,” “may be bendable together with the bending area BA,” and “may overlap the bending area BA, the first panel area AA1 and the second panel area AA2.” Ex-1005 ¶¶148–149. Shin also teaches that “bending protection layer BPL may be disposed on one portion

of the first panel area AA1 and one portion of the second panel area AA2 in addition to the bending area BA.” Ex-1005 ¶148.

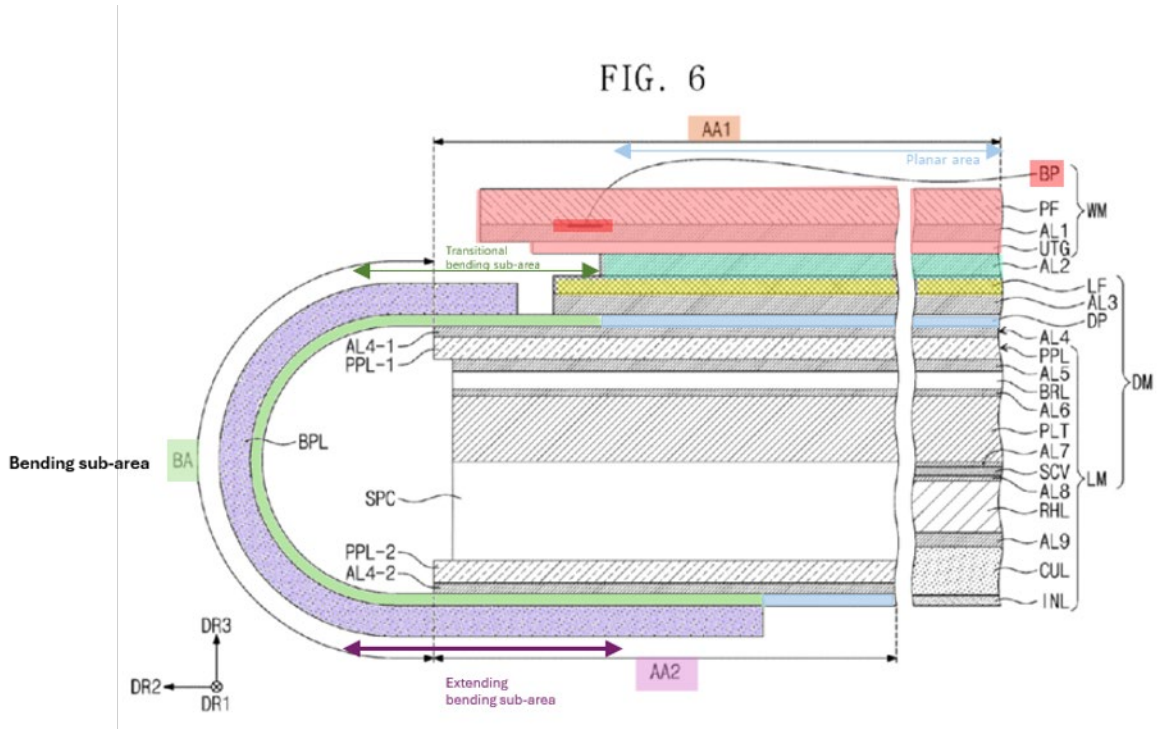


- (3) **5[b]: the coverplate is connected to the color filter by an optical adhesive, and the coverplate completely covers the planar area and covers at least the part of the transitional bending sub-area.**

115. In my opinion, Shin teaches Element 5[b].

116. Shin teaches that the coverplate (i.e., WM) is connected to the color filter (i.e., LF) by an optical adhesive. As shown in annotated Figure 6 below, Shin teaches that “second adhesive layer AL2 [teal] couples the optical film LF [yellow] to the window module WM [red].” Ex-1005 ¶115, Fig. 6. Shin further teaches that

AL2 is “a pressure sensitive adhesive or a transparent adhesive such as the *optically clear adhesive*.” Ex-1005 ¶111.

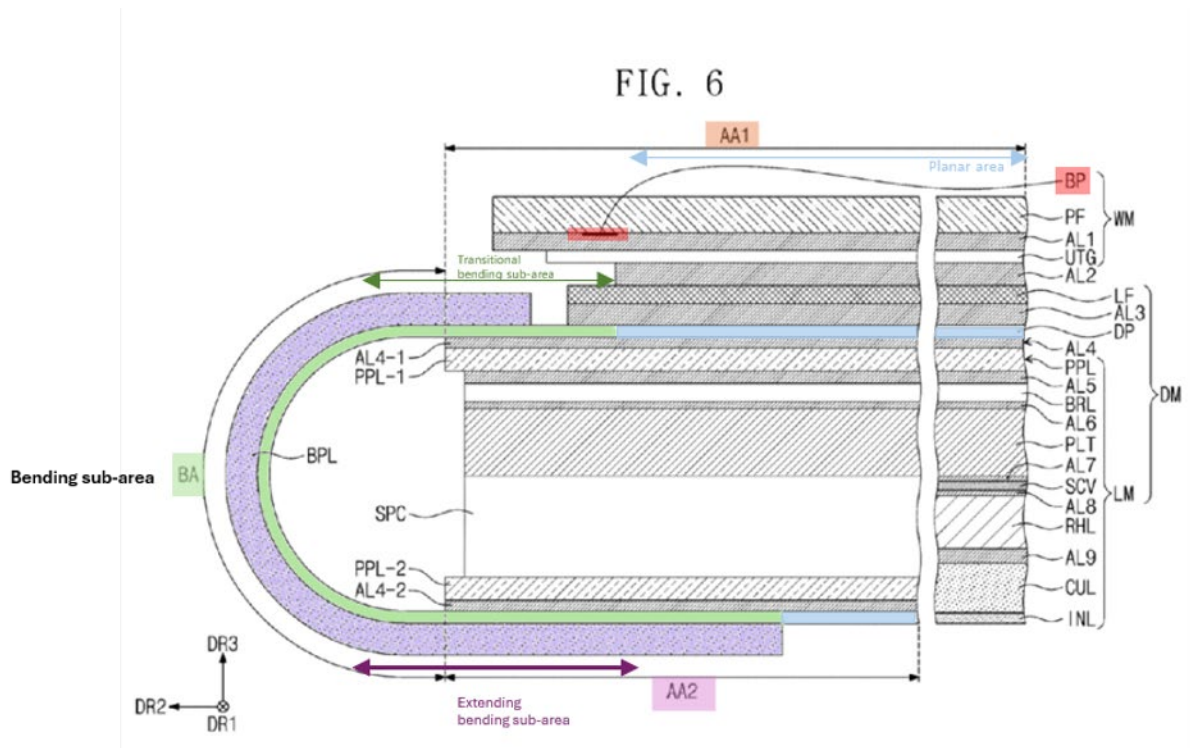


117. As also shown above, Shin’s coverplate (i.e., WM (red)) completely covers the planar area of first panel area AA1 (the area from BP, extending to the right, designated by the blue arrow) and covers at least the part of the transitional bending sub-area (the area from BP extending to the left, designated by the green arrow). Ex-1005, Fig. 6.

- d. **Claim 7: The display device according to claim 5, wherein the protective layer further covers at least a part of the extending bending sub-area.**

118. In my opinion, Shin teaches Claim 7.

119. Shin teaches that the protective layer (i.e., BPL) further covers at least a part of the extending bending sub-area for the reasons described in Section VII.A.2.b. Specifically, Shin teaches that bending protection layer BPL “may overlap the bending area BA, the first panel area AA1 and the second panel area AA2.” Ex-1005 ¶¶148–149. Shin also teaches that “bending protection layer BPL may be disposed on one portion of the first panel area AA1 and one portion of the second panel area AA2 in addition to the bending area BA.” Ex-1005 ¶148. As shown in annotated Figure 6 below, the protective layer (i.e., BPL (purple)) covers at least a part of the extending bending sub-area of second panel area AA2 (designated by the purple arrow). Ex-1005, Fig. 6.



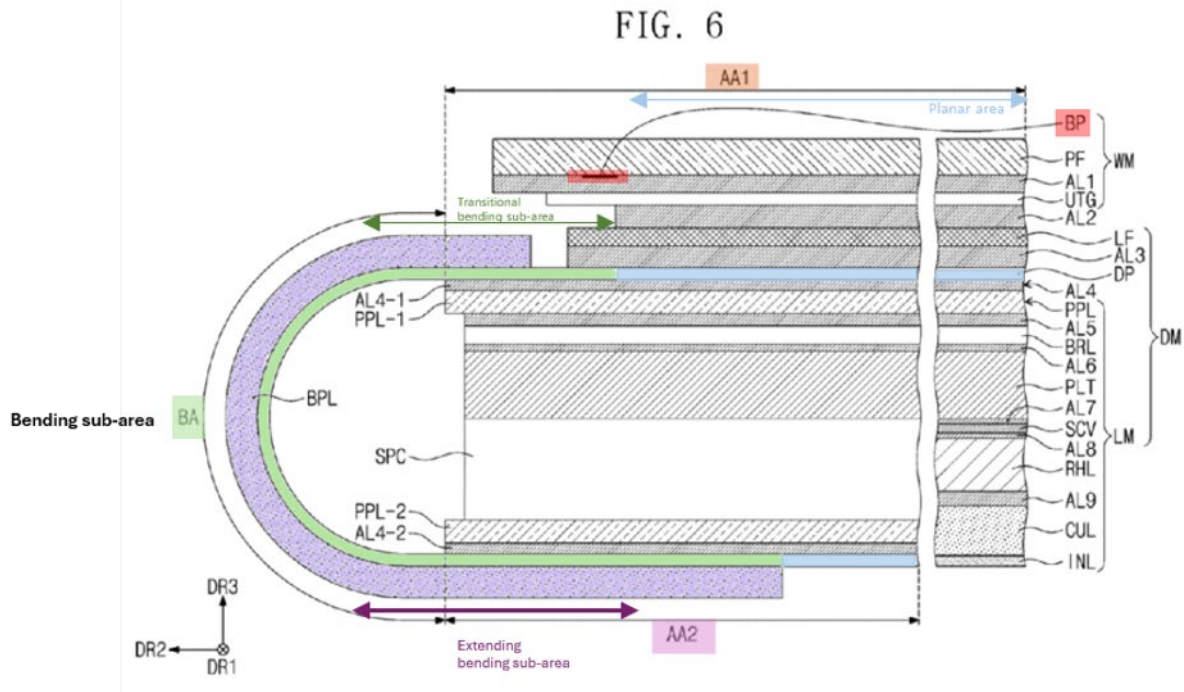
- e. **Claim 9: The display device according to claim 5, further comprising: a support layer, wherein one side of the support layer supports the planar area and the transitional bending sub-area, and another side of the support layer away from the planar area supports the extending bending sub-area.**

120. In my opinion, Shin teaches Claim 9.

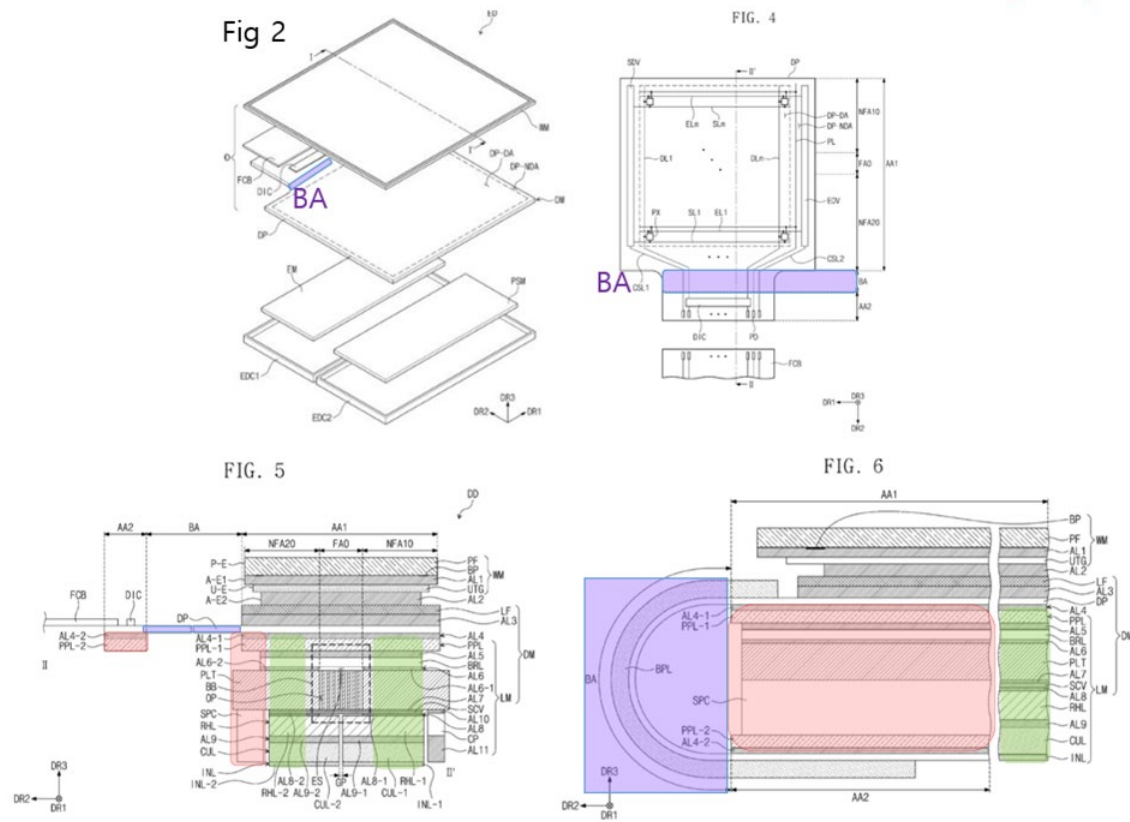
121. Shin's display device includes a support layer, wherein one side of the support layer supports the planar area and the transitional bending sub-area, and another side of the support layer away from the planar area supports the extending bending sub-area. Shin teaches that lower member LM includes "*a support layer supporting the display panel DP.*" Ex-1005 ¶88. Specifically, Shin teaches panel protection layer PPL, which includes "a flexible plastic material," protects "a lower portion of the display panel DP" (i.e., LM) and reduces or effectively prevents "scratches from being generated on a rear surface of the display panel DP in a process of manufacturing." Ex-1005 ¶116. As shown in annotated Figure 6 below, panel protection layer PPL (navy) includes "a first panel protection layer *PPL-1 protecting the first panel area AA1* of the display panel DP and a second panel protection layer *PPL-2 protecting the second panel area AA2.*" Ex-1005 ¶117, Fig. 6; *see also id.* ¶¶118 ("second panel protection layer PPL-2 may be disposed below the first panel protection layer PPL-1 and the first panel area AA1 together with the second panel area AA2 of the display panel DP"), 119 (fourth adhesive layer AL4

includes “a first portion AL4-1 corresponding to the first panel protection layer PPL-1 and a second portion AL4-2 corresponding to the second panel protection layer PPL-2” wherein “[t]he first portion AL4-1 may couple the first panel protection layer PPL-1 to the first panel area AA1 of the display panel DP, and the second portion AL4-2 may couple the second panel protection layer PPL-2 to the second panel area AA2 of the display panel DP”).

122. Shin’s PPL corresponds to the recited “support layer,” PPL-1 corresponds to the recited “side of the support layer [that] supports the planar area [designated by the blue arrow] and the transitional bending sub-area” of first panel area AA1 (designated by the green arrow), and PPL-2 corresponds to the recited “side of the support layer away from the planar area [that] supports the extending bending sub-area” of second panel area AA2 (designated by the purple arrow). PPL-2 is the side of the support layer “away from” the planar area because it is configured in the same manner as the ’031 Patent’s corresponding support layer. *See, e.g.,* Ex-1001, 5:46-55 (“[T]he planar area AA and the transitional bending sub-area B1 of the flexible screen body 10 are disposed on a same side of the support layer 20, and ***the extending bending sub-area B3 of the flexible screen body 10 is disposed on another side of the support layer 20 away from the planar area AA.***”). Shin’s PPL-2 is “on another side of the support layer” opposite from the planar area. *Id.*



123. For clarity purposes, I note that Shin's device is initially unbent in Figure 5 and takes the form of Figure 6 when it is assembled and bent. Ex-1005, Figs. 5, 6 (annotated to show highlight overlapping areas in the unbent and bent positions). The bending area is also shown in Shin's Figures 2 (electronic device) and 4 (display panel). Ex-1005, Figs. 2, 4 (annotated to show the bending area).

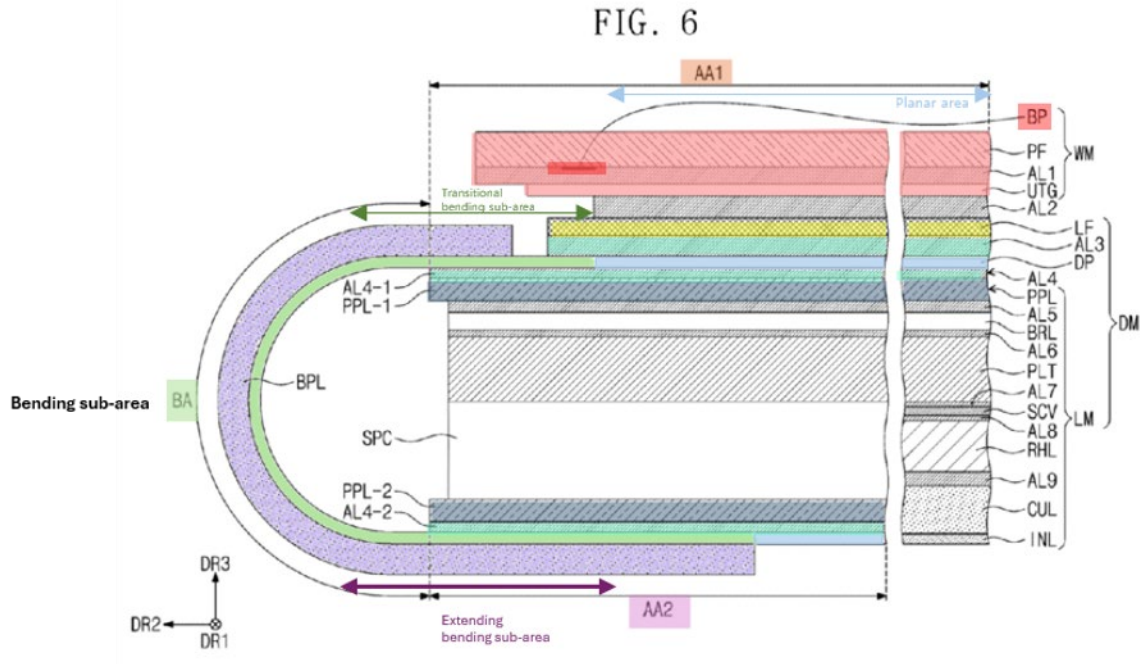


- f. **Claim 10: The display device according to claim 9, wherein the support layer comprises a first backplate disposed on one side of the planar area and the transitional bending sub-area away from the cover plate and a second backplate disposed on one side of the extending bending sub-area away from the protective layer.**

124. In my opinion, Shin teaches Claim 10.

125. As shown in annotated Figure 6 below, Shin teaches that the support layer (i.e., PPL (navy)) comprises a first backplate (i.e., PPL-1 (navy)) disposed on one side of the planar area (designated by the blue arrow) and the transitional bending sub-area (designated by the green arrow) and a second backplate (i.e., PPL-2 (navy)) disposed on one side of the extending bending sub-area (designated by the

purple arrow). Ex-1005, Fig. 6; *see also* Section VII.A.2.d. The '031 Patent does not define the term “backplate” but states that “first backplate 201 is configured to support and protect the planar area AA and the transitional bending sub-area B1 of the flexible screen body 10, thereby preventing them from being damaged by the external impact” and “second backplate 202 is configured to support and protect the extending bending sub-area B3 of the flexible screen body 10, thereby preventing it from being damaged by the external impact.” Ex-1001, 8:21–28. The '031 Patent also states that “[m]aterials of the first backplate 201 and the second backplate 202 may be polyethylene terephthalate (PET) material.” Ex-1001, 8:28–30. Shin teaches that the “PPL may include a flexible plastic material,” “a colored polyimide film,” or “an opaque yellow film” but “the invention is not limited thereto.” Ex-1005 ¶116. Shin also teaches that the PPL “reduce[s] or effectively prevent[s] scratches from being generated on a rear surface of the display panel DP in a process of manufacturing the display panel DP.” Ex-1005 ¶116. A POSITA would thus have understood that PPL-1 and PPL-2 correspond to the recited first backplate and second backplate, respectively, because like the backplates in the '031 Patent, they are made from a plastic material and protect the DP from being damaged by external impact.



126. As also shown in annotated Figure 6, Shin's first backplate (i.e., PPL-1) is disposed "away from" the coverplate (i.e., WM (red)) because these components are separated from one another by at least AL4-1 and AL3 (teal)⁵, and LF (yellow). Ex-1005, Fig. 6. Shin's first backplate is also disposed "away from" the coverplate because it is on the side of the planar area and the transitional bending sub-area that is opposite from the cover plate. *Id.*; *see also, e.g.*, Ex-1001, 5:46-55 (disclosing that "away from" may modify a "side" of a layer). Shin's second backplate (i.e., PPL-2) is disposed "away from" the protective layer (i.e., BPL

⁵ The '031 Patent figures do not explicitly depict a glue or an adhesive layer but the specification discloses its use (Ex-1001, 8:18–20), similar to Shin's AL4-1 and AL4-2 layers. Ex-1001, 8:18–20 ("the extending bending sub-area B3 may be fixed onto the second backplate 202 by gluing or physical methods").

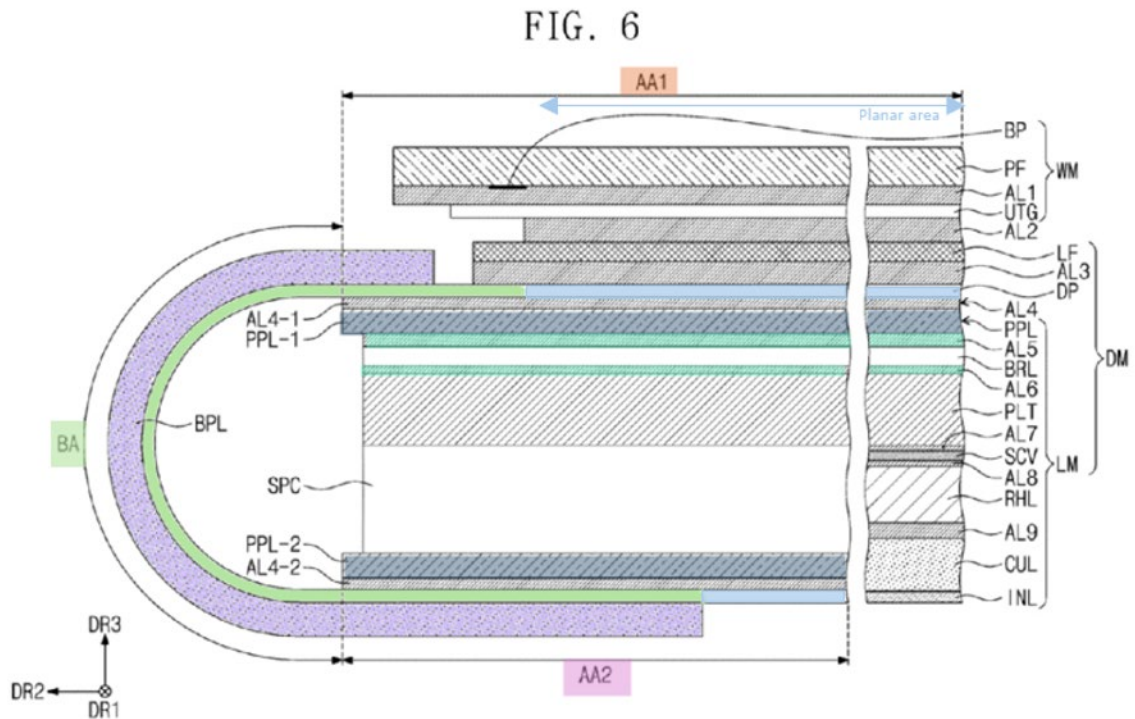
(purple)) because these components are separated from one another by at least AL4-2 (teal). Ex-1005, Fig. 6. Shin's second backplate is also disposed "away from" the BPL because it is on the side of the extending bending sub-area that is opposite from the BPL. *Id.*; *see also, e.g.*, Ex-1001, 5:46-55.

g. Claim 11: The display device according to claim 10, wherein a foam is disposed between the first backplate and the second backplate.

127. In my opinion, Shin teaches Claim 11.

128. Shin teaches that a foam is disposed between the first backplate and the second backplate. As shown in annotated Figure 6 below, Shin teaches adhesive layers (AL5 and/or AL6) (teal), which are disposed between the first backplate (i.e., PPL-1) and the second backplate (i.e., PPL-2) (navy). Ex-1005, Fig. 6, ¶¶126 ("sixth adhesive layer AL6 may be disposed between the barrier layer BRL and the support layer PLT"), 132 ("[F]ifth adhesive layer AL5 may be disposed between the panel protection layer PPL and the barrier layer BRL to couple the barrier layer BRL to the panel protection layer PPL."). A POSITA would have known that the adhesive layers may comprise a foam-type adhesive or polyolefin foam. *See, e.g.*, Ex-1038 (Kwon), 15:57–16:3; Ex-1006 (Luo), 16:15–20; *see also* Ex-1005 ¶142 (Shin teaching that other layers such as cushion layer CUL "may include a foam sheet having an elastic force").

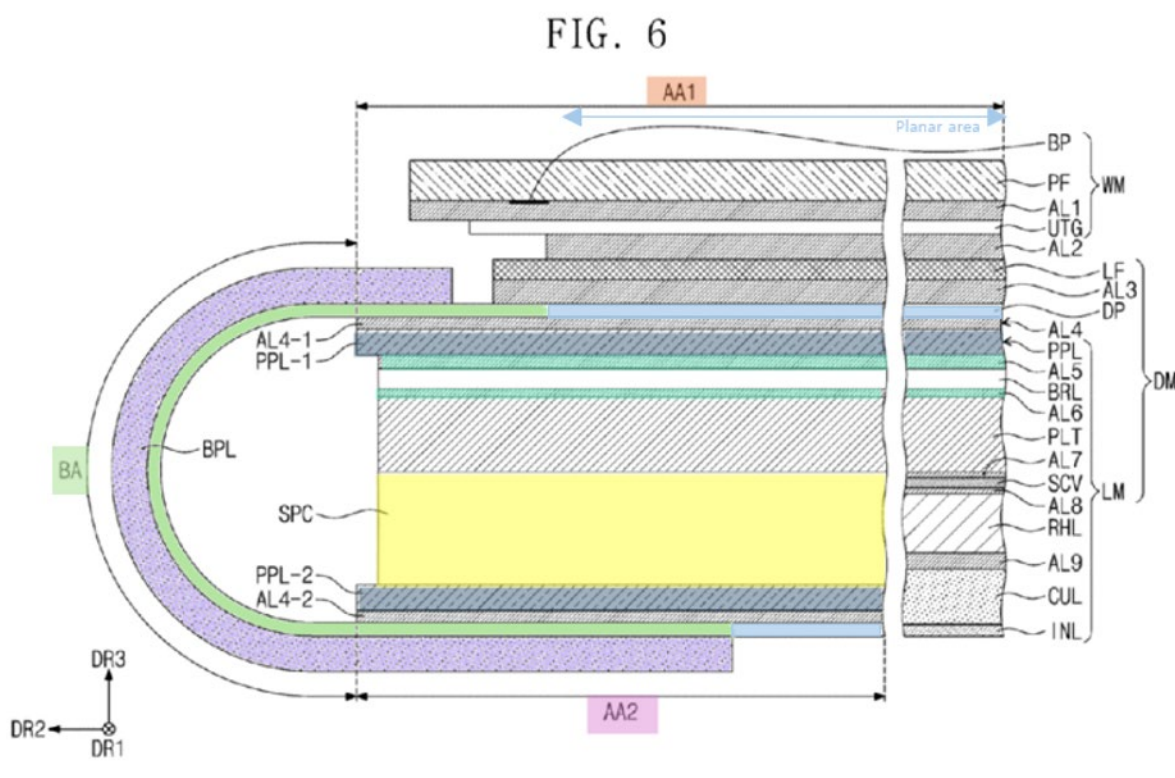
129. Shin teaches support layers both in the single form as well as the support form. Shin's single support layer (PLT) is positioned below the display panel, with a pattern of openings. It also teaches lower support layers disposed below the support layer PLT. Shin further teaches that a cushion layer (CUL of which there are CUL-1 and CUL-2) may include a 'foam sheet having an elastic force' or a sponge/ polyurethane.



- h. Claim 12: The display device according to claim 11, wherein a stiffener plate is disposed between the foam and the second backplate.**

130. In my opinion, Shin teaches Claim 12.

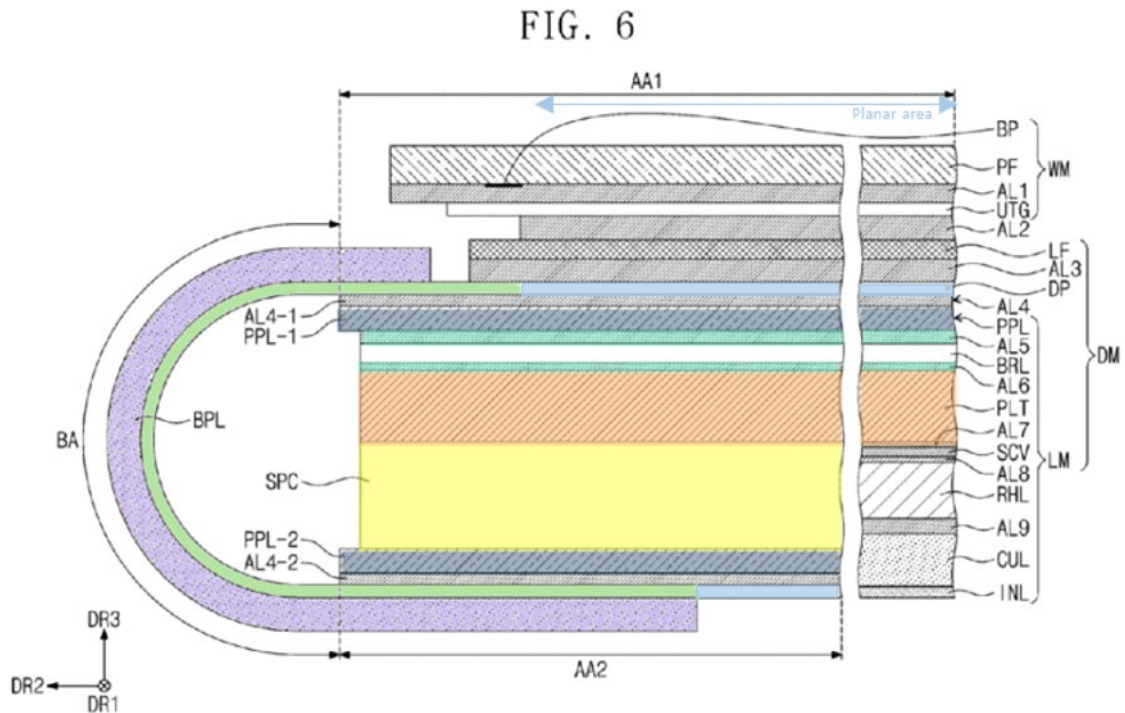
131. Shin teaches that a stiffener plate is disposed between the foam and the second backplate. As shown in annotated Figure 6 below, Shin teaches a spacer SPC (yellow), which is disposed between the foam (i.e., AL5 and/or AL6 (teal)) and the second backplate (i.e., PPL2 (navy)). Ex-1005, Fig. 6. The '031 Patent does not define the term “stiffener plate” but states that it may be “a graphite layer.” Ex-1001, 9:20–27. A POSITA would have understood that Shin’s spacer SPC corresponds to the recited “stiffener plate” because Shin’s “SPC may have a multi-layered structure” comprising a “baser layer ... disposed between two adhesive layers,” which includes “graphite.” Ex-1005 ¶150.



i. Claim 13: The display device according to claim 12, wherein a heat dissipation layer is disposed between the foam and the stiffener plate.

132. In my opinion, Shin teaches Claim 13.

133. Shin teaches that a heat dissipation layer is disposed between the foam and the stiffener plate. As shown in annotated Figure 6 below, Shin teaches a support layer PLT (orange) disposed between the foam (i.e., AL5 and/or AL6 (teal)) and the stiffener plate (i.e., SPC (yellow)). Ex-1005, Fig. 6. Shin's support layer PLT corresponds to the recited "heat dissipation layer" because Shin teaches that "the support layer PLT may improve a heat dissipation performance of the display device DD." Ex-1005 ¶123. A POSITA would have understood that disposing the heat dissipation layer (PLT) specifically between the stiffener plate (SPC) and the foam layer (AL5 and/or AL6) serves several critical thermodynamic and structural purposes including, for example, direct thermal coupling to a heat source and thermal protection of the foam layer.

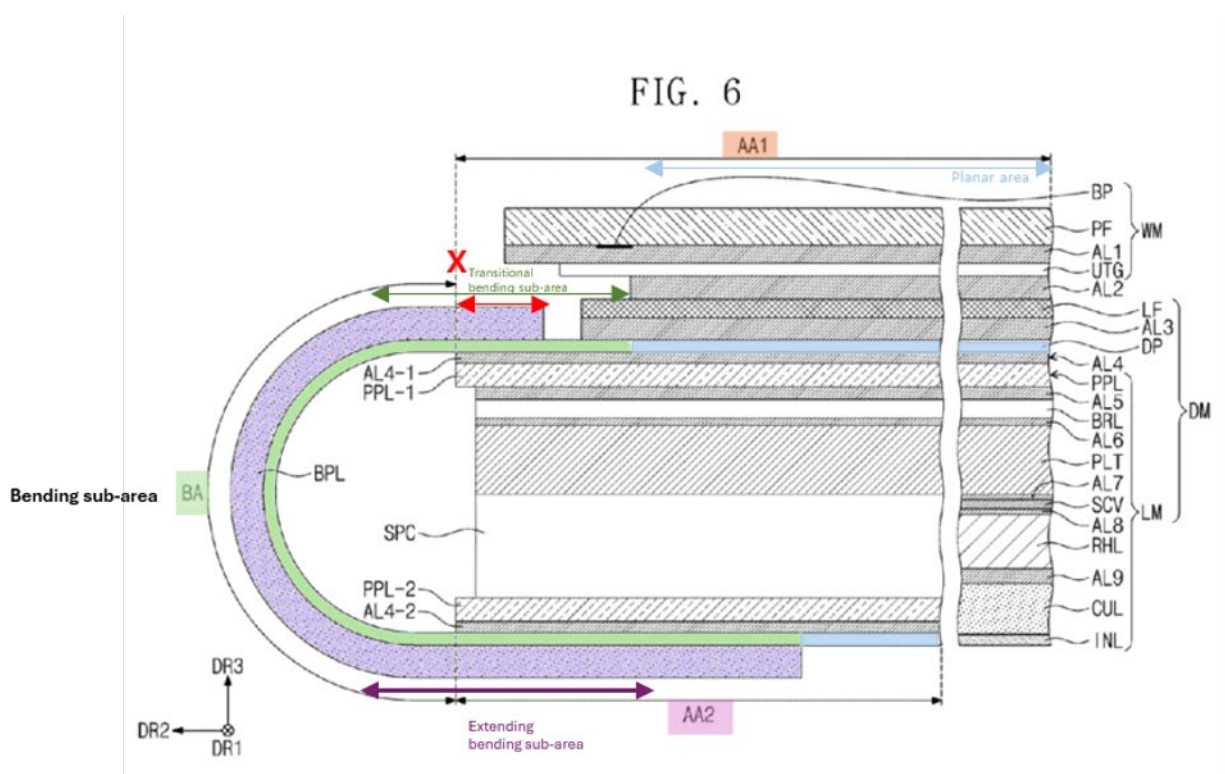


- j. **Claim 14:** The display device according to claim 5, wherein a distance between one side end of the protective layer adjacent to the planar area and an initial bending position of the flexible screen body is greater than a first default value, wherein the first default value is greater than or equal to 0, and the initial bending position is a jointed position of the bending sub-area and the transitional bending sub-area.

134. In my opinion, Shin teaches Claim 14.

135. As shown in annotated Figure 6 below, Shin teaches that a distance between one side end of the protective layer (i.e., BPL (purple)) adjacent to the planar area (designated by the blue arrow, blue extending from BP to the right) and an initial bending position of the flexible screen body (i.e., DP-NDA, green)

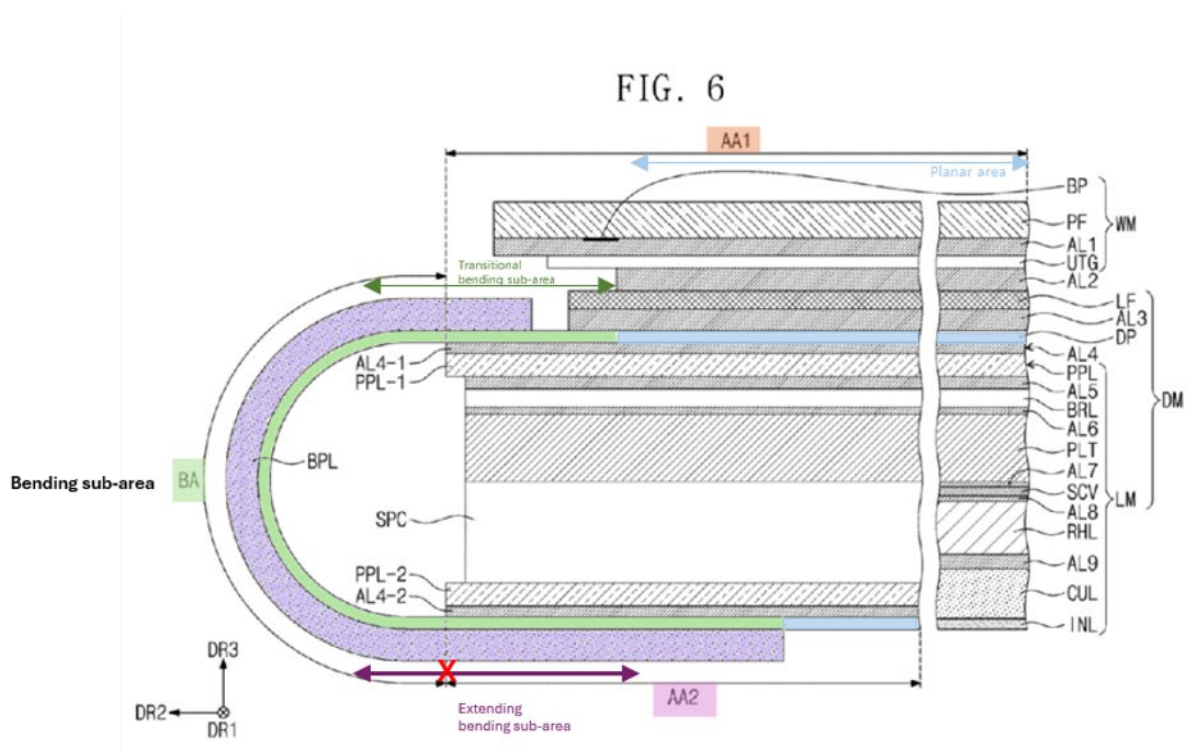
(designated by the red arrow) is greater than a first default value, wherein the first default value is greater than or equal to 0. Ex-1005, Fig. 6. Moreover, as shown in Figure 6, the initial bending position (designated by the red X) is a jointed (i.e. bendable) position of the bending sub-area (designated by the black arrow) and the transitional bending sub-area (designated by the green arrow). Ex-1005, Fig. 6.



- k. **Claim 15:** The display device according to claim 14, wherein a distance between one side end of the protective layer adjacent to the extending bending sub-area and a terminal bending position of the flexible screen body is greater than a second default value, wherein the second default value is greater than or equal to 0.

136. In my opinion, Shin teaches Claim 15.

137. As shown in annotated Figure 6 below, Shin teaches that a distance between one side end of the protective layer (i.e., BPL (purple)) adjacent to the extending bending sub-area (designated by the purple arrow) and a terminal bending position of the flexible screen body (i.e., DP-NDA, green) is greater than a second default value, wherein the second default value is greater than or equal to 0. Ex-1005, Fig. 6. As also shown in Figure 6, Shin's terminal bending position (designated by the red X) is a jointed (i.e. bendable) position of bending area BA (designated by the black arrow) and extending bending sub-area. Ex-1005, Fig. 6.



- 1. Claim 17: The display device according to claim 5, wherein the optical adhesive is an optically clear adhesive (OCA).**

138. In my opinion, Shin teaches Claim 17.

139. Shin teaches that the optical adhesive (i.e., AL2) is an optically clear adhesive (OCA) for the reasons described in Section VII.A.2.b. Specifically, Shin teaches that “second adhesive layer AL2 couples the optical film LF to the window module WM.” Ex-1005 ¶115. Shin further teaches that AL2 is “a pressure sensitive adhesive or a transparent adhesive such as the *optically clear adhesive*.” Ex-1005 ¶111.

m. Claim 18: The display device according to claim 13, wherein a material of the heat dissipation layer is a metal material or graphite, and the metal material comprises one or more combinations of copper foil, aluminum foil, or stainless steel foil.

140. In my opinion, Shin teaches Claim 18.

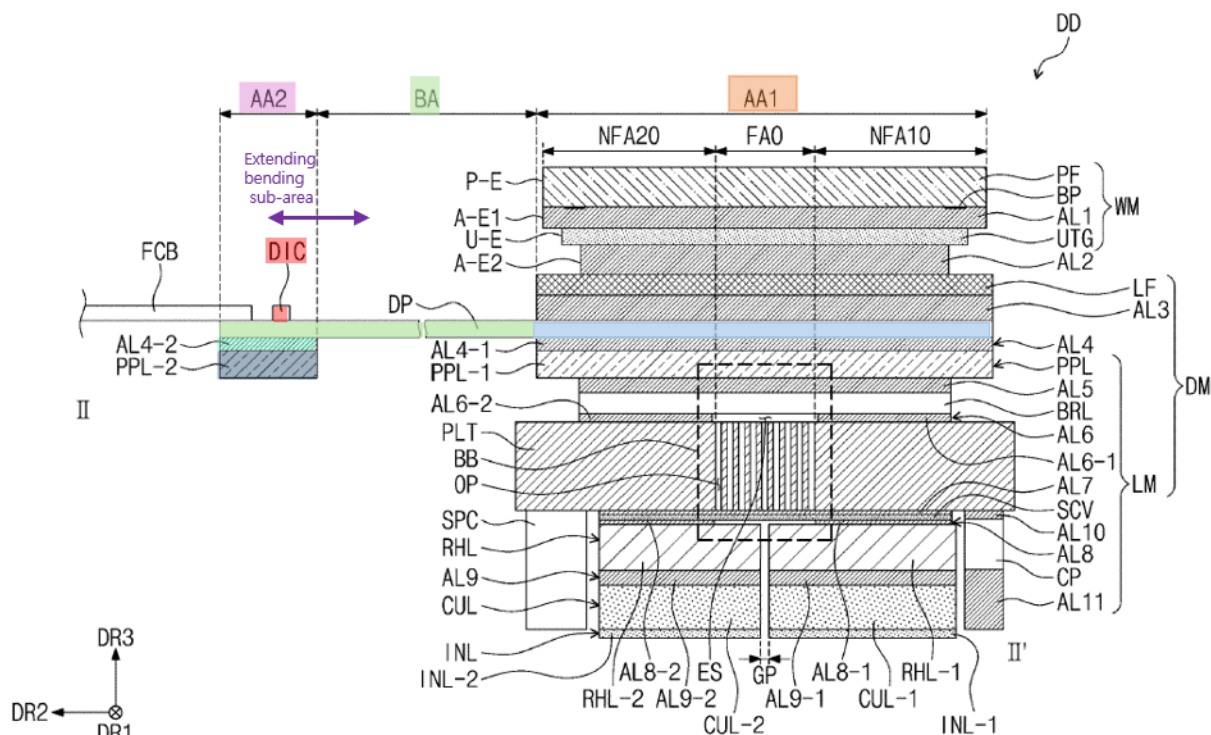
141. Shin teaches that a material of the heat dissipation layer (i.e., PLT) is a metal material comprising one or more combinations of copper foil, aluminum foil, or stainless steel foil. Specifically, Shin teaches that “[t]he support layer PLT may include a metal material such as stainless steel” or “various metal materials.” Ex-1005 ¶123. It would have been obvious to a POSITA that the “various metal materials” would include “one or more combinations of copper foil, aluminum foil, or stainless steel foil” because Shin teaches that its other heat dissipation layer RHL “may include metal or metal alloy, e.g., copper, copper alloy, or graphite.” Ex-1005 ¶137.

- n. Claim 19: The display device according to claim 9, further comprising a driving unit disposed on one surface of the extending bending sub-area away from the support layer.**

142. In my opinion, Shin teaches Claim 19.

143. As shown in annotated Figure 5 below, Shin teaches a driving unit (i.e., DIC (red)) disposed on one surface of the extending bending sub-area (designated by the purple arrow, over the bending portion of DP, green (DP-NDA)) away from the support layer (i.e., PPL-2 (navy)). Specifically, Shin teaches that “display module DM may include a driving chip DIC disposed in the non-display area DP-NDA” and “a flexible circuit film FCB coupled to the display panel DP at the non-display area DP-NDA.” Ex-1005 ¶69, Fig. 5.

FIG. 5



144. Shin's driving chip DIC corresponds to the recited "driving unit" because Shin teaches that "[a]n electrical signal may be provided to the" DP "through the driving chip DIC and/or the flexible circuit film FCB" and "driving chip DIC may include a driving element for driving a pixel PX of the display panel DP, e.g., a data driving circuit." Ex-1005 ¶¶69–70. As shown in Figure 5 above, Shin's driving chip DIC is disposed on one surface of the extending bending sub-area in the second panel area AA2 "away from" the PPL because there is an AL4-2 layer (teal) between the DIC and PPL-2. *See, e.g.*, Ex-1005 ¶¶95 ("The data lines DL1 to DLn may each extend along the second direction DR2 and through the bending area BA and be electrically connected to *the driving chip DIC at the second*

panel area AA2.”). Shin’s DIC is also disposed “away from” the PPL because it is on the side of the extending bending sub-area that is opposite from the PPL. *See, e.g.,* Ex-1001, 5:46-55 (disclosing that “away from” may modify a “side” of a layer).

B. Ground 2: Claims 1–3, 5, 7–15, and 17–19 Are Obvious over Shin in View of Luo

1. A POSITA would have been motivated to combine Shin’s teachings with Luo’s teachings and would have had a reasonable expectation of success.

145. A POSITA would have been motivated to combine the teachings of Shin and Luo and had a reasonable expectation of success in doing so because each relates to a flexible, bendable display device including multiple defined layers and components. Ex-1005, Abstract, Fig. 6; Ex-1006, Abstract, Figs. 4A, 4B.

146. Shin teaches a “foldable display device and an electronic device including the same.” Ex-1005 ¶2. Shin further teaches that its display device comprises a bending protection layer BPL, which is disposed on the display panel DP and “may overlap the bending area BA, the first panel area AA1 and the second panel area AA2.” Ex-1005 ¶148. Additionally, Shin teaches “window module WM (e.g., window),” which is coupled to an optical film LF by a second adhesive layer AL2 and “provides or defines the front surface of the electronic device ED.” Ex-1005 ¶¶67, 102, 115. Shin also teaches that adhesive layer AL2 may “have a thickness of about 35 μm to about 65 μm , e.g., about 50 μm .” Ex-1005 ¶111. Shin thus teaches a “default value” for the distance in an overlapping area of the BPL and

WM components, which encompasses at least the entire thickness of AL2 of “about 50 μm ,” which is greater than 0. *Id.* Shin also teaches that this distance may be adjusted as needed to encompass “a thickness of about 35 μm to about 65 μm .” Ex-1005 ¶111.

147. Luo teaches a display apparatus having “an intricate structure to eliminate” interference “by defining critical parameters including at least one of the first shortest distance Ds1, the second shortest distance Ds2, the third shortest distance Ds3, or the fourth shortest distance Ds4.” Ex-1006 ¶77. Luo teaches that “a fourth shortest distance Ds4 between the orthographic projection of the edge Eoca ... on the plane ... of the display portion DP and the orthographic projection of the edge Ecf of the cover window CF adjacent to ... the plane ... of the display portion DP is equal to or greater than a second value.” Ex-1006 ¶68. Luo further teaches that “the second value is equal to a bonding tolerance of the optically clear adhesive layer OCA,” which may be “in a range of 100 μm to 200 μm , e.g., 100 μm to 125 μm , 125 μm to 150 μm , 150 μm to 175 μm , or 175 μm to 200 μm ” such that, for example, “the fourth shortest distance Ds4 is equal to or greater than 150 μm .” Ex-1006 ¶69. Luo also teaches that “not only the interference between the cover window CF and the coating layer MCL can be eliminated, but also other defects such as cover window depression, bending portion cracking, and light leakage, can be effectively prevented or entirely eliminated.” Ex-1006 ¶77. Luo specifically defines vertical

factors such as heights h_1 and h_2 by adjusting parameters like Ds_1 , Ds_3 , point E_{pt} , or tapering, which consequently ensures a vertical gap. Ex-1006 ¶¶64, 68. Moreover, Luo explicitly recognizes that the absence of a vertical gap (like first interference region, Ri_1) leads to defects and interference (i.e., cracking). Ex-1006 ¶¶76–79, Fig. 6. Consequently, Luo proposes solutions by controlling various parameters to prevent such issues. In other words, Luo provides teachings regarding the recognition of similar problems as Shin arising in similar processes. Luo thus teaches a “default value” for the distance in the overlapping area of the MCL and WM components “equal to or greater than $150\text{ }\mu\text{m}$,” which is greater than 0. Ex-1006 ¶69. Additionally, Luo teaches that this distance may be adjusted as needed to encompass “a range of $100\text{ }\mu\text{m}$ to $200\text{ }\mu\text{m}$, e.g., $100\text{ }\mu\text{m}$ to $125\text{ }\mu\text{m}$, $125\text{ }\mu\text{m}$ to $150\text{ }\mu\text{m}$, $150\text{ }\mu\text{m}$ to $175\text{ }\mu\text{m}$, or $175\text{ }\mu\text{m}$ to $200\text{ }\mu\text{m}$.” Ex-1006 ¶69. Moreover, Luo teaches that the purpose of the default value is to avoid, among other things, cracking during bending. Ex-1006 ¶77; Ex-1001, 7:1–10.

148. The presence of similar elements and recognized issues in the prior art implies the existence of comparable processes. Specifically, product manufacturing includes steps such as protective layer coating, manufacturing a Shin LF or polarizer, and window attachment performed after the Panel Process (BP). A POSITA would have understood that cracking issues frequently arise during these steps, necessitating precise parameter control.

149. To the extent that a POSITA was interested in additional implementation details for the “default value” taught by Shin, such as the purpose for this value, a POSITA would have looked to Luo, which teaches the existence of multiple “critical parameters” or “shortest distances” having the function of avoiding cracking during bending. Ex-1006 ¶77. Shin already explains, for example, that the varied dimensional areas of AL1 and AL2 may prevent “a buckling phenomenon or a crack” in the UTG and decrease “a probability of foreign substances attached to” AL2. Ex-1005 ¶113. Moreover, a POSITA would have understood that Luo’s MCL (Ex-1006 ¶80) corresponds to and performs identical functions as Shin’s BPL (Ex-1005 ¶149). The Shin-Luo combination is shown in the modified, annotated version of Shin’s Figure 6’ below. Ex-1005, Fig. 6’. It would have been obvious to a POSITA that setting a minimum thickness value of AL2 between the BPL and WM components would avoid “bending portion cracking,” as taught by Luo.

support layers disposed below the support layer PLT. Shin further teaches that a cushion layer (CUL of which there are CUL-1 and CUL-2) may include a ‘foam sheet having an elastic force’ or a sponge/ polyurethane. Shin also teaches that the cushion layer is disposed below the support layer PLT and also below the heat dissipation layer RHL. Shin also teaches in an example that a cushion layer can be disposed between the PLT and the display panel DP. A POSITA designing a flexible, narrow-bezel OLED display would have been motivated to combine a multi-layer stack and support structure of Shin with specific gap and clearance of Luo. Further, a POSITA would have seen that the combination would aid in stress prevention and elimination of cracking and would see that these are known techniques and would have generated expected results without undue research and development. This is because the combination simply applies geometric spacing and standard adhesive setbacks as taught by Luo to standard flexible OLED packaging layers as taught by Shin. The combination would have generated improvements in display durability and manufacturing yield.

152. A POSITA would have had a reasonable expectation of success in combining the teachings of Shin and Luo. Both describe flexible, bendable display devices including similar layers and components. Ex-1005, Abstract, Fig. 6; Ex-1006, Abstract, Figs. 4A-4B. A POSITA would thus have understood that these references disclose interrelated teachings based on well-understood technologies

that would have been amenable to various well-understood and predictable combinations. A POSITA would have also understood that Shin and Luo are synergistic. Combining Shin's controlled physical plate displacement with Luo's internal shear-absorbing stack would help ensure that external mechanical movement aligns better with internal material deformation. A POSITA would have seen the advantage of such a combination. For example, the combination would have had the benefit of potentially preventing overall display optical distortion and delamination.

2. Independent Claim 1

a. 1[pre]: A display device, comprising:

153. In my opinion, Shin in view of Luo ("Shin-Luo") teaches Element 1[pre] for the reasons described in Section VII.A.1.a.

b. 1[a]: a flexible screen body comprising a planar area and a bending area connected to the planar area;

154. In my opinion, Shin-Luo teaches Element 1[a] for the reasons described in Section VII.A.1.b.

c. 1[b]: a color filter disposed on the flexible screen body and at least covering the planar area;

155. In my opinion, Shin-Luo teaches Element 1[b] for the reasons described in Section VII.A.1.c.

- d. **1[c]: a protective layer disposed on the flexible screen body and at least covering a part of the bending area; and**

156. In my opinion, Shin-Luo teaches Element 1[c] for the reasons described in Section VII.A.1.d.

- e. **1[d]: a coverplate disposed on the color filter and at least covering the planar area;**

157. In my opinion, Shin-Luo teaches Element 1[d] for the reasons described in Section VII.A.1.e.

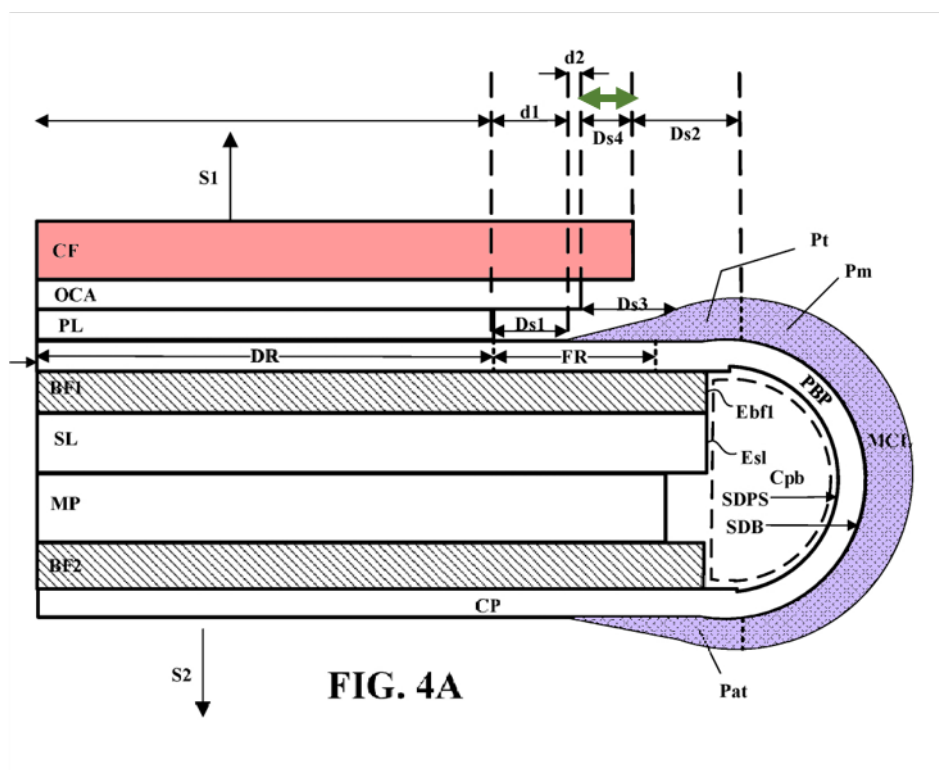
- f. **1[e]: wherein in an overlapping area of the protective layer and the coverplate, a distance between the protective layer and the coverplate is greater than or equal to a default value, wherein the default value is greater than 0.**

158. In my opinion, Shin-Luo teaches Element 1[e].

159. Shin teaches Element 1[e] for the reasons described in Section VII.A.1.f. To the extent that a POSITA was interested in additional implementation details for the “default value” limitation of 1[e], a POSITA would have looked to Luo. Luo teaches the existence of multiple “critical parameters” or “shortest distances” that have the function of mitigating cracking during bending.

160. As shown in Figure 4A below, Luo teaches “an intricate structure to eliminate” interference “by defining critical parameters including at least one of the first shortest distance $Ds1$, the second shortest distance $Ds2$, the third shortest distance $Ds3$, or the *fourth shortest distance $Ds4$* [designated by the green

arrow].” Ex-1006 ¶77. Luo teaches that “FIG. 4A is a cross-sectional view around a bending portion of a display apparatus,” which “includes a display portion DP; a polarizer PL on a first side S1 of the display portion DP; **a cover window CF [red]** on the first side S1 of the display portion DP, and on a side of the polarizer PL away from the display portion DP; a connecting portion CP; a bending portion PBP connecting the display portion DP and the connecting portion CP.” Ex-1006 ¶58. Luo further teaches that “[t]he bending portion PBP is bent so that the connecting portion CP is facing a second side S2 of the display portion DP, forming a bending cavity Cpb that is surrounded by the bending portion PBP” and “the second side S2 is opposite to the first side S1.” Ex-1006 ¶58, Fig. 4A. And that “the display apparatus further includes **a coating layer MCL [purple]** covering a back side SDB of the bending portion PBP opposite to a side SDPS directly surrounding the bending cavity Cpb.” Ex-1006 ¶59. Luo’s coating layer MCL corresponds to the recited “protective layer” and cover window CF corresponds to the recited “coverplate.” Luo’s fourth shortest distance Ds4 corresponds to the recited “overlapping area of the protective layer and the coverplate.”

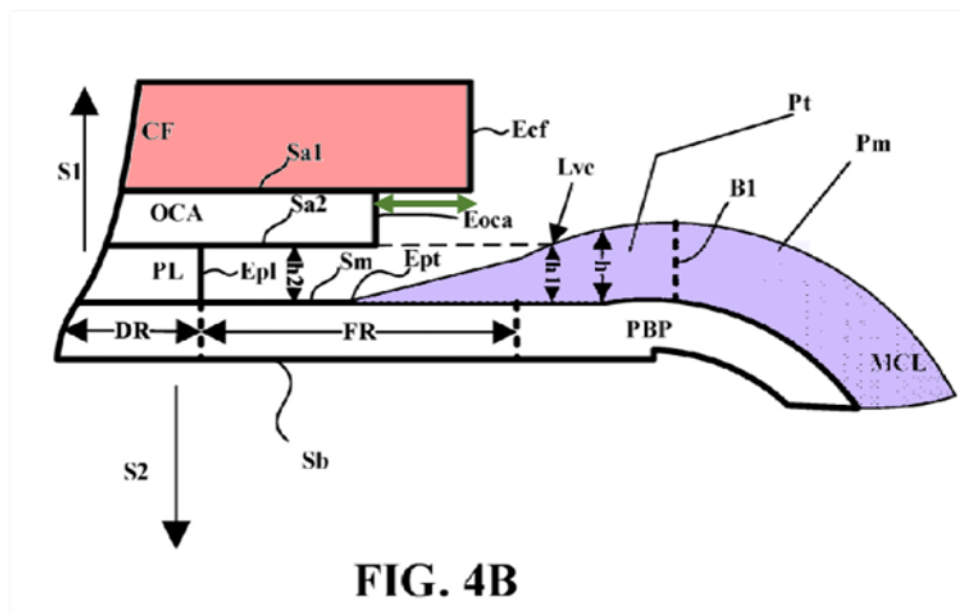


161. Luo further teaches, as shown in Figure 4B below, that “*a fourth shortest distance Ds4 [designated by the green arrow] between the orthographic projection of the edge Eoca connecting the first adhering surface Sa1 and the second adhering surface Sa2 on the plane comprising the main surface Sm of the display portion DP and the orthographic projection of the edge Ecf of the cover window CF adjacent to the tapered portion Pt on the plane comprising the main surface Sm of the display portion DP is equal to or greater than a second value.*” Ex-1006 ¶68. Additionally, Luo teaches that “*the second value is equal to a bonding tolerance of the optically clear adhesive layer OCA,*” which may be “in a range of 100 μm to 200 μm, e.g., 100 μm to 125 μm, 125 μm to 150 μm, 150 μm to 175 μm, or 175 μm

to 200 μm ” such that, for example, “the fourth shortest distance D_{s4} is *equal to or greater than 150 μm* .” Ex-1006 ¶69 (“bonding tolerance refers to a tolerance for an error or a range of error in bonding two parts of the display apparatus, for example, in bonding the optically clear adhesive layer OCA, e.g., to the cover window CF or to the polarizer PL”). Luo also teaches that “[i]n the present display apparatus, *not only the interference between the cover window CF and the coating layer MCL can be eliminated, but also other defects such as cover window depression, bending portion cracking, and light leakage, can be effectively prevented or entirely eliminated.*” Ex-1006 ¶77. Luo thus teaches that a “default value” for the distance in the overlapping area of the MCL and WM components is “*equal to or greater than 150 μm ,*” which is greater than 0. Ex-1006 ¶69. Additionally, similar to the ’031 Patent, Luo teaches that this distance may be adjusted as needed to encompass “a range of 100 μm to 200 μm , e.g., 100 μm to 125 μm , 125 μm to 150 μm , 150 μm to 175 μm , or 175 μm to 200 μm .” Ex-1006 ¶69; Ex-1001, 7:1–10 (the default value “may be flexibly adjusted according to actual needs”). Moreover, like the ’031 Patent, Luo teaches that the purpose of the default value is to avoid, among other things, cracking during bending. Ex-1006 ¶77; Ex-1001, 7:1–10.

162. As discussed in Section VII.B.1, Luo recognizes the issue of a vertical gap. Ex-1006 ¶¶64, 68, 76–79, Fig. 6. While not explicitly stated, Luo implicitly teaches adjusting various factors (considering D_1 , D_2 , D_{s4} , and process-controlled

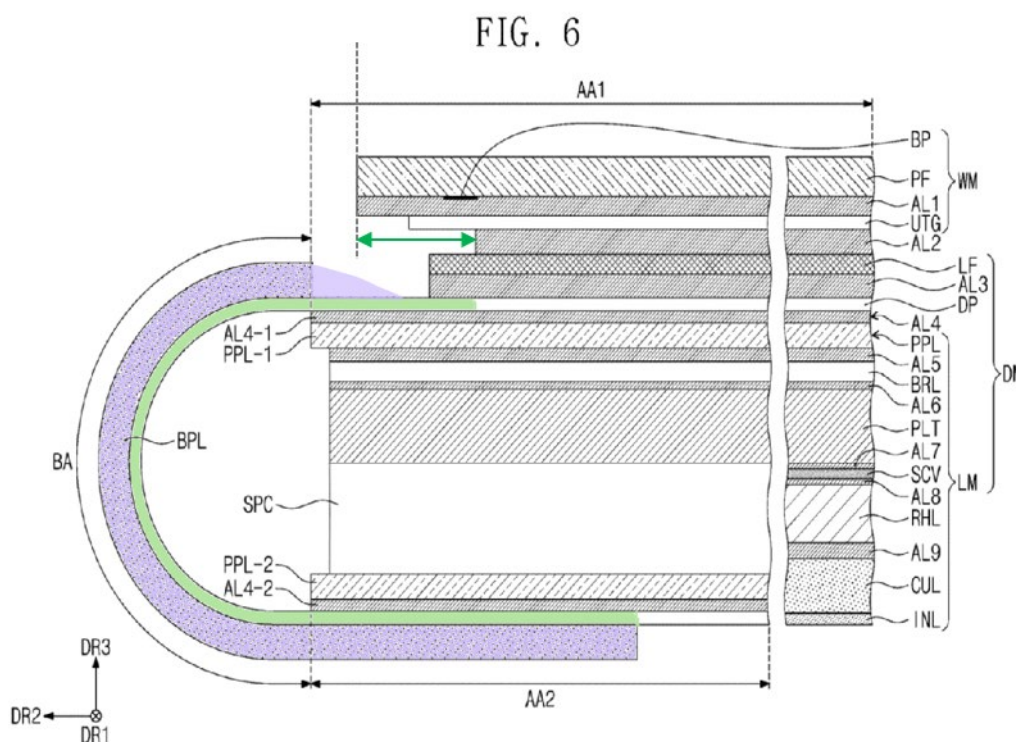
Ds1, Ds3, tapering of MCL) to control the 'Ept' point, thereby preventing the upper surface of the MCL from contacting the OCA or CF. Thus, a POSITA would have understood that Luo adjusts specific parameters to ensure the protective layer's upper surface does not contact the bottom surfaces of the CF or OCA, thereby clearly teaching Element 1[e].



163. A POSITA would have been motivated to combine Shin with Luo and had a reasonable expectation in doing so for the reasons described in Section VII.B.1. As noted in the text, a POSITA would have been motivated to combine the flexible display assembly of Shin with the geometric clearance and setback teachings of Luo using several standard techniques. For example, Luo recognizes failure modes of cracking and squeezing stress by teaching a non-zero vertical/lateral

separation in the where the cover window overlaps the bending boundary. A POSITA would have known to implement a clearance gap to prevent the rigid coverplate from exerting damaging compressive forces onto the protective layer, which prevents display panel cracking during assembly. Further, a POSITA would have seen that Luo's defined non-zero spacing provides a well understood physical buffer zone that allows adhesive tolerancing without causing bubbling or delamination. Lastly, a POSITA would have seen that Shin and Luo are in the same field of endeavor of flexible and bendable OLED display packaging, of which a narrow-bezel is utilized. Further, the combination of Shin's stack that includes backplates, bending protection resin, and window module with Luo's predefined structural separation gap would have involved the implementation of well-known mechanical tolerance clearances to standard flexible display components without undue research and development. The results would have been predictable and would have led to higher manufacturing yield and panel reliability.

164. In the Shin-Luo combination, Luo's "fourth shortest distance Ds4 [designated by the green arrow]," which is "equal to or greater than a second value," i.e., the recited "default value" is designated by the green arrow in Shin's annotated Figure 6 below.



3. Dependent Claims 2–3, 5, 7–15, and 17–19

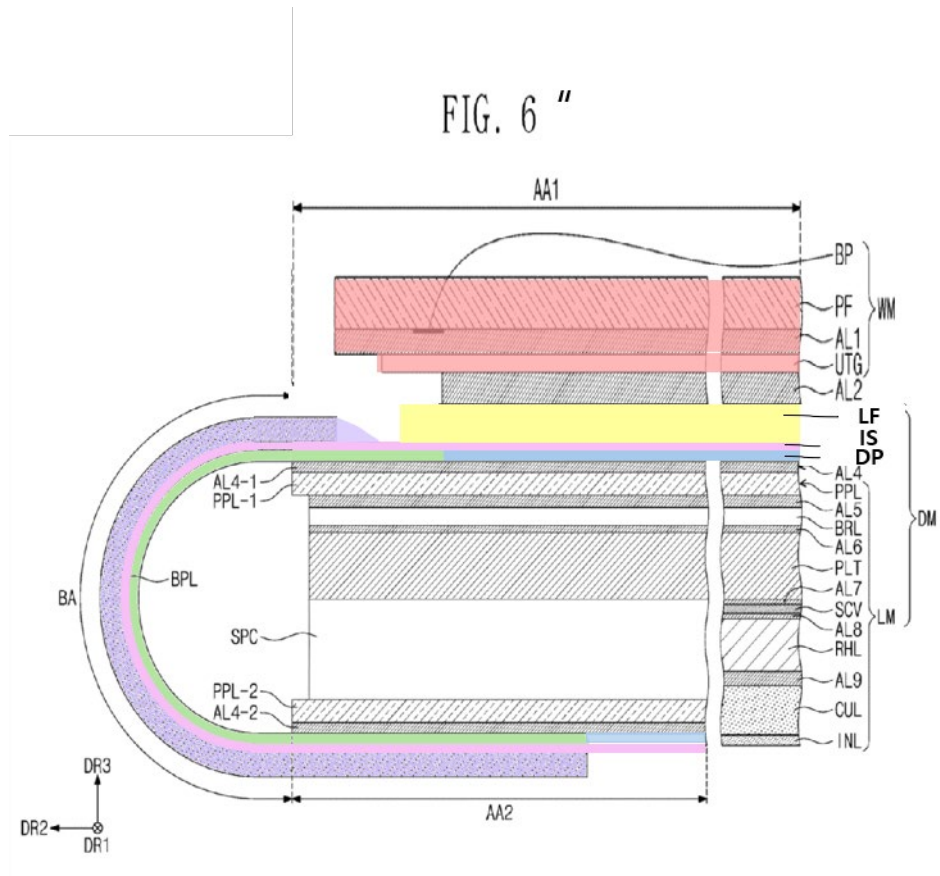
- a. **Claim 2:** The display device according to claim 1, wherein the protective layer is disposed on a surface of the flexible screen body, and a thickness of the protective layer on the surface of the flexible screen body is less than or equal to a distance between one side of the coverplate adjacent to the flexible screen body and one side of the flexible screen body adjacent to the coverplate.

165. In my opinion, Shin-Luo teaches Claim 2 for the reasons described in Section VII.A.2.a.

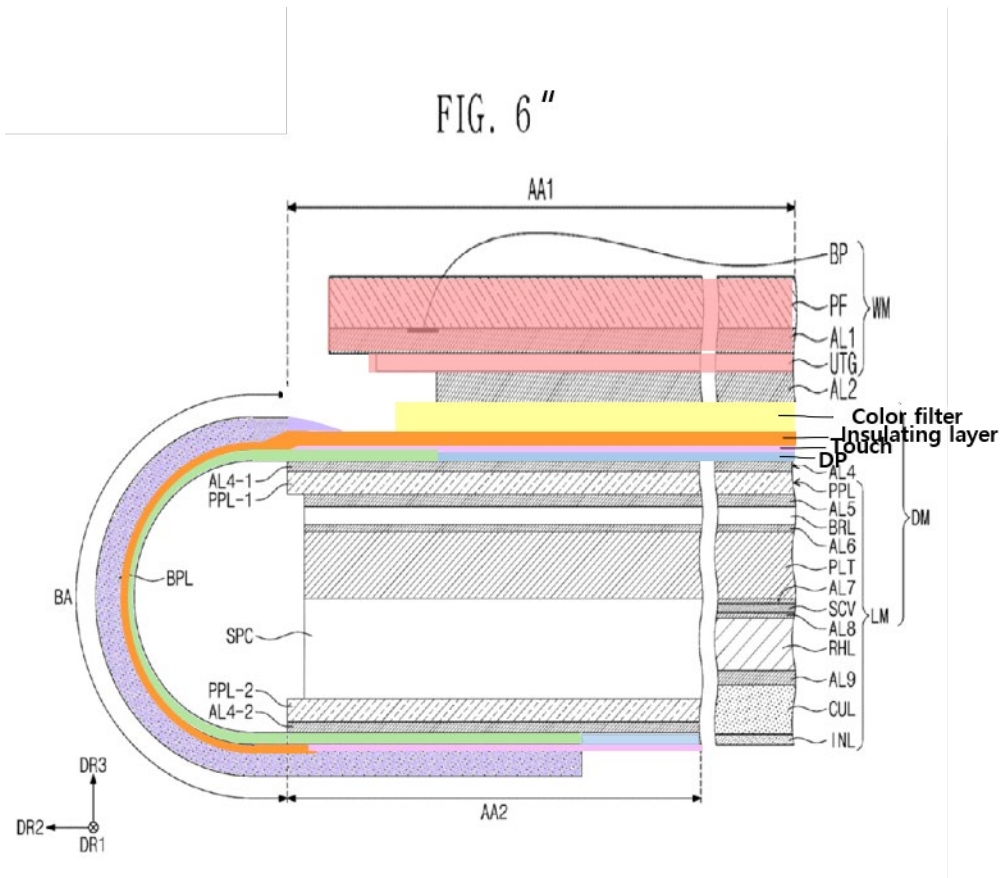
- b. Claim 3: The display device according to claim 1, further comprising a touch control layer disposed between the flexible screen body and the color filter and an insulating layer disposed between the touch control layer and the color filter; wherein the protective layer is disposed on a surface of the insulating layer, and a thickness of the protective layer on the surface of the insulating layer is less than or equal to a distance between one side of the coverplate adjacent to the insulating layer and one side of the insulating layer adjacent to the coverplate.**

166. Shin-Luo teaches Claim 3 for the reasons described in Section VII.A.2.b.

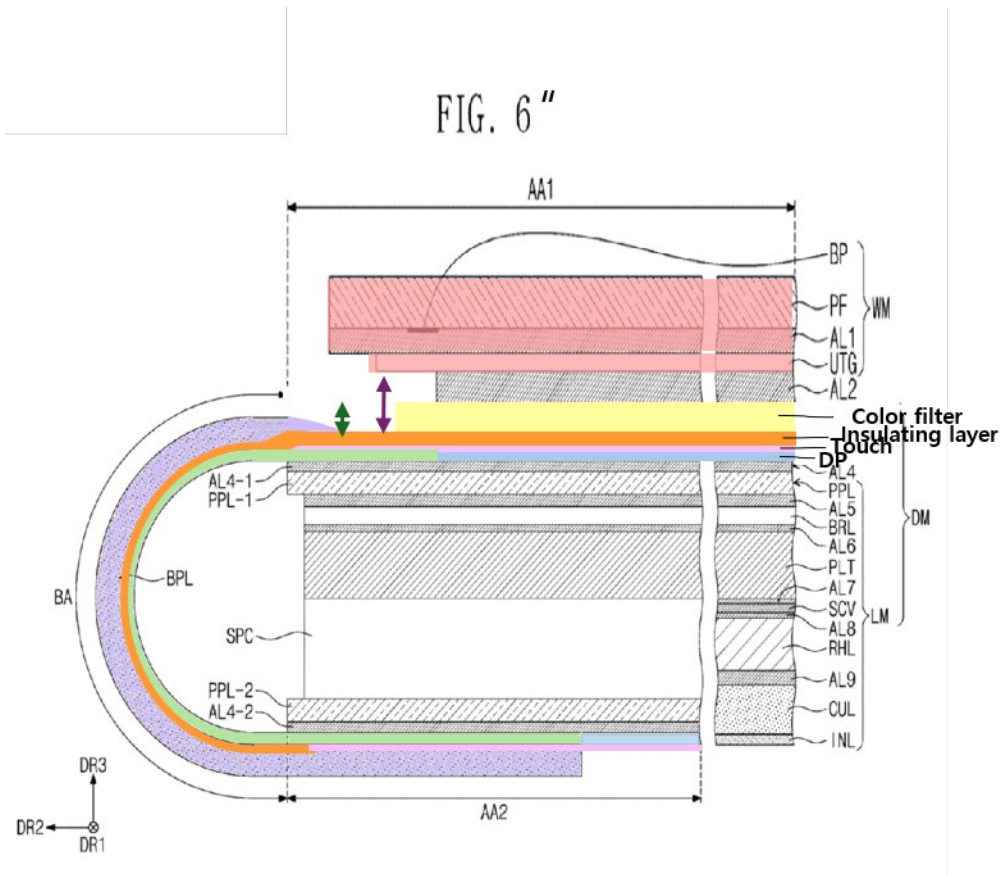
167. In the modified, annotated version of Shin's Figure 6 below, Shin's optical film LF (yellow) is disposed on input sensor IS (pink), as taught by Shin for Figure 3, with Luo's teachings described above. Ex-1005, 6'' (Shin-Luo).



168. In the Shin-Luo combination, a POSITA would have implemented Shin's Figure 6 embodiment with the BPL disposed on a surface of the insulating layer (orange) of the input sensor IS (pink), which is, in turn, attached to the DP, as shown in Figure 6'' below.



169. As shown in modified, annotated versions of Shin's Figure 6 below, the thickness of the BPL (designated by the green arrow) on the surface of the insulating layer (orange) is less than the distance between one side of the coverplate (i.e., WM (red)) adjacent to the insulating layer and one side of the insulating layer adjacent to the coverplate (designated by the purple arrow). Ex-1005, Fig. 6''.



c. Claim 5

- (1) 5[pre]: The display device according to claim 1, wherein the bending area comprises a transitional bending sub-area, a bending sub-area, and an extending bending sub-area defined in sequence, and the transitional bending sub-area is connected to and flush with the planar area;

170. In my opinion, Shin-Luo teaches Element 5[pre] for the reasons described in Section VII.A.2.b.1.

- (2) **5[a]: the protective layer completely covers the bending sub-area and covers at least a part of the transitional bending sub-area; and**

171. In my opinion, Shin-Luo teaches Element 5[a] for the reasons described in Section VII.A.2.b.2.

- (3) **5[b]: the coverplate is connected to the color filter by an optical adhesive, and the coverplate completely covers the planar area and covers at least the part of the transitional bending sub-area.**

172. In my opinion, Shin-Luo teaches Element 5[b] for the reasons described in Section VII.A.2.b.3.

- d. **Claim 7: The display device according to claim 5, wherein the protective layer further covers at least a part of the extending bending sub-area.**

173. In my opinion, Shin-Luo teaches Claim 7 for the reasons described in Section VII.A.2.c.

- e. **Claim 8: The display device according to claim 5, wherein the protective layer is a UV glue.**

174. In my opinion, Shin-Luo teaches Claim 8.

175. Luo teaches that the protective layer (i.e., MCL) is a UV glue. Specifically, Luo teaches that “[v]arious appropriate materials and various appropriate fabricating methods may be used to make the coating layer” such as “a UV curable adhesive material” including, for example, those containing “a free radical generating photoinitiator and a compound having multiple unsaturated

groups (e.g., acrylate, methacrylate or vinyl groups), such as an oligomer having multiple unsaturated groups and, optionally, a monomer having multiple unsaturated groups,” “type I or type II photoinitiators, such as benzoin ether, 1-hydroxycyclohexylphenyl-ketone or benzophenone, among others,” “epoxy acrylates (e.g., bisphenol-A-epoxy acrylate), aliphatic urethane acrylates (e.g., IPDI-based aliphatic urethane acrylates), aromatic urethane acrylates, polyether acrylates, polyester acrylates, aminated acrylates, and acrylic acrylates,” and/or “a cationic photoinitiator and an epoxide compound.” Ex-1006 ¶116. Luo’s UV curable adhesive material that is used for the coating layer corresponds to the recited “UV glue.”

176. In addition to the reasons described in Section VII.B.1, a POSITA would have been motivated to implement Shin’s BPL as a UV glue, as taught by Luo, because UV curable adhesive materials like glues are typically chosen to protect layers in electronic devices during bending due to their flexibility, temperature performance, and ability to keep layers bonded to each other during dynamic bending.

- f. Claim 9: The display device according to claim 5, further comprising: a support layer, wherein one side of the support layer supports the planar area and the transitional bending sub-area, and another side of the support layer away from the planar area supports the extending bending sub-area.**

177. In my opinion, Shin-Luo teaches Claim 9 for the reasons described in Section VII.A.2.d.

- g. Claim 10: The display device according to claim 9, wherein the support layer comprises a first backplate disposed on one side of the planar area and the transitional bending sub-area away from the coverplate and a second backplate disposed on one side of the extending bending sub-area away from the protective layer.**

178. In my opinion, Shin-Luo teaches Claim 10 for the reasons described in Section VII.A.2.e.

- h. Claim 11: The display device according to claim 10, wherein a foam is disposed between the first backplate and the second backplate.**

179. In my opinion, Shin-Luo teaches Claim 11 for the reasons described in Section VII.A.2.f.

- i. Claim 12: The display device according to claim 11, wherein a stiffener plate is disposed between the foam and the second backplate.**

180. In my opinion, Shin-Luo teaches Claim 12 for the reasons described in Section VII.A.2.g.

- j. **Claim 13: The display device according to claim 12, wherein a heat dissipation layer is disposed between the foam and the stiffener plate.**

181. In my opinion, Shin-Luo teaches Claim 13 for the reasons described in Section VII.A.2.h.

- k. **Claim 14: The display device according to claim 5, wherein a distance between one side end of the protective layer adjacent to the planar area and an initial bending position of the flexible screen body is greater than a first default value, wherein the first default value is greater than or equal to 0, and the initial bending position is a jointed position of the bending sub-area and the transitional bending sub-area.**

182. In my opinion, Shin-Luo teaches Claim 14 for the reasons described in Section VII.A.2.i.

- l. **Claim 15: The display device according to claim 14, wherein a distance between one side end of the protective layer adjacent to the extending bending sub-area and a terminal bending position of the flexible screen body is greater than a second default value, wherein the second default value is greater than or equal to 0.**

183. In my opinion, Shin-Luo teaches Claim 15 for the reasons described in Section VII.A.2.j.

- m. Claim 17: The display device according to claim 5, wherein the optical adhesive is an optically clear adhesive (OCA).**

184. In my opinion, Shin-Luo teaches Claim 17 for the reasons described in Section VII.A.2.k.

- n. Claim 18: The display device according to claim 13, wherein a material of the heat dissipation layer is a metal material or graphite, and the metal material comprises one or more combinations of copper foil, aluminum foil, or stainless steel foil.**

185. In my opinion, Shin-Luo teaches Claim 18 for the reasons described in Section VII.A.2.l.

- o. Claim 19: The display device according to claim 9, further comprising a driving unit disposed on one surface of the extending bending sub-area away from the support layer.**

186. In my opinion, Shin-Luo teaches Claim 19 for the reasons described in Section VII.A.2.m.

C. Grounds 3–4: Claim 3 Is Obvious over Shin in View of Lee’538 or Shin-Luo in View of Lee’538

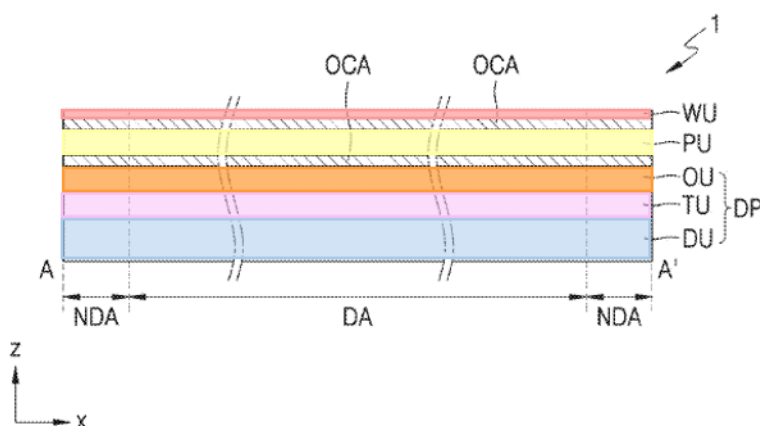
1. Dependent Claim 3

- a. Claim 3: The display device according to claim 1, further comprising a touch control layer disposed between the flexible screen body and the color filter and an insulating layer disposed between the touch control layer and the color filter; wherein the protective layer is disposed on a surface of the insulating layer, and a thickness of the protective layer on the surface of the insulating layer is less than or equal to a distance between one side of the coverplate adjacent to the insulating layer and one side of the insulating layer adjacent to the coverplate.**

187. In my opinion, Shin in view of Lee’538 (“Shin-Lee’538”) (Ground 3) or Shin-Luo in view of Lee-538 (“Shin-Luo-Lee’538”) (Ground 4) teaches Claim 3.

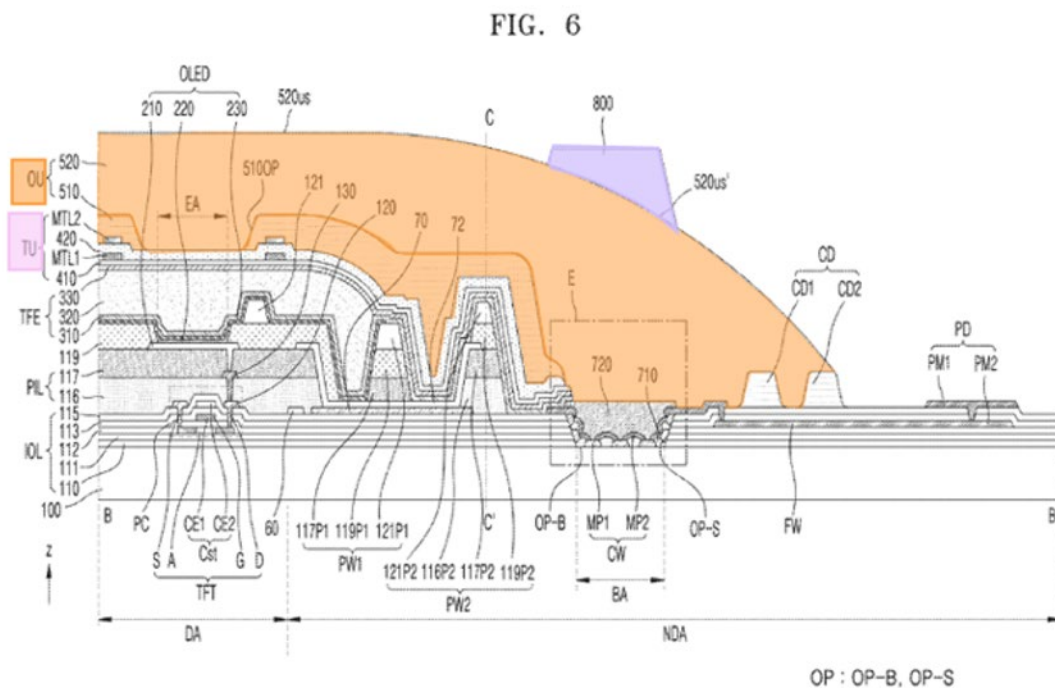
188. To the extent PO argues that Shin or Shin-Luo does not teach the particular layer configuration recited by claim 3, the configuration is also taught by Lee’538. Lee’538 teaches display apparatus 1, which includes “display layer DU,” “touch sensing layer TU,” “optical functional layer OU,” “polarization layer PU,” and a window layer WU.” Ex-1007, 6:33–36. As shown in annotated Figure 2A below, Lee’538’s touch control layer (i.e., TU (pink)) is disposed between the flexible screen body (i.e., DU (blue)) and the optical functional layer (i.e., OU (orange)). Ex-1007, Fig. 2A. Moreover, Lee’538’s polarization layer PU (yellow) is disposed between the OU and WU (i.e., the coverplate) layers. *Id.*

FIG. 2A



189. Lee’538 further teaches an insulating layer disposed between the touch control layer and color filter and a protective layer disposed on a surface of the insulating layer. Specifically, as shown in annotated Figure 6 below, Lee’538 teaches that “optical functional layer OU may be disposed on the touch sensing layer TU” and includes “**first layer 510 [orange]** that covers the second conductive layer MTL2 and is arranged on the second insulating layer 420, and **the second layer 520 [orange] arranged on the first layer 510.**” Ex-1007, 15:39–44, Fig. 6. Lee’538 also teaches that “**first layer 510 may include an insulating material** having a first refractive index.” Ex-1007, 15:43–59. Moreover, Lee’538 teaches that second layer 520 “may include **an organic insulating material**” (Ex-1007, 8:53–54) and “may **extend over the peripheral area NDA while covering the bending area BA.**” Ex-1007, 11:40–41. Lee’538 further teaches stress reduction layer 800 (purple), which is “disposed on the second layer 520 of the optical functional layer OU,” “arranged

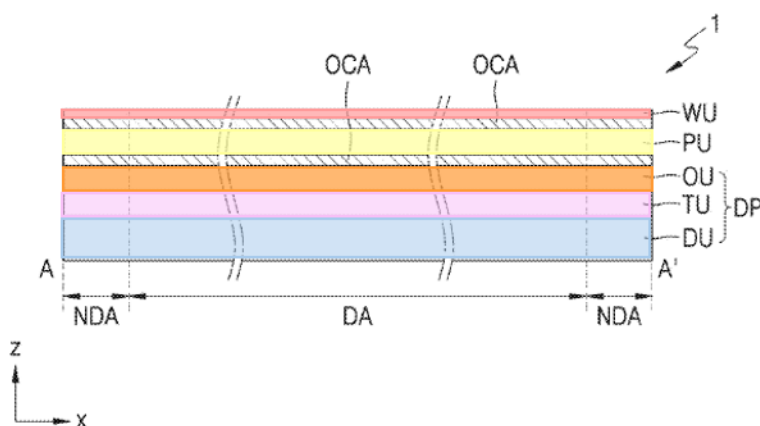
to correspond to the bending area BA,” and includes “an organic insulating material.” Ex-1007, 19:18–22. First layer 510 and second layer 520 together correspond to the recited “insulating layer” and stress reduction layer 800 corresponds to the recited “protective layer disposed on a surface of the insulating layer.”



190. Lee’538 further teaches that a thickness of the protective layer (i.e., 800) on the surface of the insulating layer (i.e., 510, 520) is less than or equal to a distance between one side of the coverplate (i.e., window layer WU in Fig. 2A) adjacent to the insulating layer and one side of the insulating layer adjacent to the coverplate. While Lee’538 teaches that the thicknesses of layers are “arbitrarily illustrated” (Ex-1007, 5:20–24), a POSITA would have understood that because at

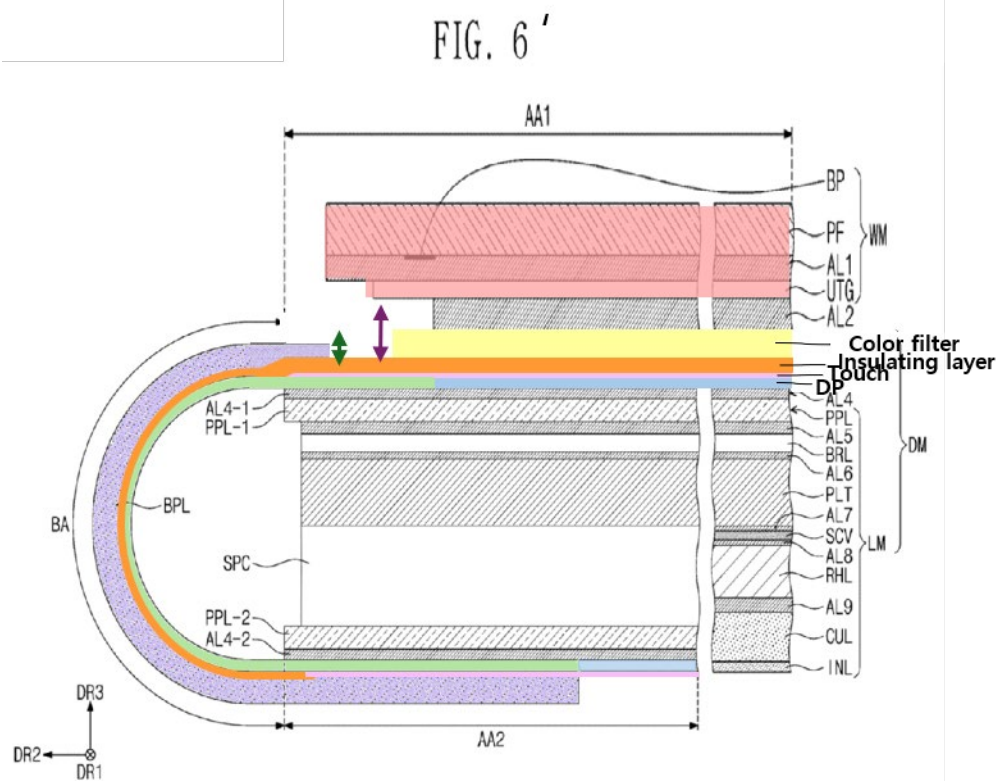
least the polarization layer PU (yellow) is disposed between the insulating layers (i.e., 510, 520) of the OU (orange) and the coverplate (i.e., WU (red)), which, like all physical structures, must have some finite thickness (*see* Fig. 2A), the thickness of the protective layer (800) on the surface of the insulating layer (510, 520) would have a thickness less than the distance between the WU and the insulating layer (510, 520).

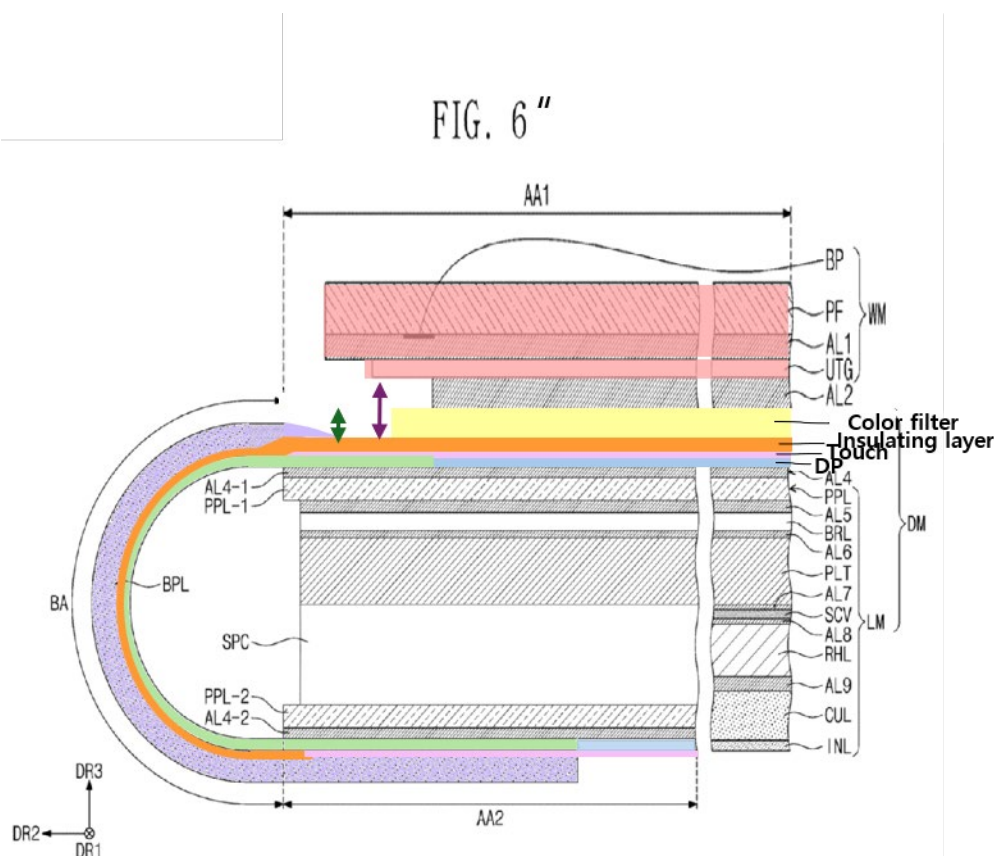
FIG. 2A



191. Lee'538 thus clearly depicts the specific positional relationships between the touch layer, insulation layer, and protective layer in the bending area. Lee'538's optical functional layer (orange) corresponds to Shin's insulating layer; Lee'538's polarization layer PU (yellow) corresponds to Shin's color filter LF; Lee'538's stress reduction layer (purple) corresponds to Shin's BPL and Luo's MCL; and Lee'538's touch sensing layer TU (pink) corresponds to Shin's input sensor IS. *See* Sections VII.A.2.b and VII.B.3.b. Ex-1002 ¶[[[]]. Shin, Luo, and

Lee'538 all share the common objective of preventing cracks and facilitating bending. *Id.* They similarly disclose forming a protective layer on the display panel surface and bonding a polarizer or LF to a cover plate or window (indicating that such a process exists). Lee'538 provides specific teachings on how the back plane in the panel should be configured before and after the bending area (BA). In the Shin-Lee'538 (Ground 3) or Shin-Luo-Lee'538 (Ground 4) combination, as shown in modified, annotated versions of Shin's Figure 6 below, Shin's BPL is disposed on a surface of the insulating layer, as taught by Lee'538, and a thickness of the BPL is less than or equal to a distance between one side of the coverplate (i.e., WM) adjacent to the insulating layer and one side of the insulating layer adjacent to the WM, as taught by Lee'538.





192. A POSITA would have been motivated to combine the teachings of Shin and Lee'538 (Ground 3) or Shin-Luo and Lee'538 (Ground 4) and had a reasonable expectation of success in doing so because all three relate to flexible, bendable display devices including multiple defined layers and similar components. *See* Section VII.B.1; Ex-1007, Abstract, Figs. 2A, 6. Moreover, both Shin and Luo's vertical structures are similar, which ultimately implies that they employ similar processes. A POSITA would thus have understood that these references disclose interrelated teachings based on well-understood technologies that would have been amenable to various well-understood and predictable combinations.

D. Grounds 5–6: Claims 4–6 Are Obvious over Shin in View of Lee’703 or Shin-Luo in View of Lee’703

- 1. A POSITA would have been motivated to combine Shin’s teachings with Lee’703’s teachings or Shin-Luo’s teachings with Lee’703’s teachings and would have had a reasonable expectation of success.**

193. A POSITA would have been motivated to combine the teachings of Shin and Lee’703 (Ground 5) or Shin-Luo and Lee’703 (Ground 6) and had a reasonable expectation of success in doing so because all three relate to flexible, bendable display devices including multiple defined layers and similar components. *See* Section VII.B.1; Ex-1009, Abstract, Fig. 12.

194. Shin teaches that its protective layer (i.e., BPL) is adjacent to instead of disposed on the surface of its color filter (i.e., LF) (*see, e.g.*, Ex-1005, Fig. 6). However, a POSITA would have understood that the placement of the protective layer vis-à-vis the color filter is a design choice and it would have been obvious to dispose the protective layer on the surface of the color filter. Additionally, Shin teaches that the coverplate (i.e., WM) is connected to the color filter (i.e., LF) by an optical adhesive (i.e., AL2) and that the BPL covers the transitional bending sub-area. While Shin does not expressly describe the thickness of the BPL vis-à-vis the AL2 layer, a POSITA would have understood that an obvious design choice would have been to make the thickness of the AL2 greater than a maximum thickness of the BPL in the transitional bending sub-area.

195. Lee'703 teaches "a polarizer and an organic light-emitting display device equipped therewith." Ex-1009, Abstract. Specifically, Lee'703 teaches that "polarizer (100) is disposed beneath the planar surface portion (420) of the cover glass (400)" and "comprises a first adhesive layer (120), a polarizing layer (130)," and a second adhesive layer (140)." Ex-1009 ¶108. Lee'703 further teaches that organic light-emitting display panel (500) includes coating layer (560), which may be disposed on a portion of the upper surface of the polarizing layer (130)." Ex-1009 ¶¶110, 117. Lee'703 also teaches that coating layer (560) "is composed of an insulating material" and "intended to prevent moisture penetration and wiring cracks, and may be disposed so as to cover at least the bent region." Ex-1009 ¶116. Moreover, Lee'703 teaches a first adhesive layer (120) between the polarizer layer (130) and the coverplate (400) and that the thickness of first adhesive layer (120) is greater than a maximum thickness of coating layer (560) on the transitional bending sub-area. Ex-1009 ¶108, Fig. 12.

196. Lee'703 coating layer 560 corresponds to Shin's BPL; Lee'703's polarizer 130 corresponds to Shin's color filter LF; and Lee'703's coverplate 400 corresponds to Shin's coverplate WM. While Lee'703's protective layer is disposed on a surface of a polarizer instead of a color filter, in the Shin-Lee'703 or Shin-Luo-Lee'703 combination, the protective layer (purple) would be disposed on the surface of Shin's color filter (yellow) as shown in modified, annotated Figure 6' below. Ex-

1005, Fig. 6'. A POSITA would have been motivated to arrange Shin's components in this manner because, for example, it would prevent cracks, as taught by Lee'703, which is also a goal of Shin's invention. *See, e.g.*, Ex-1005 ¶¶109, 113. Specifically, Lee'703 teaches that its key inventive elements focus on managing micro-scale shear stress, impact absorption, and interfacial adhesion within flexible display stacks. A POSITA would have also been motivated to implement Lee'703's teachings that the thickness of the BPL is less than or equal to a distance between one side of the WM (red) adjacent to the LF and one side of the LF adjacent to the WM and the thickness of the AL2 (teal) is greater than a maximum thickness of the BPL on the transitional bending sub-area, in Shin's display device.

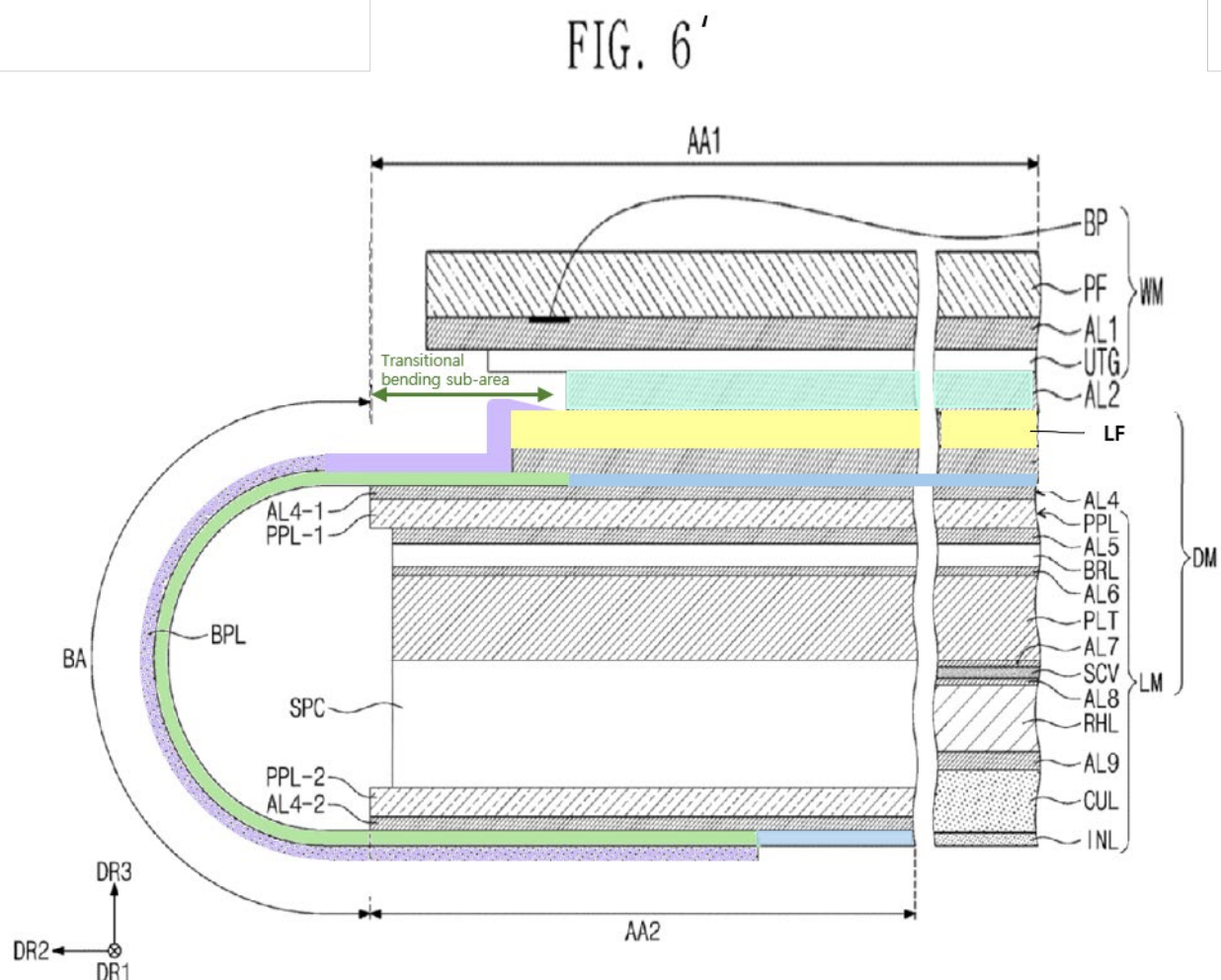
197. A bending area is an area that can cause damage and Shin teaches that cracking and delaminating are issues that need to be addressed. Shin teaches the effect of intense mechanical stress, especially tensile stress on the outer bending layers in the form of stretching, as well as compressive stress on the inner bending layers in the form of squeezing and squishing. This is pertinent for the UTG and PF layers that are bound by OCA for the folding movement. Shin also teaches that if the adjacent organic layers such as protective coatings, encapsulation and cushion layers, adhesive layers etc., are over compressed or improperly dimensioned, the resulting stress distribution in the layers is uneven and could lead to micro-cracking. Examples would be delamination between the glass and protective film or cracking

of the UTG, or even deformation, creasing or other non-linear effects of the organic layers. Shin teaches that controlling the layer thickness, stiffness, and squeezing or compression of the organic layers is important for high-quality operation of the display. Shin notes that the regions around the UTG are especially important during the bending process. For example, regulating the thickness ratios of the PF, adhesives and UTG is important. Shin also teaches that avoiding compression over-squeeze and regulation of viscosity and flow characteristics will help mitigate layer delamination. For example, if layers are too thick and become over compressed during the lamination process then their performance will deteriorate. This also is important for the viscosity specifications of organic layers especially those close or adjacent to the UTG and PF interface.

198. A POSITA would have been motivated to combine the structural teaching of Lee with Shin and Luo to improve the engineering trade-offs with bendable displays. A POSITA would have looked to improve display flexibility at the bend radius while also improving surface rigidity and impact resistance across whole display. A POSITA would also have been able to address a broad-spectrum mechanical failure modes that are common in flexible, bendable displays that range from micro-scale organic adhesive shear stress to macro-scale hinge plate mechanics and kinematics with the combination. A POSITA would have understood that both micro-scale and macro-scale issues needed to be addressed in order to improve

bendable display quality, and potentially to reduce failure modes such as UTG cracking, adhesive delamination, severe creasing, or poor impact resistance. A POSITA would have understood that this combination uses standard techniques in the industry which would not have needed significant research and development.

199. As shown in Figure 6' below, in the Shin-Lee'703 (Ground 5) or Shin-Luo-Lee'703 (Ground 6) combination, Shin's BPL is disposed on a surface of the LF, and a thickness of the BPL is less than or equal to a distance between one side of the WM adjacent to the LF and one side of the LF adjacent to the WM, as taught by Lee'703. Moreover, the thickness of the AL2 is greater than a maximum thickness of the BPL on the transitional bending sub-area, as taught by Lee'703.



200. A POSITA would have had a reasonable expectation of success in combining the teachings of Shin and Lee'703 (Ground 5) and Shin-Luo and Lee'703 (Ground 6). All three describe flexible, bendable display devices including similar layers and components. *See* Section VII.B.1; Ex-1009, Abstract, Fig. 12. A POSITA would thus have understood that these references disclose interrelated teachings

based on well-understood technologies that would have been amenable to various well-understood and predictable combinations.

2. Dependent Claims 4–6

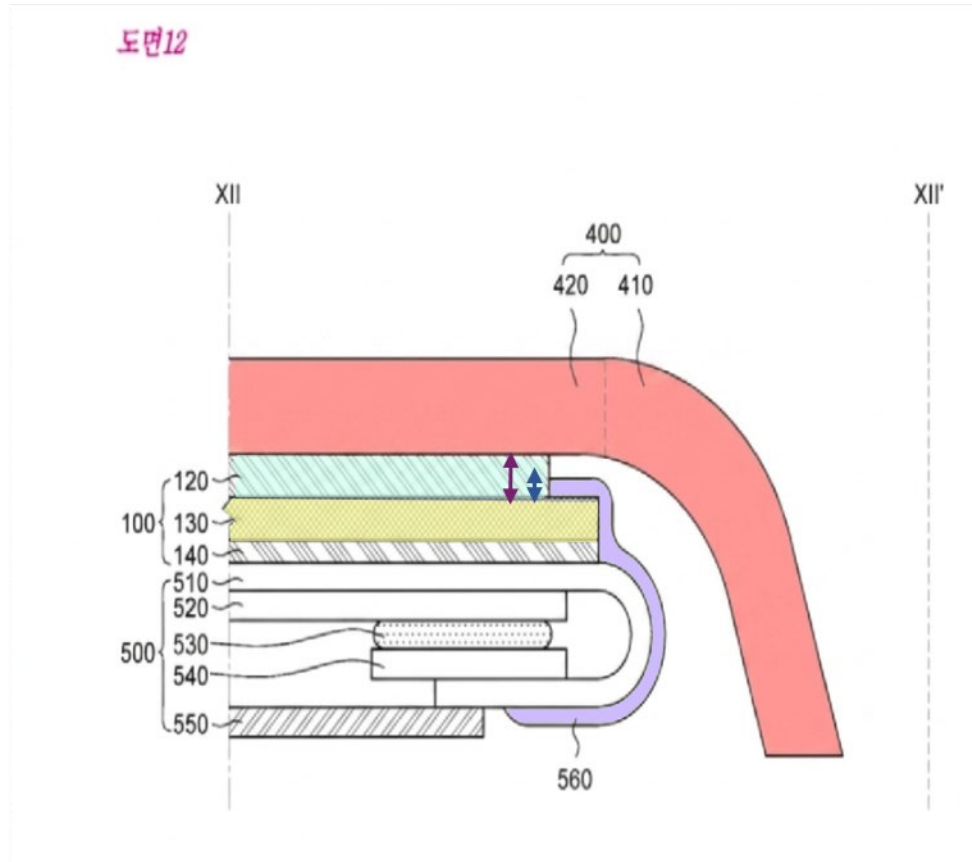
- a. **Claim 4: The display device according to claim 2, wherein the protective layer is further disposed on a surface of the color filter, and a thickness of the protective layer on the surface of the color filter is less than or equal to a distance between one side of the coverplate adjacent to the color filter and one side of the color filter adjacent to the coverplate.**

201. In my opinion, Shin in view of Lee’703 (“Shin-Lee’703”) (Ground 5) or Shin-Luo in view of Lee’703 (“Shin-Luo-Lee’703”) (Ground 6) teaches Claim 4.

202. Shin illustrates the protective layer (i.e., BPL) as adjacent to instead of disposed on the surface of the color filter (i.e., LF). *See, e.g.*, Ex-1005, Fig. 6. However, a POSITA would have understood that the placement of the protective layer vis-à-vis the color filter is a design choice and it would have been obvious to dispose the protective layer on the surface of the color filter. A similar arrangement is taught by Lee’703.

203. As shown in annotated Figure 12 below, Lee’703 teaches that “polarizer (100) and the organic light-emitting display panel (500) are disposed inside the *cover glass (400) [red]*.” Ex-1009 ¶106, Fig. 12. Specifically, Lee’703 teaches that “polarizer (100) is disposed beneath the planar surface portion (420) of the cover glass (400)” and “comprises a first adhesive layer (120), a polarizing layer

(130) [yellow],” and a second adhesive layer (140).” Ex-1009 ¶108. Lee’703 further teaches that “organic light-emitting display panel (500) includes a substrate (510) with a bent portion, a first back plate (520), a foam tape (530), a second back plate (540), a driving unit (550), and *a coating layer (560) [purple]*.” Ex-1009 ¶110. Moreover, Lee’703 teaches that “coating layer (560) may be disposed on a portion of the upper surface of the polarizing layer (130).” Ex-1009 ¶117. Lee’703 also teaches that coating layer (560) “is composed of an insulating material” and “intended to prevent moisture penetration and wiring cracks, and may be disposed so as to cover at least the bent region.” Ex-1009 ¶116. Lee’703’s cover glass (400) corresponds to the recited “coverplate” and coating layer (560) corresponds to the recited “protective layer.” While Lee’703’s protective layer is disposed on a surface of a polarizer instead of a color filter, in the Shin-Lee’703 or Shin-Luo-Lee’703 combination, the protective layer would be disposed on the surface of Shin’s color filter. A POSITA would have been motivated to arrange Shin’s components in this manner because, for example, it would prevent cracks, as taught by Lee’703, which is also a goal of Shin’s invention. *See, e.g.*, Ex-1005 ¶¶109, 113. Indeed, this was a well-known arrangement of such components by the time of the invention. *See, e.g.*, Ex-1010 (Park) ¶130 (teaching a bending protection layer (“BPL”) 600 disposed on the surface of a color filter 520), Fig. 3).



204. Lee’703 further teaches that a thickness of the coating layer (i.e., 560) on the surface of the polarizer (i.e., 130) is less than or equal to a distance between one side of the coverplate (i.e., 400) adjacent to the polarizer and one side of the polarizer adjacent to the coverplate because, as shown in Figure 12, the thickness of coating layer (560) on polarizer layer (130) (designated by the blue arrow) is less than the distance between polarizer layer (130) and the cover glass (400) (designated by the purple arrow). Indeed, Lee’703 teaches that the purpose for this distance “to prevent the coating layer (560) from overflowing.” Ex-1009 ¶117 (“a step may be formed between the first adhesive layer (120) and the polarizing layer (130) in the

area in contact with the coating layer (560) to prevent the coating layer (560) from overflowing”).

205. Additionally, as explained in Section VII.B.1, Luo teaches that a thick protective layer leads to issues such as first interference region, R_{i1} . Consequently, the problem to be solved is clearly disclosed in Luo itself. Specifically, Luo proposes keeping the thickness of the MCL (BPL) lower than the sum of the OCA and polarizer and adjusting parameters such as tapering. Ex-1006 ¶¶76–79, Fig. 6. In contrast, Lee’703 employs a different approach: it increases the thickness of the OCA and utilizes a coating layer thinner than the OCA to cover the polarizer, thereby creating a step difference.

206. As shown in modified, annotated version of Shin’s Figure 6 below, in the Shin-Lee’703 or Shin-Luo-Lee’703 combination, Shin’s protective layer (i.e., BPL) is further disposed on the surface of the color filter (i.e., LF), and a thickness of the BPL on the surface of the LF is less than or equal to a distance between one side of the coverplate (i.e., WM) adjacent to the LF and one side of the LF adjacent to the coverplate, as taught by Lee’703. While Lee’703’s teachings relate to a polarizer, a POSITA would have been motivated to arrange Shin’s components (including Shin’s color filter) in this manner because, for example, it would prevent the BPL from overflowing, as taught by Lee’703.

that can create shear forces that might lead to delamination, cracking etc., that would deteriorate display performance. A POSITA looking to use a color filter would have looked to Shin's BPL and would have seen a smaller step-height and less associated stress with the combination, which would potentially result in improved display performance. A POSITA would have understood that such performance could be measured in increased manufacturing yield, lower cost, longer lifetime, and higher reliability. A POSITA would have understood that typical color filters are composed of photo-patterned organic resins. To ensure integrity of these materials under tight bending conditions, a POSITA would have looked to Shin's BPL to help distribute stress more evenly, and mitigate potential deterioration of the display stack. A POSITA would have understood that the combination would have increased overall display performance with a number of parameters and performance specifications.

b. Claim 5

- (1) 5[pre]: The display device according to claim 1, wherein the bending area comprises a transitional bending sub-area, a bending sub-area, and an extending bending sub-area defined in sequence, and the transitional bending sub-area is connected to and flush with the planar area;**

208. In my opinion, Shin-Lee'703 or Shin-Luo-Lee'703 teaches Element 5[pre] for the reasons described in Section VII.A.2.b.1.

- (2) **5[a]: the protective layer completely covers the bending sub-area and covers at least a part of the transitional bending sub-area; and**

209. In my opinion, Shin-Lee'703 or Shin-Luo-Lee'703 teaches Element 5[a] for the reasons described in Section VII.A.2.b.2.

- (3) **5[b]: the coverplate is connected to the color filter by an optical adhesive, and the coverplate completely covers the planar area and covers at least the part of the transitional bending sub-area.**

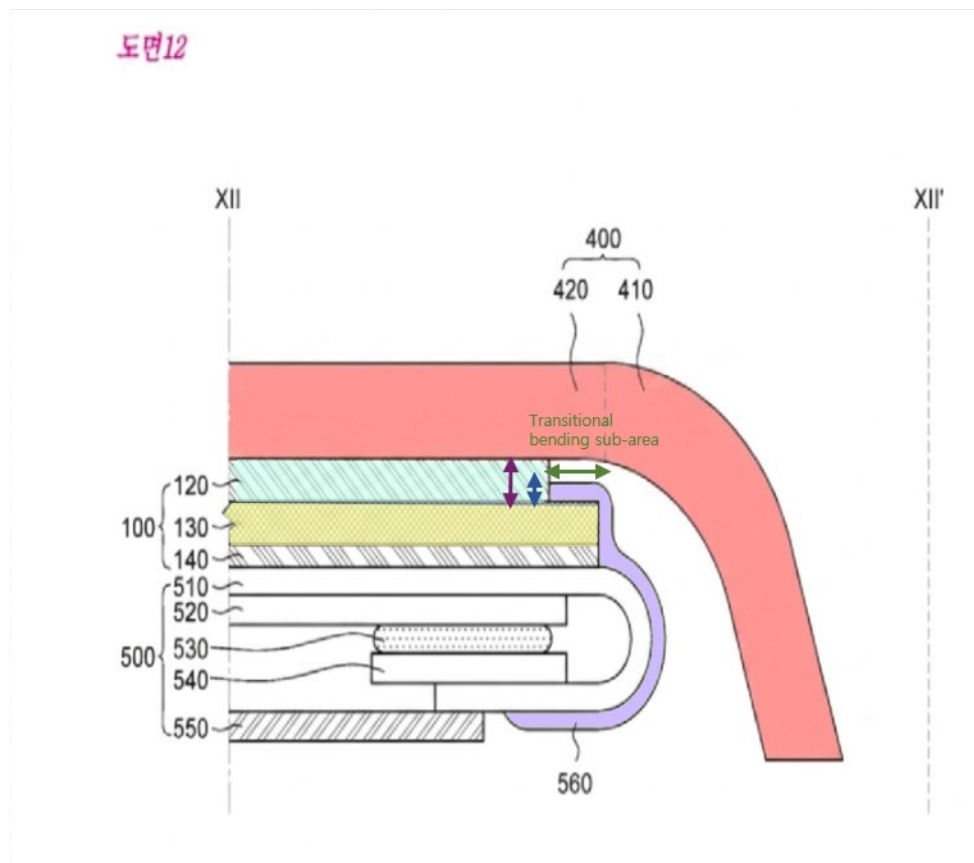
210. In my opinion, Shin-Lee'703 or Shin-Luo-Lee'703 teaches Element 5[b] for the reasons described in Section VII.A.2.b.3.

- c. **Claim 6: The display device according to claim 5, wherein a thickness of the optical adhesive is greater than a maximum thickness of the protective layer on the transitional bending sub-area.**

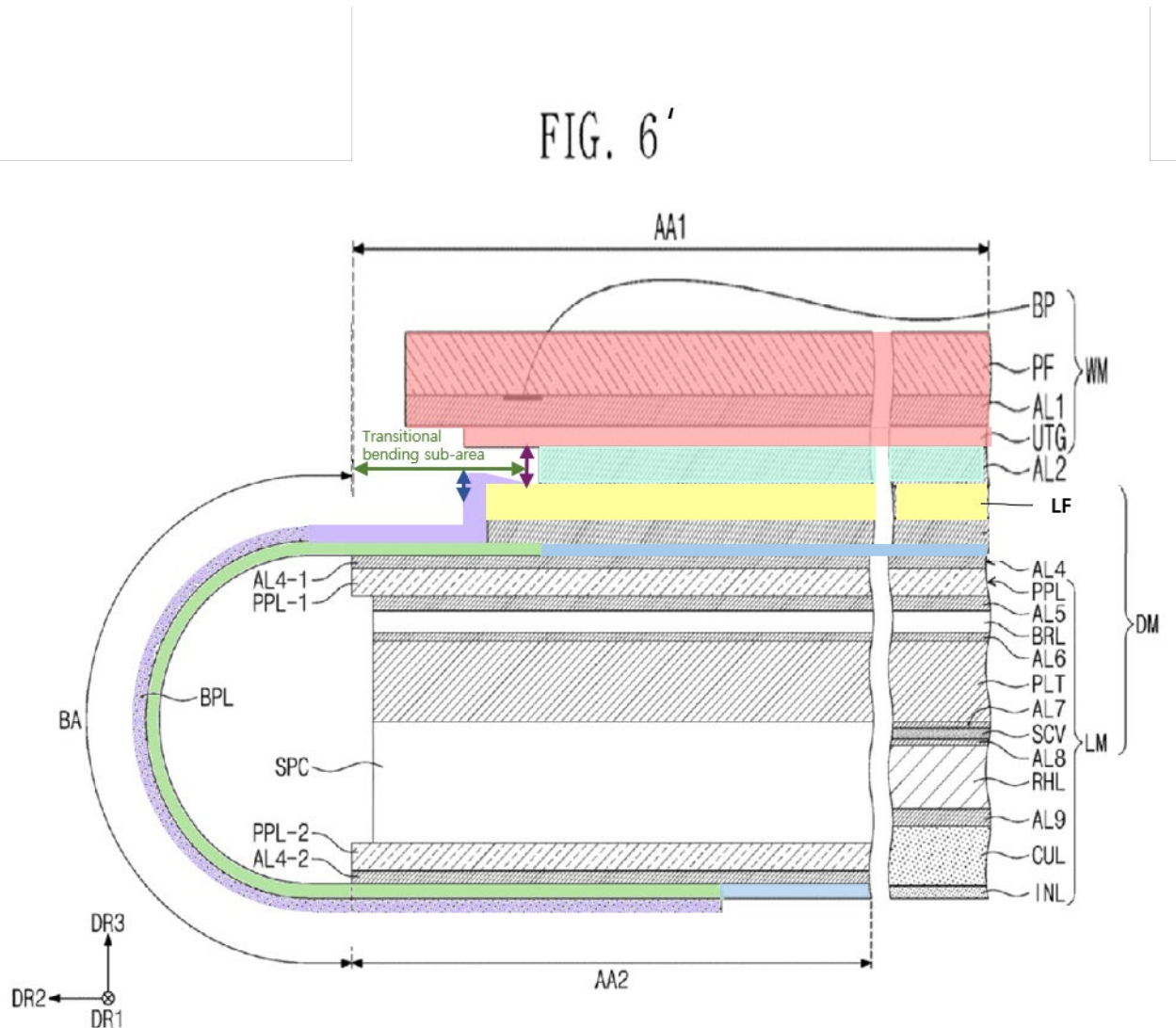
211. In my opinion, Shin-Lee'703 or Shin-Luo-Lee'703 teaches Claim 6.

212. Shin teaches that the coverplate (i.e., WM) is connected to the color filter (i.e., LF) by an optical adhesive (i.e., AL2) and that the protective layer (i.e., BPL) covers the transitional bending sub-area for the reasons described in Section VII.A.2.b. Shin does not expressly describe the thickness of the protective layer (i.e., BPL) vis-à-vis the AL2 layer but a POSITA would have understood that an obvious design choice would have been to make the thickness of the AL2 greater than a maximum thickness of the BPL in the transitional bending sub-area, as taught by Lee'703.

213. As shown in annotated Figure 12 below, Lee’703 teaches a first adhesive layer (120) (teal) between the polarizer layer (130) (yellow) and the coverplate (400) (red). Ex-1009 ¶108, Fig. 12; *see also id.* ¶109 (“first adhesive layer (120) of the polarizer (100) may be bonded to the lower surface of the planar surface portion (420) of the cover glass (400)” and “secure[s] the cover glass (400) and the polarizer (100) together”). Additionally, Lee’703 teaches that the thickness of first adhesive layer (120) (designated by the purple arrow) is greater than a maximum thickness of coating layer (560) (designated by the purple arrow) on the transitional bending sub-area (designated by the blue arrow).



214. As shown in modified, annotated version of Shin's Figure 6 below, in the Shin-Lee'703 or Shin-Luo-Lee'703 combination, the thickness of Shin's optical adhesive (i.e., AL2) is greater than a maximum thickness of Shin's protective layer (i.e., BPL) on the transitional bending sub-area, as taught by Lee'703. Ex-1005, Fig. 6'.



E. Grounds 7–8: Claim 16 Is Obvious over Shin in View of Park or Shin-Luo in View of Park

1. Dependent Claim 16

- a. Claim 16: The display device according to claim 1, wherein the planar area comprises a plurality of red sub-pixel units, green sub-pixel units, and blue sub-pixel units, the color filter comprises a plurality of color resists and a black matrix disposed among the color resists, and the color resists comprise red color resists, green color resists, and blue color resists; and wherein the red color resists are disposed corresponding to the red sub-pixel units, the green color resists are disposed corresponding to the green sub-pixel units, and the blue color resists are disposed corresponding to the blue sub-pixel units.**

215. In my opinion, Shin in view of Park (“Shin-Park”) (Ground 7) or Shin-Luo in view of Park (“Shin-Luo-Park”) (Ground 8) teaches Claim 16.

216. Shin teaches that the planar area where the color filter resides comprises a plurality of color filters and a black matrix. Specifically, Shin teaches “optical film LF may include color filters in a color filter layer,” which “may have an arrangement ... be determined in consideration of emitted colors of the pixels PX in the display panel DP.” Ex-1005 ¶86. Shin also teaches that “optical film LF may further include a black matrix.” Ex-1005 ¶86. Shin leaves the implementation details regarding the specific sub-pixel units that may be included with the color filter to a POSITA. It would have been obvious that red, green, and blue color sub-pixel units and their

corresponding color resists would be included because these are the most common color arrays used in color filters. These are also taught by Park.

217. Park teaches a plurality of red sub-pixel units, green sub-pixel units, and blue sub-pixel units. Specifically, Park teaches that “display area DA includes pixels P,” each of which “may be connected to a signal line, such as a scan line SL extending in the first direction or a data line DL extending in the second direction.” Ex-1010 ¶57. Park also teaches that “pixels P may include electronic elements, such as a thin film transistor (“TFT”) and a storage capacitor, electrically connected to the signal line and the power line and an organic light-emitting device (“OLED”) connected to the electronic elements.” Ex-1010 ¶58. Park further teaches that “pixels P may emit, for example, a red light, a green light, a blue light or a white light through the OLED” and “pixels P may each be a sub-pixel that emit light of one of a red color, a green color, and a blue color as described above, or a sub-pixel that emit light of any one of a red color, a green color, a blue color, and a white color.” Ex-1010 ¶58. A POSITA would thus have understood that Park teaches a display area containing a plurality of red, green, and blue sub-pixel units. Park also teaches that the active display area (DA) includes a plurality of light-emitting elements (OLEDs) arranged across sub-pixels and that these sub-pixels are configured to emit light of different primary colors in a RGB sub-pixel format to form color images across the display area.

218. Moreover, a POSITA would have understood that Park teaches a color filter as part of the top layer filter, comprising a plurality of color resists and a black matrix. Specifically, Park teaches a top film, which may be a color filter. Ex-1010 ¶92. Park further teaches that “the color filter may clarify emission color and reduce the reflection of external light due to the inclusion of a matrix of a color corresponding to the color of each pixel and a black matrix.” Ex-1010 ¶93. A POSITA would have understood that Park’s apparatus includes color resists corresponding to the sub-pixel units because it was known that the color matrix and color resists are applied in sequence and work together to form the complete color filter structure. Additionally, it was known that the color matrix resist (i.e., black matrix) and the color resists are essential parts of the color filter. Thus, a POSITA would have understood that Park includes the recited “color resists” comprising “red color resists, green color resists, and blue color resists; and wherein the red color resists are disposed corresponding to the red sub-pixel units, the green color resists are disposed corresponding to the green sub-pixel units, and the blue color resists are disposed corresponding to the blue sub-pixel units.”

219. A POSITA would have been motivated to combine the teachings of Shin and Park (Ground 7) or Shin-Luo and Park (Ground 8) and had a reasonable expectation of success in doing so because all three relate to flexible, bendable display devices including multiple defined layers and similar components. *See*

Section VII.B.1; Ex-1010, Abstract. A POSITA would thus have understood that these references disclose interrelated teachings based on well-understood technologies that would have been amenable to various well-understood and predictable combinations. In the Shin-Park or Shin-Luo-Park combination, Shin's color filter comprising a plurality of color filters and a black matrix further comprises a plurality of red sub-pixel units, green sub-pixel units, and blue sub-pixel units and a plurality of color resists comprising red color resists, green color resists, and blue color resists, which are disposed corresponding to the red sub-pixel units, the green sub-pixel units, and the blue sub-pixel units, respectively, as taught by Park.

VIII. CONCLUSION

220. For at least the reasons cited above, I believe that Claims 1-19 of the '031 Patent are unpatentable in view of the prior art.

221. I declare under the penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Dated: September 10, 2026

Respectfully Submitted,



Michael Lebby, Ph.D.