

Declaration of Dr. Ioannis Kymissis
U.S. Patent No. 8,132,952
Claims 1, 2, 4, 5

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD. AND
SAMSUNG ELECTRONICS AMERICA, INC.
Petitioner

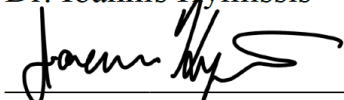
v.

SINOTECHNIX LLC
Patent Owner

Case IPR2025-00335
U.S. Patent No. 8,132,952
Claims 1, 2, 4, 5

DECLARATION OF IOANNIS KYMISSIS, PH.D.
ON BEHALF OF PETITIONER

Name: Dr. Ioannis Kymissis

Signature: _____

Date: January 6, 2025

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I, Ioannis Kymissis, declare as follows:

1. My name is Ioannis Kymissis.
2. I have been retained as an expert witness on behalf of Petitioner Samsung Electronics Co., LTD., and Samsung Electronics America, Inc. to provide expert opinions on the validity of U.S. Patent No. 8,132,952 (“’952 Patent”).

I. Introduction

3. I am currently the Kenneth Brayer Professor in Electrical Engineering and Vice Dean of Infrastructure and Innovation at Columbia’s school of Engineering and Applied Science in New York, NY. I have been a faculty member in the Department of Electrical Engineering since 2006.

4. I received a bachelor’s (S.B.) in Electrical Engineering and Computer Science in 1998, a master’s (M.Eng.) in Electrical Engineering and Computer Science in 1999, and a doctoral degree (Ph.D.) in Electrical Engineering and Computer Science in 2003, all from Massachusetts Institute of Technology (MIT) in Cambridge, MA. I was a co-op at IBM research while I was a student, and worked at IBM’s laboratories in Yorktown Heights, New York, and Tokyo, Japan while also pursuing my undergraduate and M.Eng degrees. Part of this work was on backplanes and new technologies for liquid crystal displays, in collaboration with IBM’s Display Business Unit. My Ph.D. thesis was in the field of field emission displays.

I also completed a post-doc at MIT, where I worked on OLED technologies, semiconductors, and quantum dot-based materials.

5. After my post-doc, I worked as a Technical Consultant and Senior Engineer at QDVision from 2005-2006. QDVision was, at that time, developing quantum dot sensitized OLED displays (QDLEDs) and quantum dot based downconversion elements for LCD display backlights (QLED).

6. I joined the faculty at Columbia University in 2006, where I have been teaching and conducting research for around 18 years. In general, I teach courses in solid state electronics, including undergraduate and graduate level courses in physics, thin film electronics, and displays. I have taught a course on displays for nearly 20 years, in which we cover a broad range of topics, including organic light emitting diode (“OLED”) displays, liquid crystal displays (“LCD”), visual perception, color science, wave optics, emissive displays, and their mechanisms, display back panels, and 3D displays.

7. Over the course of my career, I have supervised many students, including around twenty Ph.D. candidates and fourteen post-doctoral associates. Several of these theses related to LED devices, and one current student is working on LCDs, including backplane design and backlight integration.

8. I have authored over 150 publications in peer-reviewed academic journals, transactions, and books. Many of these publications are in the field of

OLED displays, LCD displays, color science, and display back panels. I have also presented at and/or contributed to over 150 conferences, where many of my presentations were on the topic of OLED displays, LCD displays, color science, and display back panels.

9. I am a named inventor in 51 issued U.S. patents across 39 families; many of these concern various designs and manufacturing methods for semiconductor-based devices, including LEDs, field effect transistor systems, methods for patterning thin films, and lithography techniques.

10. I am a member of and have held positions in many professional organizations, program committees, and editorial boards. I am currently President and have served as President Elect, Treasurer, Secretary, and Publication Chair for the Society for Information Display (SID). I have also served as the Editor in Chief for the Journal of the Society for Information Display, and have served as an Associate Editor for the IEEE Open Journal of Immersive Displays, among other editorial boards.

11. I have received several awards for my technical experience. I am a fellow of Optica, SID, SPIE, the National Academy of Inventors, and the Institute of Electrical and Electronics Engineers.

12. A copy of my curriculum vitae (“CV”) is attached as Appendix A. My CV includes my employment history, education, awards, advisory positions, publications, conference presentations, and patents.

13. In general, I am familiar with matters involving patents, including analyzing claims from the perspective of a person of ordinary skill in the art at the time the purported invention was made.

14. I am familiar with the technology described in U.S. Patent No. 8,132,952 (“’952 Patent”).

15. To my knowledge and understanding, the ’952 Patent claims priority to U.S. Patent No. 7,959,321 filed September 25, 2007, which claims priority to PCT/KR2006/000885 filed March 13, 2006, which claims priority to KR 10-2005-0027133 filed March 31, 2005.

16. I am familiar with the knowledge and capabilities of a person of ordinary skill in the art at the time of the earliest possible priority date of the ’952 Patent, which is March 31, 2005.

17. In preparation for this declaration, I have reviewed and considered the following references, which I understand to be prior art in view of the earliest possible priority date of the ’952 Patent:

- U.S. Patent Publication No. 2005/0007516 (“Hong”)
- W.O. Patent Publication No. 2004/097949 (“Lee”)

- Applicant Admitted Prior Art (“AAPA”), which is provided in the ’952 Patent in the “Background Art” section encompassing the specification at column 1, line 25 to column 2, line 53, and Figure 1

18. Below, I provide the list of exhibits that I considered during my preparation of this Declaration. I have reviewed all of the exhibits and all documents mentioned in my Declaration. Further, my opinions are based on my technical education, experience, and training in the field.

Exhibit No.	DESCRIPTION
1001	U.S. Patent No. 8,132,952 (“’952 Patent”)
1003	U.S. Patent Publication No. 2005/0007516 (“Hong”)
1004	PCT Application Publication No. WO Patent Publication No. 2004/097949 (“Lee”)
1005	U.S. Patent Publication No. 2004/0233665 (“West”)
1006	U.S. Patent Publication No. 2002/0187571 (“Collins”)
1007	PCT Application Publication No. WO 2000/060406 (“Johnson”)
1008	U.S. Patent Publication No. 2005/0184638 (“Meuller”)
1009	U.S. Patent No. 6,252,254 (“Soules”)
1010	U.S. Patent Publication No. 2005/0254258 (“Lee ’258”)
1011	PCT Application Publication No. WO 1997/048134 (“Turnbull”)
1014	File History of the ’952 Patent
1015	File History of U.S. Application No. 11/909,700
1016	U.S. Patent Publication No. 2004/0130884 (“Yoo”)
1017	“Resins for Optics,” Three Bond Technical News, Jul. 1, 2004
1018	U.S. Patent No. 6,738,120 (“Song”)
1019	U.S. Patent No. 4,229,783 (“Eberhardt”)
1020	U.S. Patent No. 5,587,816 (“Gunjima”)

19. I have been retained as an expert for Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. in the field of display devices including backlight panels.

20. My compensation for this case is at my usual and customary rate for the time I spent on this IPR. My compensation is not and will not be affected by the outcome of this case.

21. I have no financial interest in the outcome of the case. I also do not have any financial interest in either Samsung Electronics Co., Ltd. or Samsung Electronics America, Inc.

22. I do not have personal contact or knowledge of the named inventors in the '952 Patent.

II. Relevant Law

23. I am not an attorney. Petitioner's counsel has informed me about the following aspects of patent law, which I applied in my analysis and conclusions.

A. Person of Ordinary Skill in the Art

24. I have been informed that a patent and prior art should be reviewed from the perspective of a person of ordinary skill in the art ("POSITA"). I understand that a POSITA is an individual who is hypothetical, is of ordinary creativity, and would have been familiar with the prior art as of the patent's claimed priority date.

25. I have been informed that there are various factors that are applicable in determining the level of a person of ordinary skill in the art. These include:

- (1) the educational level of the inventor;
- (2) type of problems encountered in the art;
- (3) prior art solutions to those problems;
- (4) rapidity with which innovations are made;
- (5) sophistication of the technology; and
- (6) educational level of active workers in the field.

26. I have been informed that not all such factors may be present in every case, and one or more of these or other factors may predominate.

B. Claim Construction

27. I have been informed that claim construction is a matter of law that will ultimately be determined by the Board. To determine the meaning of claim terms for the purposes of the *inter partes* review, I have been informed that one should generally use the ordinary and customary meaning as understood by a POSITA at the time of the claimed priority date, in view of the claim language, patent specification, and the file history. I have been informed that the proper interpretation of the claim term should be arrived at in light of the patent's claims, specification, and file history.

28. Further, I understand that although a claim term should be read in light of the specification, limitations should not be imported into the claim from the specification. I understand that interpreting a claim term to exclude a preferred embodiment is often inaccurate. I have also been informed that the prosecution history can facilitate the meaning of a claim term or a claim by demonstrating how the inventor understood the invention and by showing whether the inventor limited the claim term or claim during the course of prosecution or caused the claim scope to be narrower than it otherwise would be.

C. Obviousness

29. I have been informed that a claim is invalid if the claim would have been obvious from the perspective of a POSITA at the time the alleged invention was made.

30. I understand that an obviousness evaluation involves consideration of several factors, including:

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

31. In determining whether a combination based on multiple references would have been obvious, it is appropriate to consider, among other factors:

- a. whether the teachings of the prior art references disclose known concepts combined in familiar ways, which, when combined, would yield predictable results;
- b. whether a person of ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so;
- c. whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by those skilled in the art;
- d. whether a person of ordinary skill would have recognized a reason to combine known elements in the manner described in the claim;
- e. whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and
- f. whether the claim applies a known technique that had been used to improve a similar device or method in a similar way.

32. I understand that a claim is obvious if it combines old elements without any change to their respective functions. I also understand that a claim is obvious if

the claim simply substitutes one element for another element known in the field, and the resulting combination yields predictable results. Further, while it may be helpful for there to be a reason for the combination, I understand that it is not strictly required to find an express teaching, suggestion, or motivation to combine within the references. Market forces, such as design incentives, can prompt variations of a product, either in the same field or a different field. Further, for techniques, if a technique has been used to improve one device and if a POSITA would recognize that applying the same technique would have improved a different device in a comparable way, then it would have been obvious if common sense directs one to combine multiple prior art references or add missing factors.

33. I have been informed and understand that hindsight bias must be avoided when determining obviousness. Accordingly, the patent's claims and descriptions cannot be used as a roadmap when analyzing combinations of prior art references.

D. Summary of Opinions

34. As I explain below, I conclude that claims 1, 2, 4, and 5 of the '952 Patent are obvious in view of prior art: Hong, Lee, and, optionally, AAPA.

Ground	35 U.S.C.	Claims	Prior Art Reference(s)
I	§103	1, 2, 4, 5	Hong, Lee
II	§103	2, 4, 5	Hong, Lee, Applicant Admitted Prior Art ("AAPA")

III. Technology Background

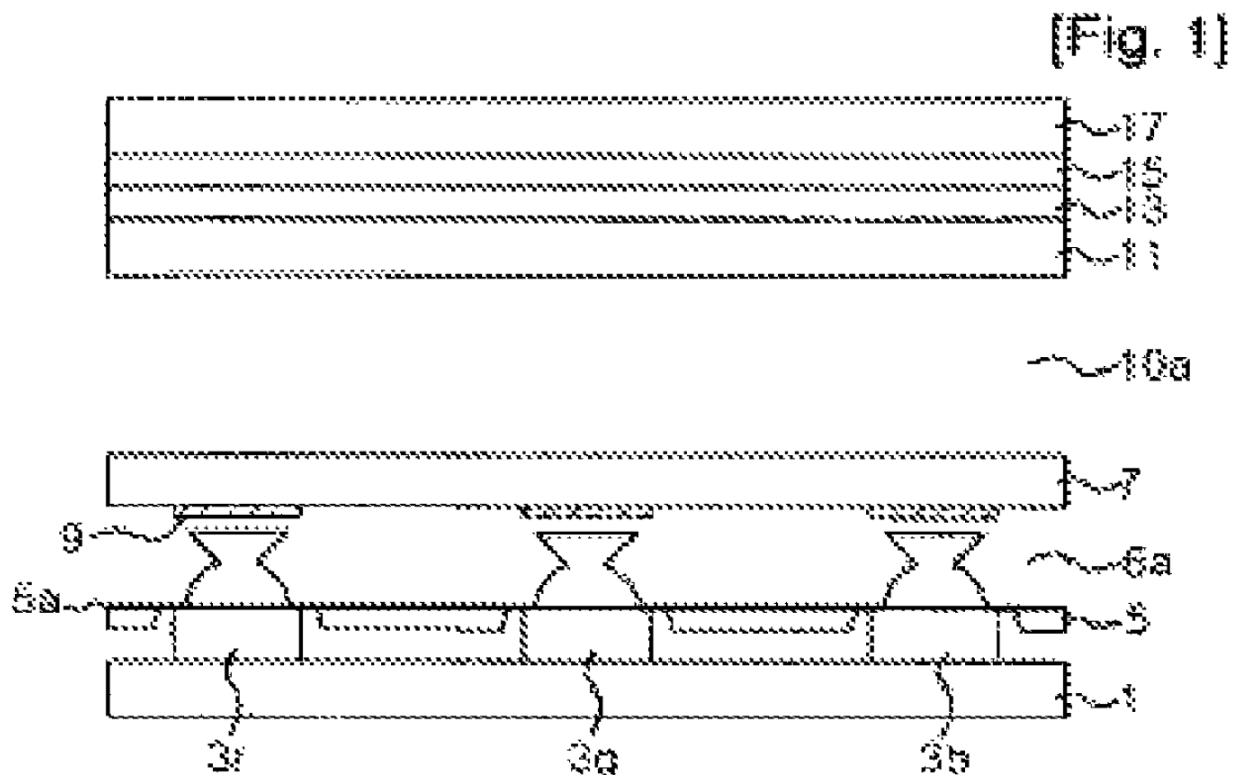
A. Backlight Panels In Liquid Crystal Display (LCD) Device

35. By the time of the earliest claimed priority date of the '952 patent, it was well known that liquid crystals had light modulating properties, such that liquid crystals could be incorporated into a liquid crystal display (LCD) panel of an LCD device to present an image or other information. EX1018, 1:12-26. Liquid crystals are unable to generate light, however, and as such, when LCD panels display images or other information in low-light conditions, the information can be difficult or impossible to see. EX1016, [0018]. Accordingly, an LCD device can incorporate a separate light source, such as a backlight panel, to be able to display the information even in low lighting conditions and improve the display of the information. EX1016, [0012], [0045].

36. Backlight panels are not new. In fact, backlight panels have been progressively developed for several decades. As one example, U.S. Patent 4,229,783 titled "Backlight for Electrooptic Display" was filed in 1979. EX1019, *Title*. Multiple light sources can be used to generate light for a backlight panel and other components may also be incorporated into the backlight panel to make the light coming from the backlight panel more uniform. EX1001, 1:45-2:31 (describing "Background Art"). Some of the other components can include a light mixing chamber, a diffusion sheet, a reflection sheet, and a brightness enhancement sheet.

The diffusion sheet can diffuse light, which makes the light coming from the backlight panel more uniform. The reflection sheet directs the light coming from the light sources to the LCD panel, which can improve brightness. Further, the brightness enhancement sheet further improves the brightness by directing light to the LCD panel. EX1001, 1:58-2:31; EX1005, [0022], [0030], [0032], Figure 3; EX1016, [0020], [0052].

37. A configuration of a backlight panel that was well known at the time of the '952 Patent is illustrated by Figure 1 of the '952 Patent (which is Applicant Admitted Prior Art), reproduced below.



EX1001, Figure 1.

B. White Light Emitting Diodes For Backlight Panels

38. Backlight panels in general use white light to shine light onto an LCD panel, so that the LCD panel may have colors that span the color gamut. EX1011, 1:22-28. A wide variety of light sources may be used to generate white light, including, for example, incandescent lamps and fluorescent lamps. EX1019, 2:33-37. EX1020, 4:35-48. In comparison to those sources, LEDs generally have less power usage and a longer effective life. EX1004, 1:18-21; EX1007, 3:11-15. Accordingly, backlight panels with LEDs became widespread. EX1001, Figure 1; EX1003, Figures 1, 3, [0012]-[0013].

39. LEDs natively emit light in specific colors, including red, green, and blue, and do not generally emit white light, which causes challenges to their application in backlight panels. EX1009, 1:16-19. Therefore, several ways have been developed for LEDs to generate white light in a backlight panel – e.g., by using red LEDs, green LEDs, and blue LEDs, each of which can emit red, green, and blue light, respectively, and the mix of which can create white light. EX1001, 1:48-51, 2:7-19; EX1003, [0021]. White light can also be created with a blue LED chip and arranging phosphors that emit red and green light on top of the blue LED chip. EX1004, 14:10-20. When red and green phosphors are arranged on top of the blue LED chip, the phosphors emit green and red light when the phosphors absorb the blue light from the blue LED chip, and white light is created by mixing light from

each of those sources (blue light from the blue LED chip, red light emitted by the red phosphor, and green light emitted by the green phosphor). The phosphors can be provided on a blue LED chip using a resin that has the phosphor particles mixed therein. EX1004, Figure 5 14:10-21; EX1008, [0031].

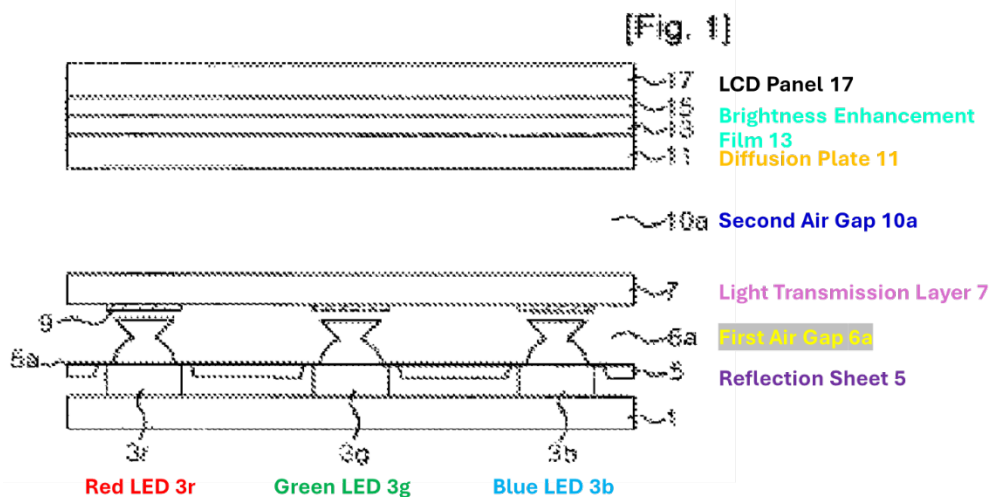
IV. Overview Of The '952 Patent

A. Alleged Problems

40. The '952 Patent is directed to “a backlight panel for backlighting a display panel, and more particularly, to a backlight panel employing a white light emitting diode with red and green phosphors as a light source to enhance color reproducibility and luminance.” EX1001, 1:19-23.

41. In Figure 1 of the '952 Patent describing AAPA, as reproduced below, “a partial sectional view illustrating a conventional backlight panel for backlighting an LCD panel using light emitting diodes (LEDs)” is shown. EX1001, 1:45-47. The conventional backlight panel, as explained by the '952 Patent, includes red LEDs, which generate red light, green LEDs, which generate green light, and blue LEDs, which generate blue light. To reflect the red, green, and blue light from the red, green and blue LEDs, the conventional backlight panel, as explained by the '952 Patent, also includes a reflection sheet 5. The light from the reflection sheet 5 is reflected towards an LCD panel 17. Further, to mix the red, green, and blue lights, the backlight panel also includes a first air gap 6a. A light transmission layer 7 is

also included in the backlight panel and the light transmission layer 7 transmits the mixed light. In addition, the backlight panel includes another air gap (a second air gap 10a) in which the mixed light transmitted through the light transmission layer 7 is further mixed. The backlight panel also includes a diffusion plate 11, which receives light from the second air gap 10a, diffuses the received light, and causes the received light to become more uniform. Still further, the backlight panel includes a brightness enhancement film (BEF) 13, which is placed on the diffusion plate 11 (e.g., on a top surface of the diffusion plate 11). EX1001, 1:45-2:31.



EX1001, Fig. 1.¹

42. In the conventional configuration described by the '952 Patent, a backlight panel uses individual red, green, and blue LEDs and has multiple air gaps (e.g., the first air gap 6a and the second air gap 10a). As mentioned above, the red,

¹ All annotations are added unless noted otherwise.

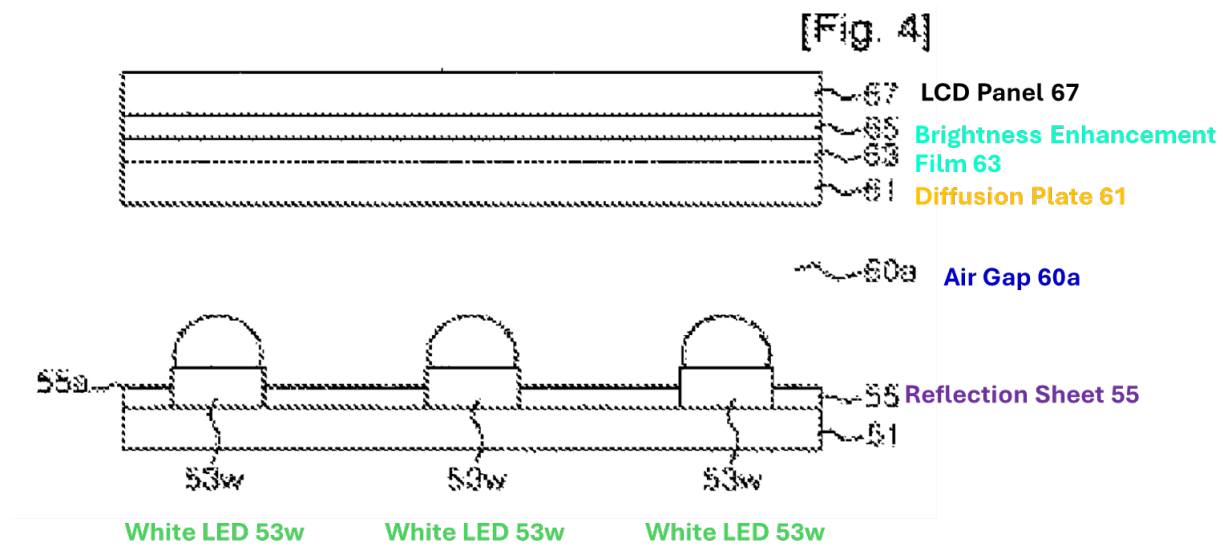
green, and blue light emitted by the red, green, and blue LEDs is mixed in the first air gap 6a and the second air gap 10a to create white light. However, having the first air gap 6a and the second air gap 10a “result in an increase in thickness of a backlight panel.” EX1001, 2:34-41. In addition, “while light emitted from the LEDs is mixed, light loss is generated. Thus, such light loss should be compensated by increasing an amount of current supplied to the LEDs, by using a larger number of LEDs or by using the [brightness enhancement film].” EX1001, 2:42-46. Using more current, using more LEDs, or by using brightness enhancement films increases the power consumption, cost of manufacturing, and bulkiness of the backlight panel.

B. Purported Invention

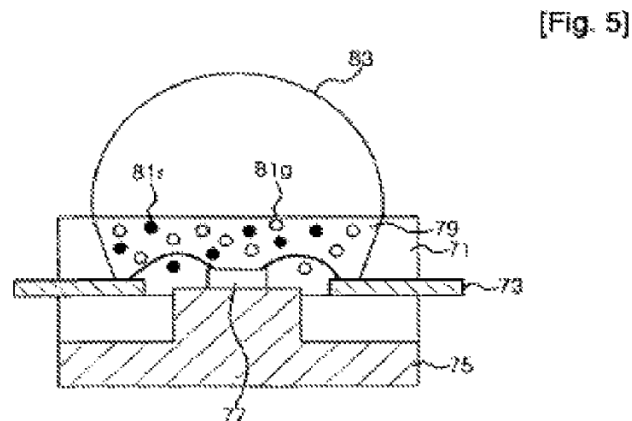
43. To address these problems, the '952 Patent substitutes the red, green, and blue LEDs with “white light emitting diode[s] with red and green phosphors,” each unit of which would generate light, rather than using individual red, green, and blue LEDs, the emitted light of which would then have to be mixed to create white light. EX1001, 2:66-3:1.

44. In Figure 4, reproduced below, a backlight panel incorporates the white LEDs as described above such that “white LEDs 53w are arranged below the bottom surface of the diffusion plate 61 at a certain interval from the diffusion plate 61.” EX1001, 6:14-25. Further, in Figure 5, reproduced below, “each of the white LEDs 53w includes a blue LED chip, and green and red phosphors positioned over the blue

LED chip.” EX1001, 6:20-22. In particular, the ’952 Patent describes “The red and green phosphors may be either coated on the LED chip 77 or positioned in a molding member 79 in a state where they are contained therein as shown in this figure. The molding member 79 may be made of an epoxy or silicone resin and formed into a single layer or multiple layers.” EX1001, 7:45-50.



EX1001, Figure 4.



EX1001, Figure 5.

45. Comparing the conventional backlight panel of Figure 1 (shown in Section IV.A [Alleged Problems]) with the backlight panel of Figure 4, it is evident that both backlight panels are substantially similar. The primary difference between the two panels is that the backlight panel in Figure 1 has separate red, green, and blue LEDs and the one in Figure 4 substitutes those separate red, green, and blue LEDs with white LEDs. The backlight panel of Figure 4 does not have the first air gap 6a and the light transmission layer 7 of the backlight panel of Figure 1, since the backlight panel of Figure 4 includes white LEDs, each of which generate white light by combining blue light emitted by a blue LED chip and red light emitted by red phosphors and green light emitted by green phosphors. Thus, white light is emitted directly onto the bottom surface of the LEDs by the LEDs. EX1001, Figures 1, 5, 6:49-55.

C. Prosecution History Of The '952 Patent

46. I have reviewed the file history of the '952 patent and the parent application of the '952 Patent, which is U.S. Patent Application No. 11/909,700. EX1014; EX1015. Below, I summarize the relevant information from the file history of the '952 Patent and any additional relevant information from the file history of related applications that is pertinent to my opinion.

47. The '952 Patent was filed as U.S. Application No. 12/904,219 ("219 Application") on October 14, 2010. The '219 Application is a continuation

application of U.S. Application No. 11/909,700 (“’700 Application”), filed September 25, 2007. The ’700 Application is a national stage application of PCT Application No. PCT/KR2006/000885, filed March 13, 2006, which claims priority to Korean Patent Application No. 10-2005-0027133, filed March 31, 2005. EX1014 [FH of the ’219 Appl], 5-6; EX1015 [FH of the ’700 Appl].

48. The ’219 Application originally included claims 1-8. During prosecution, the Examiner issued a Non-Final Office Action on March 3, 2011. EX1014, 810. In that office action, the Examiner rejected claims 1, 2, 4, and 5 under 35 U.S.C. 103(a) based on U.S. Patent Application Publication No. 2005/0254258 (Lee ’258) and U.S. Patent Application Publication No. 2005/0247953 (Lin). EX1014, 812-813. A provisional statutory double patenting rejection was also issued over claims 1-7 of U.S. Patent Application No. 11/909,700. EX1014, 813-814.

49. In the response dated June 2, 2011, the Applicant filed a certified copy of the Korean priority reference (Korean Application No. 10-2005-0027133) to disqualify Lee ’258 as a prior art reference. EX1014, 938-959. The Applicant also argued that filing a terminal disclaimer over U.S. Patent Application No. 11/909,700 would be premature, as the claims had not been allowed. EX1014, 937.

50. The Examiner then issued a Final Office Action on September 2, 2011. In the Final Office Action, the Examiner maintained the double patenting rejection

over claims 1-7 of U.S. Patent Application No. 11/909,700. EX1014, 962-965.

51. On October 28, 2011, the Applicant filed a response with a terminal disclaimer over claims 1-7 of U.S. Patent Application No. 11/909,700. EX1014, 988.

52. The Examiner then issued a Notice of Allowability on November 9, 2011, which provided that claim 1 was allowable “because the prior art of record failed to teach or suggest all of the features of the claimed invention...” EX1014, 1001, 1006.

53. Accordingly, the claims of the original application (’219 application) issued in the ’952 Patent without any amendment.

V. Level Of Ordinary Skill In The Art

54. I have reviewed the factors relevant for determining the level of a POSITA outlined in Section II.A in the context of the ’952 Patent. The ’952 Patent relates to a backlight panel that uses light emitting diodes. EX1001, Title, Abstract (“Disclosed is a backlight panel employing a white light emitting diode. The white light emitting diode includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip”). The concept of using LEDs in backlight panels was well known by March 31, 2005 (the claimed priority date). In fact, backlight panels date back many decades, as explained above in Section III.A. EX1019 (which was filed in 1979). Accordingly, backlight panels

with LEDs were prevalent by March 31, 2005. EX1003–EX1006. EX1004, 1:22-23 (“In recent years, white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD).”).

55. As such, a POSITA as of the earliest claimed priority date of the ’952 Patent would have had a Bachelor’s degree in Electrical Engineering, Electronics Engineering, Material Science, Physics, or an equivalent field, and approximately two years of experience in the field of display design, including LCD displays. Lack of professional experience can be substituted by additional education, and vice versa.

56. At the time of the claimed priority date of the ’952 Patent (March 31, 2005), I met and/or exceeded the above requirements for a POSITA.

VI. Claim Construction

57. I have reviewed the specification, the claims, and the file history of the ’952 Patent.

58. I have been asked to determine if any claim term should be construed so the Board can understand how the prior art references read on the challenged claims. I have not identified any terms that the Board needs to construe for the purposes of this IPR.

VII. Specific Grounds Of Invalidity

A. Ground I: Hong And Lee Render Obvious Claims 1, 2, 4, And 5.

1. Overview Of Hong

59. I will begin with the description of a prior art reference called Hong. EX1003.

60. Hong already disclosed most of the claimed subject matter before the '952 Patent. Similar to the '952 Patent, Hong describes “a liquid crystal display panel with a reduced thickness, a lower weight and an improved picture quality.” EX1003, [0028].

61. Hong presents a similar configuration compared to the '952 Patent. For instance, Hong explains that prior art backlight panels used “red, green, and blue lights emitted from the LED arrays,” and that the light emitted from the LED arrays were “combined to be converted into a white light.” EX1003, [0008], [0017], [0023].²

[0017] A light beam going through the light input part is reflected at a desired incline angle from the rear side provided with the printed patterns 15 and 25 to propagate uniformly toward the output face. The above-mentioned arrangement of the printed patterns insures that a distance “d” is adequate for combining *red, green and blue lights emitted from the LED arrays* 30a and

² In the rest of the Declaration, when I quote a portion of a prior art reference, I will also reproduce, where appropriate, the full paragraph of the prior art reference in which the quote appears.

30b to generate white light.

[0023] The lights 36a and 36b emitted from the plurality of LED's 34a and 34b are scattered by the scattering patterns 15 and 25 provided at the first and second light guide plates 10 and 20 to have a propagation direction towards the liquid crystal display panel 6. If the plurality of LED's 34a and 34b emitting red, green and blue lights are used as light sources, then a partial area of the first and second light guide plates 10 and 20 is used as a region in which the red, green and blue lights are ***combined to be converted into a white light*** and the brightness of lights output from the first and second light guide plates 10 and 20 is scattered only at the remaining area.

EX1003, [0017], [0023].

62. Hong also notes that such prior art backlight panels were heavy and thick. EX1003, [0025].

[0025] The above-mentioned backlight unit of the liquid crystal display module suffers from the following draw backs. The backlight unit has ***a large thickness*** "d1" because the light guide plates 10 and 20 are used to uniformly distribute the brightness. Thus, a weight of the backlight unit increases accordingly. Furthermore, a brightness of the light 38a output from the first light guide plate 10 is reduced accordingly because of the propagation through the second light guide plate 20. Such a brightness reduction phenomenon deteriorates the display quality of the liquid crystal display module 1.

EX1003, [0025].

63. Such issues associated with the prior art backlight panels were addressed by Hong in ways substantially similar to the '952 Patent: by substituting the individual red, green, and blue LEDs with white LEDs emitting white light.

EX1003, [0049]-[0054]. For instance, Hong teaches a backlight unit that includes: (1) an LED array with white LEDs, (2) a reflective sheet that deflects light toward the LCD panel from the LED array, (3) a diffusion plate that diffuses light to the LCD panel from the LED array, (4) a gap from the LED array to the diffusion plate, (5) optical sheets that helps improve light efficiency from light output by the diffusion plate. EX1003, [0050], [0053]-[0057], [0059], [0078]. Such backlight unit is illustrated in Figure 6, which I reproduced below.

[0053] The main support 114 is a molded product. An inner side wall surface of the main support 114 is molded into a stepped coverage face. This stepped coverage face includes a securing part to which a plurality of optical sheets 108 is safely secured. A backlight unit, a diffusion plate 110, a reflective sheet 112, and a plurality of optical sheets 108 are disposed at the inner side layer of the main support 114. The backlight unit includes a light emitting diode (LED) array 130 for irradiating a light onto the liquid crystal display panel 106. **The diffusion plate 110 diffuses a light input from the LED array 130 to irradiate the light onto the liquid crystal display panel 106.** **The reflective sheet 112 is disposed at a rear side of the LED array 130.** The optical sheets 108 are disposed on the diffusion plate 110.

[0054] FIG. 7 is a plan view of an exemplary light emitting diode array according to the first embodiment of the present invention. As shown in FIG. 7, the LED array 130 of the liquid crystal display module 100 according to the first embodiment of the present invention includes a plurality of LED's 134 for generating lights, and a printed circuit board (PCB) 132 mounted with a circuit for controlling an emission of the plurality of LED's 134. **The LED 134 is a point light source and which emits a white**

light. The PCB 132 supports the LED 134 and controls an emission of the LED 134 by a circuit configured thereon. A light generated from the LED 134 is incident onto the diffusion plate 110.

[0055] The **diffusion plate 110** propagates a light input from the LED array 134 in a front direction of the liquid crystal display panel 106, and diffuses the light in such a manner to have a large range of uniform distribution. Thus, the diffusion plate irradiates light onto the liquid crystal display panel 106. A coating of light-diffusing member may be applied to both sides of the diffusing plate 110. The light-diffusing member may include a film made of a transparent resin.

[0056] The **reflective sheet 112** is located at the rear side of the LED array 130. Light propagated toward the bottom of the LED array 130 is reflected by the reflective sheet 112 toward the output face, which is the liquid crystal display panel 106. Light output through the diffusion plate 110 is incident onto the liquid crystal display panel 106 via the plurality of optical sheets 108.

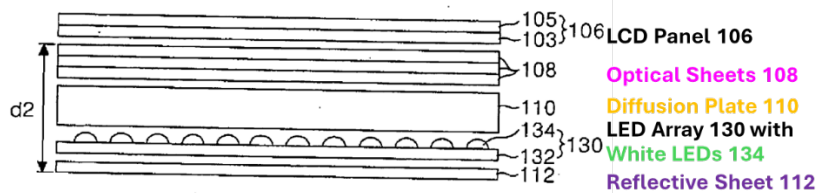
[0057] Light output from the diffusion plate 110 is diffused and has a large viewing angle. To this end, the optical sheets 108 are arranged on the diffusion plate 110. ***The plurality of optical sheets 108 vertically raises light output from the diffusion plate 110 to thereby improve light efficiency.*** Thus, the light output from the diffusion plate 110 is incident onto the liquid crystal display panel 106 through the plurality of optical sheets 108.

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the LED array 130 is located at the rear side of the diffusion plate 110. The backlight unit consists of a single diffusion plate 110. Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby ***reducing a gap between the diffusion plate 110***

and the LED array 130. A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

EX1003, [0053]-[0057], [0059].

FIG.6



EX1003, Figure 6.

64. Through utilizing white LEDs rather than individual red, green, and blue LEDs, the thickness of the backlight unit (which is graphically shown above in Figure 6 as “d2”) was reduced by reducing the gap between the diffusion plate and the LED array. EX1003, [0059]-[0060].

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the LED array 130 is located at the rear side of the diffusion plate 110. The backlight unit consists of a single diffusion plate 110. Furthermore, it becomes possible to apply *the LED array 130*

emitting a white light, thereby reducing a gap between the diffusion plate 110 and the LED array 130. A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

[0060] Due to the above-mentioned structure, *a thickness “d2” of the backlight unit of the liquid crystal display module 100 according to the first embodiment of the present invention is reduced* compared to the thickness “d1” of the backlight unit of the related art liquid crystal display module.

EX1003, [0059]-[0060].

2. Hong In Combination With Lee (“Hong/Lee”)

65. As stated above in Section VII.A.1 [Overview of Hong], Hong discloses a backlight panel. The backlight panel of Hong includes LEDs, where each LED could be “a point light source and [] emit[] white light”. EX1003, [0054].

[0054] FIG. 7 is a plan view of an exemplary light emitting diode array according to the first embodiment of the present invention. As shown in FIG. 7, the LED array 130 of the liquid crystal display module 100 according to the first embodiment of the present invention includes a plurality of LED's 134 for generating lights, and a printed circuit board (PCB) 132 mounted with a circuit for controlling an emission of the plurality of LED's 134. The LED 134 is *a point light source and which emits a white light*. The PCB 132 supports the LED 134 and controls an emission of the LED 134 by a circuit configured thereon. A light generated from the LED 134 is incident onto the diffusion plate 110.

EX1003, [0054].

66. How white LEDs would be implemented is not explicitly disclosed by Hong. But implementations of white LEDs were well-known in the art.

67. Lee provides one such example, where “white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD).” EX1004, 1:22-23. EX1004, 15:20-16:2. The white LEDs in Lee are described to have green and red phosphors in a resin layer arranged on a blue LED. EX1004, 3:21-4:3.

The inventive white light semiconductor light emitting device has a **blue LED** having a light emitting chip with a permeable **resin layer** with which **a silicate-base green phosphor and a selenium-base red phosphor are mixed**, thereby emitting white light generated by a combination of blue light emitted from the blue LED, green light emitted from the silicate-base phosphor absorbing a portion of the blue light, and red light emitted from the selenium-base red phosphor absorbing a portion of the blue light.

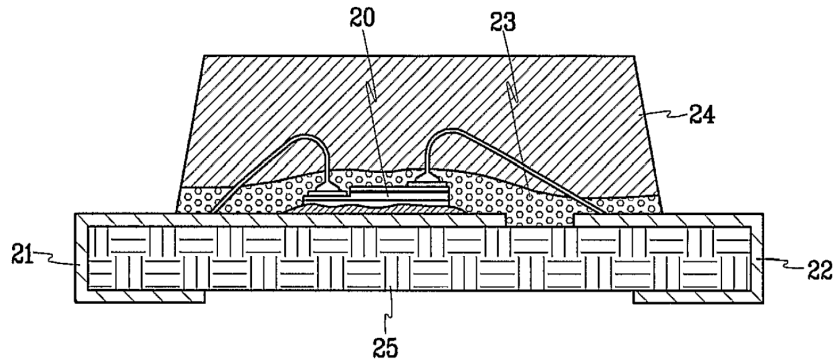
EX1004, 3:21-4:3.

68. As reproduced below, Figure 5 of Lee shows “a schematic view of a surface mounting type white light semiconductor light emitting device of a PCB type, which utilizes a barium-silicate-base green phosphor and a zinc-selenium-base red phosphor.” EX1004, 14:10-14. Lee further explains:

A white light semiconductor light emitting device of this embodiment comprises an **LED chip 20**, an anode lead 22, a cathode 15 lead 21, and an **epoxy resin layer 23 containing phosphors**. The LED chip 20 is located on a PCB 25, having N-

type and P-type electrodes connected to the leads 21 and 22, respectively. *The phosphors contained in the epoxy mold layer 23 include a barium-silicate-base green phosphor and a zinc-selenium-base red phosphor. ... The LED chip 20 may be formed of a blue LED chip or a UV LED chip.*

EX1004, 14:13-21.

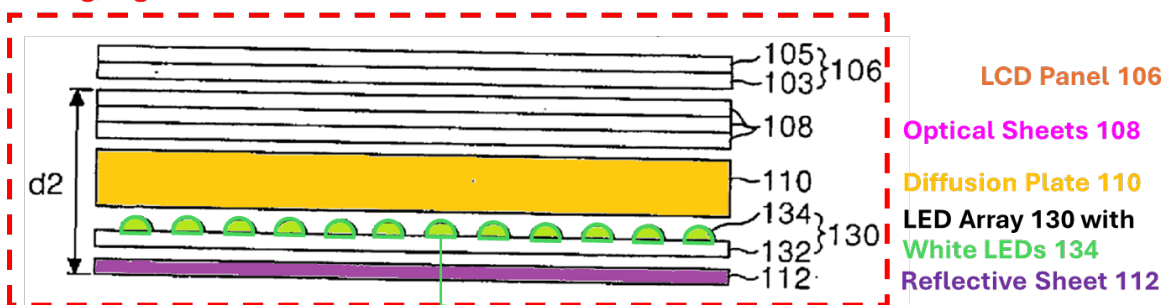
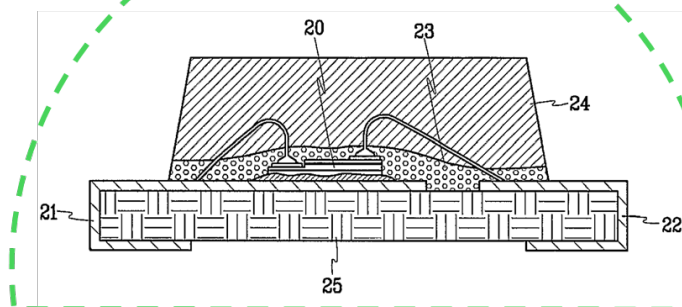


EX1004, Figure 5.

69. It would have been obvious to a POSITA to combine Hong with Lee to use Lee's white LEDs as the white LEDs in Hong's backlight panel. Indeed, Lee specifically states that Lee's white LEDs are "appropriate for the backlight of a LCD" (EX1004, 15:22-16:2) and that in general, "white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD)" (EX1004, 1:22-23). An annotated diagram of this combination is shown below.

Hong In Combination With Lee

Hong, Figure 6



Lee, Figure 5

EX1003, Figure 6; EX1004, Figure 5.

i. Reasons To Combine Hong's Backlight Unit With Lee's White LED With A Reasonable Expectation Of Success

70. A POSITA would have had a motivation to combine Hong with Lee in the manner described above, as explained below.

71. Hong states that in the backlight panel, each LED “emits white light” (EX1003, [0054]) without specifically disclosing how the white LEDs could be implemented. As such, there would have been a motivation to search for an implementation of white LEDs for use in backlight panels. A POSITA would have understood that the white LEDs as taught by Lee would have been readily applicable

to the backlight panel disclosed by Hong. EX1004, 1:22-23, 3:21-4:3.

In recent years, white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD), as well as for general lighting devices.

EX1004, 1:22-23.

The inventive white light semiconductor light emitting device has a blue LED having a light emitting chip with a permeable resin layer with which a silicate-base green phosphor and a selenium-base red phosphor are mixed, thereby emitting white light generated by a combination of blue light emitted from the blue LED, green light emitted from the silicate-base phosphor absorbing a portion of the blue light, and red light emitted from the selenium-base red phosphor absorbing a portion of the blue light.

EX1004, 3:21-4:3.

72. A POSITA would have been motivated to combine the white LEDs as disclosed by Lee with the backlight unit of Hong because Lee explicitly motivates using Lee's white LEDs—with red and green phosphors arranged on a blue LED—in Hong's backlight unit. For example, Lee states that there are several implementations of white LEDs, such as a white LED incorporating yellow phosphors arranged above a blue LED and a white LED incorporating “a package composed of red, green, and blue LEDs.” EX1004, 1:22-2:5.

In recent years, white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD), as well as for general lighting devices. The white light emitting diode is

realized by *combin[ing] a YAG:Ce phosphor to a blue LED*, or by a package composed of red, green, and blue LEDs. *The white LED using the blue LED excites a YAG:Ce yellow phosphor* deposited on an upper layer using blue light in a frequency range of 450-470 nm, thereby emitting white light formed by a light mixture of the blue and yellow colors.

EX1004, 1:22-2:7.

73. However, Lee explains that those designs are not well suited for backlight panels because those designs had “a color purity problem” and that those designs are expensive to make. EX1004, 2:5-12.

However, the phosphor material used for the white LED using the blue LED having the frequency range of 450-470 nm is limited to YAG:Ce, which has a *color purity problem*. In order to make a white light semiconductor light emitting device using the red, green, and blue LEDs, a variety of substrates such as GaAs, AlGaInP, InGaN, and GaN should be separately prepared, utilizing different semiconductor layers. This causes the *manufacturing costs to be increased*, while *complicating the manufacturing process*.

EX1004, 2:5-12.

74. Lee further explains that another design of a white LED—a white LED with red and green phosphors arranged on a blue LED—is more “is more appropriate for the backlight of a LCD” because that white LED does not have color purity issues and the manufacturing cost issues like the alternative designs. EX1004, 15:22-16:2; 17:11-15. Therefore, a POSITA would have been motivated to use Lee’s white LED (a blue LED with red and green phosphors arranged thereon) in the backlight unit of

Hong in order to obtain predictable results of improving the color purity in the white light for the backlight unit and to also reduce manufacturing costs.

Fig. 7 is a graph illustrating a light emitting spectrum of a white LED that is formed by a combination of a barium-silicate-base green phosphor, a zinc-selenium-base red phosphor, and a blue LED according to the present invention. As shown in the graph, a part of the reference light generated from the blue LED chip is absorbed by the phosphors. The reference light emitted from the blue LED, and the green and red lights emitted by the phosphors absorbing the reference light are mixed to realize the white light. **Accordingly, the white light semiconductor light emitting device of the present invention is more appropriate for the backlight of a LCD as compared with a device emitting white light by combining blue light generated from the blue chip and yellow light emitted from the YAG:Ce yellow light emitting phosphor.**

EX1004, 15:16-16:2.

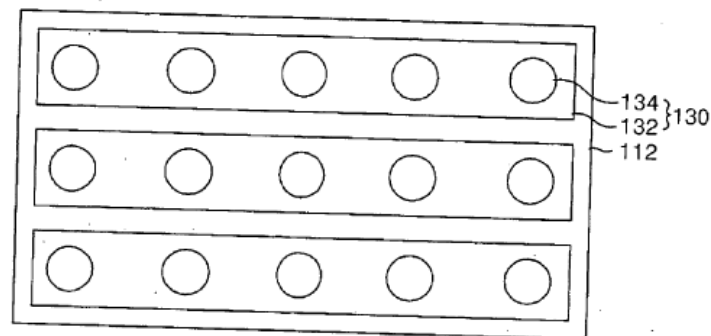
Particularly, **by applying green and red phosphors** to a single blue LED chip, the white light is realized, thereby providing **high quality color purity** as compared with a prior semiconductor light emitting device having red, green, and blue LED chips, while reducing the manufacturing costs simply and simplifying **manufacturing processes.**

EX1004, 17:11-15.

75. There would have been a reasonable expectation of success in combining the backlight unit of Hong with white LEDs of Lee. For example, the white LEDs of Lee is compatible with the backlight unit of Hong. The white LEDs disclosed in Lee are described as “a **surface mounting type** white light semiconductor light emitting device.” EX1004, 14:10-13. Hong describes the LEDs

in LED array 130 of the backlight unit similarly – that the LED array 130 includes multiple LEDs that are attached to a printed circuit board (PCB). EX1003, [0054] (*“The PCB 132 supports the LED 134 and controls an emission of the LED 134 by a circuit configured thereon.”*). As such, a POSITA would have readily recognized that Hong’s LED array 130 would use Lee’s white LEDs to provide white light to the LCD panel.

FIG. 7



EX1003, Figure 7.

76. Further, the combination would have simply been a straight-forward substitution of known white LEDs (Hong’s white LEDs 134 in the LED array 130 of the backlight unit) for other known white LEDs (Lee’s white LEDs that include blue LEDs with overlying green and red phosphors) to obtain predictable results of

providing white light in Hong's backlight unit. Specifically, Hong's backlight unit includes white LEDs 134 in the LED array 130. EX1003, [0054] ("As shown in FIG. 7, the LED array 130 ... includes a plurality of LED's 134 ... The LED 134 is a point light source and which emits a *white light*."); [0059] ("it becomes possible to apply the LED array 130 emitting a *white light*..."), FIG. 7. Further, Lee discloses white LEDs that are "appropriate for the backlight of a LCD." EX1004, 15:22-16:2. As such, combining the backlight panel of Hong with the white LEDs of Lee would have obtained predictable results that Hong's backlight panel provides white light to Hong's LCD panel using Lee's white LEDs.

77. At the very least, a POSITA would have found it obvious to try to apply the white LEDs in Lee to the backlight unit of Hong. A POSITA would have been motivated to find white LEDs that were known in the art for use in the backlight panel of Hong, as Hong has a design gap where Hong does not teach how white LEDs are implemented. Lee, on the other hand, provides a finite number of examples of white LEDs, including (1) red, green, and blue LEDs in a package, (2) yellow phosphors on top of a blue LED, and (3) green and red phosphors on top of a blue LED. EX1004, 1:23-2:7, 17:11-15.

In recent years, white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD), as well as for general lighting devices. The white light emitting diode is realized by combine a YAG:Ce phosphor to a blue LED, or by a package composed of red, green, and blue LEDs. The white LED

using the blue LED excites a YAG:Ce yellow phosphor deposited on an upper layer using blue light in a frequency range of 450-470 nm, thereby emitting white light formed by a light 5 mixture of the blue and yellow colors. However, the phosphor material used for the white LED using the blue LED having the frequency range of 450-470 nm is limited to YAG:Ce, which has a color purity problem.

EX1004, 1:22-2:7.

Particularly, by applying green and red phosphors to a single blue LED chip, the white light is realized, thereby providing high quality color purity as compared with a prior semiconductor light emitting device having red, green, and blue LED chips, while reducing the manufacturing costs simply and simplifying 15 manufacturing processes.

EX1004, 17:11-15.

78. Further, Lee teaches that “white light emitting diodes have been widely used as a backlight for liquid crystal displays (LCD),” so a POSITA would have had a reasonable expectation of using any one of white LEDs described by Lee in Hong’s backlight unit. EX1004, 1:22-23.

79. In fact, as stated above, using a white LED with green and red phosphors over a blue LED in the backlight unit of Hong would have had a reasonable expectation of success. As such, a POSITA would have found it to be common sense and obvious to try to use a white LED incorporating red and green phosphors over a blue LED as disclosed by Lee as the white LEDs of the backlight

unit disclosed by Hong.

3. **Claim 1**

i. [1Pre] A **backlight panel**, comprising:

80. Hong/Lee teaches a “backlight panel.”

81. Hong discloses an LCD module that includes an LCD panel and a **backlight unit** (which is the claimed “backlight panel”). EX1003, Title, [0006] (“The liquid crystal display module consists of a liquid crystal display panel ... and a **backlight unit** for irradiating a light on the liquid crystal display panel.”).

[0006] The liquid crystal display module consists of a liquid crystal display panel having liquid crystal cells arranged in a matrix between two glass substrates, and a ***backlight unit for irradiating a light onto the liquid crystal display panel***. The liquid crystal display module includes optical sheets for vertically raising a light propagating from the backlight unit toward the liquid crystal display panel.

EX1003, [0006].

82. There are two reasons for why the claimed “**backlight panel**” is met by Hong’s “**backlight unit**.”

83. First, both the “**backlight panel**” of the ’952 Patent and the “**backlight unit**” of Hong both provide white light to the LCD panel. For example, the ’952 Patent describes “a backlight panel for backlighting a display” (EX1001, 1:34-36) and Hong discloses “a backlight unit for irradiating light onto the liquid crystal display panel” (EX1003, [0006]).

A passive display device such as a liquid crystal display (LCD) reflects or absorbs ambient sunlight or indoor light to display images on an LCD panel. Thus, the ambient sunlight or indoor light is required for a user to view the displayed image. However, in a case where intensity of the ambient sunlight or indoor light is not sufficient to illuminate a display panel, there is a problem in that the user cannot view the displayed image. As an alternative to such a problem, *a back light panel for backlighting a display panel is generally employed.*

EX1001, 1:26-36.

[0006] The liquid crystal display module consists of a liquid crystal display panel having liquid crystal cells arranged in a matrix between two glass substrates, and *a backlight unit for irradiating a light onto the liquid crystal display panel.* The liquid crystal display module includes optical sheets for vertically raising a light propagating from the backlight unit toward the liquid crystal display panel.

EX1003, [0006].

84. Second, as explained further later in Sections VII.A.3.ii—VII.A.3.iv, VII.A.4, VII.A.5 [limitations [1A]-[1C], Claims 2, 4], both the “backlight panel” of the ’952 Patent and the “backlight unit” of Hong include white LEDs, a reflective sheet, an air gap, a diffusion plate, and optical sheets.

85. For example, Hong discloses that “[t]he backlight unit includes a light emitting diode (LED) array 130 [with white LEDs] for irradiating a light onto the liquid crystal display panel 106.” EX1003, [0053]. Hong also teaches that the backlight unit includes “a diffusion plate 110.” EX1003, [0059] (“The backlight unit consists of a single diffusion plate 110.”). The reflective sheet 112 and the optical

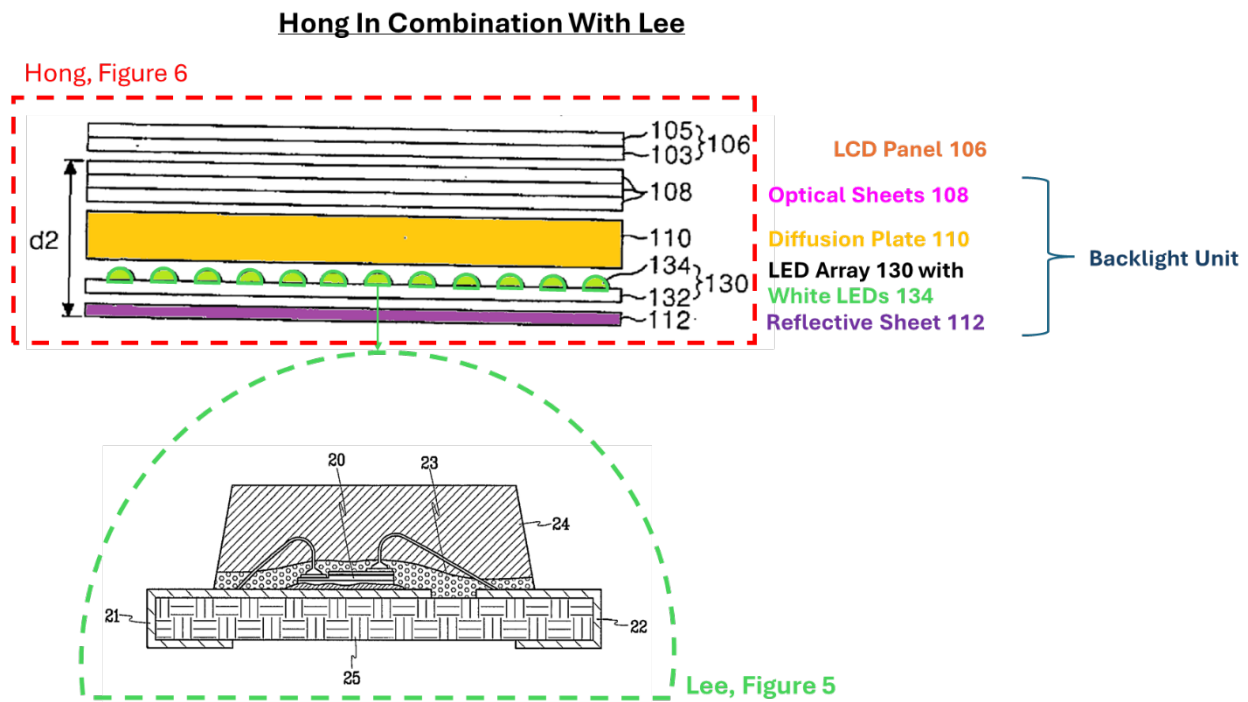
sheets 108 are also part of the backlight unit because Figure 6 of Hong depicts the “thickness ‘d2’ *of the backlight unit*” to include the reflective sheet 112, the optical sheets 108, and the “gap between the diffusion plate 110 and the LED array 130.” EX1003, [0053], [0059].

[0053] The main support 114 is a molded product. An inner side wall surface of the main support 114 is molded into a stepped coverage face. This stepped coverage face includes a securing part to which a plurality of optical sheets 108 is safely secured. A backlight unit, a diffusion plate 110, a reflective sheet 112, and a plurality of optical sheets 108 are disposed at the inner side layer of the main support 114. *The backlight unit includes a light emitting diode (LED) array 130 for irradiating a light onto the liquid crystal display panel 106.* The diffusion plate 110 diffuses a light input from the LED array 130 to irradiate the light onto the liquid crystal display panel 106. The reflective sheet 112 is disposed at a rear side of the LED array 130. The optical sheets 108 are disposed on the diffusion plate 110.

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the LED array 130 is located at the rear side of the diffusion plate 110. The backlight unit consists of a single diffusion plate 110. Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby reducing a gap between the diffusion plate 110 and the LED array 130. *A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130.* Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

EX1003, [0053], [0059].

86. Further, as mentioned above, Hong also discloses that the “**backlight unit** [] irradiat[es] a light onto the liquid crystal display panel.” EX1003, [0006]. Irradiating light onto the LCD panel is the function of several components combined (e.g., the LED array, the reflective sheet, the diffusion sheet, the optical sheets, and the gap). EX1003, [0067] (“a **backlight unit** of the liquid crystal display module 200 according to the second embodiment of the present invention *includes a light emitting diode (LED) array 230, a diffusion plate 210, a reflective sheet 212 and a plurality of optical sheets 208.*”).



EX1003, Figure 6; EX1004, Figure 5.

- ii. [1A] a **diffusion plate** comprising a top surface and a bottom surface;

87. Limitation [1A] is taught by Hong/Lee.

88. Hong/Lee's backlight unit includes "a diffusion plate." In fact, Hong states that "the backlight unit consists of a single diffusion plate 110." [EX1003], [0059].

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the LED array 130 is located at the rear side of the diffusion plate 110. ***The backlight unit consists of a single diffusion plate 110.*** Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby reducing a gap between the diffusion plate 110 and the LED array 130. A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

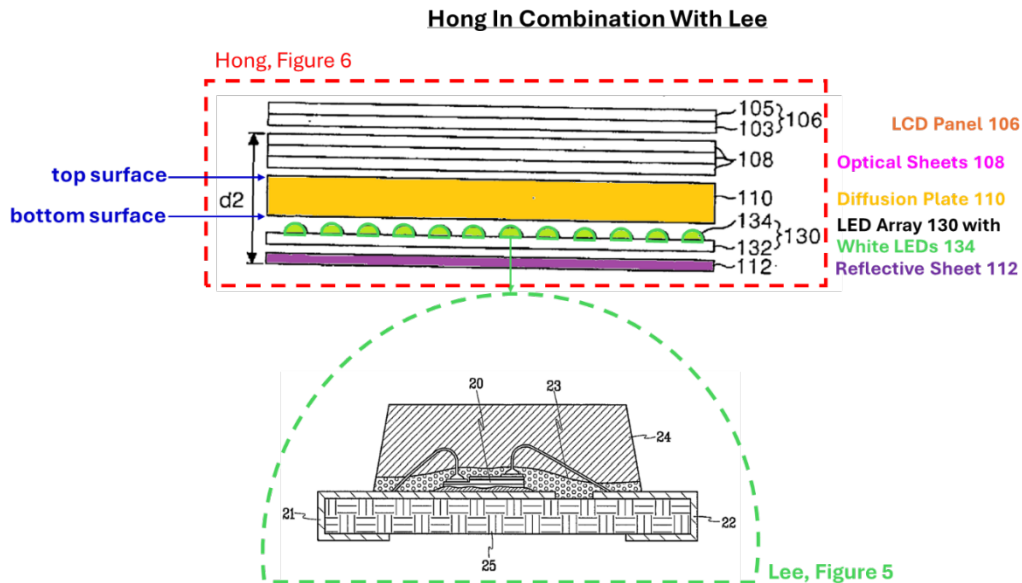
EX1003, [0059].

89. Further, "the diffusion plate 110 diffuses a light input from the LED array 130 to irradiate the light onto the liquid crystal display panel 106." EX1003, [0053].

[0053] The main support 114 is a molded product. An inner side wall surface of the main support 114 is molded into a stepped coverage face. This stepped coverage face includes a securing part to which a plurality of optical sheets 108 is safely secured. A backlight unit, a diffusion plate 110, a reflective sheet 112, and a plurality of optical sheets 108 are disposed at the inner side layer of the main support 114. The backlight unit includes a light emitting diode (LED) array 130 for irradiating a light onto the liquid crystal display panel 106. ***The diffusion plate 110***

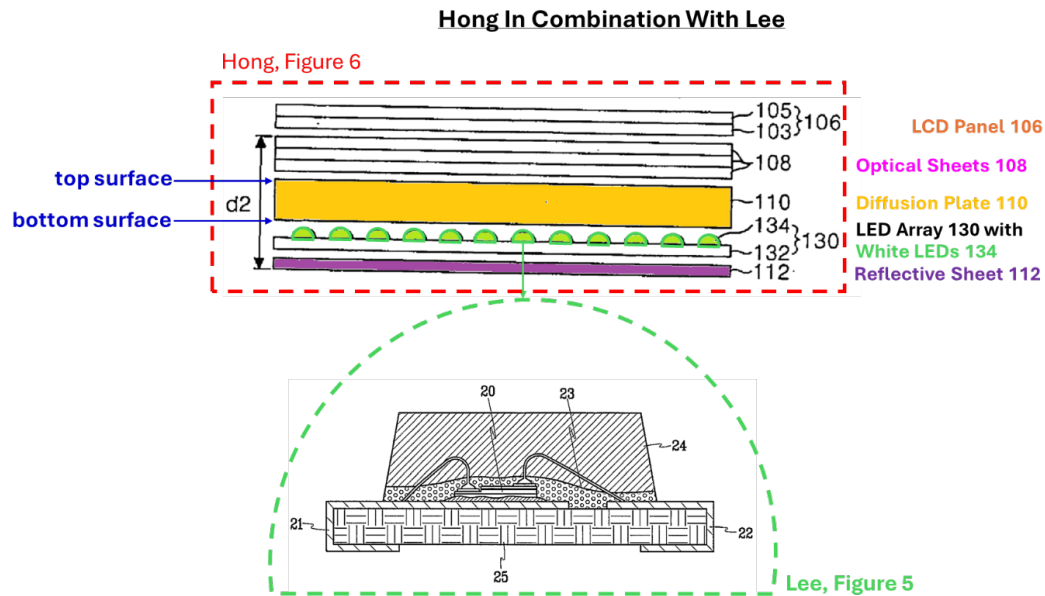
diffuses a light input from the LED array 130 to irradiate the light onto the liquid crystal display panel 106. The reflective sheet 112 is disposed at a rear side of the LED array 130. The optical sheets 108 are disposed on the diffusion plate 110.

EX1003, [0053].



EX1003, Figure 6; EX1004, Figure 5.

90. In addition, the **diffusion plate** as disclosed by Hong has a “top surface and a bottom surface” as required by limitation [1A]. As shown by the annotation below, the “diffusion plate 110” has a top surface and a bottom surface, where the top surface faces the LCD panel 106 and the bottom surface faces the LEDs 134 in LED array 130.



EX1003, Figure 6; EX1004, Figure 5.

- iii. [1B] a **plurality of white light emitting diodes** arranged below the bottom surface of the **diffusion plate**, the **white light emitting diodes** to emit light directly onto the bottom surface of the **diffusion plate**;

91. Limitation [1B] is taught by Hong/Lee.

92. As a first point, “a **plurality of white light emitting diodes**” is included in the backlight of Hong. In particular, Hong states “[t]he backlight unit includes a light emitting diode (LED) array 130 for irradiating a light onto the liquid crystal display panel 106.” EX1003, [0053].

[0053] The main support 114 is a molded product. An inner side wall surface of the main support 114 is molded into a stepped coverage face. This stepped coverage face includes a securing part to which a plurality of optical sheets 108 is safely secured. A backlight unit, a diffusion plate 110, a reflective sheet 112, and a plurality of optical sheets 108 are disposed at the inner side layer of the main support 114. *The backlight unit includes a*

light emitting diode (LED) array 130 for irradiating a light onto the liquid crystal display panel 106. The diffusion plate 110 diffuses a light input from the LED array 130 to irradiate the light onto the liquid crystal display panel 106. The reflective sheet 112 is disposed at a rear side of the LED array 130. The optical sheets 108 are disposed on the diffusion plate 110.

EX1003, [0053].

93. The plurality of white LEDs 134 (the claimed “plurality of white light emitted diodes”) is included by the LED array 130. In particular, “the LED array 130... includes a **plurality of LED’s 134** for generating lights ... The **LED 134** is a point light source and which emits *a white light.*” EX1003, [0054]. Further, Hong states that “the LED array 130 inherently emits a *white light.*” EX1003, [0059]. Hong also claims “generating a white light using a **white light emitting diode**” in claim 12. EX1003, claim 12.

[0054] FIG. 7 is a plan view of an exemplary light emitting diode array according to the first embodiment of the present invention. As shown in FIG. 7, *the LED array 130 of the liquid crystal display module 100 according to the first embodiment of the present invention includes a plurality of LED's 134 for generating lights*, and a printed circuit board (PCB) 132 mounted with a circuit for controlling an emission of the plurality of LED's 134. *The LED 134 is a point light source and which emits a white light.* The PCB 132 supports the LED 134 and controls an emission of the LED 134 by a circuit configured thereon. A light generated from the LED 134 is incident onto the diffusion plate 110.

EX1003, [0054].

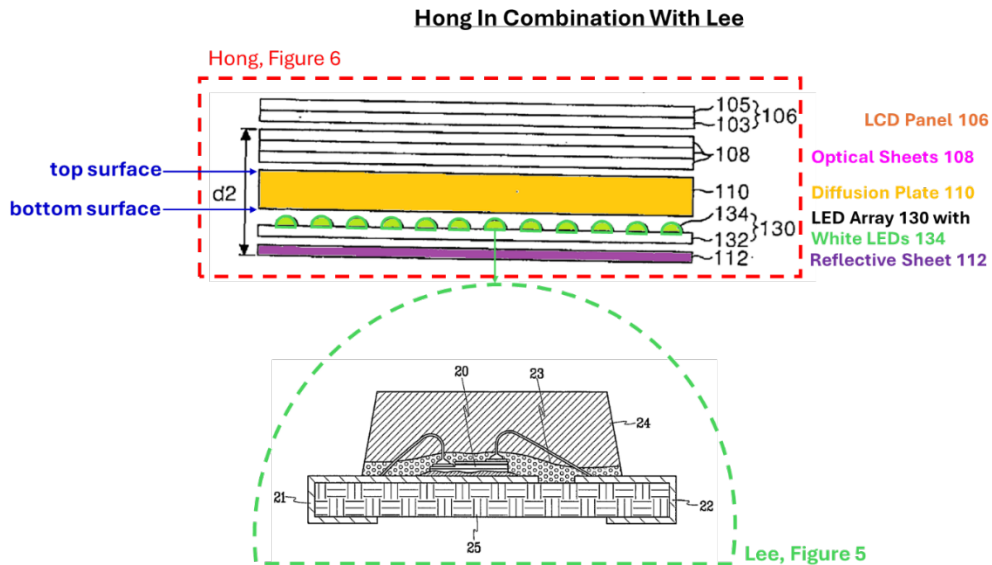
[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the LED array 130 is located at the rear side of the diffusion plate 110. ***The backlight unit consists of a single diffusion plate 110.*** Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby reducing a gap between the diffusion plate 110 and the LED array 130. A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

EX1003, [0059].

Claim 12. The method according to claim 11, wherein the step of turning on the light source during a desired time duration includes ***generating a white light using a white light emitting diode.***

EX1003, claim 12.

94. As a second point, in Hong, “arranged below the bottom surface of the diffusion plate” are the white LEDs 134 in the LED array 130. In particular, as shown below, “the LED array 130 is located at the rear side of the diffusion plate,” and the LED array 130 includes the white LEDs 134. EX1003, [0059].

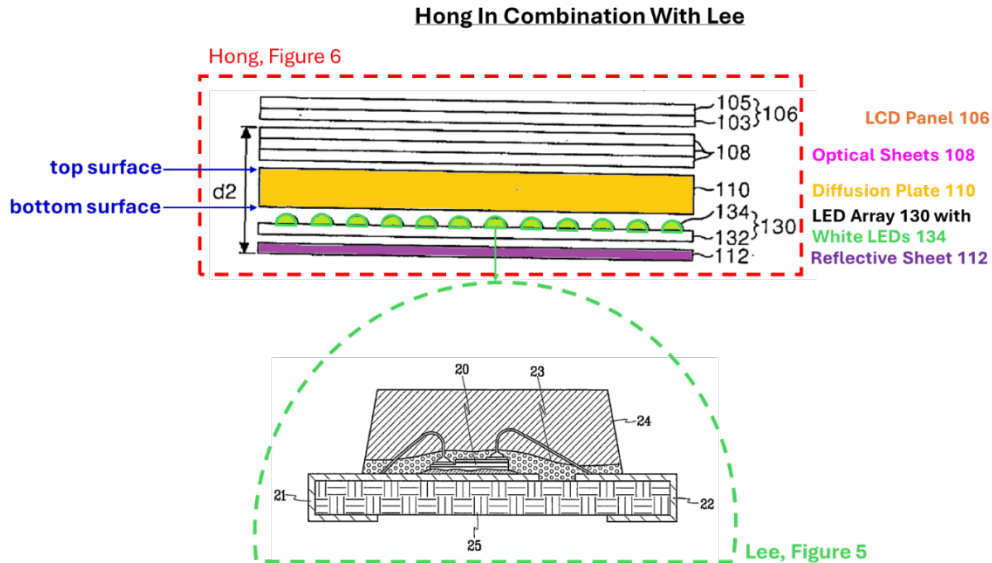


EX1003, Figure 6; EX1004, Figure 5.

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the **LED array 130** is **located at the rear side of the diffusion plate 110**. The backlight unit consists of a single diffusion plate 110. Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby reducing a gap between the diffusion plate 110 and the LED array 130. A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

EX1003, [0059].

95. As a third point, Hong discloses that the **white LEDs 134** “emit light directly onto the bottom surface of the **diffusion plate**,” which is shown in the figure below.



EX1003, Figure 6; EX1004, Figure 5.

96. Hong states that “[a] light generated from the LED 134 is incident onto the diffusion plate 110” (EX1003, [0054]) and that the white LEDs 134 are “at the rear side of the diffusion plate” (EX1003, [0059]).

[0054] FIG. 7 is a plan view of an exemplary light emitting diode array according to the first embodiment of the present invention. As shown in FIG. 7, the LED array 130 of the liquid crystal display module 100 according to the first embodiment of the present invention includes a plurality of LED's 134 for generating lights, and a printed circuit board (PCB) 132 mounted with a circuit for controlling an emission of the plurality of LED's 134. The LED 134 is a point light source and which emits a white light. The PCB 132 supports the LED 134 and controls an emission of the LED 134 by a circuit configured thereon. ***A light generated from the LED 134 is incident onto the diffusion plate 110.***

EX1003, [0054].

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, the **LED array 130** is **located at the rear side of the diffusion plate 110**. The backlight unit consists of a single diffusion plate 110. Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby reducing a gap between the diffusion plate 110 and the LED array 130. A thickness of the backlight unit also is reduced in accordance with the reduction of the gap between the diffusion plate 110 and the LED array 130. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

EX1003, [0059].

97. As shown in the illustration above, there is no physical structure that blocks the light from the **LEDs 134** to the bottom surface of the **diffusion plate 110**,. Further, no light from the **LEDs 134** is directed away from the vertical direction by any lenses that are coupled to **LEDs 134**. Therefore, the **white LEDs 134** “emit light directly onto the bottom surface of the **diffusion plate**.”

iv. [1C] a **reflection sheet** arranged below light exit surfaces of the **white light emitting diodes**, the **reflection sheet** to reflect light toward the **diffusion plate**,

98. Limitation [1C] is taught by Hong/Lee.

99. As a first point, Hong discloses a backlight unit with “a **reflection sheet**.” In particular, “disposed at a rear side of the LED array 130” is the “**reflective sheet 112**” (which is the claimed “**reflection sheet**”) of the backlight unit in Hong.

EX1003, [0053].

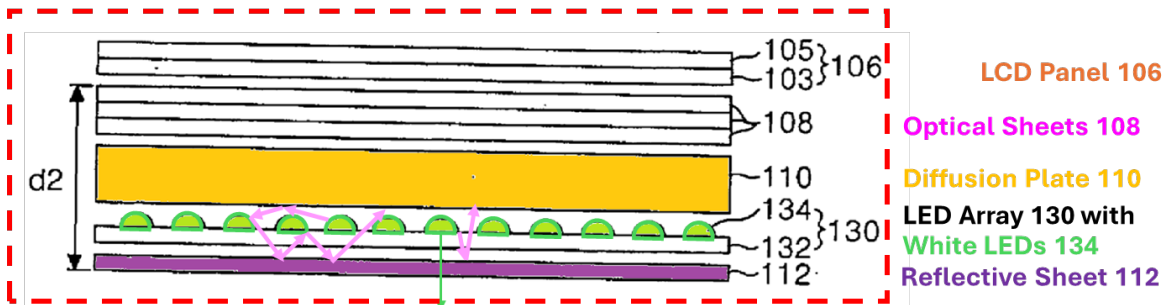
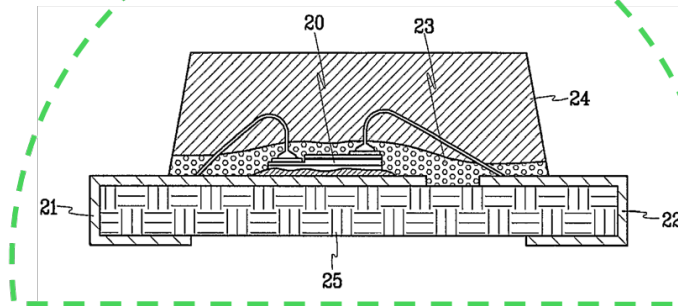
[0053] The main support 114 is a molded product. An inner side wall surface of the main support 114 is molded into a stepped coverage face. This stepped coverage face includes a securing part to which a plurality of optical sheets 108 is safely secured. A backlight unit, a diffusion plate 110, a reflective sheet 112, and a plurality of optical sheets 108 are disposed at the inner side layer of the main support 114. The backlight unit includes a light emitting diode (LED) array 130 for irradiating a light onto the liquid crystal display panel 106. The diffusion plate 110 diffuses a light input from the LED array 130 to irradiate the light onto the liquid crystal display panel 106. *The reflective sheet 112 is disposed at a rear side of the LED array 130.* The optical sheets 108 are disposed on the diffusion plate 110.

EX1003, [0053].

100. As annotated below in pink, Hong's "**reflective** sheet 112" reflects the "[l]ight propagated toward the bottom of the LED array 130 ... toward the output face, which is the liquid crystal display panel 106." EX1003, [0056]. That is similar to the "reflective sheet" of the '952 Patent that "reflects light emitted from the LEDs in an upward direction." EX1001, 1:60-61.

Hong In Combination With Lee

Hong, Figure 6



Lee, Figure 5

EX1003, Figure 6; EX1004, Figure 5.

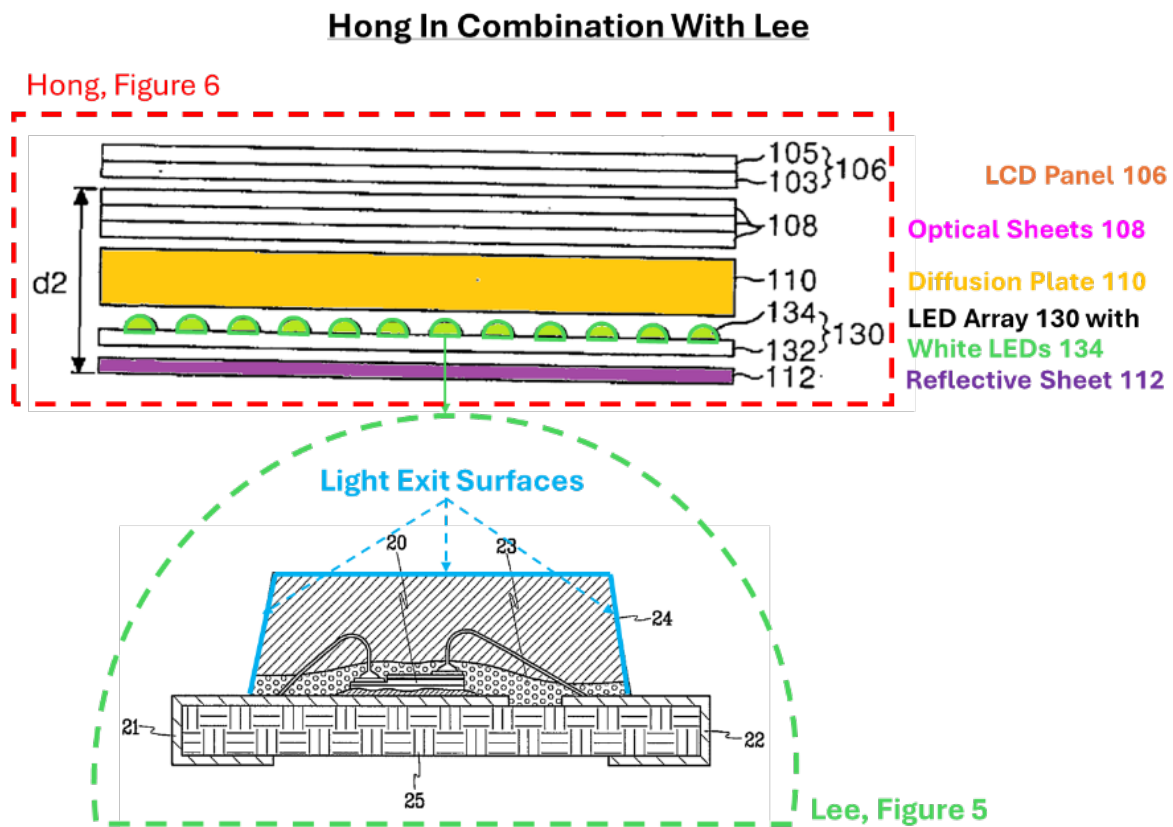
[0056] The reflective sheet 112 is located at the rear side of the LED array 130. ***Light propagated toward the bottom of the LED array 130 is reflected by the reflective sheet 112 toward the output face, which is the liquid crystal display panel 106.*** Light output through the diffusion plate 110 is incident onto the liquid crystal display panel 106 via the plurality of optical sheets 108.

EX1003, [0056].

A reflection sheet 5 is positioned below light exit surfaces of the LEDs. The reflection sheet may be formed with a reflection layer 5a on the top thereof. The reflection sheet reflects light emitted from the LEDs in an upward direction.

EX1001, 1:58-61.

101. As a second point, “arranged below light exit surfaces of the **white light emitting diodes**” is **reflective sheet 112**. For instance, the “**reflective sheet 112** is disposed at a *rear* side of the LED array 130,” and the **white LEDs 134** are part of the LED array 130. EX1003, [0053], [0056]. As such, arranged below the **surfaces** where the light exits the **white LEDs 134** is the **reflective sheet 112**, as shown in the annotations below in the Hong/Lee combination.



EX1003, Figure 6; EX1004, Figure 5.

102. As a third point, Hong discloses that the **reflective sheet 112** “reflect[s] light toward the **diffusion plate**.” In particular, “[l]ight propagated toward the

103. Because the **diffusion plate** 110 is positioned between the liquid crystal display panel 106 and the **reflective sheet** 112, the **reflective sheet** 112 “reflect[s] light toward the **diffusion plate**,” as required by limitation [1C].

- v. [1D] wherein each **white light emitting diode** comprises a blue light emitting diode chip and a red phosphor and a green phosphor arranged on the blue light emitting diode chip.

104. Limitation [1D] is taught by Hong/Lee.

105. As a first point, Hong/Lee’s combination uses white LEDs as taught by Lee, and Lee teaches that each such white LED includes “a blue light emitting diode chip.” In particular, “[a] white light semiconductor light emitting device of this embodiment comprises an **LED chip 20** ... and an epoxy resin layer 23 containing phosphors. ... The **LED chip 20** may be formed of a **blue LED chip**.” EX1004, 14:10-20. In addition, Lee similarly states “[t]he reference light emitted from the **blue LED**, and the green and red lights emitted by the phosphors absorbing the reference light are mixed to realize the white light.” EX1004, 3:21-4:3; 15:20-22.

Fig. 5 is a schematic view of a surface mounting type white light semiconductor light emitting device of a PCB type, which utilizes a barium-silicate-base green phosphor and a zinc-selenium-base red phosphor, according to another embodiment of the present invention. *A white light semiconductor light emitting device of this embodiment comprises an LED chip 20, an anode lead 22, a cathode lead 21, and an epoxy resin layer 23 containing phosphors.* The LED chip 20 is located on a PCB 25, having N-type and P-type electrodes connected to the leads 21 and 22, respectively. The phosphors contained in the epoxy mold

layer 23 include a barium-silicate-base green phosphor and a zinc-selenium-base red phosphor. The epoxy mold layer 23 is formed covering the LED chip 20. A transparent silicone layer or mold layer 24 is formed on the epoxy mold layer 23.

The LED chip 20 may be formed of a blue LED chip or a UV LED chip.

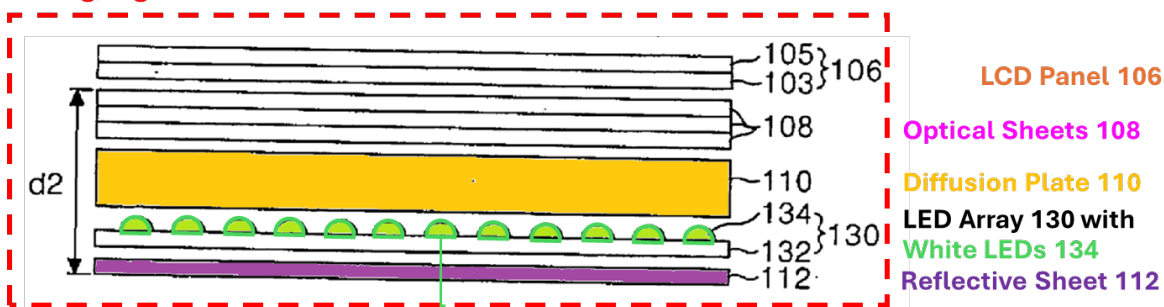
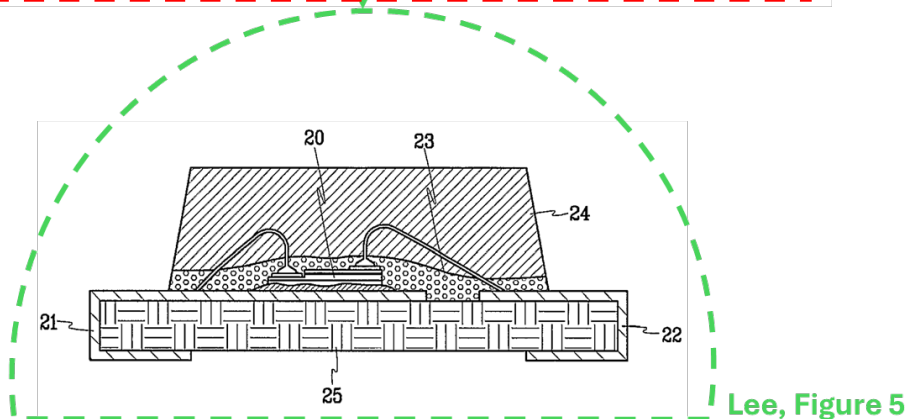
EX1004, 14:10-21.

Fig. 7 is a graph illustrating a light emitting spectrum of a white LED that is formed by a combination of a barium-silicate-base green phosphor, a zinc-selenium-base red phosphor, and a blue LED according to the present invention. As shown in the graph, a part of the reference light generated from the blue LED chip is absorbed by the phosphors. ***The reference light emitted from the blue LED, and the green and red lights emitted by the phosphors absorbing the reference light are mixed to realize the white light.*** Accordingly, the white light semiconductor light emitting device of the present invention is more appropriate for the backlight of a LCD as compared with a device emitting white light by combining blue light generated from the blue chip and yellow light emitted from the YAG:Ce yellow light emitting phosphor.

EX1004, 15:16-16:2.

Hong In Combination With Lee

Hong, Figure 6



EX1003, Figure 6; EX1004, Figure 5.

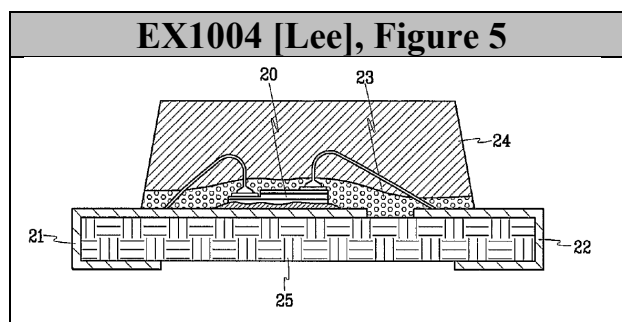
106. As a second point, “a red phosphor and a green phosphor” are included in each **white LED**. In particular, Lee states that “[a] white light semiconductor light emitting device of this embodiment comprises an LED chip 20 ... and an epoxy resin layer 23 containing *phosphors*. ... The phosphors contained in the epoxy mold layer 23 include a barium-silicate-base *green phosphor* and a zinc-selenium-base *red phosphor*.” EX1004, 14:10-19.

Fig. 5 is a schematic view of a surface mounting type white light semiconductor light emitting device of a PCB type, which utilizes a barium-silicate base green phosphor and a zinc-selenium-base red phosphor, according to another embodiment

of the present invention. *A white light semiconductor light emitting device of this embodiment comprises an LED chip 20, an anode lead 22, a cathode 15 lead 21, and an epoxy resin layer 23 containing phosphors.* The LED chip 20 is located on a PCB 25, having N-type and P-type electrodes connected to the leads 21 and 22, respectively. The phosphors contained in the epoxy mold layer 23 include a barium-silicate-base green phosphor and a zinc-selenium-base red phosphor. *The epoxy mold layer 23 is formed covering the LED chip 20.*

EX1004, 14:10-19.

107. As a third point, the red phosphor and the green phosphor are “arranged on the blue light emitting diode chip,” as required by limitation [1D]. As shown below in Figure 5 of Lee (and explained above), the epoxy resin/mold layer 23 contains the red phosphor and the green phosphor. EX1004, 14:17-18, Figure 5. Further, as shown below, “[t]he epoxy mold layer 23 is formed **covering** the [blue] LED chip 20.” EX1004, 14:18-19.

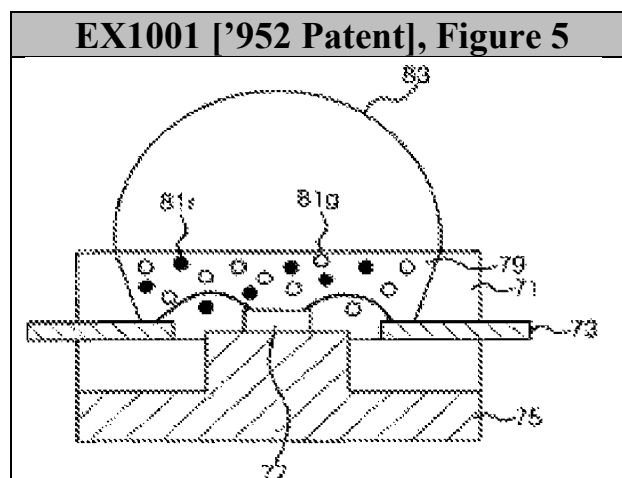


108. The arrangement of phosphors in Lee is just like the arrangement of phosphors in the '952 Patent. For example, in the '952 Patent, “[o]ver the blue LED chip 77 is positioned **red and green phosphors 81r and 81g** The red and green phosphors may be ... positioned in a **molding member 79** in a state where they are

contained therein as shown in this figure. The molding member 79 may be made of an *epoxy or silicone resin* and formed into a single layer or multiple layers.” EX1001, 7:41-50. Thus, just like the '952 Patent that discloses a blue LED chip with phosphors in a molding member 79 covering the blue LED chip, Lee discloses a blue LED chip with phosphors in a resin mold layer 23 covering the blue LED chip. Therefore, Lee meets limitation [1D].

Over the blue LED chip 77 is positioned red and green phosphors 81r and 81g which are excited by blue light to radiate red and greenlight, respectively, such that the radiated light is mixed with a portion of blue light emitted from the LED chip 77 to become white light. The red and green phosphors may be either coated on the LED chip 77 or positioned in a molding member 79 in a state where they are contained therein as shown in this figure. The molding member 79 may be made of an epoxy or silicone resin and formed into a single layer or multiple layers.

EX1001, 7:41-50.



4. **Claim 2**

- i. **The backlight panel of claim 1, further comprising a **brightness enhancement film** and/or a dual brightness enhancement film arranged on the top surface of the **diffusion plate**.**

109. For the reasons provided in Section VII.A.3 [Claim 1], claim 1 is rendered obvious by Hong/Lee. The additional limitation of claim 2 is also taught by Hong.

110. In particular, Hong discloses a backlight panel including at least one “**optical sheet 108**.” EX1003, [0057], claim 6.

Light output from the diffusion plate 110 is diffused and has a large Viewing angle. *To this end, the **optical sheets 108** are arranged on the **diffusion plate 110**.* The plurality of optical sheets 108 vertically raises light output from the diffusion plate 110 to thereby improve light efficiency. Thus, the light output from the diffusion plate 110 is incident onto the liquid crystal display panel 106 through the plurality of optical sheets 108.

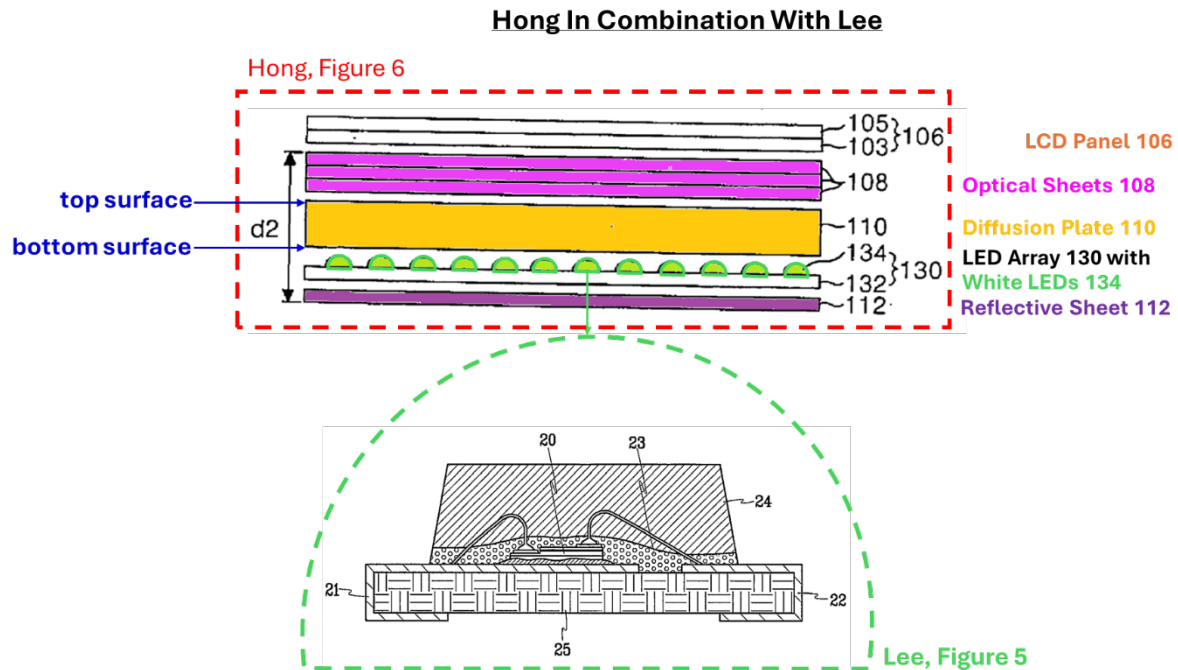
EX1003, [0057].

6. The liquid crystal display module according to claim 1, further comprising:
a reflective sheet arranged at the rear side of the light source; and
*at least one **optical sheet** arranged on the **diffuser**.*

EX1003, claim 6.

111. Further, as shown in the figure below, arranged on the top surface of the **diffusion plate** are the **optical sheets 108**. EX1003, [0057] (“the **optical sheets**

108 are *arranged on the diffusion plate 110.*"); claim 6 ("at least one optical sheet arranged on the *diffuser.*").



EX1003, Figure 6; EX1004, Figure 5.

112. Further, the optical sheets 108 are “brightness enhancement” sheets because the optical sheets 108 are intended to improve the brightness of the backlight unit. For instance, Hong discloses that “[l]ight output from the diffusion plate 110 is diffused and has a large viewing angle.” EX1003, [0057]. The light output from the diffusion plate 110 with a large viewing angle would lower the brightness of the backlight unit. To improve the brightness, Hong uses the optical sheets: the “optical sheets 108 *vertically raises* light output from the diffusion plate 110 to thereby *improve light efficiency.*” EX1003, [0057].

[0057] *Light output from the diffusion plate 110 is diffused and*

has a large viewing angle. To this end, the optical sheets 108 are arranged on the diffusion plate 110. *The plurality of optical sheets 108 vertically raises light output from the diffusion plate 110 to thereby improve light efficiency.* Thus, the light output from the diffusion plate 110 is incident onto the liquid crystal display panel 106 through the plurality of optical sheets 108.

EX1003, [0057].

113. The optical sheets 108 in the Hong/Lee combination works substantially the same way as the “brightness enhancement film (BEF) 13” of the ’952 Patent. The ’952 Patent states that “[t]he BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 *into light with a small showing angle* such that the light can be incident onto the LCD panel 17.” EX1001, 2:20-31.

A brightness enhancement film (BEF) 13 such as a prism sheet is positioned on a top surface of the diffusion plate 11. The BEF may be composed of two sheets which have upward prisms formed in longitudinal and transverse directions, respectively. In addition, a dual brightness enhancement film (DBEF) 15 such as a dual brightness enhancement film embossed (DBEF-E) is positioned on a top surface of the BEF 13. *The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a small showing angle* such that the light can be incident onto the LCD panel 17. Accordingly, the luminance of the LCD panel is increased.

EX1001, 2:20-31.

114. Further, the optical sheets 108, collectively or individually, meet the “brightness enhancement film” limitation because the ’952 Patent itself states that

both *one sheet* or *multiple sheets* may form the brightness enhancement “film.” For instance, the “background art” of the ’952 Patent states “[a] brightness enhancement *film (BEF)* 13 such as a prism *sheet* is positioned on a top surface of the diffusion plate 11. *The BEF may be composed of two sheets* which have upward prisms formed in longitudinal and transverse directions, respectively.” EX1001, 2:20-24. In addition, both the *optical sheets* 108 and the brightness enhancement film (BEF) 13 function similarly. EX1001, 2:20-31 (describing “background art”).

A brightness enhancement film (BEF) 13 such as a prism sheet is positioned on a top surface of the diffusion plate 11. The BEF may be composed of two sheets which have upward prisms formed in longitudinal and transverse directions, respectively. In addition, a dual brightness enhancement film (DBEF) 15 such as a dual brightness enhancement film embossed (DBEF-E) is positioned on a top surface of the BEF 13. The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a small showing angle Such that the light can be incident onto the LCD panel 17. Accordingly, the luminance of the LCD panel is increased.

EX1001, 2:20-31.

5. Claim 4

- i. **The backlight panel of claim 1, further comprising an air gap arranged between the bottom surface of the diffusion plate and the reflection sheet.**

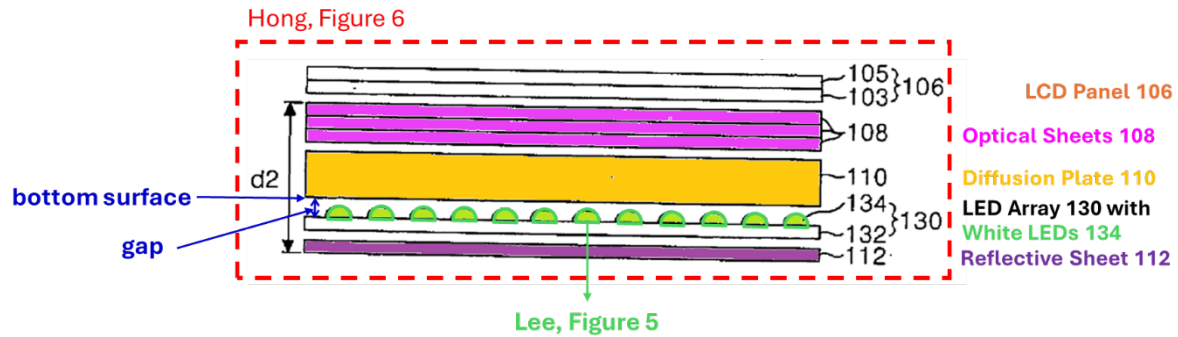
115. For the reasons provided in Section VII.A.3 [Claim 1], Hong/Lee renders obvious claim 1. The additional limitation of claim 4 is also taught by Hong.

116. As a first point, Hong/Lee's backlight unit has a "gap arranged between the bottom surface of the diffusion plate and the reflection sheet." In particular, Hong states that "the LED array 130 is located at the *rear* side of the diffusion plate 110" and that there is "a *gap* between the diffusion plate 110 and the LED array 130." EX1003, [0059].

[0059] In the liquid crystal display module 100 according to the first embodiment of the present invention, *the LED array 130 is located at the rear side of the diffusion plate 110*. The backlight unit consists of a single diffusion plate 110. Furthermore, it becomes possible to apply the LED array 130 emitting a white light, thereby reducing *a gap between the diffusion plate 110 and the LED array 130*. A thickness of the backlight unit also is reduced in accordance with the reduction of the *gap between the diffusion plate 110 and the LED array 130*. Specifically, the LED array 130 inherently emits a white light to thereby eliminate a requirement of the desired distance for combining the red, green and blue light to generate a white light.

EX1003, [0059].

117. As shown below, that gap between diffusion plate 110 and the LED array 130 is arranged between the bottom surface of the diffusion plate 110 and the reflection sheet 112, as required by claim 4.



EX1003, Figure 6.

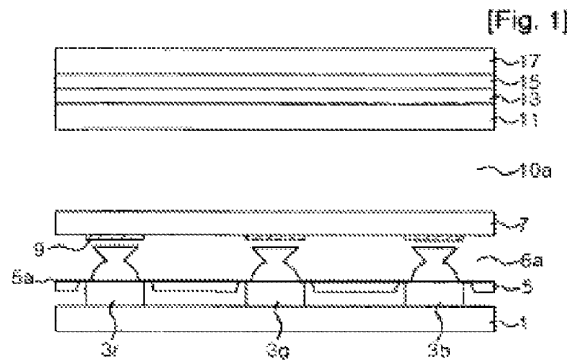
118. As a second point, a POSITA would have understood that the “gap between the diffusion plate 110 and the LED array 130” is an air gap. In particular, a POSITA would have understood that the “gap between the diffusion plate 110 and the LED array 130” is there to reduce hot spots of light produced by the LEDs by mixing the light from the LEDs 134, as it was commonly done in the art. EX1005 [West], [0032] (“The light emitted from diffuser 33 is *further mixed in mixing chamber 32*, and is then incident on second diffuser 31. Mixing chamber 32 eliminates the appearance of the individual openings in high reflectance material 34 from the brightness profile and *provides uniform light* to diffuser 31.”), Figure 3.

[0032] In some embodiments, high reflectance material 34 is highly reflective on both sides. Diffuser 33 may be a holographic, bulk or film diffuser, and is selected to be thin, to be highly transmissive, and to scatter light forward toward LCD layers 30. In embodiments using diffuse reflecting material as high reflectance material 34, diffuser 33 may be omitted. *The light emitted from diffuser 33 is further mixed in mixing chamber 32, and is then incident on second diffuser 31. Mixing chamber 32 eliminates the appearance of the individual openings in high*

reflectance material 34 from the brightness profile and provides uniform light to diffuser 31. Above diffuser 31 one or more brightness enhancing films such a BEF and DBEF available from 3M may be incorporated before the remaining LCD layers, which maybe, for example, layers 14, 16, 18, 22, and 24 of FIG. 1.

EX1005, [0032].

119. And as is admitted in the “background art” section of the ’952 Patent, such a gap is commonly formed using *air*. EX1001, Figure 1, 2:7-9 (“The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a *first gap 6a* which is an *air layer*.”), 2:12-19 (“The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a *second gap 10a* which is an *air layer*.”).



EX1001, Figure 1.

The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a *first gap 6a* which is an *air layer*. The first gap is a region where red, green and blue light emitted respectively from the LEDs 3r, 3g and 3b are mixed with one another.

A diffusion plate 11 is positioned above and spaced apart from the light transmission layer 7. The diffusion plate 11 diffuses

light incident thereon to make the light uniform. *The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a second gap 10a which is an air layer.* Thus, the light transmitted through the light transmission layer 7 is again mixed within the second gap 10a and the mixed light is then incident onto the diffusion plate 11.

EX1001, 2:7-19.

120. In fact, there were known benefits to forming that “gap between the diffusion plate 110 and the LED array 130” with air. For instance, it was known that it is desirable to make the gap using a lightweight material, a material that did not absorb light, and has an index of refraction near 1.0. EX1005, [0022] (“The material filling mixing chamber 37 is selected to be *light weight*, to be *non-absorbing of light*, and to have an *index of refraction close to 1.0.*”).

FIG. 3 illustrates a first embodiment of a device for providing a predetermined brightness profile. FIG. 3 illustrates a cross section of a hollow mixing chamber in a backlight, according to a first embodiment of the invention. FIG. 4 illustrates a top view of a portion of the mixing chamber illustrated in FIG. 3. As illustrated in FIG. 4, two rows of LEDs are disposed in a hollow mixing chamber 37. LEDs 36 may be mounted on a circuit board 35 such that the lenses of LEDs 36 protrude through the bottom 37B of mixing chamber 37. LEDs 36 may be, for example, red, green, and blue LEDs selected such that when the light emitted by LEDs 36 is mixed, it appears white. The number of LEDs may depend on the area of mixing chamber 37. In general, for a given brightness, larger areas require more LEDs. Mixing chamber 37 may be hollow and filled with air. Other materials, for example,

other gases, may fill mixing chamber 37 instead of air. *The material filling mixing chamber 37 is selected to be light weight, to be non-absorbing of light, and to have an index of refraction close to 1.0.*

EX1005, [0022].

121. And air is a material that satisfies those desirable characteristics. Indeed, air is lightweight, has a refractive index close to 1, and does not absorb any significant amount of light. EX1017, Table 1.

Table 1 General Refractive Index

Material	nD
Air	1.0
Water	1.3
Glass	1.5

EX1017, Table 1.

122. Because it would have been inexpensive and easy to fill the gap with air and because air has a refractive index of close to 1, a POSITA would have understood that Hong's "gap between the diffusion plate 110 and the LED array 130" is an air gap, as was common prior to the '952 Patent.

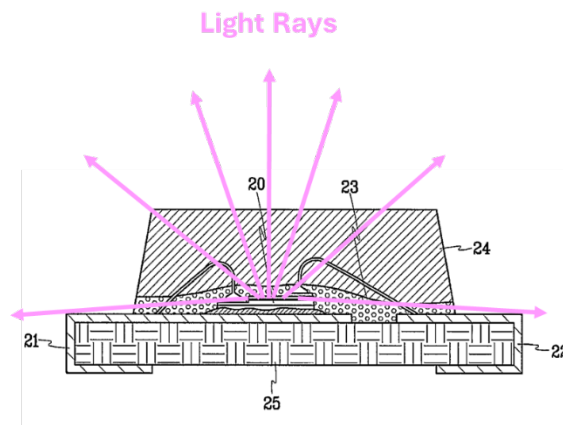
6. **Claim 5**

- i. **[5] The backlight panel of claim 4, wherein light emitted from the white light emitting diodes is mixed together in the air gap before being emitted directly onto the bottom surface of the diffusion plate.**

123. For the same reasons stated in Section VII.A.5 [Claim 4], Hong/Lee

renders obvious claim 4. The additional limitation of claim 5 is also taught by Hong/Lee.

124. As a first point, Hong/Lee teach that the “light emitted from the white light emitting diodes is mixed together in the air gap.” A POSITA would have understood that Lee’s white LED is a flip-chip type LED and such flip-chip type LED emits light in all directions, as illustrated below in annotated Figure 5. EX1016, FIG. 19.



EX1004, Figure 5 (annotations added).

125. Since Hong/Lee’s LEDs emit light in all directions, a POSITA would have recognized that the light rays would intersect in the air gap, as illustrated below. As such, in Hong/Lee, the “light emitted from the white light emitting diodes is mixed together in the [] gap,” which, as I explained above for claim 4, would have been understood to be an air gap. Section VII.A.5 [Claim 4]. A POSITA would have recognized that this is consistent with the well-known purpose of air gaps in backlight units. EX1001, 2:16-19, 2:9-11, EX1005, [0022].

Thus, *the light transmitted through the light transmission layer 7 is again mixed within the second gap 10a* and the mixed light is then incident onto the diffusion plate 11.

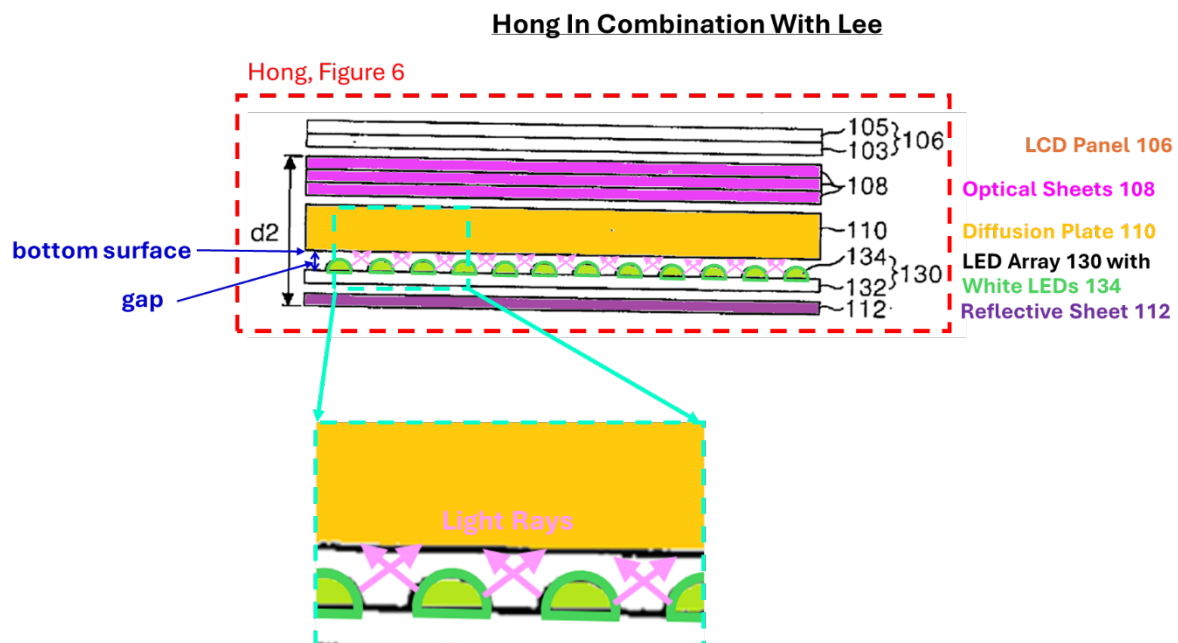
EX1001, 2:16-19 (describing “background art.”)

The first gap is a region where red, green and blue light emitted respectively from the LEDs 3r, 3g and 3b are *mixed with one another*.

EX1001, 2:9-11 (describing “background art.”)

As illustrated in FIG. 4, two rows of LEDs are disposed in a *hollow mixing chamber 37*. LEDs 36 may be mounted on a circuit board 35 such that the lenses of LEDs 36 protrude through the bottom 37B of mixing chamber 37. LEDs 36 may be, for example, red, green, and blue LEDs selected such that when the light emitted by LEDs 36 is *mixed*, it appears white.

EX1005, [0022].



EX1003, Figure 6; EX1004, Figure 5.

126. As a second point, in Hong/Lee, the light from the white LEDs is mixed together in the air gap “before being emitted directly onto the bottom surface of the diffusion plate.” The white light emitting diodes directly emit light onto the diffusion plate 110’s bottom surface, as explained in Section VII.A.3.iii [limitation [1B]]. And as shown in the above annotated figure, the rays of light are mixed in the air gap prior to the light rays being emitted onto the diffusion plate 110.

B. Ground II: Hong, Lee, And AAPA Render Obvious Claims 2, 4, And 5.

1. Claim 2

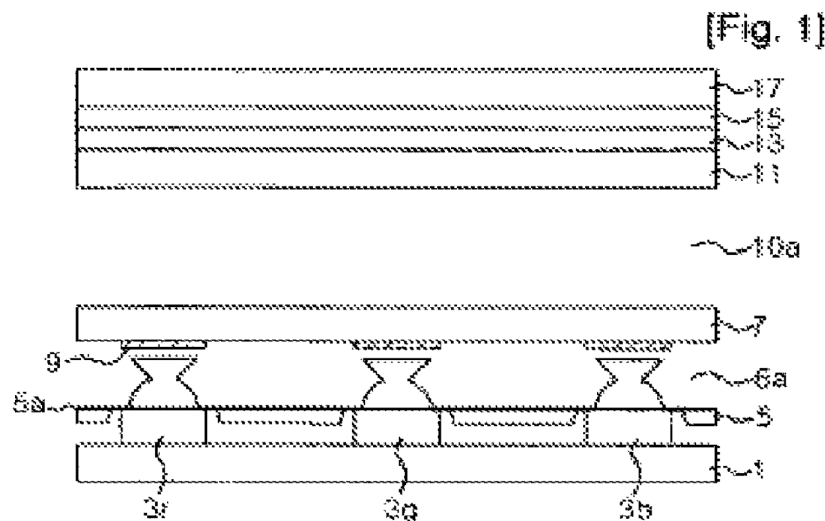
- i. The backlight panel of claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film arranged on the top surface of the diffusion plate.**

127. As described in Section VII.A.3 [Ground I, Claim 1], claim 1 is rendered obvious by Hong/Lee. Further, for the reasons described in Section VII.A.4 [Ground I, Claim 2], claim 2 is also rendered obvious by Hong/Lee because the optical sheets 108 are “arranged on” top of the diffusion plate.

128. If, however, Hong/Lee is found not to teach that the optical sheets 108 are “arranged on” the top surface of the diffusion plate because the top surface of the diffusion plate is not touching the optical sheets 108, a POSITA would have found it obvious to modify Hong/Lee in view of AAPA (“Hong/Lee/AAPA”) to

arrange the top surface of **diffusion plate** to touch the **optical sheets** as taught by AAPA.

129. Specifically, the brightness enhancement film (BEF) 13 and the diffusion plate 11 are included in a “conventional backlight panel” disclosed by the “background art” section of the ’952 Patent. EX1001, 1:45-47, Figure 1. In Figure 1, the top surface of the diffusion plate 11 is physically touching the BEF 13. EX1001, 2:20-24 (“A brightness enhancement film (BEF) 13 such as a prism sheet is *positioned on a top surface of the diffusion plate 11*. The BEF may be composed of two *sheets* which have upward prisms formed in longitudinal and transverse directions, respectively.”).



EX1001, Figure 1.

130. A POSITA would have found it obvious to modify Hong/Lee in view of AAPA so that the top surface of the diffusion plate 110 physically touches the **optical sheets** 108 as taught by AAPA. Such a modification is merely a substitution

of one well-known element (Hong/Lee's **optical sheets** 108) for another well-known element (the AAPA's brightness enhancement film, which makes physical contact with the top surface of the diffusion plate) to obtain predictable results of a backlight panel with enhanced brightness. As explained in Section VII.A.4[Ground I, Claim 2], the BEF 13 in AAPA serves the same function as the optical sheets 108 in Hong/Lee. Accordingly, it would have been obvious to a POSITA that the physical arrangement of the BEF 13 in AAPA is also readily applicable to the physical arrangement of the optical sheets 108 in Hong/Lee. EX1001, 2:27-31 ("The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a *small showing angle* such that the light can be incident onto the LCD panel 17. Accordingly, *the luminance of the LCD panel is increased.*") (describing "background art"); EX1003, [0057] ("The plurality of optical sheets 108 *vertically raises light output* from the diffusion plate 110 to *thereby improve light efficiency.*").

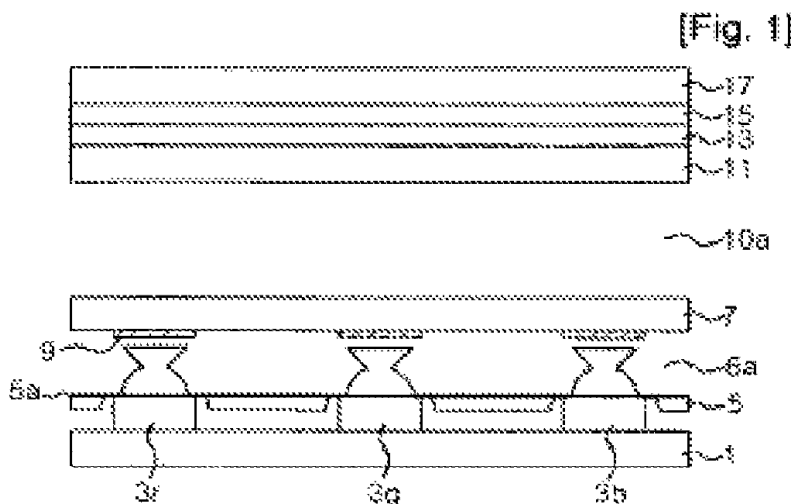
2. Claim 4

- i. **The backlight panel of claim 1, further comprising an air gap arranged between the bottom surface of the diffusion plate and the reflection sheet.**

131. As provided in Section VII.A.3 [Ground I, Claim 1], claim 1 is rendered obvious by Hong/Lee. And as provided in Section VII.A.5 [Ground I, Claim 4], the additional limitation of claim 4 is also taught by Hong.

132. If, however, Hong/Lee is found not to teach that the “gap arranged between the bottom surface of the diffusion plate and the reflection sheet” is an “air gap,” such “air gap” would have been obvious in view of Hong/Lee and AAPA.

133. The AAPA teaches that an “air gap” was often used in backlight units. For instance, the '952 Patent admits that a prior art backlight unit was known to have an air gap that mixes light before the light is provided to the diffusion plate. EX1001, Figure 1 (reproduced below), 2:7-9 (“The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a *first gap 6a* which is an *air layer*.”), 2:12-19 (“The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a *second gap 10a* which is an *air layer*.”) (describing “background art”). And it was no accident that prior art backlight units used air gaps: as I explained above in Section VII.A.5 [Ground I, Claim 4], using an air gap (as opposed to gaps filled with other materials) had benefits. EX1005, [0022].



EX1001, Figure 1.

134. Forming “gap between the **diffusion plate** 110 and the LED array 130” with air would have been obvious in view of AAPA. EX1001, Figure 1, 2:7-19. Hong/Lee already has a “gap between the **diffusion plate** 110 and the LED array 130.” And naturally, the gap would have air unless the gap was filled with other material or was vacuumed.

135. A POSITA would have had a motivation to fill the gap with air. A POSITA would have understood, as explained in Section VII.A.5[Ground I, Claim 4], that in order for the light to mix well, the gap is desirably formed with a light-weight and non-light-absorbent material with “an index of refraction close to 1.0.” EX1005, [0022] (“The material filling mixing chamber 37 is selected to be *light weight*, to be *non-absorbing of light*, and to have an *index of refraction close to 1.0*.”). Air is one such material, and a POSITA would have recognized that air is lightweight with an index of refraction close to 1.0 and does not absorb a substantial amount of light. EX1017, Table 1. As such, a POSITA would have had a motivation to make the “gap between the **diffusion plate** 110 and the LED array 130” as an air gap.

136. A POSITA would have also found it obvious to use air in the “gap between the **diffusion plate** 110 and the LED array 130” because using air in the gap would have involved a mere substitution of a well-known element (Hong/Lee’s

backlight unit with a gap) for another (the air gap taught by AAPA), to obtain predictable results of a backlight unit that is bright and light-weight.

137. A POSITA would have found it obvious to use air in the “gap between the diffusion plate 110 and the LED array 130” also because that would have amounted to merely using a known technique (using air in the gap between the LEDs and a diffusion plate as taught by AAPA) to improve similar devices (AAPA’s backlight panel with a gap and Hong/Lee’s backlight unit with a gap) in the same way (a backlight unit that is bright and light weight).

138. There would have been a reasonable expectation of success using an air gap in Hong/Lee’s backlight unit because a POSITA would have recognized that using air would not change or lower the performance of Hong/Lee’s backlight panel. Indeed, a POSITA would have understood that air would not affect the functioning of the components within the liquid crystal display module, and that the diffusion plate, an LED array with white LEDs, a reflection sheet, would still work appropriately in the presence of air, as is taught by AAPA. EX1001, Figure 1, 2:7-9, 2:12-13 (describing “background art”); EX1005, [0022], [0026]-[0028]. And in fact, a POSITA would have understood that the performance of the backlight unit would be improved by the air gap. EX1005, [0022] (“[t]he material filling mixing chamber 37 is selected to be light weight, to be non-absorbing of light, and to have an index of refraction close to 1.0.”); [0035] (“Since the mixing chamber is hollow,

it is much lighter than a light guide formed from a sheet of plastic, as illustrated in FIG. 2. ... Further, eliminating the plastic light guide of FIG. 2 eliminates losses associated with interfaces between the plastic and adjoining surfaces and absorption in the plastic.”).

[0022] FIG.3 illustrates a first embodiment of a device for providing a predetermined brightness profile. FIG. 3 illustrates a cross section of a hollow mixing chamber in a backlight, according to a first embodiment of the invention. FIG. 4 illustrates a top view of a portion of the mixing chamber illustrated in FIG. 3. As illustrated in FIG. 4, two rows of LEDs are disposed in a hollow mixing chamber 37. LEDs 36 may be mounted on a circuit board 35 such that the lenses of LEDs 36 protrude through the bottom 37B of mixing chamber 37. LEDs 36 may be, for example, red, green, and blue LEDs selected such that when the light emitted by LEDs 36 is mixed, it appears white. The number of LEDs may depend on the area of mixing chamber 37. In general, for a given brightness, larger areas require more LEDs. Mixing chamber 37 may be hollow and filled with air. Other materials, for example, other gases, may fill mixing chamber 37 instead of air. ***The material filling mixing chamber 37 is selected to be light weight, to be non-absorbing of light, and to have an index of refraction close to 1.0.***

EX1005, [0022].

[0035] The use of a mixing chamber as illustrated in FIGS. 3 and 4 offers several advantages. ***Since the mixing chamber is hollow, it is much lighter than a light guide formed from a sheet of plastic***, as illustrated in FIG.2. Much of the light emitted from the LEDs reflects off the bottom, sides, and/or top of the mixing chamber before being emitted from the mixing chamber from the

openings in the reflective material on the top of the mixing chamber. The light cannot escape mixing chamber 37 without mixing with other light. In addition, improved mixing within the mixing chamber may eliminate the need for additional structures for mixing, which may reduce the thickness of a display incorporating a hollow mixing chamber. ***Further, eliminating the plastic light guide of FIG. 2 eliminates losses associated with interfaces between the plastic and adjoining surfaces and absorption in the plastic.***

EX1005, [0035].

139. There would have been a reasonable expectation of success using an air gap in Hong/Lee's backlight unit also because a POSITA would have recognized that providing an air gap in Hong/Lee's backlight unit would not have involved any specific modification. Indeed, implementing the combination would have merely involved making sure that air is present inside the display module package, and that would not have involved any specific modification.

140. At a minimum, it would have been obvious to try to use an air gap in Hong/Lee's backlight unit because it is so simple to fill the gap in Hong/Lee's backlight unit using air and air has an index of refraction close to 1.0. The modification would have involved no complex instruments or sealing, so it would have been common sense to use air in Hong/Lee's backlight unit.

3. **Claim 5**

- i. **[5] The backlight panel of claim 4, wherein light emitted from the white light emitting diodes is mixed together in the air gap before being emitted directly onto the bottom surface of the diffusion plate.**

141. For the reasons provided in Section VII.B.2 [Ground II, Claim 4], a POSITA would have found that Hong/Lee/AAPA renders obvious claim 4. The additional limitation of claim 5 is also taught by Hong/Lee/AAPA for the reasons provided above in Section VII.A.5 [Ground I, Claim 5].

VIII. Conclusion

142. Accordingly, it is my opinion that claims 1, 2, 4, and 5 of the '952 Patent are unpatentable.

IX. Availability for Cross-Examination

143. In signing this declaration, I acknowledge that this declaration will be filed before the Patent Trial and Appeal Board of the United States and Patent Office as evidence for a case. I also acknowledge that I may be subject to cross-examination in that case and that cross examination will occur in the United States. If I am required to submit to cross-examination, I will appear for cross-examination within the United States during the time allotted for cross-examination.

X. Right to Supplement

144. I reserve the right to supplement my opinions in the future to consider any new information as it becomes available to me and to respond to any arguments

that the Patent Owner may raise.

XI. Jurat

145. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1101 of Title 18 of the United States Code.

CLAIMS AT ISSUE

Claim 1

[1Pre] A backlight panel, comprising:

[1A] a diffusion plate comprising a top surface and a bottom surface;

[1B] a plurality of white light emitting diodes arranged below the bottom surface of the diffusion plate, the white light emitting diodes to emit light directly onto the bottom surface of the diffusion plate; and

[1C] a reflection sheet arranged below light exit surfaces of the white light emitting diodes, the reflection sheet to reflect light toward the diffusion plate,

[1D] wherein each white light emitting diode comprises a blue light emitting diode chip and a red phosphor and a green phosphor arranged on the blue light emitting diode chip.

Claim 2

[2] The backlight panel of claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film arranged on the top surface of the diffusion plate.

Claim 4

[4] The backlight panel of claim 1, further comprising an air gap arranged between the bottom surface of the diffusion plate and the reflection sheet.

Claim 5

[5] The backlight panel of claim 4, wherein light emitted from the white light emitting diodes is mixed together in the air gap before being emitted directly onto the bottom surface of the diffusion plate.

APPENDIX A

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EDUCATION

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EMPLOYMENT

**Vice Dean of Infrastructure and
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**Kenneth Brayer Professor
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PI, the Columbia Laboratory for Unconventional Electronics (CLUE).

Technical consultant/Senior engineer

**QDVision, Inc. (Now Samsung
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Assisted the technical launch of the company. Built out facilities, interviewed, hired, and trained initial staff, developed the core processes and demonstration vehicles for the company. Acquired by Samsung Electronics, the company's technology is part of the QLED display platform.

**Postdoctoral Associate
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**MIT
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2003 – 2006**

Advisor: Vladimir Bulovic.

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Microsystems Technology
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1999 – 2003**

Thesis: Field Emission from Organic Semiconductors. Advisor: Tayo Akinwande

**Summer Intern
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Developed a new characterization technique for analyzing ion density in liquid crystals and susceptibility of display alignment materials to charging and PDLC display systems. Advisor: Yoichi Taira

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1996-1999**

Led several aspects of the organic field effect transistor effort, most notably developing a photolithographic process for fabricating transistors and investigating the role of semiconductor crystallization on macroscopic performance parameters. Also worked on a program on screen printable high-K dielectrics and novel lead free soldering systems. (Three assignments, Summer 1996, 1997, June 1998-January 1999). Advisors: Christos Dimitrakopoulos and Sampath Purushothaman

AWARDS

2024 Fellow, SPIE
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2022 Fellow, Optica
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2021 Outstanding Volunteer Award 2021 by IEEE Kolkata Section
2019 Kenneth Brayer Professorship, Columbia University
2019 IEEE EDS Distinguished Lecturer
2018 40 under 40, Greek America Foundation
2018 Fellow, Society for Information Display
2017 Architizer A+ Award (Radiator Labs)
2016 Finalist, Verizon Powerful Answers Award (Chromotion)
2015 Winner, Verizon Powerful Answers Award (Radiator Labs)
2014 National Academy of Engineering, Frontiers of Engineering Education Meeting Attendee
2014 National Academy of Engineering, Indo-American Frontiers of Science Meeting Attendee
2014 Popular Science, Invention of the Year (Radiator Labs)
2013 IBM faculty award
2012 Interdigital Innovation Challenge, first prize
2012 MIT/USDOE Clean Energy Prize, first prize
2011 Ocean Optics Blue Ocean Award
2011 Kim Award for Undergraduate Involvement
2010 IBM Faculty award

	2009 Vodaphone Americas Foundation Wireless Innovation Award 2008 Google faculty award 2007 NSF CAREER award 2002 IVMC Shoulders Gray Spindt award 1998-2002 IBM Fellowship 2002 IBM Research First Plateau 2002 IBM Outstanding Technical Achievement Award 2000-2002 IBM Invention Achievement Award 1997 Tau Beta Pi, Eta Kappa Nu 1994-1998 National Merit Scholar
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ADVISORY POSITIONS	Tangible - Co-founder and technical advisor. BOD member. Solchroma - SAB member Chromation - Co-founder and CTO. BOD member. Radiator Labs - Co-founder and technical advisor. BOD member. Lumiode - Co-founder and interim CEO. BOD member. Lelantos - Co-founder and technical advisor. BOD member.
BOOK / BOOK CHAPTERS	Ioannis Kymissis (monograph). <i>Organic Field Effect Transistors: Theory, Fabrication and Characterization</i> Springer, New York, 2009. Lampert ZA, Cavallari MR, Kymissis I. Large Area Flexible Organic Field-effect Transistor Fabrication. Flexible Flat Panel Displays. 2023 Feb 14:47-66.
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5. "Patterning Pentacene Organic Thin Films." I. Kyymissis, C. D. Dimitrakopoulos, S. Purushothaman. *Journal of Vacuum Science and Technology B*. 20 (3): 956-959 May-Jun 2002.
4. "High-performance bottom electrode organic thin-film transistors." I. Kyymissis, C. D. Dimitrakopoulos, S. Purushothaman. *IEEE Transactions on Electron Devices* 48 1060-1064 June 2001.
3. "Low Voltage, High Mobility Pentacene Transistors with High Dielectric Constant Insulators." C. D. Dimitrakopoulos, I. Kyymissis, S. Purushothaman, D. A. Neumayer, P. R. Duncombe, R. B. Laibowitz. *Advanced Materials* 11 1372-1375 Nov 1999.
2. "Low Operating Voltage and High Mobility Field Effect Transistors Comprising Pentacene and Relatively High Dielectric Constant Insulators." C. D. Dimitrakopoulos, S. Purushothaman, J. Kyymissis, A. Callegari. *Science* 283 822-824 Feb 5 1999.
1. "Trans-trans 2, 5 bis(2-(5-(2-thienyl)ethenyl) Thiophene: Synthesis, Characterization, Thin Film Deposition, and Fabrication of Organic Field Effect Transistors." C. D. Dimitrakopoulos, A. Afzali-Ardakani,, B. Furman, J. Kyymissis, S. Purushothaman. *Synthetic Metals* 89 193-197 Sep 1997.

SHORT COURSES

(invited) SID Short course on MicroLED (Aug 2021)

(invited) SID Seminar on MicroLED (Aug 2020)

(invited, short course) SID Short Course on MicroLED, San Jose, CA, May 2019

(invited) University of Bologna Summer School on Physical Sensing and processing; July 2019

CONFERENCE
PRESENTATIONS/
POSTERS/ DEMOS
(PAST 5 YEARS)

IEEE Expert Now online short course on organic field effect transistors (2006)

(invited, keynote) Eurodisplay 2024

(invited, keynote) ASRC Nano Symposium 2024

(invited) IMID 2024

(invited) IDW MEET 2024

(invited) CMOC 2024

(invited, plenary) IEEE EDS Summer School in Neuromorphic Computing 2024

(invited) IWPSD 2023

(invited, plenary) CPES 2022

(invited) IDW 2022

(invited, plenary) IEEE ECTC

(invited) MRS Spring 2022

(invited) ICDT invited presentation (TBD) (June 2021)

(Invited, plenary) IEEE EDS Mini-Colloquium on Photonics and Photovoltaics (Spain chapter) June 2020

(Invited, plenary) IEEE EDS Brazil Chapter Seminar, Electronics on Anything, August 2020

(invited, plenary) SID LA one day conference on Advanced Displays, Los Angeles, CA; February 2020

(invited, plenary) MicroLED Display Summit, Nanjing China, December 2019

(invited, plenary) IEEE Frontiers In New Emerging Technology 2019 (FINE TECH) ; August 2019

(invited, plenary) IEEE EDSSC, Xi'an China, June 2019

Characterizing Image Retention for HDR OLED Displays SID Display Week 2020

Micro LED Defect Analysis via Photoluminescent and Cathodoluminescent Imaging, SID Display Week 2020

A brief survey of MicroLED Technologies, SID Display Week 2020

Bahamonde JA, Krishnaswamy H, Kymissis I. A Tunable Surface Acoustic Wave Device on Zinc Oxide via acoustoelectric interaction with AlGaIn/GaN 2DEG. InConference digest 2019 Jun.

A non-reciprocal surface acoustic wave filter based on asymmetrical delay lines and

parametric interactions-MEMS 2020, Vancouver, Canada.

A Hybrid PVDF/PDMS Electronic Skin for Accurate Touch Localization - Spring MRS 2019 (Phoenix, AZ)

(Demo) Display Week 2019 IZONE

Chae SH, Seo D, Cao Q, Hua X, Shih EM, Taniguchi T, Watanabe K, Kwon J, Lee GH, Dean CR, Schiminovich D. Near ultraviolet light emission in hexagonal boron nitride based van der Waals heterostructures. InCLEO: Science and Innovations 2019 May 5 (pp. SM1O-2). Optical Society of America.

Kim Y, Marone A, Danias G, Neville KE, Frantz AT, Kapoor T, Geraldino-Pardilla L, Kim HK, Askanase AD, Kymissis I, Hielscher AH. Flexible electronic bands for the dynamic optical spectroscopic assessment of systemic lupus erythematosus in finger joints. InOptical Diagnostics and Sensing XIX: Toward Point-of-Care Diagnostics 2019 Feb 20 (Vol. 10885, p. 108850Z). International Society for Optics and Photonics.

Khorramshahi F, Aljafari B, Kymissis I, Takshi A. Laser assisted rapid fabrication of perovskite photodetector. Organic and Hybrid Sensors and Bioelectronics XII 2019 Aug 30 (Vol. 11096, p. 110960C). International Society for Optics and Photonics.

US PATENTS (ISSUED)

12,156,715 Flexible optical imaging bands and optical imaging methods for the diagnosis and monitoring of systemic lupus erythematosus in finger joints
12,123,601 Dual function domestic hot water preheater and integrated space heater
12,104,114 Solution-processable superatomic thin-films
11,973,490 Non-reciprocal filter
11,759,147 Systems and methods for real-time concussion diagnosis by electroencephalogram activity monitoring
11,624,561 Thermal mass for heat pre-load and time-controlled dispersion in building heating systems
11,380,252 Addressing for emissive displays
11,133,866 All optical identification and sensor system with power on discovery
10,859,437 Integration of optical components within a folded optical path
10,663,361 Systems and methods for tactile sensing
10,656,013 Nanostructure based article, optical sensor and analytical instrument and method of forming same
10,652,963 LED display structures and fabrication of same
10,122,345 Co-integrated bulk acoustic wave resonators
10,107,612 Systems and methods for contact localization through spatially overlapping signals
10,041,689 Wireless automatic temperature control of radiator heating
9,863,979 Systems, apparatus, and methods for energy monitoring
9,666,600 Direct bandgap substrates and methods of making and using
9,431,623 Flexible devices including semiconductor nanocrystals, arrays, and methods
9,420,701 Flexible direct or USB plug-in platform for foldable or flexible electronics
9,390,920 Composition including material, methods of depositing material, articles including same and systems for depositing material
9,366,571 Photonic crystal sensor apparatus and techniques
9,293,553 Graphene electrodes for electronic devices
9,257,606 Direct bandgap substrates and methods of making and using
9,255,912 Monolithic FBAR-CMOS structure such as for mass sensing
9,252,013 Methods and articles including nanomaterial
9,194,801 Systems and methods for a DNA-based thermometer

9,120,149 Methods and articles including nanomaterial
 9,099,661 OFET including PVDF-TRFE-CFE dielectric
 9,096,425 Methods for depositing nanomaterial, methods for fabricating a device, methods for fabricating an array of devices and compositions
 9,054,329 Light-emitting devices and displays with improved performance
 8,906,804 Composition including material, methods of depositing material, articles including same and systems for depositing materials
 8,854,624 Photonic crystal spectrometer
 8,835,941 Displays including semiconductor nanocrystals and methods of making same
 8,750,517 Friend or foe detection
 8,472,758 Optical structures including nanocrystals
 8,470,617 Composition including material, methods of depositing material, articles including same and systems for depositing material
 8,441,018 Direct bandgap substrates and methods of making and using
 7,955,766 Software-controlled maskless optical lithography using fluorescence feedback
 7,858,975 Organic field effect transistor systems and methods
 7,683,323 Organic field effect transistor systems and methods
 7,345,764 Apparatus and method for a slim format spectrometer
 6,870,312 Organic field emission device
 6,569,707 Method for improving performance of organic semiconductors in bottom electrode structure
 6,500,604 Method for patterning sensitive organic thin films
 6,335,539 Method for improving performance of organic semiconductors in bottom electrode structure
 6,180,956 Thin film transistors with organic-inorganic hybrid materials as semiconducting channels

UNIVERSITY
 LEADERSHIP

Vice Dean for Infrastructure and Innovation, SEAS (2024-present)
 Chair. Provost research advisory committee to the library research subcommittee (PACL) (2022-2025)
 Chair, School at Columbia Advisory committee (2023-2025)
 co-chair, School at Columbia Advisory HOS search committee (2021-2023)
 Faculty in Residence, Hartley Hall/first-year zone (2012-present)
 Columbia Maker Space, Director (2014-present)
 Member, School at Columbia Advisory committee (2020-2023)
 Provost Leadership Fellow (2017-2019)
 Member. Provost research advisory committee to the library (PACL) + research subcommittee (2018-present)
 CNI Shared Facilities, faculty Director (2016-present)
 Faculty advisor, TBP (2016-present)
 Faculty advisor, Columbia Space Initiative (2015-present)
 Nano Initiative co-chair (2014-2016)
 CISE/Columbia Nano Initiative executive committee (2012-present)
 EFRC: Thrust leader and executive committee member (2008-2014)
 Institute for Data Sciences and Engineering: Space planning committee (2012-2019)
 Columbia University Cleanroom Committee (2008-present)
 NSEC: Outreach and education committee member (2008-2010)
 Columbia Environmental Health and Safety Faculty Working Group (2008-2015)

DEPARTMENT
 LEADERSHIP

EE Department Chair (2020-2024)
 EE Department vice-chair (2019-2020)
 EE Department undergraduate program chair (2010-2019, 2024-present)

	EE Safety committee (2020-present) EE Department ombudsman (2019-2020)
UNIVERSITY ADMINISTRATIVE PROGRAMMING	Path to professorship (panelist) (2018-present) Responsible conduct of research (panelist) (2019-present) COI monitor (2017-2023) Family Weekend (EE, Makerspace programs) (various) Organizing committee, NanoDay 2009
EXTERNAL ACADEMIC SERVICE	External Advisory Board, Tufts University Department of Electrical Engineering (2023-present) External Advisory Board, University of Delaware Department of Electrical Engineering (2023-present) FWO (Flanders Research Foundation) Energy, Electrical Engineering, Electronics and Mechanics External expert (2019-2023) External Evaluator, National Technical University of Athens EE program (2021)
PROGRAM COMMITTEES	IEEE IFETC Program Committee 2022 IMID: Program committee/Advisory board 2019,2018 ICDT: International Advisory Board 2022, 2021, 2020, 2019, 2018 IDW: Program committee/EAB 2024, 2019, 2018, 2017, 2016, 2015 SID: EMD program committee 2025, 2024, 2023, 2022, 2021, 2020, 2019, 2018, 2017, 2016, 2015 SID: Vice program chair, 2019 SIGGRAPH: External reviewer 2022, 2021, 2020, 2018, 2017 EMC: Program committee 2022, 2021, 2020, 2019, 2018, 2017, 2016 IEDM: Program committee 2016, 2015, 2014 MRS: Symposium organizer 2021, 2019, 2015, 2013, 2011, 2009, 2007 DRC: GenChair 2014, TPC Chair 2013, TPC VC 2012, TPC member 2011, board member (2014-present) SPIE: Symposium organizer 2025, 2024, 2023, 2022, 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011, 2010, 2009, 2003 LOPE-c: VP Americas/program committee 2014, 2013, 2012, 2011 IEEE/MRS/ACS Organic Electronics Workshop: Executive committee 2009-2011 SID-MAC Workshop on Organic and Thin Film Electronics, chair, 2009 CS/IEEE/MRS North East Regional Meeting, co-organizer, 2006 International Vacuum Nanoelectronics Conference: Local arrangements 2004
EDITORIAL POSITIONS	Publication chair, Society for Information Display (SID) 2015-2018 Editor in Chief, Journal of the Society for Information Display (JSID). 2012-2015 Associate Editor, Journal of the Society for Information Display (JSID). 2015-present Associate Editor, KIDS Journal of Information Display (KIDS JID). 2011-2016 Associate Editor, IEEE Transactions on Electron Devices (IEEE TED). 2014-2022 Associate Editor, IEEE Open Journal of Immersive Displays (2024-) Advisory Board (EDS representative) - Journal of Electronic Materials (2024-)
ELECTED POSITIONS	EDS Distinguished Lecturer 2019-present Armstrong Memorial Research Foundation, Board/Treasurer 2016-present President, Society for Information Display. 2024 - 2026 President Elect, Society for Information Display. 2022 - 2024 Treasurer, Society for Information Display. 2020 - 2022

Secretary, Society for Information Display. 2018 - 2020
 Director, Device Research Conference Inc. (a non-profit foundation). 2014-present
 VP Americas East, Society for Information Display. 2017-2018
 IEEE EDS Regions 1-3 & 7 SRC Vice Chair; IEEE Electron Device Society. 2012-2017
 Director, Society for Information Display, Mid Atlantic Chapter. 2012-2017
 Publication Chair, Society for Information Display. 2015-2018
 Chairman, EDS Vice-chair. IEEE New York Section Electron Device/Solid State Circuit Society Joint Chapter. 2007-present
 Secretary, Treasurer, Vice-chair , Chair. Society for Information Display, Mid Atlantic Chapter. 2007-2011

GRADUATE THESES Completed:

SUPERVISED

Christine McGinn (PhD, NIST)
 “MicroLED and Microdevices for Next-Generation Display Systems”, Keith Beherman, 2021 (PhD, Fathom Radiant)
 “Non-reciprocal Acoustic Devices for RF Communications”, Columbia University EE, Jose Bhanmode 2019 (PhD, Lelantos)
 “Flexible Electronics for Large Area Sensing and Stimulation”, Columbia University EE, Caroline Yu 2019 (PhD, Apple)
 “Domain Broadening in Periodic Poling of Thinned Lithium Niobate and Spectroscopic Methods for Whole Blood Analysis” Columbia University APAM, Peter Bullen 2019 (PhD, PsiQuantum)
 “Optoelectronic Neural Implant Sensors for Cerebral Blood Volume Monitoring” Columbia University EE, Christopher Choi 2018 (PhD, Trackonomy)
 “Monolithic Integration Piezoelectric Resonators on CMOS for Radio-Frequency and Sensing Applications” Columbia University EE, Aida Colon Berrios 2018 (PhD, Apple)
 “Charge Injection and Transport in Pentacene Field-Effect Transistors” Columbia University EE, Amrita Masurkar 2016 (PhD, BAE Systems)
 “Monolithically Integrated Acoustic Resonators on CMOS for Radio-Frequency Circuit Applications” Columbia University EE, Hassan Eddrees 2016 (PhD, Apple)
 “Ionizing Radiation Effects on Graphene Based Field Effects Transistors” Columbia University EE, Kostas Alexandrou 2016 (PhD, Intel)
 “Optimization of Printed Electronics”, Columbia University EE, Shyuan Yang 2015 (PhD, Apple)
 “Excimer Laser Crystallization of Silicon Thin Films for Monolithic 3D Integration”, Columbia University EE, Fabio Carta 2015 (PhD, IBM)
 “Harvest,” School of Visual Arts, MFA Damon Ahola, 2014 (MS, Lyft)
 “Organic photovoltaic device architectures”, Columbia University EE, Jonathan Beck 2013 (PhD, Apple)
 “Systems for Pervasive Electronics and Interfaces”, Columbia University EE, John Sarik 2013 (PhD, Nanohmics)
 “Electrowetting on dielectrics”, Columbia University EE, Haig Norian (Co-supervised with Ken Shepard) 2013 (PhD, ASML)
 “Processes and Materials for Organic Photovoltaics”, Columbia University EE, 2012, Marshall Cox. (PhD, Kelvin)
 “Ultrasound Data Communications for Ultra-low-power Wake-up in Sensor Nodes”, Columbia University EE, 2012, Kshitij Yadav. Co-supervised with Peter Kinget. (PhD, Qualcomm)
 “Advanced Integration of Devices Enabled by Laser Crystallized Silicon”, Columbia University EE, 2012, Vincent Lee. (PhD, NSF)
 “The Integration and Applications of Organic Thin Film Transistors and Ferroelectric Polymers” Columbia University EE, 2012, Yu-Jen Hsu. (PhD, Space/X)
 “Interfacial Studies in Organic Field-Effect Transistors”, Columbia University APAM, 2011, Zhang Jia. (PhD, Meta)

Columbia University EE, Kevin Kam (PhD, Apple)
Columbia University EE, Vikrant Kumar (PhD, Apple)

In progress:

Columbia University EE, Zicong Huang
Columbia University EE, Peter Ballentine
Columbia University EE, Reem Alshanbari
Columbia University EE, Oliver Durnham
Columbia University EE, Megan Noga
Columbia University EE, Huaquan Guo
Columbia University EE, Ye Zhang

POST-DOCTORAL
ASSOCIATES
SUPERVISED

Completed:
Sung-Jin Kim (Chungbuk National University)
Nadia Pervez (Rice University)
Brian Tull (Space/X)
Htay Hliang (Applied Materials)
En-Chen Chen (KLA-Tencor)
Steve Park (KAIST)
Marco Roberto Cavallari (State University of Campinas (Unicamp), Brazil)
Lei (Andy) Zhang (University of Melbourne)
Stylianios Siontas (Lelantos)
Zachary Lample (Exponent)
Sayan Dey (IIT Bhubaneswar)
Rajinder Deol (Washington University/St. Louis)
Sourabh Pal (Max Planck Institute for Polymer Physics)
Nikita Batra

In progress:
Ilaria Fratelli

POST-DOCTORAL
ASSOCIATES
CO-SUPERVISED
(50%)

Completed:
Theanne Schiros (SUNY/FIT)
Robert Barton (Amazon)
Octavi Semonin (Powerhouse)