

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

MIANYANG BOE OPTOELECTRONICS TECHNOLOGY CO., LTD.; WUHAN
CHINA STAR OPTOELECTRONICS SEMICONDUCTOR DISPLAY
TECHNOLOGY CO., LTD.; TIANMA MICROELECTRONICS CO. LTD.; AND
VISIONOX TECHNOLOGY, INC.,

Petitioner,

v.

SAMSUNG DISPLAY CO., LTD.,

Patent Owner.

U.S. Patent No. 10,854,683

Case No. IPR2023-00988

DECLARATION OF P. MORGAN PATTISON, PH.D.

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I, P. Morgan Pattison, Ph.D., declare as follows:

I. INTRODUCTION

1. I have been retained by Mianyang BOE Optoelectronics Technology Co., Ltd. (“BOE”) as an independent expert consultant in this proceeding before the United States Patent and Trademark Office (“PTO”). I am not an employee of BOE or any affiliate or subsidiary of BOE.

2. I have been asked to consider whether certain references teach or suggest the features recited in the claims of U.S. Patent No. 10,854,683, which I refer to herein as the ’683 patent.

3. My opinions and the bases for my opinions are set forth below.

4. I am being compensated at my standard consulting rate for my time. My compensation is based solely on the amount of time that I devote to activity related to this case and is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other financial interest in this proceeding.

II. EDUCATION BACKGROUND, PROFESSIONAL EXPERIENCE, AND OTHER QUALIFICATIONS

5. My curriculum vitae (“CV”) is attached hereto as Attachment A and provides an accurate identification of my background and experience.

6. I have over (25) years of experience in the areas of light emitting diodes (LEDs), organic light emitting diodes (OLEDs), lighting, solid state lighting (SSL), displays, lasers, and optoelectronic materials and devices

7. I am the Founder and President of Solid State Lighting Services, Inc. In that capacity, I am responsible for, among other things, providing technical, strategic, and market expertise in the areas of LEDs, OLEDs, lighting, SSL, displays, and optoelectronic materials and devices. I am also involved in connecting optical device technical performance with application requirements for displays, general illumination, color discrimination applications (medical, retail), and various novel lighting applications enabled by SSL technology.

8. From January 2006 through November 2007, I worked as a Project Manager at the U.S. Department of Energy (DOE). In that capacity, I was responsible for managing DOE funded research and development projects in SSL including LED and OLED lighting technologies. My duties included managing the solicitation and selection of R&D projects with the objective of saving energy. As part of the solicitation and selection process, I evaluated and identified priority areas of research necessary for advancement of SSL in terms of efficiency, lighting performance, and cost.

9. From September 2000 through January 2006, I was a Graduate Student Researcher at University of California Santa Barbara (UCSB). I performed my

Doctoral thesis research under Professor Shuji Nakamura (Nobel Prize in Physics 2014) on gallium-nitride (GaN) based micro-cavity light emitting diodes. The research included: epitaxial structure design and growth by MOCVD, semiconductor process development, materials characterization, and electro-optical device characterization. While at UCSB, I participated in additional areas of research, including research and development of UV LEDs, vertical cavity surface emitting lasers (VCSEL), and edge emitting laser diodes.

10. From November 1966 through May 2000, I worked as a Laser Test Engineer at Cymer Laser. I was responsible for testing and developing test methodology for production and prototype KrF and ArF excimer lasers used in deep UV photolithography for manufacturing of advanced semiconductor products. Testing included optical characterization and full system troubleshooting. I also developed new electrical and optical test methodologies to improve test cycle times, automated test procedures, and developed test documentation.

11. I earned a Ph.D. in Materials Science, Electronic and Photonic Materials from the UCSB in 2006. As stated above, my graduate work focused on development of Fabrication and Characterization of Gallium Nitride Based Micro-Cavity LEDs.

12. I obtained a Master's Degree in Electrical Engineering, Electronics and Photonics from UCSB in 2003.

13. I obtained a Bachelor's Degree in Electrical Engineering, Electronic Devices and Materials from UC San Diego in 1996.

14. I am listed as an inventor on at least 11 issued patents, including multiple patents in the field of LED materials and device design, LED lighting product design, and home automation and controls for lighting.

15. I have authored numerous peer reviewed journal articles and publications on the topics of LED materials and device design.

16. Since 2008, I have also authored annually updated R&D and technology and manufacturing roadmaps used by the DOE to guide federal lighting R&D efforts. I frequently give presentations and talks on the topic of LED technology, SSL status and R&D opportunities, and application advancements enabled by LED technology.

III. ASSIGNMENT AND MATERIALS CONSIDERED

17. I have been asked to provide analysis and explain the subject matter of the '683 patent, including the state of the art when the application underlying the '683 patent was filed. I have also been asked to consider, analyze, and explain certain prior art to the '683 patent including how that art relates to the challenged claims of the '683 patent and to provide my opinions regarding whether that art invalidates the claimed subject matter.

18. The opinions expressed in this declaration are not exhaustive of opinions I may offer in the future regarding the unpatentability of the claims of the '683 patent. Therefore, the fact that I do not address a particular point should not be understood to indicate an agreement on my part that any claim complies with the requirements of any applicable patent or other rule.

19. I reserve the right to amend and supplement this declaration in light of additional evidence, arguments, or testimony presented during this IPR or related proceedings on the '683 patent.

20. In forming the opinions set forth in this declaration, I have considered and relied upon my education, knowledge of the relevant field, knowledge of scientific and engineering principles, and my experience. I have also reviewed and considered the '683 patent (Exhibit 1001), its prosecution history (Exhibit 1002), and the following additional materials:

Exhibit	Description
1004	U.S. Patent No. 6,897,855 B1 to Matthies et al.
1005	U.S. Patent No. 7,091,986 B2 to Phan
1006	JP 4496852 B2 to Murai et al.
1007	Certified translation of JP 4496852 B2 to Murai et al. and associated translator's declaration
1008	U.S. Patent No. 6,366,025 B1 to Yamada
1009	U.S. Patent No. 7,250,722 to Cok et al.

1010	U.S. Pub. 2005/0116615 A1 to Matsumoto et al.
1011	U.S. Patent No. 3,971,065 to Bayer
1012	U.S. Pub. 2009/0302331 A1 to Smith et al.
1013	U.S. Pub. 2003/0128179 A1 to Credelle
1014	U.S. Patent No. 8,354,789 B2 to Kim
1015	File History of U.S. Patent No. 9,818,803
1016	U.S. Pub. 2011/0291549 A1 to Kim
1017	U.S. Patent No. 6,867,549 to Cok et al.

IV. UNDERSTANDING OF THE LAW

21. I am not an attorney, but have been instructed in and applied the law as described in this section.

22. I understand that the first step in comparing an asserted claim to the prior art is for the claim to be properly construed. I address how a person of ordinary skill in the art (POSITA) would have understood the claims of the alleged invention in Section VII below.

23. I have been further instructed and understand that a patent claim is unpatentable and invalid as obvious if the subject matter of the claim as a whole would have been obvious to a POSITA of the claimed subject matter as of the time of the invention at issue. I understand that when assessing the obviousness of claimed subject matter, the following factors are evaluated: (1) the scope and content of the prior art; (2) the difference or differences between each claim of the patent

and the prior art; and (3) the level of ordinary skill in the art at the time the patent was filed.

24. I understand that claimed subject matter may be obvious in view of more than one item of prior art. I understand, however, that it is not enough to show simply that all the limitations of the claimed subject matter are spread throughout the prior art. Instead, for claimed subject matter to be obvious over multiple references, there must be some reason or motivation for a POSITA to combine the prior art references to arrive at the claimed subject matter.

25. I have been informed that, in seeking to determine whether an invention that is a combination of known elements would have been obvious to a POSITA at the time of the invention, one must consider the references in their entirety to ascertain whether the disclosures in those references render the combination obvious to such a person.

26. I have been informed and understand that, while not required, the prior art references themselves may provide a teaching, suggestion, motivation, or reason to combine, but other times the motivation linking two or more prior art references is common sense to a POSITA at the time of the invention.

27. I understand that a particular combination may be proven obvious by showing that it was obvious to try the combination. I have been informed that, if a technique has been used to improve one device, and a POSITA would recognize that

it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

28. I further understand that an obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references also may be supplied by the direction of the marketplace. For example, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a POSITA has good reason to pursue the known options within his or her technical grasp because the result is likely the product not of innovation but of ordinary skill and common sense.

29. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. Thus, where all of the elements of a claim are used in substantially the same manner, in devices in the same field of endeavor, the claim is likely obvious.

30. Additionally, I understand that a patent is likely to be invalid for obviousness if a POSITA can implement a predictable variation or if there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. Therefore, when a work is available in one

field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one.

31. I further understand that combining embodiments related to each other in a single prior art reference would not ordinarily require a leap of inventiveness.

32. I also understand that a POSITA must have had a reasonable expectation of success when combining references for claimed subject matter to be obvious.

33. I have been informed and I understand that factors referred to as “objective indicia of non-obviousness” or “secondary considerations” are also to be considered when assessing obviousness when such evidence is available. I understand that these factors can include: (1) commercial success; (2) long-felt but unresolved needs; (3) copying of the invention by others in the field; (4) initial expressions of disbelief by experts in the field; (5) failure of others to solve the problem the claimed subject matter solved; and (6) unexpected results.

34. I also understand that evidence of objective indicia of non-obviousness must be commensurate in scope with the claimed subject matter. I further understand that there must be a relationship, sometimes referred to as a “nexus,” between any such secondary indicia and the claimed invention.

35. Finally, I have been informed that one cannot use hindsight to determine that an invention was obvious.

36. I provide my opinions in this declaration based on the guidelines set forth above.

V. LEVEL OF SKILL IN THE ART

37. I have been informed and understand that the level of ordinary skill in the relevant art at the time of the invention is relevant to inquiries such as the meaning of claim terms, the meaning of disclosures found in the prior art, and the reasons a POSITA may have for combining references.

38. I have been informed and understand that factors that may be considered in determining the level of ordinary skill include: (1) the education of the inventor; (2) the 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) education level of active workers in the relevant field. I have been further informed and understand that a person of ordinary skill in the art (POSITA) is also a person of ordinary creativity.

39. In my opinion, a POSITA in the field of the '683 patent would have had a degree in electrical engineering, materials science, physics, or a similar discipline, along with 2 years of professional experience working with display design, including OLED displays, or an equivalent level of skill, knowledge, and experience. This POSITA would have been aware of and generally knowledgeable about OLED materials, and display pixel design, layout, and operation.

40. In view of my educational background (*e.g.*, Ph.D. in Materials Science, Electronic and Photonic Materials) and years of experience working with various display technologies as discussed in Section II, I was a person of more than the ordinary level of skill in the art as of March 2012. In forming my opinion, I have drawn on my academic background and professional experiences. My opinions herein, however, were formed taking into account the perspective of an ordinarily skilled artisan.

VI. THE '683 PATENT

A. Effective Filing Date

41. I understand that the application leading to the '683 patent was filed on November 13, 2017.

42. Based on my review of the '683 patent, I note that it identifies itself as a continuation of an application filed September 13, 2012 (which led to U.S. Patent No. 9,818,803). It also references a March 6, 2012 foreign filing on its face.

43. For purposes of this declaration, I have been instructed to use March, 2012 as the effective filing date of the '683 patent. My opinions in this declaration were formed from the perspective of a POSITA as of March 6, 2012, including both the knowledge of a POSITA at that time as well as how a POSITA would have understood the prior art. My opinions, however, would be the same even if the patent is only entitled to a September 2012 filing date.

B. Overview

44. The '683 patent relates to “a pixel arrangement structure of an organic light emitting diode (OLED display).” (Ex. 1001, 1:20-21.)

45. The patent explains that an “OLED display includes a plurality of pixels for emitting light of different colors.” (*Id.*, 1:34-45.)

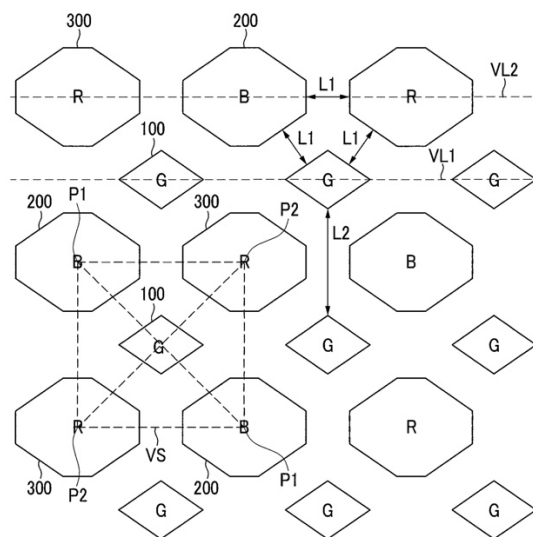
46. Next, according to the patent, in an OLED display, the pixels can be “deposited and formed” on a substrate “by using a ... fine metal mask (FMM).” (*Id.*, 1:43-45.)

47. However, forming pixels in this way purportedly leads to two countervailing considerations: “[w]hen reducing a gap between the neighboring pixels to obtain a high aperture ratio of the pixel, deposition reliability may be deteriorated.” (*Id.*, 1:45-47.) But, “when increasing the gap between the pixels to improve the deposition reliability, the aperture ratio of the pixel may be deteriorated.” (*Id.*, 1:48-50.)

48. In an apparent effort to address these considerations, the '683 patent discusses “a pixel arrangement structure for an OLED display having an improved aperture ratio of a pixel while efficiently setting up a gap between the pixels.” (*Id.*, 1:59-67.)

49. Figure 1 of the '683 patent, which is reproduced below, provides an example:

FIG.1



(*Id.*, Fig. 1.)

50. This figure depicts an example “OLED display” including red, green, and blue pixels. (*Id.*, 3:56-59, 4:16-17, 4:34-35; 4:47-48.)

51. The pixels are arranged in a “virtual square VS” (the dotted box) with a green pixel 100 “at a center point.” (*Id.*, 4:8-25.) The blue pixels 200 and red pixels 300 are located at “vertices” P1 and P2 of the “virtual square VS.” (*Id.*, 4:26-59.)

52. The blue and red pixels are both the same size and have “a larger area” than the green pixels. (*Id.*, 4:28-30; 4:40-42.)

53. The ’683 patent states that “by enclosing each of the” green pixels within “a pair” of red and blue pixels, “the aperture ratio” of all the pixels is somehow “improved.” (*Id.*, 5:24-27.)

54. Beyond stating that “aperture ratio” is “improved,” the ’683 patent does not explain why this is the case, or why it is important to use a “virtual square” instead of some other shape. (*See generally id.*) The independent claims of the ’683 patent discussed in this declaration do not reference a “virtual square.”

55. The patent also does not explain how “aperture ratio” (*i.e.*, the ratio of light emitting area to total pixel area) can be improved when using the relatively small pixel sizes and relatively large spaces between pixels shown in the ’683 patent’s figures. (*See generally id.*)

56. The patent also does not explain how it maintains an “improved aperture ratio” while locating non-light emitting elements “such as a gate line, a data line, a driving power line, and the like” in the spaces “among” the pixels. (*Id.*, 3:62-65.) All of these elements—many of which are formed from opaque conductive material—serve to reduce a particular pixel’s aperture ratio.

57. According to the ’683 patent, in the pixel arrangement of Figure 1, there is also a “distance” L1 between the red, green, and blue pixels. (*See id.*, 5:1-8.) The “distance” L2 between different green pixels is “longer than” distance L1. (*Id.*, 5:8-10.)

58. The ’683 patent states that use of these distances somehow “results in improved deposition reliability when using a fine metal mask to form the green, blue, and red” pixels, it also does not explain why this is. (*See id.*, 5:20-23.)

59. But, the patent also explains that use of other, completely different pixel-to-pixel spacings can purportedly produce this same benefit. (*See, e.g., id.*, 6:26-38.)

60. Moreover, the patent explains that the dimensions and spacings in its figures, including those in Figure 1 and the patent's other figures, are "arbitrar[y]" and are not meant to be "limit[ing]" in any way. (*Id.*, 3:36-40.)

61. While the '683 patent's claims reference two "distances," they are not the same distances as those depicted in Figure 1.

62. The '683 patent also explains that the pixel arrangement shown in Figure 1 can be varied in different ways.

63. For instance, the pixels can have different shapes and sizes. (*See id.*, 3:45-50.) In Figure 2, the blue pixels are largest and the green pixels are smallest. (*See id.*, Fig. 2.)

64. According to the '683 patent, sizing the pixels in this way "suppress[es] the deterioration of the life span of the OLED display" by accounting for the fact that the blue pixels have "the shortest lift span." (*Id.*, 6:46-53.)

C. Prosecution History

65. As noted above, I have reviewed the '683 patent's prosecution history.

66. The patent's claims were repeatedly rejected over a series of prior art references, including:

- U.S. Pub. 2003/0128179 A1 to Credelle (Ex. 1013, “Credelle”),
- U.S. Patent No. 8,354,789 B2 to Kim (Ex. 1014, “Kim”), and
- U.S. Pub. 2011/0291549 A1 to Kim (Ex. 1016, “Kim ’549”).

(*See, e.g.*, Ex. 1002, pp. 386-395, 433-443, 487-495, 525-535, 710-719, 777-787.)

67. In response to these prior art rejections, the claims were repeatedly amended and narrowed.

68. For instance, in one amendment a limitation was added requiring that the “first pixel” be green and smaller. (*Id.*, p. 306.)

69. In another amendment, a limitation was added requiring “line[s]” that pass through the “centers” of the pixels. (*Id.*, p. 501.)

70. In each response, Patent Owner relied on the small design differences between the claims and the prior art (including those added via amendment) in an effort to distinguish the prior art references the Examiner was citing

71. Patent Owner argued that in both Credelle and Kim, the green pixel was larger—not smaller—than the other pixels. (*See id.*, pp. 311-312.)

72. With respect to Kim ’549, Patent Owner argued that the “first pixel/third sub-pixels ... are offset such that” lines do not pass through the pixel “centers.” (*Id.*, p. 498.)

73. Patent Owner then made a final amendment limiting to claims such that “each of the second pixels has a larger area than each of the third pixels.” (*Id.*, pp. 617-618.)

74. After this, the claims were allowed. (*See id.*, p. 711.))

D. Claims

75. For reference, claims 1-2, 4-10, 13, and 15 of the '683 patent are reproduced below:

1. A pixel arrangement structure of an organic light emitting diode (OLED) display comprising:

a plurality of pixels for displaying an image on the OLED display and comprising:

a first pixel;

a pair of second pixels separated from the first pixel, the second pixels being located at opposite sides of the first pixel along a first line on which the first pixel, the second pixels, and another first pixel are consecutively arranged such that the first line passes through respective centers of the first pixel, the second pixels, and the other first pixel; and

a pair of third pixels separated from the first pixel and the second pixels, the third pixels being located at opposite sides of the first pixel along a second line on which the first pixel, the third pixels, and an additional first pixel are consecutively arranged such that the second line passes through respective centers of the first pixel, the third pixels, and the additional first pixel, the second line crossing the first line at a location of the first pixel,

wherein a first distance between the second pixels is greater than a second distance between one of the second pixels and a neighboring one of the third pixels,

wherein the first pixels are configured to emit green light, which is a color that is different from light emitted by the second pixels and the third pixels,

wherein the first pixels are smaller than at least one of the second pixels or the third pixels, and

wherein each of the second pixels has a larger area than each of the third pixels.

2. The pixel arrangement structure of claim 1, wherein the first pixels, the second pixels, and the third pixels have polygonal shapes, and

wherein each of the second pixels and the third pixels has a larger area than the first pixel.

4. The pixel arrangement structure of claim 1, wherein the first pixels, the second pixels, and the third pixels are configured to emit different color lights.

5. The pixel arrangement structure of claim 4, wherein the second pixels are configured to emit blue light, and the third pixels are configured to emit red light.

6. The pixel arrangement structure of claim 1, wherein each of the second pixels has a larger area than that of the first pixel.

7. The pixel arrangement structure of claim 1, wherein the second pixels are substantially equidistant from the first pixel interposed between the second pixels, and the third pixels are substantially equidistant from the first pixel interposed between the third pixels.

8. The pixel arrangement structure of claim 1, wherein the first distance is measured between respective centers of the second pixels, and the second distance is measured

between respective centers of the one of the second pixels and the neighboring one of the third pixels.

9. The pixel arrangement structure of claim **1**, wherein the first line passes through respective centers of the first pixel and the second pixels, and the second line passes through respective centers of the first pixel and the third pixels.

10. The pixel arrangement structure of claim **1**, wherein each of the first pixels, the second pixels, and the third pixels has a convex shape.

13. A pixel arrangement structure of an organic light emitting diode (OLED) display comprising:

- a plurality of pixels for displaying an image on the OLED display and comprising:

- a first pixel;

- a pair of second pixels separated from the first pixel, the second pixels being located at opposite sides of the first pixel along a first line on which the first pixel, the second pixels, and another first pixel are consecutively arranged such that the first line passes through respective centers of the first pixel, the second pixels, and the other first pixel; and

- a pair of third pixels separated from the first pixel and the second pixels, the third pixels being located at opposite sides of the first pixel along a second line on which the first pixel, the third pixels, and an additional first pixel are consecutively arranged such that the second line passes through respective centers of the first pixel, the third pixels, and the additional first pixel, the second line crossing the first line at a location of the first pixel,

- wherein a first distance between the second pixels is greater than a second distance between one of the

second pixels and a neighboring one of the third pixels,
wherein the first pixels are configured to emit green light,
wherein the first pixels have a smaller size than at least one of the second pixels or the third pixels, and
wherein each of the second pixels has a larger area than each of the third pixels.

15. A pixel arrangement structure of an organic light emitting diode (OLED) display comprising:

a plurality of pixels for displaying an image on the OLED display and comprising:

a first pixel;

a pair of second pixels separated from the first pixel, the second pixels being located at opposite sides of the first pixel along a first line passing through respective centers of the first pixel and the second pixels on which the first pixel, the second pixels, and another first pixel are consecutively arranged such that the first line passes through respective centers of the first pixels, the second pixels, and the other first pixel; and

a pair of third pixels separated from the first pixel and the second pixels, the third pixels being located at opposite sides of the first pixel along a second line passing through respective centers of the first pixel and the third pixels on which the first pixel, the third pixels, and an additional first pixel are consecutively arranged such that the second line passes through respective centers of the first pixel, the third pixels, and the additional first pixel, the second line crossing the first line at a location of the first pixel,

wherein a first distance between the second pixels is greater than a second distance between one of the

second pixels and a neighboring one of the third pixels,
wherein the first pixels are configured to emit green light, which is a color that is different from light emitted by the second pixels and the third pixels,
wherein the first pixels are smaller than at least one of the second pixels or the third pixels, and
wherein each of the second pixels has a larger area than each of the third pixels.

VII. CLAIM CONSTRUCTION

76. I am not a legal expert or an attorney and offer no opinions on the law. I understand that claim construction is a matter of law. However, I have been informed by counsel of the legal standards that apply to claim construction in an *inter partes* review, and I have applied them in forming my opinions. I understand that during an *inter partes* review, the same claim construction standard used in federal district court is applied when addressing the meaning of claim terms.

77. I have been informed that the words of a claim are generally given the ordinary and customary meaning that the term or phrase would have to POSITA at the time of the invention in view of the surrounding claim language, the specification and the file history (collectively, the “intrinsic evidence” or “intrinsic record”).

78. I also understand that courts may consider extrinsic evidence, such as expert and inventor testimony, dictionaries, and learned treatises (collectively, the “extrinsic evidence” or the “extrinsic record”), but that such extrinsic evidence should be given less weight than the intrinsic evidence.

79. In my opinion, the terms of the '683 patent's claims can be afforded their plain and ordinary meaning for purposes of the analysis of the prior art that I am conducting in this declaration.

VIII. UNPATENTABILITY ANALYSIS

80. For the reasons I explain in greater detail below, it is my opinion that as of the effective filing date of the '683 patent, a POSITA would have considered claims 1-2, 4-10, 13, and 15 of the '683 patent to be unpatentable as obvious over the prior art discussed in this declaration.

A. Overview of the Prior Art

81. The following paragraphs provide an overview of the main prior art references I discuss throughout this declaration.

1. Matthies

82. Matthies indicates on its face that it issued May 23, 2005. (Ex. 1004, Cover.) In view of this date of issuance, which predates the '683 patent date of filing by more than a year, I understand that Matthies is prior art under at least § 102(b).

83. Matthies is not cited by the '683 patent and was not considered during prosecution. (*See generally* Exs. 1001, 1002.)

84. Matthies relates to “electronic display devices and, in particular, large-area display devices which are formed as an array of tiled display devices.” (Ex. 1004, 1:8-10.)

85. Matthies explains that by “[b]uilding a large-area display out of smaller tiles,” the display can be made larger while “reduc[ing] manufacturing costs.” (*Id.*, 1:48-65.)

86. According to Matthies, existing tiled displays do not “allow a display to be constructed so that pixels can be brought up to the very edge ... while at the same time allowing for electronics to address each tile.” (*Id.*, 2:2-7.)

87. To address this need, Matthies teaches an “improved tiled display structure.” Figure 1 provides a “front plan view of” one such improved “partially assembled large-area display 100.” (*Id.*, 5:35-36.)

88. The depicted display 100 includes a large number of “emissive ... elements” (or sub-pixels) that are arranged in “arrays on tiles” like labeled tiles 122 and 124. (*Id.*, 5:37-55.)

89. Matthies explains that while the example display 100 is shown to include tiles with “16 pixel forming elements in a four by four array,” each tile can be larger and can include for instance “896 pixel forming elements arranged as a 32 by 28 matrix.” (*Id.*, 5:56-61.) Figure 1 is reproduced below for reference:

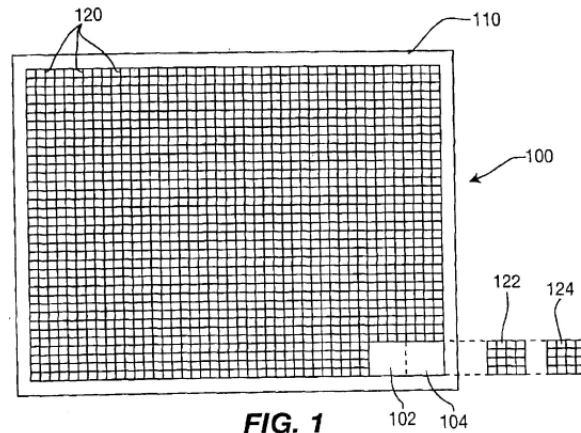


FIG. 1

(*Id.*, Fig. 1.)

90. Each sub-pixel or “pixel forming element” can be made from “organic light emitting diode (OLED) material.” (*Id.*, 6:17-22.) Matthies repeatedly explains that it employs “OLED” “pixel[s]” (*id.*, Abstract) and that its “invention is described in terms of an [organic] light emitting diode (OLED) display device” (*id.*, 5:29-30).

91. According to Matthies, “it is desirable for” the OLED sub-pixels “to occupy only a portion (e.g. about 25 percent) of the pixel area.” (*Id.*, 13:11-14.)

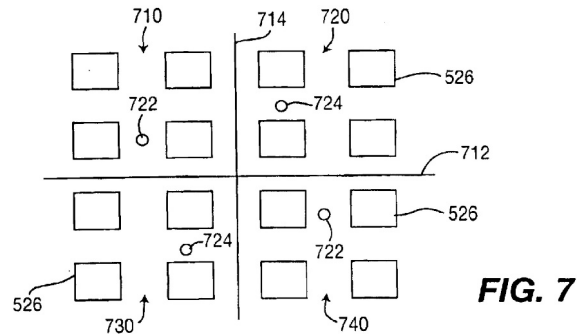
92. Matthies explains that including space around the sub-pixels “leaves room” for the “vias 520 and 522 to connect to the row and column electrodes of the pixel without interfering with the regular spacing of the pixels across tile boundaries.” (*Id.*, 15:67-16:14; *see also id.*, 2:36-40.)

93. Matthies includes numerous examples of its sub-pixel arrangement and spacing.

94. For instance, “FIG. 7” depicts a “layout” where “the active portions 526 of the pixels are centered in their respective regions and the vias which connect the

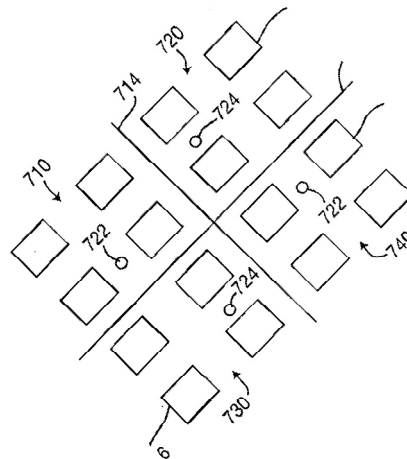
row and column electrodes of the display to the electronics are formed between respective pixel elements.” (*Id.*, 16:21-26.)

95. As shown, “[t]he distance between the edge of an active region 526” and adjoining structure “is equal on all sides.” (*Id.*, 16:26-30.)



(*Id.*, Fig. 7.)

96. This, and Matthies’s other figures, employ pixels arranged in a “virtual square.” While the shape formed by Matthies’ pixels is square regardless of this, rotating Figure 7 by a 45° angle makes the presence of this square with a pixel at its center (and other pixels at the square vertices) even more apparent:



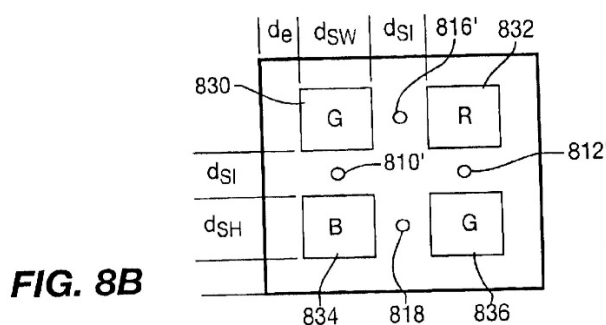
(*Id.*, Fig. 7 (rotated and cropped).)

97. Figure 8B provides an example of a “[c]olor pixel[.]” (*Id.*, 16:40-41.)

98. According to Matthies, “[t]his structure is known as a quad sub-pixel....” (*Id.*, 16:62-67.)

99. The depicted quad sub-pixel includes “[t]wo ... sub-pixel elements, 830 and 836” that “emit green light” and “two pixel elements, 832 and 834” that “emit red and blue light, respectively.” (*Id.*) “[T]he use of two green sub-pixels allows for a brighter display.” (*Id.*, 16:67-17:4.)

100. Matthies explains that “[t]he geometry of the quad sub-pixel structure is defined by the dimensions d_{SH} , the height of the sub-pixel, d_{SW} , the width of the sub-pixel, d_e , the distance from the active sub-pixel areas to the edge of the pixel area, and d_{SI} , the distance adjacent sub-pixels.” (*Id.*, 17:16-20.)



(*Id.*, Fig. 8B.)

101. While other dimensions can also be employed (*e.g.*, *id.*, 17:31-38), Matthies includes a table providing example dimension values that leads to an array of equally spaced, square sub-pixels:

TABLE 2

d_{SH}	.25P
d_{SW}	.25P
d_e	.125P
d_{S1}	.25P

(*Id.*, 17:24-29.)

102. Matthies also recognizes that OLED pixel “aging” and “decay” presents a problem. (*Id.*, 11:47-12:40.)

103. It proposes various methods to address and account for these effects. (*Id.*)

104. And, it also explains that “any other method” may be used along with the methods Matthies itself references “either as a check or to augment the performance of the other method.” (*Id.*, 12:41-47.)

2. Phan

105. Phan indicates on its face that it issued August 15, 2006. (Ex. 1005, Cover.) In view of this date of issuance, which predates the ’683 patent date of filing by more than a year, I understand that Phan is prior art under at least § 102(b).

106. Phan is not cited by the ’683 patent and was not considered during prosecution. (*See generally* Exs. 1001, 1002.)

107. Phan teaches a “display comprising pixels and dots.” (Ex. 1005, 1:18-19.)

108. According to Phan, this display can be an “Organic Light Emitting Diode (OLED)” display. (*Id.*, 1:18-29.)

109. The dots 11 making up a display 10 are “arranged along horizontally and/or vertically extending lines” and “consist of ... the three basic colours of red, green and blue.” (Ex. 1005, 1:57-61.)

110. Phan explains that each dot is individually addressable. (*Id.*, 5:12-21.) Making the dots addressable allows them to be grouped into “dynamic-generated ... pixels” to “give a perception of” a “higher resolution display.” (*Id.*, 2:63-3:18.)

111. According to Phan, the colored dots are arranged in “square” groups in “a well known grid pattern.” (*Id.*, 4:41-43.)

112. Figure 2a, which is reproduced below, provides an example. Squares 17 indicate groups of four dots that form a standard pixel. The circles 18 represent Phan’s dynamic pixels formed by re-grouping the dots:

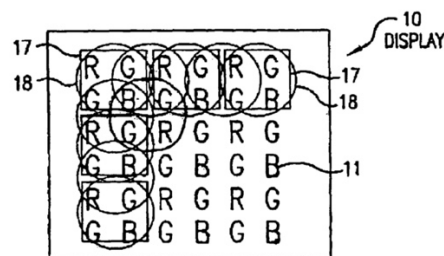


FIG. 2a

(*Id.*, Fig. 2a.)

113. Phan explains that dots making up its display can have different sizes and shapes.

114. For instance, the red, green, and blue dots can form a “square quad pixel,” with all the dots having the same size. Alternatively, the blue dot can be made larger than the other colors. These two dot designs are respectively shown in Figures 11a and 11b below:

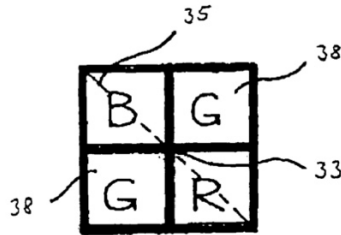


FIG. 11a

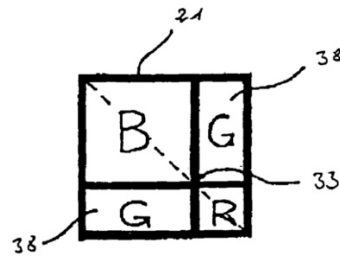


FIG. 11b

(*Id.*, 5:47-54; Figs. 11a-b.)

3. Murai

115. Murai published in Japanese. The below discussion cites to an English language translation of this reference. (Ex. 1007.)

116. Murai indicates on its face that it published April 23, 2010. (Ex. 1007, Cover.) In view of this date of issuance, which predates the '683 patent date of filing by more than a year, I understand that Murai is prior art under at least § 102(b).

117. Murai is not cited by the '683 patent and was not considered during prosecution. (*See generally* Exs. 1001, 1002.)

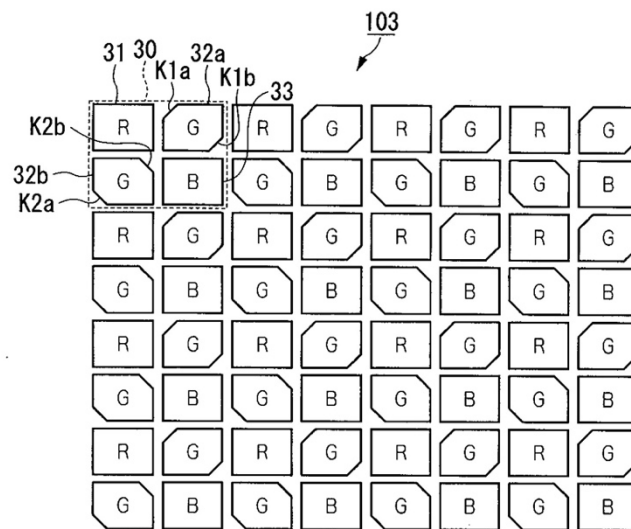
118. Murai relates to a “color image display device.” (Ex. 1007, ¶ [0001].)

119. According to Murai, this display can be “an organic EL display device[.]” (*Id.*, ¶ [0058].)

120. The display is formed from multiple “red (R),” “green (G),” and “blue (B)” dots 31, 32a, 32b, and 33. (*Id.*, ¶¶ [0028]-[0029].)

121. The “dots” can be arranged in a “rectangle” or square at a “diagonal” from each other. (*Id.*, ¶ [0010].) In other words, the red, green, and blue dots “are disposed to surround one point, and make up a rectangle made up of four rectangles” (or a “square” of four squares). (*Id.*, ¶¶ [0017]; [0006]; [0032].)

122. Figure 3, which is reproduced below for reference, provides an example of Murai’s dot arrangement:



(*Id.*, Fig. 3.)

123. According to Murai, arranging pixels in a square pattern like that shown in Figure 3 improves “the aperture ratio.” (*Id.*, ¶ [0010].)

124. Murai also teaches that its dots can have different sizes. This is accomplished by including a “cut-off portion[]” in the dot corner to adjust the dot area. (*Id.*, ¶¶ [0006], [0011], [0013], [0039]; Figs. 5(b), 6(a)-(b).)

125. Murai explains that including cut-offs improves the displayed image because it “prevents dots (pixels) of the same color from being placed next to each other in the vertical direction, the horizontal direction, and the diagonal direction of the screen.” (*Id.*, ¶ [0005].)

4. Yamada

126. Yamada indicates on its face that it issued April 2, 2002. (Ex. 1008, Cover.) In view of this date of issuance, which predates the ’683 patent date of filing by more than a year, I understand that Yamada is prior art under at least § 102(b).

127. While Yamada is cited on the face of the ’683 patent, it was not discussed during prosecution. (*See generally* Exs. 1001, 1002.)

128. Yamada relates to an “electroluminescent display apparatus.” (Ex. 1008, 1:6-10.)

129. According to Yamada, this type of display includes blue, red, and green “pixel[s] ... arranged in a matrix configuration.” (*Id.*, 2:55-60; see also *id.*, 6:44-7:2.) T

130. Yamada goes on to explain that these differently colored pixels have different “emission efficienc[ies].” (*Id.*, 2:53-54.)

131. To improve the display's life and avoid premature deterioration, Yamada teaches that the pixels should be re-sized “in accordance with the emission efficiency of” each color’s “emissive element.” (*Id.*, 2:55-3:6, 3:16-27, 4:4-14, 10:61-11:3.)

132. The “emissive element of a color with the highest emission efficiency” (for instance, green) is made “smaller,” while the “emissive element of a color with the lowest emission efficiency” (for instance, blue) is made “larger.” (*Id.*, 3:38-44, 3:51-57; 7:3-12, 8:19-28; 8:47-52; 10:52-55; 11:4-15.)

133. Figure 4, which is reproduced below, provides an example of an OLED display's pixels re-sized following Yamada's teachings:

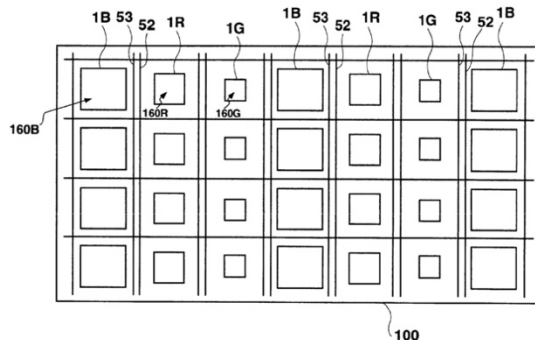


Fig. 4

(*Id.*, Fig. 4.)

B. Ground 1: Claims 1-2, 4-10, 13, and 15 Are Obvious Over Matthies in View of Yamada

134. In my opinion, a POSITA would have considered Matthies (Ex. 1004) and Yamada (Ex. 1008) to be within the scope of the prior art and highly relevant to the patentability of the '683 patent's claims.

135. In my opinion, when viewed and considered in light of the knowledge possessed by a POSITA, Matthies and Yamada together disclose all the limitations of and renders claims 1-2, 4-10, 13, and 15 of the '683 patent obvious.

136. In addition, in my opinion, a POSITA would have been motivated to combine Matthies' and Yamada's teachings to arrive at the subject matter claimed by the '683 patent and would have had a reasonable expectation of success when doing so.

1. Claim-By-Claim Analysis

a. Claims 1, 13, and 15

137. Claims 1, 13, and 15 are independent.

138. Because these claims include nearly identical limitations they will be discussed together.

[1-pre]/[13-pre]/[15-pre] “A pixel arrangement structure of an organic light emitting diode (OLED) display comprising:”

139. In my opinion, to the extent this preamble language is limiting, this is taught by Matthies.

140. Matthies teaches a tiled “electronic display device.” (Ex. 1004, 1:8-10.)

141. This display device display can be an “OLED ... display device” that includes “pixel forming elements” made from “an organic light emitting diode

(OLED) material.” (*Id.*, 5:29-30; 6:18-22, 16:40-43.) Similarly, Matthies explains that “the pixels on the tile are organic light emitting diodes (OLEDs).” (*Id.*, 3:6-7.)

142. Matthies also discusses how the pixels making up its display device are arranged.

143. In particular, Matthies explains that its display includes “tiles ... constructed with pixel forming elements evenly spaced up to the edge of the tiles.” (*Id.*, 5:47-48.)

144. “[T]he tiles are formed such that, when they are joined, the inter-pixel distance between the edge pixels of two adjacent tiles is the same as the inter-pixel distance of adjacent pixels in the interior of a tile.” (*Id.*, 5:49-53.)

145. In one example, a “display 100” is “formed from tiles having 16 pixel forming elements in a four by four array.” (*Id.*, 5:56-61; *see also id.*, Fig. 1.)

[1-a]/[13-a]/[15-a] “a plurality of pixels for displaying an image on the OLED display and comprising:”

146. This, in my opinion, is taught by Matthies.

147. In the ’683 patent, the “term pixel refers to a minimum unit for displaying images.” (Ex. 1001, 1:36-37; 3:59-60.)

148. Again, as explained when discussing claim 1’s preamble, Matthies relates to an “OLED ... display device.” (Ex. 1004, 3:6-7, 5:29-30; 6:18-22, 16:40-43.)

149. Further, Matthies' device is formed as a "tiled display" that includes a multitude of "picture element[s]" or "pixels." (Ex. 1004, Abstract.) Similarly, Matthies explains that it teaches a "display" with "pixtute element[s]" or "pixels." (*Id.*, 2:35-37.)

150. In one embodiment, the display pixels can be formed from "red, green, and blue OLED materials...." (Ex. 1004, 13:1-2; 16:40-44 (discussing "red (R) ..., green (G) ... and blue (B) ... sub-pixels").)

151. According to Matthies, the sub-pixels receive "image data for display." (*Id.*, 2:58-63.)

152. The display also includes "pixel driving circuitry which controls the scanning and illumination of the pixels on the" display's tiles. (*Id.*) In other words, the display includes "electrical structure" that allows for "addressing of the display pixels." (*Id.*, 9:10-13; Fig. 2.) For instance, each of the "pixel emissive areas" can "controlled by a single row and column electrode pair." (*Id.*, 16:38-41.)

153. Moreover, there can be a large number of "pixel forming elements" (the sub-pixels) in each of the display's tiles (*i.e.*, from 16 to 896). (*Id.*, 5:54-61.)

154. In sum, in my opinion, Matthies teaches a "***plurality of pixels***" (its red, green, and blue OLED sub-pixels) that together form an "***OLED display***" for "***displaying an image.***"

[1-a(1)]/[13-a(1)]/[15-a(1)] “a first pixel;”

155. This, in my opinion, is taught by Matthies

156. These claims require a “first,” “second,” and “third” pixel. The claims later specify that the “first” pixel be green.

157. Matthies’ display includes “red (R) ..., green (G) ... and blue (B) ... sub-pixels.” (See Ex. 1004, 13:1-2; 16:40-44; 16:62-17:4; Fig. 8B.)

158. In my opinion, the green sub-pixels are the claimed ***“first pixel.”***

[1-a(2)]/[13-a(2)]/[15-a(2)] “a pair of second pixels separated from the first pixel, the second pixels being located at opposite sides of the first pixel along a first line [passing through respective centers of the first pixel and the second pixels] on which the first pixel, the second pixels, and another first pixel are consecutively arranged such that the first line passes through respective centers of the first pixel[s], the second pixels, and the other first pixel; and”

159. This, in my opinion, is taught by Matthies.

160. Again, Matthies display includes red, green, and blue sub-pixels. (See Ex. 1004, 13:1-2; 16:40-44; 16:62-17:4; Fig. 8B.)

161. In my opinion, the blue sub-pixels are the claimed ***“pair of second pixels.”***

162. Next, in Matthies, the sub-pixels are spaced apart.

163. According to Matthies, “it is desirable” that the sub-pixels “occupy only a portion (e.g. about 25 percent) of the pixel area.” (*Id.*, 13:11-14; *see also id.*, 15:67-16:2.)

164. Matthies repeatedly references the existence of space between its sub-pixels. (*E.g.*, *id.*, 5:49-53 (referencing “inter-pixel distance” between “edge[s]”); 8:48-50 (explaining that “there is a continuity in the pixel spacing over the display”).)

165. According to Matthies, ensuring that the sub-pixels occupy no more than 25% of the pixel area and including space between sub-pixels allows “an electrical via” to be included between the sub-pixels “without interfering with the active region of the pixel.” (*Id.*, 2:35-40.)

166. In figure 8B for instance, there is a “distance” “ d_{SI} ... between the adjacent sub-pixels.” (*Id.*, 17:16-20.)

167. In sum, because there is space and distance between sub-pixels, in Matthies, the blue “second pixels” are “**separated**” from the green “first pixels.”

168. In my opinion, Matthies also teaches the claimed pixel arrangement.

169. Matthies’ display includes tiled “pixel forming elements” (or “sub-pixels”) arranged in a “matrix.” (Ex. 1004, 5:56-62.)

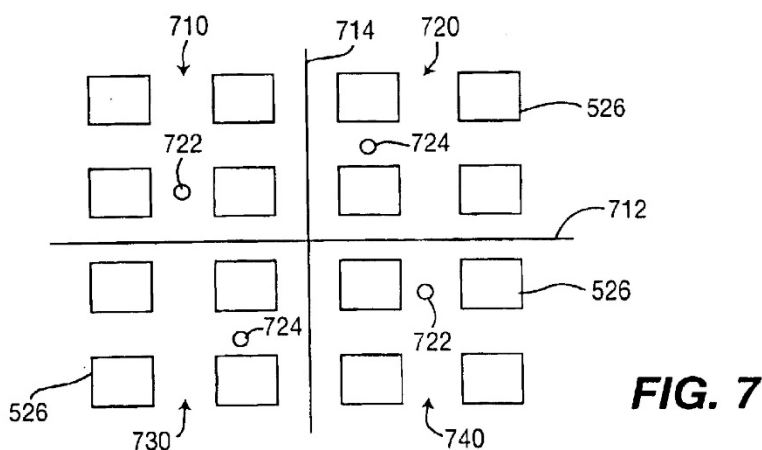
170. The sub-pixels are arranged “such that ... the inter-pixel distance between the edge pixels of two adjacent tiles is the same as the inter-pixel distance of adjacent pixels in the interior of a tile.” (*Id.*, 5:49-53.) Likewise, Matthies explains that the display is “tile[d]” “such that there is a continuity in the pixel spacing over the display.” (*Id.*, 8:48-50.)

171. Not only are the sub-pixels evenly spaced, but each sub-pixel can be “centered in the pixel area.” (*Id.*, 2:46-47.)

172. Figure 7, which is reproduced below, provides an example of this.

173. Here, “[t]he active portions 526 of the pixels are centered in their respective pixel regions.” (*Id.*, 16:21-25.) “[V]ias” 722 and 724 are “formed between respective pixel elements.” (*Id.*, 16:25-27.)

174. “The distance” between “the center of the active pixel region to the edge” of the tile that contains the pixel “is $\frac{1}{2}$ of the pixel pitch.” (*Id.*, 16:26-30.) Because of this, all 16 of the pixels are equally spaced in a repeating, square pattern:



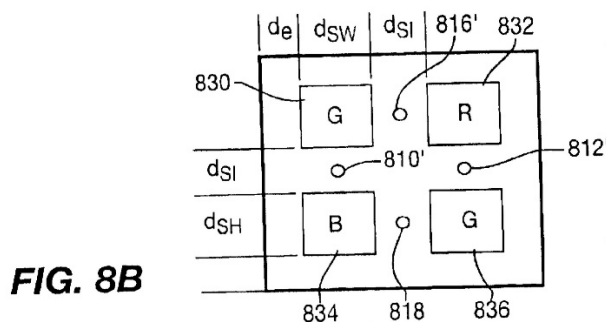
(*Id.*, Fig. 7.)

175. Figure 8B, also reproduced below, provides another an example employing “[c]olor pixels.” (*Id.*, 16:40-41.)

176. This figure shows “a quad sub-pixel structure” including two green, one red, and one blue “sub-pixel elements” 830, 832, 834, and 836. (*Id.*, 16:62-67.)

“[V]ias” 810', 812', 816', and 818 are located between the “sub-pixels” to facilitate electrical interconnection to the display device’s “row” and “column electrodes.” (*Id.*, 17:10-17.)

177. According to Matthies, “[t]he geometry of the quad sub-pixel structure is defined by the dimensions d_{SH} , the height of the sub-pixel, d_{SW} , the width of the sub-pixel, d_e , the distance from the active sub-pixel areas to the edge of the pixel area, and d_{SI} , the distance between the adjacent sub-pixels.” (*Id.*, 17:16-20.)



(*Id.*, Fig. 8B.)

178. Table 2 provides an example of these pixel geometry defining values (the variable “P” refers to the total “pixel pitch”):

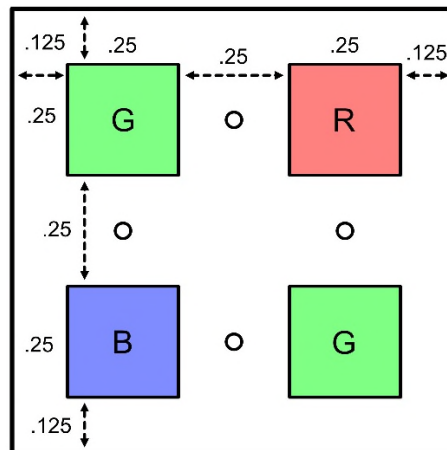
TABLE 2	
d_{SH}	.25P
d_{SW}	.25P
d_e	.125P
d_{SI}	.25P

(*Id.*, 16:53-55; 17:20-29.)

179. As can be seen, both the sub-pixel dimensions and spacing are “equal in the horizontal and vertical directions.” (*Id.*, 17:31-33.) This results in square sub-pixels arranged in an evenly spaced, square matrix.

180. While Matthies’ explains that its own figures are “not to scale” (*id.*, 5:26-27), it provides sufficient information to allow a POSITA to construct a scale drawing of its pixel arrangement.

181. The below demonstrative is a scale drawing of the Figure 8B’s “quad sub-pixel structure” generated using the example dimensions of Table 2:



(*See id.*, Fig. 8B; Table 2.)

182. Because the pixels are equally sized and consistently spaced across the display, the center-to-center distance between adjacent green and red/blue pixels will always be the same.

183. Further, the center-to-center distance between pixels located diagonally from each other will also always be the same.

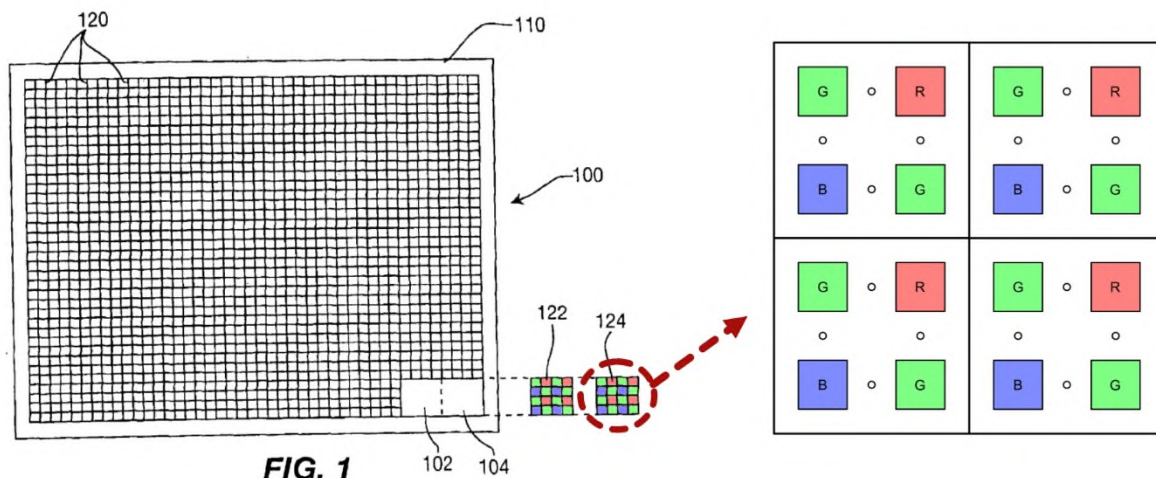
184. In other words, the pixels are arranged in a repeating, square shape.

185. Matthies also teaches how this “quad sub-pixel structure” should be integrated into a display.

186. Matthies explains that its “display 100” can be “formed from tiles having 16 pixel forming elements in a four by four array.” (*Id.*, 5:56-61.)

187. To obtain such a larger tile, the pixel geometry shown in Figure 8B and the above demonstrative is simply repeated. (*See, e.g., id.*) According to Matthies, “display 100” is formed from “relatively small arrays on tiles” that are “assembled” together “to produce the large area display” with “[t]he tiles ... constructed with pixel forming elements evenly spaced.” (*Id.*, 5:38-55.) Figure 7 provides an example of this, showing a 16 pixel tile with equal pixel spacing. (*See id.*, Fig. 7.)

188. In the below demonstrative, tile 124 from Figure 1 has been expanded in size to the right. Matthies’ “quad sub-pixel structure” (once again drawn to scale using the dimensions of Table 2) has been applied to the tile.



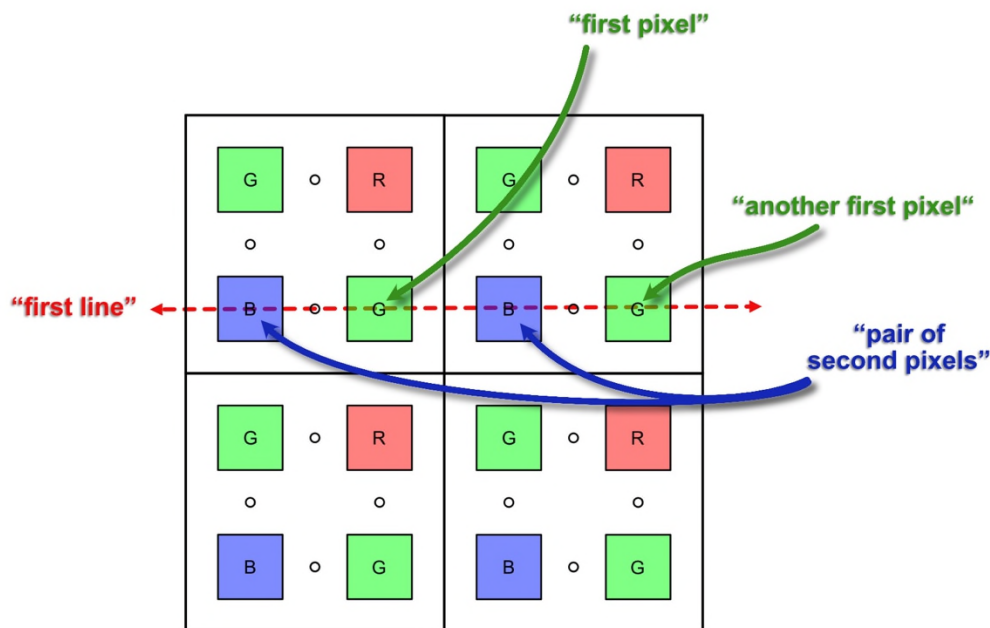
(*Id.*, Figs. 1; 8B.)

189. I will employ this scale drawn version of Matthies' tile 124 throughout the discussion of Matthies below.

190. Again, because Matthies builds its "large-area display out of smaller tiles" that are "the basic unit of manufacture" and ensures a "continuity" of pixel spacing (*id.*, 1:56-65; 8:48-50; *see also id.*, 5:36-46), in my opinion, a POSITA would have understood that the other tiles making up the display would have (or at least could obviously have) the same structure.

191. In my opinion, because Matthies' sub-pixels are arranged in a repeating, square matrix the blue and green sub-pixels have "***respective centers***" that are located "***along a first line.***" Put another way, arrangement of square pixels in a square pattern with a continuity of spacing ensures that the pixels in any given row or column will be located one after another along a line.

192. Further, because there are twice as many green sub-pixels as there are blue and red sub-pixels in Matthies' matrix, the blue and green sub-pixels alternate with each other and are "***consecutively arranged***" with blue sub-pixels on "***opposite sides***" of the green sub-pixels as this limitation requires. This is shown in the below demonstrative:



[1-a(3)]/[13-a(3)]/[15-a(3)] “a pair of third pixels separated from the first pixel and the second pixels, the third pixels being located at opposite sides of the first pixel along a second line [passing through respective centers of the first pixel and the third pixels] on which the first pixel, the third pixels[,] and an additional first pixel are consecutively arranged such that the second line passes through respective centers of the first pixel, the third pixels, and the additional first pixel, the second line crossing the first line at a location of the first pixel,”

193. This, in my opinion, is taught by Matthies.

194. Again, Matthies display includes red, green, and blue sub-pixels. (See Ex. 1004, 13:1-2; 16:40-44; 16:62-17:4; Fig. 8B.)

195. The red sub-pixels are the claimed **“pair of third pixel.”**

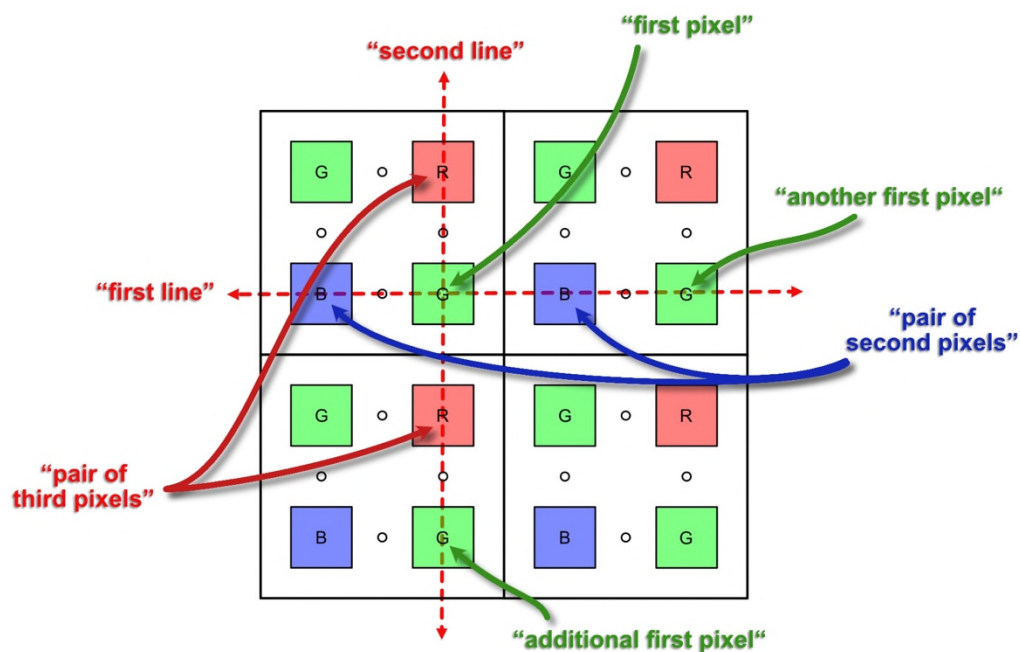
196. Once again, as I have explained, Matthies arranges its sub-pixels in a repeating, square matrix. (See *supra* limitation [1-a(2)].)

197. Further, Matthies’ “quad sub-pixel structure” includes two green sub-pixel for every red and blue sub-pixel. (Ex. 1004, 16:62-67; Fig. 8B.)

198. As shown in the below demonstrative, this arrangement and relative number of green sub-pixels results in the red sub-pixels having their “*centers*” on a “*second line*” that runs through the red sub-pixels and the green “*first pixel*.”

199. And, as shown by the annotations below, there is also “*an additional*” green “*first pixel*” on the same “*second line*” as the other red and green sub-pixels.

200. Further, as shown, the “*second line*” “*cross[es] the first line*” at a green sub-pixel as required. Once again, the pixels are “*consecutively arranged,*” with “*third pixels*” (red sub-pixels) on “*opposite sides*” of the “*first pixel[s]*” (green sub-pixels).



[1-b]/[13-b]/[15-b] “wherein a first distance between the second pixels is greater than a second distance between one of the second pixels and a neighboring one of the third pixels,”

201. This, in my opinion, is taught by Matthies.

202. As I have explained, Matthies teaches use of a “quad sub-pixel structure” with twice as many green as blue/red sub-pixels. (See Ex. 1004, 16:62-17:4; Fig. 8B.)

203. Because of this, there are green sub-pixels located between Matthies’ “second pixels” (the blue sub-pixels). (See *id.*, Fig. 8B.)

204. Moreover, the “second pixels” (the blue sub-pixels) and the “third pixels” (the red sub-pixels) are arranged diagonally from each other with no intervening pixels. (See *id.*, Fig. 8B.)

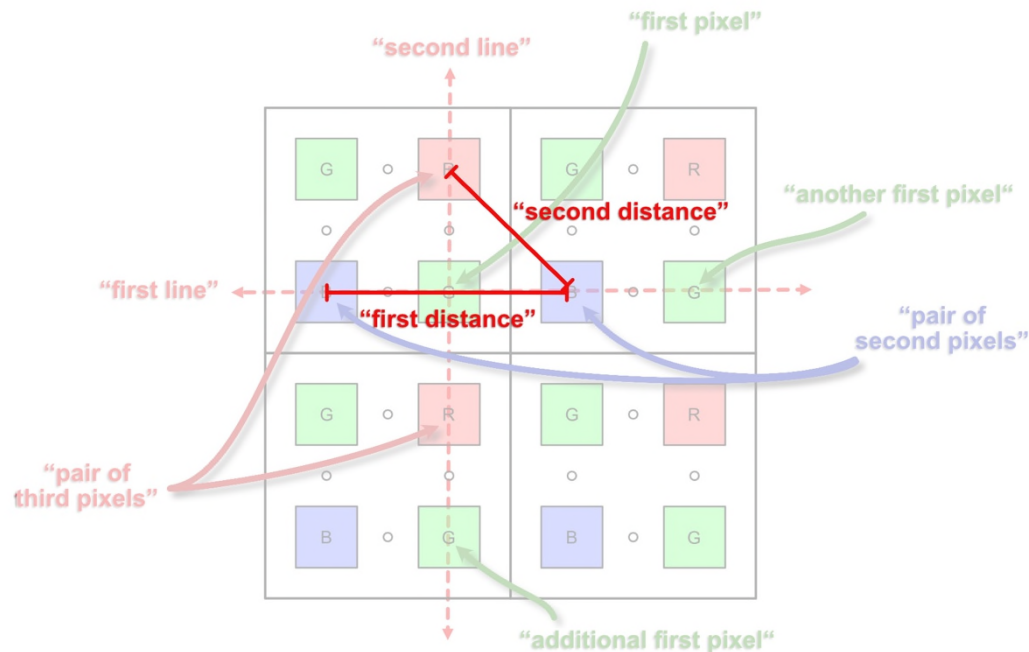
205. Claim 8 of the ’683 patent—which depends on claim 1—specifies that the claimed “distance” can be “measured between respective centers” of the pixels in question. (See Ex. 1001, 9:48-52.)

206. Because of the geometrical arrangement Matthies employs, the “**first distance**” between blue sub-pixels (which are separated by an intervening green sub-pixel) is “**greater**” than the “**second distance**” between adjacent blue and red sub-pixels (which are located on a diagonal to each other but are not separated by any other sub.pixels).

207. This will be the case regardless of the pixels’ actual numerical sizes. Showing this, if the pixel center to pixel center distance is x , the “first distance” between red pixels will be $2x$. The “second distance” between blue and red pixels will be only $\sqrt{x^2 + x^2}$ or $1.4x$.

208. Alternatively, using the values from Table 2, the “first distance” between blue sub-pixels will be $2 \times 0.5P$, or P . The second distance will be $0.7P$.

209. The below demonstrative (the same scale drawing of tile 124) shows these two distances, including the greater “first distance” and the shorter “second distance.”



[1-c]/[13-c]/[15-c] “wherein the first pixels are configured to emit green light, [which is a color that is different from light emitted by the second pixels and the third pixels,]”

210. This, in my opinion, is taught by Matthies.

211. Again, as explained when discussing limitation [1-a(1)], Matthies’ “first pixels” are green.

212. Its other sub-pixels emit different colored light (blue and red). (See Ex. 1004, 13:1-2; 16:40-44; 16:62-17:4; Fig. 8B.)

[1-d]/[13-d]/[15-d] “wherein the first pixels are smaller [have a smaller size] than at least one of the second pixels or the third pixels, and”

[1-e]/[13-e]/[15-e] “wherein each of the second pixels has a larger area than each of the third pixels.”

213. This, in my opinion, is obvious over Matthies and Yamada.

214. These limitations collectively require larger “second pixels” and smaller “third pixels” and “first pixels.”

215. Again, as discussed above, Matthies provides an example of a display with equally sized sub-pixels, with sub-pixel spacing equal to the sub-pixel height and width. (See, e.g., Ex. 1004, 16:62-17:29; Fig. 8B.)

216. This, however, is not the extent of what Matthies teaches.

217. In particular, while the sub-pixels in Figure 8B have equal size, Matthies explains that it also “contemplates both larger and smaller pixel apertures.” (*Id.*, 17:36-38.) Further, Matthies also explains that the sub-pixel spacing can also be “different.” (*Id.*, 17:31-33.) Likewise, Matthies explains that it allows for the use of “different pixel pitches.” (*Id.*, 19:9-10.)

218. Yamada, like Matthies, relates to an “electroluminescent display apparatus.” (Ex. 1008, 1:6-10.) Again, as I have explained, a POSITA would have understood this to include OLED displays.

219. Also like Matthies, Yamada explains that such a display includes blue, red, and green “pixel[s] ... arranged in a matrix configuration.” (*Id.*, 2:55-60; see also *id.*, 6:44-7:2.)

220. Yamada explains that in such a display, the “emission efficiency of the emissive layer for emitting light of various colors differs with each color.” (*Id.*, 2:53-54.)

221. To address this, rather than making the different color “emissive areas” “identical ... in size[,]” Yamada teaches that the pixels should be re-sized “in accordance with the emission efficiency of” each color’s “emissive element.” (*Id.*, 2:55-60, 3:16-27.)

222. Thus, the “emissive element of a color with the highest emission efficiency” is made “smaller,” while the “emissive element of a color with the lowest emission efficiency” is made “larger.” (*Id.*, 3:38-43, 3:51-57.)

223. According to Yamada, in a typical OLED display, the “green pixel” has the highest efficiency and is thus made smallest, while the “blue pixel” has the lowest efficiency and is made largest. (*Id.*, 7:3-12, 8:19-28; 8:47-52; 10:52-55; 11:4-15.)

224. Figure 3 of Yamada shows an OLED display where the red, green, and blue pixels all have the same sizes. In Figure 4, the same pixel arrangement, spacing, and geography has been employed (thus the pixel centers to not move), but the pixels have been re-sized in accordance with their emission efficiencies:

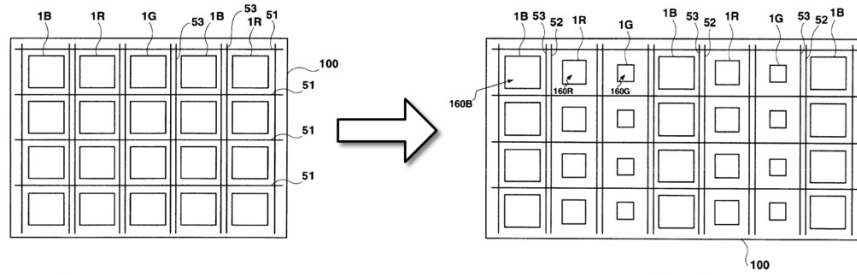


Fig. 3 RELATED ART

Fig. 4

(*Id.*, Figs. 3, 4.)

225. Yamada also includes an example where the area ratios of green, red, and blue pixels is 1:2.6:5.6. (*See id.*, 11:4-10.)

226. In my opinion, applying Yamada’s teaching regarding OLED pixel sizing to Matthies results in what claims 1, 13, and 15 requires.

227. In particular, rather than making the pixels all the same size, Matthies’ sub-pixels would be re-sized in accordance with their emission efficiency.

228. The remainder of Matthies would remain the same, including Matthies’ overall pixel array arrangement. The sub-pixels would still be ordered in the same way (with alternating green and red, or green and blue pixels) and arranged in the same type of “quad sub-pixel structure” that forms a repeating, square matrix with the same type of spacing.

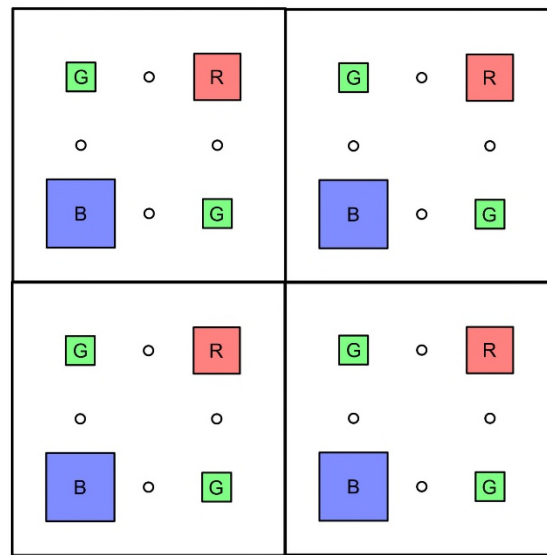
229. The below demonstrative provides an example.

230. This demonstrative, like the figures above, is again drawn to scale. Now, however, Yamada’s example green:red:blue pixel area ratio of 1:2.6:5.6 to Matthies’ “quad sub-pixel structure.”

231. Per Yamada, the blue pixel has kept its original size. The other pixels have been reduced in size in accordance with Yamada’s example ratio.

232. The same regular sub-pixel spacing taught by Matthies continues to be employed. Each pixel is still “centered in the pixel area” as Matthies teaches. (Ex. 1004, 2:46-47, 16:22-25, 16:62-17:30.)

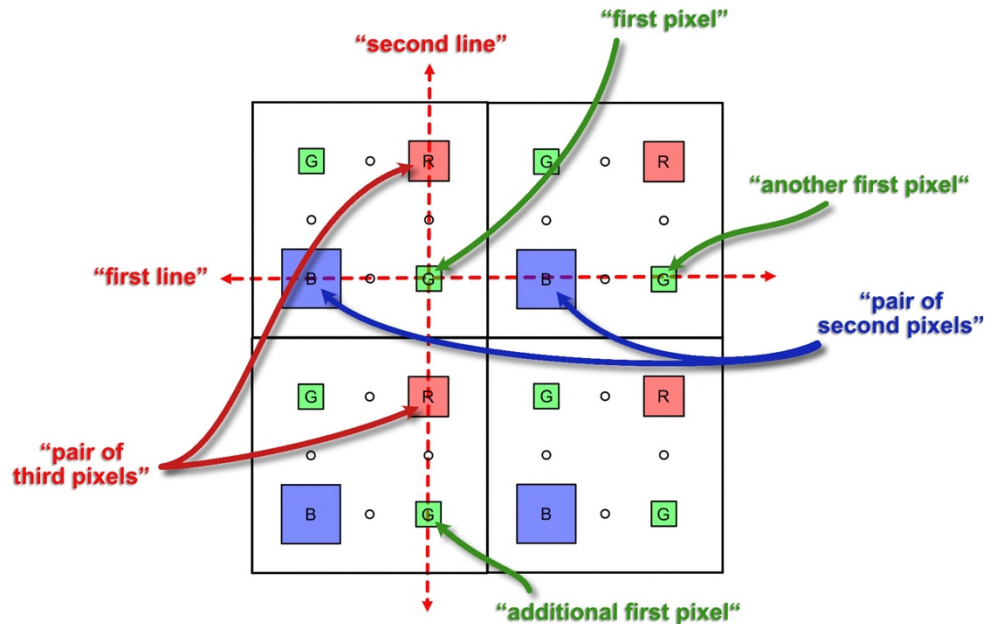
233. And, consistent with Matthies’ teaching, it continues to be the case that no pixel occupies more than “¼ of the total pixel area.” (*Id.*, 15:67-16:2; *see also id.*, 13:11-14.)



234. When modified following Yamada, Matthies teaches exactly what this limitation requires.

235. Matthies’ “first pixels” (the green sub-pixels) are “**smaller**” than the “second pixels” (the blue sub-pixels). Further, the “second pixels” (the red blue sub-pixels) have a “**larger area**” than the “third pixels” (the red sub-pixels pixels).

236. Further, the sub-pixels continue to be consecutively arranged on the claimed “line[s]” due to the continued use of the repeating, square matrix Matthies teaches:



b. Claim 2

237. Claim 4 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

[2-a] “wherein the first pixels, the second pixels, and the third pixels have polygonal shapes, and”

238. This, in my opinion, is taught by Matthies.

239. Matthies’ pixels have a square shape. (Ex. 1004, 8:50-52; 25:47-54; Fig. 8B.)

240. Squares and rectangles are both ***“polygonal”*** shapes (as they are closed shapes with more than three straight sides).

241. Claim 2 also requires:

[2-b] “wherein each of the second pixels and the third pixels has a larger area than the first pixel.”

242. This, in my opinion, is taught by Matthies and Yamada.

243. As I discussed above when addressing claims 1, 13, and 15, Matthies teaches an OLED employing red, green, and blue sub-pixels arranged in a repeating, square matrix.

244. Yamada teaches that in such a display, the blue pixel should be made largest and the green pixel smallest. (See Ex. 1008, 3:38-44, 3:51-57; 7:3-12, 8:19-28; 8:47-52; 10:52-55; 11:4-15.)

245. Applying this to Matthies results in what this claim requires: Matthies’ blue ***“second pixels”*** and red ***“third pixels”*** both have a ***“larger area”*** than its green ***“first pixels.”***

c. Claim 4

246. Claim 4 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the first pixels, the second pixels, and the third pixels are configured to emit different color lights.”

247. This, in my opinion, is taught by Matthies.

248. Matthies' display includes red, green, and blue pixels. (See Ex. 1004, 13:1-2; 16:40-44; 16:62-17:4; Fig. 8B.)

249. Red, green, and blue are different colors.

d. Claim 5

250. Claim 5 depends on claim 4. As I have explained, Matthies and Yamada teach and render obvious everything claim 4 requires. This claim also further requires:

“the second pixels are configured to emit blue light, and the third pixels are configured to emit red light.”

251. This is taught by Matthies' for the same reasons I discussed for claims 1, 13, and 15: Matthies teaches blue ***“second pixels”*** and red ***“third pixels.”***

e. Claim 6

252. Claim 6 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“each of the second pixels has a larger area than that of the first pixel.”

253. This is obvious for the same reasons I discussed above for limitations [1-d] and [1-e]: when modified following Yamada, Matthies' OLED's green sub-pixels would be smaller than the blue/red sub-pixels.

f. Claim 7

254. Claim 7 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the second pixels are substantially equidistant from the first pixel interposed between the second pixels, and the third pixels are substantially equidistant from the first pixel interposed between the third pixels.”

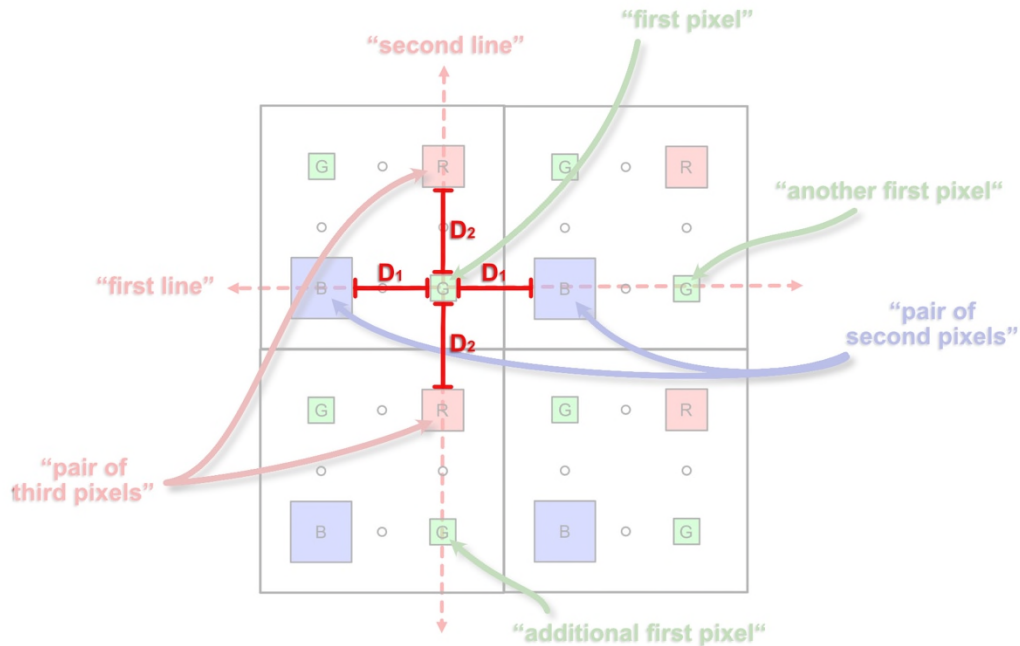
255. This, in my opinion, is taught by Matthies.

256. Matthies explains that it employs “a continuity in the pixel spacing over the display,” includes “equal” distances between adjacent pixels, and “evenly space[s]” its “pixel forming elements.” (Ex. 1004, 2:46-47; 5:47-53; 8:48-50; 16:21-36; 17:16-36; Fig. 8B.)

257. Further, each of its sub-pixels is “centered in the pixel area.” (*Id.*)

258. As shown in the below demonstrative (again employing a scale version of Matthies’ tile 124), because of this regular spacing, Matthies’ “first pixels” are ***“substantially equidistant”*** to two surrounding “second pixels” (label D₁).

259. Likewise, the “first pixels” will also be ***“substantially equidistant”*** to two surrounding “third pixels” (label D₂):



g. Claim 8

260. Claim 8 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the first distance is measured between respective centers of the second pixels, and the second distance is measured between respective centers of the one of the second pixels and the neighboring one of the third pixels.”

261. This is taught by Matthies for the same reasons I described for limitation [1-b].

h. Claim 9

262. Claim 9 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the first line passes through respective centers of the first pixel and the second pixels, and the second line passes through respective centers of the first pixel and the third pixels.”

263. This is taught by Matthies for the same reasons I described for limitations [1-a(2)] and [1-a(3)].

i. Claim 10

264. Claim 10 depends on claim 1. As I have explained, Matthies and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“each of the first pixels, the second pixels, and the third pixels has a convex shape.”

265. Matthies’ pixels have a square shape. (Ex. 1004, 8:50-52; 25:47-54; Fig. 8B.)

266. Because of this, they are all **“convex.”** A POSITA would understand a square or rectangle to be convex because all of the internal angles in such a shape are less than 180° (they are all 90°).

2. Motivation to Combine

267. In my opinion, a POSITA would have considered it obvious and would have been motivated to apply Yamada’s teaching to Matthies.

268. According to Yamada, in certain prior art OLED devices, the red, green, and blue pixels all have “identical emissive areas in size.” (Ex. 1008, 2:55-60.)

269. But, making all the OLED pixels the same size gives rise to a problem. In particular, the different pixel colors have different “emission efficienc[ies].” (*Id.*,

2:60-63.) Because of this, to achieve a consistent pixel luminance, the pixels with lower emission efficiencies (like the blue pixels) must be supplied with a larger current than the pixels with higher emission efficiencies (like the green pixels). (*See id.*) Supplying the blue pixels with the required larger current “causes the life of those display pixels ... to shorten” impacting the overall life of the display. (*Id.*, 2:64-66.) Further, these different emission efficiencies make display “color balance ... difficult to achieve” by requiring further adjustments to supplied current. (*Id.*, 3:1-6.) This not only adds design complication, but results in even further “deterioration.” (*Id.*)

270. To address these problems, Yamada teaches that the pixels with lower emission efficiencies (like the blue pixels) should be made larger than pixels with higher emission efficiencies (like the green pixels). (*See id.*, 3:38-44, 3:51-57; 7:3-12, 8:19-28; 8:47-52; Figs. 4, 9.)

271. Because the pixels have different sizes, luminance can be balanced while supplying each of the pixels with similar amounts of current or power. (*See id.*, 3:65-4:9.)

272. This in turn avoids the life shortening deterioration problem experienced in prior art OLED displays with same-sized pixels and “extend[s] the life of the display device.” (*See id.*, 4:5-14; *see also* 10:61-11:3 (explaining that “the life for the overall display apparatus can be extended”).)

273. Further, because each pixel is supplied with the “same amount of power,” Yamada explains that the overall display design becomes “simplified” and “extremely easy to control” as each pixel is supplied with “the same amount of power.” (*Id.*, 4:57-5:8; *see also id.*, 5:41-49 (explaining that the “emissive area of the organic EL element can be easily set” simply by “changing the electrode area”).)

274. In my opinion, all of this would have provided a POSITA with a strong motivation to apply Yamada to Matthies.

275. As I have explained, Matthies teaches a display that employs pixels that “are organic light emitting diodes (OLEDs).” (Ex. 1004, 3:6-7; *see also id.*, Abstract (similarly referencing a “display” where “[e]ach pixel position has an organic light-emitting diode (OLED) active area”); 6:17-22 (similar).)

276. Matthies teaches that this OLED display can employ a “quad sub-pixel structure” where each of the red, green, and blue sub-pixels making up the display has an equal size. (*E.g.*, *id.*, 16:62-17:31; Figs. 1; 8B; *see also id.*, 16:21-34 (referencing identical pixels that are “centered in their respective regions” and have “equal” space “on all sides”); Fig. 7.)

277. Matthies also explains that its display operates to provide a different “magnitude of current” to a “OLED pixel” to control “[t]he level of light emitted.” (*Id.*, 10:14-18.)

278. Matthies employs this approach in “the exemplary embodiment of the invention ... to match the amount of light emitted by [a given] pixel to the amounts of light emitted by every other pixel in the display device.” (*Id.*, 10:24-27.)

279. In my opinion, because each pixel has the same size, a POSITA would have understood that the display device employing Matthies’ “quad sub-pixel structure” would be subject to the problems identified by Yamada.

280. In particular, the pixels would need to be supplied with different currents to achieve a consistent luminance. Matthies itself recognizes this when it explains and details the use of various structure to supply its sub-pixels with different currents to achieve a consistent luminance across its display.

281. As Yamada explains, different OLED pixels emitting different colors have different efficiencies and decay lifetimes. This is a particular problem with respect to the blue pixels – these pixels need to be supplied with an increased current due to their lower efficiency and thus have a much shorter life. Early failure of the blue pixels would shorten the display’s life (as the blue pixels are needed for the display of a proper, acceptable image).

282. Applying Yamada’s teachings and re-sizing the pixels in accordance with their emission efficiencies—the blue pixels would become largest and the green the smallest—would allow each pixel to be supplied with the same current (but lower

current density for the blue pixels). This would address the pixel life issue (by prolonging the life of the blue pixels) and increase the overall display life.

283. Further, not only would the life of Matthies' display be improved after applying Yamada, but a POSITA would have recognized that Matthies' design would be simplified.

284. Because its display employs similarly sized pixels, Matthies system includes a series of extra components to tailor the supplied current on a pixel-by-pixel basis in an effort to level out pixel luminance.

285. For instance, a "non-volatile memory 214" is included to store required current "value[s] for the pixel cell." (Ex. 1004, 10:58-61.) This memory must be accessed to obtain the stored value each time a pixel is addressed. (*Id.*, 10:61-64.)

286. The display also includes "programmable current sources 216" that allow the current provided to the display's pixels to vary. (*Id.*, 10:66-11:5; Fig. 2; *see also id.*, 2:63-65 (noting that Matthies includes "circuitry" to "compensate[e] for luminance chromaticity non-uniformities").)

287. Further, because different OLED pixels age at different rates, Matthies "also include[s] circuitry" such as a "light sensor" or "circuitry 134" with an "electronic compensation system which continually adjusts the brightness of individual pixels" to "compensate for aging of the display material." (*Id.*, 11:47-60.)

288. In my opinion, a POSITA would have recognized that Yamada is able to achieve a similar effect— more balanced pixel luminance and reduced aging effects —without the need for all the extra structure referenced in Matthies.

289. In my opinion, this simplification of design would have further motivated application of Yamada to Matthies. It is also consistent with and furthers Matthies own expressed goal of “reduc[ing] manufacturing costs.” (*Id.*, 1:64-65.)

290. Next, Matthies itself repeatedly recognizes that OLED pixels are subject to “aging” and “decay.” (Ex. 1004, 11:47-49, 11:54-60, 12:3-8, 12:13-16.)

291. While it proposes a number of methods to address these deleterious effects (including use of the light sensors and circuitry I discuss above), it also explains that “any of these methods ... may be combined with any other method either as a check or to augment the performance of the other method.” (*Id.*, 12:41-47.)

292. In my opinion, this would have motivated a POSITA to consider applying other known methods for addressing OLED pixel aging and display, including that set forth in Yamada.

293. Indeed, Matthies itself explicitly recognizes that the “geometry of the pixels” plays a role in the “rate of decay,” and suggests that “suitable adjustments may be readily determined by one skilled in the art of designing OLED displays by monitoring the performance of an exemplary pixel over time.” (Ex. 1004, 12:3-13.)

294. In my opinion, a POSITA would have considered this an obvious invitation and direction to apply the different pixel geometries set forth in Yamada to address the aging and decay problems Matthies references.

295. Next, in my opinion, a POSITA would have recognized that applying Yamada's teachings would have provided Matthies with greater design flexibility.

296. Matthies purposefully limits the "the active portions ... of the pixels" to "only about $\frac{1}{4}$ of the total pixel area" so as to "leave[] room along the edges of the display" for the "vias 520 and 522 to connect to the row and column electrodes of the pixel without interfering with the regular spacing of the pixels across tile boundaries." (Ex. 1004, 15:67-16:4; *see also id.*, 2:36-40.)

297. In my opinion, a POSITA would have recognized that reducing the size of the more luminant green and red sub-pixels, while leaving the blue sub-pixels at their existing $\frac{1}{4}$ of total pixel area size, would create additional space for Matthies' vias and other circuitry.

298. In my opinion, such a design would continue to exhibit the benefits set forth in Matthies (*i.e.*, an improved, larger tiled display) and would also have enhanced life (due to the use of relatively larger blue sub-pixels and relatively smaller green sub-pixels).

299. I have been informed and understand that when a patent simply arranges old elements with each performing the same function it had been known to

perform and yields no more than one would expect from such an arrangement, the combination is obvious.

300. In my opinion, this is all the '683 patent does here.

301. Matthies teaches an improved OLED display that is tiled (and thus can be made large), is easier to manufacture, and has improved performance (*See, e.g.*, Ex. 1004, 1:56-65; 2:35-40; 2:62-65.)

302. Yamada teaches that deterioration of this type of OLED display can be avoided by adjusting the sizes of its pixels to account for their emission efficiency. (Ex. 1008, 4:5-14; *see also* 10:61-11:3.)

303. In my opinion, the combined display would continue to provide these same benefits.

304. There are other reasons why a POSITA would have been motivated to apply Yamada's teachings to Matthies.

305. The prior art repeatedly explains, like Yamada, that use of larger blue pixels and smaller green pixels is preferable in OLED displays.

306. For instance, one prior art reference explains that "[i]t has been proposed to adjust the relative sizes of the different colored light emitting elements to compensate for color-dependent age-related degradation in luminous efficiencies." (*See, e.g.*, Ex. 1015, 1:63-67.)

307. Another prior art reference similarly explains that the “blue colour-forming regions” of an OLED should be made “with a larger area” allowing them to be “driven at a lower voltage” and “increasing the lifetime” of the display. (Ex. 1011, ¶ [0062].)

308. In my opinion, the fact that both the problem Yamada addresses and the solution it proposes was well-known and in routine use as of the ’683 patent’s filing would have further motivated its application to Matthies. Because OLED displays were routinely designed with larger blue pixels, intermediately sized red pixels, and smaller green pixels, a POSITA would not only have been aware of this design, but would have been motivated to employ it with Matthies to obtain the benefits of this relative pixel sizing known and discussed in the prior art.

309. In my opinion, a POSITA would also have had a more than reasonable expectation of success.

310. Again, as explained, it was well-known and routine in the art to resize OLED pixels to improve display lifetime.

311. Further, Matthies itself already contemplates that the sizes of and space between its pixels can be adjusted. (*See, e.g.*, Ex. 1004, 17:31-37; *see also id.*, 12:9 (referencing the possibility of different “geometry of the pixels”).)

312. Moreover, Matthies also invites use of different “other methods” “to maintain a predetermined brightness level” of its pixels. (*Id.*, 12:41-46.)

313. Thus, a POSITA would have considered application Yamada to amount to nothing more than the use of known design option—that Matthies itself already contemplates and allows for—to solve a known prior art problem experienced by OLED displays like that taught by Matthies.

314. Next, Yamada explains that the benefits of its invention (in particular, improved pixel and display life and design simplification) are not limited to just the example “arrangement of ... display pixels” shown in its figures, but extends to other “layouts” as well. (Ex. 1008, 12:37-40.)

315. In my opinion, this would not only have further motivated application of Yamada’s teachings. A POSITA would have understood that Yamada’s teachings are meant to be (and can successfully used) with a variety of different pixel arrangements, including that taught by Matthies.

316. Moreover, Yamada’s explanation that its teachings apply to a variety of layouts would have emphasized to a POSITA that combination of the references would be successful.

317. Finally, both Matthies and Yamada relate to pixel designs intended for use with, among other things, OLED displays.

318. In my opinion, this similarity in purpose would have given a POSITA yet another reason to believe that the references’ teachings can be successfully used together.

C. Ground 2: Claims 1, 4-10, 13, and 15 Are Obvious Over Phan

319. In my opinion, a POSITA would have considered Phan (Ex. 1005) to be within the scope of the prior art and highly relevant to the patentability of the '683 patent's claims.

320. In my opinion, when viewed and considered in light of the knowledge possessed by a POSITA, Phan itself disclose all the limitations of and renders claims 1, 4-10, 13, and 15 of the '683 patent obvious.

321. In addition, in my opinion, a POSITA would have been motivated to combine and collectively consider Phan's teachings to arrive at the subject matter claimed by the '683 patent and would have had a reasonable expectation of success when doing so.

1. Claim-By-Claim Analysis

322. Claims 1, 13, and 15 will again be analyzed together in view of their similarity.

a. Claims 1, 13, and 15

323. Claims 1, 13, and 15 are independent.

324. Because these claims include nearly identical limitations they will again be discussed together.

[1-pre]/[13-pre]/[15-pre] “A pixel arrangement structure of an organic light emitting diode (OLED) display comprising:”

325. In my opinion, to the extent this preamble language is limiting, this is taught by Phan.

326. In particular, Phan teaches a “display comprising pixels and dots.” (Ex. 1005, 1:18-19.)

327. According to Phan, these pixels and dots are grouped and arranged to “provide a display ... which has a higher optical resolution....” (*Id.*, 2:51-53.)

328. Phan explains that its teachings—including the pixel arrangement it employs—can be used with various “display technologies,” including “Organic Light Emitting Diode (OLED)” displays. (*Id.*, 1:18-29.)

[1-a]/[13-a]/[15-a] “a plurality of pixels for displaying an image on the OLED display and comprising:”

329. This, in my opinion, is taught by Phan.

330. As an initial matter, the ’683 patent uses the term “pixel” to refer to “a minimum unit for displaying images.” (Ex. 1001, 1:36-37; 3:59-61.) In an “OLED display,” the different “pixels” “emit[] light of different colors.” (*Id.*, 1:29-31.)

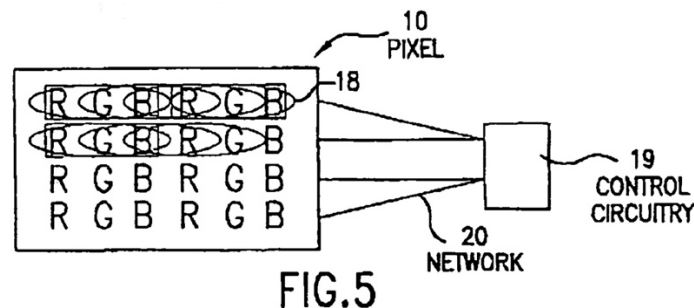
331. In my opinion, Phan teaches this claimed **“plurality of pixels.”**

332. According to Phan, a typical “display” includes “so-called pixels” that “consist of so-called dots representing the three basic colours of red, green and blue.” (Ex. 1005, 1:57-61.) The “[d]ots are sources of luminous radiation the light” for

purposes of generating a display. (*Id.*, 1:61-64.) Each “dot” may be “surrounded by a black mask or black barrier ribs ... to obtain a higher contrast.” (*Id.*, 4:34-36.)

333. Further, Phan explains that its display is a “dot-addressed display.” (*Id.*, 2:63-65; 5:13-15.) Thus, “each dot has a receiver of its own” that allows it to be addressed and controlled by “control circuitry 19 through a network 20.” (*Id.*, 5:12;21.)

334. Figure 5, which is reproduced below, shows the dot control circuitry:



(*Id.*, Fig. 5.)

335. Because the dots are individually addressable, Phan explains that its display allows for the use of what it calls “dynamic-generated ... pixels” formed by “grouping” different collections of dots to “give a perception of” a “higher resolution display.” (*Id.*, 2:63-3:18.)

336. In other words, in my opinion, Phan’s dots are its display’s minimum unit. Thus, they correspond to the claimed “pixels.”

337. Phan also teaches that its “pixels” are part of an “**OLED display**” for “**displaying an image.**”

338. In this regard, Phan’s “invention relates to a display comprising pixels and dots” that employs “display technologies” like “Organic Light Emitting Diode (OLED)....” (Ex. 1005, 1:18-29.)

339. Further, Phan’s display is intended to allow for generation of a “high resolution ... image.” (*Id.*, 4:19-24; *see also id.*, 2:51-3:25 (similarly referencing “higher optical resolution” images intended for viewing by the “human eye”).)

[1-a(1)]/[13-a(1)]/[15-a(1)] “a first pixel;”

340. This, in my opinion, is taught by Phan.

341. Again, as I have explained, claims 1 and 13 require a “first,” “second,” and “third” pixel. The “first” pixel must be green.

342. Phan explains that its display includes “[p]ixels” that “comprise regularly disposed dots 11 radiating the basic colours red (red dot 13), green (green dot 14) and blue (blue dot 15).” (Ex. 1005, 4:29-32.)

343. Phan’s green dots are the claimed “***first pixel.***”

[1-a(2)]/[13-a(2)]/[15-a(2)] “a pair of second pixels separated from the first pixel, the second pixels being located at opposite sides of the first pixel along a first line [passing through respective centers of the first pixel and the second pixels] on which the first pixel, the second pixels, and another first pixel are consecutively arranged such that the first line passes through respective centers of the first pixel[s], the second pixels, and the other first pixel; and”

344. This, in my opinion, is taught by Phan.

345. Phan includes not only “green” but also “red” and “blue” dots. (Ex. 1005, 4:29-32: Fig. 11b.) The blue dots are the claimed “***pair of second pixels.***”

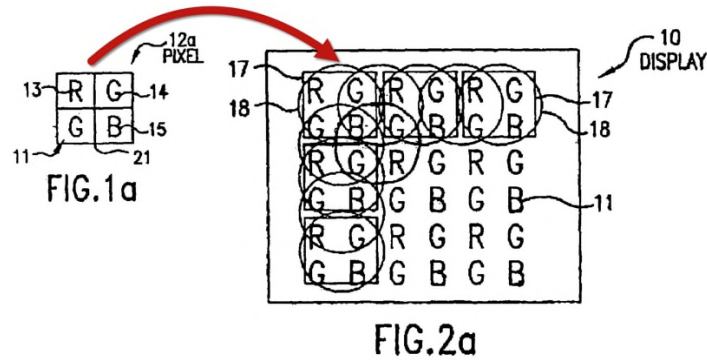
346. Phan also explains that its dots are “surrounded by a black mask or black barrier ribs 21 to obtain a higher contrast.” (*Id.*, 4:33-37; Figs. 1a-c; 10a-11b.) Thus, adjacent dots are “***separated.***” Additionally, while Figure 11b shows the blue, red, and green dots in close proximity to each other, a POSITA would have understood that when implemented in a display, there would be at least some physical space between the dots so as to allow for the required signal lines passing between the dots.

347. In my opinion, Phan also teaches the claimed pixel arrangement.

348. Phan explains that “the arrangement of the different dots 13, 14, and 15 should be identical in each static pixel 17 within a display 10.” (*Id.*, 4:38-40.)

349. The pixels may be “square” and arranged in “a well known grid pattern.” (*Id.*, 4:41-43.)

350. Figure 2a, which is reproduced below, provides an example of a “display with square pixels” (like that shown in Figure 1a) “with well-known static pixels being shown within squares, and the dynamic pixels of the invention within circles.” (*Id.*, 3:33-36; 4:41-47.) Each group of four pixels (two green, one red, and one blue) would be an identically structured square like that shown in Figure 1a:



(*Id.*, Figs. 1a, 2a.)

351. Phan also provides other examples of how individual pixels that make up a display (and the colored dots those pixels contain) are structured.

352. For instance, “FIG. 11a shows a square quad pixel” like that of Fig. 1a “where the crosspoint 33 is in the center of the four dots (individual elements) of equal light emitting area and space, contoured by black mask or black barrier ribs 21 with the same structure.” (*Id.*, 5:47-50.)

353. And, “FIG. 11b” shows a variation of this “square quad pixel” where the “crosspoint 33” has “mov[ed] along the diagonal line 35” to “form[] two dots (individual elements) of equal light emitting area and space 38 of green color (G).” (*Id.*, 5:51-54)

354. These two figures are reproduced below for reference:

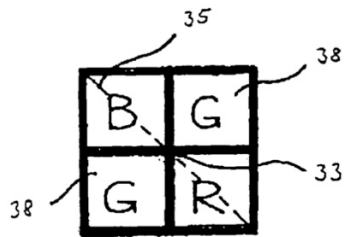


FIG. 11a

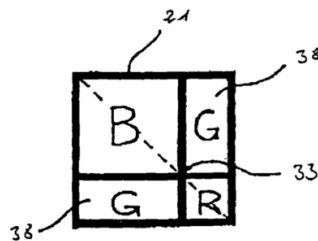


FIG. 11b

(*Id.*, Figs. 11a, 11b.)

355. According to Phan, either example “quad pixel” is intended for use in, for instance, the “quad pixel display” of Fig. 12. (*Id.*, 5:47-60; Fig. 12.)

356. The demonstrative below shows the application of the pixel structure from Fig. 11b to the display of Fig. 12. Again, as each group of four pixels is identical, the same pattern is simply repeated to form the complete display:

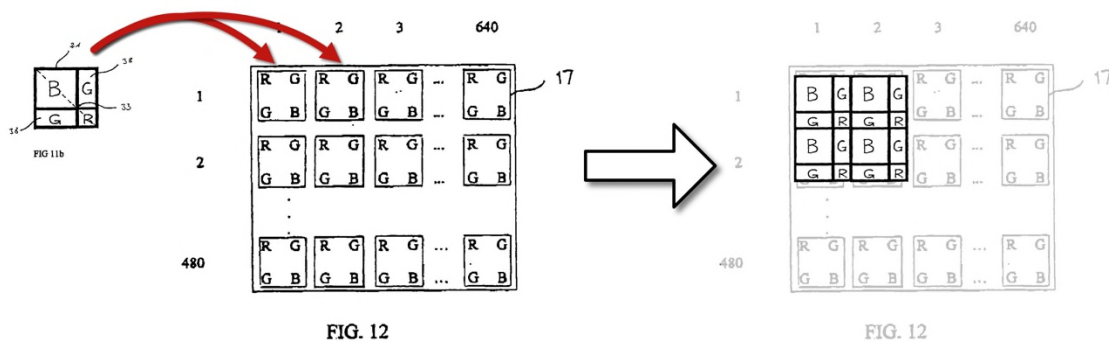


FIG. 12

FIG. 12

(*Id.*, Figs. 11b, 12 (annotated); *see also* Figs. 13aa, 13bb, 13cc, 13dd (also showing the arrangement of R, G, and B pixels in Phan’s “[i]nvented display”).)

357. In my opinion, use of the pixel structure shown in Fig. 11b in a grid or matrix to produce Phan’s display results in what this limitation requires.

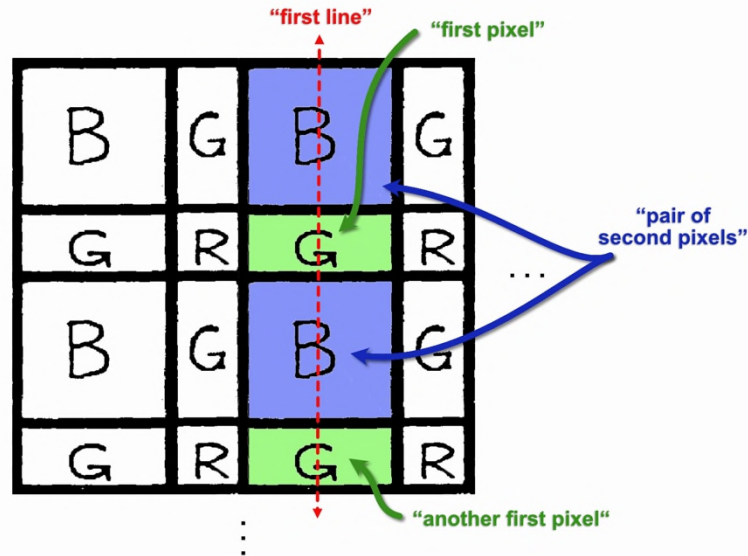
358. In particular, Phan’s green dots are the claimed ***“first pixel”*** and ***“another first pixel.”***

359. Again, Phan teaches that its pixels and dots are “regularly disposed,” arranged “along lines,” and form a “square.” The square pixels are arranged in a grid or matrix where every pixel is “identical.” (See, e.g., *id.*, 4:29-32; 4:41-43; 5:47-54.)

360. Due to the use of a square pixel shape that is regularly arranged on lines in an identically repeating matrix, Phan’s blue and green dots have ***“respective centers”*** that are located ***“along a first line.”***

361. Further, because there are twice as many green dots as there are red and blue dots in Phan’s “quad pixel,” the blue and green dots alternate with each other and are ***“consecutively arranged”*** with blue pixels on ***“opposite sides”*** of the green pixels.

362. This is shown below. To prepare the figure below, the pixel structure of Figure 11b has simply been repeated four times as Phan teaches (see above discussion). This same pattern would of course continue across the entire display.



363. Because Phan’s pixels are arranged in a quad square and are regularly disposed, a line passes through the respective centers of the blue and green pixels.

[1-a(3)]/[13-a(3)]/[15-a(3)] “a pair of third pixels separated from the first pixel and the second pixels, the third pixels being located at opposite sides of the first pixel along a second line [passing through respective centers of the first pixel and the third pixels] on which the first pixel, the third pixels[,] and an additional first pixel are consecutively arranged such that the second line passes through respective centers of the first pixel, the third pixels, and the additional first pixel, the second line crossing the first line at a location of the first pixel,”

364. This, in my opinion, is taught by Phan.

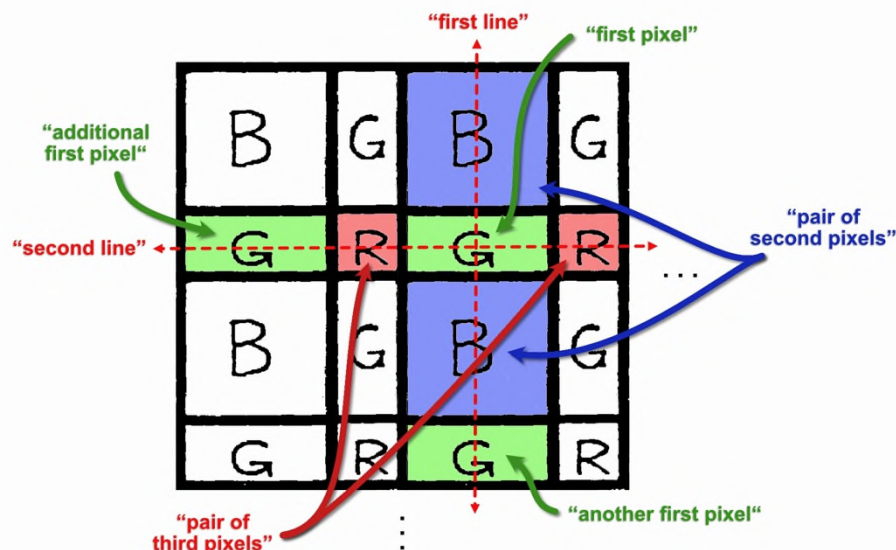
365. Again, Phan’s pixels include red, blue, and green dots. (Ex. 1005, 4:29-32: Fig. 11b.) The red dots are the claimed **“pair of third pixel.”**

366. As I have explained, all of Phan’s dots are “surrounded by a black mask or black barrier ribs 21 to obtain a higher contrast.” (*Id.*, 4:33-37; Figs. 1a-c; 10a-11b.) This **“separate[s]”** adjacent dots. As noted above, a POSITA would also understand additional space to be present.

367. Further, Phan teaches that its pixels (and dots) are all “identical” and “regularly disposed” along lines in a repeating grid or matrix. (Ex. 1005, 4:29-32; Fig. 11b.) They also have a “square quad shape.” (*Id.*, 5:47-54.)

368. Because of Phan’s use of this geometry and layout, along with the fact that there are twice as many green dots as blue and red dots, the red dots have their “centers” on a “second line” that runs through the red dots, the green “first pixel” and “an additional” green “first pixel.” The “second line” “cross[es] the first line” at a green pixel as required. And, the pixels are “consecutively arranged,” with “third pixels” (red dots) on “opposite sides” of the “first pixel[s]” (green dots).

369. This is shown in the below demonstrative (which was also prepared using Figure 11b in the same manner discussed above):



[1-b]/[13-b]/[15-b] “wherein a first distance between the second pixels is greater than a second distance between one of the second pixels and a neighboring one of the third pixels,”

370. This, in my opinion, is taught by Phan.

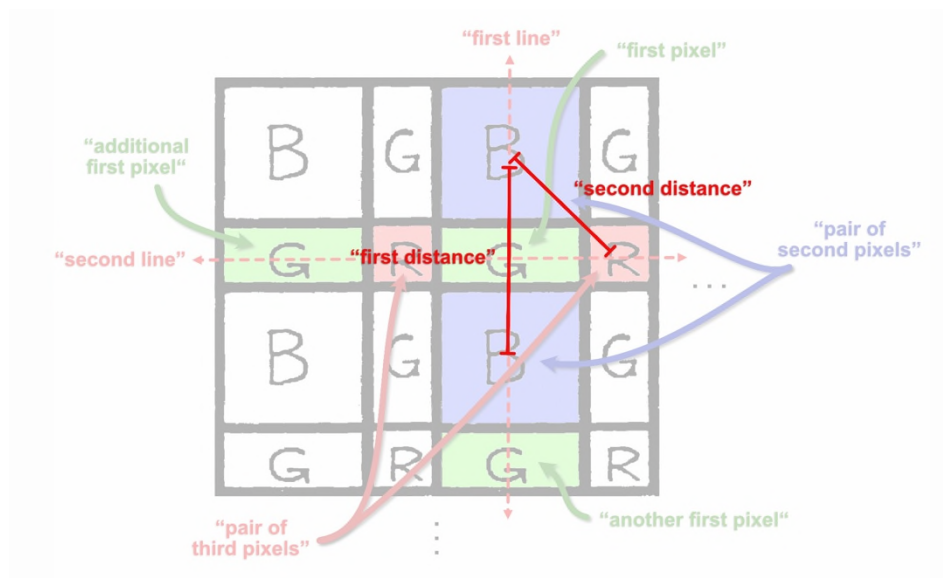
371. Phan’s “square quad pixels” include twice as many green dots as blue or red dots. (See Ex. 1005, 5:47-54; Figs. 11a-b.)

372. Because of this, there are green dots located between all of Phan’s “second pixels” (the blue dots). (See, e.g., Fig. 12.)

373. Moreover, the “second pixels” (the blue dots) and the “third pixels” (the red dots) are arranged diagonally with no intervening pixels. (*Id.*, Figs. 11a-b.)

374. Because of the pixel shape and geometrical arrangement Phan employs, the “**first distance**” between Phan’s blue dots will always be “**greater**” than a “**second distance**” between adjacent blue and red dots.

375. The below demonstrative provides an example of this. If the dot center to dot center distance is x , the “first distance” between blue pixels will again be $2x$ (as it spans three pixels). The “second distance” between blue and red pixels will once again be only $1.4x$ (as it is the hypotenuse of an isosceles right triangle with two sides equal to x).



[1-c]/[13-c]/[15-c] “wherein the first pixels are configured to emit green light, [which is a color that is different from light emitted by the second pixels and the third pixels,]”

376. This, in my opinion, is taught by Phan.

377. Again, as I have explained, each of Phan’s pixels includes a “green dot 14.” (Ex. 1005, 4:29-32; Fig. 11b.) Further, the green light emitted by this pixel is different in color than the red and green light emitted by Phan’s other pixels. (See *id.*)

[1-d]/[13-d]/[15-d] “wherein the first pixels are smaller [have a smaller size] than at least one of the second pixels or the third pixels, and”

[1-e]/[13-e]/[15-e] “wherein each of the second pixels has a larger area than each of the third pixels.”

378. This, in my opinion, is taught by Phan.

379. Again, these limitations collectively require larger “second pixels” and smaller “third” and “first pixels.”

380. As explained, Phan’s green dots are the claimed “first pixel,” its blue dots are the claimed “second pixel,” and its red dots are the claims “third pixel.”

381. In Fig. 11b, the central “crosspoint” of the pixel has been shifted “along diagonal line 35” resulting in dots with non-equal areas. (Ex. 1005, 5:47-54.) As shown, the blue dots have a larger area than the red dots:

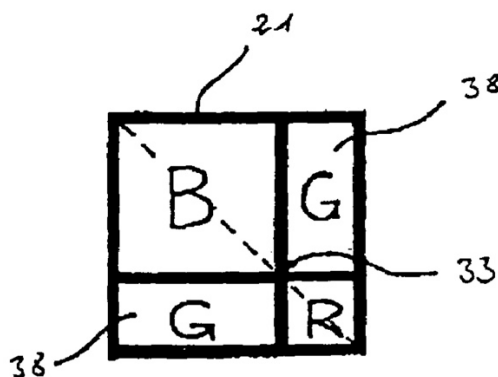


FIG 11b

382. Thus, in my opinion, Phan teaches that its “first pixels” (green dots) are “**smaller**” than at least its “second pixels” (blue dots).

383. Further, Phan’s “second pixels” (blue dots) also have a “**larger area**” than the “third pixels” (red dots).

b. Claim 4

384. Claim 4 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

“the first pixels, the second pixels, and the third pixels are configured to emit different color lights.”

385. This, in my opinion, is taught by Phan.

386. Phan’s “[p]ixels” include red, green, and blue dots. (Ex. 1005, 4:29-32; *see also id.*, Figs. 11b, 12.)

387. As explained when discussing limitations [1-a(1)] through [1-a(3)], Phan’s green dot is the claimed **“first pixel,”** its blue dot is the claimed **“second pixel,”** and its red dot is the claimed **“third pixel.”**

c. Claim 5

388. Claim 5 depends on claim 4. As I have explained, Phan teaches and renders obvious everything claim 4 requires. This claim also further requires:

“the second pixels are configured to emit blue light, and the third pixels are configured to emit red light.”

389. This is taught by Phan for the same reasons I discussed for limitations [1-a(1)] through [1-a(3)] of claim 1.

d. Claim 6

390. Claim 6 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

“each of the second pixels has a larger area than that of the first pixel.”

391. This, in my opinion, is taught by Phan.

392. As shown in Figure 11b below, Phan’s **“second pixel”** (the blue dot) has a **“larger area”** than its **“first pixel”** (the green dot):

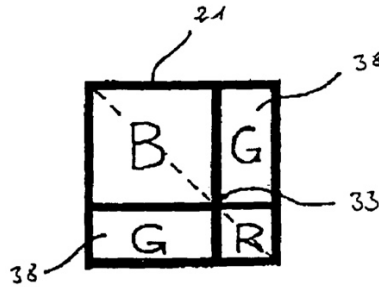


FIG 11b

(Ex. 1005, Fig. 11b.)

e. Claim 7

393. Claim 7 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

“the second pixels are substantially equidistant from the first pixel interposed between the second pixels, and the third pixels are substantially equidistant from the first pixel interposed between the third pixels.”

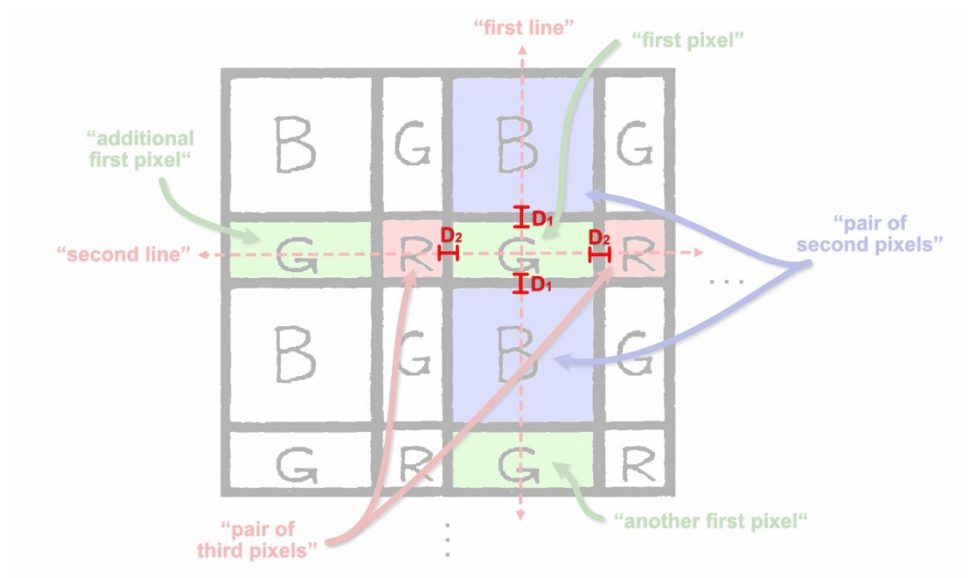
394. This, in my opinion, is taught by Phan.

395. As explained repeatedly above, Phan’s pixels (and the dots the pixels contain) are “identical” and “regularly disposed” in a repeating grid or matrix. (Ex. 1005, 4:29-32; Fig. 11b.) Further, each pixel has a “square quad” shape, with the pixel’s dots surrounding a “crosspoint.” (Ex. 1005, 5:47-54; Figs. 11a-b.)

396. Due to its use of dots arranged in regularly disposed squares, the distances between dots will be the same across the display.

397. The below demonstrative shows this. As shown below, a “first pixel” will be ***“substantially equidistant”*** to two surrounding “second pixels” (label D₁).

398. Similarly, the “first pixel” will also be “*substantially equidistant*” to two surrounding “second pixels” (label D_2):



399. The distance between dots is determined by the “black mask or black barrier ribs 21” that surrounds the dots. (Ex. 1005, 4:33-37.)

400. In my opinion, when the pixel design of Figure 11b is used, a POSITA would have understood that this mask has (or at least obviously could have) the same width/thickness across Phan’s display.

401. Making the black mask the same across the display when using a pixel like that in Figure 11b (where the dots are close to each other and have minimal space between) would facilitate the use of “regularly disposed” dots Phan teaches.

f. Claim 8

402. Claim 8 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

“the first distance is measured between respective centers of the second pixels, and the second distance is measured between respective centers of the one of the second pixels and the neighboring one of the third pixels.”

403. This is taught by Phan for the same reasons I described for limitation [1-b].

g. Claim 9

404. Claim 9 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

“the first line passes through respective centers of the first pixel and the second pixels, and the second line passes through respective centers of the first pixel and the third pixels.”

405. This is taught by Phan for the same reasons I described for limitations [1-a(2)] and [1-a(3)].

h. Claim 10

406. Claim 10 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

“each of the first pixels, the second pixels, and the third pixels has a convex shape.”

407. This, in my opinion, is taught by Phan.

408. Phan’s dots are square or rectangular. (Ex. 1005, 5:47-54; Figs. 11a-b.)

409. Squares and rectangles are examples of **“convex”** shapes: all of their internal angles are less than 180°.

2. Motivation to Combine

410. In my opinion, a POSITA would have considered it obvious and would have been motivated to employ Phan's teachings together in the manner discussed above.

411. Phan includes two example pixel designs. As a result, a POSITA would have considered these an obvious starting place when implementing the rest of what Phan teaches.

412. Further, Phan characterizes the example "quad pixel" designs of Figures 11a and 11b that I have discussed above as "typical." (Ex. 1005, 5:47-54.)

413. In my opinion, this would both motivate a POSITA to use and give a POSITA every reason to believe that those example pixels are meant to be used with the displays referenced elsewhere in Phan.

414. Further, Phan also explains that its examples are not meant to be limited, and are instead intended to be "varied" by a POSITA. (*Id.*, 7:12-17.) This would, in my opinion, have further motivated a POSITA to use Phan's various teachings together, and would have given that POSITA a reasonable expectation of success when doing so.

D. Ground 3: Claim 2 Is Obvious Over Phan and Yamada

415. In my opinion, a POSITA would have considered both Phan (Ex. 1005) and Yamada (Ex. 1008) to be within the scope of the prior art and highly relevant to the patentability of the '683 patent's claims.

416. In my opinion, when viewed and considered in light of the knowledge possessed by a POSITA, Phan and Yamada together disclose all the limitations of and render claim 2 of the '683 patent obvious.

417. In addition, in my opinion, a POSITA would have been motivated to combine Phan's and Yamada's teachings to arrive at the subject matter claimed by the '683 patent and would have had a reasonable expectation of success when doing so.

418. Claim 2 depends on claim 1. As I have explained, Phan teaches and renders obvious everything claim 1 requires. This claim also further requires:

[2-a] “wherein the first pixels, the second pixels, and the third pixels have polygonal shapes, and”

419. This, in my opinion, is taught by Phan.

420. Phan explains that the dots making up its pixels can be formed as a “square quad.” (Ex. 1005, 5:47-54.)

421. In Fig. 11a, for example, each dot is an “equal” part of the “square” pixel (and thus is also square). (*Id.*, 5:47-50.)

422. And, in Fig. 11b, while the overall pixel still has a square shape, the “crosspoint” that separates the dots has “mov[ed]” along a “diagonal line” resulting in square and rectangular shaped dots. (*Id.*, 5:51-54.)

423. These two figures are reproduced below. These square and rectangular shaped dots are all “***polygonal***” (as they are closed shapes with at least three straight sides) as this limitation requires:

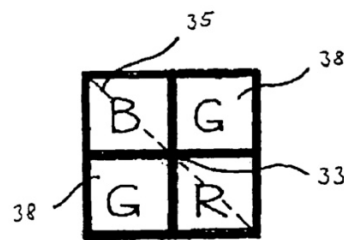


FIG. 11a

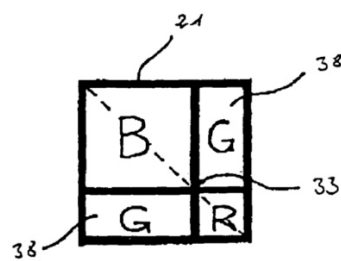


FIG 11b

(*Id.*, Figs. 11a, 11b.)

424. Claim 2 also requires:

[2-b] “wherein each of the second pixels and the third pixels has a larger area than the first pixel.”

425. This, in my opinion, is taught by Phan and Yamada.

426. Phan teaches that its “second pixel” (the blue pixel) can be made larger than its “first pixel” (the green pixel). (*See* Ex. 1005, Fig. 11b.)

427. Thus, it is open to and contemplates OLED displays where the differently colored pixels making up the display have different sizes.

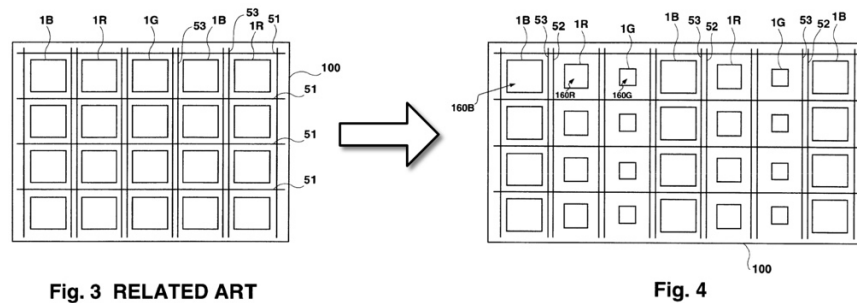
428. Phan does not however, provide an example where its “third pixel” (the red pixel) is also larger than the green pixel.

429. Regardless, in my opinion, a POSITA would have considered this obvious in view of Yamada’s teachings.

430. As I have explained, Yamada teaches an OLED display with red, green, and blue pixels re-sized “in accordance with the emission efficiency of” each color’s “emissive element.” (*Id.*, 2:55-60, 3:16-27.)

431. In one OLED-specific example, the “green pixel” has the highest efficiency and is thus made smallest, while the “blue pixel” has the lowest efficiency and is made largest. (*Id.*, 7:3-12, 8:19-28; 8:47-52; 10:52-55; 11:4-15; *see also id.*, 3:38-44, 3:51-57.)

432. This is shown in Figure 4 of Yamada:



(*Id.*, Figs. 3 4.)

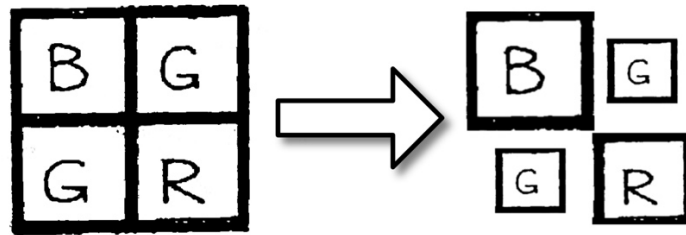
433. As I have discussed, Phan provides examples of “square” pixels and pixels with “square quad” shapes. (*See* Ex. 1005, 4:29-30; 5:47-54; Figs. 1a-c, 11a-b.)

434. In these examples, each pixel includes two green, one blue, and one red dot. (*See id.*)

435. A POSITA would have understood that in addition to the pixel shapes taught by Phan, other shapes would have been obviously employed.

436. For instance, following Yamada's teachings, while maintaining the square pixel shape Phan already employs, the green pixel would be made smallest, the red pixel would have an intermediate size, and the blue pixel would be largest.

437. The following provides an example:



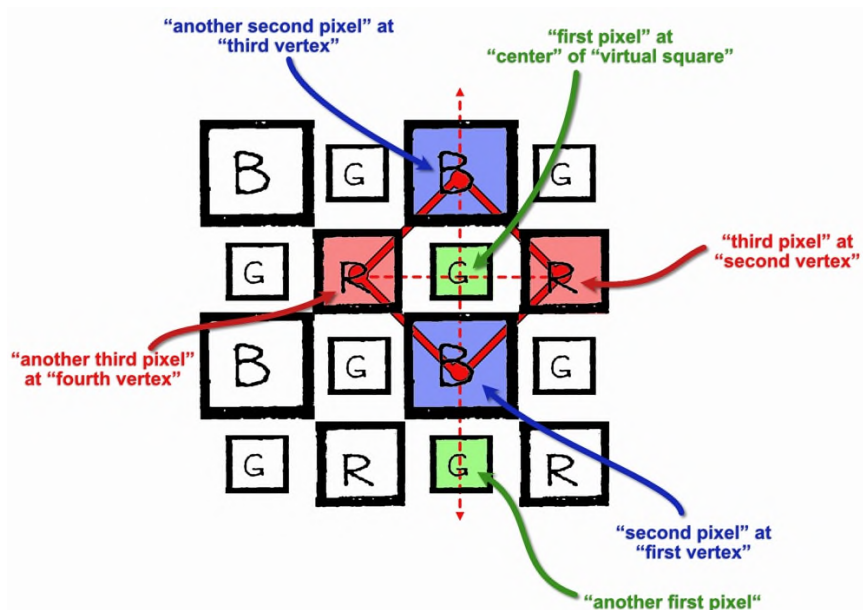
438. The figure on the left is derived from Figure 11a of Phan. The figure on the right has been modified to employ the same overall square pixel shape as Figure 11a (and all of Phan's "square quad" embodiments), just with the blue dot made largest and the green dot made smallest as Yamada instructs.

439. While the pixels are no longer touching each other as they are shown to be in Fig. 11a, a POSITA would have understood that there already is space (even if not depicted) between the pixels to allow for the intermediate signal lines.

440. Thus, this modification simply entails increasing this space (by decreasing the size of the green and red pixels so as to allow all the pixels to be supplied with the same current).

441. Note that this below figure is only meant to be representative. A POSITA would have recognized that either more or less space could be included between the pixels so long as: (1) the area ratio of the blue, red, and green pixels is such that the same current can be supplied to all three pixels and (2) there is sufficient space for each pixel and the signal lines. A POSITA would have, in my opinion, been readily able to balance these design details.

442. When this Yamada-modified square pixel design used in a display matrix, with identical pixels arranged in a regularly spaced matrix like that shown in Figure 12 of Phan, the following results:



443. In my opinion, this is exactly what claim 5 requires: both the “**second pixel**” (Phan’s blue pixel) the “**third pixel**” (Phan’s red pixel) have a “**larger area**” than the “**first pixel**” (Phan’s green pixel).

444. In my opinion, a POSITA would have been motivated to apply Yamada to Phan in the manner discussed above for the same reasons it would have been obvious to apply Yamada to Matthies.

445. As I explained in Section VIII.B.2, it was well-known that adjusting pixel size by making pixels with lower emission efficiencies (like OLED blue pixels) larger and pixels with higher emission efficiencies (like OLED green pixels) smaller reduces deterioration and improves display life.

446. As I also explained, it was well known to employ this approach to improve the life of an OLED display. And, numerous prior art references teach doing so. *See supra* Section VIII.B.2.

447. In my opinion, a POSITA would have recognized that applying Yamada to Phan would have similarly improved the life of Phan’s display.

448. More particularly, by making the blue pixels largest and the green pixels smallest, the same current could be supplied to all the pixels reducing display deterioration and dot failure.

449. Further, as also explained in Section VIII.B.2, re-sizing pixels in accordance with their emission efficiency was also known to simplify display design. This is because each pixel can be supplied with the same current or power.

450. In my opinion, this also would have motivated application of Yamada to Phan. In particular, a POSITA would have understood that Phan's display, like others in the prior art, would be simplified because the same current could be supplied to all of Phan's dots. It would no longer be necessary to include components or circuitry capable of supplying different current to different pixels.

451. Moreover, as I have explained, Phan already teaches that differently sized red, green, and blue dots can be used. (*See, e.g.*, Ex. 1005, Fig. 11b.)

452. In my opinion, because it is already open to the use of larger and smaller pixels, a POSITA would consider application of Yamada's teachings, where the blue dots are made largest and the green dots the smallest, to be nothing more than a routine, minor design variation of Phan's existing teachings.

453. Next, in my opinion, a POSITA would also consider the combination of Phan and Yamada to constitute a simple arrangement of old elements with each performing the same function it had been known to perform producing expected results.

454. In particular, because Phan's dots would still be individually controllable in the manner Phan teaches, the combined display of Phan and Yamada

would still allow for Phan's dynamic pixels (providing for improved resolution), while also having improved life and design simplicity due to Yamada's teachings.

455. In my opinion, a POSITA also would have had a reasonable expectation of success when combining these references.

456. Showing this, while Phan provides examples of certain pixel shapes, it also explains that "[o]ther ... shapes are contemplated" and can be used. (Ex. 1005, 5:29-32.)

457. A POSITA would have understood that this could of course include variations on the differently sized pixels that Phan already teaches. This, in my opinion, would have included relative pixel sizing like that taught by Yamada.

458. Similarly, Yamada explains that its pixel-resizing teachings can be applied to a variety of different display layouts. (Ex. 1008, 12:37-40.)

459. In my opinion, this would have further motivated application of Yamada's teachings: Yamada itself invites application of its pixel sizing to other pixel arrangements and geometries.

460. It also would have led a POSITA to believe that Phan and Yamada would be successfully combined.

461. Finally, both Phan and Yamada relate to pixel designs intended for use with OLED displays.

462. In my opinion, this similarity in purpose between the two references would have given a POSITA yet another reason to believe that the references' teachings can be successfully used together.

E. Ground 4: Claims 1-2, 4-10, 13, and 15 Are Obvious Over Murai in View of Yamada

463. In my opinion, a POSITA would have considered both Murai (Ex. 1007) and Yamada (Ex. 1008) to be within the scope of the prior art and highly relevant to the patentability of the '683 patent's claims.

464. In my opinion, when viewed and considered in light of the knowledge possessed by a POSITA, Murai and Yamada together disclose all the limitations of and render claims 1-2, 4-10, 13, and 15 of the '683 patent obvious.

465. In addition, in my opinion, a POSITA would have been motivated to combine Murai's and Yamada's teachings to arrive at the subject matter claimed by the '683 patent and would have had a reasonable expectation of success when doing so.

1. Claim-By-Claim Analysis

a. Claims 1, 13, and 15

466. Claims 1, 13, and 15 are independent.

467. Because these claims include nearly identical limitations they will once again be discussed together.

[1-pre]/[13-pre]/[15-pre] “A pixel arrangement structure of an organic light emitting diode (OLED) display comprising:”

468. In my opinion, to the extent this preamble language is limiting, this is taught by Murai.

469. In particular, Murai teaches “a color image display device[.]” (Ex. 1007, ¶ [0001].)

470. This device includes colored “dots” arranged into “unit pixel[s].” (*Id.*, ¶ [0006].) Murai discusses the “dot arrangement” used by its “color image display device” at length. (*Id.*, ¶ [0015].)

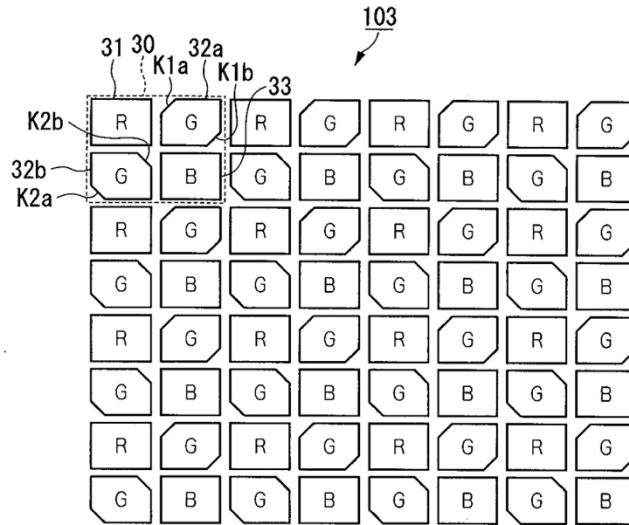
471. Further, Murai explains that the display can be “an organic EL display device.” (*Id.*, ¶ [0058].) A POSITA would understand this to be a reference to an OLED display.

[1-a]/[13-a]/[15-a] “a plurality of pixels for displaying an image on the OLED display and comprising:”

472. This, in my opinion, is taught by Murai.

473. Murai explains that its “FIG. 3 is a plane view showing a dot shape and dot arrangement in a color image display device.” (Ex. 1007, ¶ [0027].)

474. This figure is reproduced below. As shown, Murai’s device includes multiple “red (R),” “green (G),” and “blue (B)” dots 31, 32a, 32b, and 33 arranged into “unit pixels 30.” (*Id.*, ¶¶ [0028]-[0029].)



(*Id.*, Fig. 3.)

475. Next, Murai explains that the red, green, and blue dots are separated from each other. Not only is this apparent from Figure 3 (which shows space between the dots), but Murai also explains that there is a “gap” between rows and columns of dots to allow “a scanning line” to be “disposed in each gap.” (*Id.*, ¶ [0041].) Similarly, “a signal wire may be disposed in each gap” between columns of dots. (*Id.*)

476. Each dot may include a “TFT: thin film transistor” that drives/activates the dot. (*Id.*) While most of Murai refers to dots 31, 32a, 32b, and 33 as “dots,” it also characterizes them as “pixel[s].” (*E.g., id.*, ¶ [0016].)

477. Again, as I have explained, in the ’803 patent, a “pixel” is the “minimum unit for displaying images.” (Ex. 1001, 1:31-32, 34-37; 3:55-56.) This

is what Murai teaches: its colored dots/pixels are the claimed “*plurality of pixels*” because they are the minimum unit of Murai’s display.

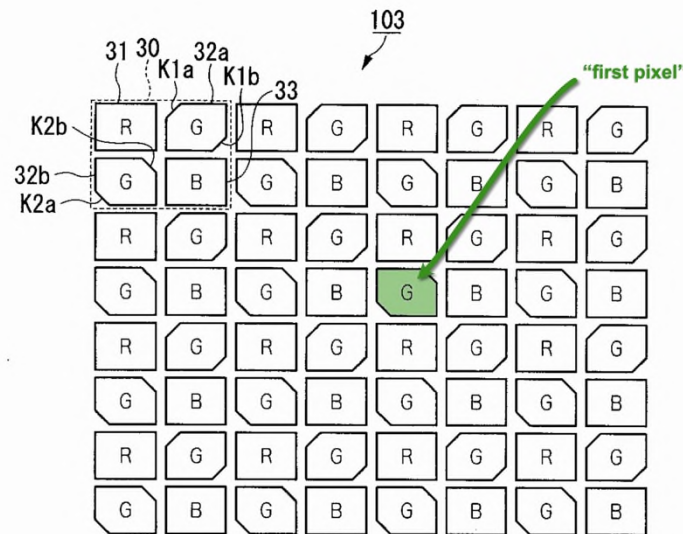
[1-a(1)]/[13-a(1)]/[15-a(1)] “a first pixel;”

478. This, in my opinion, is taught by Murai.

479. As I explain above, these claims require a “first,” “second,” and “third” pixel. They later specify that the “first” pixel be green.

480. Murai’s display includes “green (G),” “red (R),” and blue (B)” dots. (Ex. 1007, ¶¶ [0016], [0018], [0028]-[0029], [0031].)

481. The green dots/pixels are the claimed “*first pixel.*” One such green pixel is annotated in Figure 3 below:



(*Id.*, Fig. 3 (annotated).)

[1-a(2)]/[13-a(2)]/[15-a(2)] “a pair of second pixels separated from the first pixel, the second pixels being located at opposite sides of the first pixel along a first line [passing through respective centers of the first pixel and the second pixels] on which the first pixel, the second pixels, and another first pixel are consecutively arranged such that the first line passes through respective centers of the first pixel[s], the second pixels, and the other first pixel; and

482. This, in my opinion, is taught by Murai.

483. Again, Murai’s pixels also include “red (R)” and “blue (B)” dots/pixels.
(Ex. 1007, ¶¶ [0016]; [0018]; [0028]-[0029], [0031].)

484. Murai’s blue dots are the **“pair of second pixels.”**

485. Murai also explains that there are “gaps” between its dots that accommodate “scanning” and “signal” lines. (*Id.*, ¶ [0041]; *see also* Fig. 3.) This can also be seen in Figure 3. Because of the presence of this “gap,” Murai’s dots are **“separated”** from each other.

486. Murai’s “color image display device” includes “unit pixels ... made up of four dots disposed as a grid in the vertical and horizontal direction.” (Ex. 1007, ¶ [0015].)

487. Each unit pixel includes two “dots” that “are pixels that display green (G),” one “dot” that “is a pixel that displays red (R),” and one “dot” that “is a pixel that displays blue (B).” (*Id.*, ¶ [0016].) Similarly, Murai explains that “R and B may be displayed by one dot and G may displayed by two dots.” (*Id.*, ¶ [0018]; ¶¶ [0028]-[0029], [0031] (similar).)

488. Murai also discusses both the dot shape, and their layout.

489. In particular, the dots “are respectively rectangular, and have substantially the same shape. It is preferable for the rectangular shape ... to be a square.” (*Id.*, ¶ [0017]; *see also id.*, ¶ [0030] (again referencing “substantially the same” pixels shaped as a “square”).)

490. Further, the “four dots ... are respectively disposed to surround one point, and make up a rectangle made up of four rectangles.” (*Id.*, ¶ [0017]; *see also id.*, ¶ [0006] (dots are “disposed on a diagonal” of a “rectangular shape”); ¶ [0010] (similar); ¶ [0032] (similar).)

491. The two green dots/pixels “are disposed on a diagonal of the unit pixel....” (*Id.*, ¶ [0019].)

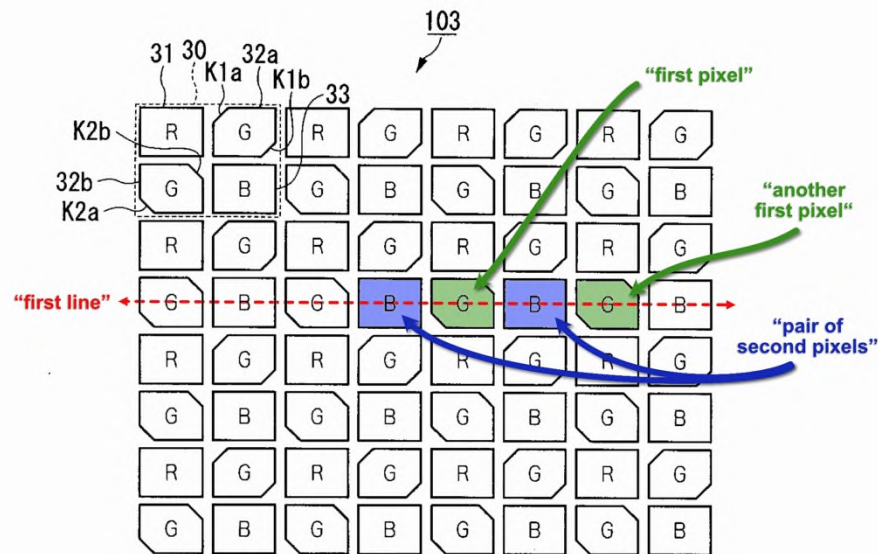
492. According to Murai, all of the dots are “accurately” and “regularly disposed” for purposes of “improv[ing]” “the aperture ratio.” (*Id.*, ¶ [0010].) In my opinion, a POSITA would understand this reference to “regularly disposed” dots to mean that the dots are equally spaced from each other. This is what is shown in all of Murai’s figures. (*See id.*, Figs. 1, 3.)

493. Figure 3, which is reproduced in annotated form below, provides an example.

494. Due to its use of a square dot shape, with dots arranged in a grid with a rectangular/square shape, Murai’s blue and green dots have “**respective centers**” located “**along a first line.**”

495. Further, because there are twice as many green as blue and red dots, with the green dots located diagonally, there is ***“another first pixel”*** (green dot) on the same line.

496. And, the green and blue dots alternate with each other and are ***“consecutively arranged”*** with blue dots on ***“opposite sides”*** of the green dots:



(*Id.*, Fig. 3 (annotated).)

[1-a(3)]/[13-a(3)]/[15-a(3)] “a pair of third pixels separated from the first pixel and the second pixels, the third pixels being located at opposite sides of the first pixel along a second line [passing through respective centers of the first pixel and the third pixels] on which the first pixel, the third pixels[,] and an additional first pixel are consecutively arranged such that the second line passes through respective centers of the first pixel, the third pixels, and the additional first pixel, the second line crossing the first line at a location of the first pixel,”

497. This, in my opinion, is taught by Murai.

498. Again, as noted above, Murai’s display includes red, blue, and green dots/pixels. (Ex. 1007, ¶¶ [0016]; [0018]; [0028]-[0029], [0031].)

499. The red dots are the claimed **“third pixel.”** These dots, like all of Murai’s dots, are separated from the other dots in Murai’s display by a “gap.” (*Id.*, ¶ [0041]; *see also* Fig. 3.)

500. Next, as I have also explained, Murai employs square dot shapes, with the dots “accurately” and “regularly disposed” in a “grid” with groups of dots located at “diagonals” in a rectangular/square pattern. (*See* Ex. 1007, ¶¶ [0006], [0010], [0015], [0017], [0019], [0030], [0032].)

501. Further, in Murai’s display there are two green dots/pixels for every red dot/pixel and blue dot/pixel. The green dots are located diagonally from each other. (*See id.* ¶¶ [0016], [0018], [0028]-[0029], [0031].)

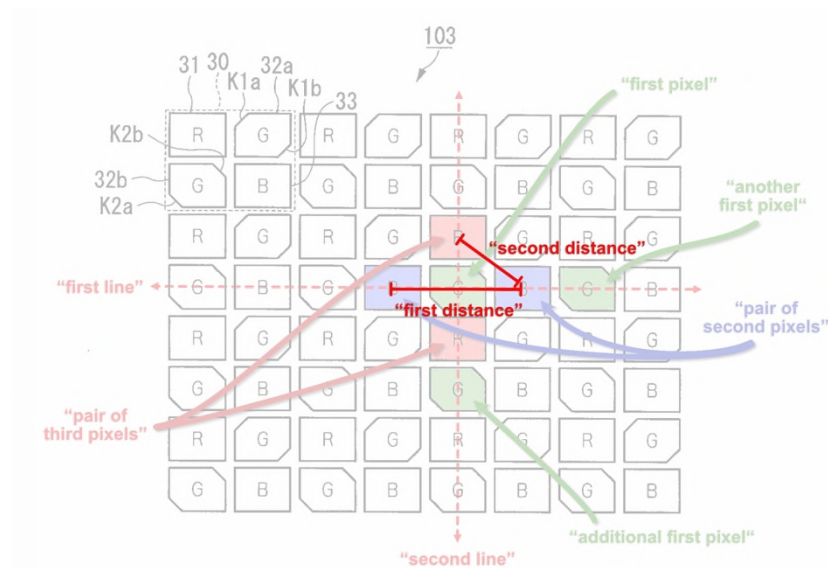
502. Once again, this geometry (and relative number of green versus red and blue dots), results in red dots with **“centers”** on a **“second line”** that runs through the red dots, the green **“first pixel”** and **“an additional”** green **“first pixel.”**

503. Further, the “second line” **“cross[es] the first line”** at a green dot as required. The pixels are **“consecutively arranged,”** with “third pixels” (red dots) on **“opposite sides”** of the “first pixel[s]” (green dots). This is all shown in the below annotated version of Figure 3:

507. According to Murai, all of its dots are square, and are accurately and regularly arranged. (See *id.* ¶¶ [0006], [0010], [0015], [0017], [0019], [0030], [0032].)

508. Because of this geometric arrangement, the “**first distance**” between Murai’s blue dots (which are separated by a green dot) is “**greater**” than the “**second distance**” between adjacent blue and red dots (which are not separated from other dots, but are instead located diagonally).

509. If the dot-center-to-dot-center distance is x , these distances will respectively be $2x$ and $1.4x$ for the same reasons explained above in Section VIII.B.1.[1-b]). The distances are annotated below in Figure 3:



[1-c]/[13-c]/[15-c] “wherein the first pixels are configured to emit green light, [which is a color that is different from light emitted by the second pixels and the third pixels,]”

510. This, in my opinion, is taught by Murai.

511. Again, Murai’s display includes “green” dots/pixels. (Ex. 1007, ¶¶ [0016]; [0018]; [0028]-[0029], [0031]; Fig. 3.) This green dot is the claimed ***“first pixel”*** for the reasons I discussed for limitation [1-a(1)]. Further, green is a different color from the red and blue colors employed by Murai’s other pixels.

[1-d]/[13-d]/[15-d] “wherein the first pixels are smaller [have a smaller size] than at least one of the second pixels or the third pixels, and”

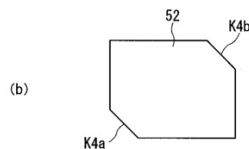
[1-e]/[13-e]/[15-e] “wherein each of the second pixels has a larger area than each of the third pixels.”

512. A POSITA would have considered this obvious in view of Murai and Yamada.

513. As an initial matter, Murai already teaches that the sizes of its dots can be adjusted.

514. In this regard, Murai explains that the dots/pixels making up its display can include a “cut-off portion” that adjusts the dot area. (Ex. 1007, ¶ [0006].) For instance, “at least one corner of the rectangular shape” can be “cut off[.]” (*Id.*, ¶ [0011].)

515. Figure 5(b), which is reproduced below, provides an example:



(*Id.*, Fig. 5(b).)

516. As shown, the example “dot 52” includes “cut-off portions K4a and K4b.” (*Id.*, ¶ [0039].)

517. Murai does not limit this to any particular color of dot. Instead, it contemplates including cut-off portions in various dots. (*See id.*, Figs. 3, 5, 6.)

518. Murai also teaches that differently sized cutouts can be used.

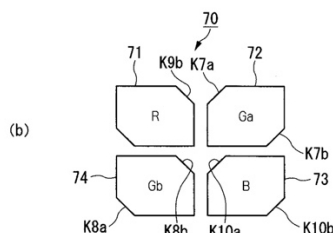
519. Showing this, according to Murai, some “cut-off portion[s]” “may have a smaller shape” than others. (*Id.*, ¶ [0013].)

520. In Figure 5(b) above, for example, “cut-off portion K4b” is “more cut off” than “cut-off portion K4a.” (*Id.*, ¶ [0039].) Thus, a single dot has two differently sized cut-offs.

521. In addition to employing differently sized cut-offs, Murai also explains that different numbers of cutouts may also be employed in different dots.

522. For example, in Figure 3 (reproduced below) green dots 32a and 32b include two cutouts each, while red dots 31 and blue dots 33 include no cutouts. The presence of these two cut-offs results in green dots that smaller than both the red and blue dots:

524. Alternatively, as shown in Fig. 6(b), all four dots can include cutouts. Again, Murai teaches that the cut-outs can have different sizes. So, this arrangement can also result in different relative dot sizes despite all the dots having cut-outs.



(*Id.*, Figs. 6(b).)

525. In sum, a POSITA reviewing Murai would recognize that Murai contemplates, is open to, and teaches an OLED display with differently sized red, green, and blue dots, and provides a means to achieve these different dot sizes (i.e., the use of different numbers and sizes of cut-offs).

526. Next, as I have explained, Yamada teaches an OLED display with red, green, and blue pixels re-sized “in accordance with the emission efficiency of” each color’s “emissive element.” (Ex. 1008, 2:55-60, 3:16-27.)

527. As I have also explained, in one OLED-specific example, the “green pixel” has the highest efficiency and is thus made smallest, while the “blue pixel” has the lowest efficiency and is made largest. (*Id.*, 7:3-12, 8:19-28; 8:47-52; 10:52-55; 11:4-15; *see also id.*, 3:38-44, 3:51-57.) This is done will maintaining the overall pixel geometry. (*See id.*)

528. This is shown in Figures 3 and 4 of Yamada:

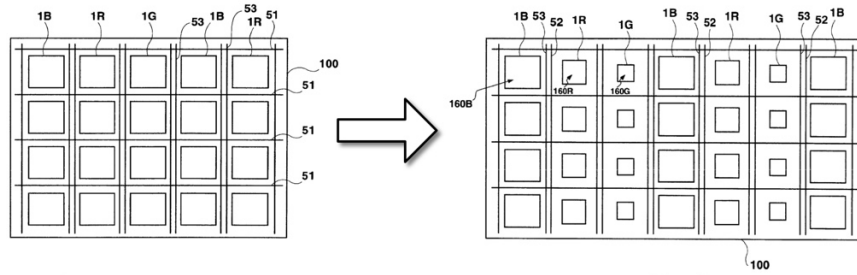


Fig. 3 RELATED ART

Fig. 4

(*Id.*, Figs. 3, 4.)

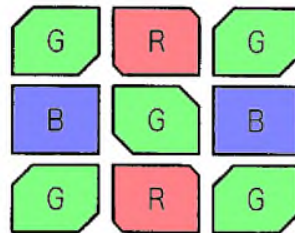
529. In my opinion, applying this to Murai results in what the claim requires. In particular, Murai’s dots would be relatively re-sized per Yamada using the method Murai already teaches—the use of different numbers and sizes of cutouts.

530. Doing so, the “**first pixel**” (the green dot) would continue to be “**smaller**” than the other pixels. Now, however, the “**area**” of the “second pixels” (the blue dots) would also be made relatively “**larger**” than that of the “**third pixel**” (the red dots).

531. The rest of Murai would remain the same, including the dot geometric arrangement and spacing.

532. The below demonstrative provides one example of how a POSITA would have obviously accomplished this. The green dots are made smallest via the inclusion of two larger cutouts. The red dots have an intermediate size with two smaller cutouts. The blue dots are largest because they include no cutouts. The overall dot geometry (including arrangement of the dots in a regular matrix, with

groups of four dots located at diagonals and forming a square shape) remains the same:



b. Claim 2

533. Claim 2 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

[2-a] “wherein the first pixels, the second pixels, and the third pixels have polygonal shapes, and

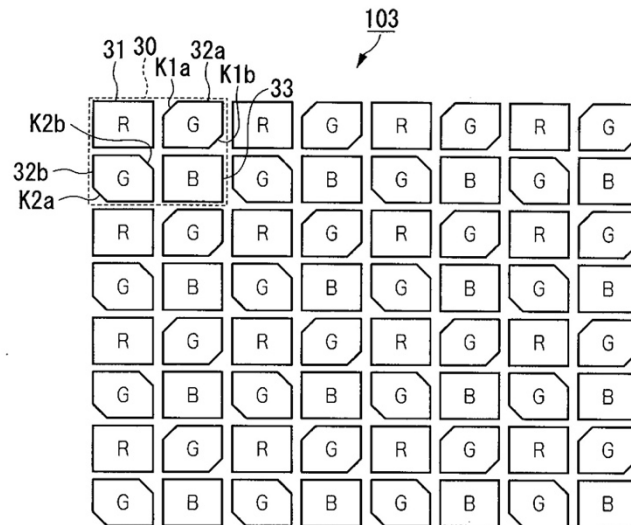
[2-b] “wherein each of the second pixels and the third pixels has a larger area than the first pixel.”

534. This, in my opinion, is taught by Murai.

535. Murai explains that its of its dots/pixels have a “rectangular shape” that is preferably “a square.” (Ex. 1007, ¶¶ [0017]; [0024]; [0030]; Fig. 3.) Because of this, the dots are ***“polygonal.”***

536. Further, Murai explains that its green dots can include two corner “cut-offs.” (See *id.*, ¶¶ [0031]-[0032].)

537. As shown in Figure 3, which is reproduced below, the presence of these corner cutouts makes Murai's ***"first pixel"*** (the green dots) smaller than both its ***"second pixels"*** (the blue dots) and its ***"third pixels"*** (the red dots):



(*Id.*, Fig. 3.)

c. Claim 4

538. Claim 4 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

"the first pixels, the second pixels, and the third pixels are configured to emit different color lights."

539. This, in my opinion, is taught by Murai.

540. As explained, Murai's pixels emit "red (R)," "green (G)," and "blue (B)" light. (Ex. 1007, ¶¶ [0002], [0006]-[0007], [0009], [0016], [0028]-[0029].)

Red, green, and blue are different colors.

d. Claim 5

541. Claim 5 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 4 requires. This claim also further requires:

“the second pixels are configured to emit blue light, and the third pixels are configured to emit red light.”

542. This is taught by Murai for the same reasons I discussed for limitations [1-a(1)] through [1-a(3)].

e. Claim 6

543. Claim 6 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“each of the second pixels has a larger area than that of the first pixel.”

544. This is taught by Murai for the same reasons I discussed for limitations [1-d] and [2-b]: Murai’s ***“second pixel[s]”*** (blue dots) have a ***“larger area”*** than its ***“first pixel[s]”*** (green dots).

545. As explained when discussing limitations [1-d] and [2-b], in Figure 3, the green dots include corner cut-offs making them smaller.

546. A POSITA would understand that this would continue to the case even after application of Yamada. As noted above, Yamada explains that the green pixels should be made smallest.

f. Claim 7

547. Claim 7 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the second pixels are substantially equidistant from the first pixel interposed between the second pixels, and the third pixels are substantially equidistant from the first pixel interposed between the third pixels.”

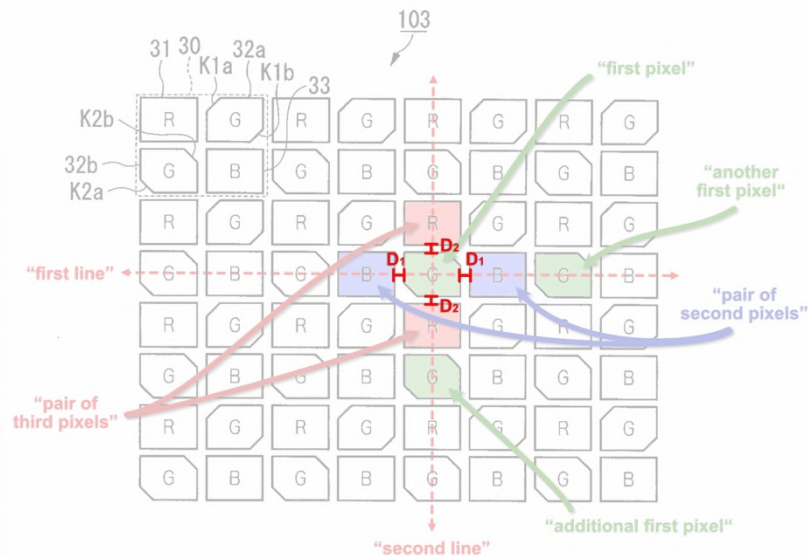
548. This, in my opinioin, is taught by Murai.

549. Again, Murai employs square dot shapes, with the dots “precisely” arranged in an “accurate” and “regular[]” “grid” with groups of dots located at “diagonals” of a rectangle/square pattern. (See Ex. 1007, ¶¶ [0006], [0010], [0015], [0017], [0019], [0030], [0032].)

550. Because of Murai’s use of a regular grid with square pixels (with dots located at diagonals from each other), Murai’s “first pixel” will be ***“substantially equidistant”*** to two surrounding “second pixels” (label D₁).

551. For similar reasons, the “first pixel” will also be ***“substantially equidistant”*** to two surrounding “second pixels” (label D₂).

552. This is shown in the below annotated version of Figure 3:



g. Claim 8

553. Claim 8 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the first distance is measured between respective centers of the second pixels, and the second distance is measured between respective centers of the one of the second pixels and the neighboring one of the third pixels.”

554. This is taught by Murai for the same reasons I described for limitation [1-b].

h. Claim 9

555. Claim 9 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“the first line passes through respective centers of the first pixel and the second pixels, and the second line passes through respective centers of the first pixel and the third pixels.”

556. This is taught by Murai for the same reasons I described for limitations [1-a(2)] and [1-a(3)].

i. Claim 10

557. Claim 10 depends on claim 1. As I have explained, Murai and Yamada teach and render obvious everything claim 1 requires. This claim also further requires:

“each of the first pixels, the second pixels, and the third pixels has a convex shape.”

558. This, in my opinion, is taught by Murai.

559. Murai’s pixels have a rectangular/square shape. (Ex. 1007, ¶¶ [0006], [0010], [0015], [0017], [0019], [0030], [0032].)

560. As explained above, rectangles and squares are examples of ***“convex”*** shapes.

2. Motivation to Combine

561. In my opinion, a POSITA would have been motivated to apply Yamada to Murai in the manner discussed above for the same reasons it would have been obvious to apply Yamada to both Matthies and Phan.

562. Once again, as I have explained, it was well-known that an OLED display’s life can be improved by adjusting pixel size.

563. In particular, as noted in Section VIII.B.2, making pixels with lower emission efficiencies (like blue pixels) larger and pixels with higher emission efficiencies (like green pixels) smaller reduces deterioration and improves display life.

564. As I also explain in Section VIII.B.2, this approach to improving OLED display life was well-known in the art when the '683 patent was filed and applied by numerous references for purposes of improving display lifetime.

565. In my opinion, a POSITA would have recognized that applying Yamada to Murai would have similarly improved the life of Murai's display.

566. In particular, by making the blue pixels largest and the green pixels smallest, display deterioration and pixel failure would have been reduced.

567. Next, as also explained in Section VIII.B.2, re-sizing pixels in accordance with their emission efficiency was also known to simplify display design because each pixel can be supplied with the same current or power.

568. In my opinion this also would have motivated application of Yamada to Murai.

569. In particular, a POSITA would have understood that Murai's display would be simplified because the same current could be supplied to all of Murai's pixels. It would no longer be necessary to include structure and circuitry capable of supplying different currents to different pixels.

570. Moreover, as I have explained when discussing claim 1, Murai already teaches a display with differently sized pixels.

571. While Murai does this for purposes of improving image quality by preventing continuous bands of color, in my opinion, a POSITA would have understood that this existing design feature could also be used to improve pixel life.

572. Given this, a POSITA would consider application of Yamada's teachings, where the blue pixels are made largest and the green pixels the smallest, to be nothing more than a routine, minor design variation of Murai's existing teachings. Murai already allows for and is open to the use of differently sized pixels. Yamada simply supplements this existing teaching by explaining how making the blue pixels largest and the green pixels smallest improves display life and simplifies display design.

573. Moreover, in my opinion, a POSITA would have recognized that the combined display of Murai and Yamada would exhibit the benefits referenced in both references.

574. In particular, due to its continued use of Murai's pixel layout and notches, the combined display would exhibit improved color.

575. Further, because the dots would be resized in accordance with their emission efficiencies, the display of Murai and Yamada would be simpler and have improved life.

576. Thus, once again, in my opinion the combination is nothing more than a simple arrangement of old elements with each performing the same function it had been known to perform producing expected results.

577. In my opinion, a POSITA also would have had a reasonable expectation of success.

578. As I have repeatedly explained, Murai is already open to the re-sizing of its pixels. And, it does not limit this to any particular color pixel: all of its display pixels can incorporate cut-offs if necessary.

579. Likewise, Yamada explains that its pixel-resizing teachings can be applied to a variety of different display layouts. (Ex. 1008, 12:37-40.)

580. In my opinion, this would both have further motivated application of Yamada's teachings to Murai (since it emphasizes that Yamada's teachings are meant for use with other pixel layouts like that taught by Murai), but would have emphasized to a POSITA that Murai and Yamada would be successfully combined.

581. Finally, both Murai and Yamada relate to pixel designs for use with OLED displays.

582. In my opinion, this similarity in purpose would have given a POSITA yet another reason to believe that the references' teachings can be successfully combined.

F. Secondary Considerations of Non-Obviousness

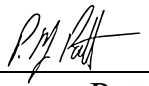
583. Based on my review of the '683 patent's prosecution history, I note that no secondary considerations of non-obviousness were identified in connection with the patent's claims.

584. I am not separately aware of any evidence of commercial success, skepticism, failure of others, industry praise, unexpected results, or the like. Instead, as discussed above, it is my opinion that the subject matter embraced by the '683 patent's claims was known in the art and would have been expected to function as a working OLED display device.

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 willfully 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.

Date: 6/21/2023

Location: 1300 Buffalo St., Johnson City, TN

Signature: 
Morgan Pattison, Ph.D.

ATTACHMENT A

P. Morgan Pattison
morgan@sslsinc.com
(805)217-3878

Experience

Solid State Lighting Services, Inc. **November 2007 - Present**
Founder/President- Provide technical, strategic, and market expertise in the areas of LEDs, OLEDs, Lighting, Solid State Lighting (SSL), displays, and optoelectronic materials and devices. LED device, lighting, and materials product development. Horticultural lighting research and strategy. Light pollution measurement, evaluation, and mitigation. LED and lighting product failure and reliability evaluation. Human physiological responses to light. Scout and evaluate new technologies for investment.

U.S. Department of Energy **January 2006 – November 2007**
National Energy Technology Laboratory, Morgantown WV
Project Manager- Managed DOE funded R&D projects in SSL including LED and OLED lighting technologies. Managed solicitation and selection of new funded R&D projects. Identified priority areas of research necessary for advancement of SSL efficiency, performance, and price.

University of California, Santa Barbara **September 2000 – January 2006**
Graduate Student Researcher- Doctoral thesis research under Professor Shuji Nakamura (Nobel Prize in Physics 2014) on GaN based micro-cavity light emitting diodes. Research included: epitaxial structure design and growth by MOCVD, semiconductor process development, materials characterization, and electro-optical device characterization. Additional areas of research included UV LEDs, vertical cavity surface emitting laser (VCSEL), and edge emitting laser diodes.

Cymer Laser, San Diego **November 1996 – May 2000**
Laser Test Engineer- Tested and developed test methodology for production and prototype KrF and ArF excimer lasers used in deep UV photolithography for manufacturing of advanced semiconductor products. Testing included optical characterization and full system troubleshooting. Test development of new electrical and optical test methodologies to improve test cycle, Labview automation of test procedures, and development of test documentation.

Education

Ph.D. Materials Science, Electronic and Photonic Materials
University of California, Santa Barbara, 2006
Thesis: *Fabrication and Characterization of Gallium Nitride Based Micro-Cavity LEDs*
M.S. Electrical Engineering, Electronics and Photonics
University of California, Santa Barbara, 2003
B.S. Electrical Engineering, Electronic Devices and Materials
University of California, San Diego, 1996

Expertise

Optoelectronic materials and devices, lighting, LED, OLED, R&D and technology evaluation, LED-OLED-Quantum Dot display technology, SSL product evaluation and selection, LED lighting product development, R&D Management, technology roadmapping, technical meeting moderation, technical writing, IP evaluation, trial expert witness, lighting color evaluation and selection, advanced lighting performance evaluation, Energy Star LED lighting testing, photometric characterization and testing, R&D Management, Federal R&D funding processes, R&D Proposal review and evaluation, ESCO contracts and performance measurement & verification (M&V), horticultural lighting, wildlife responses to light, human physiological responses to light

Accreditations, Affiliations, and Professional Societies

Oregon State University, Civil and Construction Engineering, Courtesy Faculty
Lighting Certified (LC) by National Council on Qualifications for Lighting Professionals
Member - Illuminating Engineering Society of North America (IESNA)
 Member – IES Horticultural Lighting Committee
 Chair – Outdoor Nighttime Environments (ONE) Committee
Member - International Society of Horticultural Scientists (ISHS)
Member – International Dark-Sky Association (IDA)
Member – International Society for Optics and Photonics (SPIE)
Member – American Society of Agricultural and Biological Engineers (ASABE)
Project Management Professional (PMP) *Lapsed*, Project Management Institute (2006)
U.S. Government Contracting Officer's Representative (COR) (2006)

Leadership

Senior Technical and Strategic Advisor to DOE SSL R&D Program
Lead writer of DOE SSL R&D Opportunities, R&D Plan, and Multi-Year Program Plan
Technical content supervisor of annual DOE SSL R&D Workshop
Manage organization of DOE SSL topical R&D meetings on: LED devices and materials, OLEDs, luminaire integration, roadway lighting, germicidal ultraviolet (UV) LEDs, human physiological responses to light, domesticated and wild animal responses to light, roadway and area lighting, and horticultural lighting
New business creation/development –*Action Spectrum*, *Ultra-Yield Solutions*, *Guidance LED*, *Zuli*, *Canvas*, *Intellilight/Next*, *SSLs, Inc.*, *Diel Lighting Science*
Scientific Advisory Board member to *GLASE (Greenhouse Lighting and System Engineering)*, NYSERDA funded controlled environment agriculture R&D program
Technical Advisory Committee of Resource Innovation Institute
Advisory Board Member of *Phosphor Global Summit* annual meeting
Advisor to *Cyclotron Road* – Clean Technology Incubator at Lawrence Berkeley National Lab
Project sponsor for Senior Design Course at UCSB (2011-2012)
 1. Design and development of spectro-goniophotometer
 2. Design and development of smartphone light controller (co-founder and original board member of resulting company now called *Zuli*)
Designed, fabricated, and characterized world's first gallium nitride microcavity LED
Fabricated and characterized world's first gallium nitride semipolar LED

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IES Raleigh Section "Horticultural Lighting – A Growing Opportunity", IES Street and Area Lighting Conference 2022, National Park Service Science and Technology – Skyglow Measurements at Channel Islands National Park 2022, UCSB Nitride Seminar 2022, International SSL Alliance 2021 General Assembly, The Limits of Food Production – Vertical Farming 2021, Horticonn 2020, U.C. Davis Energy and Efficiency Institute, California Energy Administration, 2020 DOE Lighting R&D Workshop, Charleston Catholic High School STEM Seminar, East Tennessee State University Physics and Astronomy Seminar, IES Rocky Mountain Section – CU Boulder, 2019 DOE SSL R&D Workshop, Harvard ES-173 Guest Lecture, U.S. DOE Building Technologies Office Brown Bag Seminar, U.C. Santa Barbara Nitrides Seminar 2018, Phosphor Global Summit 2018, West Virginia State University – Biology Seminar, East Tennessee State University Entrepreneur Club 2018, IES Aviation Lighting Committee Meeting 2017 (Best Technical Paper), ICCEA Panama 2017, NCERA 101 Controlled Environment Agriculture meeting, DOE SSL R&D Workshop 2017, The College of New Jersey Physics Colloquium, DOE SSL R&D Workshop 2017, NREL 2016, Harvard University Engineering Seminar, LightSym 2016, DOE SSL R&D Workshop 2016, DOE SSL Technology development Workshop 2015, DOE SSL R&D Workshop 2015, IDTechX Internet of Things Applications, Phosphor Global Summit 2014, International Conference on Nitride

Semiconductors 2013, IES Illuminate Philadelphia 2012, Strategies in Light 2012, Energy Efficiency Expo 2011, Tennessee Association of Physical Plant Administrators 2011, East Tennessee State University Faculty Development Sustainability Seminar 2011, LED Discovery 2010, Think Tomorrow Today 2008, International Conference on Nitride Semiconductors 2005, International Symposium on Blue Lasers and Light Emitting Diodes 2004, Fall Materials Research Society 2001.

Patents

Technique for growth and fabrication of semipolar (Ga, Al, In, B) N thin films, heterostructures, and devices. #9793435, #9231376, #8686466, #7846757, #10529892

Lighting unit having lighting strips with lighting elements and a remote luminescent material. #8491165

Lighting unit with heat dissipating chimney #8360607

Lighting unit with indirect light source #8684566 B2

System for monitor and control of equipment. #9432210

Semiconductor light emitting device #8227820, #8643036

Etching technique for the fabrication of thin (Al, In, Ga) N layers. #7795146

Semiconductor micro-cavity light emitting diode. Application # 11/510,240 (abandoned)