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.

Case IPR2023-00987
U.S. Patent No. 9,818,803

DECLARATION OF IOANNIS KYMISSIS, PH.D.

I, Ioannis Kymissis, Ph.D., declare and state, to the best of my knowledge, understanding, and belief, as follows:

1. I have been retained as a technical consultant on behalf of Samsung Display Co., Ltd. ("Samsung Display" or "Patent Owner"), who I understand is the owner of U.S. Patent No. 9,818,803 (Ex. 1001) ("'803 Patent"). I understand that Mianyang BOE Optoelectronics Technology Co., Ltd. ("BOE"), Wuhan China Star Optoelectronics Semiconductor Display Technology Co., Ltd. ("CSOT"), Tianma Microelectronics Co., Ltd. ("Tianma"), and Visionox Technology, Inc. ("Visionox") (collectively, "Petitioner") have filed a petition for *Inter Partes* Review of the '803 Patent (Paper No. 1) ("Petition") and a declaration by Dr. P. Morgan Pattison (Ex. 1003) ("Pattison Declaration").

2. I have been asked by counsel for Samsung Display to provide my expert opinions concerning the validity of claims 1-5 and 19-21 of the '803 Patent ("Challenged Claims"). In particular, I have been asked to consider certain arguments presented in the Petition and Dr. Pattison's opinions provided in the Pattison Declaration. I have also been asked to consider the state of the art and various references on which Petitioner and Dr. Pattison rely.

3. I submit this Declaration in support of Samsung Display's Response to the Petition. My opinions are based on my review of certain materials (described

below) and my knowledge, education, experience, and training. My opinions are subject to supplementation or change if new information becomes available.

4. I am being compensated at my standard consulting rate for my time. My compensation is in no way contingent on the result of this or any other proceeding relating to the ’803 Patent, or on the substance of any opinion I provide.

I. EXPERIENCE AND QUALIFICATIONS

5. I am the Kenneth Brayer Professor of Electrical Engineering at Columbia University in New York City. I also serve as the Chair of the Department of Electrical Engineering. I have been a faculty member in the Department of Electrical Engineering at Columbia University since 2006. I typically teach courses in solid state electronics, including undergraduate and graduate device physics, thin film electronics, and displays. In my course on displays, which I have taught for nearly twenty years, we cover a broad range of topics, including organic light-emitting diode (“OLED”) displays, liquid crystal displays (“LCD”), visual perception, color science, wave optics, emissive displays and their mechanisms, display panel backplanes, and 3D displays. Over the course of my career, I have supervised twenty Ph.D. candidates and fourteen post-doctoral associates.

6. I received my bachelor’s degree (S.B.) in electrical engineering from the Massachusetts Institute of Technology (“MIT”) in 1998. I received my master’s degree in engineering (M.Eng.) in 1999, and a doctoral degree (Ph.D.) in 2003, both

from MIT. My Ph.D. thesis was on field emission displays. I also completed a post-doc at MIT working on OLED technologies, organic semiconductors, and quantum dot-based materials.

7. I have published over 150 peer-reviewed journal papers and have delivered more than 100 invited, plenary, and keynote presentations on display technology and thin film electronics.

8. I am a fellow of the Society for Information Display (and currently president elect of that society), a fellow of Optica, and a fellow of the IEEE. I previously served as the Editor-in-Chief of the Journal of the Society for Information Display, where my role included reading and assessing each paper. I am an associate editor of the IEEE Open Journal on Immersive Displays, the Journal of the Society for Information Display, and Advanced Science. I am a distinguished lecturer of the IEEE Electron Device Society, and have served on more than 40 program committees for international conferences in the past 10 years including positions in SID (Society for Information Display), DRC (Device Research Conference), EMC (Electronic Materials Conference), SIGGRAPH (The Association for Computing Machinery's Special Interest Group on Computer Graphics and Interactive Techniques), IEDM (International Electron Devices Meeting), MRS (Materials Research Society), SPIE (Society of Photo-Optical Instrumentation Engineers), and LOPEC (Large-area, Organic & Printed Electronics Convention). I served as the

general chair for the Device Research Conference, one of the leading conferences in device electronics, in 2014. From 2009 to 2011, I was on the executive committee for the Organic Electronics Workshop sponsored jointly by IEEE, MRS, and ACS (American Chemical Society).

9. I am the recipient of more than thirty technical awards listed on my CV, including the IEEE EDS Paul Rappaport Award, and am a fellow of the Society for Information Display, Optica, and the IEEE for my work on displays and thin film electronics.

10. I am the named inventor on several dozen patents, including many patents relating to electronic displays, organic materials, and fabrication of semiconductor devices.

11. I have been involved in a number of display development programs. My interest in displays began as a student. I worked at IBM in New York and Tokyo for a total of about 18 months while I was a student. My master's degree research was conducted at IBM Research in Yorktown Heights, New York on organic semiconductor electronics for display technologies. I also worked at the IBM Tokyo Research Laboratory as a doctoral student, working on liquid crystal displays. My Ph.D. thesis was on field emission displays, and I completed a post-doc at MIT working on OLED technologies, organic semiconductors, and quantum dot-based materials.

12. In addition to my research work, I have further worked at a number of companies on the development of display technologies. I was the first employee of QDVision, a small company based in Watertown, Massachusetts from 2005-2006, and designed the display demonstrators and prototypes used by that company. My work at QDVision included making and testing OLED display devices. I am also a co-founder of Lumiode, a company that specializes in the development of advanced backplanes for microLED displays, and continue as a co-inventor and lead designer for the display demonstrators developed by the company.

13. I also serve as a consultant and board member for Chromation, Lumiode, Lelantos, and Kelvin (formerly Radiator Labs). I have also served as a consultant for Corning and Applied Materials in connection with microLED display technologies. In addition, I have had a number of sponsored research projects with other companies and government agencies, including Magic Leap, RDS, IBM, Samsung Electronics, the U.S. Air Force, and the National Science Foundation ("NSF"). For example, I performed a research project with Magic Leap concerning microLED technologies, a project from approximately 2018 to 2019 with Samsung Electronics to measure the degradation and lifetime of OLED displays with RGBW pixel arrangements, and projects from approximately 2006 to 2009 with the U.S. Air Force and from approximately 2013 to 2017 with the NSF involving OLED technologies.

14. My work at QDVision and Lumiode involved designing every aspect of the display, including the pixel arrangement structures to be used. At QDVision, I was the first employee and designed the test vehicles used for all internally fabricated displays over the life of the company. At Lumiode, I serve as a technical advisor and continue to be involved in the design and reviews for all layouts and pixel formats.

15. A copy of my curriculum vitae further detailing my education, experience, awards and honors, and publications that may be relevant to my opinions is attached to this declaration as Exhibit 2010.

16. In sum, I have extensive expertise in OLEDs, displays, and pixel arrangements. I am familiar with the state of the art at the relevant time up to the time of the invention of the ’803 Patent.

II. MATERIALS REVIEWED

17. In preparing this declaration, I have reviewed the ’803 Patent, including the claims of the patent in view of the specification, and the prosecution history of the ’803 Patent. I have reviewed the petition for *inter partes* review and the declaration of Dr. Pattison, as well as numerous prior art and technical references from the time of the invention of the ’803 Patent. Specifically, I have reviewed each of the following:

Exhibit	Description
1001	U.S. Patent No. 9,818,803
1002	File History of U.S. Patent No. 9,818,803
1003	Declaration of P. Morgan Pattison, Ph.D.
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.
1008	U.S. Patent No. 6,366,025 B1 to Yamada
1009	U.S. Pub. 2009/0121983 A1 to Sung et al.
1010	U.S. Patent No. 3,971,065 to Bayer
1011	U.S. Pub. 2009/0302331 A1 to Smith et al.
1012	U.S. Patent No. 7,274,383 B1 to Brown Elliot
1013	U.S. Pub. 2010/0171440 A1 to Satou
1014	U.S. Pub. 2003/0128179 A1 to Credelle
1015	U.S. Patent No. 6,867,549 to Cok et al.
2001	Claim Construction Order, Inv. No. 337-TA-1351
2002	Joint Submission of Agreed Upon and Disputed Claim Terms, Inv. No. 337-TA-1351
2003	U.S. Patent No. 5,644,327
2011	U.S. Patent No. 6,747,618 (“Arnold”)
2012	U.S. Patent No. 8,716,929 (“Yoo”)

Exhibit	Description
2013	Korea Industry Post, *Popularity of Galaxy S4 to Kickstart Demand for AMOLED Market*, (2013)
2014	Dr. Raymond M. Soneria, *Galaxy S4 Display Technology Shoot-Out*, DisplayMate
2015	U.S. Patent No. 9,697,760 ("Wang")
2016	Jiin-Joi Lih et al., *The Challenge of High Resolution to Active-Matrix OLED*, Society for Information Display (2006)
2017	Ho-Kyoon Chung et al., *AMOLED Technology for Mobile Displays*, Society for Information Display (2006)
2018	U.S. Patent Publication No. 2007/0278933 ("Chao")
2019	Society of Information Display, *Mobile Display Technology and Applications* (Achintya K. Bhowmik et al.) (2008)
2020	Journal of Display Technology, *New Pixel Design on Emitting Area for High Resolution Active-Matrix Organic Light-Emitting Diode Displays* (Soon-Kwang Hong et al.) (2010)
2021	U.S. Patent Publication No. 2008/001525 ("Chao")
2022	Bogdan Petrovan, *Diamond Pixels: Galaxy S4's Unique Subpixel Arrangement Gets a Close Up* (2013)
2023	Hyunjung Jung, *History of Advancement of 'AMOLED', Core Competitiveness of Galaxy* (2014)
2024	Nell Hughes, *Apple Won't Adapt AMOLED Displays in iPhones Until 2019 at the Earliest, Insider Says* (2015)
2025	Dr. Raymond M. Soneira, *Smartphone "Super" LCD-OLED Display Technology Shoot-Out*
2026	Jin-Gyu Meyong, *Sharper Galaxy S4, the Secret Weapon is the 'Diamond'* (2013)

Exhibit	Description
2027	Dr. Raymond M. Soneira, *Samsung Diamond Pixels*
2029	Teardown Photos of Samsung Galaxy S22 Ultra Product
2030	INTENTIONALLY LEFT BLANK
2031	INTENTIONALLY LEFT BLANK
2032	INTENTIONALLY LEFT BLANK
2033	Chung-Chia Chen et al., *Low Power Consumption and Wide Color Gamut AMOLED Display with Four Primary Colors*, Society for Information Display (2015)
2034	*Detailed Explanation: Why Zhou Dongyu's BOE Screen is Not as Good as Samsung Screen*
2035	Xiaojian, *What Exactly was the Scolded "Dongyu Zhou" Screen Like? Is it Really Unusable?* (2020)
2036	Li-Qin Shao et al., *The Development of 403ppi Real RGB Printing AMOLED*, Society of Information Display (2019)
2037	*Secret to the Face of Galaxy S4, Reason for Striking Resolution* (2013)
2038	Chris Davies, *The iPhone X has the Best Smartphone Display Around* (2017)
2039	Dr. Raymond M. Soneira, *iPhone X Display Technology Shoot-Out*
2040	Bryan Jones, *iPhone X Pixels* (2017)
2041	*Samsung Display Co., Ltd. v. BOE Tech. Co. Ltd. et al.*, Case No. 2-23-cv-00309, Compl. (E.D. Tex. Jun. 26, 2023)
2044	Teardown Photos of Group Vertical Product
2045	Teardown Photos of Phone LCD Parts Product

Exhibit	Description
2046	Teardown Photos of Sourcely Plus Product
2047	Teardown Photos of eTech Parts Product
2048	Teardown Photos of Parts4LCD Product
2049	Teardown Photos of MobileSentrix Product
2050	Teardown Photos of Mobile Defenders Product
2051	Teardown Photos of Injured Gadgets Product
2052	Teardown Photos of Fixez Product
2053	Teardown Photos of Repairs Universe Product
2054	Teardown Photos of SEGMobile Product
2055	Teardown Photos of Parts4Cells Product
2056	Teardown Photos of Wholesale Gadget Parts Product
2057	Teardown Photos of Captain Mobile Parts Product
2058	Teardown Photos of DFW Products
2059	Teardown Photos of Mengtor Product
2060	Teardown Photos of Gadgetfix Product
2061	Declaration of Aris Silzars, Ph.D.
2062	Transcript of March 20, 2024 Deposition of Dr. Morgan Pattison
2063	Declaration of Adam Fontecchio, Ph.D.
2064	Sung-eun Kim, *Climbing Mt. Fuji on Handstand?* (including certified English translation)
2065	Yoon Jeong-hyun, *Samsung Display Achieves the Highest Definition Quality With Tenacity, Full HD AMOLED*

Exhibit	Description
	"Revolution," BIZ Insight (2013) (including certified English translation)
Ex. 2066	*Public-Private Commitment to Ceaseless Effort for Display Super Gap*, Ministry of Trade, Industry, and Energy (2023)
Ex. 2067	Dr. Raymond M. Soneira, *About Display Mate Technologies*
Ex. 2068	Dr. Raymond M. Soneira, *iPhone XS Max Diamond Sub-Pixels*
Ex. 2069	Dr. Raymond M. Soneira, *iPhone X Diamond Sub-Pixels*
Ex. 2070	Dr. Raymond M. Soneira, *iPhone 14 Pro Max Diamond Pixels*
Ex. 2071	Dr. Raymond M. Soneira, *iPhone 13 Pro Max Diamond Pixels*
Ex. 2072	Dr. Raymond M. Soneira, *iPhone 12 Pro Max Diamond Sub-Pixels*
Ex. 2073	Amal Ghosh et al., *Short Course S-1: Fundamentals of OLEDs*, Society for Information Display
Ex. 2074	G. Gu et al., *Design of Flat-Panel Displays Based on Organic Light-Emitting Devices*, IEEE Journal on Selected Topics in Quantum Electronics, Vol. 4, No. 1, (1998)
Ex. 2075	DE Patent No. 10 2011 053 000 B4 (including certified English translation)
Ex. 2076	D. Braun, *Crosstalk in Passive Matrix Polymer LED Displays*
Ex. 2077	Jong In Park et al., *Direct Prediction Methods on Lifetime Distribution*, IEEE Transactions on Reliability 59 (2010)
Ex. 2078	Priyanka Tyagi et al., *Degradation of Organic Light Emitting Diode: Heat Related Issues and Solutions*, Synthetic Metals 216 (2016)

Exhibit	Description
Ex. 2079	M.M. Azrain et al., *Analysis of Mechanisms Responsible for the Formation of Dark Spots in Organic Light Emitting Diodes (OLEDs): A Review*, Synthetic Metals 235 (2018)
Ex. 2080	Jiun-Haw Lee et al., *Introduction to flat panel displays* (2008)
Ex. 2081	U.S. Patent Publication No. 2011/0234550 ("Hong")

III. LEGAL STANDARDS

18. I am not a lawyer or an expert in patent law, and I am not offering opinions about the relevant law. For purposes of this declaration, I have been informed by counsel for Samsung Display of the relevant legal standards that apply to my analysis, and I have applied these legal standards in forming my opinions.

19. I have been informed that each issued claim of a patent is presumed to be valid. I understand that in this proceeding, to overcome the presumption of validity, Petitioner bears the burden of proving unpatentability by a preponderance of the evidence. I understand that a "preponderance" means "more likely than not." I understand that general and conclusory assertions without underlying factual evidence may not support a conclusion that something is more likely than not.

20. I understand that a patent claim is obvious in view of the prior art if the differences between the patented claims and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the art ("POSITA") at the time of the claimed invention. I understand that the factors to be

considered in analyzing whether a claim was obvious are: (i) the scope and content of the prior art; (ii) the differences between the prior art and the claim; (iii) the level of ordinary skill in the art; and (iv) any objective indicia of nonobviousness, such as copying.

21. I further understand that obviousness may be based on one reference or a combination of prior art references. I understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I have been informed that, if obviousness is based on the combination of multiple prior art references, then there must have been some reason or motivation for a POSITA to combine the references so as to arrive at the claimed invention, with a reasonable expectation of success. I understand that a patent claim composed of several limitations is not proven obvious merely by demonstrating that each limitation was independently known in the prior art.

22. I am informed that it is improper to analyze obviousness by working backwards from the claimed invention with the aid of hindsight. Thus, the prior art cannot be combined with the specific problem solved by the invention in mind. Thus, when considering what a POSITA would have been motivated to do, and what that person would find obvious, one cannot proceed with the asserted patent in mind. It is improper to pick and choose prior art teachings so as to reconstruct the claimed invention.

23. I understand that the scope and content of the prior art should be examined as a whole to determine what it would have taught a POSITA at the time of the claimed invention.

24. I have also been informed that it is relevant to consider whether the prior art includes references that "teach away" from the claimed invention. A reference teaches away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken in the claim.

25. I am informed that obviousness grounds must rely on analogous art and that art is considered analogous if it is: (1) from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) reasonably pertinent to the problem faced by the inventor (even if not in the same field of endeavor as the invention). I also understand that a reference is reasonably pertinent only when it logically would have commended itself to an inventor's attention in considering his problem. I understand that if a prior art reference is not in the same field of endeavor as the challenged patent, or not reasonably pertinent to solving the problem the inventor aimed to solve, it is not analogous art and should not be considered as part of an obviousness analysis.

26. I understand that objective indicia of non-obviousness refer to real-world considerations and facts that show that a patent claim would not have been

obvious to a POSITA at the time of the invention. I understand that objective indicia of nonobviousness include long-felt but unmet need, failure of others, copying, unexpected results, commercial success, skepticism, and industry praise and acceptance. I also understand that such objective indicia must be considered from the perspective of a POSITA.

27. I also understand that objective indicia evidence demonstrates non-obviousness because it shows that others working in the field would have been motivated to create a product having the attributes of the claimed invention if they had the necessary inventive skill to do so. I have been informed that it is appropriate to consider objective indicia if there is a nexus, or connection, between the claimed invention and the objective indicia.

IV. CLAIM CONSTRUCTION

28. I have been informed that, unless a term has been construed to have a particular meaning, every term of a patent claim is to be given its plain and ordinary meaning as would be understood by a POSITA at the time of the invention. I further understand that neither Petitioner nor Patent Owner has argued that any claim term requires construction. Therefore, in forming my opinions, I have applied the plain and ordinary meaning to every claim term.

V. BACKGROUND OF THE TECHNOLOGY

29. The ’803 Patent relates to a pixel arrangement structure of an organic light emitting diode (“OLED”) display. In this section I provide a brief overview relevant to understanding this technology, and the differences between it and the prior art.

A. Electronic Display Basics

30. Electronic displays provide an interface through which various types of information, such as text, images, or video, can be transmitted electronically and presented to a viewer. There have been many different types of electronic display devices developed over the years. For many decades, cathode ray tube (“CRT”) technology was the predominant display technology, and CRT televisions and computer monitors were in widespread use. Starting in the 1980s and 1990s, liquid crystal displays (“LCDs”) and plasma displays started being commercialized, with LCDs becoming more widespread in the 1990s and 2000s with the introduction of TFT-LCDs, which used thin-film-transistor (“TFT”) technology to drive the LCDs. The first practical OLED display device is credited to Eastman Kodak in 1987. It is described in what is sometimes referred to as “the first OLED paper.” But even by the 2000s, commercial OLED display devices remained elusive. This was, in part, due to challenges that were difficult to overcome in mass-producing OLED displays.

31. Typically, an electronic display is configured to display images using a two-dimensional array of picture elements, commonly called pixels. Pixels output light that can be viewed by a user, and the intensity of the light output by each pixel can be controlled to display different images. For color displays, individual pixels can be configured to output light of different colors at different intensities. When users view different color pixels together from a sufficient distance, they will perceive a color that is the combination of the colors output by each individual pixel.

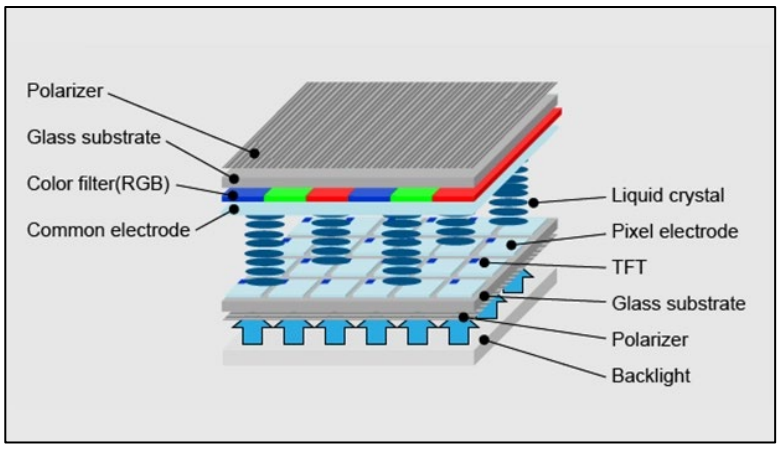
32. As a point of nomenclature, the combination of color elements in a display can be referred to as the single pixel, with the smaller units containing individual colors being referred to as the sub-pixels. Or each of the smaller units containing individual colors can be referred to as a pixel. Either way, a pixel in a display generally refers to the basic unit that constitutes the images on the screen. Pixels of various colors have been used in OLED displays, such as red (R), green (G), blue (B), white (W), and yellow (Y). An array of a large number of pixels together can form images to be displayed. A pixel arrangement refers to the shape, sizing, and positioning of these pixels.

B. Principles of Operation – LCDs vs OLED Displays

33. Today, both liquid crystal displays ("LCD") and OLED displays are found in a variety of applications such as TVs, computer monitors, laptops, and

smartphones. But LCDs and OLED displays have significant structural, manufacturing, and operational differences.

34. LCDs display images using a two-dimensional array of picture elements, commonly known as pixels. To display color images, individual pixels can be configured to allow light of different colors to pass through. Typically, these colors are: red, green, and blue. By turning on and off each of these pixels, and by controlling their corresponding brightness, different images can be displayed.



[1]

35. In an LCD, a backlight (shown above) is required to provide light to the entire display. Each pixel of the LCD includes a layer of material called liquid crystals, as well as a pair of electrodes. When a voltage is applied to the electrodes, an electric field is formed between the electrodes. Liquid crystals are sensitive to electric fields, and twist and turn in response to the electric field. Depending on the

[1] From https://www.j-display.com/images/product/displaybasic/img_04_en.webp.

orientation of the liquid crystals, a different amount of light is allowed to pass through the pixel.

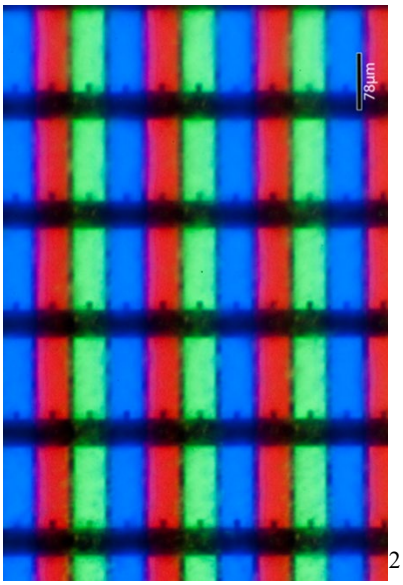
36. Liquid crystal materials occur in several varieties, but as an example, some liquid crystals are organic molecules in a rod-like shape with an electrical polarizability that is different in the long direction versus the other two directions. This allows for two important functionalities—the material can be manipulated through the application of an electric field (the molecule will orient itself to align the higher dielectric constant direction along the field) and the index of refraction is also anisotropic (and higher in the direction with the higher dielectric constant). These two effects are used in a variety of modes to create structures that can, under electrical control, manipulate the polarization of light and create controllable shutters for displays.

37. Because LCDs operate as spatial light modulators, each pixel either passes or blocks light, and the individual pixels do not themselves generate light. As illustrated in the figure above, a color filter (which is an array of patterned dyes) filters the light from a backlight to create the color in these displays. Light passes through all of the layers of the display, and the fill factor is especially important in evaluating the efficiency and visual quality of such a display.

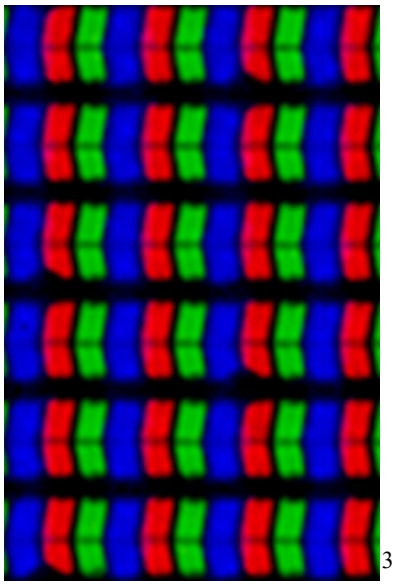
38. LCD displays have a single layer of liquid crystal shared by multiple pixels, with pixel boundaries being defined by the locations of pixel electrodes and

color filters. Adjacent pixels in an LCD thus run right up against each other, bounded only by thin black masks that demark boundaries of pixels by virtue of simply blocking the light from being seen by the user in that part of the display. The aperture ratio of LCD displays is thus very high, with non-emission areas generally limited to the black masks between adjacent pixels (the black masks may also extend into the pixel region over the locations of pixel driving circuitry, which can help shield the TFTs from being affected by external or reflected light).

39. In LCD displays, pixels are typically arranged in simple rows and columns, with a triplet of red, green, and blue pixels in three adjacent columns forming a unit that is repeated multiple times to form a single row, with the same color pattern repeated for each row. Variations of shapes and sizes were available for different applications. For example, chevron-shaped pixels were introduced to improve the viewing angle of the display using advanced LCD modes.



[2]


[3]

40. OLEDs display images using a two-dimensional array of pixels of different colors, again typically red, green, and blue. Unlike LCDs, OLEDs do not require a separate light source. Instead, the organic materials that form each pixel emit light. And unlike LCDs, where the red, green, and blue pixels appear to be directly adjacent to each other, OLED pixels have larger gaps between pixels due to the characteristics of organic materials and limitations of the manufacturing process.

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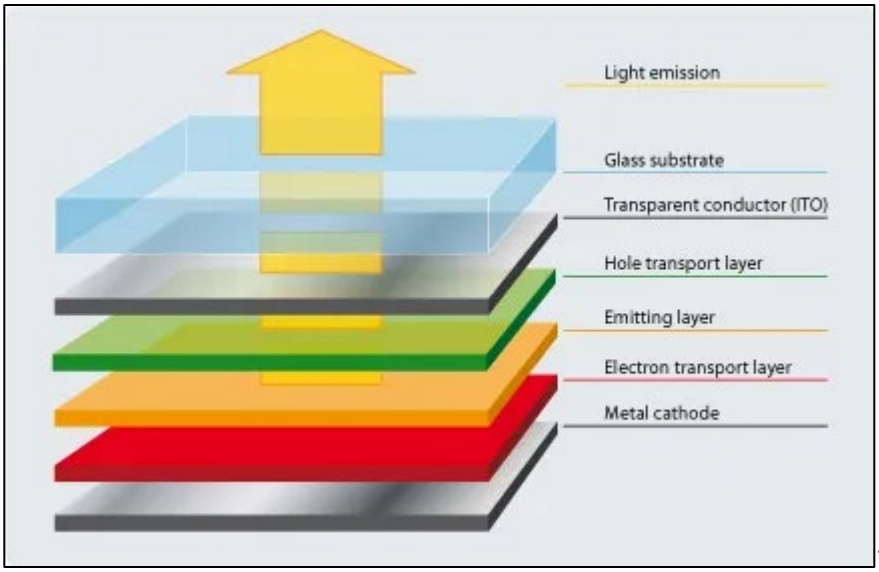
[2] From https://prometheus.med.utah.edu/~bwjones/wp-content/uploads/2010/06/iPhone-3G-Display_.jpg.

[3] From https://prometheus.med.utah.edu/~bwjones/wp-content/uploads/2014/10/iPhone6.jpg.



[4]

41. A typical OLED device is fabricated using a stack including a substrate, an anode, a hole transport layer, an emissive electroluminescent layer formed of an organic material, an electron transport layer, and a cathode. In such a device, holes are injected in the anode, electrons are injected from the cathode, and these form an excited state which recombines, emitting light. The OLED stack may include other additional layers, such as a hole injection layer between the hole transport layer and the anode, an electron injection layer between the electron transport layer and the cathode, or blocking layers to help confine charge carriers to the emissive layer.

42. Manufacturing high-resolution OLED displays for small/medium sized display applications proved difficult, with low production yield rates. One

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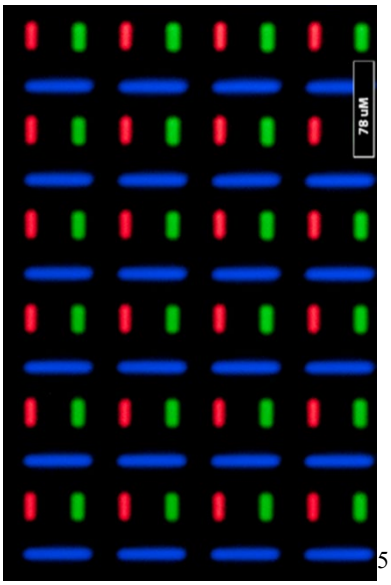
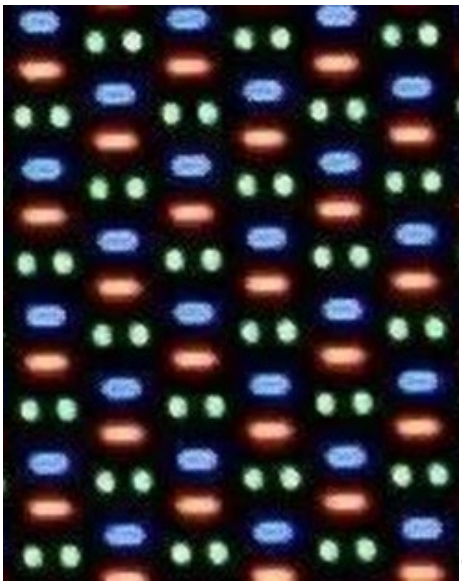
[4] From https://i0.wp.com/semiengineering.com/wp-content/uploads/2016/10/21c8niq.jpg.

significant source of the difficulty lay in the difference in methods of manufacturing the individual pixel elements for LCDs and OLEDs.

43. In LCDs, a single layer of liquid crystal material could be deposited on the entire display, with red, green, and blue color filters made of insulating material simply formed placed on top of each pixel region. But in OLEDs, the organic emissive materials that form each pixel conduct electricity, so the organic material must be sufficiently separated from each other to prevent defects. Further, when organic materials for emitting different colors are deposited too close to each other, overlap of the material can result in color mixing, compromising the color of the display. Thus, in contrast to LCDs, OLED displays have large gaps between pixels. Examples of OLED displays are shown below. Other examples can also be seen in Exs. 2023, 2034, 2035.



[5]


[6]

44. Manufacturing OLED displays, and particularly the emissive layers that are responsible for forming visible images on the display screen, requires deposition processes that are challenging from both design and manufacturing standpoints. In the case of OLED displays for mobile devices, the manufacturing process is especially complicated because the pixels are extremely small and must fit very close to one another. Further complicating the process is that the different colored pixels use different organic materials, each of which have unique characteristics, such as life span.

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[5] From https://prometheus.med.utah.edu/~bwjones/wp-content/uploads/2015/07/Apple-Watch-Pixels.jpg.

[6] From https://p1-tt.byteimg.com/origin/tos-cn-i-qvj2lq49k0/3ff6413f9f054ff7b3e2f88fed3f27a9.jpg.

45. The most common deposition method has been thermal evaporation under high vacuum using a fine metal mask. The fine metal mask ("FMM") is essentially a layer of metal with openings that define the positions, sizes, and shapes of individual OLED pixels. The FMM is placed near the surface of a display substrate, and organic materials are deposited onto the substrate such that the individual OLED pixels are formed within the opening of the FMM.

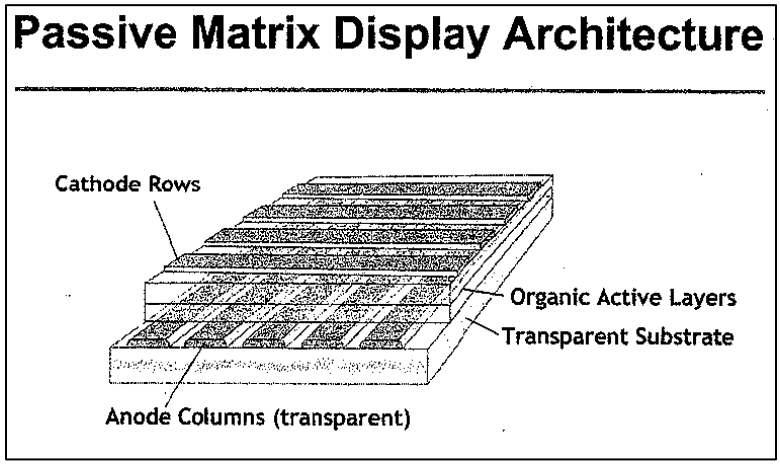
46. The locations, shapes, and sizes of the FMM mask openings correspond to the locations, shapes, and sizes of the red, blue, and green organic light-emitting materials deposited on the display substrate. Accordingly, FMM design and evaporation process considerations are closely related to the design for the red, green, and blue pixels of an OLED. Thus, the choice of OLED pixel arrangements has a significant impact on the manufacturability of the OLED display.

C. Display Architectures – Passive Matrix vs Active Matrix

47. There are two different ways to operate flat panel displays—active-matrix driving and passive-matrix driving. At a high level, active-matrix and passive-matrix driving refers to different ways in how the individual display elements are addressed for controlling the operation of each pixel (*i.e.*, how the light emitting material is controlled to change the brightness of each pixel). The two different approaches require fundamental differences in the physical structure of the

display as well. As a result, the technologies and design methods used for one are not readily transferable to the other.

48. Passive-matrix displays have row and column electrodes that have varying voltages applied in a particular time sequence to address the cells. There is no common electrode and the row and column electrodes are integral with the pixel electrodes. The basic structure of a passive-matrix display is illustrated below:



Ex. 2073 (Ghosh) at 13.

49. In a passive-matrix display, pixels are formed where column electrodes and row electrodes overlap. Ex. 2074 (Gu) at 6. Thus, the intersection of column electrodes and row electrodes defines the OLED pixel size. An individual pixel is illuminated when appropriate voltages are applied to the row and column electrodes that overlap at the location of that pixel. Note that in this configuration, a row of pixels shares one row electrode and a column of pixels shares one column electrode. When operating the display, one row of pixels is illuminated at a time by applying a

scan signal to that row, and applying data signals to each of the columns in that row. By scanning through all the rows successively within one time frame, a complete image can be output on the display in each frame.

50. Because one row of pixels emits light at a time, and an image is generated by sequentially scanning each row of pixels for a very short time while other rows are not emitting light (often called "flashing," or "pulsing"), each pixel must output a large amount of light in the sub-frame in which it is illuminated so that the average luminance for that pixel in the total duration of the frame corresponds to the desired brightness of the pixel in that frame. The light pulses must be extremely bright because of the short time within which each row is addressed, and this requires the pixels to be driven with high voltage and current density. Ex. 2074 (Gu) at 6; Ex. 2073 (Ghosh) at 12-15. The "high-instantaneous luminance requirement" was known to "lower[] the OLED power conversion efficiency" Ex. 2074 (Gu) at 6. It was also known to "shorten[] the device lifetime." Ex. 2080 (Lee) at 7-8.

51. The high voltages required for driving pixels in a passive matrix display also promotes more rapid degradation of the OLED pixels. There are several mechanisms that result in this type of degradation, but one significant mechanism is heat generation. When an OLED is biased, heat is generated because there is a potential drop at the interfaces and because the organic layer has a high resistance.

Ex. 2078 (Tyagi) at 1. Heat generation in an OLED can result in crystallization of the organic material, which reduces the luminance and efficiency of the OLED. Ex. 2078 (Tyagi) at 1-4. This effect will be more pronounced at higher voltages and current densities.

52. Voltage drop through the column and row electrodes, crosstalk, and leakage current through non-selected pixels, also present significant issues. Ex. 2074 (Gu) at 6-8. Further, with an increase in the resolution (*i.e.*, the number of rows and columns in the passive matrix display), the problems of crosstalk and leakage current—both of which can result in stray light emission—can become more pronounced. Ex. 2076 (Braun) at 1-2. Passive matrix displays were thus understood to be unsuitable for high-resolution applications, and to be limited to small, low-resolution displays. Ex. 2080 (Lee) at 5.

53. Unlike PMOLEDs, AMOLEDs do not rely on the intersection of row- and column-electrodes to drive the organic EL element. Instead, AMOLEDs comprise pixel drive circuits made up of thin-film transistors ("TFTs") and capacitors that drive each EL element while actively maintaining the state of the pixels. The capacitors allow the voltages on particular EL elements to be held constant for the duration of a frame, even when the row(s) associated with those particular EL elements are not selected. In other words, pixels can remain on while other rows of pixels are on. This allows the OLEDs to be driven at a significantly

lower voltage and driving current as compared to PMOLED. Ex. 2073 (Ghosh) at 12-15. As a result, OLEDs in active-matrix displays undergo lower rates of degradation, and different primary modes of degradation, than OLEDs in passive-matrix display. AMOLED displays thus have increased lifetime and decreased power consumption compared to PMOLED displays. Ex. 2080 (Lee) at 10-11.

54. The basic structure of an active-matrix display is illustrated in Figures 5 and 6 of Yamada, which show a basic pixel circuit with two transistors and one capacitor (called "2T1C" for short). In this example, the pixel circuit includes "a first TFT 30 for receiving a data signal," "a holding capacitor SC for holding the data signal," and a "second TFT 40 for supplying current via the power source line 53 to the organic EL element 160." Yamada, 7:19-36. Additionally, each pixel circuit is connected to a patterned electrode, usually the anode, of an OLED. It is the overlap of this electrode (as well as the counter-electrode) and the EL material that defines the light emitting region.

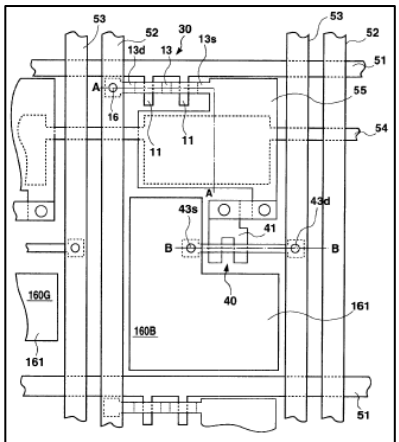


Fig. 5

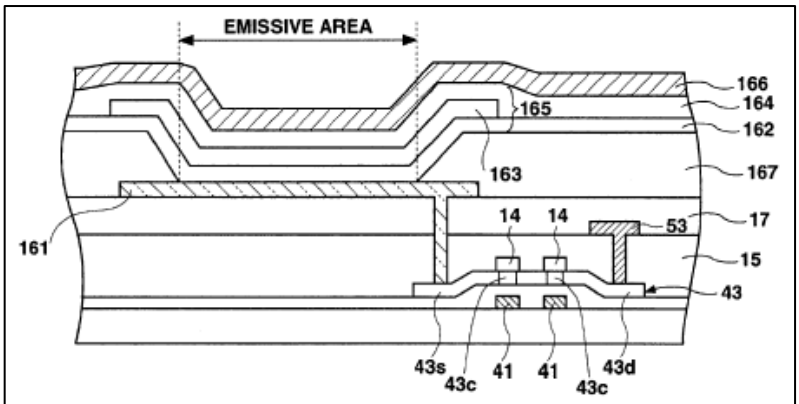


Fig. 6B

55. The additional pixel driving circuitry associated with each pixel in an active-matrix OLED, in conjunction with the power and signal lines necessary to control this circuitry, also impose different constraints on the size and locations of pixels. Ex. 2073 (Ghosh) at 12-15. For example, in Yamada's bottom-emission type AMOLED, the available lateral space is shared between the light emission area and the driving circuitry area, resulting in an irregular L-shaped pixel. Similar considerations for routing the driving circuits and signal lines also apply for top-emission type AMOLEDs. In top-emission displays, while lateral space does not have to be shared between the pixel emissive area and the driving circuitry and signal lines, the placement of the anode and emissive material directly above the driving circuitry and signal lines can lead to unwanted electrical effects, including crosstalk (both optical and electrical). This can result in poor display quality; for example, color shifting effects and other nonlinearities, such as ghost images (due to crosstalk) and distortion of the output image (due to stimulation of the TFTs in the driving circuitry due to the OLED optical output, because some TFTs are photosensitive).

56. In practice, the pixel circuits are often significantly more complicated than the 2T1C circuit shown in Yamada. For example, by the time of the invention of the '803 Patent, pixel circuit designs with as many as 6 transistors and 2 capacitors were developed to improve various device characteristics (for example, to compensate for non-uniformities in the backplane processes for manufacturing the

transistors). Thus, while these displays are more efficient and can be made for larger and higher-resolution applications, they are also more complicated to make. Ex. 2080 (Lee) at 10-11.

VI. OVERVIEW OF THE '803 PATENT

57. The '803 Patent is directed to novel pixel arrangement structures for OLED displays. As the patent explains, such displays have numerous advantages, including being small and low in power consumption, as well as having high luminance and high response speed. '803 Patent, 1:16-28. This makes them useful in mobile devices, such as mobile phones.

58. The pixel arrangement structure affects important characteristics of OLED displays, such as aperture ratio (which is the fraction of the display area that is lit up), luminance, resolution, lifetime, as well as readability and visual perception. The layout of the pixels affects all of these; the size of the pixels, for example, determines the space available in between the pixels (which affects the fill factor) and the pixel pitch (which impacts the quality of reproduction of images in the display).

59. The '803 Patent extensively discusses FMM manufacturing and its challenges. For example, the specification explains that "[a]n organic emission layer included in the pixel of an OLED display may be deposited and formed by using a mask such as a fine metal mask" and that "[w]hen reducing a gap between the

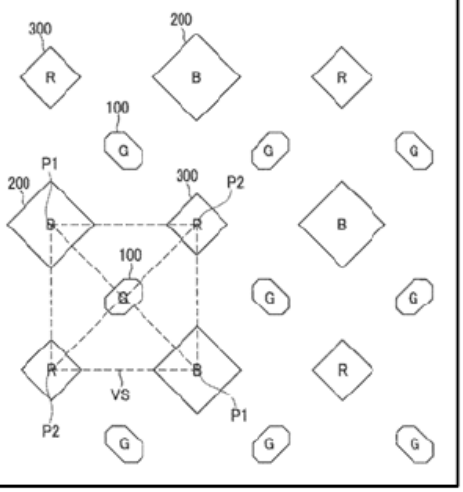
neighboring pixels to obtain a high aperture ratio of the pixel, deposition reliability may be deteriorated." '803 Patent, 1:38-42. Conversely, the specification explains that "when increasing the gap between the pixels to improve the deposition reliability, the aperture ratio of the pixel may be deteriorated." '803 Patent, 1:43-45. The '803 Patent also explains that the organic materials used to emit red, green, and blue lights have differing life spans and are prone to deterioration at different rates. '803 Patent, 7:25-32.

60. The specification discusses the importance of maintaining a high aperture ratio, which is a measure of the proportion of the display, or pixel, that emits light, as compared to the total area. An increased aperture ratio can have many benefits, such as improving the brightness, quality, and energy efficiency of a display. Reducing the gap between pixels will create a higher aperture ratio. However, doing so has trade-offs, because smaller gaps can lead to short-circuits and other issues that reduce manufacturability and yield. '803 Patent, 1:40-45. These tradeoffs present particular concerns when dealing with small screens such as those used in mobile devices, which are the focus of the '803 Patent.

61. Figures 1 through 5 in the specification show certain examples of the inventions of the '803 Patent, which teaches arrangements of red, green, and blue pixels in an OLED display. For example, Figure 5 (reproduced below) shows an exemplary embodiment in which there are green "first pixels" labeled 100, blue

"second pixels" labeled 200, and red "third pixels" labeled 300. As can be seen in Figure 5, the blue pixels are larger than the red pixels, which in turn are larger than the green pixels, and the pixels are arranged in a special pattern specified in the claims of the '803 Patent.

FIG.5



62. This pixel arrangement structure overcame the manufacturing and design challenges associated with the emissive layers of the OLED display. By arranging the red, green, and blue pixels in a RGBG format, as opposed to the traditional RGB format used in older devices such as LCDs, and by sizing and shaping the subpixels in particular ways, the '803 Patent struck the surprising and unexpected balance of improving the aperture ratio of the OLED display (by enlarging the emissive areas) while allowing for a more reliable deposition of the organic material (by ensuring sufficient gaps between pixels) during FMM manufacturing. This achievement allowed for "the manufacturing time and the

manufacturing cost of the OLED display" to be "reduced and the display quality of the image of the OLED display [to] be improved." '803 Patent, 6:40-42.

63. Moreover, the '803 Patent led to significant benefits in terms of display characteristics. Before the invention of the '803 Patent, the "established theory" in the display industry had been that "it would be difficult for AMOLED[s] to exceed the resolution of LCD[s] due to their light emitting diode and patterning limits." Ex. 2037 at 3. But "Samsung Display succeeded in innovating resolution by changing the existing rectangular patterning structure to a diamond structure." Ex. 2037 at 3.

VII. LEVEL OF ORDINARY SKILL IN THE ART

64. I understand that in a related ITC Investigation involving the '803 Patent, the ALJ has issued a claim construction order finding that a POSITA for the '578 Patent (which shares the same specification and priority date as the '803 Patent) would have had a relevant degree in Electrical Engineering, Computer Engineering, Materials Science, Physics, or the like, and experience in electroluminescence and the design of active matrix displays or pixel arrangements for such displays. Ex. 2001 at 15.

65. I understand Dr. Pattison has instead proposed that a POSITA "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," and that such a POSITA "would have been aware of and generally knowledgeable about OLED materials, and display pixel design, layout, and operation." Ex. 1003 at ¶ 39.

66. Under either definition of a POSITA, Dr. Pattison fails to show that the challenged claims of the '803 Patent are unpatentable.

VIII. OVERVIEW OF THE ASSERTED PRIOR ART

A. Matthies (Ex. 1004)

67. Matthies refers to U.S. Patent No. 6,897,855, which issued on May 24, 2005.

68. The patent is directed to "large-area display devices," which could be the size of a room, or even larger. The displays "are formed as an array of tiled display devices." Matthies, 1:8-10. As shown below in Figure 1, Matthies describes a "tiled display in which emissive or reflective elements, on which the image pixels are formed, are built as . . . small arrays on tiles 120 and assembled into a frame to produce the large-area display having a large number of pixel forming elements." Matthies, 5:35-42.

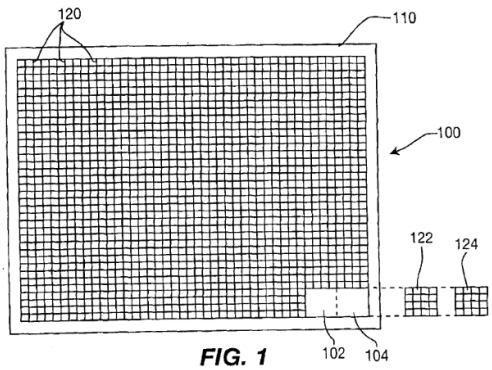


FIG. 1

69. Matthies uses a couple of different types of display, including cathode ray tubes. Matthies includes some OLED embodiments, which are passive matrix displays, also called PMOLEDs. For instance, Matthies explains that the "tiles" that form the large-area display "use a block-wise passive addressing technique," Matthies, 3:4-5, and that "the invention employs a passive addressing technique within a block in which only one row of pixels is illuminated at any time." Matthies, 10:31-33. Unlike active matrix OLEDs or AMOLEDs which use thin-film transistors as switching elements to drive the electroluminescent element, Yamada, 1:15-17, PMOLEDs like those used in Matthies involve depositing the red, green, and blue OLED materials between a column electrode and row electrode, whereby "[c]urrent flowing from one electrode to the other electrode causes the organic polymer to emit light." Matthies, 6:22-23.

70. Matthies depicts its PMOLED configuration in Figure 3 (reproduced below). As shown below, organic materials (e.g., 324 and 326) are deposited in between row electrodes 328 and column electrodes 322. The emission areas (i.e., the

areas of the display that actually emit light) are limited to the areas where the pairs of column and row electrodes overlap. Matthies, 16:38-40 ("[I]n . . . monochrome displays[,] [t]he pixels have a single emissive area which is controlled by a single row and column electrode pair."), 10:21-27 ("The amount of light emitted by a pixel when it is turned on is controlled by controlling the level of current applied to the pixel in the on state.").

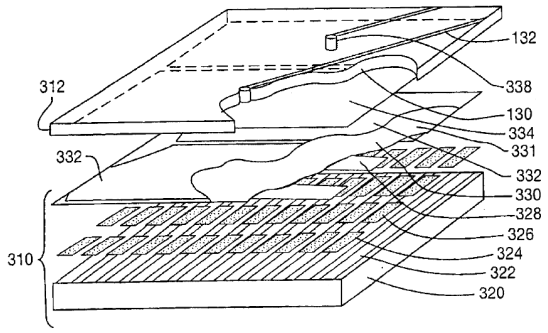


FIG. 3

71. Matthies describes a color pixel structure with a single red sub-pixel, a single blue sub-pixel, and a single green sub-pixel placed side-by-side. Matthies, 16:40-43. This is shown below in Figure 8A of Matthies. The "three sub-pixels 820 [red], 822 [green], and 824 [blue] each have a respective column electrode" and "a single row electrode . . . is used by all three of the sub pixels." Matthies, 16:40-48.

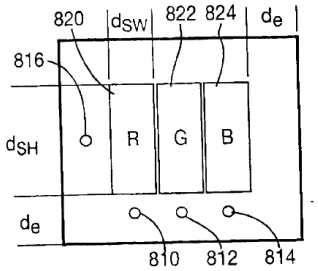


FIG. 8A

72. Matthies alternatively describes "an alternative color pixel structure" which includes "four sub-pixel elements" as shown below in Figure 8B. Matthies, 16:62-63. Sub-pixel elements 830 and 836 "emit green light when stimulated while the other two pixel elements, 832, and 834 emit red and blue light, respectively." Matthies, 16:64-66. Matthies calls this the "quad sub-pixel structure." Matthies, 16:67.

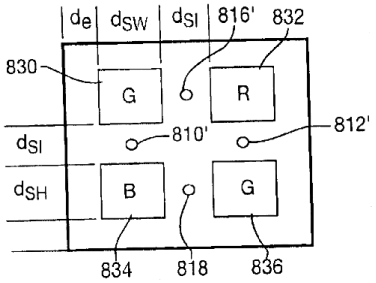
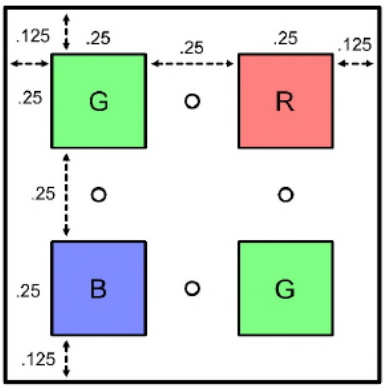


FIG. 8B

73. Matthies explains that in some cases, using two green sub-pixels could result in a brighter display. Matthies, 17:3-4. This could be the case, for example, in display technologies such as LCD or CRT. When different color pixels have different efficiencies (such as in the case of OLEDs), Matthies suggests alternative quad sub-pixel structures: "In some display technologies, the amount of light emitted by the red or blue pixel material may be less than the amount of light emitted by the green pixels. In this instance, making the pixels 830 and 836 both be red or blue pixels would improve the overall brightness of the display." Matthies, 17:6-8. Thus, if the blue pixels are least efficient in OLED displays, Matthies recommends that the quad sub-pixel structure have two blue pixels.

74. One of Matthies' stated concerns is to "eliminat[e] the visibility of the seams between tiles," Matthies, 2:7-10, given that Matthies is directed to a large-area display made up of many smaller tiles. To address this concern, Matthies explains that "[t]he tiles are constructed with pixel forming elements evenly spaced up to the edges of the tiles." Matthies, 5:47-48. As shown in the annotated version of Figure 8B in Dr. Pattison's declaration, reproduced below, Matthies teaches having even spaces between the rows of pixels and between the columns of pixels. Adjacent pixels are separated by 0.25 times the pitch. This would be the case whether the pixels are adjacent within a quad pixel or adjacent across two quad pixels that are separated by a seam in between.



B. Phan (Ex. 1005)

75. Phan is U.S. Patent No. 7,091,986, which issued on August 15, 2006.

76. Phan is directed to a "display including static pixels and dots (individual element) arranged in a predetermined manner" and a method for operating the display. Phan, Abstract, 2:51-65. Pixels are dynamically generated by grouping

adjacent dots of different colors into logical units and sequentially addressing them at a high rate. Phan, 2:54-3:4. Adjacent pixels partially overlap, such that these dynamic pixels are formed between static pixels. Phan, 3:5-3:10. As a result, the display may appear to have a higher resolution than it actually has. Phan, 3:11-18.

77. In contrast to the claimed inventions of the Diamond Pixel patents, Phan does not describe pixel arrangements for an OLED display. The only mention of OLED appears in a long laundry list of "display technologies" in the "Background" section of the specification:

> BACKGROUND OF THE INVENTION . . . The invention relates to a display comprising pixels and dots, including but not limited to the following display technologies: Cathode Ray Tube (CRT), Field Emission Display (FED), Vacuum Florescent Display (VFD), Plasma Display Panel (PDP), Liquid Crystal Display (LCD), Light Emitting Diode (LED), Organic Light Emitting Diode (OLED), Polymer Light Emitting Diode (PLED), Electroluminescence (EL), Electronic inks, Surface Emitting Display (SED), Digital Light Processing (DLP), Electro-mechanics, Phototronics, Biotronics and any light sources known or invented in the future as well as a method for controlling the (said) display.

Phan, 1:15-29. Phan also includes a "Description of Background Art" section which discusses "CRT screens," "LCD displays," "Plasma (PDP)," "FED displays," and "LED displays," but does not make any reference to OLED displays. Phan, 1:56-2:46.

78. Phan lists several "technologies" that appear not to exist. For example, I do not know what Phan is referring to when it mentions "Electro-mechanics" displays. I have also never heard of "Phototronics" or "Biotronics" displays. Based on Phan's inclusion of several "display technologies" that do not appear to exist, and even "any light sources known or invented in the future," a POSITA would not have thought that Phan contemplated real displays or pixel arrangements for each of these "display technologies."

79. Instead of OLED pixel arrangements, Phan describes a distinct type of display that is connected to a "control circuitry" through "preferably . . . an optical fiber network" that addresses individual pixels' "receivers" that convert "digital information transmitted through [the] network [] into luminous intensity levels" for the pixels. Phan, 5:9-24. Phan's use of "optical fiber network[s]" and "receivers" further shows that Phan does not concern OLED displays (which do not use, for example, optical fiber networks). Phan also describes "contour[ing]" the individual pixel elements "by black mask or barrier ribs," which are methods mainly used for LCD and plasma displays. Phan, 1:30-34.

80. Phan's pixels are "address[ed] . . . as a logical unit . . . involv[ing] high-frequency repetition, preferably at a rate of minimum 100 Hz for passive driving display." Phan, 5:20-24. This indicates that Phan's display implements something called a passive-matrix driving scheme. Phan also discusses some of the difficulties

of using actively driven displays. Phan, 2:18-43. For example, for active matrix LCDs, Phan explains that "the integration of a great number of thin film transistors (TFT) is extremely expensive and very prone to produce major amounts of rejects." Phan, 2:35-37. Even a low-resolution AMOLED display would require an even greater number of TFTs.

81. Technologies and design methods used for active-matrix displays and passive-matrix displays are not readily applicable to each other. There will be some commonalities. For example, the fundamental operation of liquid crystals twisting to allow light to pass through remains similar across active matrix and passive matrix LCDs. Similarly, the fundamental operation of organic light-emitting diodes emitting light when a current is applied remains similar across active matrix OLED (AMOLED) and passive matrix OLED (PMOLED) displays. But active-matrix and passive-matrix displays operate quite differently in how the individual display elements (e.g., pixels) are addressed. Thus, the technologies and design methods relevant to pixel design used for one are not readily transferable to the other.

82. As shown below in Phan's Figure 5, the display taught by Phan uses a stripe pixel arrangement made up of a red pixel, a green pixel, and a blue pixel.

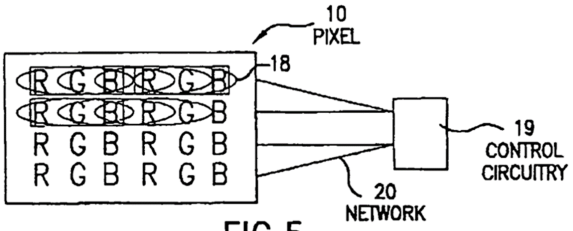


FIG.5

83. Phan also describes a different embodiment involving dots or red, green, and blue pixels arranged in a "quad pixel," as shown below in Figures 11a and 11b. Figure 11a shows a quad pixel where the "crosspoint 33 is in the centre of the four dots (individual elements) of equal light emitting area and space." Phan, 5:47-50. Figure 11b, on the other hand, shows a quad pixel where the "crosspoint 33 moving along the diagonal line 35 forms two dots (individual elements) of equal light emitting area and space 38 of green color." Phan, 5:51-54.

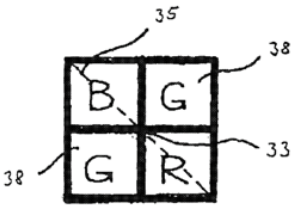


FIG. 11a

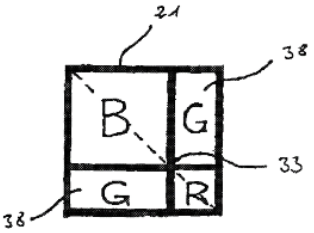


FIG 11b

84. Phan next describes a "quad pixels display with a resolution of 480x640 static pixels." Phan, 5:55-60. As shown below in Figure 12, Phan's quad pixels are arranged on a display 640 times horizontally and 480 times vertically, with some spacing in between quad pixels.

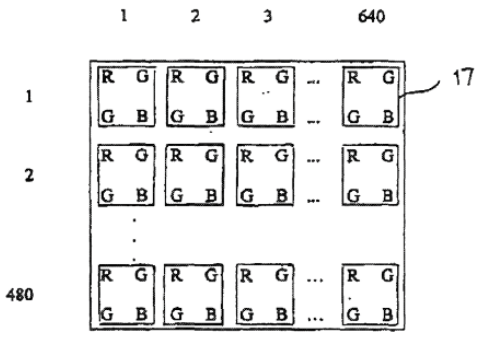


FIG. 12

85. Similar examples of displays containing quad pixels with inter-pixel spacing are shown in Phan's Figures 2a and 2b, reproduced below.

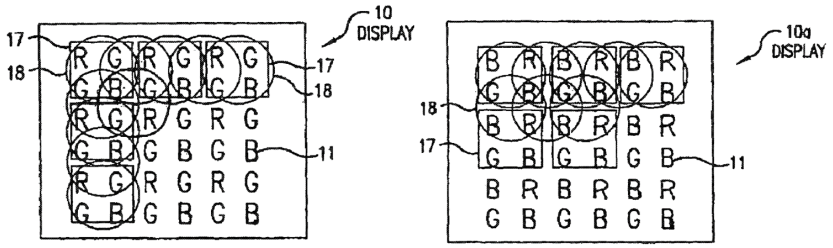


FIG.2a FIG.2b

C. Murai (Ex. 1007)

86. JP 4,496,852 ("Murai") is a Japanese unexamined patent application that was registered on April 23 2010.

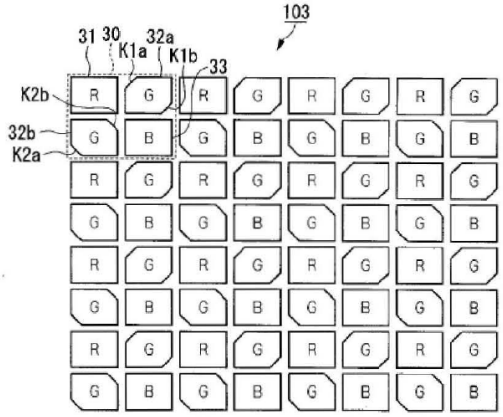
87. Murai describes a "color image display device . . . [that] has a unit pixel consisting of four rectangular dots." Murai, ¶ [0006]. The "four dots that make up the unit pixel are disposed in a rectangular shape made up of four rectangles, the second dot and fourth dot display[ing] a mutually correlating color and . . . disposed on a diagonal on the rectangle shape made up of four rectangles formed by the unit

pixel." Murai, ¶ [0006]. Murai explains that "[i]t is preferable for the four respective dots that make up the unit pixel to be rectangular." Murai, ¶ [0010].

88. Murai also explains that certain of the rectangular dots have "cut-off portions wherein at least one corner of the rectangular shape is cut off." Murai, ¶ [0011]. Moreover, "the cut-off portions can prevent dots having the same color (or a similar color) from being adjacent in the diagonal direction of the screen." Murai, ¶ [0011]. Murai states that the aperture ratio can be improved by having the cut-off corners. Murai, ¶¶ [0010], [0042].

89. Murai's rectangular dots and unit pixels (made up of four rectangular dots) are depicted below in Figure 3. Each unit pixel (30) is in the shape of an oblong rectangle and formed of four dots (31, 32a, 32b, and 33) that are "preferabl[y] . . . rectangular." Murai, ¶ [0010]. Murai explains that the "first dot 31 . . . displays red (R) as a first color;" "[t]he second dots (32a and 32b) . . . display green (G) as a second color;" and "[t]he third dot 33 . . . displays blue (B) as a third color." Murai, ¶ [0029].

[FIG. 3]



90. Murai describes purported solutions for problems that relate to liquid crystal display (LCD) devices. In particular, Murai's "Background" section references "conventional[] . . . color liquid crystal display devices" and a "Patent Document 2" (JP H10-78590) which is a Japanese patent references directed to LCD displays titled "Color Liquid Crystal Display Device and Method for Arraying Pixel." Murai, ¶ [0002]. In Murai's "Problem to Be Solved by Invention" section, Murai again refers to the Japanese LCD reference ("Patent Document 2" (JP H10-78590)) and explains that "the display device disclosed in Patent Document 2 . . . has the problem of impeding the appearance of the display image." Murai, ¶ [0004]. Murai next states: "[i]n light of the above [problem], an object of the present invention is to provide a color image display device . . . having a high-quality appearance." Murai, ¶ [0005]. Murai does not discuss OLED displays, except that it mentions, at the tail end of the specification, "organic EL display devices" alongside "plasma display devices, projectors, and the like." Indeed, Murai does not provide any explanations

of how its proposed solutions could be implemented in OLED displays, let alone active-matrix OLED displays.

D. Yamada (Ex. 1008)

91. Yamada is U.S. Patent No. 6,366,025, which issued on April 2, 2002.

92. Yamada is cited on the face of each of the Diamond Pixel patents and was thus considered by the Examiner during prosecution of each of the Diamond Pixel patents. I understand that Yamada did not lead the Examiner to conclude that the asserted claims of the Diamond Pixel patents were anticipated, obvious, or otherwise invalid. I agree with the Examiner that Yamada does not anticipate or render obvious the asserted claims, either alone or in combination with other references.

93. Yamada is directed to active-matrix OLEDs (AMOLEDs) that use thin-film transistors (TFTs) as switching elements to drive an organic electroluminescence (EL) element. Yamada, 1:6-9 ("The present invention relates to an electroluminescence display apparatus comprising an electroluminescence (hereinafter also referred to as EL) element and a thin film transistor (hereinafter referred to as TFT) element."); Yamada, 1:18-3:8.

94. Yamada describes "a color display device, in which a display pixel having an emissive element is provided for every color, wherein the emissive area of the display pixel of any one color, among the display pixels of the various colors,

is different in size from the emissive area of the display pixel of another color." Yamada, 3:16-23. Yamada further explains that "the element emissive areas in the display pixels for R, G, and B are designed to take into consideration not only the emission efficiency of the emissive elements of the display pixels but also the luminance ratio of red to green to blue in accordance with the chromaticity of the target display white of the display device and with the chromaticity of each red, green, and blue color emitted by the emissive elements of the respective display pixels." Yamada, Abstract.

95. Figure 4, which Yamada describes as a "conceptual diagram" of an embodiment, depicts pixels that are arranged in a matrix of stripes. Yamada, Fig. 4; 6:24-26 ("conceptual diagram showing emissive region areas of the EL display apparatus"); Yamada, 12:37-39 ("[T]he arrangement of the display pixels of various colors in the embodiment [i]s shown in a stripe layout."). As shown below, Yamada arranges one red pixel (1R), one blue pixel (1B), and one green pixel (1G) in a stripe layout.

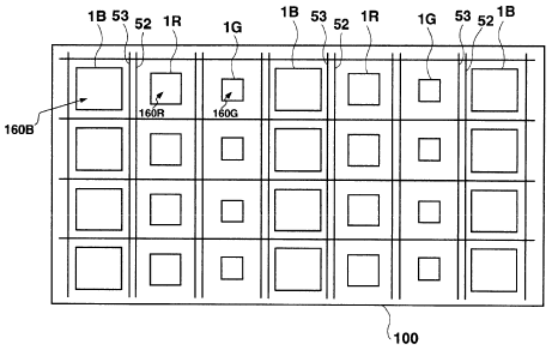


Fig. 4

96. Yamada is a bottom-emission device, as indicated by the ITO anodes and magnesium indium alloy cathodes. Yamada, 7:19-8:18. Bottom-emission means that the direction of light emission is towards the transparent ITO anode. So in the cross-sectional view of a pixel shown in Figure 6B below, light would be emitted in the downward direction. In bottom emission devices, the driving circuitry is also in the direction of the anode, which limits the area for the pixels.

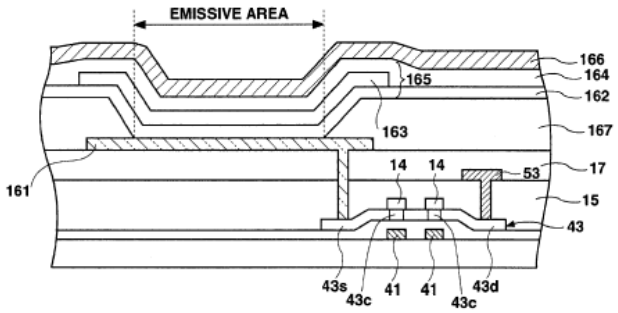


Fig. 6B

97. Yamada explains that the display pixels have "a rectangular shape or an 'L' shape." Yamada, 12:33-35. Figure 5, which Yamada describes as "a schematic top plan view of one display pixel," shows, for example, an L-shaped blue pixel (160B) that is surrounded by, for example, source lines (53), thin film transistors (30, 40), gate signal lines (51), and drain signal lines (52). Yamada, 6:28-30. The cross-section (Figure 6A) clearly shows a bottom emitting OLED device; with a transparent ITO anode (161) and a reflective metal cathode (166), MgIn. This configuration requires the transistor to be separated from the emissive area of the

pixel. Because of the space occupied by thin film transistor 40, blue pixel 160B takes on an irregular L-shape.

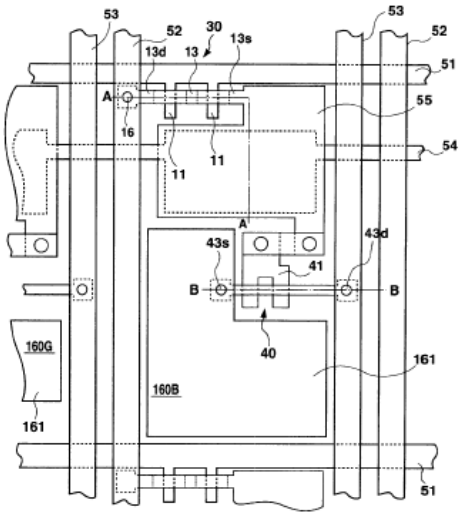


Fig. 5

98. Yamada explains that for the blue EL elements, "which have the lowest emission efficiency among the R, G, and B EL elements," Yamada, 8:47-53, "a current larger than that supplied to the other display pixels having a high emission efficiency must be supplied," causing "the life of those display pixels having a low emission efficiency, in particular, to shorten." Yamada, 2:60-67. Yamada addresses the relatively lower emission efficiency of blue pixels in an RGB structure by increasing the size of the blue pixel. The current density in the blue pixel can be decreased by increasing the light-emission area of the blue pixel, which can contribute to increased life span.

IX. OVERVIEW OF DR. PATTISON'S OPINIONS

99. In his declaration, Petitioner's expert Dr. Pattison opined as follows:

- Ground 1: Claims 1–5 and 19–21 are rendered obvious by Matthies and Yamada
- Ground 2: Claims 1–4 and 19–21 are rendered obvious by Phan
- Ground 3: Claim 5 is rendered obvious by Phan and Yamada
- Ground 4: Claims 1–5 and 19–21 are rendered obvious by Murai in view of Yamada.

100. I disagree with Dr. Pattison's opinions for the reasons below.

X. GROUND 1: MATTHIES AND YAMADA DO NOT RENDER OBVIOUS CLAIMS 1–5 AND 19–21 OF THE '803 PATENT

101. For the reasons explained below, it is my opinion that the combination of Matthies and Yamada fails to render obvious claims 1–5 and 19–21 of the '803 Patent.

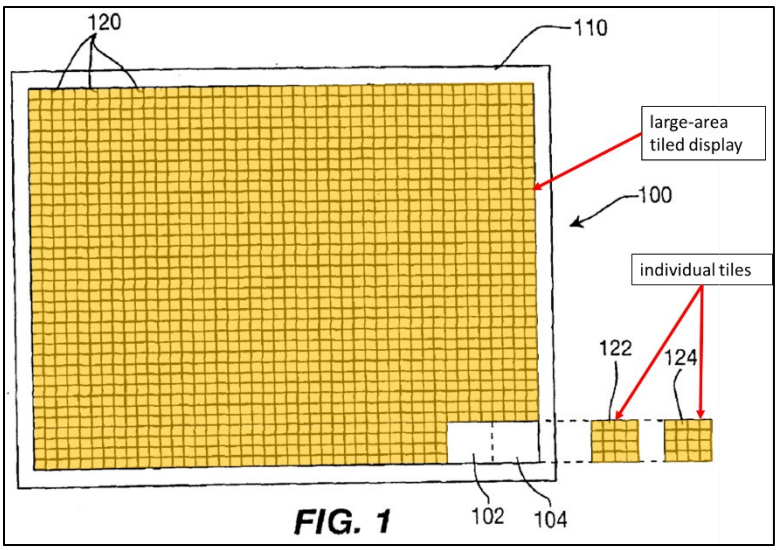
A. A POSITA would not have been motivated to combine Matthies and Yamada because they involve fundamentally different technologies and are incompatible with each other

1. Matthies is directed to a passive-matrix display built as a tiled structure

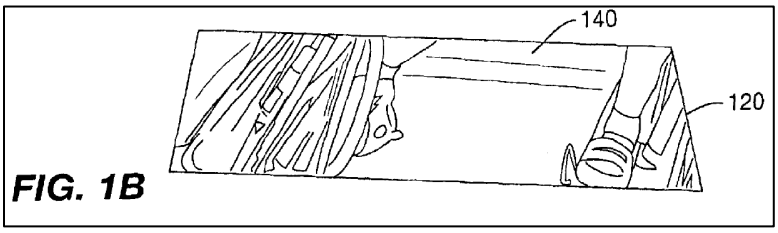
102. Matthies is directed to "large-area display devices," Matthies, 1:8-10, which would commonly be the size of an entire room, or even larger. It is difficult and expensive to build a single display that large. Matthies therefore assembles the display out of a large number of "tiles." Matthies describes a "tiled display in which emissive or reflective elements, on which the image pixels are formed, are built as . . . small arrays on tiles 120 and assembled into a frame to produce the large-area display having a large number of pixel forming elements." Matthies, 5:35-42.

Matthies states that such large-area displays can be applied to "[h]ome theater applications," "[a]pplications that require multiple viewers," "[a]pplications in which the user needs to move about in an area," and "[a]pplications where simulation of the real world is needed for training." Matthies, 1:20-25. Matthies is even titled "***Tiled*** Electronic Display Structure." Matthies, Cover.

103. Matthies shows how individual tiles can be used together to create a large area display, as I've illustrated in an annotated version of Figure 1 below:



Each individual display tile shows a small section of a complete image as shown below in Figure 1B, with the large-area tiled display combining tiles to show the full image:



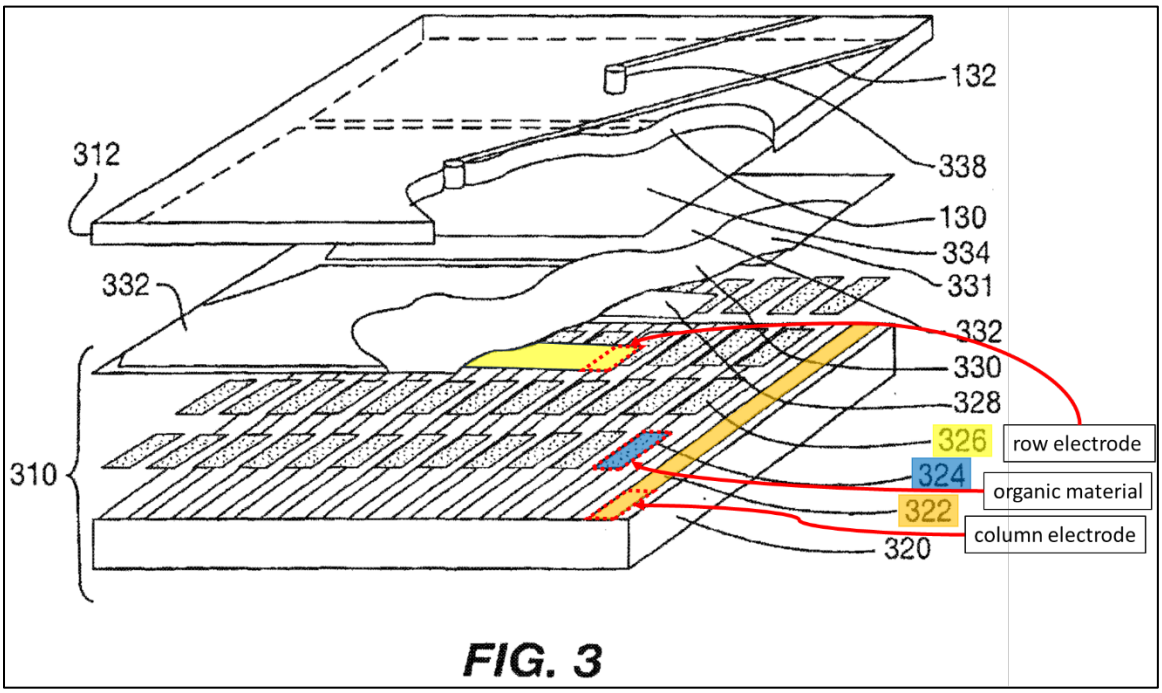
104. Matthies is primarily focused on difficulties that are encountered when trying to make displays larger. As Matthies explains, "[t]here are fundamental technical issues that impose scaling-laws and limit the size of displays that can be manufactured. These fundamental limitations are one reason why a technical solution that meets the need for large-area displays has not been achieved." Matthies, 1:34-38. As Matthies explains, "[n]o practical tiled display system has yet been developed." Matthies, at 1:66-2:2. "What has been missing is a fabrication technology that allows a display to be constructed so that pixels can be brought up to the very edge (actually, with in [sic] ½ pixel spacing period of the edge), while at the same time allowing for electronics to address each tile, even [with] those tiles completely surrounded by other tiles." Matthies, at 2:2-7. Matthies also explains that the distance between the edges of pixels on a tile and the edge of the tile is important to allow for electronics and connections between tiles, and to avoid the seams between tiles being visible. Matthies, 8:37-39, 9:23-26, 15:61-63, 16:5-9. Thus, Matthies is addressed to overcoming what it identifies as "[t]wo barriers to implementing the tiled approach": "1) eliminating the visibility of the seams between tiles, and 2) providing electrical access to the pixels." Matthies, 2:8-10. Matthies thus focuses on solutions to design issues that are unique to tiled displays.

105. Matthies also highlights the distinction between its tiled displays and monolithic (*i.e.*, single-substrate) displays, noting that "[t]iled displays have

relatively few pixels so that the number of interconnects per tile is relatively small," which confers "a significant advantage of tiled displays when compared to fabrication of large displays from single substrates." Matthies, 9:34-38.

106. Matthies' tiled displays—including the specific embodiment of the tiled display shown in Figure 8B that Dr. Pattison relies on—are PMOLED displays. Matthies, 10:31-33.

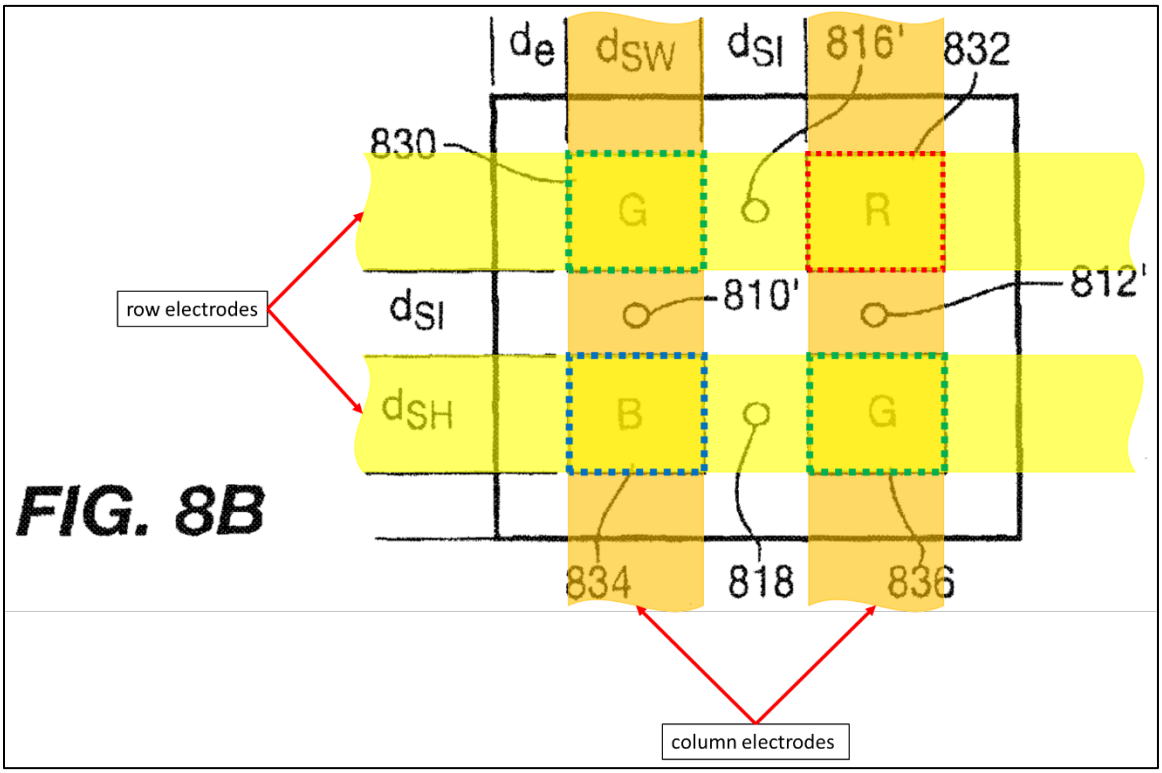
107. In Matthies' display, the basic light emitting unit consists of a red, green, or blue organic light-emitting material layer sandwiched between two electrodes: a row electrode and a column electrode, as shown in an annotated version of Figure 3, below. Matthies, 12:61-13:16, 6:19-21.



108. As Matthies explains, "[c]urrent flowing from one electrode to the other electrode" causes the organic material to emit light. Matthies, 6:22-23. Consequently,

the emissive area of a pixel is defined by the area where a column electrode and a row electrode cross (*i.e.*, the region of overlap of the vertical and horizontal electrodes), with the organic emissive material sandwiched in between. Matthies, 13: 1-5. Thus, Matthies describes a passive-matrix display.

109. The quad sub-pixel structure of Figure 8B that Dr. Pattison relies on is similarly a passive-matrix structure, and has "two row electrodes … and two column electrodes" creating the four sub-pixel regions where the electrodes cross as shown below in an annotated version of Figure 8B. Matthies, 17:10-12.



110. In this embodiment of Matthies, consistent with a PMOLED structure, "[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 adjacent sub-pixels." Matthies, 17:16-20. So in the quad sub-pixel structure, the width of the row electrode and the width of the column electrode define the pixel areas. The result is that in the quad sub-pixel structure of Matthies, each of the green, blue, and red subpixels would have the same area: $d_{SH}*d_{SW}$.

2. Yamada is directed to an active-matrix display built on a single substrate

111. On the other hand, Yamada is directed to active-matrix OLEDs ("AMOLEDs"). Yamada, 1:6-9, 1:18-3:8. And Yamada is directed to what are called monolithic displays—unitary OLED displays having many pixels built on a single substrate. Yamada, 1:12-14.

112. As explained above in Section V, Figures 5 and 6 of Yamada illustrate the basic structure of an AMOLED with a 2T1C pixel circuit. In Yamada, the pixel circuit includes "a first TFT 30 for receiving a data signal," "a holding capacitor SC for holding the data signal," and a "second TFT 40 for supplying current via the power source line 53 to the organic EL element 160." Yamada, 7:19-36.

113. As Yamada explains, "the region actually emitting light, namely, the emissive area," is the area "in contact with the emissive element layer 165 and the anode 161." Yamada, 10:39-44. This pixel structure is shown in Yamada's Figure 6B. In Yamada's devices, each pixel's driving circuitry limits the light-emitting area of the pixel. Yamada, 7:19-8:18. This can be seen in the following annotated

versions of Figures 5 and 6B of Yamada, which highlight the emissive areas in both a plan view and a cross-sectional view:

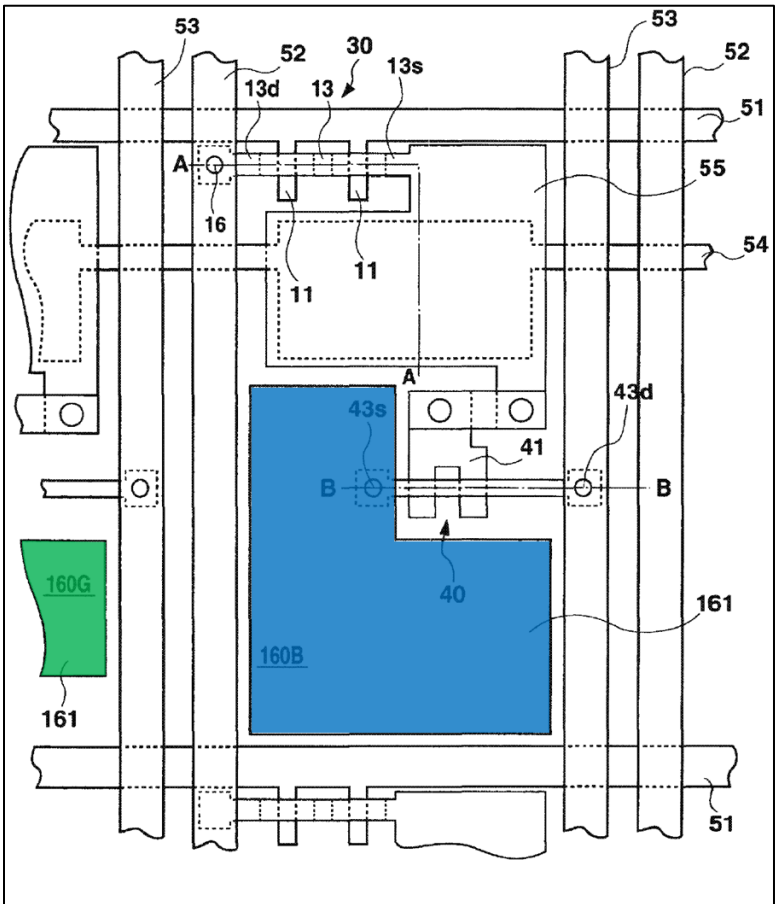


Fig. 5

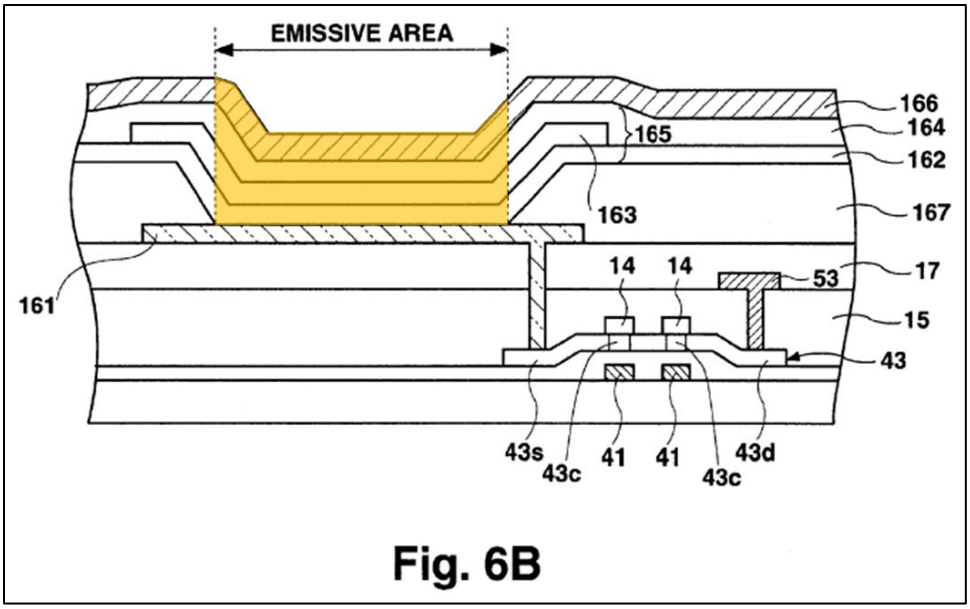


Fig. 6B

114. Thus, Yamada's AMOLED display does not use row and column electrodes, and Yamada's pixel shapes and sizes are not dictated by the dimensions of row or column electrodes. But as shown above, and as discussed in the technical background section, Yamada's pixels are still constrained by the pixel driving circuit (including transistors and a capacitor) and power and signal lines.

3. Due to their fundamental differences, a POSITA would not have looked to Yamada to modify Matthies.

115. In view of these differences, a POSITA would not have looked to Yamada's teachings regarding lifetime of OLED pixels in monolithic AMOLED displays to modify the OLED pixels in Matthies' tiled PMOLED displays.

116. As I explained above in Section V, a POSITA would have understood that passive matrix OLEDs and active matrix OLEDs drive the OLED pixels in

fundamentally different ways. The different driving methods result in differences in the degradation profile of the OLED pixels that make up the display.

117. To recap, in passive-matrix OLEDs, the rows of OLED pixels are selected sequentially, one row at a time for only a small fraction of a frame. The light pulses must be extremely bright because of the short time within which each row is addressed, and this requires the pixels to be driven with very high voltage and current density. This "high-instantaneous luminance requirement" was known to "lower[] the OLED power conversion efficiency" Ex. 2074 (Gu) at 6. Further, the high voltages required for driving pixels in a passive matrix display also promotes more rapid degradation of the OLED pixels due to several different mechanisms. Heat generation is one major mechanism. When an OLED is biased, heat is generated due to potential drops at the interfaces between the different layers of the OLED device stack. The electrical resistances at the different interfaces of the stack, as well as the high resistance of the organic layer, all contribute to heating. Heat generation in an OLED can result in crystallization of the organic material, which reduces the luminance and efficiency of the OLED. Ex. 2078 (Tyagi) at 1-4. This effect will be more pronounced at the higher voltages and current densities required to drive a PMOLED display.

118. On the other hand, in active-matrix OLED displays, the capacitors allow the voltages on particular OLED pixels to be held constant for the duration of

a frame, even when the row(s) associated with those particular OLED pixels are not selected. Thus, pixels can remain on while other rows of pixels are selected. This allows the OLEDs to be driven at a significantly lower voltage and driving current as compared to the OLEDs in passive-matrix OLED displays. Ex. 2073 (Ghosh) at 12-15. As a result, OLEDs in active-matrix displays undergo lower rates of degradation, and different primary modes of degradation, than OLEDs in passive-matrix displays.

119. Further, there were well-recognized shortcomings with PMOLED displays, and well before the time of the invention of the ’803 Patent, the industry was shifting away from PMOLED displays to AMOLED displays. PMOLED displays have limited resolution. As discussed above, PMOLED displays require significantly higher voltages than AMOLED displays, and the voltages required to drive PMOLED displays scales with the resolution of the display. The more rows, the higher the voltage necessary, so this imposes a constraint on the resolution of a PMOLED display. By the time of the ’803 Patent, display resolution had increased to a point where PMOLED displays would no longer be practical for most applications. Thus, a POSITA by the time of the invention would have had no reason to look to implement a color PMOLED display shown in Matthies, let alone modify it based on the disclosures of Yamada’s teachings focused on AMOLED displays.

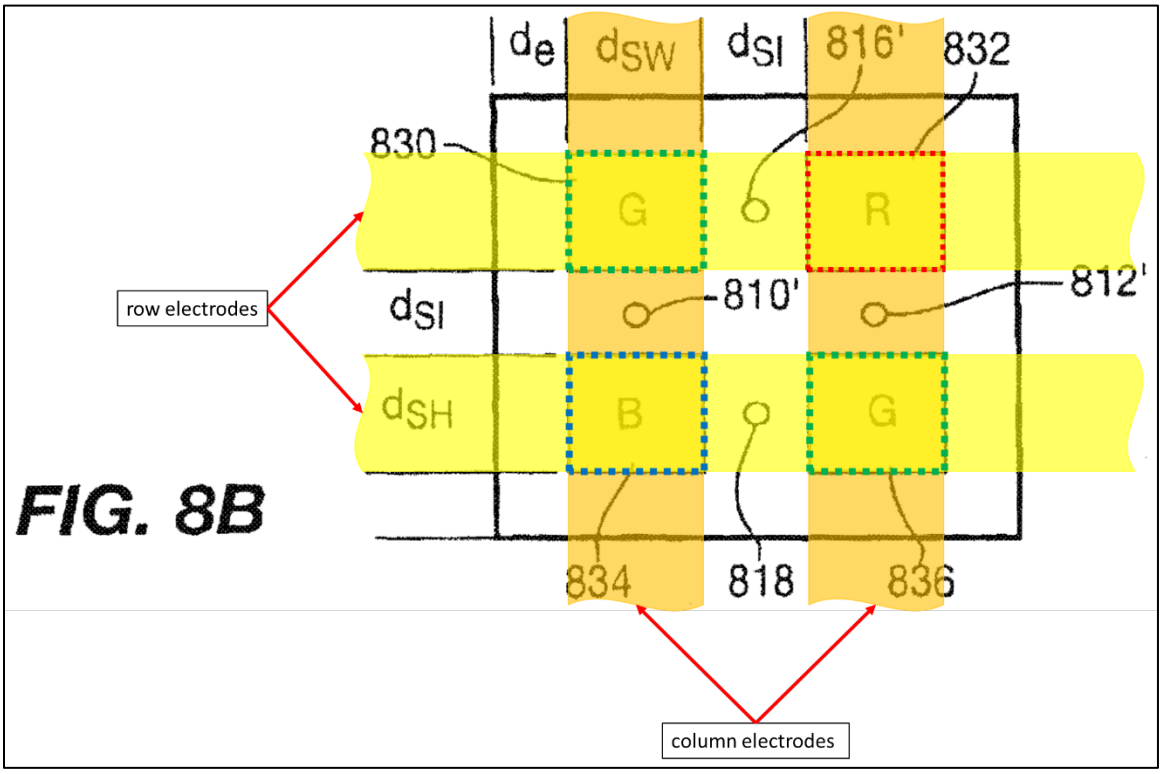
120. Thus, a POSITA would not have expected that proposed solutions to OLED pixel degradation and aging in the context of active-matrix OLED displays would have been directly applicable to OLED pixels used in passive-matrix OLED displays, and would not have considered Matthies and Yamada together.

121. Even if a POSITA were to consider these two references together, a POSITA would not have been motivated to modify Matthies' passive matrix display by varying pixel sizes based on Yamada's disclosures, given the significant structural differences between active matrix and passive matrix displays.

122. As I explained above in Section V, passive-matrix OLED displays and active-matrix OLED displays require fundamentally different structures that implicate different design considerations and constraints.

123. And as I just explained, in the PMOLED of Matthies, the light-emitting area is defined by the overlap of the row and column electrodes. As a result, as shown in Matthies' Figure 8B (shown below with annotations), the pixels in the same row (for example, green pixel 830 and red pixel 832 in the top row) have the same height (d_{SH}), and pixels in the same column (for example, green pixel 830 and blue pixel 834 in the left column) have the same width (d_{SW}). If a POSITA were to try to change the size of a pixel in the PMOLED shown in Figure 8B, that would require changing the size of a row and/or column electrode, but doing so would also change the size of all of the other pixels defined by that row and/or column electrode. Dr. Pattison

does not give any explanation of how the pixel sizes could be individually arbitrarily changed into the proportions that he suggests should be used, and it is not clear how such a display could be made.



124. It is not a simple matter to resize the row and/or column electrodes to be irregular. An engineer would have to somehow design and develop a mask to pattern each of the row and column electrodes to be shaped to accommodate the alternatingly large and small pixel shapes required by Dr. Pattison's combination. Patterning the electrodes would further add a process step, increasing manufacturing costs and reducing yield. Additionally, if a POSITA were to try to make such irregularly sized electrodes, that would have an effect on the IR voltage drop, which would need to be compensated differently than in a typical PMOLED display with

uniformly sized electrodes, thus adding additional complexity to the design. This would necessitate changes not only to the structure of the electrodes, but also to the display driver circuitry for applying the appropriate voltages to the row and column electrodes to allow the OLED to display images.

125. Further, irregularly patterning the ITO material that forms the column electrodes can increase the risk of catastrophic failure of the OLED display. Catastrophic failure (also sometimes called "sudden death") refers to large luminance drops due to electrical shorts that develop as a result of defects in the interfaces of the OLED stack, such as non-uniform organic layers, or defects in the ITO layer. To take one example, one way these defects can occur is through morphological defects in the ITO—called ITO spikes. The organic layer in an OLED is thin. Roughness in the ITO layer can result in a topographic change in the organic layer that overlays the ITO, so the organic layer above an ITO spike will become even thinner. When a large electric field is applied, or if the OLED is operated for a long time, the electric field will be enhanced at the location of the ITO spike. This can result in a collapse at the defect position, causing an electrical short between the ITO and the cathode metal. When the two metal layers touch, they will either locally burn each other out in the best case, or short the whole display in the worst case. Localized electrical shorts at the locations of these ITO spikes can also grow over time. The result is significantly decreased luminance; and if the driving voltage and

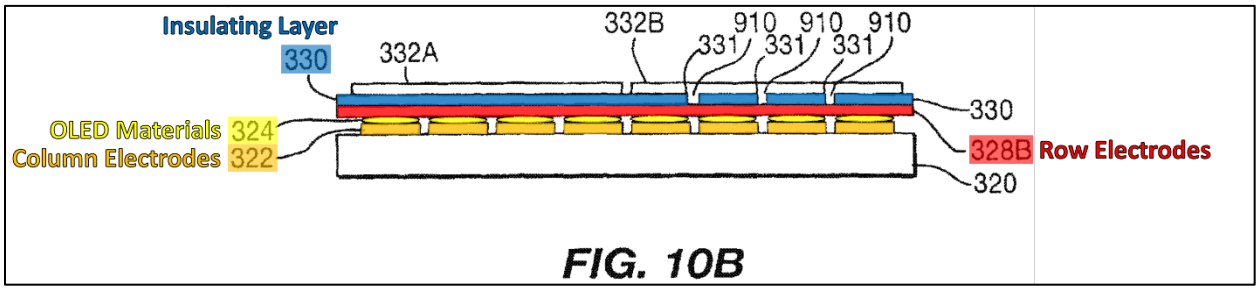
current density is increased to maintain the desired luminance, even faster degradation of the OLED pixel.

126. The defects and surface roughness at the interfaces of the OLED stack can also result in dark spot formation. Dark spots refer to non-emissive areas of the OLED. Dark spots are typically associated with moisture or other impurities, or supply of high electric current. Ex. 2079 (Azrain) at 2. When a high electric field is applied to the OLED (which can be further enhanced by surface roughness of ITO or other layers), a chemical reaction (electromigration) pulls in metal from the cathode of the OLED stack, and this migrated metal can form grain clusters at the ITO, forming dark spots and deteriorating the charge carrier injection path. The dark spot can also grow larger over time. The result is similarly significantly decreased luminance and faster degradation of the OLED pixel. Ex. 2079 (Azrain) at 6-10.

127. These effects would be particularly pronounced in a PMOLED display, given the high operating voltages necessary, as discussed previously.

128. A POSITA would also not have attempted to re-size pixels by adding additional layers. If instead of resizing the electrodes a POSITA were to try to add a blocking or isolation layer between the row and column electrodes to change the size of the overlap between the anode and organic material (and thus the emissive area of the pixels), this would require additional process steps, increasing manufacturing costs and reducing yield. This would also increase the overall thickness of the

display. Further, this design would result in electrical charge accumulation in the regions of the overlapping electrode areas that are not overlapping the organic emissive material and not contributing to the driving of the OLED, resulting in increased energy consumption. As shown in the cross-section of Matthies' display shown in Figure 10B (annotated version below), Matthies does not use any layer between the row and column electrodes for shaping the organic material, because there is no need for such a layer in the PMOLED where the electrode overlap regions define the emissive area. *See also* Matthies, 12:58-13:25.



129. A POSITA would further not have been motivated to modify Matthies' display by varying pixel sizes based on Yamada's disclosures, because they would conflict with constraints on pixel arrangements imposed by Matthies' tiled display design.

130. Matthies itself highlights the distinction between tiled and monolithic displays, noting that "[t]iled displays have relatively few pixels so that the number of interconnects per tile is relatively small," which confers "a significant advantage of tiled displays when compared to fabrication of large displays from single

substrates." Matthies, 9:34-38. In fact, Matthies turns to tiled displays specifically to avoid the complexities and costs involved in manufacturing a "monolithic multi-pixel display." Matthies, 1:62-63. The problems encountered in trying to manufacture a tiled display are distinct from those encountered in trying to manufacture a monolithic display, resulting in differences in what a POSITA would consider to the key constraints for designing the pixel arrangement structure for the display.

131. Matthies repeatedly stresses the importance of ensuring that pixels are spaced such that the distance from each pixel to the edge of the tile is the same, and the distance between pixels within a tile is the same as the distance between pixels across adjacent tile. *See, e.g.*, Matthies, 5:47-53, 8:37-41, 15:59-63, 16:5-9. As I've explained further below in Section X.D.3, this is important to Matthies' tiled display to avoid optical effects at the tile edges. *See, e.g.*, Matthies, 8:37-41, 21:22-27, 22:53-56. Matthies also places constraints on its pixel arrangements to accommodate vias and connectors. *See, e.g.*, Matthies, 15:61-63, 16:5-9, 16:22-26, 24:39-42. These constraints important to Matthies' tiled display would be incompatible with Dr. Pattison's proposed resizing of Matthies' pixels based on Yamada.

132. Thus, a POSITA at the time of the invention of the '803 Patent would not have looked to Yamada, which proposes a solution in the context of monolithic active-matrix OLED displays with significantly different electrical considerations

and pixel layout constraints, to modify Matthies' passive matrix OLED tiles. And a POSITA would not have had a reasonable expectation of success in making Dr. Pattison's proposed combination given these incompatibilities.

B. Dr. Pattison's proposed motivations to combine fail

1. Dr. Pattison's proposed combination would reduce the lifetime of the display.

133. Dr. Pattison argues that a POSITA would have been motivated to make a combination of Matthies' quad-pixel tile structure with Yamada's teachings by (1) keeping the blue sub-pixels the same size; (2) reducing the size of the red sub-pixels to be smaller than the blue sub-pixels; and (3) reducing the size of the green sub-pixels to be smaller than the red sub-pixels. Ex. 1003, ¶ 227. According to Dr. Pattison, modifying Matthies' display in this manner would extend the lifetime of the display. Ex. 1003, ¶ 282. This is incorrect.

134. Predicting the lifetime of OLED pixels is complicated, and there are many different mechanisms for OLED degradation. OLED degradation can be characterized into three categories: dark spot formation, catastrophic failure, and intrinsic degradation. Of these, Dr. Pattison's discussion of OLED lifetime is focused on the intrinsic degradation mechanism, which refers to the following phenomenon: even when an OLED is driven with constant current, over time the luminance of the OLED decreases.

135. According to Dr. Pattison, applying a "lower current density for the blue pixels" would have the effect of "prolonging the life of the blue pixels." Ex. 1003, ¶ 282. According to Yamada, blue OLED materials had lower emission efficiency, requiring blue pixels to be driven at a higher current density (current applied per unit area) to emit a given intensity of light than equally-sized red- or green-pixels. Yamada, 2:60-67; 10:61–11:3, 11:11-15. The lifetime of OLED pixels is indeed a function of current density—the amount of current applied to the pixel divided by the area of the pixel (though the relationship is not as simple as Dr. Pattison and Yamada assume, given the other degradation modes and differences in degradation profiles between passive matrix and active matrix structures). But generally speaking, if the same current is applied to two OLED pixels with different sizes, then all else being equal, the smaller OLED pixel will tend to have a shorter life than a larger OLED pixel. So absent any countervailing considerations, the preference for an OLED display designer is to have larger pixel areas when possible, to extend the lifetime of the display.

136. But Dr. Pattison's proposed combination of Matthies and Yamada would not extend the life of the display under his own theory of OLED lifetime. By keeping the blue pixels the same size, the life of the blue pixels would not be extended. And by reducing the sizes of the red and green pixels, the life of the red and green pixels would be ***reduced***. In a color display, where (for example) the red,

green, and blue pixels are configured to be driven together to express the full color gamut, the failure of any one of the color pixels would shorten the useful lifetime of the display. Thus, a POSITA, particularly a POSITA concerned with the lifetime of the display, would not have sought to reduce the sizes of any of the pixels, as Dr. Pattison suggests, because doing so would decrease the lifetime of the display.

137. Additionally, Dr. Pattison's proposed combination would increase the risk of the catastrophic failure and dark spot modes of degradation. As I've explained above in Section X.A.3, when a large electric field is applied, or if the OLED is operated for a long time, the electric field will be enhanced at the location of irregularities in the interfaces of the OLED stack (*e.g.*, at locations of ITO spikes or non-uniform organic layers), which can result in a collapse at the defect position and catastrophic failure of the OLED. Similarly, a large electric field can result in electromigration of cathode metal to the ITO and formation of dark spots. Both phenomena can result in significantly decreased luminance. And if the driving voltage and current density is increased to maintain the desired luminance, even faster degradation of the OLED would occur. By reducing the sizes of the red and green pixels, Dr. Pattison's proposed modification would require a significantly higher current density to be supplied to the red and green pixels to maintain the same brightness as before. This would increase the risks of catastrophic failure of the OLEDs and dark spot formation, and thus reduce the useful life of the display.

138. If anything, a POSITA seeking to extend the life of the display would have sought to *increase* the size of the blue pixels. But increasing the size of the blue sub-pixels in Matthies would have frustrated Matthies' goal of eliminating the visibility of seams between tiles. For example, in Figure 19 of Matthies, if the size of the pixels (1910) increases, the light from the pixels will be blocked by the black lines (2010), making the seam appear more visible. *See* Matthies, 22:53-56, 24:5-47. And due to the differences in relative sizes of the different color pixels, it will also have the same shadowing effect and color shift issues, which I discuss in Section X.D.3. Further, making the blue pixels larger could reduce the space necessary for vias and other circuitry in Matthies' tile display. *See, e.g.*, Matthies, 15:59-16:9, 2:35-41.

139. As I've explained above in Sections V and X.A.3, since PMOLED displays like Matthies were already known to suffer from shorter lifetimes, a POSITA would not have had a reason to make Dr. Pattison's proposed combination that would reduce the life of Matthies' display. Nor would a POSITA have had a reasonable expectation of success in making Dr. Pattison's proposed combination.

2. Dr. Pattison's proposed modification to Matthies' display would eliminate necessary circuitry and reduce display quality

140. Matthies discloses circuitry that "compensates for luminance chromaticity non-uniformities in the tile and among the tiles of the display,"

including over time. Matthies, 2:63-3:3. Acknowledging that Matthies provided a circuitry-based solution to the differential aging problem, Dr. Pattison argues that a POSITA could have eliminated that circuitry and thus "simplified" Matthies' display, if his proposed combination were made. Ex. 1003 at ¶ 283-289. That is incorrect. The circuitry Dr. Pattison proposes eliminating is ***necessary*** for Matthies' display to function because it both provides display data to each pixel, Matthies, 10:1-5, and ensures uniformity in brightness and color across different pixels and across different tiles—a critical requirement for Matthies' tiled display, Matthies, 10:6-9.

141. The "non-volatile memory 214" and "programmable current sources 216" are necessary to send the image data to the display because the memory stores the value for the pixel cell corresponding to the image data to be displayed, and the current source provides the electrical current to the pixel cell to cause it to emit the light corresponding to the image data to be displayed. Matthies, 10:58-11:21. It is unclear how Dr. Pattison's display would display any images without them. And Matthies explicitly acknowledges that each OLED pixel can have different characteristics due to manufacturing variations, and thus contemplates that individual OLEDs would be tuned during the manufacturing process, with necessary adjustments saved in the "non-volatile memory 214." Matthies, 11:36-46. Eliminating this memory as Dr. Pattison proposes would result in a non-uniform

display (if the display could operate at all) with poor image quality that cannot be fixed by just re-sizing the pixels.

142. Removing the additional compensation circuitry such as Matthies' optional "light sensor" or "circuitry 134" as Dr. Pattison suggests would also eliminate another key functionality. Matthies' circuitry "continually adjusts" the brightness of individual pixels to compensate for aging throughout the life of the display as it is used—something Yamada's static re-sized pixels cannot do. Matthies, 11:61-12:41. Further, POSITAs in the field understood that the decay slope for each color pixel is different (owing to differences in the light-emitting materials) and non-linear, and Yamada's static re-sizing of pixels would fail to account for the resulting differential aging of the OLED pixels as they are used over time, resulting in color shift through the life of the display, and some pixels dying off faster than others. Ex. 2077 (Park) at 8-10, Figs. 4-6; Ex. 2011 (Arnold) at Fig. 10.

143. Thus, without Matthies' circuitry, the display's color would shift over time, rendering the display defective.

144. Dr. Pattison also claims that shrinking pixel sizes would provide "greater design flexibility" because it "would create additional space for Matthies' vias and other circuitry." Ex. 1003 at ¶ 295-298. But that is not a benefit at all. Taking away this "additional space" from the pixels would lower the aperture ratio of the display. To maintain the same brightness with smaller emissive area, the OLEDs

would have to be driven harder at a higher current density to maintain the same brightness as before, resulting in lower lifetime; alternatively, if the OLEDs were driven at the same current density with a reduced area, the display would be dimmer than before. Dr. Pattison's modification would remove light-emitting area, thus lowering the aperture ratio and resulting in either worse lifetime or reduced brightness, when Matthies sought to improve the overall brightness of the display. *See, e.g.*, Matthies, 17:3-4, 17:8-10.

145. A POSITA would have sought to *increase* the aperture ratio of the display because OLED displays traditionally had (and indeed, continue to have) relatively low aperture ratios, due to the manufacturing difficulties I described above in the background of the technology. *See* Section V. Other prior art emphasized the need to improve aperture ratio. Ex. 2081 (Hong), ¶¶ [0013], [0036], [0044]. Matthies' display prior to Dr. Pattison's proposed modification already has enough space for the vias, so Dr. Pattison's proposed combination would reduce the aperture ratio for no reason.

146. At the same time, Dr. Pattison's proposed modifications would introduce asymmetries in pixel size and spacing that Matthies seeks to avoid. These modifications would be inconsistent with Matthies' PMOLED structure, and would be in conflict with Matthies' design rules intended to avoid optical effects at tile edges, as I discuss in Sections X.A.3, X.D.3, X.D.4.

C. A POSITA would not have been motivated to modify Matthies' quad sub-pixel structure based on Yamada's teachings directed to triple-pixel structures

147. Even if a POSITA would have had a reason to modify Matthies based on Yamada, a POSITA would have had no motivation to try to apply Yamada's teachings to Matthies' quad sub-pixel structure shown in Figure 8B, because Yamada does not disclose or suggest a quad-pixel structure.

148. Matthies describes different displays, some of which use a quad sub-pixel structure and others which use an RGB stripe. An example of such an RGB stripe is shown in Figure 8A of Matthies, shown below with annotations.

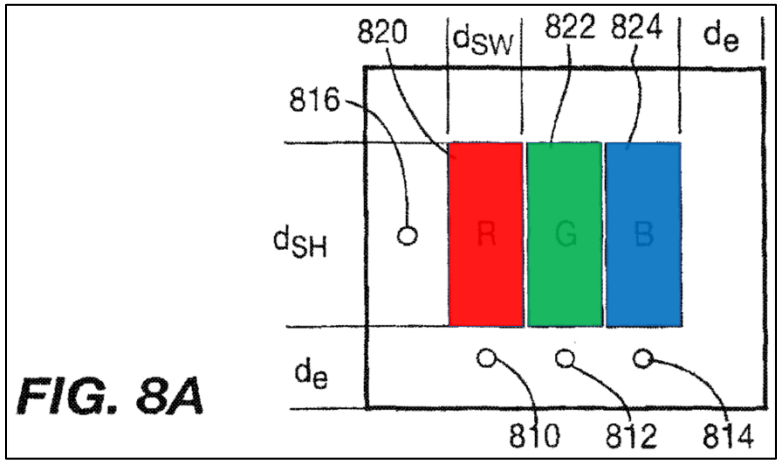
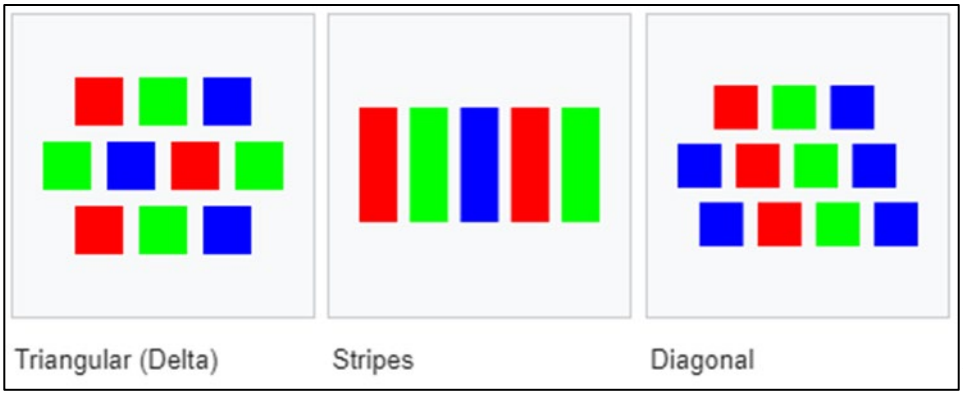


FIG. 8A

149. Yamada only contemplates R/G/B triplet structures, as evidenced by its reference to only "stripe," "delta," and "diagonal" layouts. Yamada, 12:37-43. These pixel structures are illustrated below:



[7]

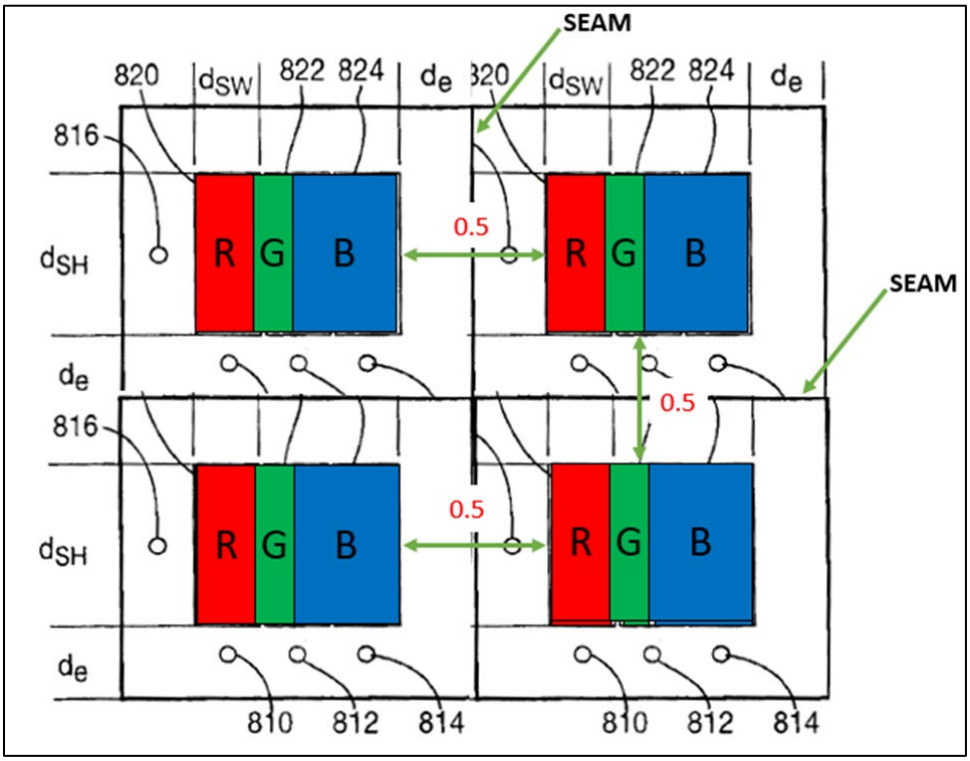
150. Yamada does not discuss or contemplate using quad-pixel structures, or resizing pixels in a quad-pixel structure. Yamada's approach of re-sizing pixels is tied to pixel arrangements with equal numbers of red, green, and blue pixels, and in the context of AMOLED displays.

151. Dr. Pattison provides no explanation of why a POSITA would have been motivated to combine two fundamentally different pixel structures (i.e., Matthies' quad sub-pixel structure and Yamada's RGB stripe structure), and why a POSITA would have had a reasonable expectation of success in arriving at the pixel arrangement structure claimed in the '803 Patents.

152. A POSITA would not have had any reason to do so. If a POSITA were to try to change the relative sizes of pixels in Matthies, then Matthies' triple-pixel structure of Figure 8A would have been a more suitable starting point. In that structure, each column electrode contains only one color, such that changing the

[7] From https://en.wikipedia.org/wiki/Pixel_geometry.

relative width of each column electrode would allow re-sizing pixels of each color. Shown below is this alternative potential modification of Matthies:



153. This arrangement would allow the spacing between adjacent pixels separated by tile seams to remain the same, even after resizing the width of the red, green, and blue sub-pixels, which is what Matthies teaches. This arrangement also increases the size of the blue pixels which, unlike Dr. Pattison's proposed combination, would actually increase the life of the display. This approach would also avoid the need to pattern the electrodes or add additional layers to re-size the pixel areas, thus avoiding all of the electrical and manufacturing problems that would create, which I explained in Section X.A.3 above.

154. In contrast, attempting to adjust the width of any electrodes in Matthies' quad sub-pixel structure of Figure 8B would result in two different colors being resized in the same way, which would not be consistent with Dr. Pattison's purported goal of re-sizing pixels according to emission efficiencies, purportedly based on Yamada's teachings.

155. Additionally, a POSITA would have understood that, generally speaking, RGB stripe pixel arrangements can result in greater light emission area (i.e. aperture ratio) than quad-pixel arrangements. With a greater light emission area, a display can achieve the same level of brightness at a lower current density. This in turn results in a longer lifetime for the display. This would have been particularly important for Matthies' PMOLED display, because the higher voltages necessary to drive PMOLED displays result in lower lifetimes. Thus, a POSITA would have understood that it would have been much more desirable to start with Matthies' RGB stripe pixel arrangement in making a combination with Yamada, particularly under Dr. Pattison's own theory that the reason for such a POSITA to make the combination is to extend the lifetime of Matthies' display.

156. Thus, even if a POSITA would have had a reason to modify Matthies based on Yamada, a POSITA would not have been motivated to modify Matthies' quad-pixel structure as Dr. Pattison proposes, when making the combination with

Matthies' RGB stripe pixel structure would have resulted in more advantages and fewer incompatibilities and technical difficulties.

157. If a POSITA were to make any combination, a POSITA would have modified Matthies' RGB stripe structure. Such a combination, however, when tiled, would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1. Specifically, this structure fails to meet at least the following limitations:

- "a first pixel having a center coinciding with a center of a virtual square;" (claim 1, limitation [1-a(1)])
- "a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;" (claim 1, limitation [1-a(2)])
- "another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and" (claim 1, limitation [1-a(3)])
- "a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square," (claim 1, limitation [1-a(4)])

- "wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and" (claim 2, limitation [2-a])
- "wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and" (claim 3, limitation [3-a])
- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])

D. Even if a POSITA tried to modify Matthies' quad sub-pixel structure based on Yamada' teachings, the modification would not meet the challenged claims

1. Matthies teaches a POSITA to use two blue pixels in its quad sub-pixel design if blue-emitting material is less efficient

158. Even a POSITA had tried to modify Matthies' quad sub-pixel structure based on Yamada, the POSITA would not have had any reason to use the quad sub-pixel structure with two green subpixels (an RGBG arrangement). The references that address the different efficiencies of materials for emitting different colors would actually have led a POSITA away from a quad sub-pixel structure having two green subpixels.

159. Yamada teaches that "blue EL elements" can have "the lowest efficiency" and that "green EL elements" can have "the highest emission efficiency." Yamada, 8:47-52. Yamada's motivation for creating a display with different sizes of emissive areas for different colors is its observation that, if all the pixels of various colors have the same emissive areas, then "in order to obtain the same luminance at the display pixels having a low emission efficiency, a current larger than that supplied to the other display pixels having a high emission efficiency must be supplied." *Id.* at 2:55-64. But doing so would cause "the life of those display pixels having a low emission efficiency, in particular, to shorten." *Id.* at 2:64-67.

160. But Matthies already contemplates a solution for this situation where different light emitting materials have different emission efficiencies for its quad sub-pixel arrangement: when a pixel of one color has lower efficiency, double up on pixels of that lower efficiency color: "In some display technologies, the amount of light emitted by the red or blue pixel material may be less than the amount of light emitted by the green pixels. In this instance, making the pixels 830 and 836 both be red or blue pixels would improve the overall brightness of the display." Matthies at 17:5-10. Examples of these quad sub-pixel arrangements are illustrated in annotated versions of Figure 8B shown below:

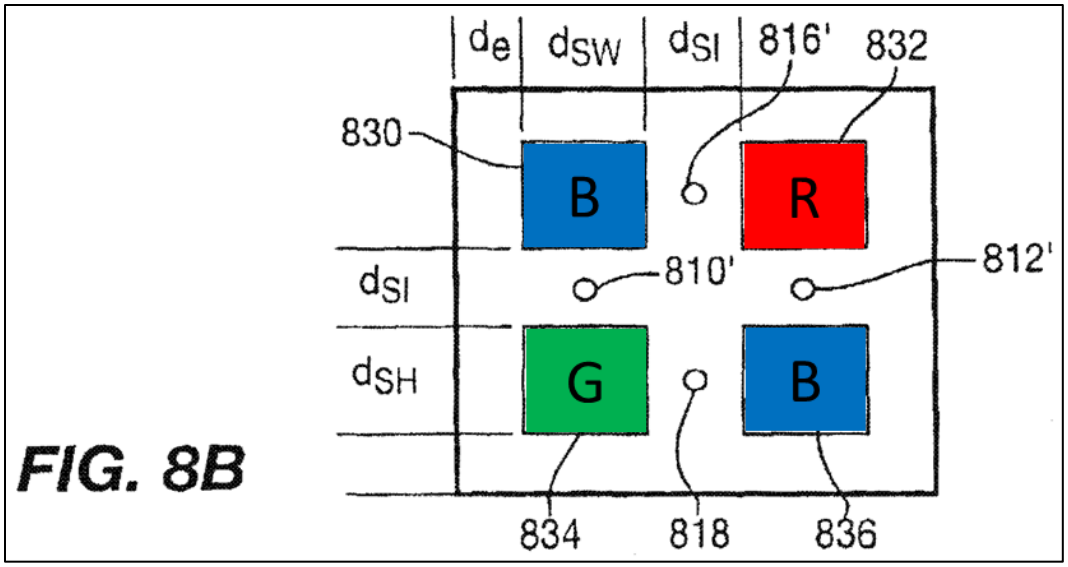


FIG. 8B

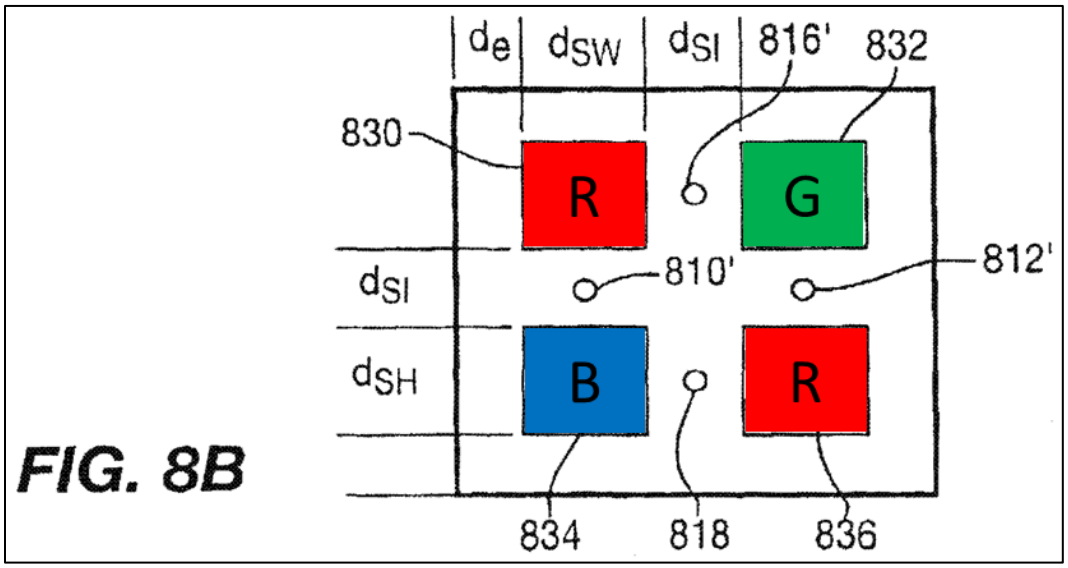


FIG. 8B

161. Thus, if the emissive material for the blue pixel had the lowest emission efficiency as stated in Yamada, then Matthies directed a POSITA to use a quad sub-pixel structure in which the pixels 830 and 836 are both *blue* pixels (an RBGB arrangement), thus increasing the total emissive area of the least efficient color, rather than decrease the size of the red and green pixels as Dr. Pattison suggests. Matthies' solution to double up on the emission area of the least efficient blue pixels

is also consistent with Yamada's teaching of increasing the size of the blue light-emitting area relative. It also improves the overall brightness of the display without requiring more current to be supplied to the blue pixels, thus extending the life of the display. Following Dr. Pattison's solution would do nothing to improve the display lifetime of the display, and instead reduce the display lifetime.

162. This RBGB structure would both (1) increase the blue-light-emitting-area, both in absolute terms and relative to green, and (2) increase the display lifetime, consistent with Yamada's objective. The RBGB pixel structure would thus be the natural result of applying Yamada's teachings about emission efficiency to Matthies' quad sub-pixel structure.

163. This RBGB pixel structure, when tiled, would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1. Additionally, there is no "second pixel" that has a larger area than a "third pixel" as required by claim 1. Additionally, there are no "second pixels" and "third pixels" that each have larger areas than the "first pixel" as required by claim 5. Specifically, this structure fails to meet at least the following limitations:

- "a first pixel having a center coinciding with a center of a virtual square;" (claim 1, limitation [1-a(1)])

- “a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;” (claim 1, limitation [1-a(2)])
- “another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and” (claim 1, limitation [1-a(3)])
- “a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square,” (claim 1, limitation [1-a(4)])
- “wherein the second pixel has a larger area than that of the third pixel, and” (claim 1, limitation [1-b])
- “wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and” (claim 2, limitation [2-a])
- “wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and” (claim 3, limitation [3-a])

- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])
- "each of the second pixels and each of the third pixels has a larger area than the first pixel." (claim 5, limitation [5-b])

2. Dr. Pattison oversimplifies Yamada and disregards that the prior art was critical of, and did not follow, Yamada's teachings.

164. Dr. Pattison also misapplies Yamada's teachings. Dr. Pattison oversimplifies Yamada by asserting that it "teaches that the pixels should be re-sized" only based on "emission efficiency," such that "the 'emissive element of a color with the lowest emission efficiency' (for instance, blue) is made 'larger.'" Ex. 1003 at ¶ 136-137; *see also* Ex. 1003 at ¶ 217-218, 270.

165. Yamada does not propose only looking at the relative emission efficiencies of the different colors. Yamada teaches that the "the element emissive areas in the display pixels for R, G, and B are designed to take into consideration ***not only the emission efficiency*** of the emissive elements of the display pixels ***but also the luminance ratio*** of red to green to blue in accordance with the ***chromaticity of the target display white*** of the display device and with the ***chromaticity of each red, green, and blue color*** emitted by the emissive elements of the respective display pixels." Yamada, Abstract; *see also* Yamada, 4:29-37, 4:57-67.

166. While certain embodiments of Yamada result in the blue pixel being the largest, *see, e.g.*, Yamada, 11:4-39, a POSITA would have understood that the relative sizes of the pixels would have depended on the specific emission efficiency and chromaticity values for the selected organic materials for a display. In fact, Yamada explicitly states that different emissive efficiency and chromaticity values could result in different pixel sizes. Yamada, 10:52-60, 11:56-62.

167. As an example, Arnold, which issued in 2004, teaches that if different materials and chromaticity values are applied, then applying Yamada's teachings would result in a display with blue pixels having 2.8 times the size of blue pixels, despite the lower emissive efficiency of blue OLED materials. Ex. 2011, 15:58-16:36. Thus, contrary to Dr. Pattison's claim, Yamada does not teach 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)." Ex. 1003 at ¶ 270.

168. Dr. Pattison does not identify what organic emissive materials he proposes using in his proposed combination. He provides no analysis of the specific emissive efficiencies or chromaticity values in his proposed modification of Matthies' display. He does not perform any calculations to determine what the appropriate pixel size ratios for Matthies' display would be when applying Yamada's teachings. Without any data or analysis, Dr. Pattison's assertion that the

combination of Matthies and Yamada necessarily results in the blue pixels being largest is nothing but speculation.

169. While Dr. Pattison claims that "[a]ccording 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," Ex. 1003, ¶ 219, Yamada says nothing about the "typical" OLED display or "typical" efficiencies. The portions of Yamada that Dr. Pattison cites for this assertion make clear that Yamada concludes that green has the lowest efficiency and blue has the largest efficiency based on its specific embodiment with its set of specific materials selected as the emissive elements. *See* Yamada, 8:19-22, 10:52-56.

170. A POSITA would also have had no reason to apply Yamada's teachings because they had been criticized by others in the field for failing to account for key factors in designing pixel arrangements for displays, and because they rely on flawed assumptions.

171. Dr. Pattison does not take into account the prior art's criticisms of Yamada's failure to account for these other design considerations.

172. Cok is a U.S. Patent issued in 2005 that explains that, "[w]hile Yamada discloses light emitting elements having different sizes for optimizing the lifetime of the display, ***the display is not optimized with respect to the response of the human visual system***." Ex. 1015 at 2:5-8.

173. Arnold is a U.S. Patent issued in 2004 that explains that "***Yamada fails to discuss other important characteristics of OLED materials that will affect device lifetime***, such as the differences in the inherent luminance stability over time of different materials. ***Yamada further does not consider important optical characteristics of the target display design, each of which will influence the overall lifetime of OLED materials***." Ex. 2011 at 2:34-41.

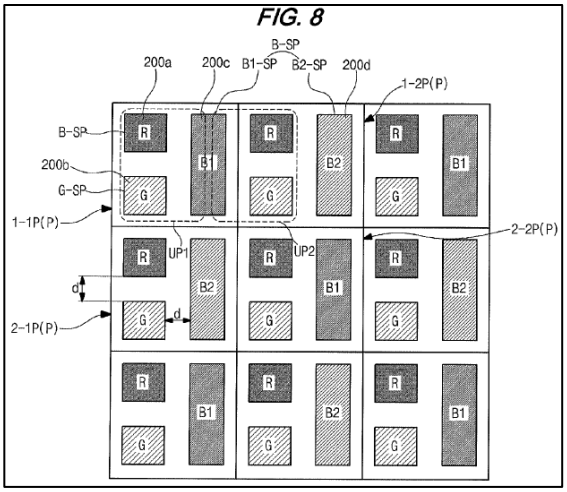
174. Additionally, a POSITA would have understood that Yamada relies on an incorrect assumption about the lifetime of OLED devices.

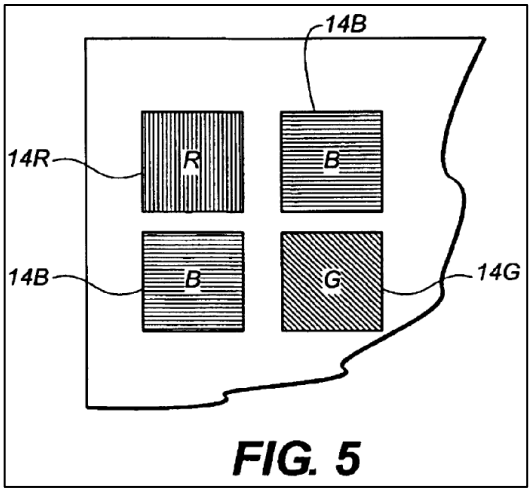
175. Yamada assumes that the organic materials for emitting each color would decay (1) linearly, and (2) at the same rate. Both are incorrect. First, the lifetime of any given OLED material decays non-linearly over time at constant current density. Ex. 2077 (Park) at 8-10, Figs. 4-6. Second, the lifetime and rate of decay of different materials varies. Ex. 2011 (Arnold) at Fig. 10. Thus, adjusting the pixel sizes for different colors according to the emission efficiency of each material as Yamada suggests would fail to maintain the same ratio of red, green, and blue light in the display over an extended period of operation. This ratio, which is also known as white balance, needs to be carefully managed in a display—consistency and predictability in the white balance is a requirement for both faithful reproduction of the source media and consistency in display operation. Additionally, because the lifetime curve of OLED materials is non-linear, the display must necessarily have

secondary compensation in order to maintain the white balance over time. Re-sizing pixels according to the ratio of emissive efficiency is neither necessary nor sufficient to achieve uniform white balance or increased life time of the display.

176. In light of these shortcomings and criticisms, a POSITA would not have sought to apply Yamada's teachings to any display, much less so the passive matrix display of Matthies, where the repercussions of shrinking pixel sizes has a particularly negative effect on the quality of the display, as discussed above.

177. Further, many other prior art references also illustrate that a POSITA would not have combined Matthies and Yamada in the manner proposed by Dr. Pattison. Several references authored by other workers in the field, including those who explicitly considered Yamada's teachings, show pixel arrangement structures that deviate from the arrangement proposed by Dr. Pattison. For example, Yoo (below, left) arrived at a triple-pixel (RGB) structure. *See* Ex. 2012, Fig. 8. And Arnold (below, right) arrived at a quad-pixel structure with two *blue* pixels, in a similar way as done by Matthies as described above. *See* Ex. 2011, Fig. 5.





3. Dr. Pattison's proposed combination conflicts with Matthies' goal of avoiding visible differences at the seams between tiles

178. Further, a POSITA would not have made Dr. Pattison's proposed combination because doing so would introduce uneven spacing between pixels and between the pixel edges and tile edges, contrary to Matthies' goal of eliminating the visibility of seams between tiles. A POSITA would thus not have had a reasonable expectation of success.

179. One of Matthies' main concerns is to "eliminat[e] the visibility of the seams between tiles" in its tiled displays. Matthies, 2:7-10; *see id.* 22:17-22. To ensure that the seams are not visible, and to allow space for materials that join adjacent tiles while ensuring that no useful light emission is blocked, Matthies teaches that the edges of pixels should be evenly spaced from the edges of the tile.

180. As Matthies explains, in tiled displays, if light scatters at the edge of a tile such that the light refracts differently than at the center, the edge may appear

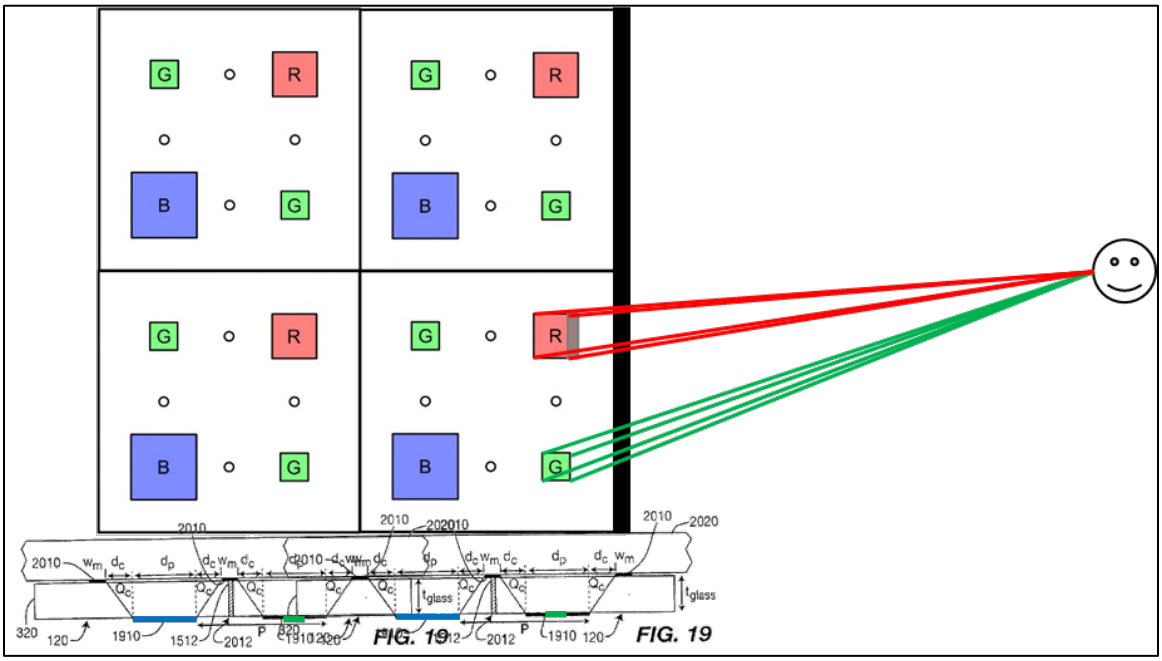
visibly different, for example as "a band of reduced brightness in the displayed image." Matthies, 22:53–56. Thus, for example, for tiled displays using mullions, this problem could arise due to a difference in the index of refraction of the mullion and the glass display substrate, edges in the structure, or due to the bottom stem of the mullion not being light-colored or transparent. Matthies, 22:47–53. The same problem of scattering could arise due to differences in the light-emitting sources themselves. Pixels that are smaller or larger, and pixels that are closer or farther from the tile edge, will result in their emitted light scattering differently at the tile edges than away from the edges, and for the reasons discussed below, differently relative to each other. Matthies explains that, to ensure the edge is not visible to a viewer, "[t]he tiles are constructed with pixel forming elements ***evenly spaced up to the edges of the tiles***." *Id.* at 5:47–48. Matthies also defines a value "d_e" to represent the distance between the edges of the outermost row or column of sub-pixels on a tile and the edge of the tile. *See* Matthies, 17:16–20, 16:49–52, Figs. 8A, 8B. Thus, in Matthies, having equal spacing between the edges of the pixels and the edges of the tiles, and allowing black stripes or mullions to be placed between adjoining tiles while blocking the gaps, is crucial to ensuring that the tile seams are not visible. Matthies, 8:37–46; 21:21–34; 22:17–25; 22:53–56.

181. Dr. Pattison's proposed modification of Matthies would eliminate this key feature of Matthies' tiled display by making the seams more apparent, because

the modification would introduce *uneven* pixel size and spacing from the edge. In particular, the larger pixels would have more of their light emission blocked by the black stripes or mullions (called "shadowing") than the smaller pixels. The different degree of shadowing for different colors would also cause the display to exhibit an undesirable color shift, contrary to the goals of both Matthies and Yamada. Further, the degree of shadowing and color shift would vary by viewing angle, resulting in an inconsistent white balance throughout the viewing space. This is particularly problematic because Matthies is directed to large displays for, for example, "[a]pplications that require multiple viewers," and "[a]pplications in which the user needs to move about in an area," in which the display must have a wide viewing angle. *See* Matthies, 1:14-25.

182. Below is an illustration of the shadowing effect, which I have created based on Dr. Pattison's modified version of Matthies' Figure 8B. A modified version of Figure 19 immediately below Dr. Pattison's figure shows what a cross-section taken along a row of blue and green pixels would look like. Because of the different sizes of the red and green pixels and their different distances to the black stripe/mullion at the right edge of the tile, a user may see the entirety of the light emission from the green pixel, but a portion of the light emission from the red pixel would be blocked (shown in a gray box below). This would result in a perceived shift in the color of the display to appear more green or cyan-ish, compared to the

unmodified version of Matthies' Figure 8B implementation with equally sized red and green pixels up to the edge.



183. Further, because the amount of the color shift will vary depending on the viewing angle, no amount of adjusting the pixel sizes would be able to alleviate this issue, further negating Yamada's goal of achieving "easy" control of the white balance based on re-sizing pixel emissive areas. *See* Yamada, 4:67-5:3.

4. Dr. Pattison's proposed combination conflicts with Matthies' other design rules for quad sub-pixel arrangements

184. Further, a POSITA would not have made Dr. Pattison's proposed combination because doing so would require an overhaul of fundamental aspects of Matthies' display.

185. Matthies' requirement for the design of its quad sub-pixel structure is that it be formed of equally-sized pixels that have equal spacing from the edge of the pixel to the edge of the tile. Matthies, 17:16-20 ("***The 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 adjacent sub-pixels."). By defining the shape of all four pixels in the quad sub-pixel structure through the two values d_{sh} and d_{sw}, Matthies reinforces that each pixel must have the same area.

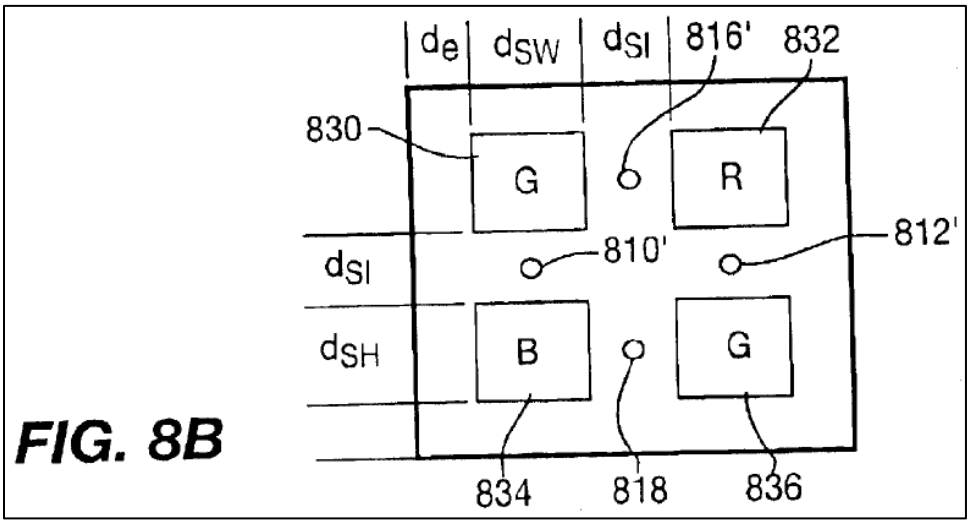
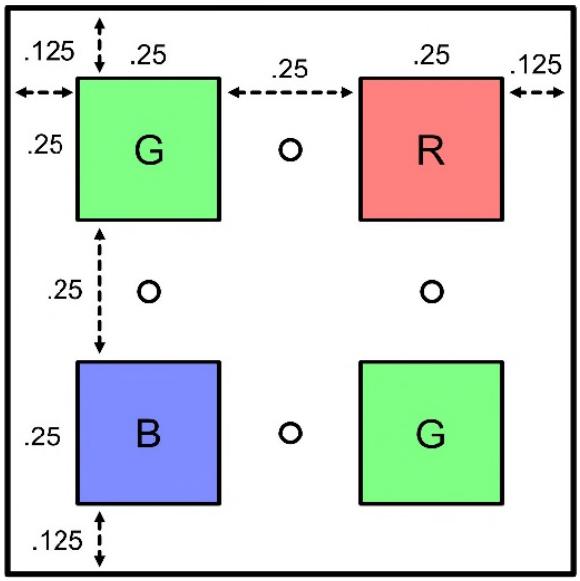


FIG. 8B

186. This design requirement naturally follows from the passive matrix OLED structure of Matthies' display, where each pixel is defined by the overlap of column and row electrodes. And because Matthies locates two different colors of pixels on each row electrode and column electrode, Matthies' design does not allow for arbitrarily varying the dimensions of any or all one of the different color sub-pixels. Instead, Matthies specifies the two dimensions it allows to be varied—"the

distances d_e and d_{SI}" may be different "in the horizontal and vertical directions," Matthies, 17:31-33. And these constraints also maintain the equal sizing of the pixels and equal distances between the edge of a row or column of pixels and the tile edge that is key to ensuring that the seams in Matthies' tiled display are not visible.

187. Further, Matthies teaches having the same spacing between the pixels, both within each tile and across adjacent tiles, as illustrated by Dr. Pattison's "scale drawing" of Matthies' quad sub-pixel structure shown in Figure 8B using the example values listed in Table 2, reproduced below. *See* Ex. 1003, ¶174.



Here, each pixel is 0.125P from the edge of the tile, and adjacent pixels are separated by a distance of 0.25P both within the tile and between tiles. (As Matthies explains, P is the pixel pitch. Pixel pitch a term of art referring to the distance between the center of a sub-pixel and the center of the same sub-pixel in an adjacent pixel. In Dr.

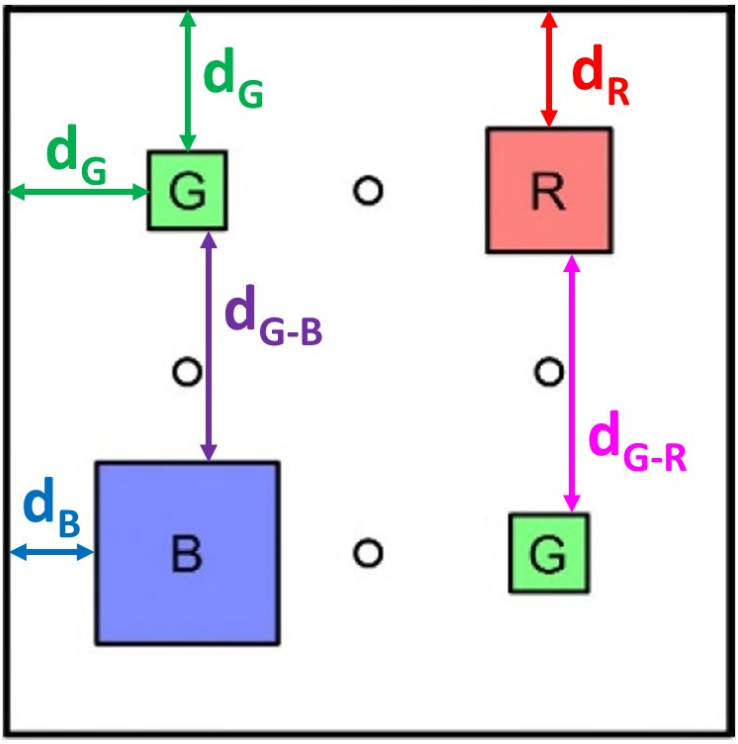
Pattison's combination, where a tile is one quad sub-pixel unit, the pixel pitch is also equal to the side length of a single tile.)

188. More generally, Matthies explains that "[t]he tiles are constructed with pixel forming elements evenly spaced up to the edges of the tiles" Matthies, 5:47-48 and "[o]ne criterion for the tiles is that the spacing between the pixels separated by the tile seam is the same as the spacing of pixels on the tile," Matthies, 8:39-41; *see* Matthies, 9:23-26.

189. Nothing in Matthies suggests that any of the pixels that share a row electrode (or a column electrode) may have (1) different sizes, or (2) different distances to the edge of the tile. That would be fundamentally inconsistent with the design requirement for Matthies' quad sub-pixel tiles composed of uniformly sized pixels arranged to ensure the gap between adjacent pixels is consistent throughout the display and the edges of pixels are equally spaced from the edges of the tiles.

190. Dr. Pattison's proposed combination with Yamada would require a POSITA to disregard Matthies' teachings and violate its design requirements for its quad sub-pixel structures. For red, green, and blue pixels to all have different sizes with respect to each other as proposed by Dr. Pattison, the distance between adjacent pixels cannot be constant, and the distance between pixels and the edges of the tile would need to be different for each color pixel. As illustrated below in an annotation of one of Dr. Pattison's annotated figures depicting his proposed combination where

the red pixels are smaller than the blue pixels and the green pixels are smaller than the red pixels (Ex. 1003, ¶229), the space between a green pixel and an adjacent red pixel would be ***greater*** than the space between a green pixel and an adjacent blue pixel. Similarly, there would be ***different*** distances between the edges of each adjacent color pixel and the edge of the tile:



191. Further, as I've explained above, Dr. Pattison's proposed modifications would also be incompatible with Matthies' passive-matrix OLED design and the fabrication of the device, and would also contradict Matthies' design goal of preventing optical differences at tile edges that result in visible seams.

192. Dr. Pattison also states that Figures 3 and 4 of Yamada show that "the same pixel arrangement, spacing, and geography has been employed (thus the pixel

centers [do] not move), but the pixels have been re-sized in accordance with their emission efficiencies." Ex. 1003, ¶220. This is an incorrect reading of Yamada. Yamada's specification does not support making these inferences from conceptual Figure 4. Yamada explicitly describes Figures 3 and 4 as just "conceptual diagrams." Yamada, 6:21-26. Figure 3 conceptually illustrates the "layout" of emissive regions in prior displays (showing the standard triplet RGB "stripe" layout, *see, e.g.*, Yamada, 12:37-39), and Figure 4 conceptually illustrates different-sized emissive regions for different colors, *see, e.g.*, Yamada, 7:3-12. But Yamada's depictions of how pixels would actually be implemented to account for its other circuitry in the "schematic" diagrams shown in Figures 5, 6A, and 6B show that the pixel shape is more complex, and incompatible with the display of Matthies' Figure 8B. Dr. Pattison also ignores the fact that Yamada is directed to active matrix OLED displays, which as discussed above have different constraints on pixel size, shape, and arrangement than the passive matrix OLED of Matthies' Figure 8B.

193. Dr. Pattison has not explained how the PMOLED display of Matthies' Figure 8B could be made with differently sized red, green, and blue sub-pixels as required in his proposed combination. Dr. Pattison has not explained how it would be possible to make a display that results in the pixel arrangement Dr. Pattison states would result from the combination while staying consistent with Matthies' disclosure. Yamada, being directed to a fundamentally different AMOLED display

architecture, also does not help. Even if a POSITA were willing to ignore the key features of Matthies' displays, the types of modifications required to form Dr. Pattison's combination would have presented complicated design and manufacturing hurdles that a POSITA would not have been motivated to make or had a reasonable expectation of success in making. For instance, as discussed above in Section X.A.3, creating electrodes with non-uniform width would introduce complex electrical effects that would impact the operation and quality of the display and would require adding process steps that would reduce yield and increase manufacturing costs. Matthies does not use (or require) a blocking or isolation layer between the row and column electrodes for defining the pixel area of the organic material. *See* Matthies, 12:58-13:25; Fig. 10B. That is of course expected, because there is no need for such a layer in the PMOLED display where the electrode overlap regions define the emissive areas. A POSITA would not have attempted to add such an additional layer, which would undesirably increase thickness and require additional process steps of deposition and patterning that would increase cost and reduce yield, and result in increased power consumption due to charge accumulation that does not contribute to the operation of the OLED, as discussed above in Section X.A.3.

194. Dr. Pattison asserts that "Matthies itself already contemplates that the sizes of and space between its pixels can [be] adjusted." Ex. 1003 ¶ 311 (relying on

Matthies, 17:31-37, 12:9). Dr. Pattison fails to appreciate that Matthies only contemplates changes to sizing that maintain the uniform spacing of pixels in a row or column, including their uniform distance from the edge of the tile, as discussed above. The cited portion only contemplates d_e and d_{SI} being different for the horizontal and vertical directions; it does not contemplate those values being different for every sub-pixel in the tile as Dr. Pattison's combination would require. Matthies does not contemplate having the kind of arbitrary *nonuniform* spacing of pixels along a row or column in its quad-pixel structure or having differently sized pixels, let alone uneven spacing to the edge of the tile would make the seams between tiles visible.

195. Dr. Pattison claims that Matthies invites changing the "geometry of the pixels" to address OLED pixel aging and decay. Ex. 1003, ¶¶ 293–294. Dr. Pattison overreads Matthies. Matthies merely observes that pixel geometry and materials relate to pixel aging. Matthies, 12:3–10. And Matthies does teach several different geometries of pixel structures, including an RGB stripe structure, Matthies, 16:40–61, Fig. 8A, and quad sub-pixel structures doubling up on pixels for colors that have less emissive efficiency, Matthies, 17:5–10. Matthies teaches that the solution to differential aging of blue pixels in a quad sub-pixel structure is to use a quad sub-pixel structure with two blue pixels. Matthies also contemplates that geometries can change by adjusting the pixel dimensions of the sub-pixels structures. Matthies,

16:49–52, 17:16–20. But nothing in Matthies suggests the type of wholesale modification of the geometries contemplated by Dr. Pattison. Matthies clearly shows that each of the sub-pixels have the same size, providing only one set of pixel height (d_{SH}) and pixel width (d_{SW}) values in each embodiment. Matthies, Fig. 8A, Table 1; Matthies, Fig. 8B, Table 2. Nothing in Matthies invites or suggests the type of modifications Dr. Pattison proposes, which as discussed would be incompatible with passive matrix OLED display architecture, violate Matthies' design rules, and further accelerate the aging of the red and green pixels.

196. Thus, a POSITA would not have been motivated to make or had a reasonable expectation of success in making Dr. Pattison's proposed combination.

XI. GROUND 2: PHAN DOES NOT RENDER OBVIOUS CLAIMS 1–4 AND 19–21 OF THE '803 PATENT

197. For the reasons explained below, it is my opinion that Phan fails to render obvious claims 1–4 and 19–21 of the '803 Patent.

A. Phan does not teach an OLED display, or pixels of an OLED display

198. Phan does not teach a pixel arrangement structure of an OLED display to a POSITA.

199. The claims of the '803 Patent require a "pixel arrangement structure of an organic light emitting diode (OLED) display," and "a plurality of pixels for displaying an image on the OLED display." '803 Patent, cl. 1. These are limitations

that require a specific physical structure. For example, as I explained in the technology background section above, a "pixel" in an OLED display has a different structure and functions differently than a "pixel" in an LCD.

200. The display being an OLED display is an essential part of the invention of the '803 Patent. The invention of the '803 Patent is directed to addressing issues that arise in OLED display manufacturing, and specifically the deposition process for manufacturing individual pixels of the OLED display. As the '803 Patent explains:

> An organic emission layer included in the pixel of an OLED display may be deposited and formed by using a mask such as a fine metal mask (FMM). When reducing a gap between the neighboring pixels to obtain a high aperture ratio of the pixel, deposition reliability may be deteriorated. On the other hand, when increasing the gap between the pixels to improve the deposition reliability, the aperture ratio of the pixel may be deteriorated.

'803 Patent, 1:15-62; *see also* '803 Patent, 5:32-34 ("the deposition process of the organic emission layer is one of the unique manufacturing characteristics of the OLED display").

201. In contrast to the claimed inventions of the '803 Patent, Phan does not describe pixel arrangements for an OLED display. None of Phan's embodiments describes an OLED display or OLED pixels. The only mention of OLED appears in

a long laundry list of "display technologies" in the "Background" section of the specification:

BACKGROUND OF THE INVENTION

1. Field of the Invention

> The invention relates to a display comprising pixels and dots, including but not limited to the following display technologies: Cathode Ray Tube (CRT), Field Emission Display (FED), Vacuum Florescent Display (VFD), Plasma Display Panel (PDP), Liquid Crystal Display (LCD), Light Emitting Diode (LED), ***Organic Light Emitting Diode (OLED)***, Polymer Light Emitting Diode (PLED), Electroluminescence (EL), Electronic inks, Surface Emitting Display (SED), Digital Light Processing (DLP), Electro-mechanics, Phototronics, Biotronics and any light sources known or invented in the future as well as a method for controlling the (said) display.

Phan, 1:15-29 (emphasis added).

202. Further, Phan lists several "technologies" that appear not to exist. For example, I do not know what Phan is referring to when it mentions Electro-mechanics displays. I have also never heard of Phototronics or Biotronics displays. Based on Phan's inclusion of several "display technologies" that do not appear to exist, and even "any light sources known or invented in the future," a POSITA would not have thought that Phan contemplated real displays or pixel arrangements for each of these "display technologies." A POSITA would understand that different display

technologies have different design considerations, manufacturing challenges, and commercial applications. No pixel arrangement structure is going to be appropriate for all display technologies. Phan does not claim that its pixel structures are appropriate for OLED displays. And for the reasons below, a POSITA would understand that Phan's pixel arrangement structures are not appropriate for an OLED display, notwithstanding Phan's single boilerplate sentence.

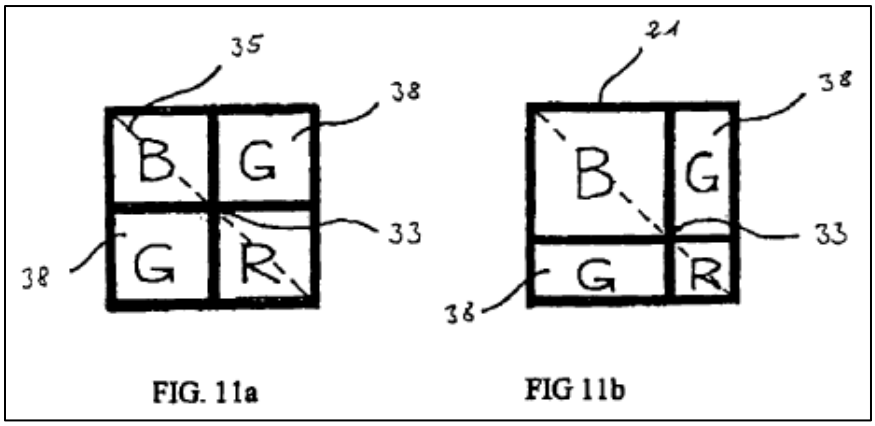
203. The other disclosures in Phan confirm to a POSITA that Phan's embodiments are not OLED displays. Instead of an OLED display, Phan describes a distinct type of display that is connected to a "control circuitry" through "preferably . . . an optical fiber network" that addresses individual pixels' "receivers" that convert "digital information transmitted through [the] network . . . into luminous intensity levels" for the pixels. Phan, 5:9-24. Phan's use of "optical fiber network[s]" and "receivers" to control the display indicates that Phan does not concern OLED displays. OLED displays do not use optical fiber networks or receivers.

204. The "Description of Background Art" section is the only part of Phan's entire (and sparse) disclosure that gets into any substantive technical description of the display technologies. But in this section, Phan mentions only "CRT screens," "LCD displays," "Plasma (PDP)," "FED displays," and "LED displays," and does not make any reference to OLED displays. Phan, 1:56-2:46. LED displays are distinct from OLED displays, and refer to displays that use an array of inorganic

solid-state light-emitting diodes as pixels. LEDs are manufactured by forming a solution of a mixture of elements (such as Gallium, Arsenic, Phosphor), crystallizing the solution on a substrate (such as Silicon), and slicing and packaging them.

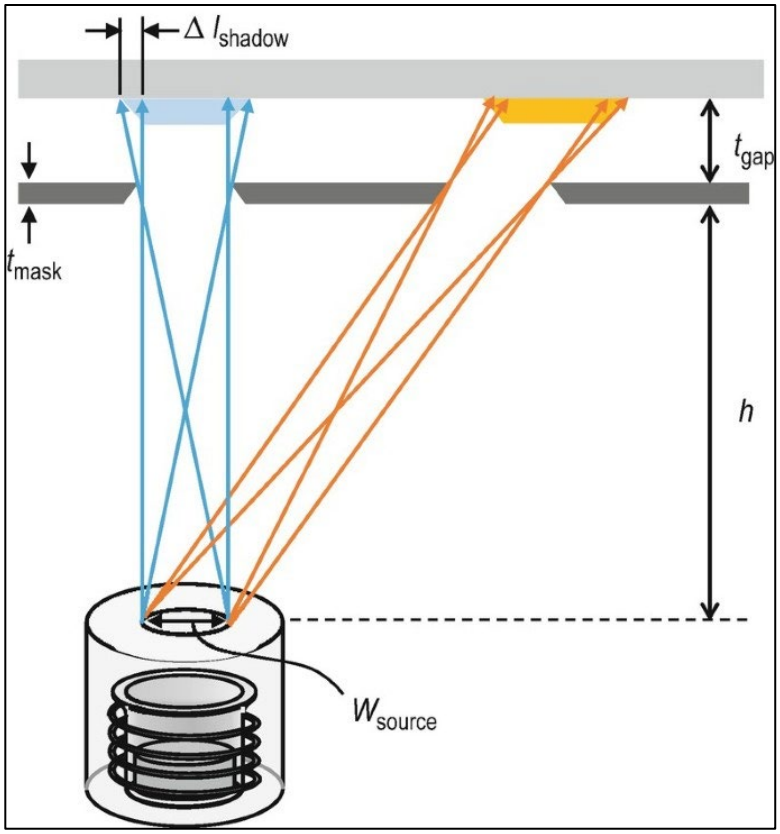
205. Phan also describes "contour[ing]" the individual pixel elements "by black mask or barrier ribs," which are methods mainly used for LCD and plasma displays, instead of OLEDs. Phan, 1:30-34. A POSITA would understand that "black mask" is typically used in LCD displays. A POSITA would understand that "black barrier ribs" are typically used in plasma displays. Neither were used in OLED displays at the time, because barrier ribs are structural elements that keep plasma displays from collapsing, and most OLEDs used a circular polarizer for contrast enhancement, and did not need a black mask to contour the individual OLED pixels.

206. Phan's figures depicting its pixel arrangements show essentially no spacing between adjacent dots. For example, shown below are Phan's quad pixel structures illustrated in Figures 11a and 11b:



The purpose, for example, of black mask is to cover a portion of the light emitting region in an LCD display. Thus, in the quad pixels shown in Figures 11a and 11b, the red, green, and blue pixels are touching each other.

207. A POSITA would have understood that such pixel arrangements were not feasible to implement in an OLED display. Due to physical limitations in the manufacturing process and a degree of randomness and variability always involved, OLED manufacturing process margins would have required large gaps between adjacent pixels. As one example, the illustration below shows how organic material is deposited on a display substrate by thermal evaporation under high vacuum using a fine metal mask (FMM). Because the FMM has a thickness and it must be separated from the surface of the display substrate, the organic material spreads out on the surface of the substrate—something called the shadow effect. There are also additional effects that affect the accuracy of the deposition process, and thus require a larger margin between pixels: alignment accuracy between the mask and substrate, hole position variation, thermal expansion, and strain in the fine metal mask under tension. Additionally, there is randomness due to drift of the vaporized organic material.



[8]

208. It would not have been feasible to have differently colored pixels so close to each other without significant risks of color mixing due to overlap in where the organic emissive materials would end up being deposited. *See, e.g.*, Ex. 2081 (Hong), ¶¶ [0010]–[0011]. Further, because the anode electrode would be designed to be within a specified margin of the pixel's emissive area, there would also be a

[8] From https://media.springernature.com/lw685/springer-static/image/chp%3A10.1007%2F978-4-431-55761-6_12-2/MediaObjects/340944_0_En_12-2_Fig4_HTML.jpg.

significant risk of shorting between adjacent pixels if there were essentially no spacing between pixels, such as in the structures depicted by Phan.

209. Additionally, the quad pixel structures of Phan, particularly if used in a tiled format to form a display in the way that Dr. Pattison proposes, would lead to a display with a very high aperture ratio (the ratio of the area of light-emitting portion of the display compared to the total area of the display). In Phan's figures, it appears that nearly the entire area of the display—everything except the "black mask or barrier ribs"—is light emitting. The aperture ratio could therefore well be over 90%, for example. But the typical aperture ratio for OLED displays at the time of the invention of the '803 Patent was much lower. (And in fact, total aperture ratios for OLED displays remain quite low even to present day.) For example, based on the references cited by Dr. Pattison, a typical aperture ratio for an OLED display would have been around 25%. In Matthies, for example, the aperture ratio of the display is approximately 25%. Matthies, 15:67-16:2. Hong, another reference cited by Dr. Pattison in a related IPR proceeding (IPR2023-01075), teaches that OLED displays at the time often had aperture ratios of around 18%. Ex. 2081, ¶ [0010]. Hong boasts that it may be possible to obtain an aperture ratio of 30%. Ex. 2081, ¶ [0048]. A POSITA would not have thought that it would be possible to create an OLED display having unusually high aperture ratios such as the display shown in Figures 11a or 11b of Phan. On the other hand, LCD displays and plasma displays can have very

high aperture ratios. This further supports my opinion that a POSITA would have understood that the quad pixel structures of Figures 11a and Figure 11b may be appropriate for an LCD display or a plasma display, but not an OLED display.

210. Further, the heart of Phan's disclosure is using virtual pixels that are generated dynamically to drive the display, but Phan's virtual driving method would not be feasible to implement in an OLED display.

211. Phan explicitly states that it implements a passive-matrix display. Phan, 5:23-24 ("Addressing involves high-frequency repetition, preferably at a rate of minimum 100 Hz for passive driving display."). Phan also criticizes the use of thin-film transistors (TFTs) in active matrix LCDs as "extremely expensive and very prone to major amounts of rejects," and discloses as its invention applying software-based "dynamic screen layers" to a passive-matrix display to create "dynamic pixels" which must be "displayed and superimposed subsequently over a time frame in order to obtain an enhanced high resolution screen." Phan, 2:35-38, 5:23-24, 5:55-60. Thus, Phan discourages using active-matrix LCDs. And as I've already explained, active-matrix OLED displays require more TFTs per pixel than active-matrix LCDs, so active-matrix OLEDs are even more highly discouraged.

212. But Phan's algorithm requires scanning through the rows of a full display at such high frequency and high brightness (requiring such high voltage and current density for an OLED), that it would be impractical to implement with a

passive-matrix OLED display. As explained in the background of the technology section above, because in a passive-matrix display only one row of pixels emits light at a time, each pixel must output a large amount of light in the sub-frame in which it is illuminated, and so very high voltages must be applied to the OLED pixels. This results in rapid degradation of the OLEDs, decreased power conversion efficiency and increased power consumption, voltage drops along row and column electrodes, and leakage current through non-selected pixels. *See* Sections V, X.D.3. Thus, Phan's display, if it could be made to work as an OLED at all, would exhibit poor luminance uniformity, poor quality, poor power consumption, and low lifetime.

213. To take an example, Phan contemplates a display having a resolution of 480 x 640 static pixels shown in Figure 12, which Dr. Pattison relies on. Each static pixel here is a quad pixel with four dots, meaning a resolution of 960 x 1280 individual dots. To run through 960 rows of dots, one row at a time, to display a single image frame, and to run the display at 100 Hz as Phan suggests would require driving each pixel at 960 times the intensity, every 1/96,000 seconds, or about once every 0.01 milliseconds. That is already impractical for a PMOLED display. Add to that the fact that to drive this display using Phan's dynamic pixel driving method (which would display four virtual pixels for each static pixel, *see* Phan, Figs. 12a-d, 4:5-11), the display must be run at 4 times the frequency that the display would be driven at normally. This is simply not practical for a PMOLED display. Further note

that because one virtual frame of dynamic quad pixels would be shown for ¼ of the normal frame time for a static implementation, each of the dots would need to be driven at 4 times the brightness for the display using Phan's dynamic driving method to have comparable brightness as a normal static pixel display. That would then require significantly higher voltage and current density to be applied to each OLED (resulting in OLED-degradation related current drop and lifetime issues), and this would be impractical if the dots were OLED.

214. Phan also never explains how any of its specific embodiments can be combined with an OLED display. It does not explain how the display using optical fiber networks and receivers shown in Figure 5 can be implemented with an OLED display. It does not explain how any of the pixel structures it describes—such as its quad pixel structures with adjacent pixels having essentially no spacing between them—can be implemented in an OLED display.

215. Thus, a POSITA would not view Phan as teaching an OLED display or a pixel arrangement structure of an OLED display. Nor would a POSITA view Phan as suggesting or motivating a POSITA to form an OLED display or a pixel arrangement structure of an OLED display. A POSITA certainly would not have had a reasonable expectation of success in making an OLED display from Phan's disclosures.

B. Phan does not teach a virtual square

216. Phan also does not teach a virtual square as described by the ’803 Patent.

217. Each claim of the ’803 Patent requires a “virtual square.” Specifically, claim 1 requires “a first pixel having a center coinciding with a center of a virtual square.” It also requires “a second pixel” and “a third pixel” having centers at the vertices of the virtual square. Dependent claims 2-4 place additional requirements on the virtual square. In order for Phan to teach any of the claims of the ’803 Patent, it must teach a pixel arrangement in which the pixels form such a virtual square. But Phan does not teach a virtual square.

218. There is not a single reference in Phan to a “virtual square,” let alone a “virtual square” that meets the limitations of claim 1. Dr. Pattison has not identified any express disclosure in Phan of a “virtual square.” Instead, he argues that the “quad pixel” from Figure 11b and the “display” from Figure 12, shown below, could be combined to create the required virtual square:

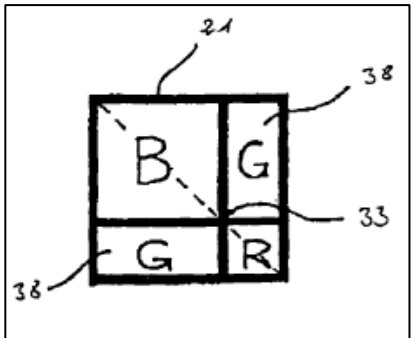


FIG 11b

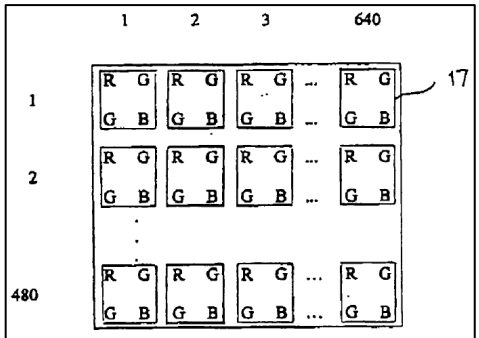


FIG. 12

219. But combining the embodiments in Figure 11b and Figure 12 would not result in the virtual square required by the claims. This combination is shown in the annotated image below. I have taken Phan's Figure 12 and replaced each of the quad pixels with a copy of Figure 11b, being careful to maintain the spaces between the quad pixels shown in Figure 12. I have also drawn red lines connecting the centers of the same pixels that Dr. Pattison connected in his demonstratives. The red lines do not form a square.

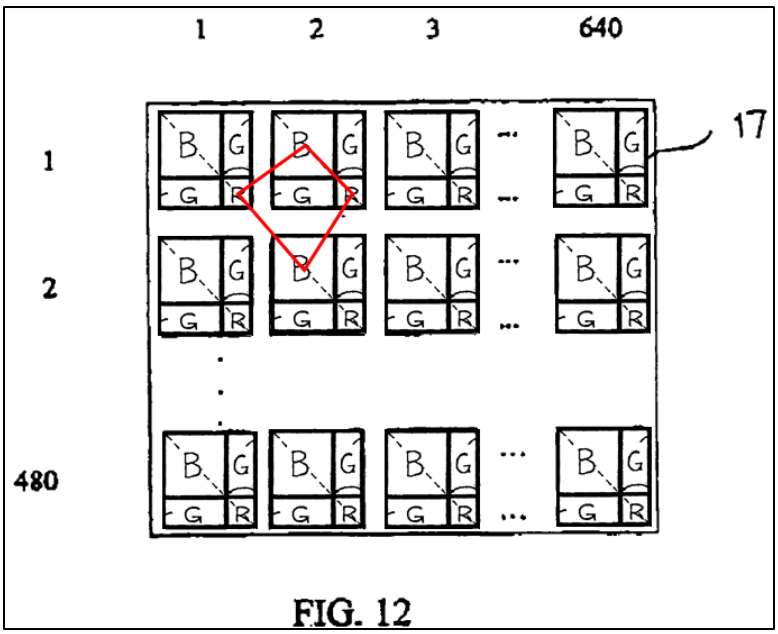


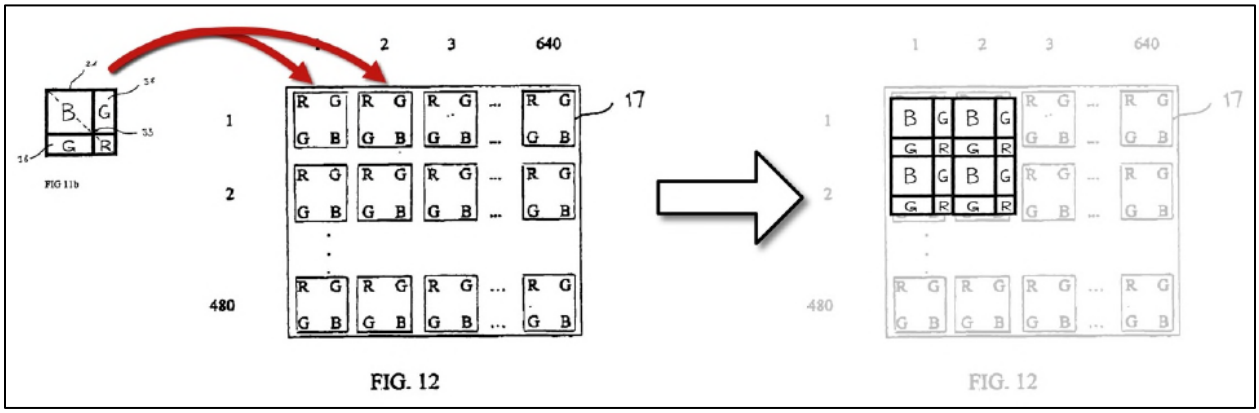
FIG. 12

220. Thus, the combination would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1 of the '803 Patent. Specifically, this structure fails to meet at least the following limitations:

- “a first pixel having a center coinciding with a center of a virtual square;” (claim 1, limitation [1-a(1)])
- “a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;” (claim 1, limitation [1-a(2)])
- “another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and” (claim 1, limitation [1-a(3)])
- “a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square,” (claim 1, limitation [1-a(4)])
- “wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and” (claim 2, limitation [2-a])
- “wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and” (claim 3, limitation [3-a])

- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])

221. The image below, reproduced from Dr. Pattison's declaration, shows how he purports to combine Figure 11b and Figure 12. But Dr. Pattison ignores the fact that Phan's Figure 12 includes clear spaces between adjacent quad pixels. When Dr. Pattison combines Figures 11b and Figure 12, he removes the spaces between the quad pixels. Dr. Pattison does not acknowledge or justify making these changes. This is contrary to the teaching of Phan, which does not disclose any display embodiment in which the quad pixels are arranged with no gaps in between.



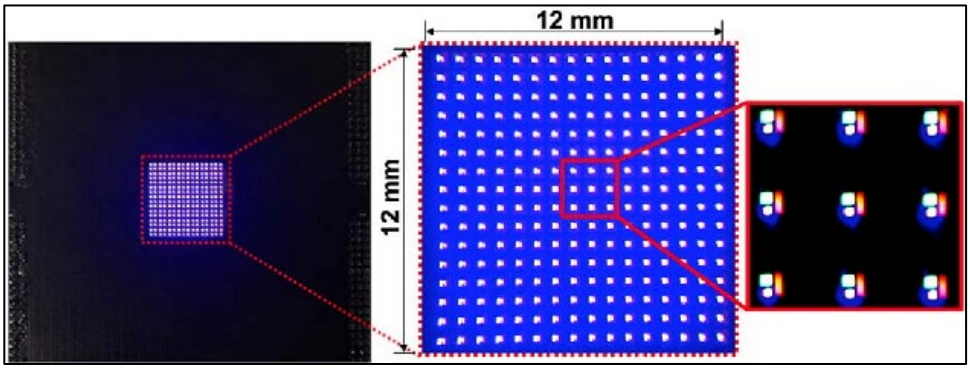
Ex. 1003, ¶ 350 (Dr. Pattison's annotated figure)

222. There is no basis in Phan for removing the spacing between quad pixels explicitly shown in Phan. Doing so would also be contrary to Phan's teachings and the purpose of Phan's invention.

223. First, a POSITA would have understood that there were reasons for separating the quad pixels in the display of Figure 12. Phan teaches, for example,

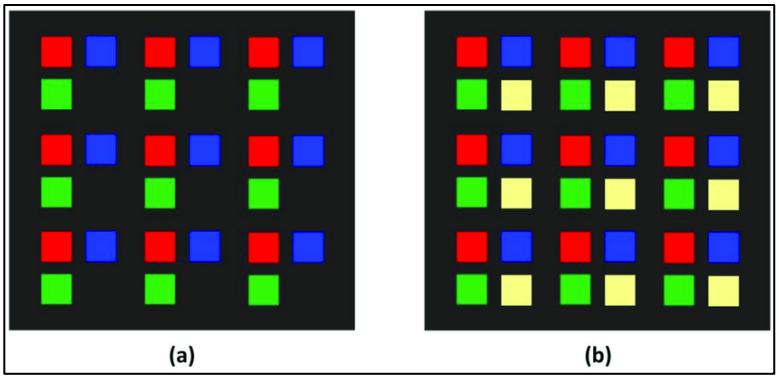
that the display requires "[c]ontrol circuitry" that "combines adjacent dots 11 to form a dynamic pixel 18 in order to then address these as a logical unit." Phan, 5:20-22. A POSITA would understand that space would be required to place and route such circuitry. Indeed, even Dr. Pattison acknowledges that "a POSITA would have understood that there already is space (even if not depicted) between the pixels to allow for the intermediate signal lines." Ex. 1003, ¶ 428. Phan's spacings could also be for placement of wiring for Phan's "optical fiber network." Phan, 5:20-24, Fig. 5.

224. In fact, it was not uncommon to see displays designed to have spacings between each set of individual pixel unit groups (such as Phan's quad pixel unit), in both literature and in manufactured display devices. This was particularly the case for LED displays. Shown below are just some illustrative examples:



[9]

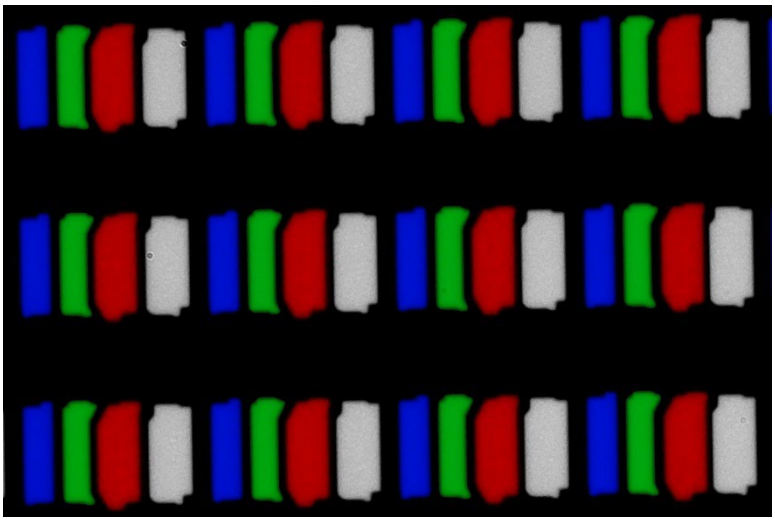
[9] https://d3i71xaburhd42.cloudfront.net/88f5c7161f5a5dbe48c256bd5148399fc83c3c8f/5-Figure10-1.png, from https://www.semanticscholar.org/paper/An-Active-



[10]

Matrix-Micro-Pixelated-LED-Display-Driver-Ahn-Hong/88f5c7161f5a5dbe48c256bd5148399fc83c3c8f.

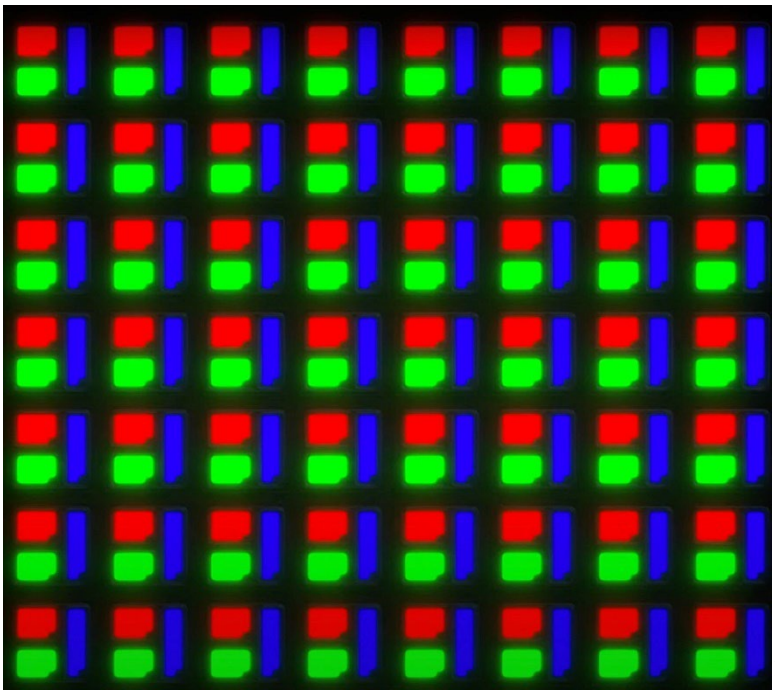
[10] https://www.researchgate.net/publication/341254392/figure/fig2/AS:888973505339392@1588959208042/An-example-of-pixel-arrangements-of-a-three-color-micro-light-emitting-diode-LED.png, from https://www.researchgate.net/publication/341254392_Design_and_Simulation_of_Low_Circadian_Action_Micro-LED_Displays_with_Four_Primary_Colors.

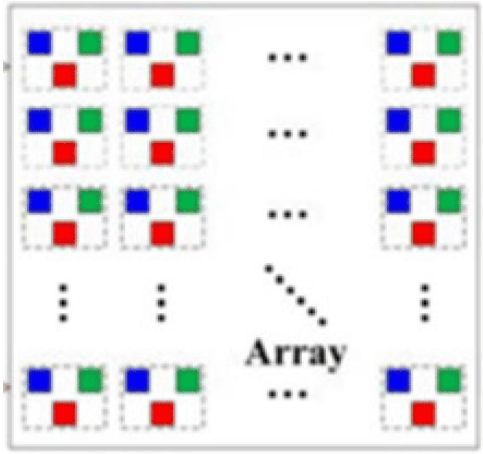
 [11]

[12]

[11] https://www.avmagazine.it/articoli/4K/1500/07.jpg, from https://www.avmagazine.it/articoli/4K/1500/supertest-oled-panasonic-55lz2000_index.html.

[12] https://pbs.twimg.com/media/E0FaWkRUUAM6ysq?format=jpg, from https://twitter.com/romainguy/status/1387489512394092546.

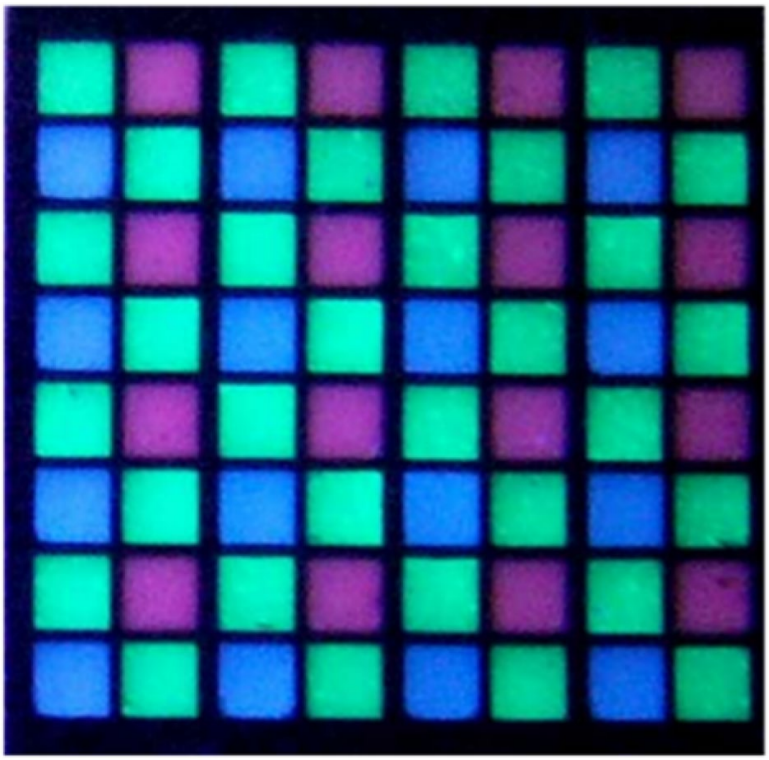
 [13]



[14]

[13] https://pbs.twimg.com/media/Fx5SXjeakAAChwF?format=jpg, from https://twitter.com/radio_research/status/1665860084264574976.

[14] https://www.mdpi.com/nanomaterials/nanomaterials-10-02482/article_deploy/html/images/nanomaterials-10-02482-g001.png, from https://www.mdpi.com/2079-4991/10/12/2482.

 [15]

225. As yet another example, Phan discloses several embodiments of non-square quad-pixels, such as Figures 10a and 10b. For a display tiled with rectangular quad-pixels, a POSITA would have recognized that it could be beneficial to have the same pixel pitch for each dot across adjacent quad-pixels. For example, this could conform the location of the dots on the display more closely to where they would expect to be in the standard raster format for digital images, and not give the appearance that the display is distorted due to seeing pairs of virtual pixels that

[15] https://www.mdpi.com/nanomaterials/nanomaterials-10-02482/article_deploy/html/images/nanomaterials-10-02482-g009.png, from https://www.mdpi.com/2079-4991/10/12/2482.

appear closer to each other than other pairs, or being too wide or narrow in one direction. For rectangular quad-pixels, this would not be possible unless there were more spacing between quad-pixels in one direction than the perpendicular direction.

226. Second, a POSITA would have understood that spacings between each quad pixel would be necessary to prevent distortion and poor image quality when using Phan's dynamic pixel driving method with quad pixels having dots of unequal sizes, such as Figure 11b of Phan.

227. If a display's static quad pixels have differently sized red, blue, and green dots, such as in the structure shown in Figure 11b, then the visual locus of the dynamic quad pixels will be perceived by the viewer to be shifted away from the center of the static quad-pixels. For example, below is an annotated version of Figure 11b of Phan, where the red cross represents the visual locus of the quad pixel:

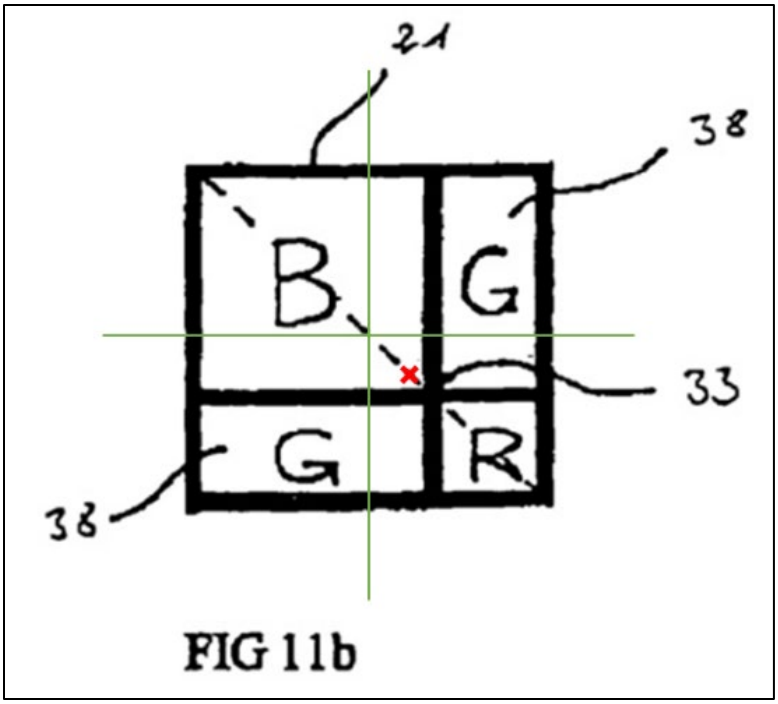
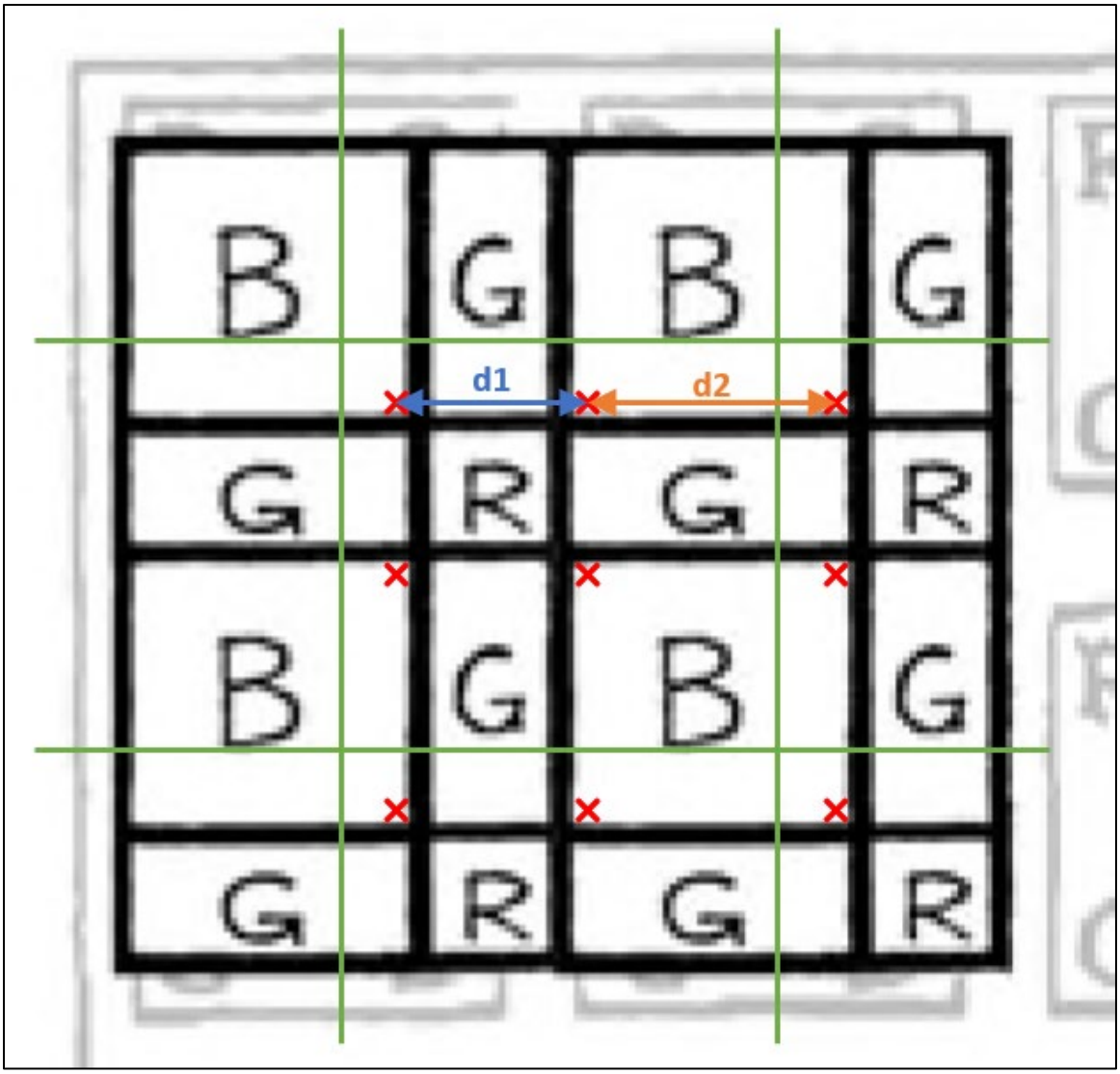


FIG 11b

If this quad pixel structure is combined with Figure 12 of Phan without any spacing between adjacent quad pixels and Phan's dynamic pixel driving method is used, the result would be that the visual locus of the overlapping dynamic quad-pixels will not lie on a regular grid. Instead, as shown below in a further annotated version of Dr. Pattison's proposed combination of Figures 11b and 12 of Phan (Ex. 1003, ¶ 350), the visual locus of the dynamic quad pixel in the middle of the top row will be offset by a distance d1 from the visual locus of the dynamic quad pixel at top left, but offset by a distance d2 from the visual locus of the dynamic quad pixel at top right. (Note that the same offsets would occur among adjacent dynamic quad pixels in the column direction as well.) The result is that the user would perceive a distortion in the dynamic pixel display.



228. The "visual locus" of a unit pixel consisting of the different color dots that constitute the unit pixel refers to the location where the user perceives the color-mixed pixel to lie. This is a function of color, area, and relative location. The human visual system is more sensitive to green light than red or blue light, and so the green dots have an outsized effect on the perceived visual locus of a unit pixel.

229. Thus, a POSITA would not have removed the gaps between quad-pixels in combining Figure 11b with Figure 12 as Dr. Pattison inexplicably has done. This

modification would contradict Phan's goal of improving resolution and image quality through "variable generation of pixels from existing dots" to create its "dynamic pixels"—the very purpose of Phan's invention. Phan, 2:54-3:19.

230. Dr. Pattison's proposed modification to remove the spacings between quad pixels in Figure 12 goes against Phan's disclosures, the goal of Phan's invention, and the understanding of a POSITA. A POSITA would thus not have made Dr. Pattison's modifications, and would not have had a reasonable expectation of success in doing so.

XII. GROUND 3: PHAN AND YAMADA DO NOT RENDER OBVIOUS CLAIM 5 OF THE '803 PATENT

231. For the reasons explained below, it is my opinion that the combination of Phan and Yamada fails to render obvious claim 5 of the '803 Patent.

232. As I explained in the previous section, Phan does not disclose an OLED display or pixels of an OLED display. For the same reasons, Dr. Pattison's proposed combination of Phan and Yamada—to re-size the pixels in Phan's display according to Yamada's teachings—would also not result in an OLED display or pixels of an OLED display, as would be required by claim 5 of the '803 Patent, since it incorporates all limitations of claim 1.

233. But even if Phan were assumed to disclose an OLED display, claim 5 of the '803 Patent would not have been obvious over the combination of Phan and Yamada.

A. A POSITA would not have been motivated to combine Phan and Yamada.

234. Phan and Yamada are incompatible technologies. Dr. Pattison's proposed re-sizing and re-spacing of the dots in Phan's quad pixels contradicts Phan's explicit teachings.

235. A POSITA would not have looked to Yamada to modify the pixel arrangement structure of Phan's display. As discussed above, Yamada is explicitly directed to active-matrix OLEDs. Matthies, 1:6-9 ("The present invention relates to an electroluminescence display apparatus comprising an electroluminescence (hereinafter also referred to as EL) element and a thin film transistor (hereinafter referred to as TFT) element."). As also discussed above, Phan is explicitly directed to a passive-matrix display for implementing its dynamic pixel driving method. Phan, 5:23-24 ("Addressing involves high-frequency repetition, preferably at a rate of minimum 100 Hz for passive driving display").

236. What's more, Phan describes its approach as an alternative to active-matrix displays, and discourages using active-matrix displays. Phan criticizes active-matrix LCDs because they require TFTs for individually controlling pixels and TFTs are expensive and prone to manufacturing failure. Phan, 2:14-43. A POSITA would have understood that active-matrix OLEDs would require more TFTs more complex pixel circuits than active-matrix LCDs: active-matrix LCDs only require one TFT per pixel because they are voltage controlled, while OLED displays are current-

driven and require at least two TFTs per pixel for an active-matrix implementation. So a POSITA would not have read Phan as contemplating an active matrix display, and especially not an active-matrix OLED display.

237. As I explained above, a POSITA would have understood that the design considerations for a pixel arrangement of a passive-matrix OLED are significantly different from the design considerations for a pixel arrangement of an active-matrix OLED. The rate and modes of degradation of OLED pixels are materially different between PMOLEDs and AMOLEDs, and this would particularly be the case with Phan's requirement for "high-frequency repetition" to implement its dynamic pixel driving display. Phan, 5:23-24.

238. As I also explained above, since Figure 12 of Phan discloses a display having 480 rows of quad pixels (and thus 960 rows of dots), a POSITA would have understood this would require that significantly higher driving voltages (and thus significantly higher current densities) be applied to each row due to the shorter "on" times for each row, compared to an AMOLED display like in Yamada. Thus, the pixel aging rate and profile for Phan's display would be significantly different from that for Yamada's display. A POSITA would thus have had no reason to look to Yamada and its teachings about pixel aging in AMOLED displays to modify a pixel arrangement in Phan, and would not have any reasonable expectation of doing so successfully.

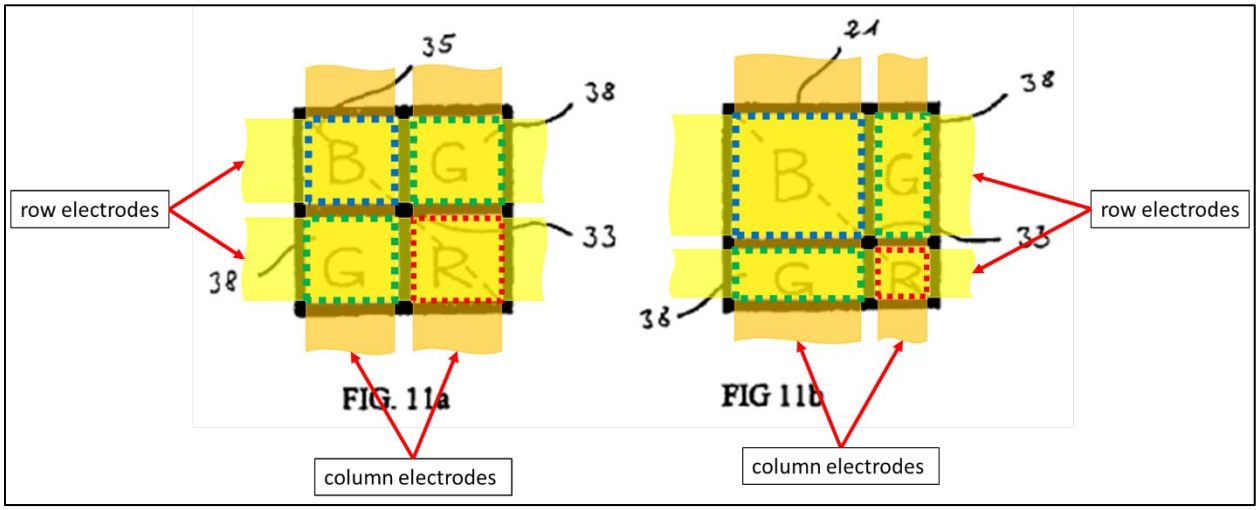
239. Further, Dr. Pattison proposes resizing the blue, red, and green pixels based on their relative sizes allegedly taught by Yamada, but Yamada's proposed resizing is inconsistent and incompatible with Phan's own pixel arrangements. To the extent that Yamada taught a POSITA that the emission efficiency of materials for emitting blue color light was lower than the emission efficiency of other colors, Phan already taught pixel arrangement structures where the blue light-emitting area was made larger, and thus provided a solution that a POSITA could have readily looked to. *See* Phan, Figures 1b, 10b, 11b.

240. For example, in Figure 1b, Phan teaches a quad pixel structure with two blue dots, which would have doubled the blue light-emitting area compared to the other colors. A POSITA would have been motivated to select this structure for the same reasons discussed with respect to Matthies in Section X.D.1 above, rather than selecting the quad pixel of 11a and seeking to further modify it inconsistent with Phan, as Dr. Pattison would suggest. If this teaching were followed, multiple requirements of claim 5 would not be met. Claim 5 depends from claim 4, which depends from claim 3, which depends from claim 2, which depends from claim 1. '803 Patent, cl. 1-5. The resulting quad pixel structure would not result in a virtual square with a center coinciding with the center of a green pixel (the claimed "first pixel" in the '803 Patent) in which two neighboring vertices coincide with the centers of a second pixel and a third pixel, as required by claim 1. '803 Patent, cl. 1

Limitation [1-b], which specifies that "the second pixel has a larger area than that of the third pixel," would also not be met. '803 Patent, cl. 1. Limitation [5-b], which requires that "each of the second pixels and each of the third pixels has a larger area than the first pixel," would also not be met. '803 Patent, cl. 5.

241. As another example, Phan explicitly teaches that the relative sizes of dots in its quad pixel arrangements can be changed. And in Figures 10b and 11b, Phan shows how the blue light-emitting area can be made largest by moving the "crosspoint" 33 along the diagonal. This would result in the green dot being second largest, and the red dot being smallest. Dr. Pattison provides no reason why a POSITA would have overlooked or ignored these teachings in Phan. If this teaching were followed, the requirements of claim 5 would not be met. Claim 5 depends from claim 4, which depends from claim 3, which depends from claim 2, which depends from claim 1. '803 Patent, cl. 1-5. Claim 5 requires that "each of the second pixels and each of the third pixels has a larger area than the first pixel." '803 Patent, cl. 5. Claim 1 requires that "the second pixel has a larger area than that of the third pixel," and that "the first pixel is configured to emit green light." '803 Patent, cl. 1. Together, claim 5 thus requires that the second pixels have a larger area than the third pixels, and that the third pixel have a larger area than the green first pixel. This would not be met because it is impossible to resize Phan's dots to have the green dot be smallest.

242. Phan's teaching of adjusting dot sizes by moving a crosspoint along a diagonal of the quad pixel has significance to Phan's display, and would not have been ignored. Moving a crosspoint along the diagonal has a direct relationship to Phan's passive-matrix structure. As I explained above, in a passive matrix display, each row of pixels shares the same row electrode and each column of pixels shares the same column electrode. Phan, by constraining resizing of pixels by moving the crosspoint along a diagonal, ensures that the pixels that share a row electrode have the same height and the pixels that share a column electrode have the same width. This is illustrated below. A POSITA would understand that this makes good sense because it is a natural way to resize pixels consistent with the passive matrix architecture. Dr. Pattison's proposed re-sizing of Phan's quad pixel structure, on the other hand, is incompatible with Phan's passive matrix structure.



243. Dr. Pattison's proposed combination is in fact a wholesale reconfiguration of Phan's quad pixel structure that ignores all context about the

structure and purpose of Phan's display. A POSITA would not have been motivated to remake Phan's pixel arrangement structure in this manner.

B. A POSITA would not have been motivated to combine Phan and Yamada in the manner proposed by Dr. Pattison.

1. A POSITA would not have re-sized Phan's dots by maintaining the blue dot size and shrinking the red and green dots.

244. Even if a POSITA had tried to combine Phan with Yamada, a POSITA would not have sought to resize the quad pixel shown in Figure 11a of Phan by keeping the blue dot size the same, reducing the size of the red dot to be smaller than the blue dot, and further reducing the size of the green dots to be smaller than the red dot.

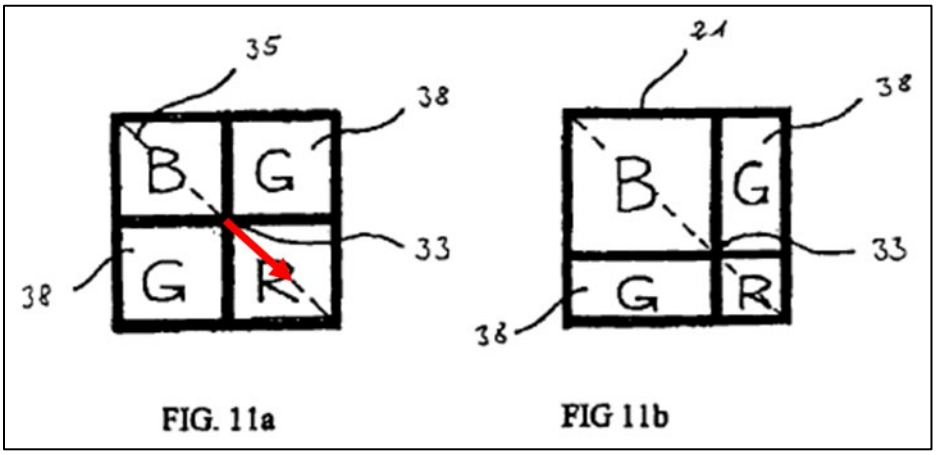
245. Dr. Pattison's proposed combination would actually have ***reduced*** the lifetime of an OLED display, and also had other negative effects. As I explained above in Section X.B regarding Dr. Pattison's proposed combination of Matthies and Yamada, a POSITA would have understood that Dr. Pattison's proposed re-sizing of the pixels to keep the blue pixels the same size and reduce the sizes of the red and green pixels would not extend the overall life of the display. Dr. Pattison's proposed combination would not increase the blue light-emitting area, and would not lower the current density. Additionally, by reducing the red and green light-emitting areas, Dr. Pattison's combination would require a ***higher*** current density to be applied to the red and green pixels to drive them at the same amount of brightness

as before, thus accelerating aging of the red and green pixels and reducing display lifetime. In Phan's passive-matrix displays, the aging and lifetime effects of higher driving voltages and current densities would be further exacerbated. And as also discussed above, Yamada does not discuss or contemplate using quad-pixel structures, or resizing pixels in a quad-pixel structure; its approach of re-sizing pixels is tied to pixel arrangements with equal numbers of red, green, and blue pixels, and in the context of AMOLED displays.

246. Dr. Pattison's combination thus fails to apply Yamada's teachings as would be understood by a POSITA, and instead results in a combination that would be expected to shorten the life of the display, contrary to the very motivation that Dr. Pattison claims a POSITA would have had for making the combination.

247. Dr. Pattison's proposed modification also conflicts with Phan's express teachings regarding adjusting the sizes of dots in its quad pixel structure. Phan teaches that the dots in its quad pixel structures can be re-sized by moving a crosspoint—the point at which the corners of all four dots meet—along a diagonal of the quad pixel structure. Phan, 5:51-54. Thus, as shown in the annotated version of Figures 11a and 11b below, the size of the blue dot in the quad pixel structure shown in Figure 11a can be increased by moving the crosspoint 33 from the center of the quad pixel along the diagonal line 35 towards the lower-right corner of the quad pixel (along the red arrow), to arrive at the quad pixel structure shown in Figure

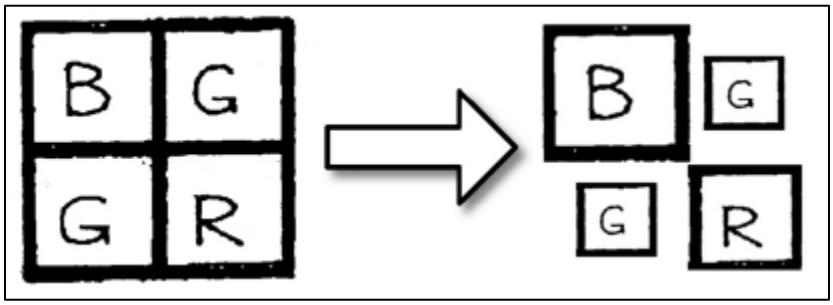
11b. Phan also teaches the same re-sizing method for rectangular quad pixel structures, as shown in Figure 10a and 10b. Phan, 5:43-46, Figs. 10a, 10b.



248. Thus, as shown in Figures 10b and 11b, when the size of the blue dot is increased, the green dot has an intermediate size and the red dot has the smallest size. In Phan's quad pixel structure, the green dot cannot be made to be smaller than both the red dot and the blue dot. When re-sizing along the crosspoint, each green pixel will necessarily have a size between that of the blue pixel and the red pixel.

249. Dr. Pattison's proposal to keep the blue dot the same size while shrinking the size of the red and green dots would contradict Phan's express teachings regarding the sizing of dots in its quad pixel structure. By resizing dots by moving the crosspoint along a diagonal line of the quad pixel structure, Phan is able to resize its dots without adding any additional dead space that does not have useful light output—and thus keeps the total aperture ratio constant. Phan, 5:43-46, 5:51-54. On the other hand, Dr. Pattison's proposed combination breaks apart Phan's quad

pixel structure and introduces arbitrary spacing between subpixels for no good reason, and with no support for doing so in Phan. Ex. 1003, ¶ 426.



250. Dr. Pattison's proposed combination is inconsistent with Phan's method of resizing by moving the crosspoint along the diagonal. As discussed above, it is also inconsistent with Phan's passive matrix architecture, which constrains pixel sizes. And it also makes a worse display by introducing dead space between pixels and reducing the aperture ratio of the display. Dr. Pattison provides no reason why a POSITA would ignore that Phan teaches enlarging the blue dot by moving a crosspoint as shown in Figure 11b of Phan.

251. Dr. Pattison asserts that the additional arbitrary spacing introduced in his drawings merely increase the existing space that would have been there and that were "required" for placement of "intermediate signal lines." Ex. 1003, ¶¶ 360, 379, 428-429. But as shown in Figure 12, Phan already provides space for these lines between the quad-pixels. Further, if Dr. Pattison is correct that Phan's display requires different spacing between dots than are actually shown in Phan's figures (he is not), then it is unclear how Dr. Pattison can infer anything about the relative

distances between dots or between quad pixels in Phan's figures and how he can make any showing that all of the limitations of the challenged claims can be met.

252. Not only is the additional spacing added by Dr. Pattison unwarranted, it would undesirably reduce the aperture ratio of the display. It would require higher current density to be supplied to the green and red dot to maintain the same brightness they had before, causing those dots to degrade more quickly and reducing the life of the display. This would be contrary to Yamada's teachings.

253. Dr. Pattison also provides no reason why a POSITA would have modified Phan' Figure 11a to resize the dots in the manner he suggests to make the red dot larger than the green dots, rather than simply using the resized quad pixel structure Phan's Figure 11b. Yamada acknowledges that the emission efficiency varies depending on the materials used, and Dr. Pattison does not identify any reason why a POSITA would make the many modifications required to make his combination—which are inconsistent with the passive matrix structure of Phan and contrary to Phan's method of resizing dots—without establishing any need to. For example, Dr. Pattison does not identify what materials would be used, or what the relative emission efficiencies or chromaticity values would be for his target display, to justify resizing the dots in this manner.

2. Dr. Pattison oversimplifies Yamada and disregards that the prior art was critical of, and did not follow, Yamada's teachings.

254. Dr. Pattison argues that a POSITA would have been motivated to apply Yamada to Phan for the same reasons as for the Matthies combination. Ex. 1003, ¶¶ 433-437.

255. As I explained above in Sections X.B and X.D.2, Dr. Pattison misreads and misapplies Yamada by oversimplifying its teachings and failing to identify or analyze efficiencies and chromaticity values of materials in Phan's display as would be necessary under Yamada's own teachings. Further, Dr. Pattison disregards that the prior art criticized Yamada for failing to take into account important display characteristics and followed divergent paths away from the challenged claims. Dr. Pattison makes the same errors in his proposed combination with Phan as he does in his proposed combination with Matthies. Dr. Pattison's proposal to re-size Phan's pixels amounts to unsupported speculation. *See* Sections X.B, X.D.2.

3. A POSITA would not have been motivated to modify Phan's quad-pixel design, rather than its stripe pattern, in a combination with Yamada's stripe pattern.

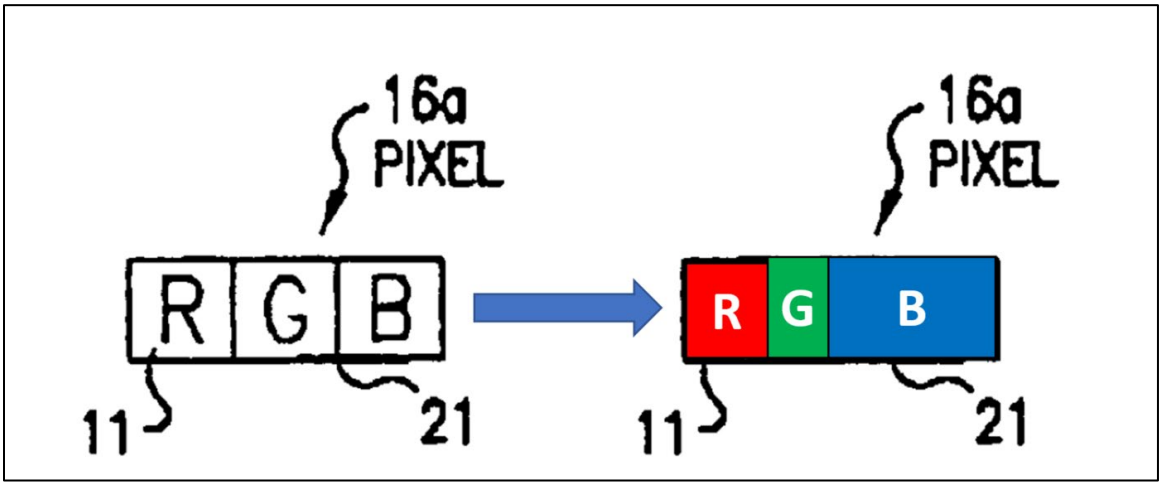
256. Even if a POSITA would have had a reason to modify Phan based on Yamada, a POSITA would have had no motivation to try to apply Yamada's teachings to Phan's quad pixel structure shown in Figure 11b, rather than Phan's RGB stripe structure, in making the combination.

257. Phan does not attribute any particular benefit to its quad pixel structures, and Dr. Pattison does not identify any reason for using Phan's quad pixel structure. Yamada does not use a quad pixel structure. Instead, Yamada only contemplates R/G/B triplet structures with one red, one green, and one pixel, for example in the RGB stripe arrangement, as evidenced by its reference to only "stripe," "delta," and "diagonal" layouts. Yamada, 12:37-43.

258. Phan discloses several different pixel structures besides the one quad pixel structure in Figure 11b on which Dr. Pattison relies. Figure 3 discloses several RGB stripe structures. Figure 3a, in particular discloses an RGB stripe structure that is the same as the RGB stripe used in Yamada. A POSITA would have understood that Yamada's RGB stripe structure is structurally more similar to the RGB stripe patterns described in Phan's Figures 3a and 3b. Dr. Pattison provides no explanation of why a POSITA would have been motivated to combine two fundamentally different pixel arrangements (*i.e.*, Phan's quad pixel structure and Yamada's RGB stripe structure), and why a POSITA would have had a reasonable expectation of success in arriving at the pixel arrangement structure claimed in the '803 Patent. If anything, a POSITA would have tried to apply Yamada's teachings to Phan's RGB stripe patterns shown in Figures 3a or 3b of Phan, for similar reasons as those discussed with respect to the combination of Matthies and Yamada above. Adjusting the sizes of Phan's red, green, and blue dots in its RGB structure would have had

fewer incompatibilities with Phan, including its passive-matrix structure, and would not have required reducing the aperture ratio of the display.

259. For example, below is an illustration showing how Figure 3a of Phan could have been modified in a combination with Yamada. On the left is Figure 3a of Phan, which shows the RGB stripe structure. On the right, I have modified the size of the red, green, and blue pixels according to Yamada. Note that, in this stripe arrangement, because the width of the pixels can be adjusted by changing the width of the column electrodes, making such combination with Phan's PMOLED display would be doable, whereas Dr. Pattison's proposed combination based on the quad pixel structure would be impracticable for the reasons discussed above. And this way of combining the references would increase the size of the blue pixels. Therefore, unlike Dr. Pattison's proposed combination, this way of combining the references would actually increase the life of the display.



260. In contrast, Phan does not disclose any quad pixel structure that could be resized to have a red dot larger than the green dot, absent wholesale changes to the structure of its display. Yamada also does not concern quad pixel structures. Thus, a POSITA would not have had any reason to make Dr. Pattison's proposed modification of Phan's quad pixel shown in Figure 11a in view of Yamada.

261. If a POSITA were to make any combination, a POSITA would have modified Phan's RGB stripe structure. Such a combination, however, even when tiled without spacing as Dr. Pattison would, would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1. Specifically, this structure fails to meet at least the following limitations:

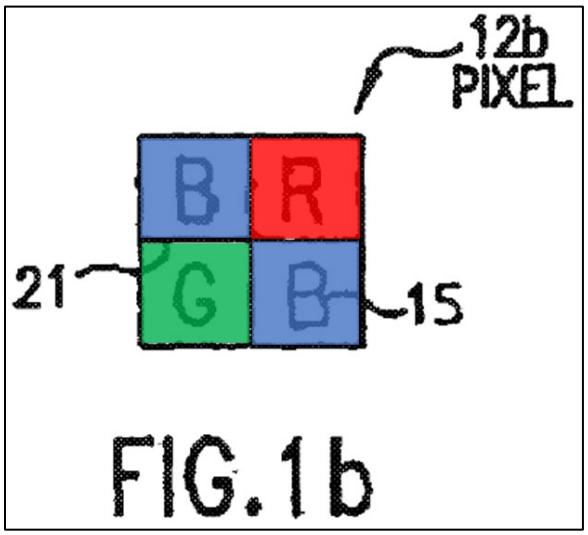
- "a first pixel having a center coinciding with a center of a virtual square;" (claim 1, limitation [1-a(1)])
- "a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;" (claim 1, limitation [1-a(2)])
- "another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and" (claim 1, limitation [1-a(3)])

- "a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square," (claim 1, limitation [1-a(4)])
- "wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and" (claim 2, limitation [2-a])
- "wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and" (claim 3, limitation [3-a])
- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])

4. Even if a POSITA tried to modify Phan's quad-pixel design based on Yamada's teachings, the modification would not meet the challenged claims

262. Even a POSITA had tried to modify Phan's quad pixel structure based on Yamada, a POSITA would not have had any reason to use the quad pixel structure with two green subpixels (an RGBG arrangement). The references that address the different efficiencies of materials for emitting different colors would actually have led a POSITA away from a quad sub-pixel structure having two green subpixels.

263. As discussed above, a POSITA would have known that, in a quad pixel structure, the lower emissive efficiency for a color pixel could be compensated for by using two pixels of that color in the quad pixel structure. *See, e.g.*, Matthies, 17:5-10; Ex. 2011, Fig. 5. Thus, if the blue pixel had the lowest efficiency, a POSITA would have expected that this could be compensated by using Phan's quad pixel structure with two blue dots. This structure, by doubling the blue emissive area, would allow the blue dots to be driven with a lower current density, thus extending the life of the display. As shown in the annotated version of Phan's Figure 1b below, Phan expressly teaches a quad pixel embodiment (and a display made up of such quad pixels) using two blue pixels which Dr. Pattison appears to disregard:



264. To the extent that the emission efficiency of materials for emitting blue color light was lower than the emission efficiency of other colors—which is the premise of Dr. Pattison's proposed combination—a POSITA would have recognized

that Phan already taught a quad pixel structure with more blue light-emitting area. A POSITA would have recognized that Phan's quad pixel structure with two blue dots would allow the blue dots to be driven with a lower current density, and thus increase the lifetime of the display, consistent with Yamada's objective. In contrast, if the emissive area of the blue dot with lowest emission efficiency were left unchanged (as it would be in Dr. Pattison's proposed combination), the life of the display would not be extended.

265. Dr. Pattison never alleges—nor could he—that a quad pixel structure with two blue dots would meet any of the challenged claims of the '803 Patent. This RBGB pixel structure, when tiled without spacing as Dr. Pattison would, would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1. Additionally, there is no "second pixel" that has a larger area than a "third pixel" as required by claim 1. Additionally, there are no "second pixels" and "third pixels" that each have larger areas than the "first pixel" as required by claim 5. Specifically, this structure fails to meet at least the following limitations:

- "a first pixel having a center coinciding with a center of a virtual square;" (claim 1, limitation [1-a(1)])

- “a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;” (claim 1, limitation [1-a(2)])
- “another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and” (claim 1, limitation [1-a(3)])
- “a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square,” (claim 1, limitation [1-a(4)])
- “wherein the second pixel has a larger area than that of the third pixel, and” (claim 1, limitation [1-b])
- “wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and” (claim 2, limitation [2-a])
- “wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and” (claim 3, limitation [3-a])

- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])
- "each of the second pixels and each of the third pixels has a larger area than the first pixel." (claim 5, limitation [5-b])

C. The combination of Phan and Yamada does not disclose a virtual square.

266. Dr. Pattison also fails to show that his proposed combination of Phan and Yamada would meet all of the limitations of claim 5 of the '803 Patent.

267. Claim 5 of the '803 Patent incorporates all limitations of claim 1, because claim 5 depends from claim 4, which depends from claim 3, which depends from claim 2, which depends from claim 1. '803 Patent, cls. 1-5. Claim 1 requires "a first pixel having a center coinciding with a center of a virtual square." It also requires "a second pixel" and "a third pixel" having centers at the vertices of the virtual square.

268. Dr. Pattison proposes that his modified quad-pixel arrangement based on re-sizing the dots in the quad pixel structure shown in Figure 11a of Phan would be used in the display of Figure 12 of Phan.

269. But just as in Ground 2, combining the embodiments in (Dr. Pattison-modified) Figure 11b and Figure 12 would not result in the virtual square required by claim 5. Dr. Pattison, again without acknowledgment or justification, draws a picture allegedly showing the combination of the modified quad pixel structure with

Phan's display of Figure 12, but removing the gaps between quad pixels clearly shown in Figure 12. As explained above, this is inconsistent with Phan, and a POSITA would not have been motivated to make such modifications or had a reasonable expectation of success in doing so, for the same reasons discussed above in Section XI.B.

270. If Dr. Pattison's modified quad pixel structure were used in the display matrix of Figure 12 of Phan, it would not have a first pixel having a center coinciding with a center of a virtual square:

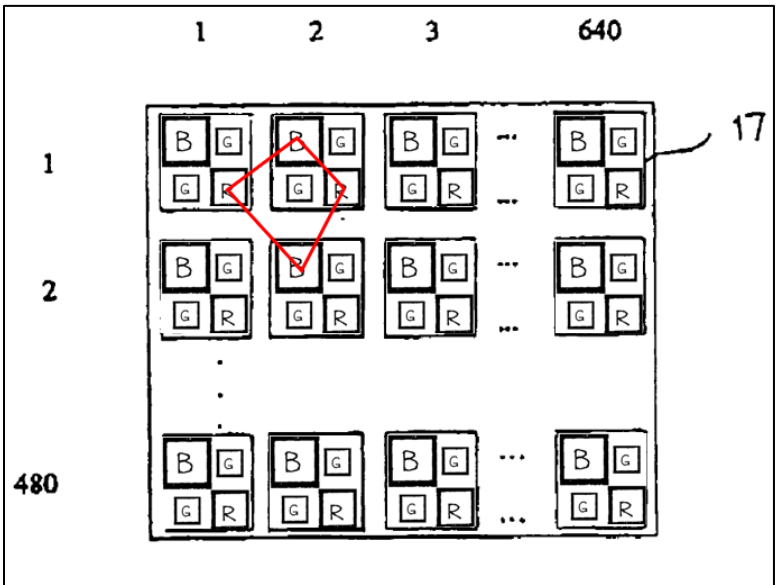


FIG. 12

271. Thus, the combination would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1 of the '803 Patent. Specifically, this structure fails to meet at least the following limitations:

- “a first pixel having a center coinciding with a center of a virtual square;” (claim 1, limitation [1-a(1)])
- “a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;” (claim 1, limitation [1-a(2)])
- “another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and” (claim 1, limitation [1-a(3)])
- “a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square,” (claim 1, limitation [1-a(4)])
- “wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and” (claim 2, limitation [2-a])
- “wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and” (claim 3, limitation [3-a])

- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])

XIII. GROUND 4: MURAI AND YAMADA DO NOT RENDER OBVIOUS CLAIMS 1–5 AND 19–21 OF THE '803 PATENT

272. For the reasons explained below, it is my opinion that the combination of Murai and Yamada fails to render obvious claims 1–5 and 19–21 of the '803 Patent.

A. The proposed combination of Murai and Yamada does not disclose an OLED display, or pixels of an OLED display.

273. As I explained in Section XI.A above, each of the challenged claims of the '803 Patent requires an OLED display and pixels of an OLED display.

274. In contrast to the claimed inventions of the '803 Patent, Dr. Pattison's combination of Murai and Yamada would not result in an OLED display or pixels of an OLED display.

275. Dr. Pattison does not propose implementing Yamada's OLED display in Murai; he only purports to re-size and re-shape the dots within each unit pixel in Murai's display shown in Figure 3, purportedly based on Yamada's teachings. But Murai's Figure 3 embodiment, like all of its other embodiments, is an LCD, not an OLED display.

276. Murai's "Background Art" section describes liquid crystal display devices. Ex.1007 at ¶ [0002]. The only detailed description of the structure of

Murai's displays describes a single thin-film transistor (TFT) for driving each dot. Murai, ¶¶ [0041]-[0043]. A POSITA would have understood that an LCD pixel can be driven with a single TFT, but that an OLED pixel requires at least two TFTs (a switching TFT and a driving TFT), because LCDs are voltage driven and OLEDs are current driven. Murai's further descriptions of the pixel electrode, holding capacitor electrode, and color filters are all further indicative of LCDs. Murai, ¶¶ [0040]-[0043]. The "Problem to Be Solved by Invention" section explains that the problem to be solved is "streaking" due to dots of the same color being adjacent and too close to each other—a problem that would only occur in displays using tightly-packed pixel arrangements, such as color LCDs. Murai, ¶¶ [0003]-[0005]. A POSITA would have understood this would not be a problem in other types of displays with substantial gaps between pixels, such as OLED displays. As discussed above in Sections V, XI.A, OLED displays have large gaps between adjacent pixels due to limitations in deposition techniques.

277. There is nothing in Murai that indicates to a POSITA that the Figure 3 embodiment that Dr. Pattison relies on is, or could be, an OLED display. The only arguable reference to OLED displays in Murai comes in a single passing sentence at the end of the specification that "[t]he color image display device according to the present invention can be applied to liquid crystal display devices, organic EL display devices, plasma display devices, projectors, and the like." Murai, ¶ [0058]. But

Murai does not explain how its LCD display solutions can be applied to an OLED display. Murai does not disclose or suggest that any of its figures, let alone Figure 3, represent how an OLED display (or any other display other than LCD) could or would be implemented.

278. As I explained in the background of the technology section, LCDs and OLED displays operate on fundamentally different principles, and these result in different structures and different manufacturing methods. *See* Section V. For example, LCD displays have a single layer of liquid crystal shared by multiple pixels, with pixel boundaries being defined by the locations of pixel electrodes and color filters. Adjacent pixels in an LCD thus run right up against each other, bounded only by thin black masks that demark boundaries of pixels by virtue of simply blocking the light from being seen by the user in that part of the display. On the other hand, organic materials for OLED displays are individually deposited due to their conductive nature, and due to limitations in deposition techniques, there must be significant gaps between adjacent pixels in an OLED display.

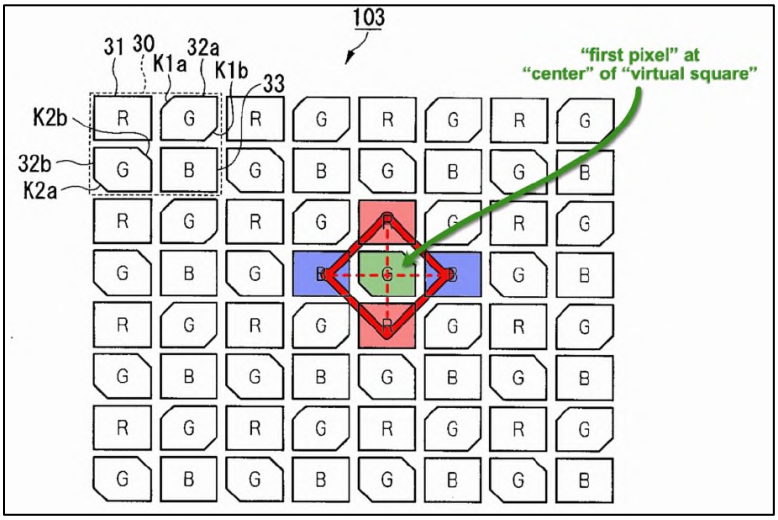
279. Given the substantial structural, manufacturing, and operational differences between LCDs and OLED displays, a POSITA would not have understood Murai's Figure 3 to represent how Murai could or would be applied to an OLED display.

B. The combination of Murai and Yamada does not disclose a virtual square.

280. Dr. Pattison's combination of Murai and Yamada also does not disclose a virtual square as described by the '803 Patent.

281. Each claim of the '803 Patent requires a "virtual square." Specifically, claim 1 requires "a first pixel having a center coinciding with a center of a virtual square." It also requires "a second pixel" and "a third pixel" having centers at the vertices of the virtual square. Dependent claims 2-4 place additional requirements on the virtual square. In order for Dr. Pattison's combination of Murai and Yamada to teach any of the claims of the '803 Patent, it must disclose a pixel arrangement in which the pixels form such a virtual square.

282. Dr. Pattison asserts that Murai's dots form the required virtual square, based on the following annotated image:



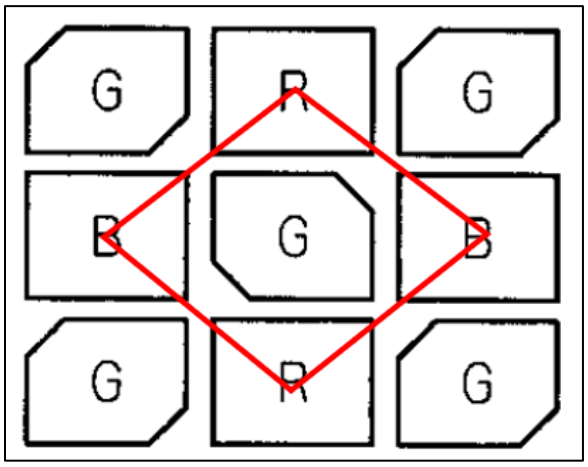
283. Dr. Pattison is simply incorrect. Upon closer inspection of the image, it clear that the bottom vertex of the alleged "virtual square" does not coincide with the center of the lower red dot; the bottom vertex is lower than where the center of that red dot would be. Further, the left and right vertices of the alleged "virtual square" do not coincide with the centers of the blue dots; the left vertex is too far right of the left blue dot to be at its center, and the right vertex is too far left of the right blue dot to be at its center. It also appears that the top vertex also appears to be placed slightly too high to coincide with the center of the top red dot.

284. The challenged claims require that the *center* of the pixels be located at the vertices of the virtual square:

- a second pixel separated from the first pixel and ***having a center at a first vertex*** of the virtual square; (claim 1, limitation [1-a(2)])
- a third pixel separated from the first pixel and the second pixel, and ***having a center at a second vertex*** neighboring the first vertex of the virtual square, (claim 1, limitation [1-a(4)])
- wherein the plurality of pixels further comprises another second pixel separated from the first pixel and ***having a center at a third vertex*** neighboring the second vertex of the virtual square, and (claim 2, limitation [2-a])

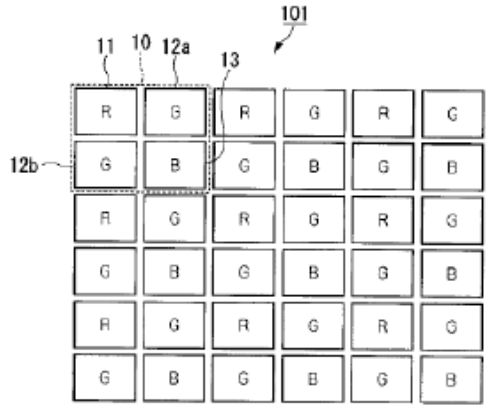
- wherein the plurality of pixels further comprises another third pixel separated from the first pixel and ***having a center at a fourth vertex*** neighboring the third vertex of the virtual square, and (claim 3, limitation [3-a])

285. When a quadrilateral centered at the center of a green dot is drawn with vertices of the quadrilateral located at the *centers* of second and third pixels as required by the challenged claims, it is clear that the quadrilateral is not a square, so no virtual square is formed. This is illustrated in the annotated version of claim 3, shown below. This makes sense that the shape is not a square, because the dots and unit pixels shown in Figure 3 are non-square rectangles (or non-square rectangles with symmetric corners cut off).

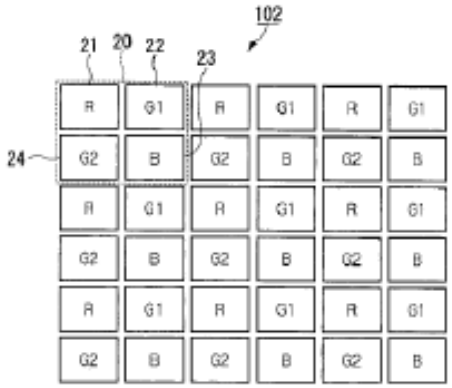


286. Figure 3 uses a rectangular dot shape and dots arranged in a rectilinear grid. As shown in the examples below, *every* figure shown in Murai uses rectangular dots, including Murai's "stripe" and "delta" embodiments (Figs. 7-8).

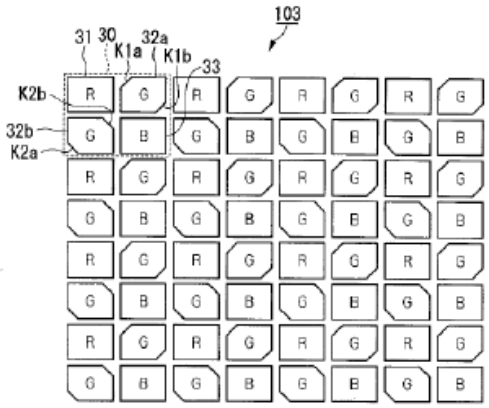
[FIG. 1]



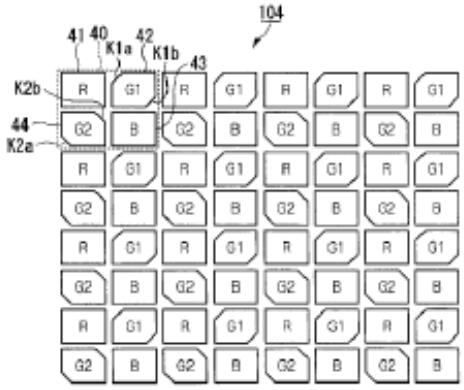
[FIG. 2]



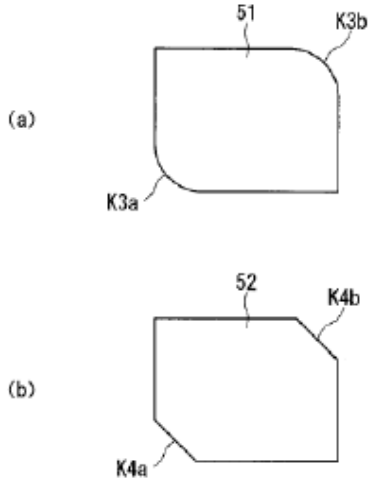
[FIG. 3]



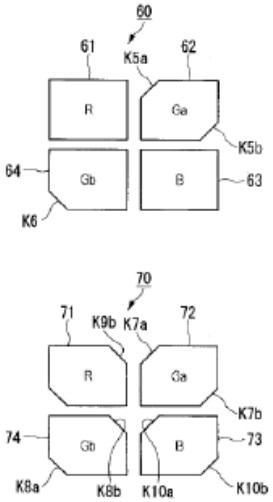
[FIG. 4]



[FIG. 5]



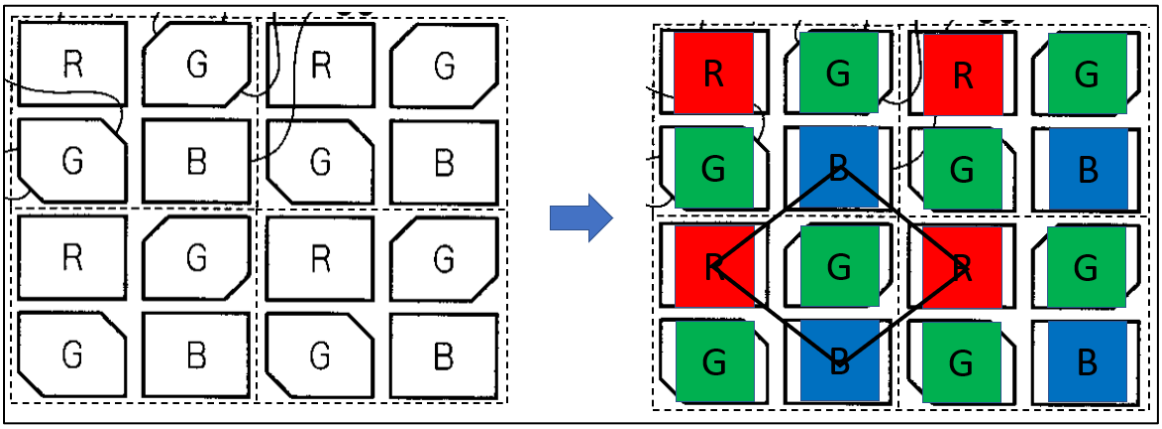
[FIG. 6]



287. In fact, Dr. Pattison admits that Figure 3 shows "slightly rectangular dots (which have a length somewhat greater than their height)," and that it is only with the use of "square dots" that the claimed "virtual square" shape results. Ex. 1003 at ¶¶ 476-478. But Dr. Pattison fails to explain why or how a POSITA would have modified what are clearly oblong rectangle shaped dots into square shaped dots. Dr. Pattison's only explanation is that "Murai explains that the dots are preferably square" Ex. 1003 at ¶ 477. But Dr. Pattison fails to note that, in every instance in which Murai mentions a square, the full sentence actually reads: "It is preferable for the rectangular shape thereof to be a square, but it may also be an ***oblong rectangle***," Murai, ¶¶ [0017], [0030], or "It is preferable for the rectangular shape thereof to be, for example, a square, but it may also be an ***oblong rectangle***," Murai, ¶ [0024]. And in each instance, the corresponding figure that the sentence describes actually does show a non-square rectangle: Murai ¶ [0017] is describing Figure 1, which as shown above clearly shows an oblong (non-square) rectangle shaped dots; Murai ¶ [0024] is describing Figure 2, which shows the same oblong (non-square) rectangle shaped dots; Murai ¶ [0030] is describing Figure 3, which shows the same oblong (non-square) rectangle shaped dots, as Dr. Pattison also acknowledges.

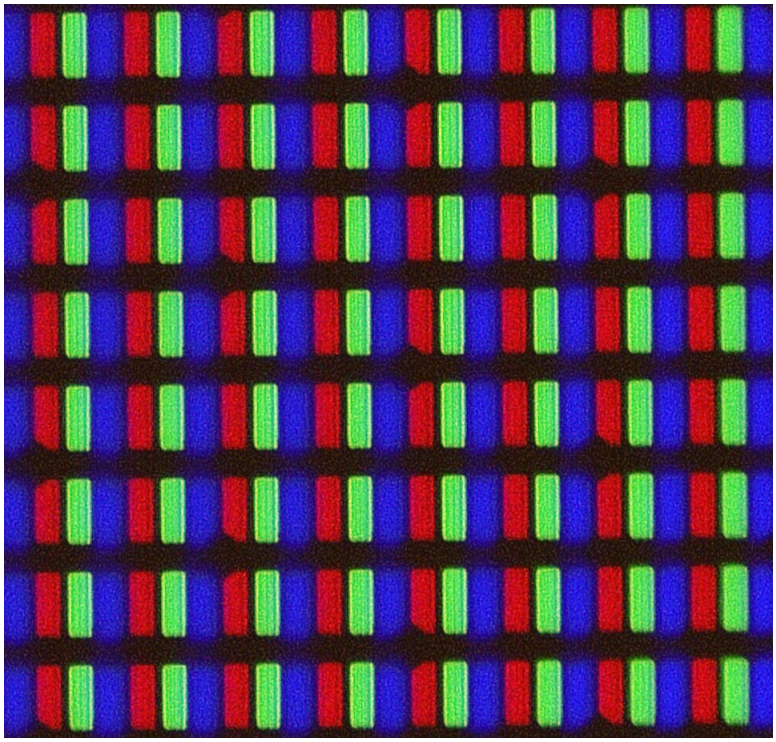
288. Dr. Pattison fails to even show what the resulting structure would look like, and thus fails to demonstrate how the virtual square limitations would be met by Figure 3 of Murai, even when using square dots.

289. Indeed, even if Figure 3 were changed to use square dots, the dots still would not form the "virtual square" required by the challenged claims. As shown in the figures above, Murai's "unit pixel" containing four grouped color dots (*i.e.*, quad-pixel) is rectangular with a differing length and height. Thus, in Murai's quad-pixel structure, a virtual square would not form even if the individual dots are squares, as shown in the annotated version of Figure 3 below, with dotted rectangles showing the quad-pixel structures. Notably, while Murai states that individual *color dots* can have a square shape, it never states, depicts, or suggests that the quad-pixel groupings can be square.



290. Additionally, even changing the dots' shapes and then further changing the spaces between the dots would not be enough to form the "virtual square" of the challenged claims. To form the virtual square, the edge-to-edge spacing between dots horizontally and vertically would need to be the same, and no extra spacing between quad-pixel groupings could be included for power or signal lines. But Murai does not state or imply that the horizontal spaces and the vertical spaces between the

dots are equally sized. Indeed, the prior art in LCD pixel arrangement structures is replete with examples of unequal horizontal and vertical spacing between sub-pixels. One example from a real display is shown below:

 [16]

291. Yamada provides another example. Yamada discloses having different spacings between columns of pixels compared to the spacings between rows of pixels, due to the different number of types of power and signal lines running between the pixels in the vertical and horizontal directions:

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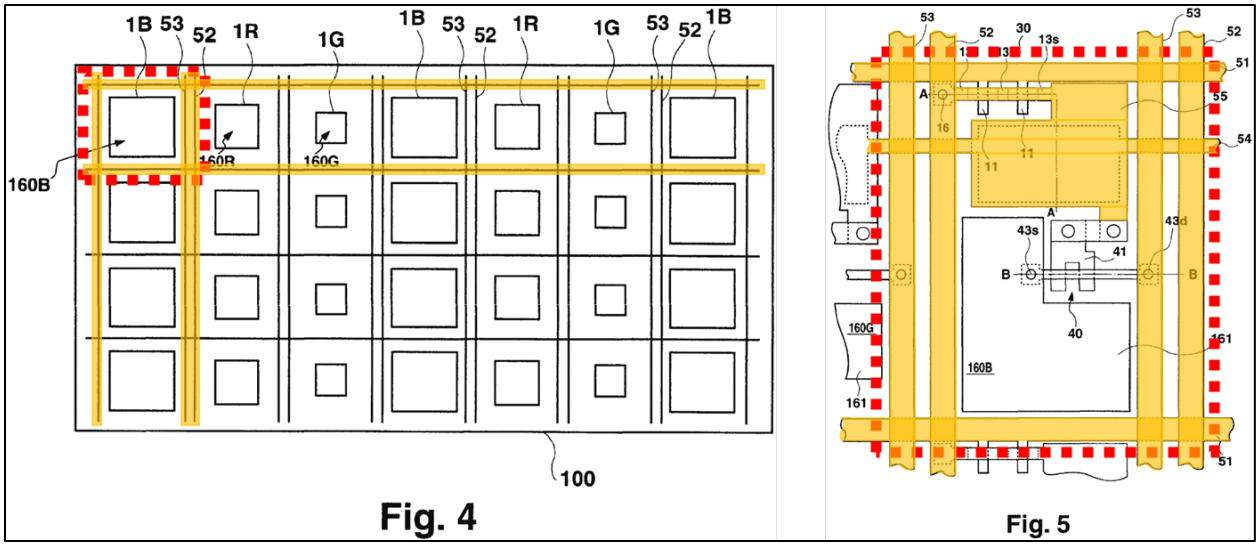
[16] https://www.exploratorium.edu/sites/default/files/PicturesPhonesPixels_I012_P960.jpg, from https://www.exploratorium.edu/snacks/pixels-pictures-phones.



Yamada, Figs. 4, 5 (annotated), 1:23-33, 6:55-60; *see also* Matthies at 17:31-33 ("[I]t is contemplated that [the spaces between the pixels in the horizontal and vertical directions] may be different."). Further, a POSITA would recognize that an OLED display would need to accommodate additional signal lines compared to Murai's LCD displays. For example, because OLEDs are current-driven and not voltage-driven, they would require at least two TFTs, and would further require more complicated pixel circuits to compensate for manufacturing variations, which could result in transistors having different threshold voltages, which would result in a non-uniform display.

292. Dr. Pattison's assertion that Figure 3 does disclose the claimed virtual square relies on a misreading of Murai. First, Dr. Pattison states that:

> 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.)

Ex. 1003 at ¶ 474. This is plainly not what Murai says. Murai ***never*** says that the ***dots*** are "regularly disposed." Murai instead states that "***each unit pixel*** can easily and accurately be regularly disposed." Murai, ¶ [0010]. Thus, Dr. Pattison's inference that all of the ***dots*** are "equally spaced from each other" is unfounded. Further, Dr. Pattison has no support for his bare assertion without any factual support or explanation that a POSITA would understand Murai's reference to "regularly disposed" to mean equally spaced on all sides, and in fact Murai's disclosure shows that interpretation is wrong. As noted above, both in the figures and text, Murai explicitly discloses embodiments with oblong rectangular dots and oblong rectangular unit pixels, such as Figure 3. And the same sentence of Murai that mentions the unit pixels being "regularly disposed" states that "the unit pixel is configured using four dots disposed in a ***rectangle*** made up of four ***rectangles***, so each unit pixel can easily and accurately be regularly disposed." Murai, ¶ [0010]. Thus, these references to rectangles must of course include the "oblong rectangle" shapes that Murai describes in its embodiments—that is not only the ordinary meaning, it's the only reading consistent with the embodiments of Murai that describe oblong rectangles. Dr. Pattison is wrong to read "regularly disposed" to require exclusively a ***square*** grid. A non-square rectangular grid of unit pixels is still

"regularly spaced" because the distance between every pair of horizontally adjacent unit pixels is the same throughout the display, and the distance between every pair of vertically adjacent unit pixels is the same throughout the display. (And even if Murai had meant that the dots must be "regularly spaced," a non-square rectangular grid of dots would be regularly spaced because the horizontal distance between dots is the same throughout and the vertical distance between the dots is the same throughout.) There is no reason that a POSITA would assume that "regularly disposed" means "equally spaced" both in the horizontal and vertical directions. That is contrary to the understanding of a POSITA as well as Murai's explicit disclosures.

293. Second, Dr. Pattison states that:

> Murai explains that its square dots are regularly spaced, surround one point, are disposed at diagonals from each other, and are arranged in groups of four forming a rectangular shape (which is preferably square). (*E.g.*, *id.*, ¶ [0017]; *see also id.*, ¶¶ [0006], [0010], [0032].)

Ex. 1003 at ¶ 479. This is also plainly not what Murai says. As an initial matter, Murai says nothing specifically about the relationship between square dots; Murai's descriptions of square dots are limited to the three sentences quoted above. Further, Murai ***never*** says that its dots, square or otherwise, "are arranged in groups of four forming a rectangular shape (which is ***preferably square***)." Murai simply does not say the dots are arranged to together form a square. Murai only states that the dots

within each unit pixel "make up a rectangle made up of four rectangles." *See, e.g.*, Murai, ¶¶ [0010], [0017], [0024], [0032].

294. Dr. Pattison's misreading of Murai leads him to incorrectly assert that the "yellow and orange box" shown in his further annotation of Murai's Figure 3 is a "square" that represents the distance between centers of four adjacent dots, that the distance between Murai's dots is "the same distance *x* between all of its adjacent dots," and ultimately that "the red box is a square." It is not, for the reasons I just explained.

295. Thus, neither Murai's quad-pixel structure with oblong rectangle shaped dots, nor Murai's quad-pixel structure with square shaped dots, in combination with Yamada, satisfies any of the challenged claims. Either combination would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1 of the '803 Patent. Specifically, these structures fail to meet at least the following limitations:

- "a first pixel having a center coinciding with a center of a virtual square;" (claim 1, limitation [1-a(1)])
- "a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;" (claim 1, limitation [1-a(2)])

- “another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and” (claim 1, limitation [1-a(3)])
- “a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square,” (claim 1, limitation [1-a(4)])
- “wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and” (claim 2, limitation [2-a])
- “wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and” (claim 3, limitation [3-a])
- “wherein the second pixels and the third pixels enclose the first pixel in the virtual square.” (claim 4, limitation [4-a])

C. A POSITA would not have been motivated to combine Murai and Yamada.

296. Murai and Yamada are incompatible technologies, and a POSITA would have had no reason to combine Murai's LCD display in Figure 3 with Yamada to resize its pixels.

297. As discussed above, each of Murai's embodiments, including Figure 3, describe LCD devices. Yamada's teachings regarding the purported need to re-size the emissive areas of different color pixels because different materials for emitting different color light have different emission efficiencies is thus simply inapplicable to Murai's LCDs. As I explained above, LCDs do not contain organic emissive layers. The backlight unit of an LCD provides one uniform color of light, which is modulated by the liquid crystal layer, and then passed through color filters to control for color. Yamada's basic premise for the need to re-size pixels—the differential efficiency of organic emissive materials for different color light—does not exist in LCD, and has no relevance to LCDs. Thus, a POSITA would not have been motivated to modify Murai's pixel sizes based on Yamada.

298. Further, Murai's disclosures—including its very reason for having cut-off corner portions in the green dots in Figure 3—are incompatible with Yamada's teachings. Murai's goal is to "improve[]" the "aperture ratio" (*i.e.*, the light-emitting area of the display) by packing pixels very closely together. Murai, ¶¶ [0010], [0042].

Dr. Pattison's proposed modification of Murai, purportedly based on Yamada's teachings, would *reduce* the display's aperture ratio, and do so for no benefit.

299. Additionally, Dr. Pattison's proposed modification of Murai ignores the reasons for Murai's cut-offs, which are incompatible with Yamada's teachings. Murai, in the context of LCD displays having packed dots placed closely together, observes that diagonal lines of green dots can create visible streaks. Murai, ¶¶ [0004]-[0005]. Thus, Murai's solution to avoid these unwanted streaks is to cut out alternating corners on adjacent green dots to increase their separation, while maximizing the light-emitting area. Murai, ¶¶ [0008], [0010], [0011], [0012], [0042]. Thus, every embodiment shows cut-off corners on the green dots, Murai, Figs. 3, 4, 6(a), 6(b), with certain specific embodiments with smaller or fewer cut-off corners in the green dots to improve "visual connectivity" of individual unit pixels, Murai, Fig. 6(a), or additional cut-off corners in red and blue dots to further reduce the streaking effect, Murai, Fig. 6(b).

300. But as I've explained above, due to manufacturing limitations of OLED displays, different color pixels in OLED displays must be spaced much farther apart than they could be in an LCD, and a POSITA would not have viewed Murai's cut-off corners as necessary in an OLED display to reduce a streaking effect: the pixels would simply not be so close that they could have a streaking effect. Indeed, because the OLED pixels would be so far apart, the OLED display may in fact have the

opposite problem: for example, it may be desirable to display a green diagonal line, but that line may not appear as one continuous line, but instead a series of discrete points. Nor would cut-off corners like in Murai's have been beneficial in an OLED display. In Murai's structure, the shortest distance between adjacent pixels is either in the vertical or horizontal directions, rather than in the diagonal directions. Because the limiting dimension for manufacturing OLED pixels is the shortest distance between two adjacent pixels, cutting off corners in an arrangement like Murai's would achieve nothing, while reducing the aperture ratio and the emissive area of the display, resulting in reduced lifetime and/or reduced brightness.

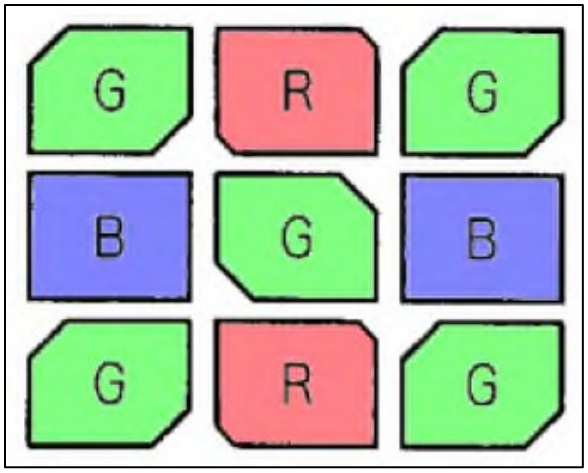
301. Further, Yamada's disclosed emissive area ratios of 1:2.6:5.6 between green, red, and blue pixels—which Dr. Pattison cites, Ex. 1003 at ¶ 508 (citing Yamada at 11:4-15), or the alternative ratio 1:14.2:35 Yamada at 11:34-39)—would result in such large cut-off corners and separations between green dots that it would nullify the reason for implementing Murai's cut-off corners. A POSITA would not have been motivated to make this combination, nor had a reasonable expectation of success given their conflicting approaches and goals.

D. A POSITA would not have been motivated to combine Murai and Yamada in the manner proposed by Dr. Pattison.

302. Even if a POSITA had tried to combine Murai with Yamada, a POSITA would not have sought to resize Murai's dots by keeping the blue dot size the same

with no cut-offs, reducing the size of the red dots by making two small cut-offs, and further reducing the size of the green dots to have two large cut-offs. A POSITA would have no reason to make these modifications.

303. ***First***, Dr. Pattison's proposed modifications are inconsistent with Yamada's teachings. Dr. Pattison proposes making small cut-offs to Murai's red dots, and slightly larger cut-offs to Murai's green dots, as illustrated in Dr. Pattison's demonstrative reproduced below. Ex. 1003 at ¶ 511. But in this proposed combination, the sizes of the emissive areas remain largely unchanged, contrary to Yamada's disclosure of achieving a balanced pixel luminance by adjusting the relative sizes of pixels according to emission efficiency of the organic light emitting material. Notably, Yamada's own calculations for pixel areas based on the organic materials it used in its embodiments resulted in significantly smaller green pixels in Dr. Pattison's other combinations with Matthies and Phan based on Yamada, than Dr. Pattison proposes would be made in the combination with Murai. Thus, Dr. Pattison's proposed modifications of Murai would reduce the aperture ratio and thus undercut Murai's purpose of improving the overall aperture ratio of the display, and simultaneously fail to adequately account for the differences in efficiency of the different organic light-emitting materials (assuming that the Murai display could somehow even be implemented as OLED pixels in the first place).



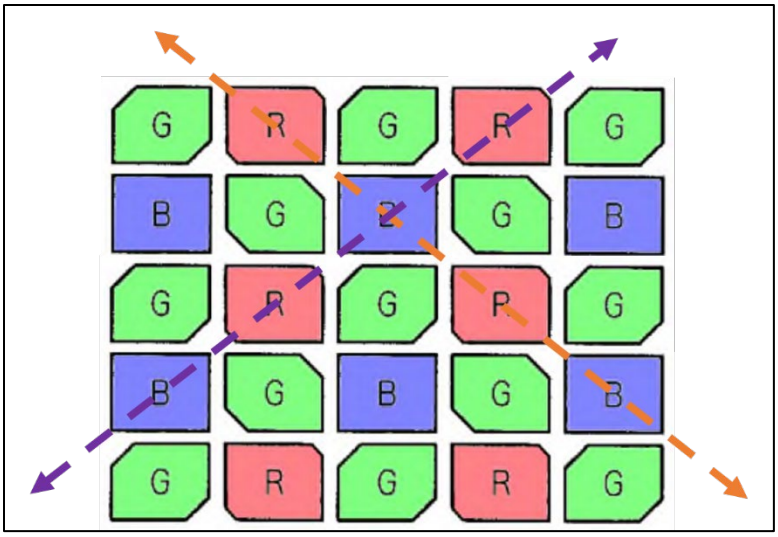
304. Unlike for its other Grounds, Dr. Pattison asserts that pixel sizes should be changed by making relatively small cut-offs from corners of pixels (allegedly according to Murai, although Murai does not disclose cut-offs of such a substantial size to sufficiently change pixel size for the type of purpose Yamada re-sizes pixels for: balancing emissive efficiency and luminance), instead of using the approach for re-sizing pixels that Dr. Pattison alleges Yamada teaches (*i.e.*, shrinking pixels equally from all sides, allegedly based on Yamada Fig. 4). But in analyzing Ground 3, although Phan also specifically taught how to resize its own pixels, Dr. Pattison alleged that a POSITA in that instance would have abandoned Phan's method for re-sizing pixels and instead used Yamada's purported approach. Dr. Pattison does not offer any explanation for his different approaches to making the combination of references in this Ground; no justifiable reason seems to exist.

305. ***Second***, again assuming that Murai's pixel structure could be applied to OLEDs, a POSITA would have understood that reducing the sizes of the green

and red dots while keeping the blue dots the same size would not extend the overall lifetime of Murai's display, for the same reasons discussed above in Sections X.A.3, X.B. In brief, according to Dr. Pattison's theory underlying his proposed combination with Yamada, blue OLED materials have lower emission efficiency, requiring blue pixels to be driven at a higher current density which promotes degradation of the organic material, shortening its lifetime. Yamada, 2:60-67; 11:11-15. But Dr. Pattison's proposed combination to keep blue dots the same size would maintain, not reduce the current density applied to the blue dots and thus would not extend the lifetime of the display. At the same time, Dr. Pattison's proposed combination would require increasing the current density applied to each of the red and green dots to maintain the same luminance and brightness, shortening the lifetime of those pixels and thus reducing the lifetime of the display. A POSITA would have had no reason to make such changes to Murai.

306. ***Third***, assuming that it were possible to make an OLED display as densely packed as Figure 3 of Murai, and assuming it were possible to make cut-offs at the corners of the dots as Murai teaches, Dr. Pattison's proposed combination would have introduced unwanted visual artifacts, contrary to Murai's purpose of removing visual streaking effects and achieving a display with a high quality appearance. *See, e.g.*, Murai, ¶¶ [0005]-[0014]. Specifically, by making Dr. Pattison's proposed combination, a diagonal of red and blue dots running from the

top-left to the bottom-right of the display would exhibit a different degree of color mixing and streaking effects than a diagonal of red and blue dots running from the top-right to the bottom-left of the display, because a corner cut-offs of different sizes would be made in the corners for one diagonal than the other. For example, in the illustration below, I have taken the 3x3 pixel array drawn by Dr. Pattison and tiled it to form a 2 more rows and 2 more columns. When looking along the orange diagonal, there are 0 cut-off corners along that diagonal. On the other hand, when looking along the purple diagonal, there are 2 cut-off corners in each red pixel along that diagonal. This would result in an asymmetry in the degree of color mixing and streaking effects in images along the two diagonals. In contrast, none of Murai's embodiments suffer from this asymmetry introduced by Dr. Pattison's proposed combination because the blue and red dots are always equally sized in Murai's embodiments. A POSITA would have had no motivation to make Dr. Pattison's proposed modifications, and would not have had a reasonable expectation of success.



307. Even if a POSITA had tried to modify Murai's quad pixel structure based on Yamada, a POSITA would not have had any reason to maintain the quad pixel structure with two green dots (an RGBG arrangement). The references that address the different efficiencies of materials for emitting different colors would actually have led a POSITA away from a quad pixel structure having two green dots. In particular, Given Yamada's teaching that blue OLED materials have lower emission efficiency, a POSITA would have sought to double the emissive area of the blue dots by employing two blue pixels in Murai's quad-pixel structure, assuming Murai's display were OLED. As discussed above, the prior art cited by Dr. Pattison, such as Matthies and Phan, each disclosed quad pixel structures with two blue pixels, and Matthies taught a POSITA to double up on the blue sub-pixels in a quad sub-pixel structure when the blue-emitting material is less efficient. *See* Sections X.D.1, XII.A, XII.B.4. Doing so would improve the overall brightness of

the display without increasing the current density applied to the blue pixels, and the life of the display would not be reduced, consistent with Yamada's aims. And as discussed above, the resulting quad pixel structure with two blue dots, one green dot, and one red dot, would fail to meet any of the challenged claims of the '803 Patent. This RBGB pixel structure, when tiled, would result in a structure that fails to meet any of the challenged claims of the '803 Patent. There is no "first pixel" (green) that has a center coinciding with a center of a virtual square as required by claim 1. Additionally, there is no "second pixel" that has a larger area than a "third pixel" as required by claim 1. Additionally, there are no "second pixels" and "third pixels" that each have larger areas than the "first pixel" as required by claim 5. Specifically, this structure fails to meet at least the following limitations:

- "a first pixel having a center coinciding with a center of a virtual square;" (claim 1, limitation [1-a(1)])
- "a second pixel separated from the first pixel and having a center at a first vertex of the virtual square;" (claim 1, limitation [1-a(2)])
- "another first pixel on a line defined by the center of the virtual square and the first vertex, the first pixel, the second pixel, and the other first pixel being consecutive pixels on the line from among the plurality of pixels; and" (claim 1, limitation [1-a(3)])

- "a third pixel separated from the first pixel and the second pixel, and having a center at a second vertex neighboring the first vertex of the virtual square," (claim 1, limitation [1-a(4)])
- "wherein the second pixel has a larger area than that of the third pixel, and" (claim 1, limitation [1-b])
- "wherein the plurality of pixels further comprises another second pixel separated from the first pixel and having a center at a third vertex neighboring the second vertex of the virtual square, and" (claim 2, limitation [2-a])
- "wherein the plurality of pixels further comprises another third pixel separated from the first pixel and having a center at a fourth vertex neighboring the third vertex of the virtual square, and" (claim 3, limitation [3-a])
- "wherein the second pixels and the third pixels enclose the first pixel in the virtual square." (claim 4, limitation [4-a])
- "each of the second pixels and each of the third pixels has a larger area than the first pixel." (claim 5, limitation [5-b])

308. Dr. Pattison argues that a POSITA would have been motivated to apply Yamada to Murai for the same reasons as for the Matthies and Phan combinations. Ex. 1003, ¶¶ 547-552.

309. As I explained above in Sections X.B and X.D.2, Dr. Pattison misreads and misapplies Yamada by oversimplifying its teachings and failing to identify or analyze efficiencies and chromaticity values of materials in Murai's display as would be necessary under Yamada's own teachings. Further, Dr. Pattison disregards that the prior art criticized Yamada for failing to take into account important display characteristics and followed divergent paths away from the challenged claims. Dr. Pattison makes the same errors in his proposed combination with Murai as he does in his proposed combination with Matthies and Phan. Dr. Pattison's proposal to re-size Murai's pixels amounts to unsupported speculation. *See* Sections X.B, X.D.2.

XIV. OBJECTIVE INDICIA OF NON-OBVIOUSNESS OF THE CHALLENGED CLAIMS

310. I have been asked by counsel for Samsung Display to provide my opinion on whether objective indicia of non-obviousness apply to the challenged claims. As I explain below, it is my opinion that the claimed inventions of the '803 Patent satisfied a long-felt but unmet need, overcame industry skepticism, that others failed while Samsung Display was successful, and that others copied the claimed inventions of the '803 Patent.

A. Long-felt But Unmet Need

311. It is my opinion that the inventions of the challenged claims of the '803 Patent satisfied long-felt but unmet needs.

312. Samsung Display pioneered the successful commercialization of AMOLED displays in 2007 and has since continued to lead the display industry in research and development of AMOLED display technologies.

> In early 2007, Samsung Display confirmed AMOLED's marketability by applying a handful of small and medium-sized OLED panels . . . In September and October of the same year, a mass production line started its official operation in Cheonan, South Chungcheong Province . . . At the time when Samsung Display announced its intention to mass-produce small and medium-sized OLED products, other global companies expressed little interest, dismissing it as having no marketability . . . Samsung Display has emerged as an unparalleled powerhouse in the current small and medium-sized OLED display market thanks to its endeavors to walk down the uncharted path that no other competitors had taken before. According to a Samsung Display official, "Ever since the official mass production of AMOLED panels, Samsung Display's small and medium-sized AMOLED panel technology has also made rapid progress along with the development of mobile IT devices."

Ex. 2064 at 5-6.

313. But AMOLED displays at the time, particularly AMOLED displays for mobile devices such as smartphones and tablets, suffered from low display resolution and image quality. As reported in the Hankyung News in November 2013:

> People have said that it would ***not be easy to realize the full HD*** (1920 × 1080 pixels) definition with active-matrix organic light-emitting

> diode (AMOLED) display. It was also said that even with the successful development of full HD AMOLED panel, securing a sufficient yield rate (ratio of finished products) for mass production will be difficult . . . However, it is difficult for the resolution of the small-sized displays to be at the level of full HDs as the pixels are realized by evaporating the light emitting organic materials. This is why even some internal voices at Samsung Display opined that that AMOLED should be abandoned and pursue LCD instead.

Ex. 2065 at 5-6 (emphasis added).

314. As another example, a Korea Industry Post article from March 2013 observed that "[r]eaching the high-resolution point with true pixel densities greater than 300 pixels per inch (ppi) has been a challenge for AMOLED displays, as it is ***difficult to achieve dense pixel arrangements*** . . . while still securing enough display brightness and not compromising power consumption"). Ex. 2013 at 3 (emphasis added).

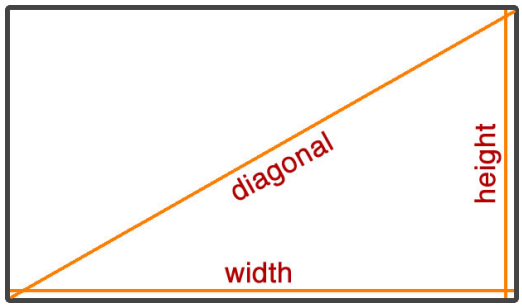
315. There was a longstanding need in the industry for pixel arrangements that would allow the mass-production of mobile device AMOLED displays with high resolution and high pixel densities (measured as pixels per inch or "PPI") while ensuring sufficient aperture ratio and adequate pixel lifetime, all in order to support "full high definition" displays.

316. Full high definition or "full HD" resolutions typically require 1920 x 1080 pixels to be present on a display screen. By the time of the '803 Patent, "there

[wa]s a tremendous amount of . . . 1920x1080 content available" and "[d]isplaying that content at its native resolution (without the need to rescale up or down)" was understood to "result[] in the best possible image quality." Ex. 2014 at 2.

317. Therefore, the technical challenge leading up to the inventions of the '803 Patent for display manufacturers was being able to manufacture small/medium-sized AMOLED displays that are suitable for use in mobile devices with *pixel densities* that are sufficiently high to enable the packing of 1920 x 1080 pixels on the display (*i.e.*, full HD).

318. Pixel densities are commonly expressed as pixels per inch or PPI. PPI indicates how many pixels are on a 1-inch line on a display. Calculating a display's PPI involves two steps. First, the Pythagorean Theorem and the screen's width and height in pixels (*e.g.*, 1920 pixels in width and 1080 pixels in height) are used to calculate the screen's *diagonal* length in pixels.



$$diagonal\ (pixels) = \sqrt{width\ (pixels)^2 + height\ (pixels)^2}$$

Then, to calculate the PPI, the display's diagonal length in pixels is divided by the length of the diagonal in inches.

$$PPI = \frac{diagonal\ (pixels)}{diagonal\ (inches)}$$

319. Thus, in order to enable full HD on an AMOLED display for a typical mobile device measuring 5.5 inches diagonally, the AMOLED display must have a pixel density of 400 ppi (or more).

$$\sqrt{1920\ width\ (pixels)^2 + 1080\ length\ (pixels)^2} \cong\ 2{,}203\ diagonal\ (pixels)$$

$$\frac{2{,}203\ diagonal\ (pixels)}{5.5\ diagonal\ (inches)} \cong 400\ PPI$$

320. Increasing the pixel densities in AMOLED displays was not a straightforward task for display companies, as factors such as manufacturing limitations, pixel aperture ratio (and display brightness/luminance), organic material lifetime, and power consumption were intertwined with the packing of additional pixels on a display. U.S. Patent No. 9,697,760 (Ex. 2015) assigned to BOE provides an in-depth discussion of these challenges:

> In practice, the resolution of a display device can be improved by increasing Pixels Per Inch (PPI) of the display device . . . Above all, the following technical problems usually occur in the display devices of the related art:
>
> 1) The actual display resolution of a display device is the same as the physical resolution thereof. To obtain higher display resolution, it is needed to improve the physical resolution of the display device by increasing the number of sub-pixels. As described above, ***it is difficult***

to further increase the resolution when the number of sub-pixels increases up to a certain amount, due to the limit of the improvement to the process;

2) The fact that the number of sub-pixels in a display device is large results in large number of data lines, and thus ***increases the power consumption of the display device and reduces the aperture ratio of the display device*** (Generally, the aperture ratio in the art refers to the ratio of the area of light-emitting region in the pixel region and the area of the repeatable pixel unit in the display region. The larger the aperture ratio is, the lower the required brightness of each pixel light-emitting region is and the lower the current density of the brightness of the light-emitting region is so as to achieve the same display brightness). ***When the resolution is high, it is hard to ensure the aperture ratio of sub-pixel, which may influence on the characteristics of the products, such as lifetime, brightness*** and the like, consequently.

3) The number of sub-pixels in the display device is large, and the area of each sub-pixel is small, which thus causes the manufacture process of the display device to have great difficulties and high cost. Take the organic light emission display (referred to as OLED) for example, in the related art of manufacturing top-emitting active matrix organic light emission diode (AMOLED), since the fine metal mask (referred to as FMM) usually has limitation to the minimum opening when used for evaporating the pixels arranged in parallel, the sub-pixels with different colors have limitations to the distance between the openings. ***Thereby, the manufacture process of the display device is inevitably limited to the area of openings of the fine metal mask and the precision of***

evaporation process, which causes the difficulty in implementing the display device with high resolution.

Ex. 2015 at 1:40-2:22 (emphases added).

321. A 2006 Society for Information Display ("SID") paper likewise explains that "physical limitations of manufacturing" were "bottlenecks of achieving high display resolution on active-matrix OLED displays," with "the highest resolution" limited to "about 180ppi." Ex. 2016 at 1. On a typical smartphone with a 5 inch diagonal display, the resolution on a 180ppi display would be just over 720x480 pixels, which is comparable to the resolutions available on VHS tapes used in the 1980s and 1990s.

322. The longstanding challenge to develop higher resolution AMOLED displays for mobile devices that could be produced at commercial scales was made especially difficult because of manufacturing challenges with OLEDs, and particularly with depositing the light-emitting organic materials. By the time of the inventions (and even today), fine metal mask ("FMM," also referred to as "shadow mask") had become the "most common method for patterning primary colors for full color AMOLED" displays. Ex. 2017 at 4 (explaining that "it is almost impossible to realize a resolution higher than 230ppi in a mass production environment" using FMM). FMM was understood as having "many disadvantages" even though the

display industry was heavily relying on it. For example, a 2007 patent publication by researchers at AU Optronics Corp. states that:

> *Lower resolution of the panel:* … the area of the opening of the [fine metal] mask determines the resolution of the organic electroluminescent panel, and the resolution of the conventional full-color panel is limited to the process capability. The resolution of the conventional panel adopting the shadow mask process is … usually not more than 180 ppi.

Ex. 2018 at [0009].

323. Because of the difficulties posed by FMM manufacturing, display manufacturers considered alternative methods to pattern organic materials, including inkjet printing and laser-induced thermal imaging ("LITI"). However, these alternative methods did not show sufficient promise to be used for commercial scale manufacturing of high pixel density AMOLED displays. In addition, manufacturers had already expended significant resources to utilize FMM in their AMOLED manufacturing lines, including to set up "all kinds of equipment[] such as mask fabrication, … precise alignment system[s], … mask chamber[s], … mask cleaning system[s], and mask inspection equipment." Ex. 2018 at [0007].

324. In 2007 (just after the start of Samsung Display's successful mass-production of AMOLED displays), the authors of the "Advances in AMOLED

Technologies" chapter in a 2008 textbook on mobile displays titled "Mobile Displays Technology and Applications" wrote:

> The merging of several multimedia applications such as DSC, cellular phones, and DMB into one mobile device will become a trend in the near future. It makes the development of high resolution a critical factor in OLED displays. However ***the limitations of FMM for high resolution will become a key issue when it comes to considering mass production***.

Ex. 2019 at 23 (emphasis added). And in December 2010 (about a year before the inventions of the '803 Patent), LG Display's researchers wrote that "the key challenging issue" for "AMOLEDs for mobile application" was the "limitation on . . . realizing a high resolution[,]" Ex. 2020 at 3, with "the highest display resolution resulting from the use of a shadow mask [being] about 230 ppi." *Id*. at 4.

325. In order to successfully design an AMOLED display with sufficiently high pixel densities for a full HD display, it was understood that the specific shapes, sizes, and layouts of the red, green, and blue sub-pixels (pixel arrangements) would be key to overcoming manufacturing limitations such as FMM. As explained by researchers at AU Optronics ("AUO"):

> [The] arrangement of the sub-pixel devices may pose a considerable level of difficulty in the display panel manufacturing process…The resolution of an OLED display panel depends on the opening dimensions of the shadow mask…Misalignment in the sub-pixel

> devices results in problems such as no deposition of the organic layer and thus the short-circuiting of the lower electrode and the upper electrode of the sub-pixel device, and deposition of the organic layer in an adjacent sub-pixel, which causes mixing of colors or non-emission of light.

Ex. 2021 at [0004]. The '803 Patent likewise discusses the impact of pixel arrangements on critical display characteristics such as aperture ratio: "An organic emission layer included in the pixel of an OLED display may be deposited and formed by using a mask such as a fine metal mask (FMM). When reducing a gap between the neighboring pixels to obtain a high aperture ratio of the pixel, deposition reliability may be deteriorated. On the other hand, when increasing the gap between the pixels to improve the deposition reliability, the aperture ratio of the pixel may be deteriorated." '803 Patent at 1:38-45.

B. Overcoming Industry Skepticism

326. As I explained above, the industry recognized a longstanding technical need for higher resolution displays with high pixel densities, sufficient aperture ratio, and manufacturability that would make them suitable as full HD AMOLED displays. Because of the significant challenges with their research and development, the industry was skeptical that any company or research group could develop a pixel arrangement that would enable the manufacture of full HD AMOLED displays for mobile devices. In fact, the industry expressed a desire to use LCDs (which did not

suffer from similar manufacturing limitations) as a preferred alternative for future full HD displays for smartphones. A November 2013 Hankyung News article captures the industry's skepticism (including skepticism from within Samsung Display itself) leading up to the inventions of the '803 Patent:

> People have said that ***it would not be easy to realize the full HD (1920 × 1080 pixels) definition with active-matrix organic light-emitting diode (AMOLED) display***. It was also said that even with the successful development of full HD AMOLED panel, ***securing a sufficient yield*** rate (ratio of finished products) f***or mass production will be difficult*** . . . [I]t is difficult for the resolution of the small-sized displays to be at the level of full HDs as the pixels are realized by evaporating the light emitting organic materials. This is why ***even some internal voices at Samsung Display opined that that AMOLED should be abandoned and pursue LCD instead***.

Ex. 2065 at 5-6 (emphases added). The article goes onto explain that the Diamond Pixel arrangement of the '803 Patent overcame the industry skepticism:

> Nevertheless, the company persevered to uphold the principle of "Samsung smartphone is AMOLED itself," and it finally overcame all the barriers . . . ***boast[ing] a sharper image quality by adopting the Diamond Pixel structure***.

Ex. 2065 at 6 (emphasis added).

327. Samsung Electronics, the maker of the popular Samsung Galaxy series devices, "consider[ed] using LCD for the Galaxy S4, due to the supposed

insurmountable technical difficulties that would prevent it from making enough panels for the upcoming blockbuster." Ex. 2022 at 2. Likewise, an article published by ZDNet Korea reported on similar expressions of skepticism by the industry:

> [F]oreign press expressed ***skepticism about AMOLED*** and said, 'Possibility to develop as the next-generation display is limitless, but there are questions as to whether it can overcome fierce competition against existing Liquid Crystal Device (LCD)' . . . AMOLED faced difficulties in implementing high resolution due to a tricky process in implementing pixels that involved detailed deposition of red, green and blue organic light emitting devices.

Ex. 2023 at 1-2. The ZDNet Korea article goes onto explain that Samsung Display overcame this industry skepticism through the introduction of the patented Diamond Pixel arrangement.

> Samsung Display invented the 'diamond pixel structure' that is beneficial to character expression and legibility starting with Galaxy S4 by continuously carrying out experiments to change the pixel structure that is deposited on the pixel to overcome the issues of resolution. This structure enhanced the character expression capability and space utilization by laying out sub pixels in a diagonal manner to create a diamond structure instead of the existing row format. Through this, the resolution was improved from Galaxy S4 to Full HD(1920×1080) level to completely resolve existing concerns that "it is difficult to implement Full HD resolution in 5-inch level screens with AMOLED."

Ex. 2023 at 2.

328. Apple did not adopt AMOLED displays for its iPhones until the iPhone X which was launched in 2017. Ex. 2024 at 2. Instead, Apple used LCD displays (under the marketing name "Retina Display") that outperformed the AMOLED displays in Samsung's Galaxy smartphones in display resolution and pixel densities. As an example, the iPhone 4 (released in 2010) featured a LCD display with 326 ppi at 960x640 pixels, beating Galaxy S1's 233 ppi AMOLED display (800x480 pixels). Ex. 2025 at 2 (DisplayMate awarding the "Best Mobile Display Award" to the iPhone 4's LCD "Retina" display, finding it "the brightest and sharpest display"). With the patented Diamond Pixel arrangement, Samsung Display overcame Apple's skepticism, and the Galaxy S4 (which was the first commercial product to adopt the '803 Patent's pixel arrangement) outperformed the LCD display in Apple's iPhone 5:

> ***Samsung Display neatly overturned the competitors' expectation of the "impossibility."*** The company developed the 4.99-inch Full HD AMOLED panel at the end of last year and in April, it was successful in mass production by applying it to Galaxy S4. ***The number of pixels per inch is 441 ppi, much higher than the iPhone 5's 326 ppi.*** A company official said that "It is putting 441 dots on one inch," and mentioned that "it required a highly sophisticated evaporation technology to accurately place the fine dots."

Ex. 2065 at 5 (emphases added).

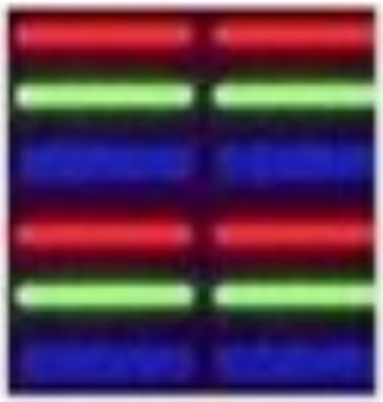
C. Failure of Others

329. Failure of others furthers supports my opinion that the challenged claims would not have been obvious. In the years before the ’803 Patent (and even after the introduction of the novel pixel arrangements of the ’803 Patent), many research groups and display manufacturers proposed pixel arrangements that would be suitable for use in commercial AMOLED displays for mobile devices that would enable higher resolution and pixel densities.

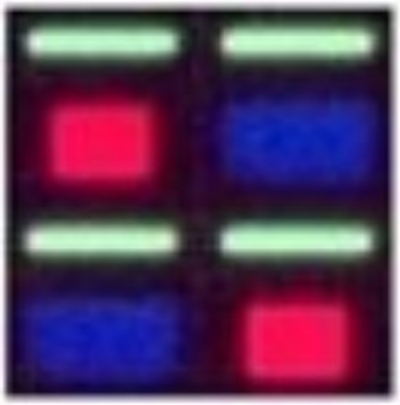
330. Companies such as Sarnoff (assignee of the Matthies reference published in 2005), Sanyo Electric (assignee of the Yamada reference published in 2002), and Seiko-Epson (assignee of the Murai reference published in 2005) and researchers such as Phan (whose reference was published in 2004) had been proposing ideas for display pixel arrangements well before the ’803 Patent. I am not aware of any of these prior pixel arrangements having been used in flagship mobile devices that use AMOLED displays. Moreover, the long duration of time between the publications of the Matthies, Yamada, Murai, and Phan references and the invention of the ’803 Patent support the non-obviousness of the challenged claims.

331. There are many examples of display pixel arrangements that came before Samsung Display’s Diamond Pixel arrangement. This includes the traditional RGB Stripe arrangement shown below which was used, for example, in the Samsung Galaxy S2 product launched in 2011. The RGB Stripe arrangement enabled a 800 x

480 resolution with 207 PPI. Ex. 2023 at 2. The Pentile arrangement (also shown below) was used in the Samsung Galaxy S product launched in 2010 and enabled a display resolution of 800 x 480 with 233 PPI. Ex. 2023 at 2.



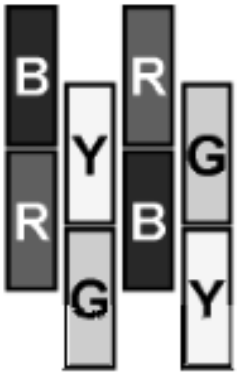
RGB Stripe Arrangement



Pentile Arrangement

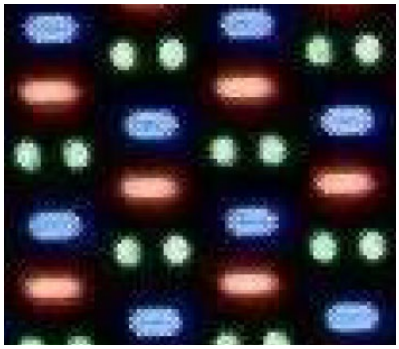
332. In December 2010, researchers at LG Display proposed a "pixel arrangement scheme based on the conventional shadow mask process and ability" which involved "shared emitting aperture area[s] between horizontally adjacent 2 sub-pixel[s]." Ex. 2020 at 3-5. LG Display's proposed pixel arrangement (shown below) led to a prototype that was still displaying images at 229 PPI ("4.3-in-sized WVGA (854xRGBx480)"), which fell short of the full HD standard. *See* Ex. 2020. at 3.

333. And in 2015, AU Optronics proposed a RGBY pixel arrangement in 2015 (Ex. 2033 at 3 fig. 4, shown below). I am not aware of any of these proposed pixel arrangements having been implemented in any full HD AMOLED display. I am also not aware of these pixel arrangements being used for any AMOLED display for a flagship mobile device.

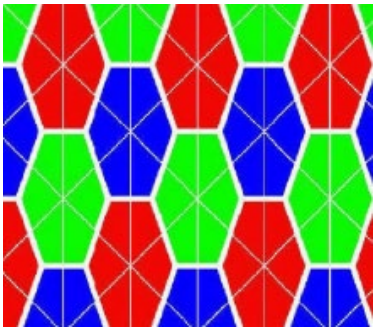


AUO's RGBY Arrangement

334. Display manufacturer BOE proposed a pixel arrangement known as "Delta" arrangement (shown below), which has also been called the "Zhou Dongyu" pixel arrangement. *See* Ex. 2034 at 1. But this arrangement was criticized as being "inferior to [Samsung Display's] diamond arrangement," having the problem "that the arrangement of sub-pixels is not uniform," Ex. 2034 at 1, and described as looking "greenish" with "blurring of the edges," Ex. 2035 at 2.



335. Display manufacturer Tianma proposed an alternative "hexagon shape" pixel arrangement (Ex. 2036 at 2, reproduced below), it avoids the use of FMM by employing an "inkjet printing process"—a method that I am not yet aware of having resulted in successfully mass-produced AMOLED displays for flagship mobile devices.



D. Industry Praise and Recognition

336. There has been significant praise for commercial products that implemented the '803 Patent's pixel arrangements, including specific praise for the pixel arrangements themselves and the higher display resolution (including high PPI) and superior image quality enabled by them.

337. The Samsung Galaxy S4 smartphone was released in April 2013 with a 5-inch "Super AMOLED" display by Samsung Display with a screen resolution of 1080 x 1920 pixels and 441 PPI. Ex. 2013 at 2. Samsung Galaxy S4's AMOLED display was the first commercial embodiment of the '803 Patent. *See* Ex. 2026 at 4. Industry praise for the Galaxy S4's AMOLED display, and specifically the novel pixel arrangement of the '803 Patent, was overwhelming:

- "Samsung Display's proprietary new technology that places pixels in a diamond form was used in the 5-inch full HD-level Super AMOLED display that Galaxy S4 is equipped with;" "[A]ll weaknesses of the existing AMOLED displays were eliminated through the pixel array method on a proprietary diamond structure;" "Full HD Super AMOLED provides the same color as the monitor for professionals." Ex. 2026 at 2.
- "Reaching the high-resolution point with true pixel densities greater than 300 pixels per inch (ppi) has been a challenge for AMOLED displays . . . Samsung Display, however, was able to enhance AMOLED display performance . . . with its new [pixel] structure . . . [a]s a result, the AMOLED display was able to achieve a denser pixel arrangement, boosting its pixel density to greater than 400 ppi and resulting in 1920x1080 Full HD display in the Galaxy S4." Ex. 2013 at 3.

- "For the first time, Active matrix (AM) . . . OLED exceeded LCD in the competition for resolution of smartphones through Galaxy S4. Until now, the established theory was that it would be difficult for AMOLED to exceed the resolution of LCD due to its light emitting diode and patterning limits . . . Samsung Display succeed[ing] in innovating resolution by changing the existing rectangular patterning structure to a diamond structure. A completely new structure was devised because it was difficult to overcome the 400ppi barrier with the existing rectangular patterning[.]" Ex. 2037 at 3.
- "A high resolution screen shot . . . shows an interesting design and sub-pixel arrangement, which Samsung calls Diamond Pixels. First of all, the Red, Green, and Blue sub-pixels have very different sizes - Blue is by far the largest because it has the lowest light emission efficiency, and Green is by far the smallest because it has the highest efficiency. The alternating Red and Blue subpixel arrangement leads to a 45 degree diagonal symmetry in the subpixel layout This allows vertical horizontal and particularly diagonal line segments and vectors to be drawn with reduced aliasing and artifacts In order to maximize the subpixel packing and achieve the highest possible pixels per inch (ppi) that leads to diamond

rather than square or stripe shaped Red and Blue subpixels . . . It's a form of high-tech display art…" Ex. 2027 at 1.

338. Moreover, after years of using LCD displays for its iPhone products, Apple adopted Samsung Display's AMOLED displays using the pixel arrangement of the '803 Patent starting with the iPhone X, drawing significant industry praise:

- "Samsung Display has made the iPhone X a very good screen . . . Apple and Samsung Display have used a diamond [pixel] layout for the OLED screen's sub-pixels on the iPhone X . . . The iPhone X is the most innovative and high performance Smartphone display that we have ever tested." Ex. 2038 at 1-2.
- "[W]e need to congratulate Samsung Display for developing and manufacturing the outstanding OLED display hardware in the iPhone X . . ."; The display has Diamond Sub-Pixels . . . with 458 pixels per inch (ppi), providing significantly higher image sharpness than can be resolved with normal 20/20 Vision at the typical viewing distances of 12 inches or more for Smartphones, so the display appears perfectly sharp." Ex. 2039 at 3-6.
- "The iPhone X display is a whole other level of definition . . . this OLED display is phenomenal . . . it is hard to believe. The individual pixel size on the iPhone X is around 458 pixels/inch with blacker blacks than I've

ever seen on a display and the colors are incredibly vivid. This looks to be a Samsung Super AMOLED display with a PenTile diamond matrix configuration with . . . green sub-pixels in a 2:1 ratio with the red and blue sub-pixels." Ex. 2040 at 1-2.

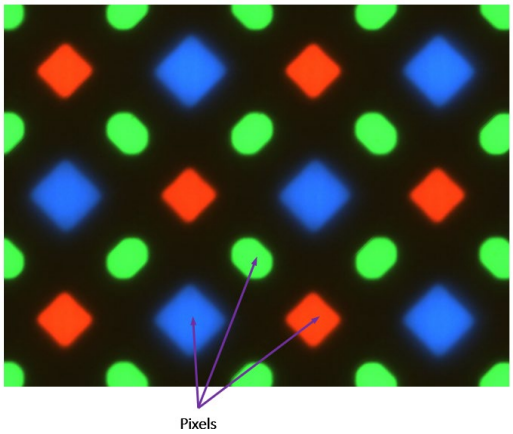
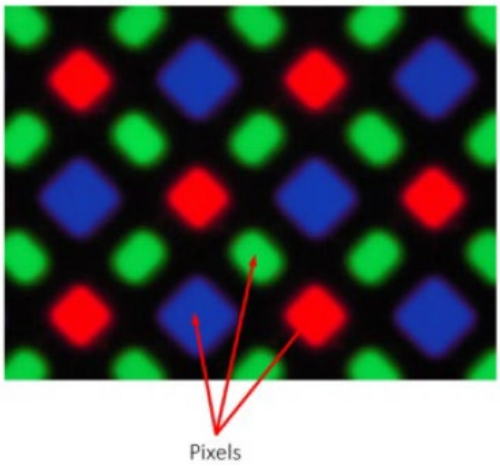
339. Flagship mobile device products following the Galaxy S4 and iPhone X have similarly received praise for having innovative displays that embody the '803 Patent's pixel arrangement. *See, e.g.*, Ex. 2068 (iPhone XS Max); Ex. 2069 (iPhone X); Ex. 2070 (iPhone 14 Pro Max); Ex. 2071 (iPhone 13 Pro Max); Ex. 2072 (iPhone 12 Pro Max).

E. Widespread Copying

340. There is extensive evidence showing that other display manufacturers, including Petitioner Mianyang BOE, copied Samsung Display's patented Diamond Pixel arrangements that practice the challenged claims of the '803 Patent.

341. I reviewed evidence of Petitioner Mianyang BOE's copying of the inventions of the '803 Patent. The teardown image shown below (left) shows the pixel arrangement used in the AMOLED display for the Samsung Galaxy S22 Ultra product. The teardown image shown to its right is of the pixel arrangement used in Mianyang BOE's AMOLED display used in the iPhone 12 and comes from a complaint filed against Mianyang BOE. *See* Ex. 2041 (*Samsung Display Co., Ltd. v. BOE Tech. Co. Ltd. et al.*, Case No. 2-23-cv-00309, Compl. (E.D. Tex. Jun. 26,

2023)). As shown below, the pixel arrangement used in Mianyang BOE's AMOLED display for the iPhone 12 is near identical to Samsung Display's patented pixel arrangement.

Samsung Display AMOLED (Galaxy S22 Ultra)	**Mianyang BOE AMOLED (iPhone 12)**
 Ex. 2029 at 5 (annotated)	 Ex. 2041 at ¶84

342. I have also reviewed extensive evidence of copying by other display manufacturers, including teardown photographs obtained from samples of AMOLED displays sold by vendors of replacement AMOLED displays for mobile phones. *See* Ex. 2061 (Declaration of Aris Silzars, Ph.D. identifying teardown photographs Ex. 2044-2060).

343. A software package called ImageJ was used to obtain certain information about the images of the Galaxy S22 Ultra's pixel arrangement structures, including data such as the areas of the sub-pixels and coordinates of the centers of the sub-pixels. ImageJ is a highly reliable image processing program developed at the National

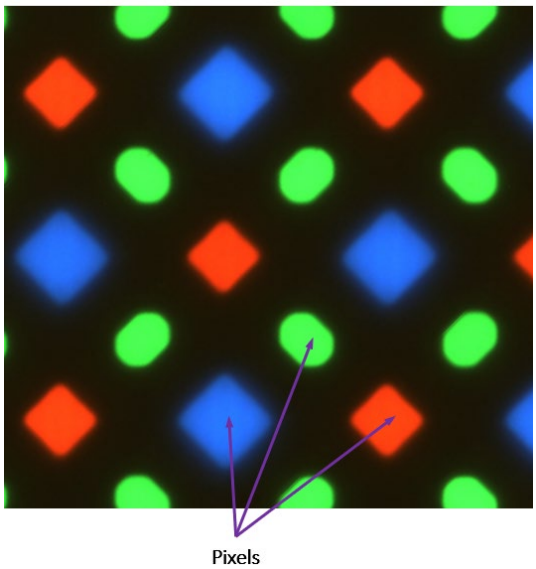
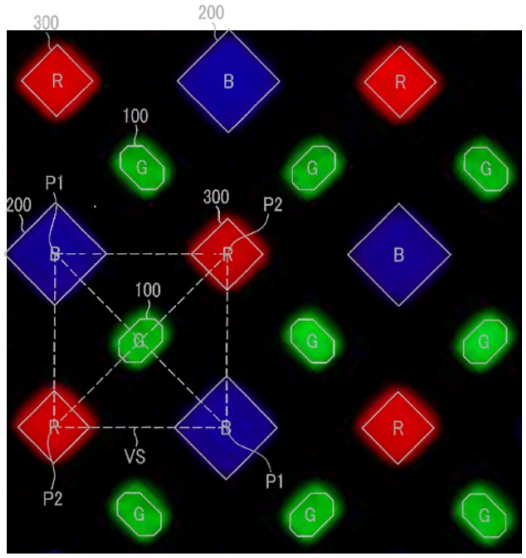
Institutes of Health and is a commonly used tool for microscope image processing, both in academia and commercially. For example, the "Analyze Particles" tool in ImageJ can extract, among other things, the area and center for each region of interest from the outline of the region.

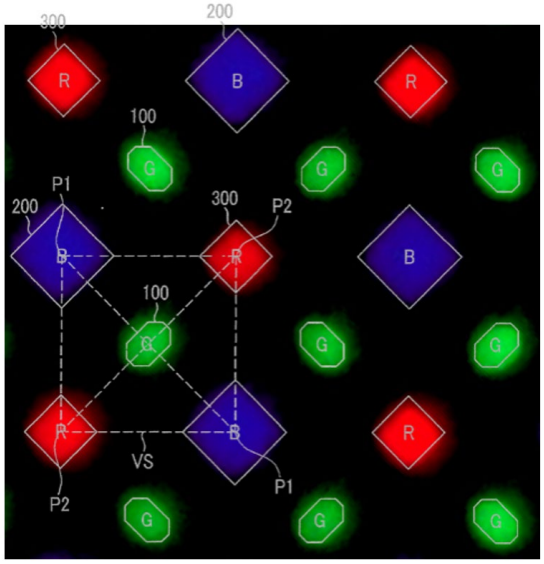
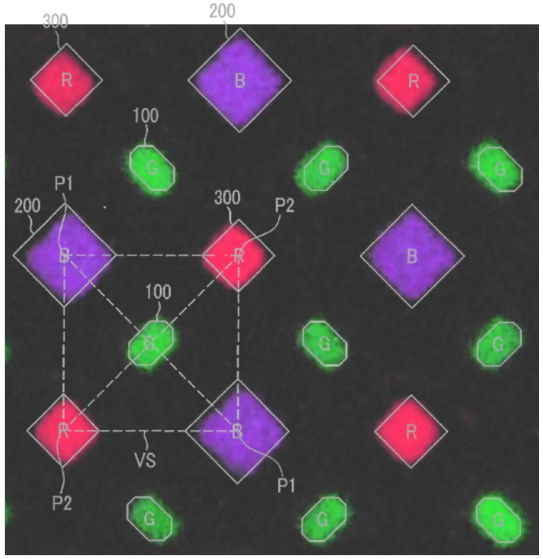
344. Based on the teardown photos and corresponding ImageJ data, I prepared claim charts demonstrating how exemplary copycat products distributed by Group Vertical and Sourcely Plus practice the challenged claims. Ex. 2042 (chart mapping claims 1-5 and 19-21 to Group Vertical AMOLED Display); Ex. 2043 (chart mapping claims 1-5 and 19-21 to Sourcely Plus AMOLED Display).

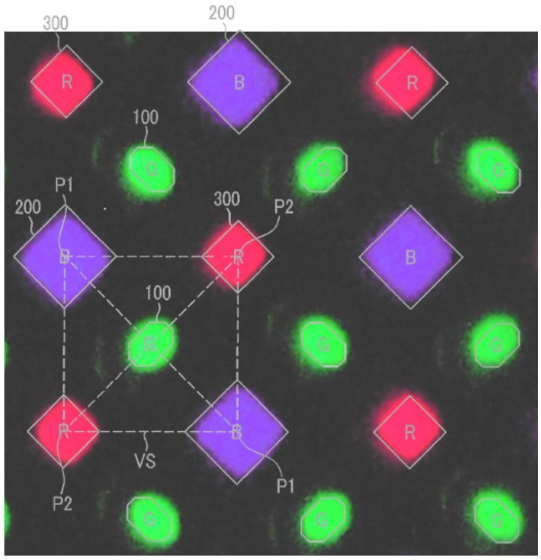
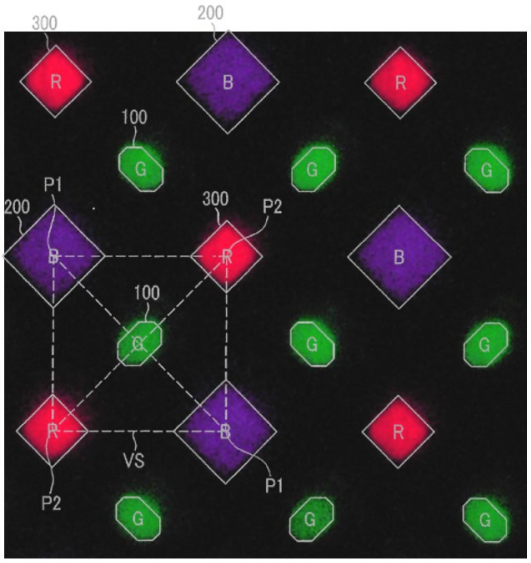
345. These replica AMOLED products and Samsung Display's products have pixel arrangements that appear almost identical, including in the grouping, shaping, sizing, and placement of the red, green, and blue sub-pixels and the formation of virtual square arrangements as required by the claims of the '803 Patent. It thus appears from the teardown photographs that other display manufacturers deliberately copied Samsung Display's pixel arrangement designs, including by having access to Samsung Display's patented products or non-public technical information.

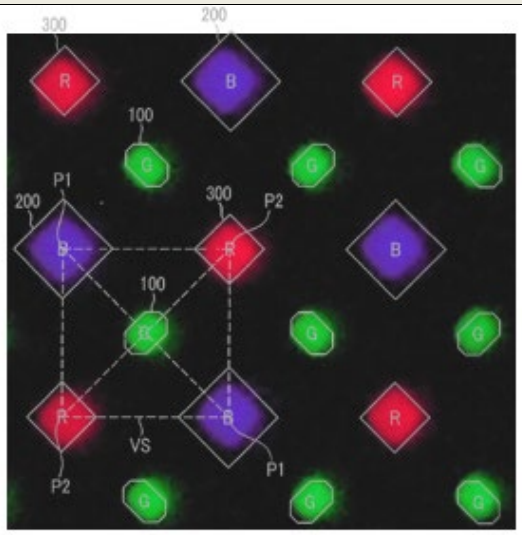
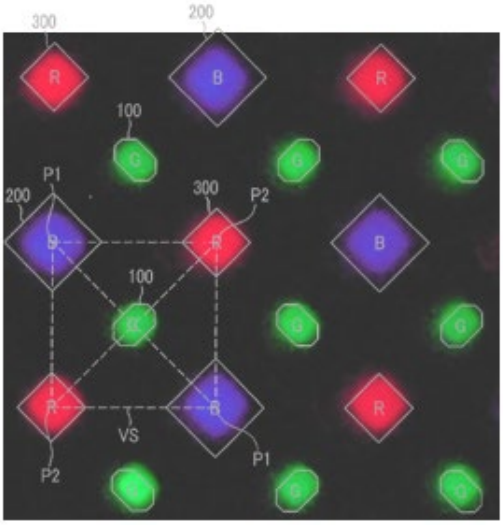
346. Exemplary teardown images of the replica products are shown below with Figure 5 of the '803 Patent overlayed on top. The pixel arrangement used in the

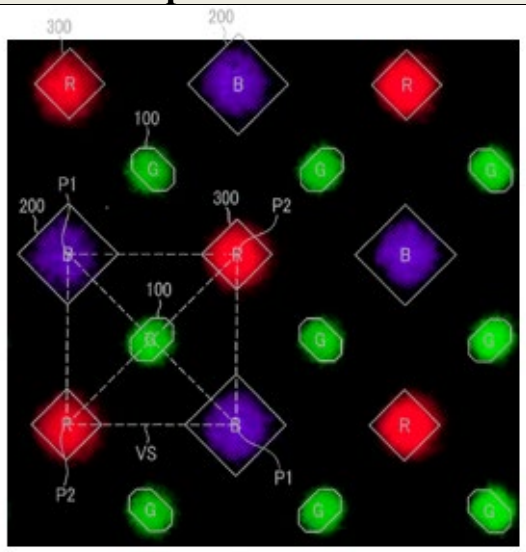
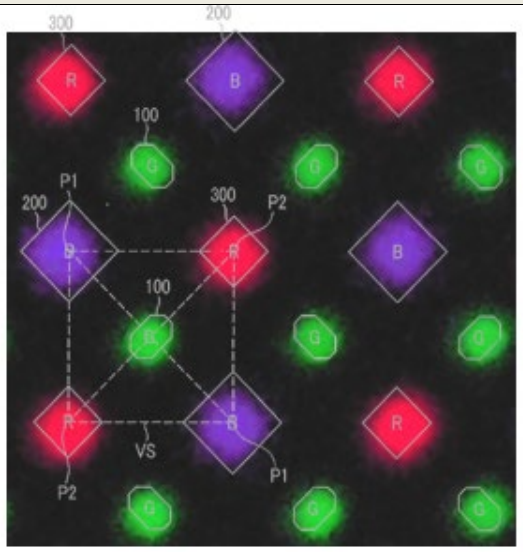
Samsung Galaxy S22 Ultra AMOLED Display (which practices the challenged claims) is shown as well for reference.

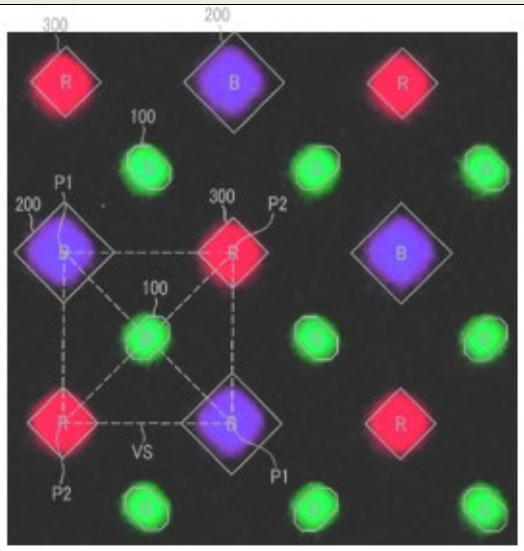
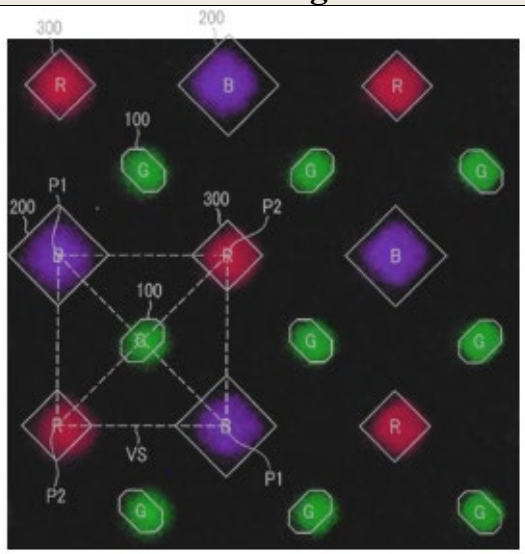
Samsung Display AMOLED (Galaxy S22 Ultra)	Group Vertical
 Ex. 2029 at 5 (annotated)	 Ex. 2044 at 4 (annotated)

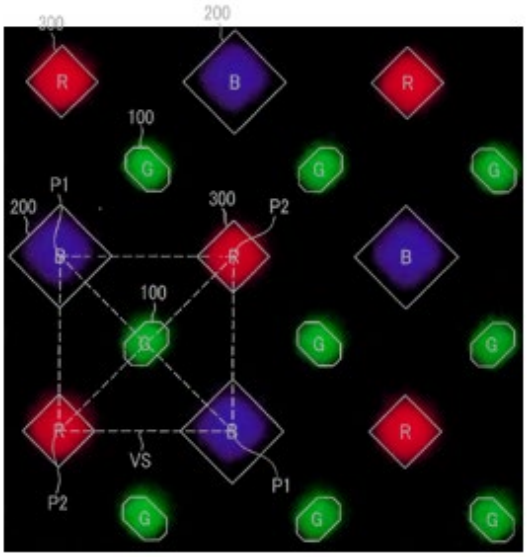
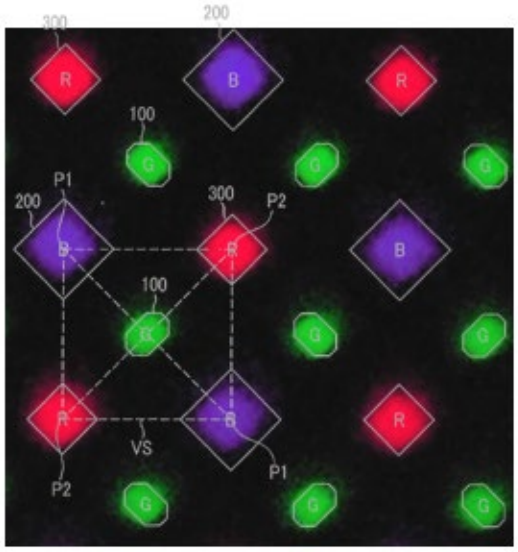
Phone LCD Parts	Sourcely Plus
 Ex. 2045 at 5 (annotated)	 Ex. 2046 at 6 (annotated)

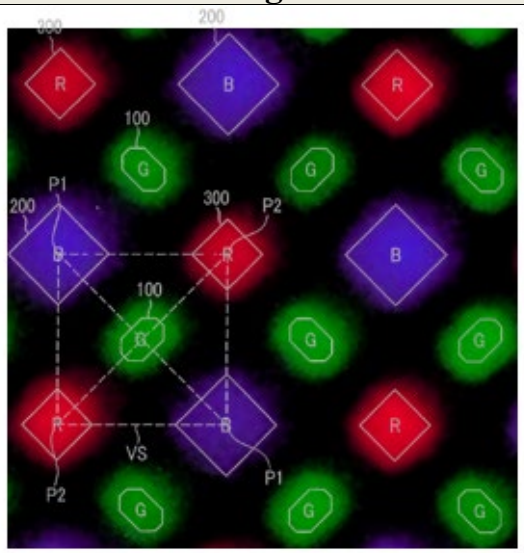
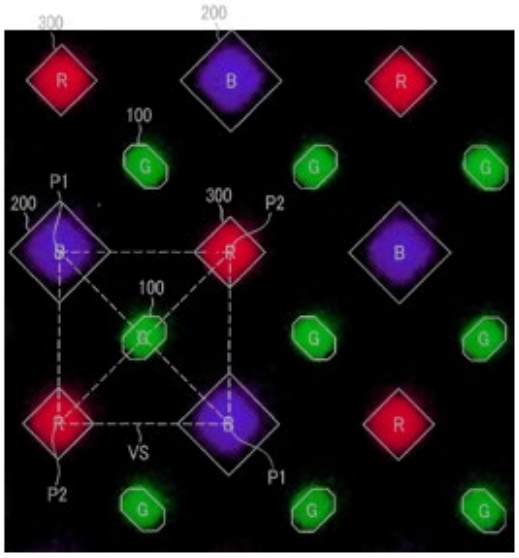
eTech Parts	Parts4LCD
 Ex. 2047 at 6 (annotated)	 Ex. 2048 at 5 (annotated)

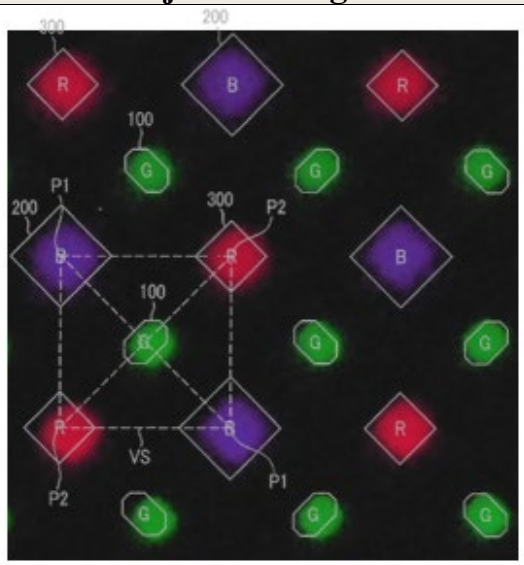
MobileSentrix	Mobile Defenders
 Ex. 2049 at 6 (annotated)	 Ex. 2050 at 6 (annotated)

Repairs Universe	SEGMobile
 Ex. 2053 at 6 (annotated)	 Ex. 2054 at 6 (annotated)

Parts4Cells	Wholesale Gadget Parts
 Ex. 2055 at 6 (annotated)	 Ex. 2056 at 5 (annotated)

Captain Mobile Parts	DFW
 Ex. 2057 at 5 (annotated)	 Ex. 2058 at 5 (annotated)

Mengtor	Gadgetfix
 Ex. 2059 at 5 (annotated)	 Ex. 2060 at 5 (annotated)

Injured Gadgets

Ex. 2051 at 6 (annotated)

F. Nexus

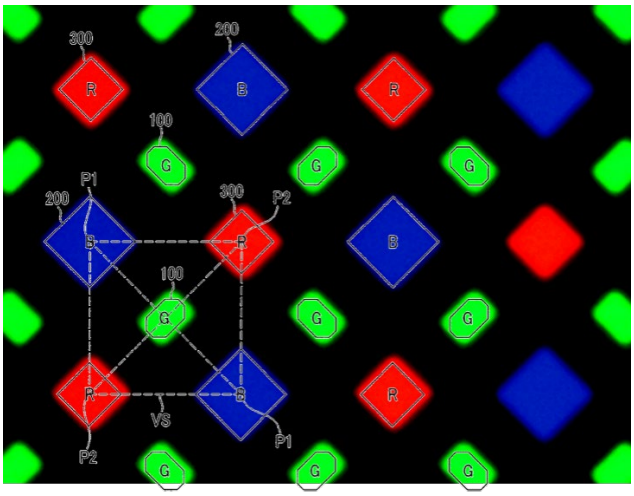
347. In my opinion, the objective indicia of nonobviousness of the ’803 Patent discussed above is sufficiently connected to the claimed inventions of the ’803 Patent.

348. The novel pixel arrangement of the ’803 Patent satisfied the industry’s long-felt need for full HD resolution AMOLED displays for mobile devices that could display images at higher PPI and could be manufactured using then-existing manufacturing methods such as FMM. The ’803 Patent’s pixel arrangement, which Samsung Display calls “Diamond Pixel,” was implemented for the first time in the AMOLED display for the Samsung Galaxy S4 smartphone product. *See* Ex. 2026 at 2 (“On [March] 20th, Samsung Display and relevant industry confirmed that Samsung Display’s proprietary new technology that places pixel[s] in a diamond

form was used in the 5-inch full HD-level Super AMOLED display that Galaxy S4 is equipped with."). Samsung Display's introduction of the novel "pixel array method . . . [using] [its] proprietary diamond structure" allowed "all weakness of the existing AMOLED displays [to be] eliminated," and "full HD-level" resolutions could be realized in AMOLED displays for mobile devices. Ex. 2026 at 2.

349. Dr. Raymond Soneira, author of DisplayMate's technology "shoot-out" article series, observed that Samsung Display's patented "Diamond Pixel[]" arrangement "maximize[s] the sub-pixel packing" to "achieve the highest possible pixels per inch (ppi)," calling it "a form of high-tech display art." Ex. 2027 at 1. *See also* Ex. 2067 (describing Dr. Raymond Soneira and DisplayMate). The '803 Patent's novel pixel arrangement has been successfully used in AMOLED displays for flagship mobile devices, including every Samsung Galaxy and Apple iPhone models that have used AMOLED displays.

350. A teardown image of the pixel arrangement obtained from a Galaxy S22 Ultra sample is reproduced below, with Figure 5 of the '803 Patent superimposed.



Ex. 2029 at 5 (Galaxy S22 Ultra teardown photograph) (annotated); *see also* Ex. 2063.

351. A software package called ImageJ was used to obtain certain information about the images of the Galaxy S22 Ultra's pixel arrangement structures, including data such as the areas of the sub-pixels and coordinates of the centers of the sub-pixels. ImageJ is a highly reliable image processing program developed at the National Institutes of Health and is a commonly used tool for microscope image processing, both in academia and commercially. For example, the "Analyze Particles" tool in ImageJ can extract, among other things, the area and center for each region of interest from the outline of the region.

352. Based on the teardown photos and corresponding ImageJ data, I prepared a claim chart demonstrating how the AMOLED display used in the Samsung Galaxy S22 Ultra product practices all challenged claims of the '803 Patent. Ex. 2028 (Galaxy S22 Ultra Claim Chart). As explained in the claim chart, the

AMOLED display in the Galaxy S22 Ultra product practices the challenged claims of the ’803 Patent.

353. The ’803 Patent introduced pixel arrangements which allow the red, green, and blue sub-pixels to be placed more densely in particular arrangements (which allows for AMOLED displays with higher resolution, and in particular, higher pixel densities for full HD displays) while maintaining sufficient inter-pixel distances (which improves manufacturability, including when using FMM). *See, e.g.*, ’803 Patent, 1:38-2:4, 2:59-62, 4:4-63, 5:20-27, 5:35-45, 7:3-32, 8:16-24, 8:25-45.

354. The pixel arrangement structures recited by the challenged claims of the ’803 Patent employ a greater number of green pixels than blue and red pixels, where the green pixel is smaller than the red and blue pixels, and alternating red and blue pixels are formed around each green pixel positioned at vertices of a “virtual square” centered on the green pixel. *See, e.g.*, ’803 Patent, 4:4-63, 8:25-45. The blue pixels are larger in area than the red pixels. *See, e.g.*, ’803 Patent, 6:43-50. The challenged claims recite specific ways to group, shape, size, and lay out the red, green, and blue OLED sub-pixels, including, for example, arranging the pixels to form a “virtual square” with certain placements and spacings (*e.g.* claims 1-5); requiring “the second pixel” to have a “larger are than that of the third pixel” (*e.g.* claim 1); requiring the “second pixel” to have a “larger area than that of the first

pixel" (*e.g.*, claim 21); requiring the first, second, and third pixels to emit green, blue, and red lights, respectively (*e.g.* claims 1, 19, 20); requiring the pixels to take on certain shapes (*e.g.*, claim 5).

355. By arranging the red, green, and blue pixels in a RGBG format (with more green pixels than red and blue pixels)—instead of the alternative RGB, RGBW, or RGBY pixel arrangements that other display manufacturers and research groups have proposed over the years which have failed to be adopted in flagship mobile devices—and by sizing and shaping the subpixels in ways that had not previously been attempted in the prior art, the '803 Patent achieved a novel balance of improving the AMOLED display's aperture ratio (by enlarging the emissive areas) while *also* allowing for a more reliable deposition of the organic material (by ensuring sufficient gaps between pixels). The '803 Patent explains these challenges. *See* '803 Patent at 1:40-45:

> When reducing a gap between the neighboring pixels to obtain a higher aperture ratio of the pixel, deposition reliability may be deteriorated. On the other hand, when increasing the gap between the pixels to improve deposition reliability, the aperture ratio of the pixel may be deteriorated

By requiring "a first pixel having a center coinciding with a center of a virtual square; a second pixel separated from the first pixel and having a center at a first vertex of the virtual square; and a third pixel separated from the first pixel and the second

pixel, and having a center at a second vertex neighboring the first vertex of the virtual square," '803 Patent at 1:54-2:4, the novel pixel arrangements of the '803 Patent overcame the manufacturing and design challenges associated with the emissive layers of the OLED display. *See, e.g.*, '803 Patent, 6:40-50. These challenges had been long understood by POSITAs as bottlenecks to achieving full HD AMOLED displays for mobile devices.

356. Prior to the '803 Patent, the "established theory" in the display industry had been that "it would be difficult for AMOLED[s] to exceed the resolution of LCD[s] due to their light emitting diode and patterning limits." Ex. 2037 at 3. However, Samsung Display overcame industry skepticism and satisfied the longstanding need by "changing the existing rectangular patterning structure to a diamond structure . . . to overcome the 400ppi barrier," delivering "the 5-inch 441ppi (pixels per inch) Full HD Super AMOLED to Galaxy S4." Ex. 2037 at 3.

XV. CONCLUSION

357. For the reasons stated above, it is my opinion that claims 1-5 and 19-21 of the '803 Patent were not obvious to a person of ordinary skill in the art based on the references cited and reasons presented by Dr. Pattison.

358. I reserve the right to supplement my opinions in the future to respond to any arguments that the Petitioner or Dr. Pattison raises. This declaration represents only those opinions that I have formed to date. I reserve the right to revise,

supplement, and/or amend my opinions herein based on new information that becomes available to me and on my continuing analysis of the materials already provided.

* * *

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

Executed on: April 1, 2024 By: _____

Date

Ioannis (John) Kymissis, Ph.D.