

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

PATENT OWNER'S RESPONSE

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Ex. 2002	Joint Statement of Agreed Upon and Disputed Claim Terms (6-29-2023)
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Ex. 2005	Declaration of Matthew Kudzin
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Ex. 2009	Declaration of Ioannis Kymissis, Ph.D.
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Ex. 2013	Korea Industry Post, <i>Popularity of Galaxy S4 to Kickstart Demand for AMOLED Market</i> , (2013)
Ex. 2014	Dr. Raymond M. Soneria, <i>Galaxy S4 Display Technology Shoot-Out</i> , DisplayMate Technologies
Ex. 2015	U.S. Patent No. 9,697,760 (“Wang”)
Ex. 2016	Jiin-Joi Lih et al., <i>The Challenge of High Resolution to Active-Matrix OLED</i> , Society for Information Display (2006)
Ex. 2017	Ho-Kyoon Chung et al., <i>AMOLED Technology for Mobile Displays</i> , Society for Information Display (2006)

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Ex. 2018	U.S. Patent Publication No. 2007/0278933 (“Chao”)
Ex. 2019	Excerpts from Society of Information Display, <i>Mobile Display Technology and Applications</i> (Achintya K. Bhowmik et al.) (2008)
Ex. 2020	Journal of Display Technology, <i>New Pixel Design on Emitting Area for High Resolution Active-Matrix Organic Light-Emitting Diode Displays</i> (Soon-Kwang Hong et al.) (2010)
Ex. 2021	U.S. Patent Publication No. 2008/001525 (“Chao”)
Ex. 2022	Bogdan Petrovan, <i>Diamond Pixels: Galaxy S4’s Unique Subpixel Arrangement Gets a Close Up</i> (2013)
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Ex. 2035	Xiaojian, <i>What Exactly was the Scolded “Dongyu Zhou” Screen Like? Is it Really Unusable?</i> (2020)
Ex. 2036	Li-Qin Shao et al., <i>The Development of 403ppi Real RGB Printing AMOLED</i> , Society of Information Display (2019)
Ex. 2037	Hyungsoo Lee, <i>Secret to the Face of Galaxy S4, Reason for Striking Resolution</i> (2013) (including certified English translation)
Ex. 2038	Chris Davies, <i>The iPhone X has the Best Smartphone Display Around</i> (2017)
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Ex. 2063	Declaration of Adam Fontecchio, Ph.D.
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Ex. 2065	Yoon Jeong-hyun, <i>Samsung Display Achieves the Highest Definition Quality With Tenacity, Full HD AMOLED</i>

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	“ <i>Revolution</i> ,” BIZ Insight (2013) (including certified English translation)
Ex. 2066	<i>Public-Private Commitment to Ceaseless Effort for Display Super Gap</i> , Ministry of Trade, Industry, and Energy (2023)
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Ex. 2074	G. Gu et al., <i>Design of Flat-Panel Displays Based on Organic Light-Emitting Devices</i> , 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, <i>Crosstalk in Passive Matrix Polymer LED Displays</i>
Ex. 2077	Jong In Park et al., <i>Direct Prediction Methods on Lifetime Distribution of Organic Light-Emitting Diodes From</i>

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	<i>Accelerated Degradation Tests</i> , IEEE Transactions on Reliability, Vol. 59, No. 1 (Mar. 2010)
Ex. 2078	Priyanka Tyagi et al., <i>Degradation of Organic Light Emitting Diode: Heat Related Issues and Solutions</i> , Synthetic Metals 216 (2016)
Ex. 2079	M.M. Azrain et al., <i>Analysis of Mechanisms Responsible for the Formation of Dark Spots in Organic Light Emitting Diodes (OLEDs): A Review</i> , Synthetic Metals 235 (2018).
Ex. 2080	Jiun-Haw Lee et al., <i>Introduction to Flat Panel Displays</i> , Society of Information Display (2008)
Ex. 2081	U.S. Patent Publication No. 2011/0234550 (“Hong”)

I. Introduction

Active-matrix organic light-emitting diode (AMOLED) displays have become the display of choice in mobile devices through innovations of Patent Owner Samsung Display. The invention of U.S. Patent No. 9,818,803 (Ex. 1001, the “’803 Patent”), which has been implemented across flagship AMOLED products since its commercial introduction in 2015, has been essential to this widespread adoption.

In the early 2000s, interest in passive-matrix OLED technologies (“PMOLED”) had waned. Short lifetimes, size limitations, and low resolution made PMOLEDs impractical for most applications. Efforts to develop OLEDs focused on AMOLEDs, despite their more complex circuitry and profound design challenges.

Before the ’803 Patent, the lack of a suitable pixel arrangement structure had hindered adoption of AMOLED displays, including in mobile devices and other applications requiring high resolution and image quality. In AMOLED displays, pixels are formed using complex deposition processes that require gaps between different-colored pixels to prevent unwanted color mixing, thereby limiting the resolution of the display. The modes and rates of degradation of organic light-emitting materials further constrained the design of AMOLED displays. As a result, AMOLED displays were not considered competitive with liquid crystal displays (LCDs). Many companies tried but failed to devise pixel arrangement structures to

meet the need for higher resolution, image quality, and pixel density in an AMOLED display that could be commercially manufactured.

The inventor of the '803 Patent succeeded where for many years others had failed, devising a novel pixel arrangement that enabled pixels to achieve higher image quality and longer display lifetime while maintaining sufficient distances between pixels to overcome manufacturing challenges. '803 Patent, 1:38–2:62, 7:12–32, 8:34–45. The pixel arrangement structures of the '803 Patent have been praised for enabling high-resolution, high-quality AMOLED displays and attained broad commercial adoption. Displays implementing the invention have become the design of choice in flagship mobile devices, and been subject to widespread copying.

The Petition challenges claims 1-5 and 19-21 of the '803 Patent based on four grounds, which attempt to cobble together references concerning disparate display technologies and suffer numerous flaws. As Dr. Ioannis Kymissis, Chair of the Department of Electrical Engineering at Columbia University and President-Elect of the Society for Information Display, explains in detail (supported by literature, patent disclosures, industry experience, and examples of real-world displays), the challenged claims were not obvious to a POSITA.

Petitioner proposes to combine references concerning fundamentally different, and incompatible, technologies that a POSITA would have had no reason to combine nor a reasonable expectation of success in combining. Indeed, Petitioner purports to

rely on pixel arrangements in Phan and Murai (for Grounds 2-4) that were not for OLED displays. Petitioner and its expert, Dr. Morgan Pattison, disregard substantial structural, manufacturing, and operational inconsistencies between the references they propose to combine and key teachings of the references contradicting the Petition's theories.

For instance, a key element of Petitioner's theory is that Yamada would have taught a POSITA that making blue pixels larger would increase a display's lifetime by reducing the current density in the blue pixels. But Petitioner's proposed combinations do not increase the size of the blue pixels and therefore would not extend display lifetime. In fact, as Dr. Kymissis explains, by shrinking the red and green pixels, Petitioner's proposed modifications would *decrease* display lifetime, contradicting Petitioner's purported rationale. Petitioner further disregards the prior art's criticism of Yamada's approach as unsuitable for proper OLED display design, and compounds its errors by failing even to apply Yamada's disclosures that require consideration of material-specific factors such as chromaticity.

The Petition's proposed modifications would conflict with the references' design goals in other ways as well. In a hindsight-driven attempt to create a structure that a POSITA would not have created, the Petition proposes modifications that violate explicit design requirements of the references and contravene the references' teachings.

Petitioner has not shown any challenged claim was *prima facie* obvious. Strong evidence of objective indicia further undercuts the Petition’s assertions. The Board should find that Petitioner has not shown any challenged claim of the ’803 Patent to be unpatentable.¹

II. Claim Construction

The Administrative Law Judge (“ALJ”) in related ITC Investigation No. 337-TA-1351 did not construe any terms of the ’803 Patent. Ex. 2001. The parties in that Investigation submitted a list of agreed-upon constructions including certain terms of the ’803 Patent. Ex. 2002. No specialized constructions are necessary in this proceeding, as Petitioner fails to prove unpatentability of any claims under any interpretation.

¹ Petitioner also challenges the patentability of two other patents in the same family as the ’803 Patent. *See* IPR2023-00988, IPR2023-01075. Because Petitioner relies on largely the same prior art and makes similar arguments across all three IPRs, Samsung Display’s Responses necessarily overlap. Arguments specific to the ’803 Patent are found in Sections V.C, V.D.1, VI.B, VII.A, VII.B.3, VII.B.4, VII.C, VIII.B, VIII.D, and IX.E.

III. Level of Ordinary Skill in the Art

Patent Owner proposes, consistent with the finding in the related ITC Investigation for the related '578 Patent, that a person of ordinary skill in the art (“POSITA”) would have had a relevant technical 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. 2009, ¶¶64, Ex. 2001 at 15.

Petitioner proposes slightly different language regarding the POSITA’s experience and general knowledge. Pet. at 12. Patent Owner did not challenge Petitioner’s proposal in the Preliminary Response, and the Board preliminarily adopted it. Paper 10 at 10–11. Petitioner fails to establish unpatentability under either definition.

IV. Technical Background

Active-matrix and passive-matrix display architectures have been understood in the art to be fundamentally different approaches to the design and operation of OLED displays. *E.g.*, Ex. 2073 at 11-15; Ex. 2074 at 6-15; Ex. 2009, ¶¶47-56.

In a passive-matrix display, pixels are formed where column electrodes and row electrodes overlap. Ex. 2074 at 6. This constrains the location and size of pixels. One row of pixels emits light at a time. An image is generated by sequentially flashing (or “pulsing”) each row of pixels at peak brightness for a very short time

while the other rows do not emit light (and their pixels are kept at zero or reverse bias). *Id.* The light pulses must be extremely bright because of the short time each row is addressed, which requires the pixels to be driven with high voltage and current density. *Id.*; Ex. 2073 at 12-15. The “high-instantaneous luminance requirement” was known to “lower[] the OLED power conversion efficiency,” Ex. 2074 at 6, and to promote more rapid degradation of the OLED pixels, including due to temperature and other effects relating to the high voltages and currents. Voltage drop through the column and row electrodes, and leakage current through non-selected pixels, also presented significant issues. *Id.* at 6-8. Passive-matrix designs were therefore understood to be unsuitable for high-resolution displays, and to be limited to small, low-resolution displays. Ex. 2009, ¶¶48-52.

In an AMOLED display, each pixel includes transistors and a capacitor to control the pixel. Ex. 2073 at 12-15. The capacitor allows the pixel to remain on while other rows of pixels are on, permitting the OLEDs to be driven at significantly lower voltage and driving current. *Id.* The pixel circuitry, and additional power and signal lines to control it, impose different constraints on the sizes and locations of pixels. *Id.* Further, due to their difference in driving, OLEDs in AMOLEDs undergo lower rates of degradation, and different primary modes of degradation, than those in PMOLEDs. *Id.* The factors affecting, and limiting, display lifetime in AMOLED

displays were known to be significantly different than those limiting PMOLED display lifetime. Ex. 2009, ¶¶53-56.

AMOLEDs also posed significant, and unique, manufacturing challenges associated with their pixel arrangement structures. Ex. 2009, ¶¶41-44, 55-59. While a high aperture ratio was desired, deposition processes to form the organic light-emitting layers for different colored pixels in a display presented design and manufacturing challenges. *Id.*, ¶¶59-60. As the '803 Patent explains, “[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 (FMM),” but “[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. Without adequate spacing, problems such as color mixing of the organic material may occur during deposition. Ex. 2009, ¶¶43-44.

The '803 Patent's inventive OLED pixel arrangement structure allowed for AMOLED displays with higher resolutions, higher brightness, improved image quality, and longer lifetimes, with improved manufacturability. *E.g.*, '803 Patent, 1:58-62, 2:59-62, 5:16-26, 6:31-50, 7:12-32, 8:25-45; Ex. 2009, ¶¶57-63. As discussed below, this structure has been implemented widely across highly successful AMOLED display products and praised since its introduction.

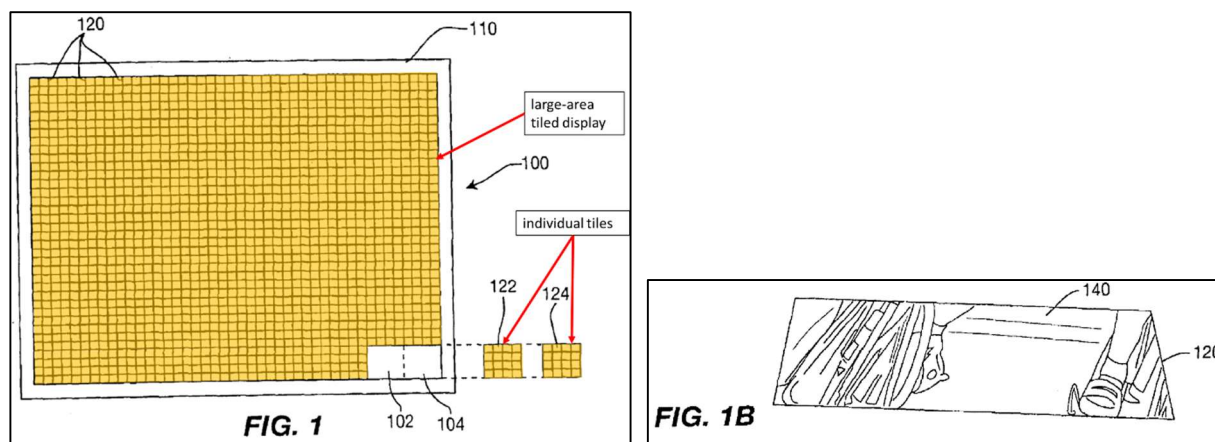
V. Ground 1: Petitioner Fails to Establish a *Prima Facie* Case of Obviousness Based on Matthies in view of Yamada.

A. A POSITA would not have been motivated to combine Matthies and Yamada, which involve fundamentally different technologies.

Matthies concerns tiled (multi-substrate), passive-matrix OLED displays. Yamada concerns single-substrate active-matrix OLED displays. Due to fundamental differences in these technologies, a POSITA would not have been motivated to select Yamada to modify Matthies. *See Adidas AG v. Nike, Inc.*, 963 F.3d 1355, 1359 (Fed. Cir. 2020) (“Fundamental differences between the references are central to th[e] motivation to combine inquiry.”).

1. Matthies is directed to tiled, passive-matrix displays.

Matthies, titled “*Tiled* Electronic Display Structure[s],” is directed to “large-area display devices which are formed as an array of tiled devices.” Matthies, 1:8-10. Matthies proposes wall-sized or larger displays (annotated Fig. 1 below) made by physically joining multiple individual display tiles (Fig. 1B below) in an array. *Id.*, 1:18-25. Each display tile shows only a section of a complete video image (as shown in Figure 1B); the large-area tiled display combines tiles to show the full video image. Ex. 2009, ¶¶102-103.

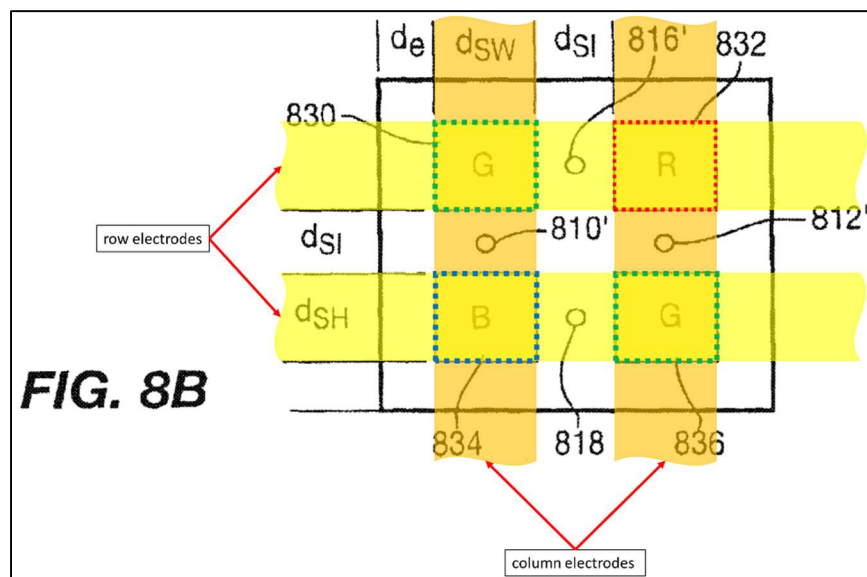


As Matthies explains, “[n]o practical tiled display system has yet been developed.” *Id.*, 1:66-2:2. Matthies sought to overcome “[t]wo barriers to implementing the tiled approach” by “eliminating the visibility of the seams between tiles” and “providing electrical access to the pixels.” *Id.*, 2:8-10. According to Matthies, “[w]hat 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...while at the same time allowing for electronics to address each tile, even [with] those tiles completely surrounded by other tiles.” *Id.*, 2:2-7. Matthies teaches the edges of the outermost pixels on a tile should be a fixed distance from the tile edge, to avoid optical effects that leave seams between tiles visible, to allow for electronics, and to allow for physical connections between tiles. *Id.*, 8:37-39, 9:23-26, 15:61-63, 16:5-9. Ex. 2009, ¶104.

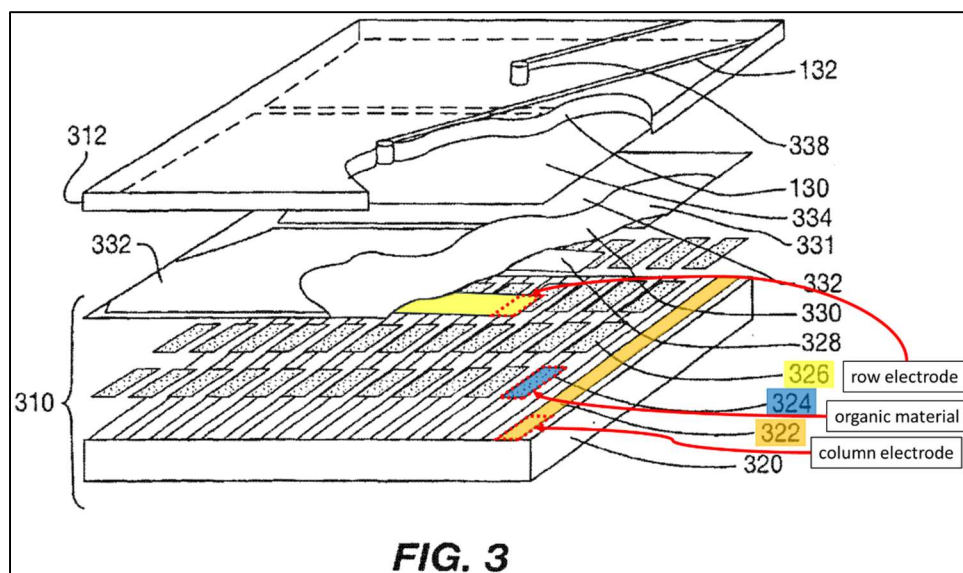
Matthies distinguishes its tiled-displays from “monolithic” (i.e., single-substrate) displays, explaining “[t]iled displays have relatively few pixels so that the number of interconnects per tile is relatively small,” which confers “a significant

advantage of tiled displays when compared to fabrication of large displays from single substrates.” *Id.*, 9:34-38. Ex. 2009, ¶105.

Matthies’ tiled displays—including the display tile of Figure 8B on which Petitioner relies—are *passive-matrix* OLEDs. *Id.*, 10:31-33, 17:10-16 (describing Figure 8B); Ex. 2009, ¶¶106-110. The light-emitting area of each pixel is defined by the overlap between row (yellow) and column (orange) electrodes, *see* Matthies, 12:61-13:11, as seen in annotated Figure 8B:



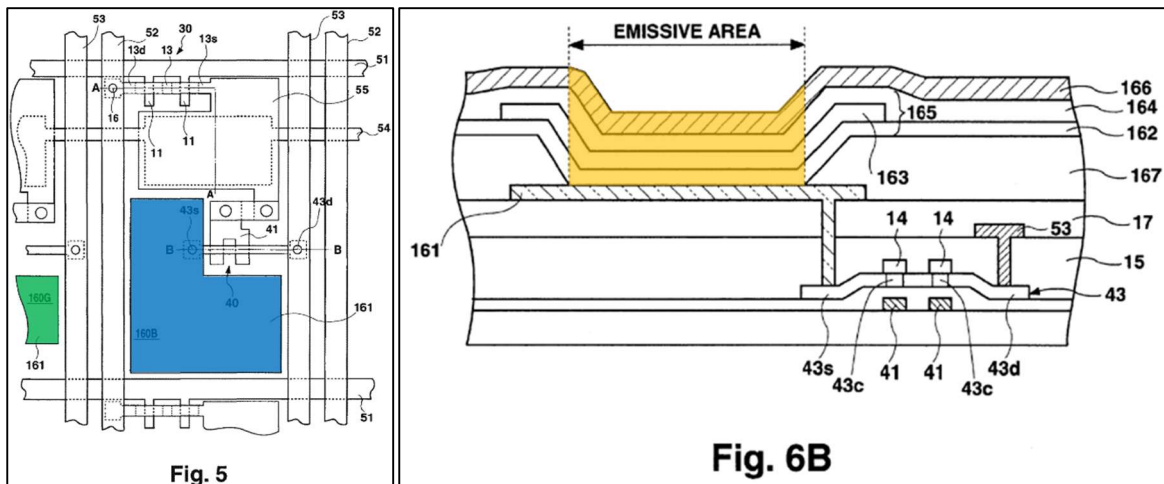
Id., Fig. 8B (annotated). Matthies’ organic light-emitting material is sandwiched between the row and column electrodes, and “[c]urrent flowing from one electrode to the other electrode” causes the organic material to emit light. *Id.*, 6:19-23. This is further illustrated in Figure 3:



Id., Fig. 3 (annotated).

2. Yamada is directed to single-substrate AMOLED displays.

In contrast, Yamada is directed to *active-matrix* OLED displays built on a *single* substrate. Yamada, 1:6-3:8; Ex. 2009, ¶¶111-114. Each pixel has its own pixel circuit with a “gate signal line 51,” a “data line 52,” a “power source line 53,” two transistors, and a capacitor, and the light-emitting area is separate from the TFTs and capacitor. Yamada, 7:19-8:18. Yamada’s pixel structure is shown in Figures 5 (plan view) and 6B (cross-section). As can be seen, the light-emitting area, which is the area “in contact with the emissive element layer 165 and the anode 161,” *id.*, 10:39-44, is constrained by space taken up by the driving circuitry, and Yamada teaches an L-shaped light-emitting area to provide space for the circuitry in non-emissive areas.

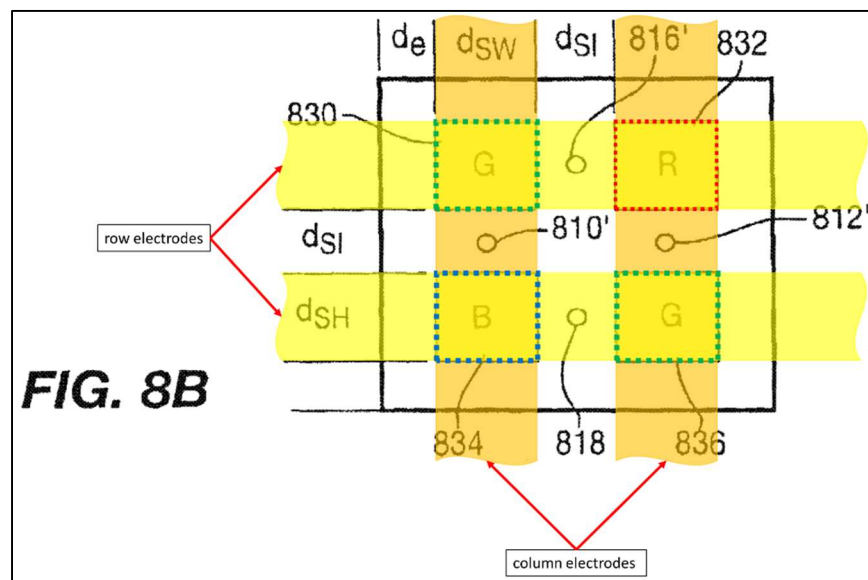


Id., Figs. 5, 6B (annotated).

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

A POSITA would not have been motivated to modify Matthies' PMOLED display made of multiple tiles based on Yamada's disclosures for AMOLED monolithic displays, let alone with a reasonable expectation of success. *First*, a POSITA would have understood the degradation profile of pixels in a PMOLED display (including thermal-and voltage-related degradation mechanisms, *see supra* Section IV) differs materially from that of AMOLED displays, due to the fundamental differences in how the pixels are driven. Ex. 2009, ¶¶115-118. Petitioner relies on Yamada's disclosures, which concern degradation of pixels in **AMOLED** displays; as Dr. Kymissis explains, a POSITA would not have looked to Yamada to understand degradation in, or how to extend the lifetime of, a **PMOLED** display like Matthies. *Id.*, ¶¶119-120.

Second, Matthies' *tilled* PMOLED display places entirely different, and incompatible, physical constraints on pixel arrangement structures from Yamada's single-substrate AMOLED displays. The light-emitting area in Matthies' PMOLED is defined by the overlap of Matthies' row and column electrodes. Thus, in Matthies' Figure 8B (reproduced below with annotations), all pixels in the same row (e.g., green pixel 830 and red pixel 832 in the top row) have the same height, and all pixels in the same column (e.g., green pixel 830 and blue pixel 834 in the left column) have the same width.



Matthies, Fig. 8B (annotated); 17:10-20. A POSITA would have recognized that, unlike in Yamada, changing the size of a pixel in Matthies' Figure 8B would entail changing the size of its row and/or column electrode, which would both (1) change the size of all the other pixels defined by that row and/or column electrode and (2)

have electrical effects that could diminish display performance. Ex. 2009, ¶¶121-128.

Further, Matthies' tiled design imposes crucial constraints on its pixel arrangement structures to avoid optical effects at tile edges and between tiles (discussed further below), to accommodate vias, and to provide space for connectors. *See, e.g.*, Matthies, 5:47-53, 8:37-41, 15:59-63, 16:5-9, 16:22-26, 21:22-27, 22:53-56. Matthies' constraints are incompatible with Petitioner's theory of making differently-sized red, green, and blue pixels based on Yamada. Ex. 2009, ¶¶129-132.

B. Petitioner's alleged motivations to combine Matthies with Yamada have no merit

1. Petitioner's proposed modification would decrease the lifetime of Matthies' display.

Petitioner's proposed combination modifies the quad-pixel display-tile structure of Matthies' Figure 8B by keeping the blue pixel the same size, reducing the size of the red pixel, and further reducing the size of the two green pixels. Pet. at 32-33. Although the purported rationale for Petitioner's proposed combination is to *increase* the lifetime of Matthies' display (Pet. at 40-41), Petitioner's proposed modifications would have had the opposite effect, *shortening* its lifetime. Ex. 2009, ¶¶133-139. "An inference of nonobviousness is especially strong where the prior art's teachings undermine the very reason being proffered as to why a [POSITA]

would have combined the known elements.” *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1326 (Fed. Cir. 2009).

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. Driving an OLED at higher current density accelerates degradation of the light-emitting material, shortening the pixel’s life. *See id.*; Ex. 2009, ¶135. Petitioner relies on Yamada as teaching to make the blue light-emitting area “**larger**.” Pet. at 19 (emphasis added). This would allow the same blue-light output at lower current density, slowing this degradation and lengthening the blue pixels’ lifetime. *Id.* at 70.

But Petitioner’s proposed modifications to Matthies’ structure do not make the blue light-emitting area larger. They would not reduce the blue pixels’ current density or extend their lifetime. Instead, Petitioner’s proposal would shrink the red and green pixels, substantially reducing their light-emitting areas, increasing their current densities and *reducing* their lifetimes. Ex. 2009, ¶¶136-137.

Petitioner’s proposed combination would **reduce** the lifetime of Matthies’ display overall, contradicting Petitioner’s purported rationale for it. Ex. 2009, ¶¶136-137. And PMOLEDs like those in Matthies were already well-known to suffer from

short lifetimes. A POSITA would have had no reason to make Petitioner's proposed combination nor a reasonable expectation of success in doing so. *Id.*, ¶¶136–139.

2. Petitioner's proposal would also remove required circuitry and diminish Matthies' display quality.

Petitioner briefly attempts to argue that its proposed modifications would have “simplified” Matthies' display by purportedly eliminating the need for “extra components to tailor the supplied current on a pixel-by-pixel basis.” Pet. at 41-42. That is incorrect. The circuitry Petitioner proposes to eliminate is necessary for Matthies' display to function, providing the required display data to each pixel, Matthies, 10:1-5, and making adjustments to provide uniform brightness and color across different pixels and different tiles, a critical requirement for Matthies' tiled display, *id.*, 10:6-9. Ex. 2009, ¶¶140-141. Further, Matthies' circuitry “continually adjusts” the brightness of individual pixels to compensate for aging as the display is used, something resizing the pixels cannot achieve. Matthies, 11:61-12:41. Different-colored pixels will decay at different rates (owing to differences in the light-emitting materials) and the decay was known to be non-linear. Without Matthies' circuitry, the display's color would shift over time, rendering the display defective. Ex. 2009, ¶¶142-143.

Petitioner also makes a cursory claim that shrinking the red and green pixels would result in “greater design flexibility” by creating “additional space for Matthies' vias.” Pet. at 43-44. This is meritless. Matthies discloses its display already has

sufficient space for its vias, and Petitioner’s modifications needlessly (1) remove light-emitting area and (2) create asymmetries in pixel size and spacing that Matthies explicitly seeks to avoid and that would be inconsistent with Matthies’ PMOLED structure. A POSITA would seek to *increase* the aperture ratio, as OLED displays had relatively low aperture ratios. Ex. 2009, ¶¶144-146.

C. A POSITA would not have been motivated to modify Matthies’ quad-pixel structure in view of Yamada’s disclosures for triple-pixel AMOLED structures.

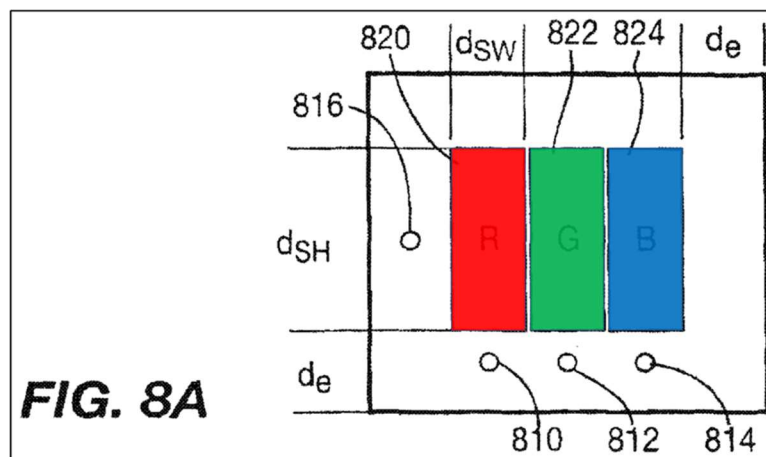
Even had a POSITA looked to modify Matthies in view of Yamada, a POSITA would not have been motivated to combine Matthies’ quad-pixel structure of Figure 8B with Yamada’s triple-pixel RGB structure. *Id.*, ¶¶147-157.

Matthies discloses two alternative pixel arrangements: (1) a triple-pixel (RGB stripe) arrangement (*see* Matthies, Figure 8A) and (2) a quad-pixel arrangement (*see* Matthies, Figure 8B). Yamada is directed to triple-pixel (RGB stripe) structures. Ex. 1008, Fig. 4.² Yamada does not discuss, nor contemplate, use of quad-pixel structures. As Dr. Pattison acknowledged, Yamada is “talking about a [RGB] stripe arrangement[s].” Ex. 2062 at 89:2-11. Yamada’s use of equal numbers of red, green,

² Yamada also references “a delta layout and a diagonal layout,” which are other triple-pixel RGB arrangements having equal numbers of red, green, and blue pixels. Yamada, 12:37-40; Ex. 2009, ¶149.

and blue pixels in tri-pixel (RGB) structures underlies its approach of varying pixel sizes to change light-emitting areas—unlike quad-pixel designs, which used an excess of one color pixel to increase the relative light-emitting area of that color. Ex. 2009, ¶¶149-150.

Petitioner fails to offer any reason a POSITA would have tried to combine Yamada's triple-pixel structures with Matthies' quad-pixel structure, rather than Matthies' triple-pixel structure. *Id.*, ¶151. If a POSITA were to attempt to change the relative sizes of pixels in Matthies, then Matthies' triple-pixel structure of Figure 8A (shown below) would have been a more suitable starting point to combine with Yamada's triple-pixel structure. Ex. 2009, ¶152. In this structure, each column electrode contains only one color, such that changing the relative width of a column electrode would allow re-sizing pixels of that color without affecting the sizes of the other colors.



Matthies, Fig. 8A (annotated); 16:40-48. Such a modification would preserve the equal spacing between both pixels and the edges of the pixels and the tile. Ex. 2009, ¶¶152-154. Matthies' triple-pixel structure also allows for a greater light-emitting area (i.e., aperture ratio), and thus lower current density, than its quad-pixel design, which is particularly significant for PMOLEDs. Ex. 2062 at 176:2-5; Ex. 2009, ¶¶155-156.

However, a POSITA would not arrive at the challenged claims; the pixel arrangement structure would not include, *inter alia*, a virtual square of pixels with a green pixel at its center. Ex. 2009, ¶157. This is Petitioner's only apparent basis for ignoring Mathies' triple-pixel structure in favor of Figure 8B.

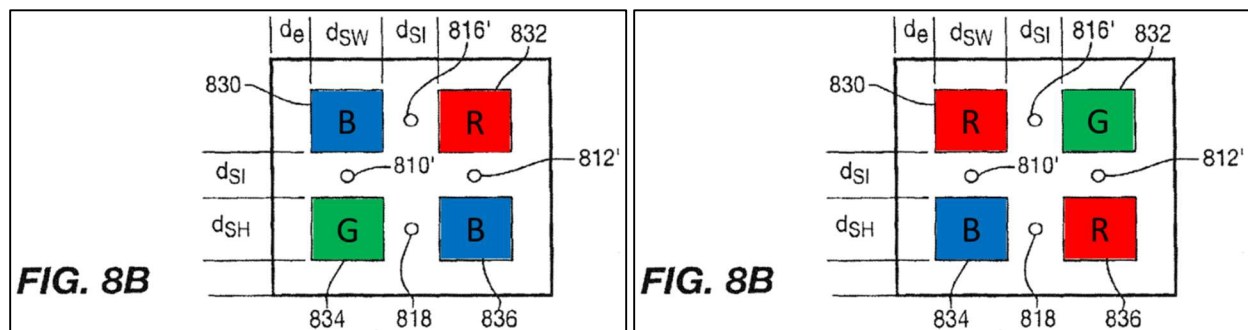
D. Even if a POSITA attempted to modify Matthies Figure 8B based on Yamada, the modification would not yield a pixel arrangement structure encompassed by the challenged claims.

Even if one attempted to combine Matthies' quad-pixel structure with Yamada, the references' teachings and other prior art teachings would have led a POSITA away from the claimed inventions and would not have resulted in a structure encompassed by the challenged claims. Ex. 2009, ¶¶158-163.

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

Matthies explicitly taught that where a particular color pixel has lower light-emitting efficiency, in its quad-pixel design *two* pixels of that color should be used. As Matthies explained, when "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, the pixels 830 and 836 may both be red or blue pixels” and “[i]n this instance, making the pixels 830 and 836 both be red or blue pixels would improve the overall brightness of the display.” Matthies, 17:5-10. This is depicted in the modified versions of Matthies’ Figure 8B below:



A POSITA addressing Yamada’s disclosure that blue OLEDs have the lowest emission efficiency (Yamada, 8:47-52) in view of Matthies’ Figure 8B would make pixels 830 and 836 both *blue* pixels (*i.e.*, an RBGB arrangement) in the quad-pixel structure—not decrease the size of the red or green pixels. Ex. 2009, ¶¶158-162. Matthies’ teaching, by doubling the emission area of the blue pixels, reduces the current density to them and increases their lifetime, consistent with Yamada’s goal. Further, Matthies teaches doing so without reducing the display’s aperture ratio.

Applying Matthies’ express teachings in view of Yamada would have led a POSITA down a divergent path from the challenged claims, resulting in a quad-pixel structure having two blue pixels, one red pixel, and one green pixel. Ex. 2009, ¶162. Such an arrangement does not meet all limitations of any challenged claim. For

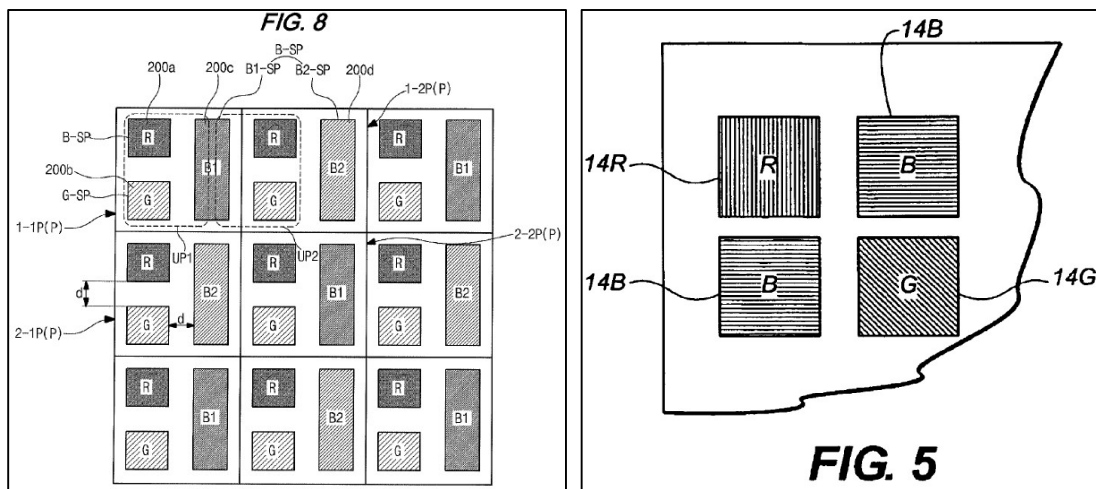
instance, it would not form a virtual square with a center coinciding with the center of a green pixel (the “first pixel”) in which two neighboring vertices coincide with the centers of a second pixel and third pixel (*i.e.*, blue and red pixel), as required by claim 1. As another example, limitation [1-b], which specifies “the second pixel has a larger area than that of the third pixel,” would not be met. *Id.*, ¶163.

2. Petitioner disregards prior art teaching away from Yamada’s approach, and misapplies Yamada’s disclosures.

Petitioner also disregards the prior art’s criticisms of Yamada, specifically for Yamada’s failure to account for relevant considerations affecting lifetime and display quality. Ex. 2009, ¶¶170-176. For example, Arnold explained 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” and “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; *see also* Ex. 1015 (“Cok”) at 2:5-8 (“Yamada[’s] ... display is not optimized with respect to the response of the human visual system”). As Arnold exemplifies, prior art criticized and taught away from reliance on Yamada and thus from Petitioner’s proposed combination. *Millenium Pharms., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1366 (Fed. Cir. 2017) (“reference[s] may be said to teach away” when a POSITA “upon reading the reference, ... would be led in a direction divergent from the path that was taken by the [inventor]”). At a

minimum, Arnold and other references show the lack of motivation to make Petitioner's proposed combination. See *Polaris Indus., Inc. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1069 (Fed. Cir. 2018).

In fact, prior art references that considered Yamada's teachings arrived at pixel arrangements entirely different from the claimed inventions, underscoring that a POSITA would not have been motivated to modify Matthies based on Yamada in the way Petitioner suggests. For example, Yoo (Ex. 2012) (below, left) arrived at a triple-pixel (RGB) structure.³ Arnold (below, right), having criticized Yamada, taught a quad-pixel structure with equally-sized pixels including *two blue* pixels.



³ Yoo's German counterpart (DE102011053000) (Ex. 2075) discusses Yamada, [0013].

Ex. 2012, Fig. 8; Ex. 2011, Fig. 5. That skilled artisans took such sharply divergent paths from the challenged claims, and Petitioner’s proposed combination, after considering Yamada is strong evidence of nonobviousness.

Indeed, in one embodiment, Yamada’s blue pixels are *35 times larger* than the green pixels. Yamada, 11:34-39. Dr. Pattison admitted in deposition that such pixel sizes would create “a lot of other problems with my device” and distort the luminance of the display “in a way that would not be I think conducive for display.” Ex. 2062, 196:14–20, 197:1-9.

Moreover, Petitioner’s theories rely on misapplication and selective reading of Yamada’s disclosures. Ex. 2009, ¶¶164-169. The Petition asserts that Yamada “teaches that the pixels should be re-sized” based on “emission efficiency,” with the “color with the lowest emission efficiency... (blue)” made “larger,” ignoring the role of chromaticity. Pet. at 19. Yet Yamada explicitly stated its pixel sizing depends “not only [on] the emission efficiency” but also the chromaticity of the light-emitting materials and the display’s target white point. Yamada, Abstract, 4:29-37. Dr. Pattison admitted Yamada requires consideration of factors such as chromaticity. Ex. 2062 at 91:8-92:17. And Yamada recognized that different emissive efficiency or chromaticity values could produce different size ratios even under its approach. Yamada, 10:52-60, 11:56-62; Ex. 2009, ¶166.

Although the emissive efficiencies and chromaticities of light-emitting materials would be necessary to apply Yamada's disclosures, Dr. Pattison admitted he did not consider, or even know, relevant values for Matthies' display nor make any calculations using such values to determine appropriate pixel size ratios. Ex. 2062 at 102:20-103:17, 105:6-9. Dr. Pattison's assertion that the blue pixels should be larger than red, and red larger than green (Ex. 1003, ¶219) is unsupported speculation. For instance, Arnold, which issued in 2004, explained that applying Yamada's teachings to the light-emitting materials for Arnold's display would result in red pixels being 2.8 times the size of blue pixels, despite the lower emissive efficiency of the blue OLED material. Ex. 2011, 15:58-16:36; Ex. 2009, ¶¶167-169.

Thus, contrary to the Petition's underlying assertion, the prior art did not teach that "the 'emissive element of a color with the lowest emission efficiency' (blue)" should always be made larger. Pet. at 19. Not only did Arnold demonstrate that Yamada's own teachings are to the contrary, but the prior art was replete with other contrary designs. Ex. 2009, ¶177.

3. Petitioner's proposal conflicts with Matthies' goal of avoiding visible differences at the seams between tiles.

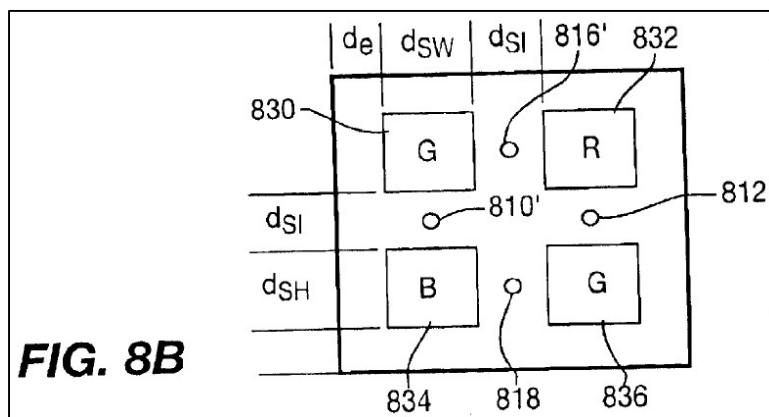
A POSITA also would not have combined Matthies with Yamada as Petitioner proposes, nor had a reasonable expectation of success, because doing so would introduce uneven spacing between pixels and between the pixel edges and tile edges, contravening Matthies' goal of "eliminat[ing] the visibility of the seams between

tiles” in tiled displays. Matthies, 2:7-10; 22:17-22; Ex. 2009, ¶¶178-179. To do so, and to allow space for materials that join adjacent tiles, Matthies taught the edges of the pixels on the outermost rows should be evenly spaced from the edge of the tile, and likewise for the outermost columns. Ex. 2009, ¶180. Matthies discusses the importance of light scattering, and teaches that differences in light scattering at the edge of a tile would make the seam appear visibly different. Matthies, 22:53-56; Ex. 2009, ¶180. To avoid this, “[t]he tiles are constructed with pixel forming elements *evenly spaced up to the edges of the tiles*,” *id.*, 5:47-48, and Matthies defines the value “ d_e ” to represent that edge-to-edge distance. *See* Matthies, 17:16-20, 16:49-52, Figs. 8A, 8B. Matthies further places black stripes or mullions between adjoining tiles. Matthies, 21:48–51, 22:3–25.

Petitioner’s proposal would accentuate, rather than prevent, the appearance of visible seams between tiles by introducing *uneven* spacing of pixels from the tile edges and *uneven* pixel sizes. Ex. 2009, ¶181. As Dr. Kymissis explains, Petitioner’s proposal would also lead to problems of undesired color shifts (due to relatively larger pixels being more “shadowed” by Matthies’ black stripes or mullions) and inconsistent white balance (due to different shadowing and color shifting based on viewing angle). Ex. 2009, ¶¶182-183.

4. Petitioner’s proposal also conflicts with Matthies’ design requirements for its quad-pixel arrangements.

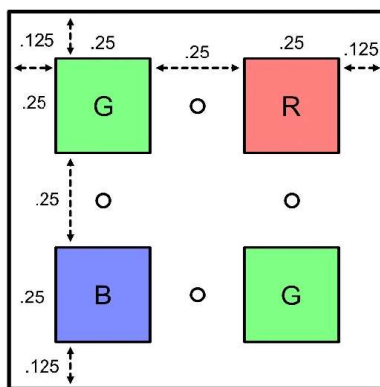
Petitioner’s proposal would also violate Matthies’ design requirement that its quad-pixel structure be composed of equally-sized pixels that have equal spacing from the edges of the pixels to the edges of the tile. Matthies, 17:16-20; Ex. 2009, ¶¶184-185. Matthies explicitly “define[s]” “[t]he geometry of the quad-pixel structure.” Matthies, 17:16-20. Matthies defines all four pixels in the quad-pixel structure as having the same height (d_{SH}) and width (d_{SW}), *id.*, underscoring that each pixel must have the same area, depicting such a structure in Figure 8B, shown below:



Matthies’ geometric requirements flow from its PMOLED design, as each pixel is defined by the overlap of column and row electrodes, and two different color pixels are found on each row (and column) electrode. Matthies, 17:10-20. Matthies specifies the two dimensions it allows to be varied—“the distances d_e and d_{SL} ” may be different “in the horizontal and vertical directions,” *id.*, 17:31-33, as changing

these maintains equal sizing of all pixels and equal distances between the outermost edge of a row or column of pixels and the tile edge. Ex. 2009, ¶186.

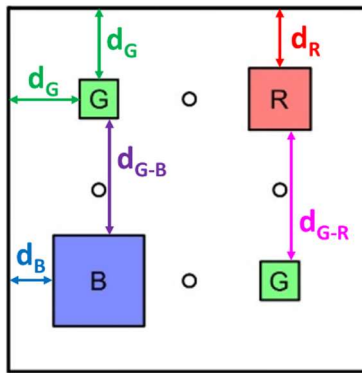
Further, as Petitioner concedes, Matthies teaches having the same spacing between the pixels, both within each tile and across adjacent tiles, as Petitioner’s “scale drawing” of the Figure 8B quad-pixel structure shows:



Pet. at 24. In this example, each pixel is 0.125 from the edge of the tile, and adjacent pixels are separated by a distance of 0.25 both within the tile and between tiles. More generally, Matthies explains “[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,” *id.*, 8:39-41; *see id.*, 9:23-26.

Petitioner’s proposed modifications violate Matthies’ geometric requirements for its quad-pixel structures. Ex. 2009, ¶¶187-190. If the red, green, and blue pixels all have different sizes, the distance between adjacent pixels would **not** be constant, and the distance between pixels and the edges of the tile would be different for each

color pixel. As demonstrated by Petitioner’s figure, below, depicting its proposed combination, the space between a green pixel and an adjacent red pixel would be *greater* than (and thus *unequal* to) the space between a green pixel and an adjacent blue pixel. Likewise, each pixel would be a *different* distance from the edge of the tile:



Pet. at 33 (annotations added of Petitioner’s drawing).

While Petitioner claims “Figures 3 and 4 of Yamada exemplify how a pixel array/matrix is to be modified using this relative sizing,” *id.* at 31, they do not. Ex. 2009, ¶¶191-192. Yamada involves AMOLED displays, which as discussed above have different constraints on pixel size, shape, and arrangement than the PMOLED of Matthies’ Figure 8B.⁴ Petitioner ignores that its proposed re-sizing is

⁴ Petitioner also asserts that Yamada’s Figure 4 requires “[t]he same pixel spacing...with the pixels centered on the same spots...and the intervening signal

incompatible with Matthies. Blue pixel 834 and green pixel 836 have the same height as the row electrode, and blue pixel 834 and green pixel 830 have the same width as the column electrode. To make the green pixel smaller would entail making one or both electrodes narrower, which would make the blue pixel correspondingly smaller (and would also have electrical and other effects). Ex. 2009, ¶193. Further, Yamada describes Figures 3 and 4 as mere “conceptual diagrams.” Yamada, 6:21-26. *See Hockerson-Halberstadt, Inc. v. Avia Grp. Int’l*, 222 F.3d 951, 956, (Fed. Cir. 2000) (“[P]atent drawings do not define the precise proportions...and may not be relied on to show particular sizes if the specification is completely silent on the issue.”). Where Yamada depicts how pixels would actually be implemented, *e.g.*, Fig. 5; *see also* Fig. 1A (Related Art), it shows the pixel shape is more complex (L-shaped) to account for its pixel circuitry, and incompatible with Matthies’ Figure 8B display.

Moreover, the Petition failed to demonstrate how the PMOLED display of Matthies’ Figure 8B could purportedly be made with differently-sized red, green, and blue sub-pixels. Even if one were willing to flout Matthies’ teachings, a POSITA would have been confronted with complicated technical and manufacturing hurdles requiring drastic re-design of Matthies that a POSITA would not have been

lines...remain[ing] in place” (Pet. at 31), but nothing in Yamada supports such inference from conceptual Figure 4.

motivated to make or had a reasonable expectation of success in making. Ex. 2009, ¶193. For instance, creating electrodes with non-uniform width would introduce complex electrical effects (e.g., IR voltage drop, enhanced electric field) that may impair the display's operation and quality and would also require wholly new process steps (e.g., patterning of electrodes) that would reduce yield and increase manufacturing complexity and cost. Ex. 2009, ¶¶124-127.

While Petitioner asserts that “Matthies itself already contemplates that the sizes and space between its pixels can be adjusted.” Pet. at 44 (relying on Matthies, 17:31-37, 12:9), Matthies allows only changes that preserve uniform spacing of pixels in a row or column, including their uniform distance from the edge of the tile, as discussed above. Matthies does not allow *nonuniform* spacing of pixels along a row (or column) in its quad-pixel structure or having different sized pixels, let alone uneven spacing to the edge of the tile that would make the seams between tiles visible. Ex. 2009, ¶194.

And while Petitioner claims that Matthies invites changing the “geometry of the pixels” to address OLED pixel aging and decay (Pet. at 42), Matthies does no such thing. Matthies simply observes that pixel aging relates to a number of factors, including pixel geometry, and addresses aging through its circuitry. Nothing in Matthies invites or suggests the type of modifications Petitioner proposes, which as

discussed would violate Matthies’ design rules and accelerate aging of the red and green pixels.

VI. Ground 2: Petitioner Fails to Establish a *Prima Facie* Case of Obviousness Based on Phan.

A. Phan does not disclose an OLED display or OLED pixels.

The ’803 Patent’s challenged claims require an OLED display and OLED pixels. The preamble recites “[a] pixel arrangement structure of an organic light emitting diode (OLED) display.” ’803 Patent, cl. 1. The preamble is limiting. “A preamble limits the claimed invention if it recites essential structure or steps, or if it is necessary to give life, meaning, and vitality’ to the claim.” *Eaton Corp. v. Rowell Int’l*, 323 F.3d 1332, 1339 (Fed. Cir. 2003) (cleaned up). Not only is an OLED display essential structure, it provides the antecedent basis for limitation [1-a] which recites “a plurality of pixels for displaying an image on *the OLED display*.” ’803 Patent, cl. 1. The OLED display is also vital to the invention which relates to pixel arrangements adapted to “the unique manufacturing characteristics of the OLED display.” *Id.*, 1:15-62, 5:32-34; Ex. 2009, ¶¶197-200. Dr. Pattison acknowledges the challenged claims require an OLED display. Ex. 2062 at 81:12-17.

Phan, however, does not disclose a pixel arrangement structure for an OLED display. Ex. 2009, ¶201. No embodiment in Phan discloses an OLED display or OLED pixels. Phan merely contains a single passing reference to “OLED,” not in connection with any embodiment, but seventh in a laundry list of every conceivable

display technology, including non-existent technologies and “any light sources known or invented in the future”:

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, 1:18-29. Neither Dr. Kymissis nor Dr. Pattison has even heard of several of Phan’s listed “display technologies” (e.g., “Phototronics,” “Biotronics”) nor knew what Phan meant by some of them. Ex. 2009, ¶202; Ex. 2062 at 159:22-160:21. A POSITA would not have read Phan’s laundry list to mean that its embodiments of pixel arrangements were for OLEDs or for each of the listed alleged “display technologies.” Ex. 2009, ¶202.

As the Federal Circuit affirmed in *Otsuka Pharm. Co. v. Sandoz, Inc.*, “one of ordinary skill in the art would not have understood [a] patent’s ‘laundry list’ of potential” therapeutic effects to mean every listed compound was disclosed as a potential antipsychotic. 678 F.3d 1280, 1294 (Fed. Cir. 2012). So too here. A

POSITA would not have understood Phan to mean that OLED technology, or “any light sources known or invented in the future,” would be appropriate for all pixel arrangements depicted in its Figures or specifically for Figures 11a and 11b on which Petitioner relies. Even Dr. Pattison admits pixel layouts would be adjusted based on the underlying technology. Ex. 2062 at 41:6-43:4. Nor is *EWP Corp. v. Reliance Universal Inc.*, 755 F.2d 898 (Fed. Cir. 1985) to the contrary. “A reference must be considered for everything it teaches,” *id.* at 907, but Phan does not teach about OLED displays. Phan does not state, nor suggest, that the pixel arrangements it draws, or Figures 11a and 11b specifically, would be suitable for an OLED display.

To the contrary, Phan’s disclosures reinforce to a POSITA that its embodiments were not OLED displays. Phan explains the display connects to “control circuitry” through “preferably...an optical fiber network” that addresses individual pixels’ “receivers” to convert “digital information transmitted through [the] network [] into luminous intensity levels” for the pixels. Phan, 5:9-24. A POSITA would recognize that displays using “optical fiber network[s]” and “receivers” do not relate to OLEDs. Ex. 2009, ¶203. Phan mentions only CRT, LCD, LED,⁵ PDP, and FED in the sole portion of its specification containing any

⁵ LED refers to solid-state light-emitting diodes, which are distinct from OLEDs. Ex. 2009, ¶204.

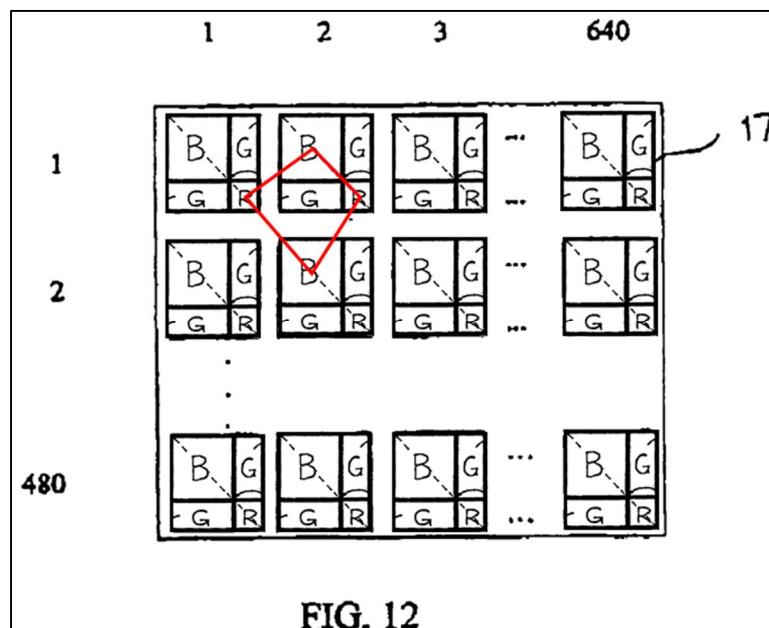
substantive discussion of the display technologies. Phan, 1:56-2:46; Ex. 2009, ¶204. Moreover, Phan's figures depict essentially no spacing between adjacent dots, which a POSITA would recognize was not feasible for an OLED display due to issues of color mixing of the organic light-emitting materials and shorting between adjacent pixels. Ex. 2009, ¶¶205-206.

Additionally, Phan's virtual driving method—the heart of Phan's disclosure—would not be feasible in an OLED display. Phan criticizes the use of TFTs in active-matrix LCDs as “extremely expensive and very prone to major amounts of rejects,” and discloses as its invention an approach of 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; Ex. 2009, ¶¶207-211. Phan's algorithm requires scanning through the rows of a full display at such high frequency and high brightness (requiring such high current for an OLED), that it would be impractical with a passive-matrix OLED display. Ex. 2009, ¶¶211-215.

Thus, a POSITA would not view Phan as disclosing an OLED display or a pixel arrangement structure of an OLED display, and would not have had a reasonable expectation of success in making Phan an OLED display.

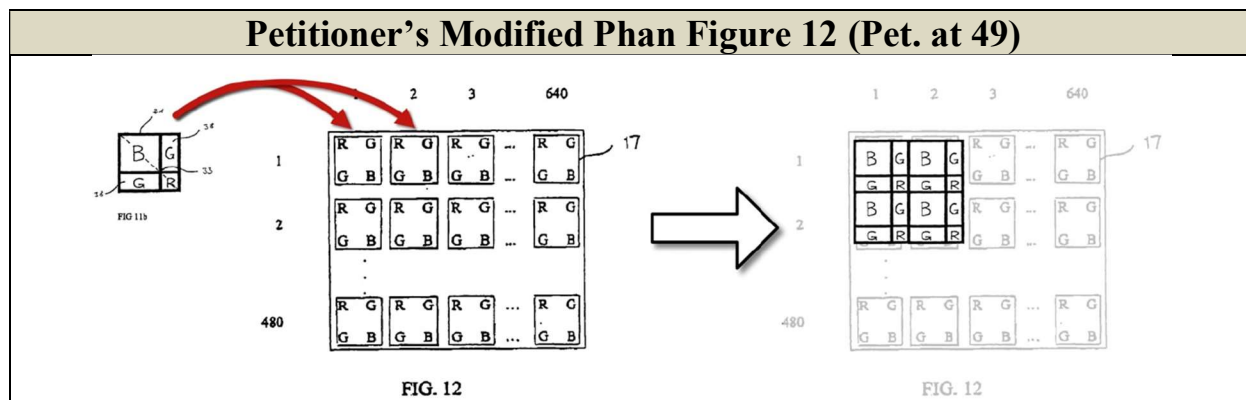
B. Phan does not disclose or suggest the challenged claims’ virtual square.

Petitioner proposes combining Phan’s quad-pixel arrangement of Figure 11b with the “quad-pixels display” in Figure 12. Pet. at 49-50. But combining Phan’s Figure 11b and Figure 12 would not result in the “virtual square” arrangement required by the challenged claims. Rather, combining the structure of Figure 11b with Phan’s display of Figure 12 would result in a structure in which the “first pixel” (green) does *not* have a center coinciding with a center of a virtual square, as shown below in an annotated version of Figure 12. Ex. 2009, ¶¶216-219.



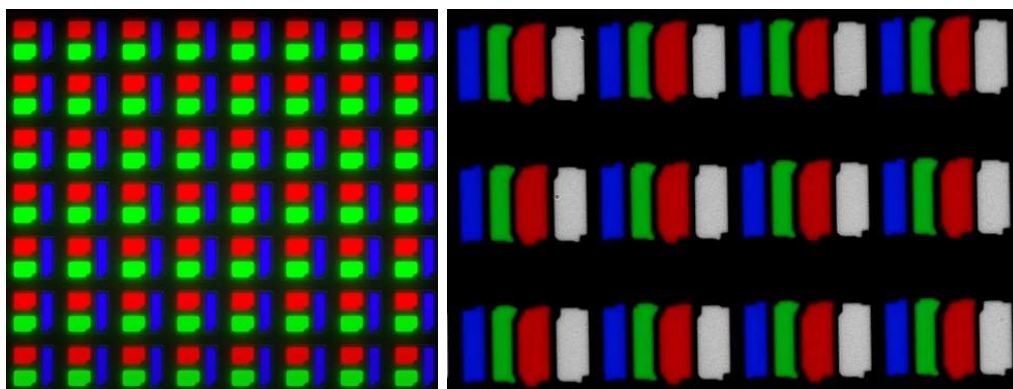
Petitioner attempts to obscure this failing by misleadingly drawing the purported combination in a manner inconsistent with Phan’s teachings. Phan’s Figure 12 shows spacings between each quad-pixel (*i.e.*, each grouping of four subpixels). When Petitioner depicts its purported combination, however, Petitioner

inexplicably changes the arrangement and geometry of Phan's Figure 12 to remove the spacings between the adjacent quad-pixels:



Petitioner and Dr. Pattison offer no justification for changing Phan's display to remove its clearly-disclosed spacings between adjacent quad-pixels, which would allow, for example, placement of wiring for Phan's "[c]ontrol circuitry," or "optical fiber network." Ex. 2009, ¶¶220-221; Phan, 5:20-24, Fig. 5.

Similar spacings between individual pixel unit groups were common in manufactured display devices, as shown below. Ex. 2009, ¶¶222-225.



Petitioner's changes are also incompatible with Phan's dynamic pixel approach. In a quad-pixel structure having differently sized red, blue, and green dots—such as the Figure 11b structure on which Petitioner relies—the visual locus

of the *dynamic* quad-pixel disclosed by Phan (*see, e.g.*, Figures 9.1-9.8) will be perceived by the viewer to be shifted from the physical center of the *static* quad-pixel. Ex. 2009, ¶¶225-226. Thus, fundamentally to Phan’s design, where the sub-pixels are of unequal sizes, spacings between each quad-pixel would be necessary to prevent distortion and poor image quality. Ex. 2009, ¶¶226-228. A POSITA could not remove the gaps between quad-pixels in combining Figure 11b with Figure 12 as Petitioner has done; such a modification would contradict Phan’s goal of improving resolution and image quality through “variable generation of pixels from existing dots,” *i.e.*, its “dynamic generation of pixels.” Phan, 2:54-3:19; Ex. 2009, ¶¶228-230.

VII. Ground 3: Petitioner Fails to Establish a *Prima Facie* Case of Obviousness of Claim 5 Based on Phan in view of Yamada.

For claim 5, Petitioner proposes to combine Phan with Yamada, taking Phan’s arrangement of Figure 11a (not the Figure 11b arrangement Petitioner relies on for Ground 2), keeping Phan’s blue dot the same size, reducing the size of the red dot, reducing the size of the two green dots even more, and placing that structure in the display of Phan’s Figure 12. Pet. at 61. As discussed in Section VI.A *supra*, Phan does not disclose OLED displays or OLED pixels. Petitioner’s purported combination does not change that. Therefore, it cannot meet the requirements of claim 5.

Yet even had Phan disclosed OLED displays, Petitioner's obviousness theory would fail for additional multiple reasons, as detailed below.

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

Phan and Yamada are incompatible technologies, and Petitioner's proposed changes to the relative sizes and spacing of sub-pixels (or "dots") in Phan's quad-pixels contradict Phan's express teachings.

Phan explicitly concerns passive-matrix displays. *E.g.*, Phan, 5:23-24 ("Addressing involves high-frequency repetition, preferably at a rate of minimum 100 Hz for passive driving display"). Phan describes its approach as an alternative to actively-driven displays, criticizing active-matrix LCDs for requiring TFTs to individually control pixels because TFTs are expensive and prone to manufacturing failure. *Id.*, 2:14-43. Indeed, a POSITA would have understood active-matrix OLEDs would require even more TFTs per pixel, and more complex pixel circuits, than LCDs. Ex. 2009, ¶¶234-235. A POSITA would not have looked to Yamada, which concerns AMOLEDs, to design a pixel arrangement for Phan, which involves a passive-matrix display intended to implement Phan's dynamic pixel driving. Ex. 2009, ¶¶235-236.

As a POSITA would have understood, the design considerations for a pixel arrangement of a passive-matrix OLED differ markedly from those of an active-matrix OLED. *See* Section IV; Ex. 2009, ¶237. The rate and modes of degradation

of OLED pixels would be materially different in a passive-matrix display than in the AMOLED displays to which Yamada was directed, particularly with Phan's requirement of "high-frequency repetition" to implement its dynamic pixels. *Id.* Indeed, Phan's Figure 12 discloses a display having 480 rows of pixels; a POSITA would understand this would require markedly higher driving voltages and current densities (due to shorter "on" times for each row) than experienced in an AMOLED, causing a pixel aging rate and profile unlike that contemplated by Yamada. *Id.*, ¶238. Thus, a POSITA would have had no reason to look to Yamada and its disclosures about pixel aging in AMOLEDs to modify a pixel arrangement of Phan, much less with any reasonable expectation of success. *Id.*

Petitioner also disregards incompatibilities between its proposed modifications purportedly based on Yamada and Phan's teachings. Ex. 2009, ¶239. Insofar as Yamada taught blue light-emitting OLED materials were less efficient, Phan already taught the solution in the form of a quad-pixel structure containing two blue subpixels, doubling the relative light-emitting area of blue light. Phan, Fig. 1b. A POSITA would have been motivated to use such a structure (which does not satisfy the challenged claim), rather than the structure Petitioner asserts, for the same reasons discussed above with respect to Matthies. *See* Section V.D.1 *supra*; Ex. 2009, ¶239. Further, in Figures 10b and 11b, Phan disclosed that a blue light-emitting pixel in a quad-pixel may be enlarged by expanding it along a diagonal cross-point. Yet

Phan teaches that this requires green pixels to be next largest and red pixels the smallest, as Phan's figures depict—which would not meet multiple requirements of claim 5. *Id.*, ¶¶240-241.

Petitioner's proposal also violates Phan's requirement of adjusting the pixel sizes along a crosspoint, which has both visual importance in terms of perception of the quad-pixel (significant to Phan's dynamic pixel driving), and relates to Phan's passive-matrix structure. Ex. 2009, ¶241. As each row of pixels shares the same row electrode, and each column of pixels shares the same column electrode, when Phan adjusts the sizes of pixels, pixels in the same column retain an equal width and pixels in the same row retain an equal height. Petitioner's blithe drawing of a picture that splits apart the subpixels and introduces uneven spacing between them ignores, and conflicts with, Phan's requirements. Petitioner's proposal would be incompatible with Phan's passive-matrix structure. *Id.*, ¶¶242-243.

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

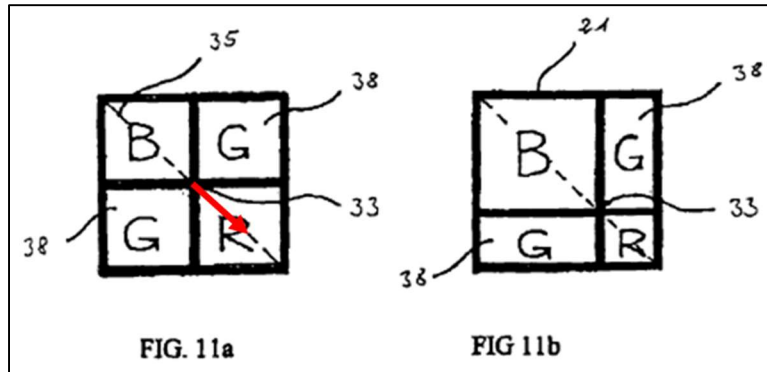
1. A POSITA would not have re-sized Phan's dots by maintaining the blue dot size and shrinking the red and green dots.

Even had a POSITA attempted to combine Phan with Yamada, the POSITA would not have followed Petitioner's proposal of maintaining the blue dot size in Phan's Figure 11a and then shrinking the red dots to be smaller and the green dots to be smallest. Pet. at 62; Ex. 2009, ¶244. The only explanation for Petitioner's

modifications is a hindsight-driven attempt to create the arrangement of the challenged claim.

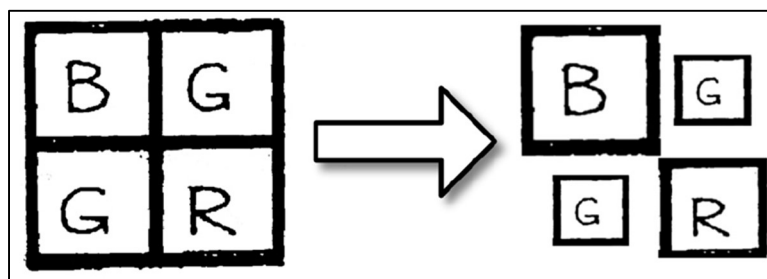
First, for reasons as discussed above in connection with Ground 1, a POSITA would have understood that keeping the blue pixel the same size and shrinking the red and green pixels would require higher current density to be applied to the red and green pixels, accelerating their aging and reducing display lifetime. These effects would be exacerbated because Phan's passive-matrix displays require high driving voltages and current densities. *Id.*, ¶¶245-246. The Petitioner's proposed combination of Phan with Yamada would have the opposite effect of Petitioner's purported motivation to combine of extending display lifetime. *Id.*

Second, Petitioner's proposed modification conflicts with Phan's express teachings concerning how to adjust the relative sizes of subpixels (dots) in a quad-pixel structure. *Id.*, ¶247. Phan discloses that the relative sizes of the dots in its square quad-pixel are changed by moving the crosspoint—*i.e.*, the point at which the corners of all four pixels meet—along a diagonal line of the square, for example along the red arrow. Phan, 5:51-54.



Id., Figs. 11a, 11b. As shown in Figures 11b, when the blue pixel's size is increased, each green pixel is necessarily made an intermediate size and the red pixel is necessarily made smallest. Ex. 2009, ¶248.

Phan teaches adjusting the sizes of dots without adding space between subpixels—keeping the overall aperture ratio constant—by moving the crosspoint along a diagonal line. Phan, 5:43-46, 5:51-54. Petitioner inexplicably breaks apart Phan's quad-pixel, contrary to Phan's requirements, and introduces arbitrary spacing between the subpixels without any support in Phan:



Pet. at 61. Not only is this inconsistent with Phan's teachings about the crosspoint, but it is inconsistent with Phan's passive-matrix design constraining adjustments of

pixel sizes. Ex. 2009, ¶¶249-250. Indeed, Petitioner provides no reason for ignoring Phan’s Figure 11b in enlarging the blue subpixel.

Dr. Pattison asserts the arbitrary spacing Petitioner adds in its drawing increases existing space that would be “required” for “intermediate signal lines.” (Ex. 1003, ¶¶360, 428-429), but this ignores that Phan provides space for such lines *between* the quad-pixels, as Figure 12 shows. Moreover, if he were correct that Phan required different spacing between subpixels than depicted in Phan’s figures (he is not), then Petitioner’s very purported basis for inferring relative distances between subpixels would dissolve. Ex. 2009, ¶251. The spacing Petitioner adds is not only unwarranted, it would undesirably reduce the aperture ratio of the display, requiring higher current densities to be supplied to the pixels to maintain brightness, causing accelerated pixel aging and reduced lifetime, contrary to Yamada’s goal. *Id.*, ¶252.

Nor does Petitioner justify why, rather than applying Phan’s Figure *11b* structure (in which blue is larger), Phan’s design rules should be broken and the red pixel should be made larger than the green pixel. *Id.*, ¶253. Petitioner offers no reason why a POSITA would make the many modifications required by Petitioner—which are inconsistent with Phan’s passive-matrix design—much less without establishing any need. *Id.*

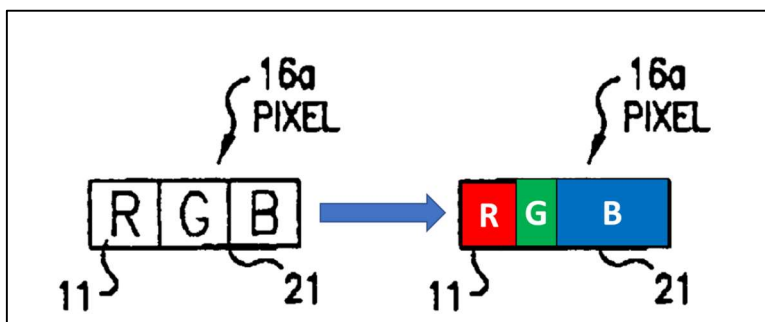
2. Petitioner disregards prior art teaching away from Yamada's approach, and misapplies Yamada's disclosures.

In its proposed combination with Phan, Petitioner misreads (and oversimplifies) Yamada's disclosures regarding sizing of pixels in the same ways discussed above with respect to Ground 1, including (1) disregarding prior art criticizing Yamada and showing a POSITA would have followed a divergent path away from the invention of the challenged claim, and (2) failing to identify or analyze efficiencies and chromaticities of materials in Phan's display as would be necessary to apply Yamada's teaching. *See* Section V.B, V.D.2; Ex. 2009, ¶¶254-255. Petitioner's proposal to change Phan's pixel sizes amounts to unsupported speculation.

3. Petitioner fails to identify a reason to use Phan's quad-pixel design, rather than its stripe pattern, in a combination with Yamada's stripe pattern.

Even assuming *arguendo* a POSITA would try to combine Phan with Yamada, the POSITA would not have been motivated to use Phan's RGBG quad-pixel structure for the combination. Ex. 2009, ¶¶256-261. Phan attributes no benefits to its quad-pixel structure, and Petitioner does not identify any reason for using such a structure. If anything, a POSITA would have tried to apply Yamada's triple-pixel RGB arrangements to Phan's triple-pixel RGB stripe patterns shown in Figures 3a-b, for similar reasons to those discussed with respect to Matthies. *Id.*, ¶¶256-259. Adjusting the sizes of Phan's red, green, and blue dots in the triple-pixel structure

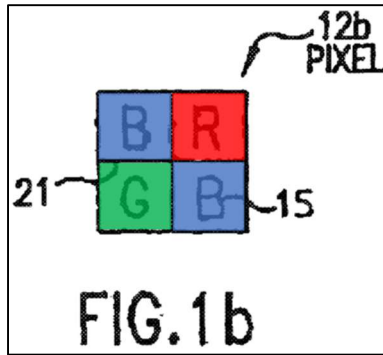
would have fewer incompatibilities with Phan and would not require reducing the aperture ratio:



Phan, Fig. 31 (annotated); Ex. 2009, ¶259. In contrast, Phan does not disclose a quad-pixel structure that can be resized to have a red dot larger than the green dot. And Yamada does not concern quad-pixel structures. *Id.*, ¶¶260-261. A POSITA would not have had reason to make Petitioner's proposed modification of Phan's Figure 11a quad-pixel in view of Yamada.

4. Even if a POSITA attempted to modify Figure 11a of Phan based on Yamada, the modification would not yield a display within the challenged claim.

Even if a POSITA were to combine Phan's quad-pixel structure with Yamada, the POSITA would have had no motivation to keep two green pixels. A POSITA would have known that, in a quad-pixel structure, using two pixels of a color could compensate for its lower efficiency. *E.g.*, Matthies at 17:5-10; Ex. 2009, ¶¶262-263. If the blue pixel had the lowest efficiency, a POSITA would use two blue pixels, allowing the blue pixels to be driven with a lower current density, consistent with Yamada's goal. Phan discloses and illustrates just such a quad-pixel structure:

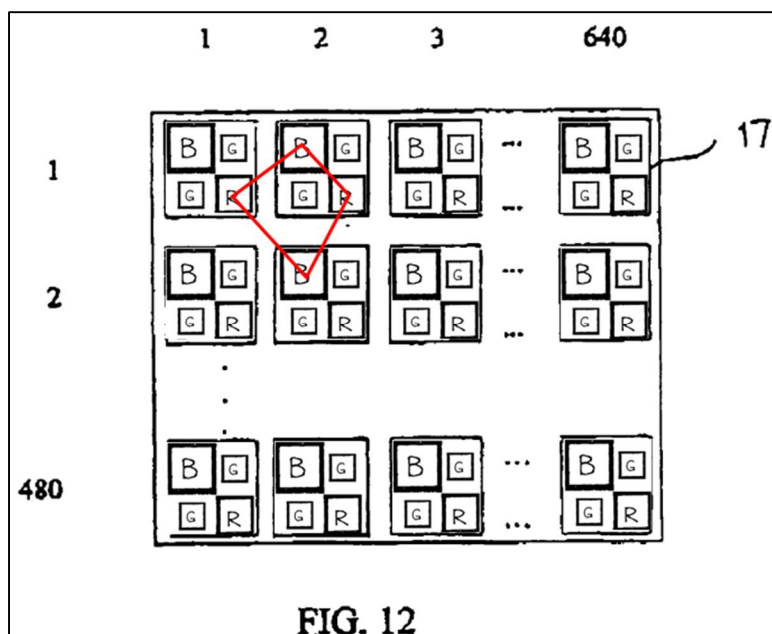


Phan, Fig. 1b.

In contrast, the life of the display would not be extended if the size of the blue pixel with the lowest emission efficiency—the blue pixel, under Petitioner’s theory—were left unchanged, as Petitioner proposes. Petitioner does not argue that a quad-pixel arrangement with two blue pixels would meet the requirements of any challenged claim 5, nor could it. In such an arrangement, there would be no virtual square centered on a green pixel as the claim requires. Ex. 2009, ¶¶264-265.

C. Petitioner’s proposed combination of Phan and Yamada lacks a virtual square.

Petitioner further fails to show that its proposed modified quad-pixel structure purportedly based on combining Phan’s Figure 11a arrangement implemented in the display of Figure 12 with Yamada (Petition at 62) would satisfy all the limitations of claim 5. It would not. The Petition’s modified display would lack, *inter alia*, a first pixel having a center coinciding with a center of a virtual square:



As in Ground 2, Petitioner obscures this failing by not drawing its proposed combination consistent with Phan's disclosures (and not acknowledging its changes). Petitioner again draws a picture that inexplicably removes the gaps between Phan's quad-pixels. But 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 in Section VI.B. Ex. 2009, ¶¶266-271.

VIII. Ground 4: Petitioner Fails to Establish a *Prima Facie* Case of Obviousness Based on Murai in view of Yamada.

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

The challenged claims require an OLED display and OLED pixels, as discussed in Section VI.A. However, Petitioner's proposed combination of Murai with Yamada would not result in an OLED display or pixels of an OLED display. Murai's Figure 3 embodiment, like its other embodiments, is an LCD display, not

an OLED display. Petitioner does not propose implementing Yamada's OLEDs in Murai; Petitioner only purports to re-shape and re-size the "dots" (sub-pixels) in the unit pixel structure of Murai's Figure 3 display, based on Petitioner's theory of Yamada's purported teachings (*see* Section V.D.2).

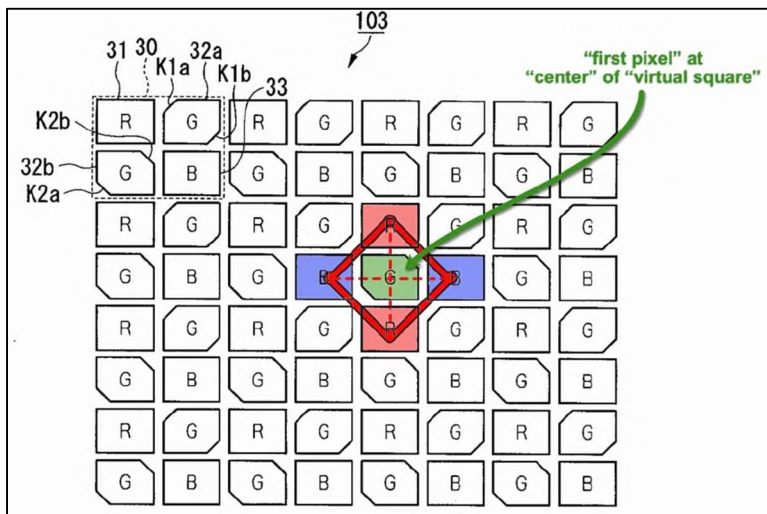
Murai's "Background Art" section describes only LCDs, Murai, ¶[0002], and its only detailed description of a display structure describes a single TFT for driving each dot, *id.*, ¶¶[0040]-[0043], a well-known structure for driving LCDs that a POSITA would have understood does not refer to OLEDs (which required at least two TFTs per pixel). Ex. 2009, ¶276. Murai's descriptions of its pixel electrode, holding capacitor electrode, and color filters are all indicative of LCDs. Murai, ¶[0040]-[0043]; Ex. 2009, ¶276. Murai's "Problem to Be Solved" section discusses an issue in displays such as color LCDs employing tightly-packed pixels, namely "streaking" due to the dense placement of same-color dots, Murai, ¶ [0003]-[0005], which a POSITA would have understood did not present a material issue in displays such as OLED displays having larger gaps between pixels (as required by OLED manufacturing). Ex. 2009, ¶276.

Nothing in Murai indicates the Figure 3 embodiment on which Petitioner relies was, or could be, an OLED display. Ex. 2009, ¶277. The entire reference makes just one passing reference to "organic EL displays" in a list. Murai, ¶[0058] ("the present invention can be applied to liquid crystal display devices, organic EL

display devices, plasma display devices, projectors, and the like”). Murai does not disclose or suggest that any of its figures, let alone Figure 3, represent how an OLED display (or the other display types besides LCD) could or would be implemented. Ex. 2009, ¶¶277-278. Given substantial structural, manufacturing, and operational differences between LCDs and OLEDs, a POSITA would not have understood Murai’s Figure 3 to represent how Murai could or would be applied to an OLED display. Ex. 2009, ¶279.

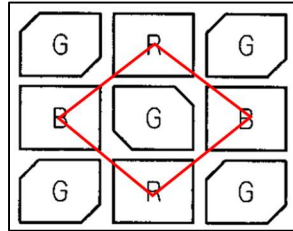
B. The combination of Murai and Yamada does not disclose a virtual square.

Petitioner inaccurately asserts that “Murai’s dots form a ‘virtual square’ with a green dot at its ‘center,’” Pet. at 67, relying on the following annotated image:



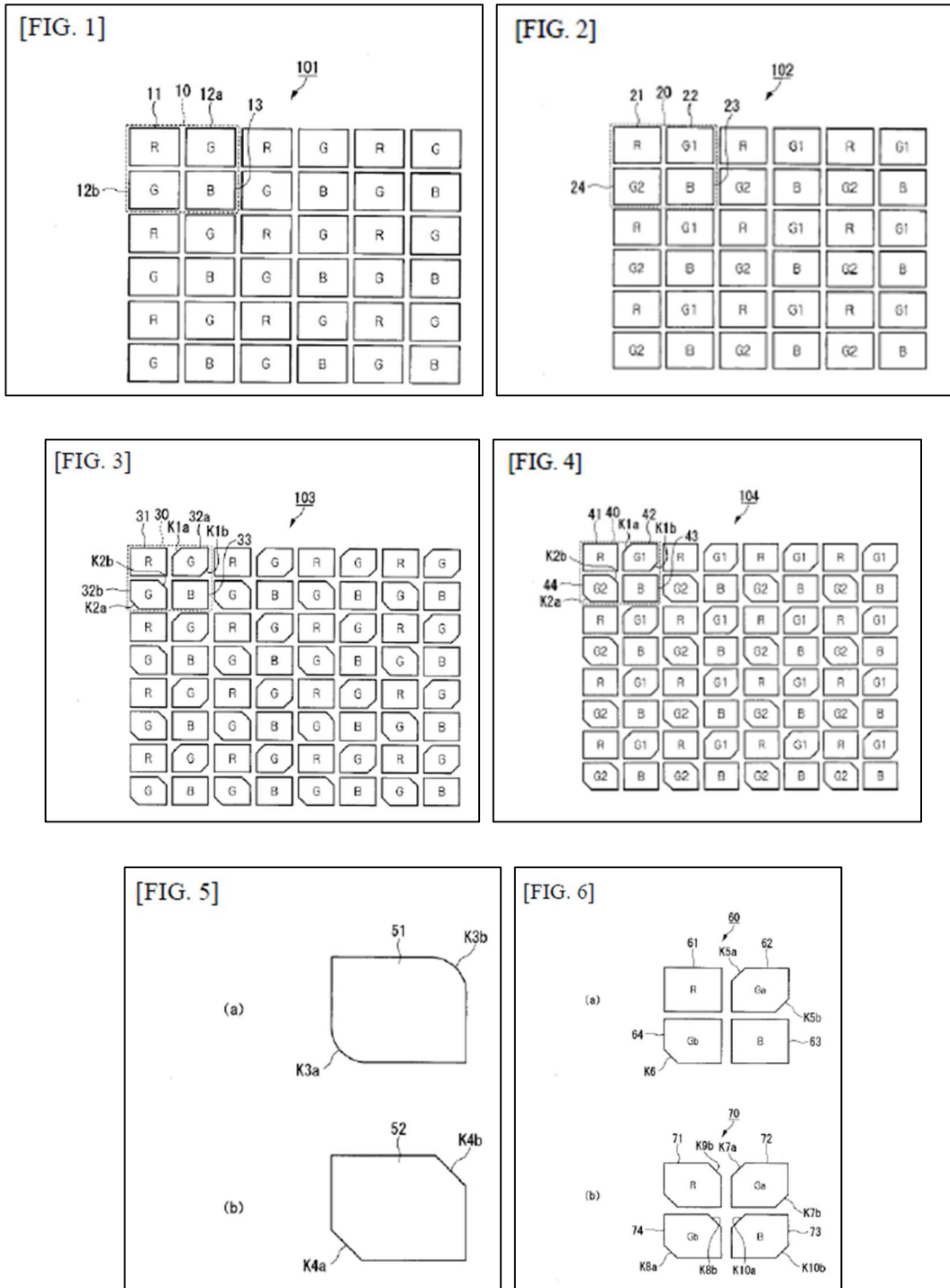
Id. at 68. Closer inspection reveals, however, that Petitioner placed vertices of the “virtual square” deceptively off the centers of the red and blue dots, to make the arrangement look like a square. Ex. 2009, ¶¶280-283. However, the challenged

claims require that the pixel *centers* be located at the vertices of the virtual square. See limitations [1-a(2)], [1-a(4)], [2-a], [3-a]. When vertices are located at the red and blue dots' *centers*—as the challenged claims require—no virtual square is formed.



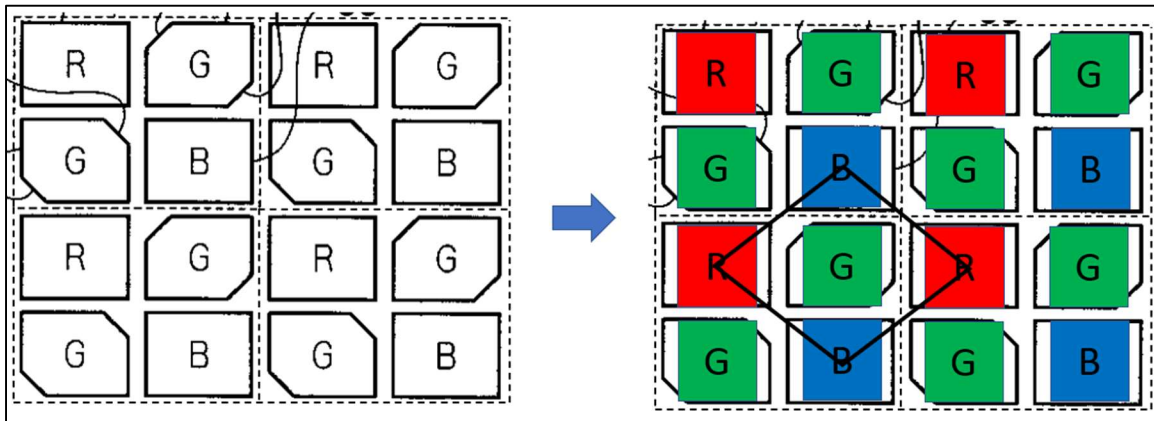
Murai, Fig. 3 (annotated).

Petitioner asserts that Figure 3 provides an example of “the use of a square dot shape, with dots arranged in a grid with a square shape.” Pet. at 67. It does not. Figure 3 uses a rectangular dot shape and dots arranged in a rectilinear grid, as Dr. Pattison admits. Ex. 1003, ¶¶476-477 (“Figure 3 shows slightly rectangular dots (which have a length somewhat greater than their height).”). As shown below, *every* figure in Murai uses rectangular dots. Petitioner provides no reason why a POSITA would depart from Murai’s consistent depiction of rectangular dots. Ex. 2009, ¶¶284-287.



Even were Murai's dots changed to squares, the dots still would not form the "virtual square" structure required by the challenged claims. Murai's "unit pixel" containing the four grouped color dots (i.e., quad-pixel) is rectangular (i.e., has a

differing length and height). Thus, even changing the individual dots in the quad-pixel structure to squares would not form a virtual square:



Murai, Fig. 3 (annotated) (dotted rectangles representing quad-pixel structures); Ex. 2009, ¶¶287-290. While Murai allows individual *dots* to be square, it never states or suggests the quad-pixel *grouping* can be square.

Petitioner does not contend a POSITA would have modified Murai’s quad-pixel structure from an oblong rectangle to a square when combined with Yamada. Petitioner merely quotes Murai’s statement that “[a]ll of the dots are ‘accurately’ and ‘regularly disposed.’” Pet. at 67 (quoting Murai, ¶ [0010]), and makes the bare—and incorrect—assertion that this means Figure 3 uses “a square dot shape, with dots arranged in a grid with a square shape,” citing only an assertion in Dr. Pattison’s declaration (which misreads Murai). *Id.* Figure 3 does not use a square dot shape. And as Dr. Kymissis explains, Murai does not state or suggest to a POSITA that its dots can be arranged in square grids. Ex. 2009, ¶¶291-293.

In any case, Murai’s quad-pixel structure, whether with oblong rectangle dots or square dots, fails to disclose the claimed “virtual square” of the challenged claims. Ex. 2009, ¶¶294-295.

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

A POSITA would have had no reason to combine Murai and Yamada. *First*, Murai’s Figure 3 describes an LCD device, to which Yamada’s disclosures would be inapplicable. LCDs do not contain organic emissive layers. And the backlight of an LCD provides one color of light, which is passed through color filters to control color. Ex. 2009, ¶¶296-297. Yamada’s disclosures regarding differential efficiencies among organic materials have no relevance to LCDs. *Id.*, ¶297. A POSITA would not have been motivated to modify Murai’s pixel sizes based on Yamada.

Second, Murai’s disclosures—including its very reason for implementing cut-outs in the green dots in Figure 3—are incompatible with Yamada. Murai’s goal was to “improve” “the overall aperture ratio” (the light-emitting area of the display) by packing pixels closely together. Murai, ¶[0042]; Ex. 2009, ¶298. Petitioner’s proposed modifications, purportedly based on Yamada, would instead *reduce* the display’s aperture ratio and do so needlessly.

Third, Petitioner disregards the reasons for Murai’s cut-outs. Having packed dots especially closely together in its display, Murai observes that its diagonal lines of close green dots create visible streaks, which Murai avoids by cutting-out

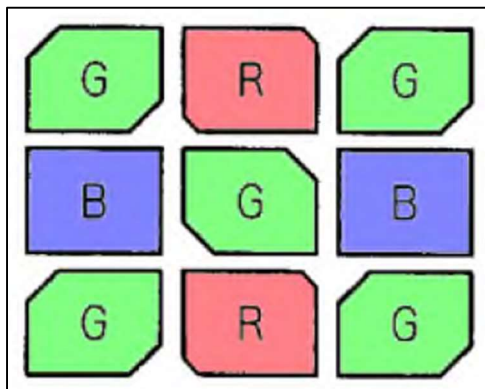
alternating corners on the green dots to increase their separation and improve “visual connectivity” of individual unit pixels, Murai, ¶[0011], Fig. 6(a). In an OLED display, however, different-colored pixels must be spaced farther apart due to manufacturing requirements, and a POSITA would not have viewed Murai’s cut-outs as necessary. Ex. 2009, ¶¶299. For instance, Yamada’s disclosed emissive area ratios of 1:2.6:5.6 between green, red, and blue pixels, or alternatively 1:14.2:35—which Petitioner cites, Pet. at 32; Yamada, 11:8-10, 11:34-39—would result in separations of green dots sufficient to nullify the reason for Murai’s cut-out portions. A POSITA would not have been motivated to make this combination nor had a reasonable expectation of success in doing so. Ex. 2009, ¶¶299-301.

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

Petitioner proposes a combination of Murai’s Figure 3 and Yamada wherein Murai’s blue dots are kept the same size and have no cutout, the red dots are modified to have two small cutouts, and the green dots are modified to have two larger cutouts. Pet. at 74. A POSITA would have had no motivation to make these modifications.

First, Petitioner’s proposed modifications are inconsistent with Yamada’s disclosures. As shown below, Petitioner proposes making small cutouts to Murai’s red dots and slightly larger cutouts to the green dots. *Id.* 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 according to the emission efficiency and chromaticity of the organic light-emitting material.⁶



Petitioner's modifications would reduce the aperture ratio and thereby undercut Murai's very purpose, while contrary to Yamada they would not account for the

⁶ Unlike for its other Grounds, Petitioner asserts that pixel size be changed by corner cutouts (allegedly according to Murai, although Murai does not disclose cutouts to change pixel size), not using the approach Petitioner alleges Yamada disclosed (*i.e.*, shrinking pixels equally along all sides, allegedly based on Yamada Fig. 4). In Ground 3, although Phan specifically taught how to resize its pixels, Petitioner alleged a POSITA would have abandoned Phan's method and used Yamada's purported approach. Petitioner offers no explanation for its about-face in this Ground. Petitioner's disparate treatment of the prior art simply underscores the hindsight-driven nature of Petitioner's analysis.

differences in efficiency of the different organic light emitters (assuming, *arguendo*, that Murai's Figure 3 could even be applied to OLEDs). ¶¶302-304

Second, if hypothetically Murai's structures could be applied to OLEDs, a POSITA would have understood that reducing the sizes of the green and red pixels while keeping the blue pixels their same size would not extend the overall lifetime of Murai's display. Ex. 2009, ¶305. *See supra*. Maintaining the blue pixels' size would not reduce the current density supplied to them so as to extend the display lifetime. Likewise, reducing the sizes of the green and red pixels would require increasing the current densities supplied to those pixels, shortening their lives. A POSITA would have had no reason to make such changes to Murai. Ex. 2009, ¶305.

Third, if it were possible to make such a densely packed display as Murai's Figure 3 with OLED and make cutouts of the dots, Petitioner's proposed combination may introduce unwanted visual artifacts, contrary to Murai's purpose. Murai's embodiments do not have the asymmetry of Petitioner's proposal and have blue and red dots equally sized. In Petitioner's combination, a top-left-to-bottom-right diagonal of red and blue dots may exhibit a different degree of color mixing and streaking effects than a top-right-to-bottom-left diagonal of red and blue dots. A POSITA would have had no motivation to make Petitioner's proposed modifications, nor a reasonable expectation of success. Ex. 2009, ¶306.

Moreover, even if a POSITA were to combine Murai's quad-pixel structure with Yamada, a POSITA would not have been motivated to maintain two green pixels in the structure (as OLED references conveyed). Matthies, 17:5-10, Ex. 2011, Fig. 5; Ex. 2009, ¶307. Given Yamada's teaching that blue OLED materials have lower emission efficiency, a POSITA would seek to double the emissive area of the blue pixels by employing two blue pixels in Murai's quad-pixel structure if Murai's display was OLED. This would improve the overall brightness of the display without increasing the current densities supplied to the blue pixels, and the life of the display would not be reduced (as was a goal of Yamada). The resulting quad-pixel structure, however, which would contain two blue pixels and one green pixel would fail to meet the claimed requirement of a "virtual square" centered on a green pixel, as discussed above. *See* Sections V.D.2, VII.B.4; Ex. 2009, ¶307.

Petitioner asserts a POSITA would have been motivated to apply Yamada to Murai's Figure 3 for the same reasons as for its proposed combinations with Matthies and Phan. Pet. at 80. Petitioner's argument further fails for the reasons discussed in Section V.B and E.2; Ex. 2009, ¶¶308-309.

IX. Objective Evidence Confirms the Non-Obviousness of the Challenged Claims

Petitioner's obviousness theories are further undercut by extensive objective evidence of non-obviousness, including long-felt need, failure of others, skepticism, praise, and copying. Ex. 2009, ¶¶310-356.⁷

A. There was a long-felt need for pixel arrangements allowing for manufacture of full-HD mobile AMOLED displays.

By the early 2010s, commercialization of AMOLED displays had become a reality, owing to groundbreaking efforts by Samsung Display to achieve mass-production of AMOLED displays for the first time in the world. Ex. 2009, ¶¶311-312 (citing Ex. 2064). However, AMOLED displays for mobile devices suffered from a significant shortcoming—namely the difficulty of manufacturing higher resolution displays. Ex. 2009, ¶¶313-322; *see* Ex. 2013 at 3 (“Reaching the high-resolution point with true pixel densities greater than 300 pixels per inch (ppi) has been a challenge for AMOLED displays...”).

There was a long-felt need to develop pixel arrangements that would enable the manufacture of high-resolution AMOLED displays that would provide superior

⁷ Samsung Display's request for authorization to move for additional discovery to seek materials from Mianyang BOE relied upon in parallel litigation was denied by the Board.

image quality, particularly displays with sufficiently high pixel densities (measured as pixels-per-inch or “PPI”), aperture ratio, and lifetime to support “full high definition” (“full-HD”) graphics in mobile devices. Ex. 2009, ¶¶315-319 (explaining full-HD to require 1920x1080 pixels or over 400 PPI in typical mobile device displays). By the time of the ’803 Patent, there was a recognized need to display 1920x1080 content “at its native resolution (without the need to rescale up or down).” Ex. 2014 at 2. The display industry, including Petitioner Mianyang BOE, recognized as “urgent technical problem[s] to be solved” the need for a manufacturable display suitable for high-resolution “to increase the aperture ratio of sub-pixels, to obtain good brightness level and to extend the lifetime.” Ex. 2015 at 2:23-27. As explained in a 2006 Society for Information Display (“SID”) paper, technical challenges had created “bottlenecks” to “achieving high display resolution on active-matrix OLED [displays,]” with “the highest resolution” limited to “about 180ppi,” Ex. 2016 at 1, comparable to the resolution of VHS tapes. Ex. 2009, ¶321.

Developing full-HD AMOLED displays for mobile devices that could be produced at commercial scales proved especially difficult because of challenges in depositing the light-emitting organic materials that define OLEDs. *See* Ex. 2065 at 5-6 (“People have said that it would not be easy to realize the full HD (1920x1080 pixels) definition with...AMOLED display...as the pixels are realized by evaporating the light emitting organic materials.”); Ex. 2009, ¶322. By the time of

the inventions (and still today), fine metal mask (“FMM,” also called “shadow mask”) had become the “most common method for patterning primary colors for full color AMOLED” displays. Ex. 2017 at 4. Nonetheless, a recognized “disadvantage[]” of FMM was “[l]ower resolution of the panel.” Ex. 2018 at [0009]. “The resolution of the conventional panel adopting the shadow mask process [wa]s...usually not more than 180 ppi” at the time. *Id.*, [0009]. As Dr. Kymissis explains, alternative organic material patterning methods, including inkjet printing, had been explored, but none showed enough promise to be used for commercial scale manufacturing. Ex. 2009, ¶323.

Shortly after Samsung Display first mass-produced AMOLED displays in 2007 (using entirely different pixel arrangement structures, with much lower resolution), the “Advances in AMOLED Technologies” chapter of a 2008 textbook on mobile displays observed that “the development of high-resolution” remained “a critical factor in OLED displays” and cautioned that “[h]owever, the limitations of FMM for high resolution will become a key issue when it comes to considering mass production.” Ex. 2019 at 23; Ex. 2009, ¶324. Even as of December 2010, researchers at LG Display observed 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.” Ex. 2020 at 4.

Skilled artisans recognized that advances in pixel arrangements—the specific designs of the groupings, shapes, sizes, and layouts of different colored pixels—would be critical to producing full-HD OLED displays that would overcome manufacturing limitations, including FMM. Ex. 2009, ¶325. As researchers at AUO explained, the “arrangement of the sub-pixel devices may pose a considerable level of difficulty in the display panel manufacturing process.” Ex. 2021 at [0004]. The ’803 Patent discusses the impact of pixel arrangements, including the “gap between...neighboring pixels,” on the “reliability” of manufacturing OLED displays with “high aperture ratio of the pixel.” ’803 Patent, 1:38-45.

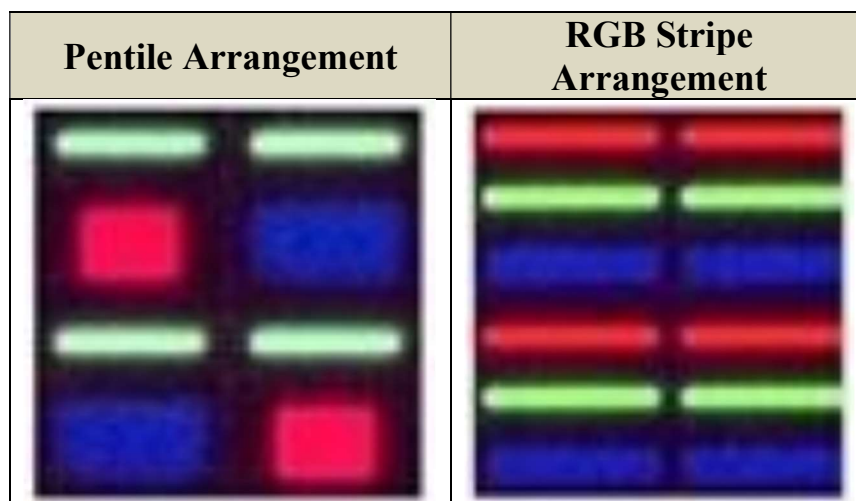
As explained further in Section IX.E, the ’803 Patent’s novel pixel arrangement, which became widely recognized as the “Diamond Pixel™” arrangement, enabled the manufacture of full-HD AMOLED displays suitable for mobile devices, satisfying the industry’s longstanding need.

B. Others repeatedly tried but failed to develop a pixel arrangement suitable for a full-HD AMOLEDs for mobile devices, leading to industry skepticism.

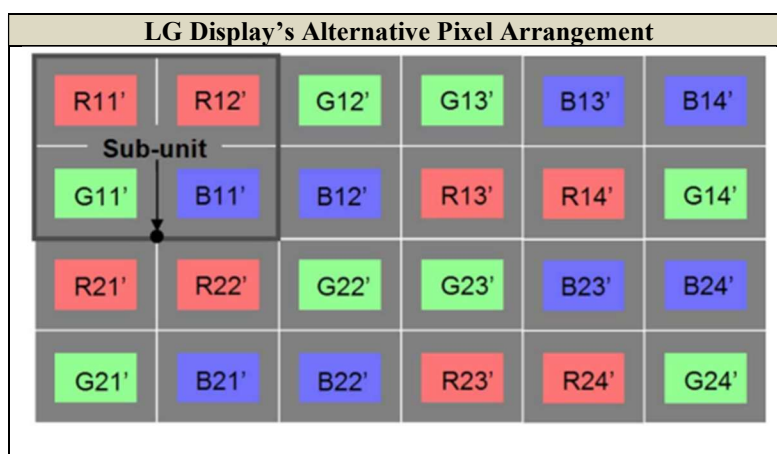
Over the years, display manufacturers and researchers proposed many AMOLED pixel arrangements in an attempt to answer the industry’s calling for full-HD AMOLED displays suitable for mobile devices. Ex. 2009, ¶¶330-336. The wide-ranging efforts by others to develop alternative pixel arrangements, without success, supports the non-obviousness of the challenged claims. This includes the prior art

arrangements disclosed in Petitioner’s cited references such as Phan (published in August 2004), Matthies (assigned to Sarnoff and published in May 2005), Yamada (assigned to Sanyo and published in April 2002), and Murai (assigned to Seiko Epson and published in December 2005). Ex. 2009, ¶331. In fact, the near-decade between the publication dates of Petitioner’s references and the inventions of the ’803 Patent, when many groups were actively attempting to solve these problems, itself supports the inventions’ nonobviousness. *See Leo Pharm. Prods., Ltd. v. Rea*, 726 F.3d 1346, 1359 (Fed. Cir. 2013) (“The length of the intervening time between the publication dates of the prior art and the claimed invention can also qualify as an objective indicator of nonobviousness.”).

Many others also tried but failed to design OLED pixel arrangements that would allow full-HD AMOLED displays. Ex. 2009, ¶¶332-336. Illustrative examples of pixel arrangements that came before Samsung Display’s Diamond Pixel arrangement are shown below, including the “Pentile” arrangement used in the Galaxy S launched in 2010 (800x480 resolution display; 233 ppi) and the “RGB Stripe” arrangement used in the Galaxy S2 launched in 2011 (800x480 resolution display; 207 ppi). Ex. 2023 at 2.



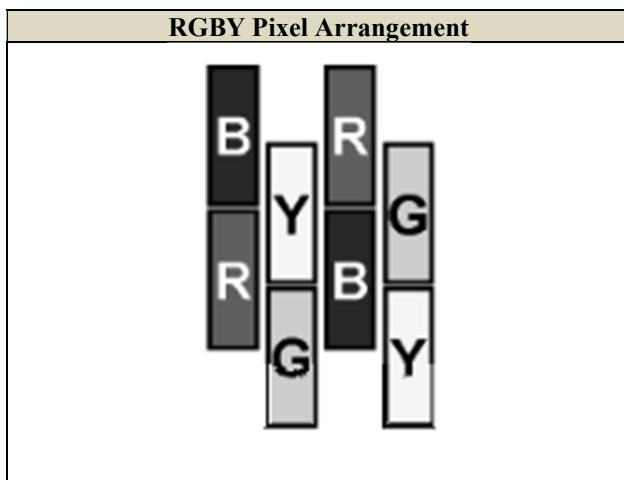
In 2010, LG Display attempted a different “pixel arrangement scheme based on the conventional shadow mask process and ability” which involved “shared emitting aperture area[s] between horizontally adjacent 2 sub-pixel[s].” Ex. 2020 at 3-5. LG Display’s alternative pixel arrangement (reproduced below) failed to satisfy industry needs, however, as the resolution of the resulting prototype display was still 229 PPI. *See* Ex. 2020 at 3. As Dr. Kymissis explains, he is unaware of this proposed pixel arrangement having been implemented in any full HD AMOLED display, let alone any AMOLED display for a flagship mobile device. Ex. 2009, ¶¶330-333.



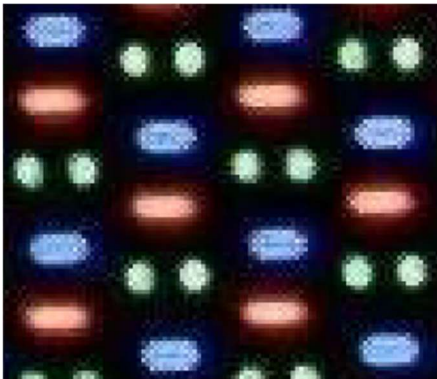
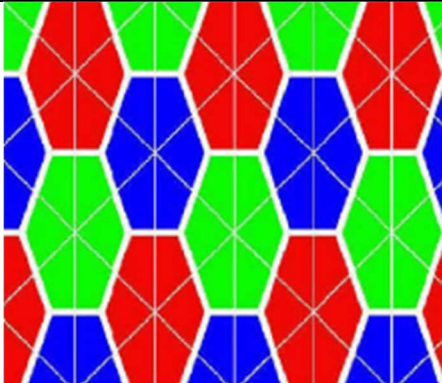
Because of the technical challenges, the industry was highly skeptical that a pixel arrangement could be devised that would enable the manufacture of full-HD AMOLED displays for mobile devices—so much so that LCDs (which did not suffer from similar manufacturing limitations) were viewed as a preferred alternative. Ex. 2009, ¶¶326-328. Because “it would not be easy to realize the full HD...definition” while “securing a sufficient yield rate...for mass production,” “even some internal voices at Samsung Display opined that [] AMOLED should be abandoned and [to] pursue LCD instead.” Ex. 2065 at 5-6; *see also* Exs. 2022, 2023. Likewise, “foreign press expressed skepticism about AMOLED” at the time, including “as to whether it can overcome fierce competition against existing Liquid Crystal Device (LCD).” Ex. 2023 at 1. Indeed, Apple did not adopt AMOLED displays for iPhones until the iPhone X, Ex. 2024 at 2, instead using LCD displays with their then-higher resolution. Ex. 2009, ¶328; Ex. 2025 at 2.

Continued research efforts *after* the inventions of the '803 Patent also failed to result in a successful pixel arrangement that has been adopted for use in flagship mobile devices. *See In re Cyclobenzaprine Hydrochloride Extended-Release Capsule Pat. Litig.*, No. 09-MD-2118, 2010 WL 3766530, at *1-2 (D. Del. Sept. 21, 2010) (“Because science necessarily builds upon past discoveries, failure of others after a patent’s issue date may be more persuasive than failures that occur before.”).

For example, AUO proposed a RGBY pixel arrangement in 2015 (Ex. 2033). Ex. 2009, ¶333.



As further examples, Petitioner Mianyang BOE proposed a pixel arrangement known as “Zhou Dongyu,” which was criticized as “inferior to [Samsung Display’s] diamond arrangement” (Ex. 2034 at 1; Ex. 2035 at 2) (below, left), and Petitioner Tianma proposed a “hexagon shape” pixel arrangement (Ex. 2036 at 2) (below, right). Ex. 2009, ¶334.

Mianyang BOE’s Zhou Dongyu Pixel Arrangement	Tianma’s Hexagon Shape Pixel Arrangement
	

Despite the wide-ranging efforts by numerous display manufacturers, it was only Samsung Display’s innovative “Diamond Pixel” arrangement, which embodies

the invention claimed in the '803 Patent, that was ultimately successful at enabling the manufacture of full-HD mobile AMOLED displays, including displays in flagship phones such as the Samsung Galaxy and Apple iPhone. Ex. 2009, ¶¶347-348.

C. The claimed inventions received industry praise.

There has been significant praise for the pixel arrangement structures of the '803 Patent, including praise for the full-HD resolution and superior image quality of the AMOLED displays implementing these arrangements. Ex. 2009, ¶¶336-339. For example, DisplayMate's "shoot-out" article series singled out praise for the innovative Diamond Pixel structure practicing the '803 Patent. Ex. 2027 at 1; Ex. 2067. DisplayMate observed that Samsung Display's patented "Diamond Pixel[]" arrangement "maximize[s] the sub-pixel packing" to "achieve the highest possible pixels per inch (ppi)," and described it as "a form of high-tech display art." Ex. 2027 at 1.

Launched in April 2013, shortly after the inventions of the '803 Patent, Samsung Galaxy S4's AMOLED display was the first commercial embodiment of the '803 Patent. Praise for the Galaxy S4's AMOLED display, and specifically the novel pixel arrangement of the '803 Patent that enabled full HD, 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;” “All weaknesses of the existing AMOLED displays were eliminated through the pixel array method [o]n a proprietary diamond structure.” Ex. 2026 at 2.

- “Samsung Display...was able to enhance AMOLED display performance...with its new [pixel] structure...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....Samsung Display succeed[ing] in innovating resolution by changing the existing rectangular patterning structure to a diamond structure.” Ex. 2037 at 3.

Despite having used LCD displays for years in its iPhone products, Apple adopted Samsung Display’s AMOLED displays implementing the pixel arrangement of the ’803 Patent starting with the iPhone X, drawing significant praise:

- “Samsung Display has made the iPhone X a very good screen...us[ing] 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).” Ex. 2039 at 3, 5; *see also* Ex. 2040.

Flagship mobile devices following the Galaxy S4 and iPhone X have similarly received praise for their displays that embody the ’803 Patent. Ex. 2009, ¶¶339 (citing Exs. 2068-2072). For his achievements, the named inventor of the ’803 Patent, Mr. Sang-Shin Lee received an award from the Commissioner of South Korea’s Intellectual Property Office. Ex. 2066 at 9.

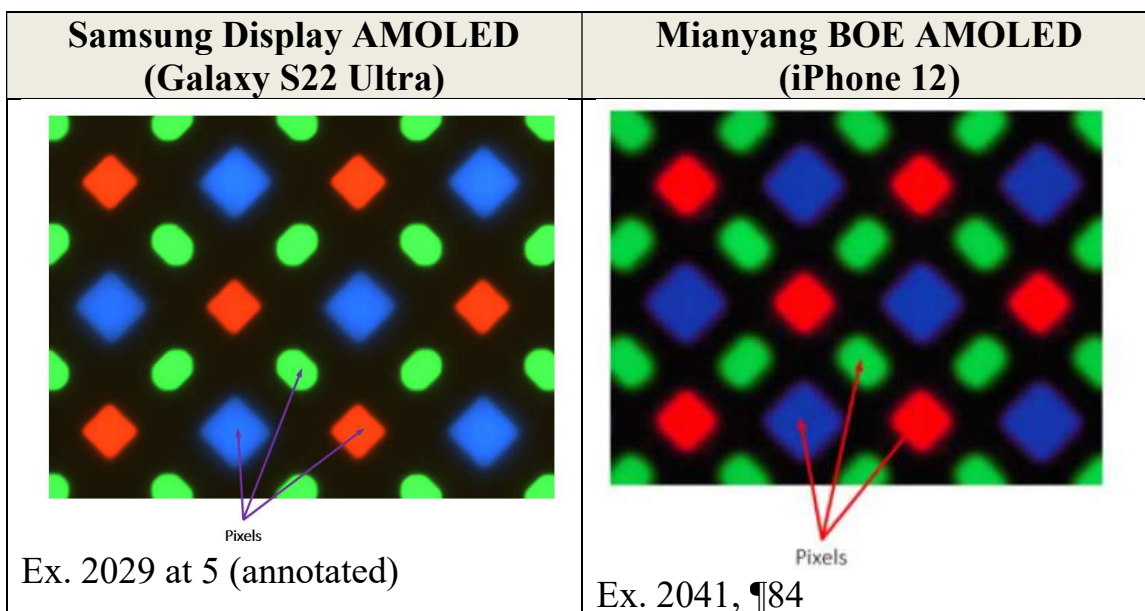
D. There has been widespread copying of Samsung Display’s patented pixel arrangements.

The Federal Circuit recently emphasized the importance of copying evidence, noting that “a determination of copying [is] strong evidence of non[-]obviousness.” *Volvo Penta of the Americas, LLC v. Brunswick Corp.*, 81 F.4th 1202, 1213 (Fed. Cir. 2023) (internal quotations and citation omitted).

Here, widespread and systemic copying is evident from teardown photographs of commercially-available AMOLED display products that employ near carbon copies of Samsung Display’s pixel arrangements. Ex. 2009, ¶¶340-346. The structures suggest the manufacturers of these replica products “had access to, and borrowed from” Samsung Display’s patented pixel arrangement technology. *Institut Pasteur v. Focarino*, 738 F.3d 1337, 1346, 1348 (Fed. Cir. 2013).

As discussed above, in 2013, Samsung Display released AMOLED displays implementing the patented Diamond Pixel arrangement to much acclaim. *See* Exs.

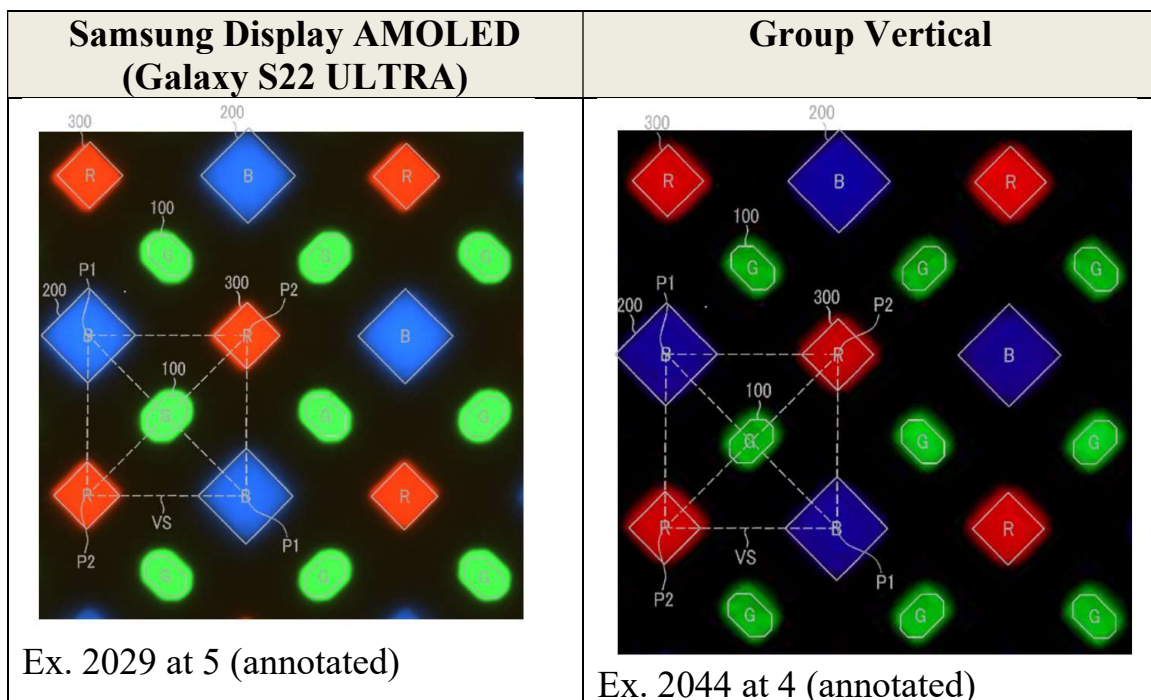
2009, ¶¶336, 348-349; 2013 at 3; 2026 at 2. Following Samsung Display’s success, Petitioner Mianyang BOE copied Samsung Display’s pixel arrangements to commercialize AMOLED displays for products including the iPhone 12. Ex. 2009, ¶341. As demonstrated below, the pixel arrangement used in Mianyang BOE’s AMOLED display for the iPhone 12 is nearly identical to Samsung Display’s patented pixel arrangement.

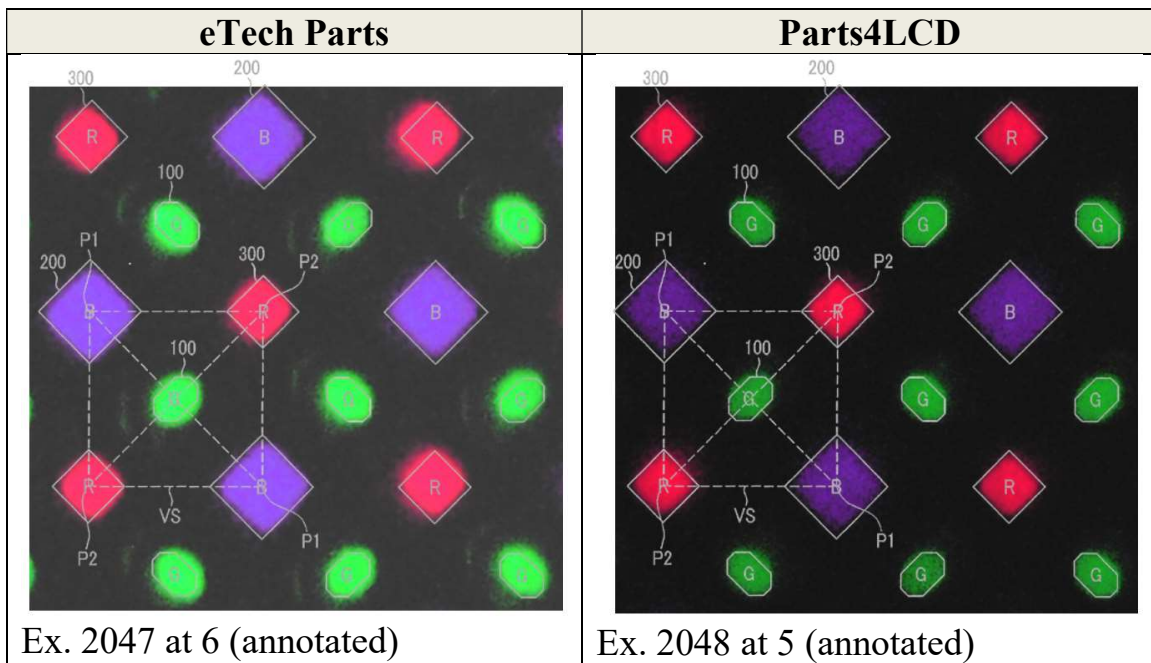
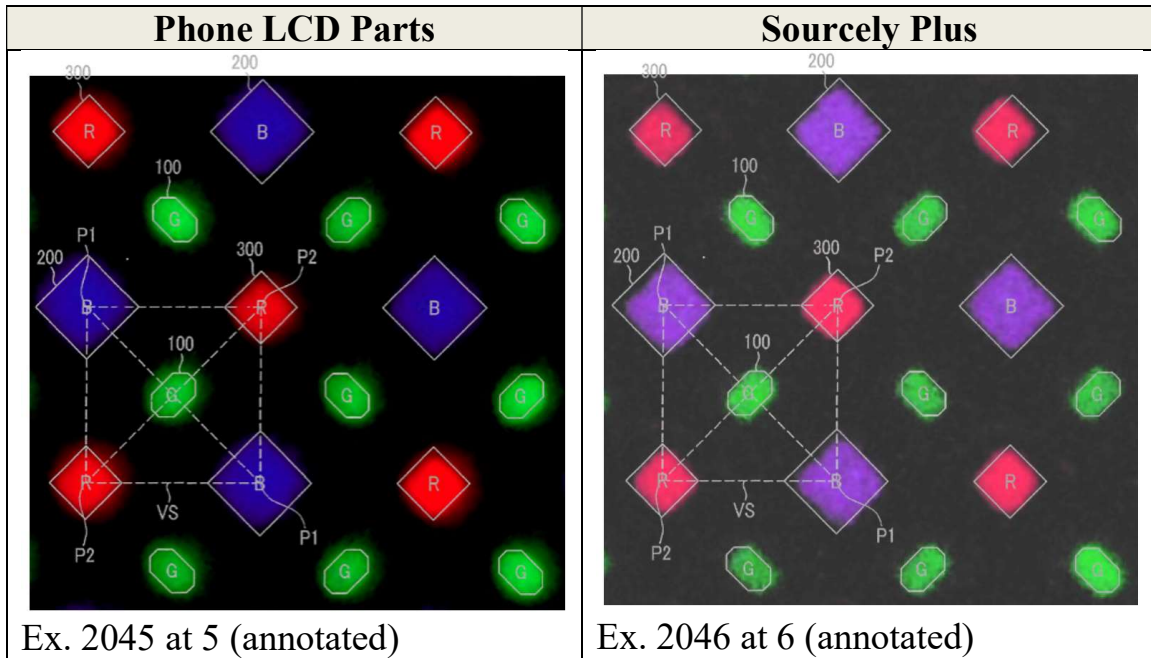


Widespread copying of the '803 Patent’s inventions is further evident from samples of AMOLED displays distributed by numerous vendors of replacement AMOLED displays for mobile phones. Exs. 2042-2061. These pixel arrangements not only infringe the challenged claims (*see, e.g.*, Ex. 2042 (chart mapping 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)), they bear such similarity to those of Samsung Display that they demonstrate copying. Ex. 2009,

¶¶342-346. *See, e.g., Medtronic, Inc. v. Teleflex Innovations S.a.r.l.*, 70 F.4th 1331, 1339-42 (Fed. Cir. 2023) (circumstantial evidence of “evidence of access to and substantial similarity with a patented product” can show copying) (emphasis omitted).

Exemplary teardown images of such replica products are shown below with Figure 5 of the '803 Patent overlaid on top, showing the exact embodiment of Figure 5:



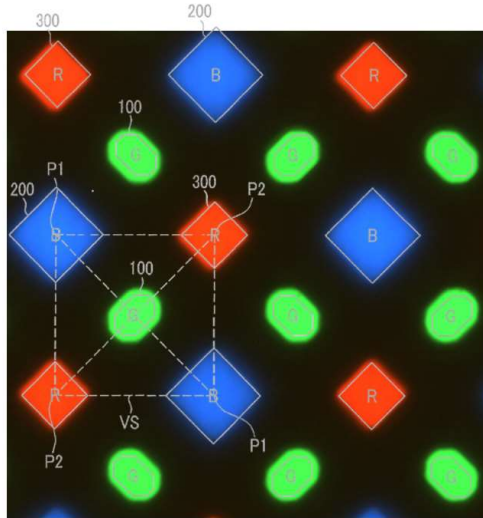


E. The '803 Patent's pixel arrangements enabled SDC to mass-produce the world's first full-HD AMOLED displays for mobile devices, establishing a strong nexus to the objective evidence.

Implementing the pixel arrangement of the '803 Patent, Samsung Display successfully mass-produced full-HD AMOLED displays for the first time in the

world, beginning with the AMOLED display for the Samsung Galaxy S4, overcoming skepticism and satisfying the industry’s long-felt need. Ex. 2009, ¶¶347-349. The introduction of the novel “pixel array method...[using] Samsung Display’s ... proprietary diamond structure” allowed “[a]ll 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; *see* Ex. 2023 at 2 (“Samsung Display invented the ‘diamond pixel structure’ that...completely resolve[d] existing concerns that ‘it is difficult to implement Full HD resolution in 5-inch level screens with AMOLED.’”).

Since its introduction by Samsung Display, the ’803 Patent’s “Diamond Pixel” arrangement has been widely adopted in AMOLED displays for flagship mobile devices, including every Samsung Galaxy and Apple iPhone model that has used AMOLED displays. Ex. 2009, ¶349. For example, the AMOLED display used in the Samsung Galaxy S22 Ultra product practices all challenged claims of the ’803 Patent. Ex. 2009, ¶350-352; Ex. 2028 (Galaxy S22 ULTRA Claim Chart); Ex. 2063. A teardown image (Ex. 2029 at 5) of the pixel arrangement obtained from a Galaxy S22 Ultra sample is reproduced below, with Figure 5 of the ’803 Patent superimposed.



The objective evidence presented above is commensurate with the scope of the challenged claims and is the direct result of the unique characteristics of the invention. Practicing the claims of the '803 Patent is what enabled the manufacture of full-HD AMOLED displays suitable for mobile devices by striking the Patent's novel balance of improving the aperture ratio of the AMOLED display (by enlarging the emissive areas) and allowing an increased density of pixels while allowing for a more reliable deposition of the organic material (by ensuring sufficient gaps between pixels), and improving the display lifetime. Ex. 2009, ¶¶353-356. A strong nexus therefore exists between the objective indicia evidence and the claimed inventions. *See ClassCo, Inc., v. Apple, Inc.*, 838 F.3d 1214, 1220 (Fed. Cir. 2016).

The challenged claims achieve the abovementioned benefits by reciting pixel arrangements with specific groupings, shapes, sizes, and layouts of the red, green, and blue OLED sub-pixels. Ex. 2009, ¶¶353-356; *see e.g.*, '803 Patent, cls. 1-5 (reciting first, second and third pixels with specific shapes arranged in a “virtual

square...wherein the second pixel has a larger area than that of the third pixel...[and] the first pixel is configured to emit green light”); cl. 19 (“the first pixel, the second pixel, and the third pixel are configured to emit different color lights”); cl. 20 (“second pixel and the third pixel are configured to emit blue light and red light, respectively”); cl. 21 (“second pixel has a larger area than that of the first pixel”). These novel pixel arrangement structures allowed Samsung Display to overcome manufacturing and design obstacles to attaining higher-resolution and higher brightness AMOLED displays relating to the sensitive light-emitting organic layers of OLEDs. *See, e.g.*, ’803 Patent, 1:54-2:4, 2:59-62, 4:4-63, 5:9-27, 5:35-45, 7:3-32, 8:16-24, 8:25-45; Ex. 2009, ¶¶353-356.

A pixel arrangement having the unique advantages of the ’803 Patent’s claimed invention was unattainable in the prior art, evidenced by the failures of other sophisticated companies and research groups over the years to design a suitable pixel arrangement that would enable high density pixel patterning, which was long recognized as “the bottleneck[] of achieving high display resolution on active-matrix OLED.” Ex. 2016 at 1.

X. Conclusion

Patent Owner respectfully submits that the Board should find the challenged claims patentable.

Date: April 1, 2024

Respectfully submitted,

By /Scott C. Weidenfeller/

David A. Garr

Registration No.: 74,932

Scott C. Weidenfeller

Registration No.: 54,531

Jeffrey H. Lerner (*pro hac vice pending*)

Daniel W. Cho (*pro hac vice pending*)

Matthew Kudzin (*pro hac vice pending*)

Kee Young Lee (*pro hac vice pending*)

Counsel for Patent Owner

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that the present paper contains 13,990 words based on the word count indicated by the word-processing program used to generate the paper and excluding those portions exempted by 37 C.F.R. §§ 42.24(a) and (b).

Date: April 1, 2024

/Scott C. Weidenfeller/
Scott C. Weidenfeller
Registration No.: 54,531

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.6, I hereby certify that the foregoing Patent Owner's Response was served by electronic mail on the following counsel of record for petitioner:

Patrick Herman (P52PTABDocket@orrick.com)
Richard F. Martinelli (RFMPTABDocket@orrick.com)
Xiang Wang (XW0PTABDocket@orrick.com)
ORRICK, HERRINGTON & SUTCLIFFE, LLP

Date: April 1, 2024

/Scott C. Weidenfeller/
Scott C. Weidenfeller
Registration No.: 54,531