

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 IPR2023-01075
U.S. Patent No. 11,594,578

PATENT OWNER'S RESPONSE

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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)
Ex. 2023	Hyunjung Jung, <i>History of Advancement of ‘AMOLED’, Core Competitiveness of Galaxy</i> (2014) (including certified English translation)
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Ex. 2036	Li-Qin Shao et al., <i>The Development of 403ppi Real RGB Printing AMOLED</i> , Society of Information Display (2019)
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Ex. 2077	Jong In Park et al., <i>Direct Prediction Methods on Lifetime Distribution of Organic Light-Emitting Diodes From Accelerated Degradation Tests</i> , IEEE Transactions on Reliability, Vol. 59, No. 1 (Mar. 2010)

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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> (2008)

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. 11,594,578 (Ex. 1001, the “’578 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 ’578 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 '578 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. '578 Patent, 1:46-3:4, 7:22-42, 8:47-67. The pixel arrangement structures of the '578 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 1-6, 10, 12, 17-19, 21-23, 40-47, and 51-52 of the '578 Patent based on two grounds, both of which attempt to combine incompatible references (Matthies, a PMOLED tiled display) with Yamada (an AMOLED, single-substrate display) concerning disparate display technologies. Petitioner's arguments 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.

A POSITA would have had no reason to combine nor a reasonable expectation of success in combining Petitioner's references. Petitioner and its expert, Dr. Morgan Pattison, disregard (1) substantial structural, manufacturing, and operational inconsistencies between the references and (2) 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. For Ground 2, the Petition further attempts to combine another disparate reference, Hong, but flouts its disclosures and proposes a structure allegedly based on Matthies that, contrary to Hong's teachings, would *decrease* the distances between pixels and reduce aperture ratio.

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 ’578 Patent to be unpatentable.¹

II. Claim Construction

The Administrative Law Judge (“ALJ”) in related ITC Investigation No. 337-TA-1351 issued a claim construction order construing two terms of the ’578 Patent. Ex. 2001. The parties in that Investigation also submitted a list of agreed-upon constructions including certain terms of the ’578 Patent. Ex. 2002. No specialized

¹ Petitioner also challenges the patentability of two other patents in the same family as the ’578 Patent. *See* IPR2023-00987, IPR2023-00988. 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 ’578 Patent are found in Sections V.C, V.D.1, V.E, VI, VII.E.

constructions are necessary in this proceeding, as Petitioner fails to prove unpatentability of any claims under any interpretation.

III. Level of Ordinary Skill in the Art

Patent Owner proposes, consistent with the finding in the related ITC Investigation, 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 13-14. Patent Owner did not challenge Petitioner’s proposal in the Preliminary Response, and the Board preliminarily adopted it. Paper 11 at 11-12. Petitioner fails to establish unpatentability under either definition.

IV. Technical Background

Active-matrix and passive-matrix display architectures are 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 passive-matrix displays, 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.*, 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 AMOLED displays, 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 '578 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.” '578 Patent, 1:46-50. Without adequate spacing, problems such as color mixing of the organic material may occur during deposition. Ex. 2009, ¶¶43–44.

The '578 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.*, '578 Patent, 1:66-2:3, 3:1-4, 5:26-36, 6:41-60, 7:22-42, 8:38-60; Ex. 2009, ¶¶57-63. As discussed below, this structure has been implemented widely across highly successful AMOLED display products and praised since its introduction.

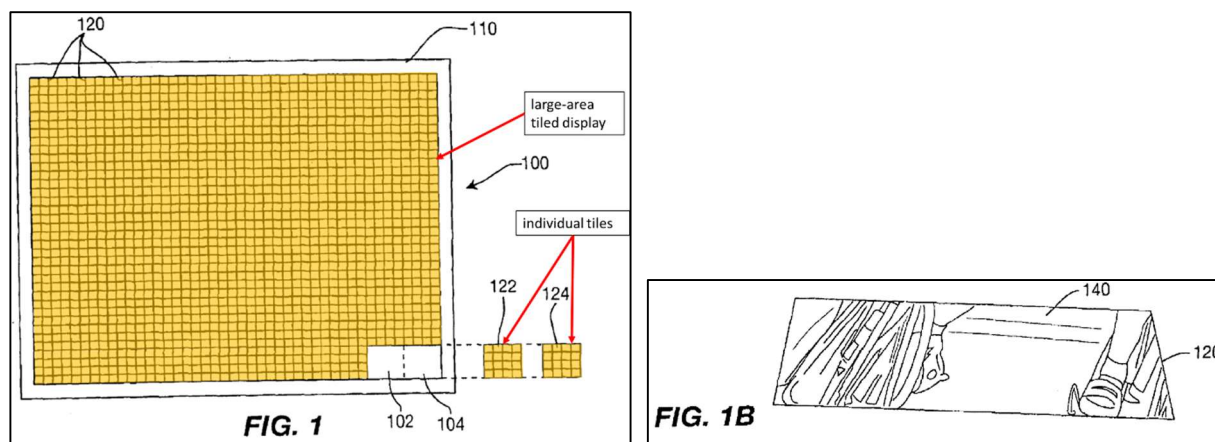
V. Ground 1: Petitioner Fails to Establish a *Prima Facie* Case of Obviousness Based on Matthies in view of Yamada For Any Challenged Claim.

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 their 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 this motivation to combine inquiry.”).

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

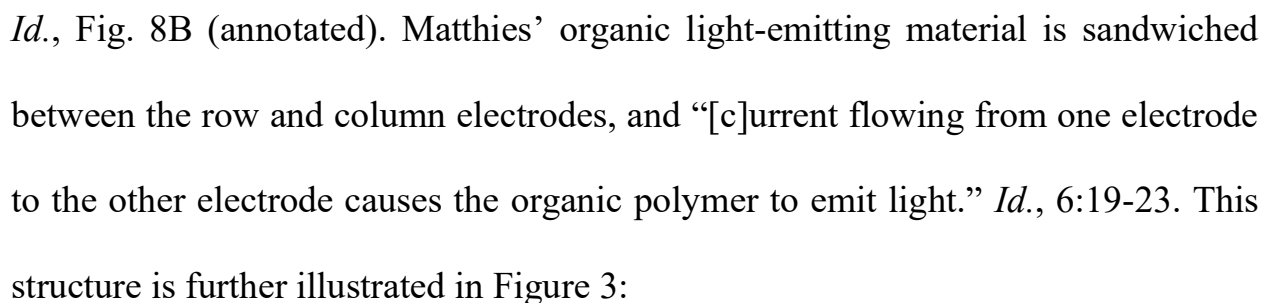
Matthies, titled “***Tiled*** Electronic Display Structure[s],” is directed to “large-area display devices which are formed as an array of tiled devices.” Matthies, 1:8-10. Matthies proposes wall-sized or larger displays (annotated Fig. 1 below) made by physically joining multiple individual display 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, ¶¶91-92.

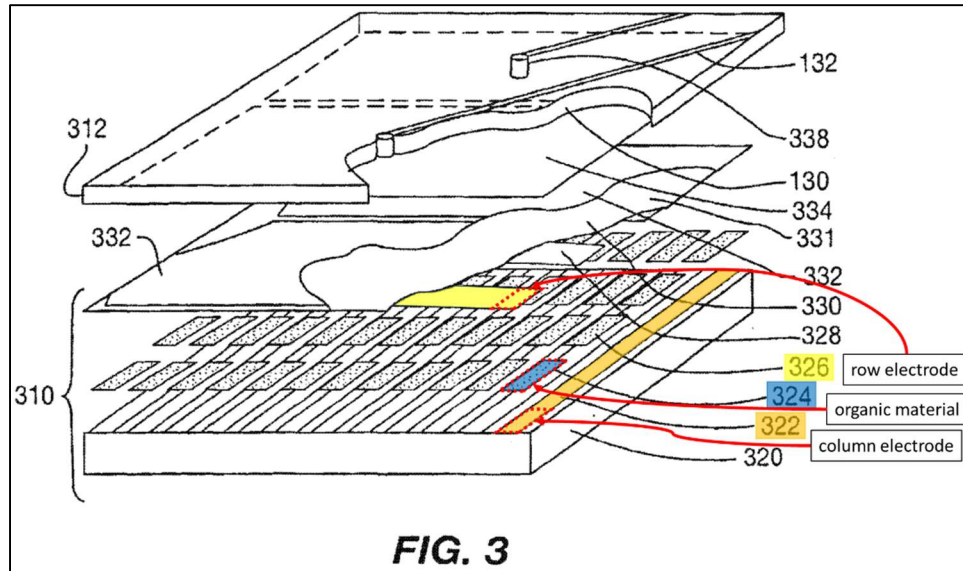


As Matthies explains, “[n]o practical tiled display system has yet been developed.” *Id.*, 1:66-2:2. Matthies sought to overcome “[t]wo barriers to implementing the tiled approach” by “eliminating the visibility of the seams between tiles” and “providing electrical access to the pixels.” *Id.*, 2:7-10. 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, ¶93.

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

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, ¶¶95-99. 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:

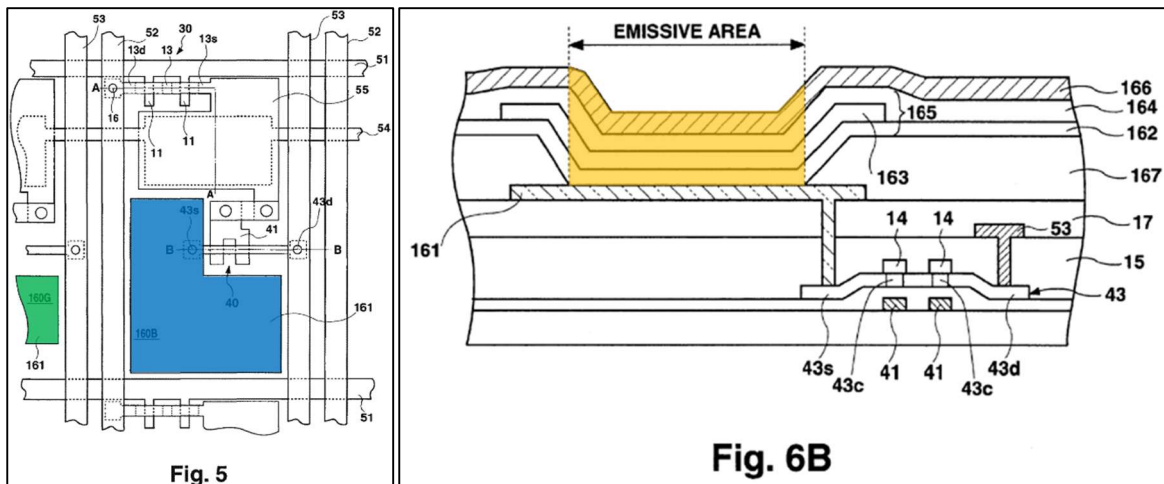




Id., Fig. 3 (annotated).

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, ¶100-103. 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 shown, 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.

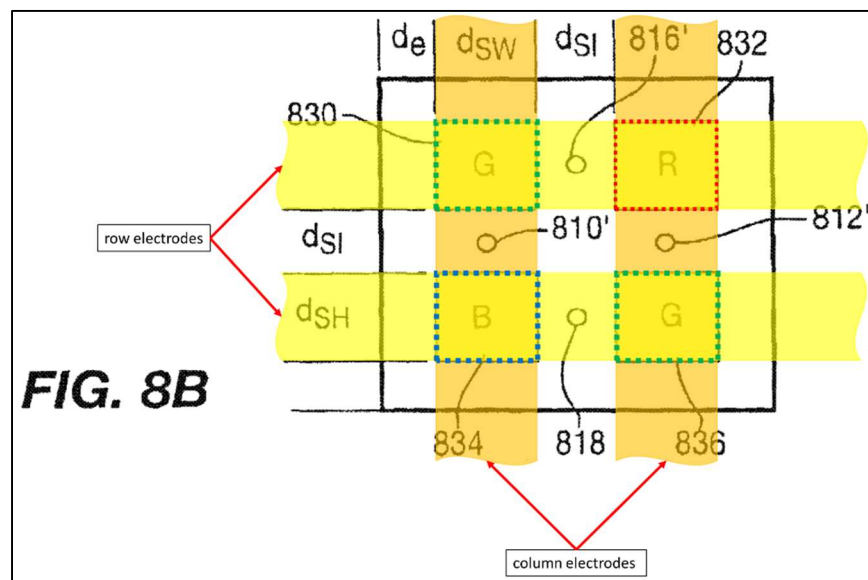


Id., Figs. 5, 6B (annotated).

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, ¶¶104-107. 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.*, ¶¶108-109.

Second, Matthies' *tiled* 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 Mathies' 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, ¶¶110-117.

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 37-39. Although the purported rationale for Petitioner’s proposed combination is to *increase* the lifetime of Matthies’ display (Pet. at 73-74), Petitioner’s proposed modifications would have had the opposite effect, *shortening* its lifetime. Ex. 2009, ¶¶122-128. “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, ¶124. Petitioner portrays Yamada as teaching to make the blue light-emitting area “***larger.***” Pet. at 19. 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, ¶¶125-126.

Petitioner’s proposed combination would ***reduce*** the lifetime of Matthies’ display overall, contradicting Petitioner’s purported rationale for it. *Id.*, ¶¶125-126. 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.*, ¶¶125-128.

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

Petitioner 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 70-71. That is incorrect. The circuitry Petitioner proposes to eliminate is necessary for Matthies’ display to function. It provides the display data to each pixel, Matthies,

10:1-5, and also makes adjustments to provide uniform brightness and color across different pixels and different tiles, a critical requirement for Mathies' tiled display, *id.*, 10:6-9. Ex. 2009, ¶¶129-130. Further, Mathies' circuitry "continually adjusts" the brightness of individual pixels to compensate for aging as the display is used, which resizing the pixels cannot achieve. Mathies, 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 Mathies' circuitry, the display's colors would shift over time, rendering the display defective. Ex. 2009, ¶¶131-132.

Petitioner claims that shrinking red and green pixels would result in "greater design flexibility" by creating "additional space for Mathies' vias." Pet. at 43-44. This is meritless. Mathies 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 Mathies explicitly seeks to avoid and that would be inconsistent with Mathies' PMOLED structure. A POSITA would seek to *increase* the aperture ratio, as OLED displays had relatively low aperture ratios. Ex. 2009, ¶¶133-135

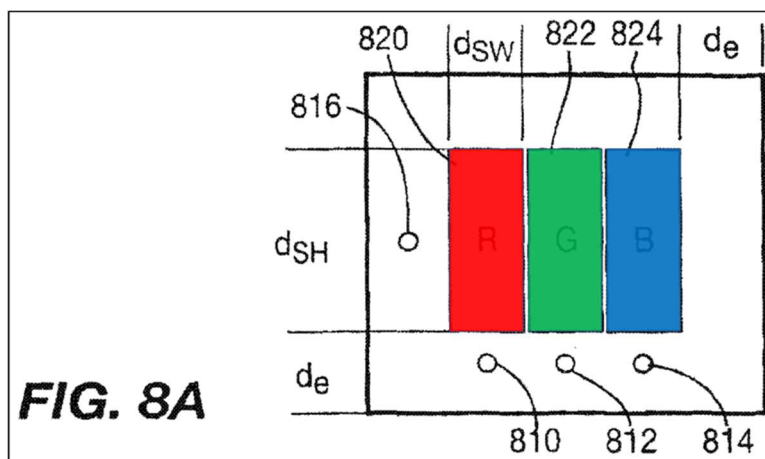
C. A POSITA would not have been motivated to modify Matthies' quad-pixel structure in view of Yamada's disclosures for triple-pixel AMOLED structures.

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.*, ¶¶136-146.

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, 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, ¶¶138-139.

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, ¶¶138.

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.*, ¶140. 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, ¶141. 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, ¶¶141-143. 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.

However, this arrangement would not meet all limitations of any challenged claim. For instance, the pixels would not form the recited “first sets,” “second sets,” “third sets,” or “fourth sets,” *see* ’578 Patent, claims 1, 42, or “virtual quadrangle,” *see id.*, claim 45. Nor would the display have the recited region “overlapping a row of the first pixels” and “entirely offset” from the second or third pixels. *See id.*, claim 1, or the “shortest distance” limitations, *see id.*, claims 1, 42, 45; Ex. 2009, ¶146. This is Petitioner’s only apparent basis for ignoring Mathies’ triple-pixel structure in favor of Figure 8B.

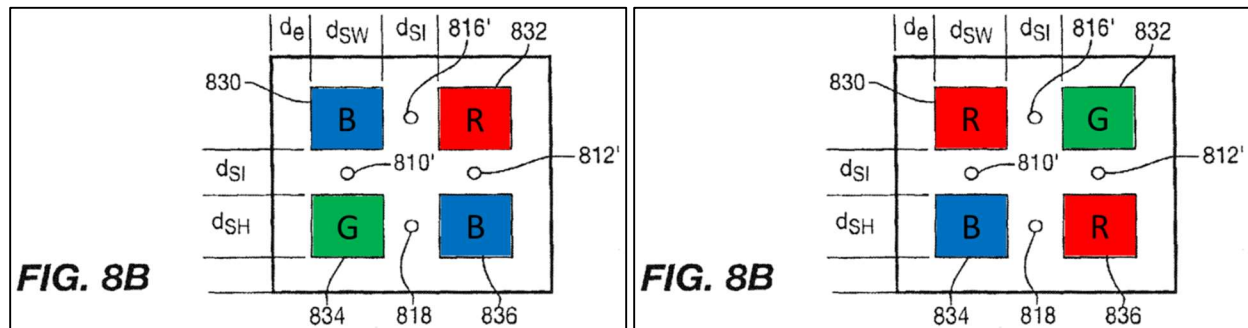
D. Even if a POSITA attempted to modify Mathies Figure 8B based on Yamada, the modification would not yield a pixel arrangement structure encompassed by the challenged claims.

Even if one attempted to combine Mathies’ 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, ¶¶147-152.

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

Mathies 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 Mathies 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, ¶¶147-151. 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, ¶151. Such an arrangement does not meet all limitations of any challenged claim. For instance, the pixels would not form the recited “first sets,” “second sets,” “third sets,” or “fourth sets.” See ’578 Patent, claims 1, 42. Nor would the display have the recited

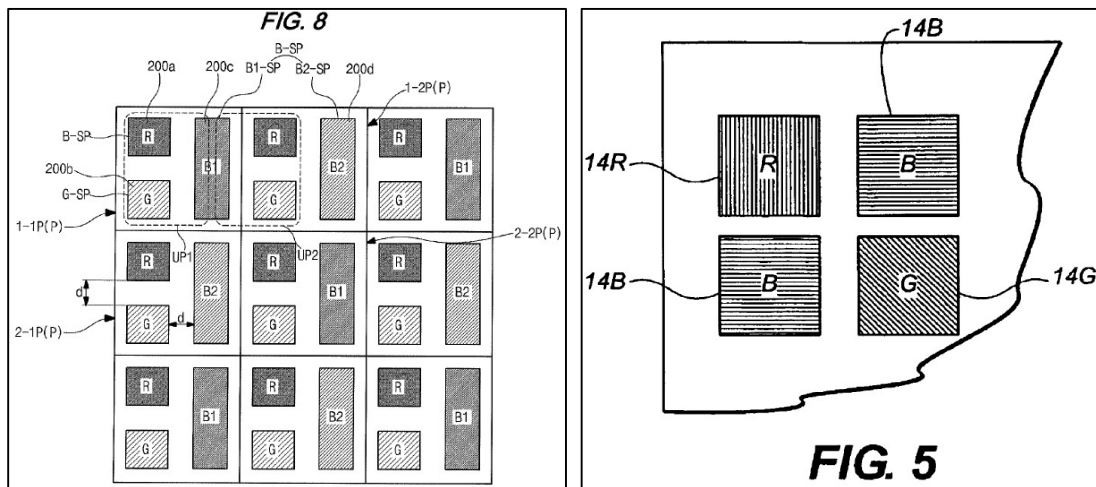
region “overlapping a row of the first pixels” and “entirely offset” from the second or third pixels, *see id.*, claim 1, or the “shortest distance” limitations, *see id.*, claims 1, 42, 45. Ex. 2009, ¶152.

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, ¶¶159-165. For example, Arnold explained “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. 2024 (“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.



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.

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

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, ¶¶153-158. 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 18. 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, ¶155.

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, ¶238) 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, ¶¶156-158.

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 18. 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, ¶166.

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, ¶¶167-168. 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, ¶169. Matthies discusses the

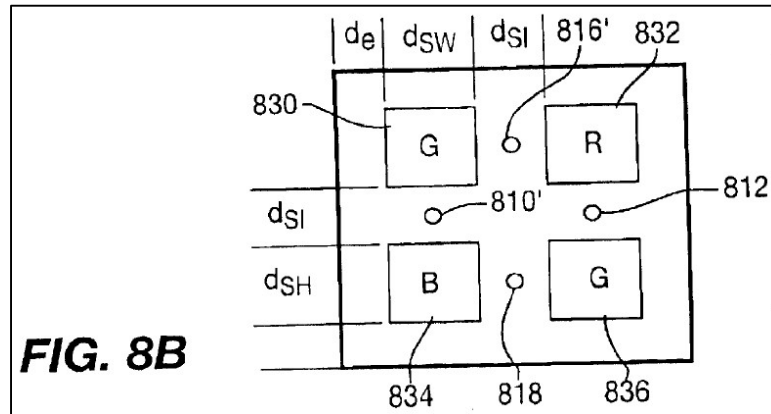
importance of light scattering, and teaches that differences in light scattering at the edge of a tile would make the seam appear visibly different. Matthies, 22:53-56; Ex. 2009, ¶169. To avoid this, “[t]he tiles are constructed with pixel forming elements *evenly spaced up to the edges of the tiles*,” *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, ¶170. 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, ¶¶171-172.

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

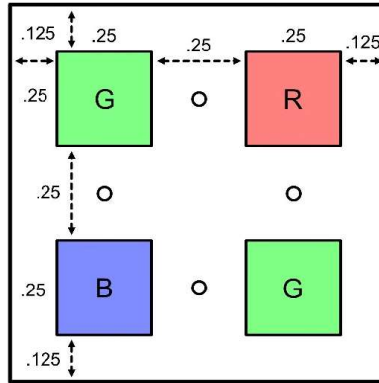
Petitioner’s proposal would also violate Matthies’ design requirement that its quad-pixel structure be composed of equally-sized pixels that have equal spacing from the edges of the pixels to the edges of the tile. Matthies, 17:16-20; Ex. 2009, ¶¶173-174. Matthies explicitly “define[s]” “[t]he geometry 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:



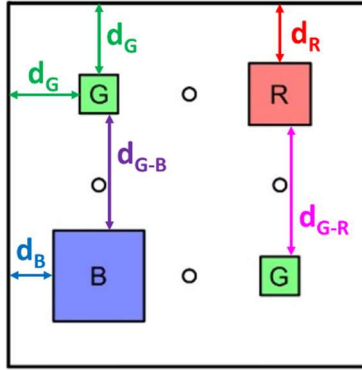
Matthies’ geometric requirements flow from its PMOLED design, as each pixel is defined by the overlap of column and row electrodes, and two different color pixels are found on each row (and column) electrode. Matthies, 17:10-20. Matthies specifies the two dimensions it allows to be varied—“the distances 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, ¶175.

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 29-30. Here, 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, ¶¶176-179. 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 39 (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, ¶¶180-181. 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 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

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 lines...remain[ing] in place” (Pet. at 37), but nothing in Yamada supports such inference from conceptual Figure 4.

(and would also have electrical and other effects). Ex. 2009, ¶182. 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 motivated to make or had a reasonable expectation of success in making. Ex. 2009, ¶182. 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, ¶¶113-116.

While Petitioner asserts that “Matthies itself already contemplates that the sizes and space between its pixels can be adjusted.” Pet. at 74 (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, ¶183.

And while Petitioner claims that Matthies invites changing the “geometry of the pixels” to address OLED pixel aging and decay (Pet. at 74), 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.

E. Petitioner’s combination of Matthies and Yamada does not satisfy all of the limitations of any challenged claim.

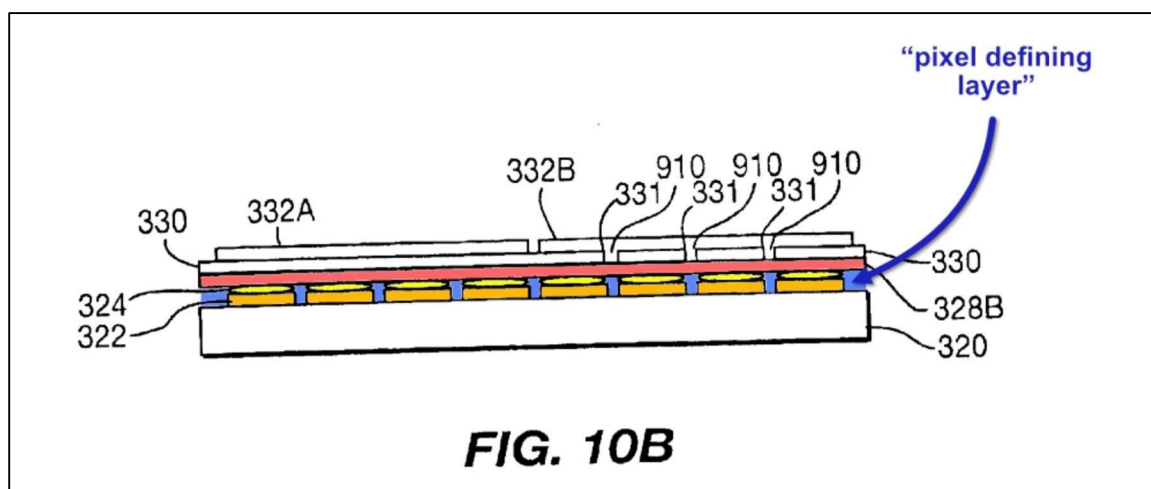
1. Matthies does not disclose or suggest a “pixel defining layer.”

Each challenged claim requires that “the OLED display comprises a pixel defining layer.” ’578 Patent, 9:11-13 (independent claim 1), 13:48-50 (independent claim 42); 14:45-47 (independent claim 45). According to the ’578 Patent, a “pixel

defining layer” is an “insulation layer” that “define[s] an area and a shape of each pixel.” *Id.*, 1:42-44. As Dr. Kymissis explains, the ’578 Patent’s usage is consistent with how the term is used in the field. Ex. 2009, ¶186.

Matthies’ tiled displays do not include a pixel defining layer, and there is no reason Petitioner’s proposed combination of Matthies and Yamada would. Ex. 2009, ¶¶187-189. The Petition failed to identify any teaching or suggestion in Matthies of a pixel defining layer, because there is none. Ex. 2009, ¶187. Matthies describes its manufacturing steps, which do not include (nor suggest) formation of a pixel defining layer. Matthies, 11:36-40, 19:29-32.

Petitioner cites Figure 10B as a “cross-sectional view” of Matthies’ display. Although Petitioner admits that a pixel defining layer is “not labeled or shown in this figure,” Pet. at 25, it shades (in blue) empty space around pixel elements 324 and column electrodes 322, and misleadingly labels it “pixel defining layer” in the figure below.



Pet. at 25.

A POSITA would have had no motivation to modify Matthies' display tile to attempt to add a pixel defining layer. Ex. 2009, ¶188. The Petition failed to identify any reason why a POSITA would add a pixel defining layer to Matthies. It did not even attempt to show that a POSITA would have a reasonable expectation of success. Petitioner merely speculated that a POSITA "could" have added a pixel defining layer. Pet. at 25. Such speculation is insufficient to prove the claims obvious due to the lack of motivation to make such changes. *See Adidas*, 963 F.3d at 1359.

Matthies' displays did not require a pixel defining layer, and a POSITA would have been discouraged from attempting to add one. Modifying Matthies' display to try to add a pixel defining layer would require introducing additional manufacturing steps and materials, adding costs, increasing complexity, and reducing yield. Ex. 2009, ¶182, 188. It would also have other undesirable effects. A pixel defining layer would increase thickness and result in charge accumulation, increasing power consumption. It may also require redesigning Matthies' row and column electrodes, which may introduce other deleterious electrical effects. Ex. 2009, ¶182.

Petitioner resorts to identifying a "planarization insulating film" in one of Yamada's embodiments, *see* Pet. at 25-26 (citing Yamada, 9:13-35), disregarding that this film relates to Yamada's **AMOLED** design and would not be applicable to, or needed in, the *passive-matrix* structure of Matthies' Figure 8B. As discussed in

Section V.A, Matthies’ tiled PMOLED involves entirely different design considerations and constraints than Yamada’s active-matrix displays. Ex. 2009, ¶189.

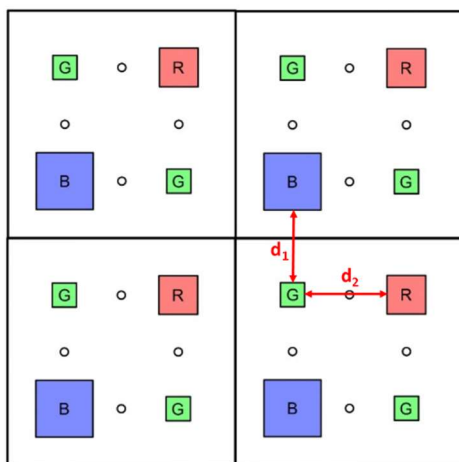
2. Petitioner’s argument that Claim 5 would have been obvious is inconsistent with the rest of the Petition.

Dependent claim 5 requires that “a shortest distance between the first pixels and the second pixels, and a shortest distance between the first pixels and the third pixels, are a same first length.” ’578 Patent, claim 5. Claim 5 depends from claim 1, thus incorporating all claim 1’s elements. But the combination Petitioner proposes for claim 1 does not meet the further limitation of claim 5, and the Petition’s theory as to claim 5 is internally inconsistent.

Petitioner consistently contends, throughout the Petition, that a POSITA would have been motivated to make the green pixels smaller than the red pixels and the red pixels smaller than the blue pixels in order to extend the life of the display. Petitioner states, for example, “a POSITA would have understood that Matthies’ sub-pixels should be re-sized in accordance with their emission efficiencies such that the *‘first pixels’* (the green sub-pixels) are smallest, the *‘second pixels’* (the blue sub-pixels) are largest, and the *‘third pixels’* (the red sub-pixels) have an intermediate size.” Pet at 38. Petitioner asserts that “following Yamada, a POSITA would have considered it obvious to make Matthies’ blue sub-pixels largest, its red sub-pixels intermediately sized, and its green sub-pixels smallest.” *Id.* at 40; *see id.*

at 47; *id.* at 51 (red pixels would “have an intermediate ‘*different . . . size*’” than blue pixels); *id.* at 60-61; Ex. 2009, ¶197.

But, as shown in the annotated figure below, under Petitioner’s theory for claim 1, the shortest distance between the first (green) pixels and the second (blue) pixels (labeled d_1) is *shorter* than the shortest distance between the first (green) pixels and the third (red) pixels (labeled d_2) and thus does not meet the requirements of claim 5. Ex. 2009, ¶194.



Id. at 39 (annotated).

For purposes of the additional limitation of claim 5, Petitioner attempts an about-face and claims “a POSITA would have considered it obvious to keep the green-to-blue and green-to-red distances the same” by making “the red and blue pixel equally sized” while making the green pixels smaller because, Petitioner now alleges, “Yamada [also] contemplates sizing pixels in this way.” *Id.* at 45-46. Petitioner musters no reason a POSITA would have been motivated to modify

Matthies' Figure 8B display this way. And the modifications that would be necessary would contravene Matthies' design requirements. Ex. 2009, ¶¶195-196.

Petitioner cannot rely on Yamada as the basis for its proposed combination to meet the limitations of claim 1 under a theory that Yamada taught making the area of blue OLED pixels larger than that of both red pixels and green pixels to extend the life of the display, and then, without justification, assert for the additional element of claim 5 that a POSITA would have kept the blue and red pixels the same size. Pet. at 45-46; Ex. 2009, ¶¶198-199. If anything, the clear and fundamental internal contradictions between Petitioner's argument for the additional limitation of claim 5 and the limitations of claim 1 (on which it depends) lay bare that the Petition is not explaining what a POSITA would have done or had reason to do, but instead is engaged in a hindsight-based effort to reconstruct the inventions of the '578 Patent. Ex. 2009, ¶198-199.

In addition, the Petition failed to show that its new pixel arrangement meets all of the requirements of claim 5. Claim 5 depends from, and therefore incorporates all of the limitations of, claim 1. Petitioner relies on one proposed modification to Matthies for claim 1 (in which blue pixels are larger than red pixels), but a starkly different modification (in which the blue and red pixels are the same size) for the additional limitations of dependent claim 5. Petitioner has not shown that *either* would simultaneously satisfy *all* of the limitations of claim 5. Ex. 2009, ¶200.

3. A POSITA would not have modified Matthies' quad-pixel structure to have pixels with "elongated" sides as required by claims 41, 44, and 52.

Claims 41, 44, and 52 require the first pixel to have "elongated" sides or edges. Petitioner asserts that non-square pixels "can" be used and "[i]n particular, Matthies teaches that its display can employ rectangular shaped sub-pixels." Pet. at 60. But Matthies discloses rectangular shaped pixels only for its RGB stripe structure. Matthies, 16:49-61, 25:46-54, Fig. 8A. Matthies does not describe or suggest using rectangular shaped sub-pixels, or any sub-pixels with elongated sides, in a quad-pixel structure. *Id.*, 17:16-29, 25:46-54, Fig. 8B; Ex. 2009, ¶¶201-202.

The Petition failed to offer any motivation for a POSITA to attempt to modify Matthies to use elongated first pixels in Matthies' quad-pixel structure as the Petition proposes. Petitioner resorts to an *ipse dixit* assertion that it would "be a routine, obvious design choice," Pet. at 60, but that is meritless. First, "[m]erely stating that a particular placement of an element is a design choice does not make it obvious." *Cutsforth, Inc. v. MotivePower, Inc.*, 636 F. App'x. 575, 578 (Fed. Cir. 2016) (non-precedential). Second, as Dr. Kymissis explains, a POSITA would have lacked a reasonable expectation of success in implementing pixels with "elongated" sides as Petitioner proposes. Such pixels may have led to uneven spacings between pixels and the edges of Matthies' display tiles, causing visual defects. Ex. 2009, ¶203. Further, with elongated pixels the region limitation of challenged claim 1 (limitation

1-12) may not be met. Indeed, Petitioner did not even attempt to show how elongated pixels would be implemented, or any reason a POSITA would have been motivated to change the shape of the pixels that way in Matthies' quad-pixel display tile.

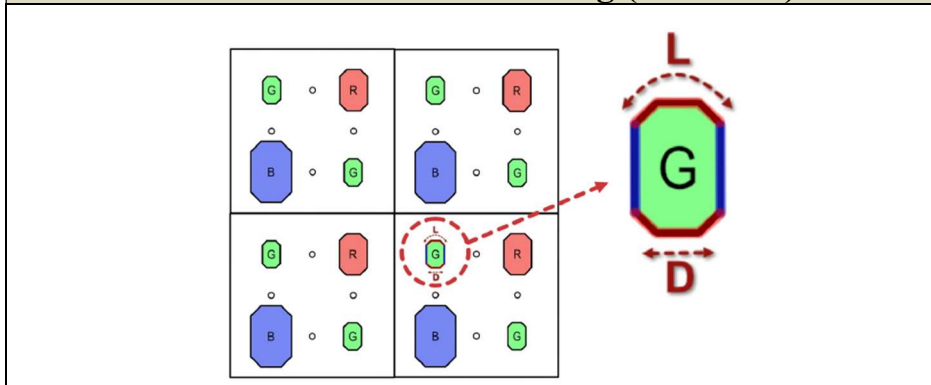
Additionally, Petitioner fails to show that a modified display tile having pixels with elongated sides meets all of the limitations of claim 41. Ex. 2009, ¶204. Dependent claim 41 includes all of the limitations of independent claim 1. Yet the Petition failed to show that a modified tile with "elongated" pixels would satisfy the limitations of claim 1, let alone that a POSITA would have been motivated to make such modifications. For example, claim 1 requires that "a region having a width in the second direction that is equal to a width of the first pixels in the second direction . . . and completely overlapping a row of the first pixels extending in the first direction, is entirely offset in the second direction from at least one of the second pixels or the third pixels." '578 Patent, claim 1. Petitioner has not offered any evidence that Matthies' tile would meet this limitation if the pixels were changed to have elongated sides. The Petition further failed to show that this new display tile would satisfy the requirement that the "shortest distance between two nearest ones of the first pixels in one of the first sets is greater than a shortest distance between one of the second pixels and one of the third pixels that are nearest each other in one of the second sets." *Id.*

Petitioner's arguments for dependent claims 44 and 52 are defective for the same reasons. Ex. 2009, ¶205. For both claims, Petitioner simply points back to its flawed analysis of claim 41, and fails to show how the structure it proposes for these claims would meet the limitations of the independent claims from which they depend. Pet. at 64, 68-69. For dependent claim 44, Petitioner makes no showing of how the modified structure it advances for claim 44 would meet all of the limitations of independent claim 42. *Id.* at 64. And for dependent claim 52, Petitioner makes no showing of how the modified structure it advances for claim 52 would meet all of the limitations of independent claim 45. *Id.* at 68-69.

VI. Ground 2: Petitioner Fails to Establish a *Prima Facie* Case of Obviousness of Claims 40, 43, 45-47, 51, or 52 Based on Matthies in view of Yamada and Hong.

In Ground 2, Petitioner proposes to take its flawed proposed combination of Matthies and Yamada, and combine that with a third reference, Hong, to further modify Matthies' tiled display. Pet. at 75-76. Wholly disregarding Matthies' teachings and the constraints of its design, Petitioner contends that, based on Hong, it would have been obvious to modify the blue, red, and green pixels to have oblong, octagonal shapes, as shown below. Pet. at 79-80.

**Petitioner’s Proposed Modified Matthies Tiled Display
in view of Yamada and Hong (Pet. at 80)**



Petitioner’s arguments fail on multiple grounds. *First*, a POSITA would not have been motivated to combine these three references. As discussed above in Sections V.A-E, a POSITA would not have been motivated to combine Matthies and Yamada, nor in the manner Petitioner alleges. Petitioner’s proposal would *shorten* the lifetime of the display, among its problems. Further combining with Hong does nothing to cure these deficiencies; it only compounds them. For instance, Hong’s use of equally sized pixels a decade after Yamada further undermines Petitioner’s superficial arguments about Yamada, including that Yamada would have been understood by POSITAs to motivate the use of differently-sized pixels. Additionally, a POSITA would not have been motivated to combine Matthies or Yamada with Hong. Hong discloses a “zigzag” pixel arrangement entirely different from Yamada’s RGB stripe arrangement and Matthies’ quad-pixel structure. Ex. 2009, ¶¶85, 227-229. Hong’s zigzag arrangement is incompatible with Matthies’ quad-pixel PMOLED design.

Second, a POSITA would not have been motivated by Hong to modify the shapes of the pixels in Matthies' quad-pixel structure. The oblong, octagonal pixels on which Petitioner relies do not even appear in Hong, Matthies, or Yamada. The Petition's pixel shape is not based on the references, but instead appears to be made out of whole cloth. Ex. 2009, ¶238. The proposed modification is also contrary to the teachings of Hong. Hong describes an embodiment using hexagonal pixels to *increase* the space between pixels. Hong, ¶¶[0060]-[0061], Figs. 8, 9. Petitioner's proposed combination, on the other hand, would *decrease* the space between pixels, which not only would provide no benefit but also would make the display more difficult and expensive to manufacture. Ex. 2009, ¶¶250-51.

Third, Petitioner's proposed combination would not result in a structure meeting the requirements of the challenged claims, and a POSITA would have had no reasonable expectation of success in Petitioner's proposed combination. Ex. 2009, ¶¶252-60.

Indeed, for dependent claims 40 and 43, the Petition presents internally inconsistent theories. The Petition relies on a different combination and different purported pixel arrangement structure for those dependent claims' additional limitations than for the limitations of the independent claims (claims 1 and 42, respectively) on which they depend. The Petition provides negligible analysis of the other challenged claims. The Petition fails to discuss, much less prove, how the

purported combination of Matthies, Yamada, and Hong meets all limitations of any challenged claim in Ground 2. Ex. 2009, ¶¶252-60.

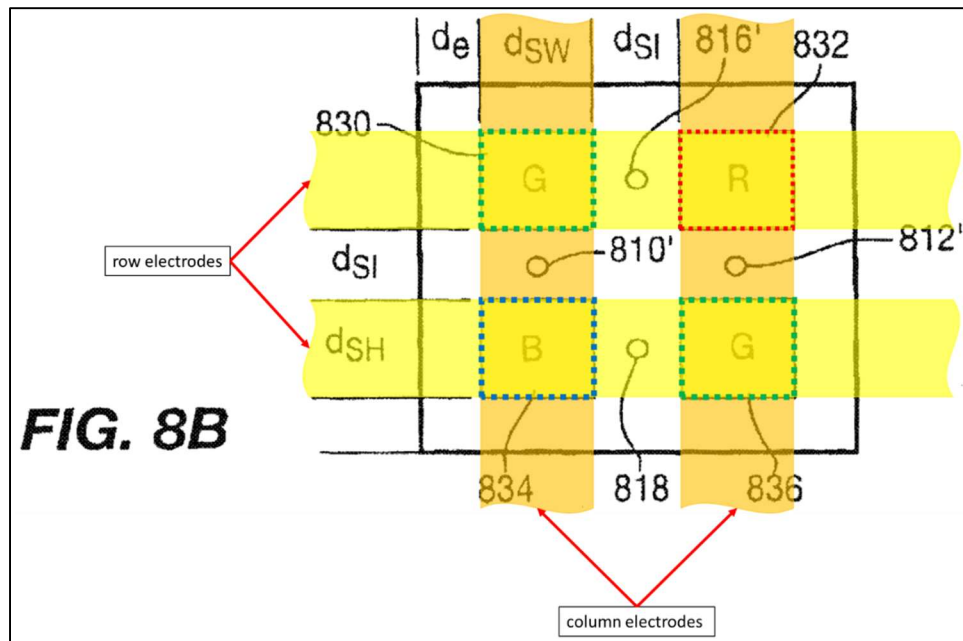
A. A POSITA would not have been motivated to combine Matthies with Yamada and Hong.

As discussed above in Section V, a POSITA would not have been motivated to combine Matthies' tiled, passive-matrix display with Yamada's monolithic, active-matrix display, much less as Petitioner claims. And the Petition's attempts to further combine those references with Hong do nothing to cure the deficiencies in the purported combination of Matthies with Yamada. The Petition's three-reference combination continues to contradict Mathies' express teachings, including teachings (1) to hide the seams between tiles with pixels evenly spaced up to the edge of the tile and have equal spacing between pixels, and (2) when a light emitting material of one color (e.g. blue) has a lower efficiency, to use two pixels of that color in the quad-pixel arrangement. Ex. 2009, ¶¶207-208. Shrinking the size of the red and green pixels, as Petitioner proposes, would have shortened the lifetime of Matthies' display. *Id.* And Petitioner misreads, and fails to apply, Yamada's disclosures. The incompatibilities and design problems would only be compounded by the Petition's three-reference proposed combination with Hong.

Petitioner further fails to offer any reason why a POSITA would be motivated to combine Matthies and Yamada with Hong to change the shape of pixels in Matthies' tiled display. Ex. 2009, ¶208. Petitioner attempts to characterize its

modifications as “nothing more than a routine, obvious design choice.” Pet. at 82. But they are no such thing. In any event, “[m]erely stating that a particular placement of an element is a design choice does not make it obvious.” *Cutsforth*, 636 F. App’x. at 578. The Petition does not identify any problems with Matthies’ square pixels or reasons to attempt to modify Matthies’ Figure 8B to somehow fashion differently-sized, elongated octagonal pixels.

Petitioner’s conclusory statement that “[a]ll pixel shapes capable of accommodating the inter-pixel electrical connections would have been considered,” Pet. at 82, is meritless. Ex. 2009, ¶217. That is not a motivation to modify Matthies’ display. *See Adidas*, 963 F.3d at 1359. And Petitioner did not show its proposed oblong, octagonal pixels are “capable of accommodating the inter-pixel electrical connections” required by Matthies. Pet. at 82. As shown in Matthies’ Figure 8B, the shape of the pixels is defined by the overlapping row and column electrodes. Ex. 2009, ¶218.



Matthies, Fig. 8B (annotated). Matthies' structure is not amenable to octagonal pixels. The Petition fails to address how Matthies' pixels could be made octagonal, which would be infeasible in its PMOLED structure. Ex. 2009, ¶218. Petitioner also reduces the separation between Matthies' blue pixel and vias, which may be problematic. In any event, Petitioner's proposal would violate Matthies design requirements concerning pixel geometries, spacing, and sizes (*see* Sections V.D.3-4, *supra*). Petitioner does not explain why a POSITA would have attempted to create irregularly-shaped, octagonal pixels in a passive-matrix display, let alone how a POSITA would do so with any reasonable expectation of success. As Dr. Kymissis explains, attempting to change the shapes of the pixels in a passive-matrix display would introduce complex electrical effects that would impact the operation and

quality of the display and would require new manufacturing processes that would reduce yield and increase manufacturing costs. Ex. 2009, ¶218.

A POSITA would not have been motivated to combine Matthies with Yamada and Hong for yet another reason. As discussed in Section V.C, Matthies discloses a triple-pixel (RGB stripe) arrangement, shown in Figure 8A and a quad-pixel structure, shown in Figure 8B.

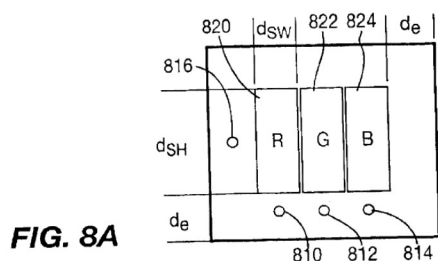


FIG. 8A

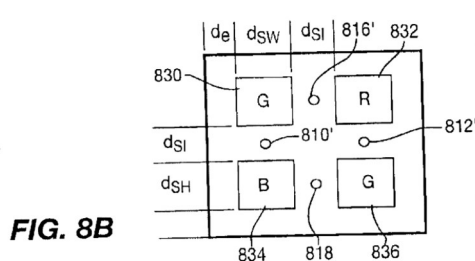


FIG. 8B

Matthies, Figs. 8A, 8B; Ex. 2009, ¶71-72. Yamada discloses a triple-pixel (RGB stripe) arrangement. Yamada, 12:35-40. Hong does not use either arrangement. Instead, Hong is directed to a different, “zigzag” pixel arrangement. Hong, Abstract, ¶¶[0015], [0016].

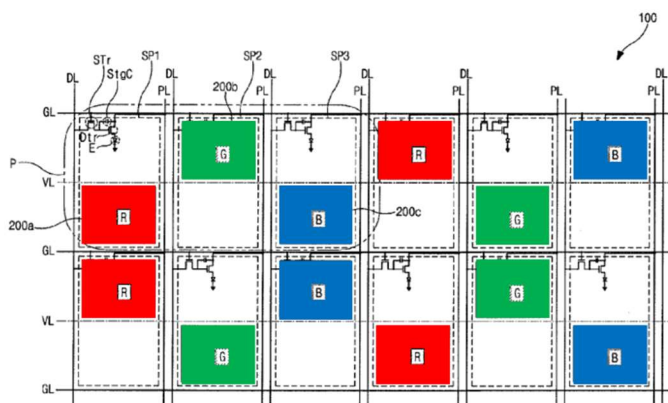


FIG. 4

Hong, Fig. 4 (annotated). Hong's zigzag arrangement is a triple-pixel arrangement with equal numbers of red, green, and blue pixels. But unlike either the RGB-stripe or the quad-pixel, Hong's zigzag arrangement places two pixels of the same color adjacent to each other in the vertical direction. Hong's arrangement further differs materially from both Matthies and Yamada in that its shortest distance between different colored pixels is along diagonal directions, whereas in Matthies and Yamada the shortest distance is in horizontal and vertical directions. A POSITA would recognize that Hong's teachings relating to truncating corners of pixels to create more spacing between diagonally adjacent pixels of different colors are simply inapplicable to any pixel structures taught in Matthies, Yamada, or Petitioner's proposed combination of the two. Ex. 2009, ¶228. Rather than increase aperture ratio, Petitioner's combination would *reduce* it, contravening Hong's teachings.

Petitioner asserts that octagonal-shaped pixels would have been "particularly desirable" because they were purportedly known to provide good aperture ratio. Pet. at 82-83. That is wrong, certainly in the context of Matthies. As Dr. Kymissis explains, any improvement to display aperture ratio would stem *not* from the pixel shapes as such, but from increasing the distances between different color pixels, which can then be taken advantage of by increasing the area of the organic patterns for each pixel. Ex. 2009, ¶¶212, 227-229. The increase in inter-pixel distances (not

pixel shapes in the abstract) is what allows the light-emitting areas to increase, which would, in turn, improve aperture ratio. *Id.* This is a consequence of Hong's zigzag pattern, in which the shortest distances between different-colored pixels are in the diagonal directions. *Id.* ¶¶85, 220 (citing Hong, ¶[0003]). Similarly, any alleged improved resolution and reduced "shadowing" in Hong results not from the pixel shape in and of itself, but from the increased distance between adjacent pixels of different colors in its zigzag pattern. Ex. 2009, ¶¶85-87, 246-247. But the Petition does not purport to take Hong's zigzag pattern, and as discussed below, in Petitioner's proposed combination, the cut-offs do not increase distances between different color pixels and the aperture ratio is reduced.

Nor is there any merit to Petitioner's assertion that octagonal pixels were purportedly "known" to be easier to manufacture and to provide good aperture ratio. Petitioner cites only an inapposite reference (Smith, Ex. 1006) that merely compares one of its embodiments to another under its specific design and manufacturing method. Ex. 2009, ¶221. There was no such generalized understanding. *Id.* Petitioner further ignores the incompatibilities of manufacturing octagonal shaped pixels *in Matthies'* Figure 8B display, with its PMOLED structure, and the problems octagonal pixels would introduce in Matthies' tiled design. *Id.*, ¶218.

Moreover, there would have been no reason for a POSITA to consider Matthies and Hong together, because the references are directed to fundamentally

different technologies. While Matthies is directed to a passive-matrix display, Hong describes an active-matrix display. Hong states each subpixel includes “a switching thin film transistor (TFT) STr, a driving TFT DTr and a storage capacitor StgC,” which is the type of driving circuitry characteristic of an active-matrix display. Hong, ¶[0040]; *see* Ex. 2009, ¶231. Additionally, Matthies’ pixel arrangement is based on unique considerations associated with tiled displays. For example, Matthies’ pixel arrangement needs to provide for vias connecting the tiles to the “[d]riving circuitry” mounted to the back side of the display. Matthies, 2:23-26; Ex. 2009, ¶232. Matthies’ pixel arrangement is also constrained by the need to have pixels “evenly spaced up to the edges of the tile.” Matthies, 5:47-48. Hong is directed to monolithic displays built on a single substrate, a fundamentally different type of display, and does not address any of Matthies’ concerns.

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

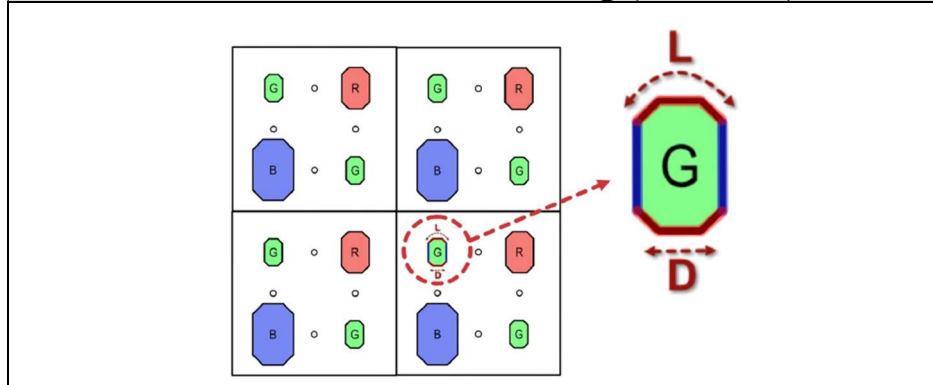
Petitioner does not claim a POSITA would have modified Matthies to use Hong’s zigzag pixel arrangement, that Hong’s pixel arrangement would be appropriate for a Matthies’ tiled display, or that Hong’s pixel arrangement addresses any problems Matthies was attempting to solve. Petitioner does not even claim that it would be feasible—much less obvious—to build a passive-matrix display having Hong’s zigzag pixel arrangement.

Petitioner ignores Hong’s zigzag pixel arrangement, never once discussing it. Instead, Petitioner claims that Hong “provides an example” of a pixel shape—divorced from the pixel arrangement—that allegedly could satisfy some claim limitations in the ’578 Patent. That is meritless, and fails to read Hong in context. Indeed, to get from the Petition’s proposed combination of Matthies and Yamada to its proposed further combination with Hong would require numerous further modifications—to elongate the pixels *and* to use octagonal shaped pixels—that a POSITA would not have been motivated to make or had a reasonable expectation of success in making. Among the failings to Petitioner’s argument, (1) Hong does not teach to elongate pixels or to use octagonal pixels, and a POSITA would not have been motivated to use elongated or octagonal pixels in Petitioner’s modified quad-pixel arrangement; and (2) Petitioner’s proposed combination actually contradicts Hong’s teachings as well as those of Matthies.

1. A POSITA would not have been motivated to modify Matthies’ quad-pixel structure by using elongated octagonal pixels.

Petitioner proposes to modify Matthies’ tiled display to use oblong, octagonal pixels with elongated sides, as illustrated in the modified figure below, purportedly based on Hong.

**Petitioner's Proposed Modified Matthies Tiled Display
in view of Yamada and Hong (Pet. at 80)**



Yet Hong does not disclose an octagonal shape pixel (nor does Matthies or Yamada). Ex. 2009, ¶¶237-242. Hong describes two embodiments of its zigzag pixel arrangement. In the first, shown in Figures 4 and 5, the pixels “have a rectangular shape.” Hong, ¶[0047].

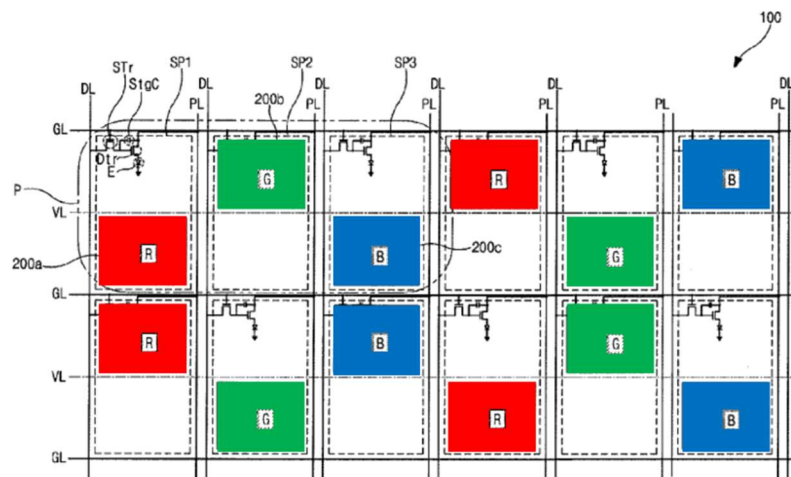


FIG. 4

Id., Fig. 4 (annotated). In the second embodiment, shown in Figures 8 and 9, the pixels “hav[e] two truncated corners,” producing a hexagonal shape. *Id.*, ¶[0061].

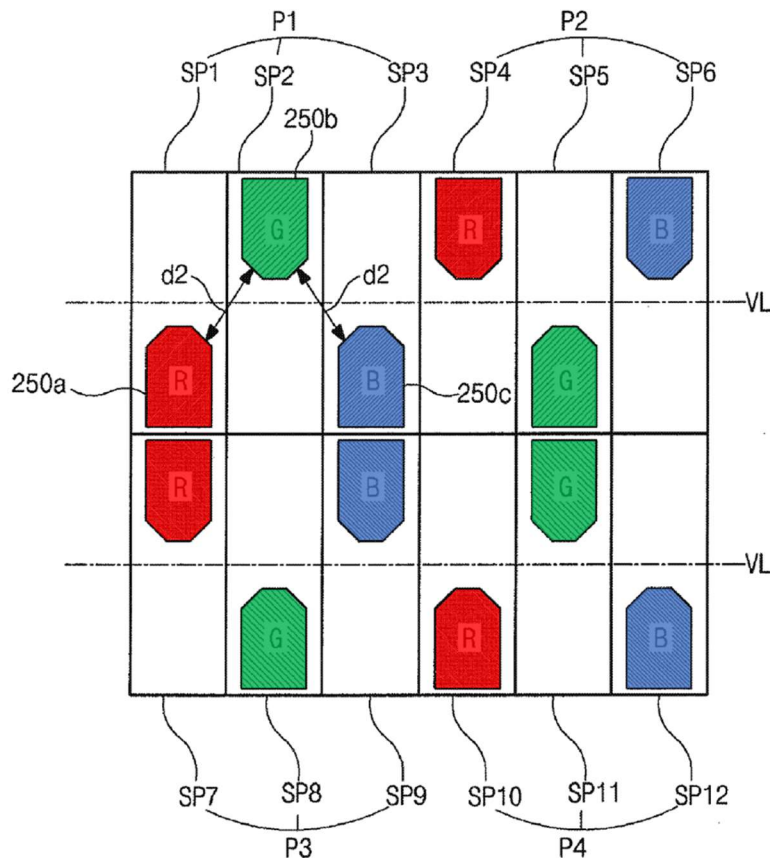


FIG. 9

Id., Fig. 9 (annotated). None of Hong's embodiments use octagonal pixels, nor do Hong's figures show an octagonal pixel.⁵ Petitioner has not cited any disclosure in Hong that would teach a POSITA to use octagonal pixels, much less outside of Hong's zigzag design. Ex. 2009, ¶¶237-242.

⁵ Petitioner also conflates the shapes of *pixels* with shapes of *organic patterns*. The hexagonal shapes shown in Hong are patterns of organic material. Hong does not suggest (and a POSITA would not have understood) that the organic patterns align exactly with the shapes of the emissive areas for the pixels. Ex. 2009, ¶243.

Additionally, nothing in Matthies, Yamada, or Hong teaches modifying an existing pixel by elongating its sides. As explained in Section V.E.3, Matthies uses rectangular shaped pixels only used for its triple-pixel RGB structure, and Matthies does not suggest modifying the square pixels in its quad-pixel structure to have elongated sides. Yamada says nothing about elongating pixels; in fact, under Petitioner’s view, Yamada disclosed resizing pixels by shrinking them *equally from all sides*. Pet. at 37. Likewise, Hong discloses truncating corners of its pixels in a zigzag arrangement and further enlarging the pixels to address shadowing effects and increase aperture ratio; Hong does *not* teach elongating the sides of pixels. Hong, ¶¶[0047]-[0048], [0060]-[0061].

Instead, the octagonal shape in Petitioner’s modified figure above (Pet. 80) appears to be the result of nothing more than Petitioner’s hindsight-driven effort to arrive key limitations of the challenged claims.

2. Petitioner’s proposed modifications of Matthies’ display tile are contrary to Hong’s and Matthies’ teachings.

Hong’s pixel layout attempts to solve a problem with OLED displays known as a “shadowing effect.” Hong, ¶[0010]. Hong describes the “vacuum thermal evaporation method” of manufacturing OLED displays in which the organic materials are deposited onto a substrate. *Id.*, ¶[0009]. This method requires space between different colored pixels, creating a “dead zone that is not used for emission.” *Id.*, ¶[0011]. If pixels are too close together, their different organic materials overlap,

which can produce incorrect colors. As Hong explains, “a border portion between the adjacent two sub-pixel regions does not emit a predetermined colored light due to overlapping, which may be referred to as a shadowing effect.” *Id.*, ¶[0010]. The need to maintain proper spacing between pixels limits the display’s aperture ratio and resolution. *Id.*, ¶[0011]; Ex. 2009, ¶246.

Hong’s zigzag pixel arrangement was intended to reduce or eliminate this shadowing effect, which presents a manufacturing challenge. Ex. 2009, ¶247. In Hong’s first embodiment, the rectangular pixels are separated by a distance, d_1 , as shown in Figure 5 (below left). By truncating the corners of the pixels in its second embodiment, Hong increased the diagonal distance between pixels. Ex. 2009, ¶248. As shown in Figure 8 (below right), the distance between pixels, d_2 , is greater than the distance d_1 in the first embodiment. Hong, ¶[0061].

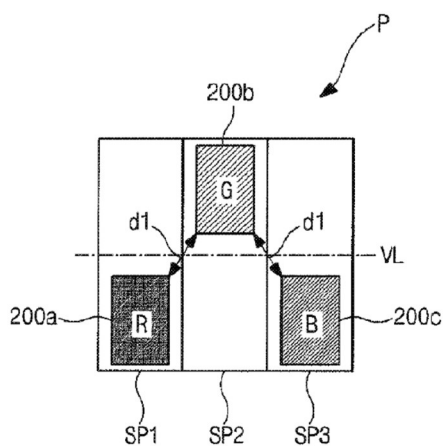


FIG. 5

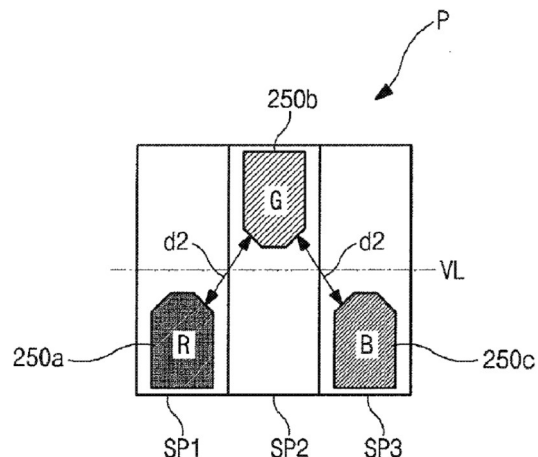
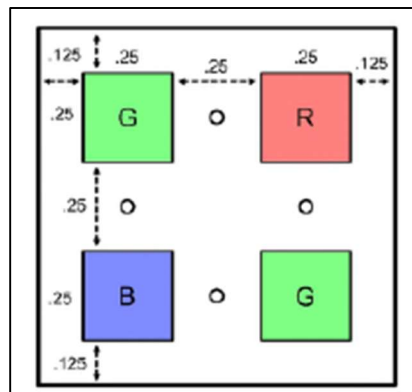


FIG. 8

Hong, Figs. 5, 8. Hong's truncated corners allowed the pixels to be placed closer together while maintaining the diagonal distance, increasing the resolution and the aperture ratio. *Id.*, ¶[0061]; Ex. 2009, ¶248.

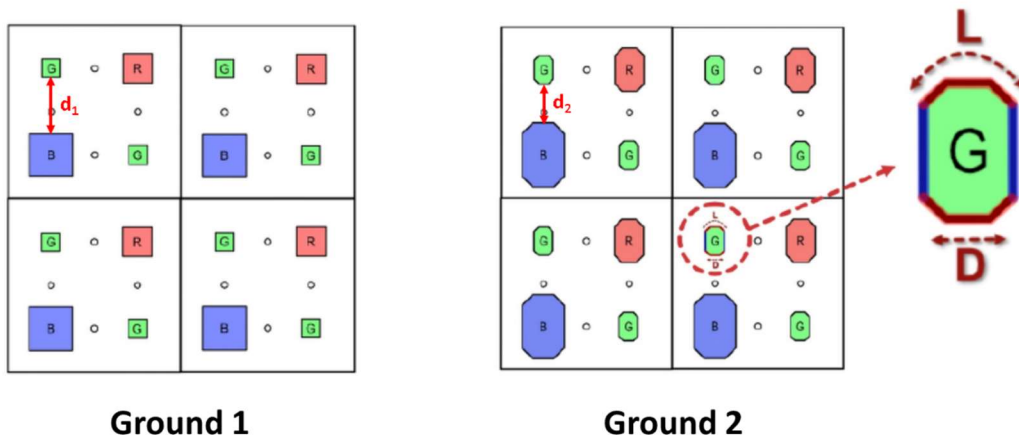
A POSITA would not have been motivated to truncate the corners of pixels in Matthies' PMOLED, tiled display and would not have expected success in doing so. Ex. 2009, ¶249. Hong's teachings regarding the increase in aperture ratio and display resolution would not have been applicable to Matthies' quad-pixel structure, where the shortest distance between different colored pixels are *not* the diagonal directions, but rather in the horizontal and vertical directions.



Pet. at 30. Truncating corners of pixels in Matthies' display would *not* increase the distance between pixels; it would simply reduce the area of the pixels and their aperture ratios for no reason. Ex. 2009, ¶249.

In fact, Petitioner's proposed combination of Matthies, Yamada, and Hong contradicts the teachings of Hong. The figure below shows the distance, d_1 , between pixels in Petitioner's proposed combination of Matthies and Yamada (below left)

and the corresponding distance, d_2 , between pixels in Petitioner's proposed combination of Matthies, Yamada, and Hong (below right).



Pet. at 39, 80 (annotated). As can be seen, distance d_2 is *smaller* than distance d_1 . Petitioner's use of oblong, octagonal pixels thus forces the pixels to be *closer* together—antithetically to Hong—and would only exacerbate any shadowing effect and increase manufacturing complexities. Ex. 2009, ¶¶250-251.

The Petition's proposed combination also contravenes Matthies' teachings and design requirements, including in drawing a pixel shape infeasible in Matthies' PMOLED structure; creating uneven spacing between pixels and a tile's edge, and uneven spacing between pixels; and introducing the very optical effects along seams that Matthies sought to avoid. *See* Sections V.D.3, V.D.4; Ex. 2009, ¶¶167-185, .

C. Petitioner fails to show that its proposed combination of Matthies, Yamada, and Hong satisfies all limitations of any challenged claim.

Petitioner's Ground 2 fails for the additional reason that Petitioner failed to show its proposed combination of Matthies, Yamada, and Hong—with its oblong,

octagonal pixels—would meet all limitations of independent claims 1, 42, or 45, on which the challenged claims (other than claim 45 itself) depend.

Claims 40, 43, 45-47, and 51-52 include, among other things, limitations on the spacing of and distances between specific pixels that would change if a square pixel were replaced with an oblong, octagonal pixel as Petitioner contends. However, the Petition failed to show its modified pixel arrangement purportedly based on Mathies with Yamada and Hong would meet all limitations of claim 45 or the independent claims from which claims 40, 43, 46-47, and 51-52 depend. Pet. at 76-82. The Petition failed to analyze claim 45 or each challenged dependent claim as a whole, and only addressed a few limitations of the independent claims.

Independent claims 1 and 42 place limitations on the distance between the first (green) pixels and the distances between the second (blue) pixel and the third (red) pixels. For example, claims 1 and 42 recite:

wherein a shortest distance between two nearest ones of the first pixels in one of the first sets is greater than a shortest distance between one of the second pixels and one of the third pixels that are nearest each other in one of the second sets.

'578 Patent, claims 1, 42. Claim 1 further requires that a defined region containing first pixels be “entirely offset” from one of the second pixels or one of the third pixels. '578 Patent, claim 1 (limitation 1-12). Petitioner does not make any showing that these limitations—or any of the other limitations of claims 1 and 42, which are

part of challenged dependent claims 40 and 43—are satisfied by its proposed combination of Matthies, Yamada, and Hong. Ex. 2009, ¶254.

Additionally, Petitioner has not shown its purported combination would satisfy all limitations of independent claim 45 or its challenged dependent claims. Petitioner’s entire analysis of claims 45-47 and 52 is just two sentences and solely addresses whether “‘some of the edges’ of the green ‘first pixels’ cooperate to form a ‘virtual quadrangle’ that encloses a single red/blue pixel.” Pet at 81. Petitioner fails to address any of the other claim limitations, other than for claim 51 simply referring back to its flawed analysis of claim 40, and its obviousness claim is necessarily deficient for that reason alone. Ex. 2009, ¶¶252-60.

Moreover, all challenged claims in Ground 2 include limitations that would be affected by changing the shape of the pixels. Petitioner has failed to demonstrate that these limitations would be satisfied by its proposed combination of Matthies, Yamada, and Hong. Ex. 2009, ¶252-60. For this reason alone, Petitioner failed to carry its burden of proving claims 40, 43, 45-47, 51, and 52 would have been obvious.

VII. 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, ¶¶261-307.⁶

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, ¶262 (citing Ex. 2064). However, AMOLED displays for mobile devices suffered from a significant shortcoming—the difficulty of manufacturing high-resolution displays. Ex. 2009, ¶¶264-273; *see also* 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

⁶ 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, ¶¶266-270 (explaining full-HD to require 1920x1080 pixels or over 400 PPI in typical mobile device displays). By the time of the ’578 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, ¶272.

Developing full-HD AMOLED displays for mobile devices that could be produced at commercial scales proved especially difficult because of challenges 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, ¶273. 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 “lower 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 for commercial scale manufacturing. Ex. 2009, ¶274.

Shortly after Samsung Display first mass-produced AMOLED displays in 2007 (using entirely different pixel arrangements, 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, ¶275. 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, ¶276. 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 ’578 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.” ’578 Patent, 1:46-53.

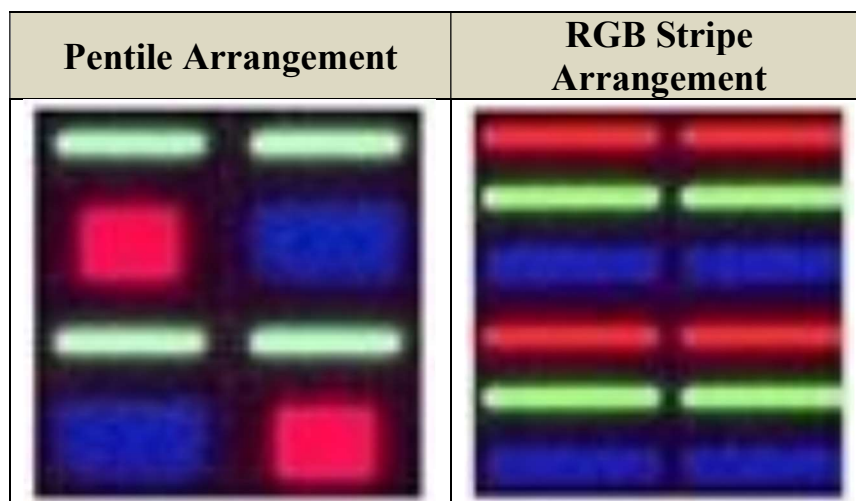
As explained further in Section VII.E, the ’578 Patent’s novel pixel arrangement, which became widely recognized as the “Diamond Pixel™” arrangement, enabled the manufacture of full-HD AMOLED displays suitable for mobile devices, satisfying the industry’s longstanding need.

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, ¶¶281-287. 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, published in May 2005), Yamada (assigned to Sanyo, published in April 2002), and Murai (assigned to Seiko Epson, published in December 2005). Ex. 2009, ¶282. In fact, the near-decade between the publication dates of Petitioner’s references and the inventions of the ’578 Patent, when many groups were actively attempting to solve these problems, itself supports the inventions’ nonobviousness. *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, ¶¶283-287. 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.



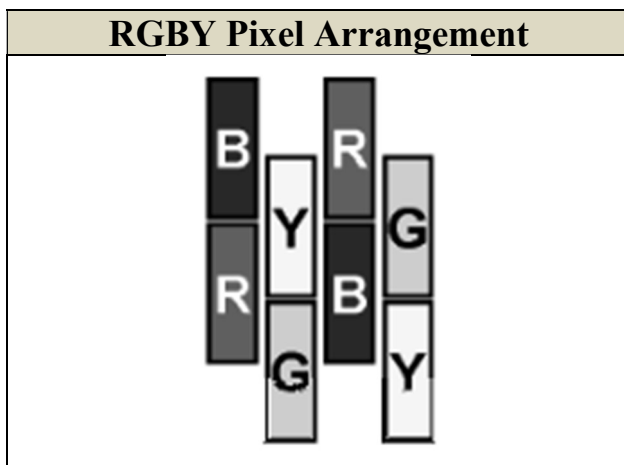
In 2010, LG Display attempted a different “pixel arrangement scheme based on the conventional shadow mask process and ability” which involved “shared emitting aperture area[s] between horizontally adjacent 2 sub-pixel[s].” Ex. 2020 at 3-5. LG Display’s alternative pixel arrangement (reproduced below) failed to satisfy industry needs, however, as the resolution of the resulting prototype display was still 229 PPI. *See id.* 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, ¶¶281-284.



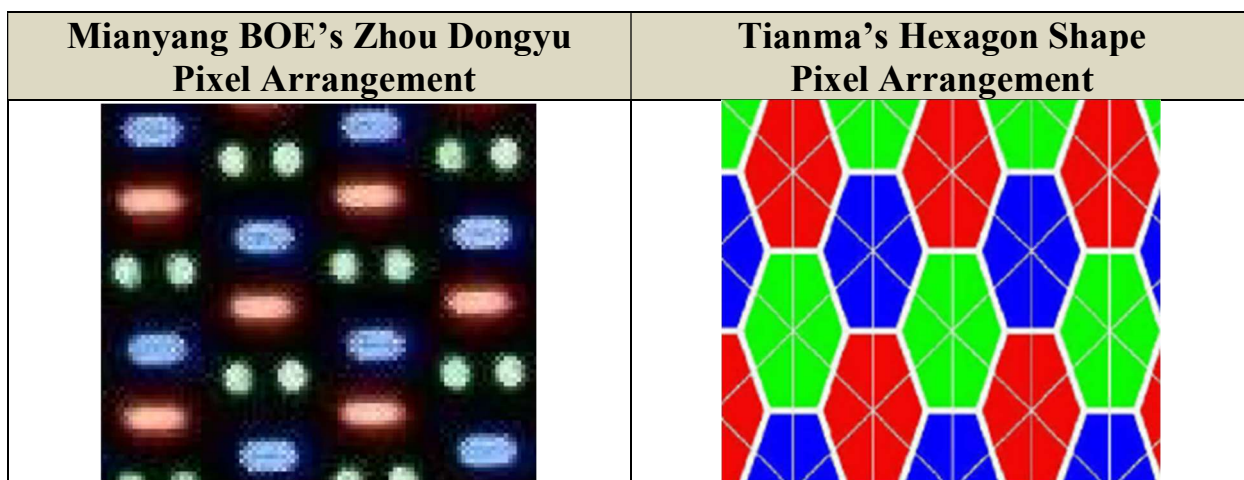
Because of the technical challenges, the industry was highly skeptical that a pixel arrangement could be devised that would enable the manufacture of full-HD AMOLED displays for mobile devices—so much so that LCDs (which did not suffer from similar manufacturing limitations) were viewed as a preferred alternative. Ex. 2009, ¶¶277-279. 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, ¶279.

Continued research efforts *after* the inventions of the '578 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, ¶284.



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, 3) (below, left), and Petitioner Tianma proposed a “hexagon shape” pixel arrangement (Ex. 2036 at 2) (below, right). Ex. 2009, ¶285.



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 ’578 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, ¶¶298-299.

C. The claimed inventions received industry praise.

There has been significant praise for the pixel arrangement structures of the ’578 Patent, including praise for the full-HD resolution and superior image quality of the AMOLED displays implementing these arrangements. Ex. 2009, ¶¶287-290. For example, DisplayMate’s “shoot-out” article series singled out praise for the innovative Diamond Pixel structure practicing the ’578 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 ’578 Patent, Samsung Galaxy S4’s AMOLED display was the first commercial embodiment of the ’578 Patent. Praise for the Galaxy S4’s AMOLED display, and specifically the novel pixel arrangement of the ’578 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 ... 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, ... 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 iPhones, Apple adopted Samsung Display’s AMOLED displays implementing the pixel arrangement of the ’578 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.

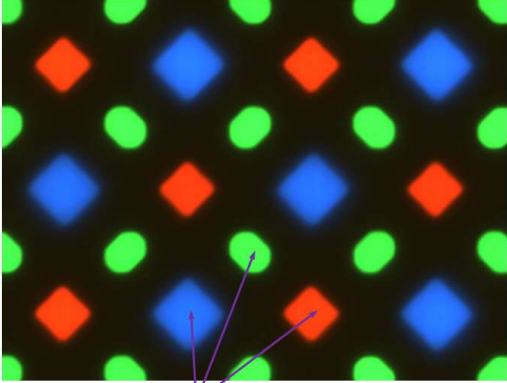
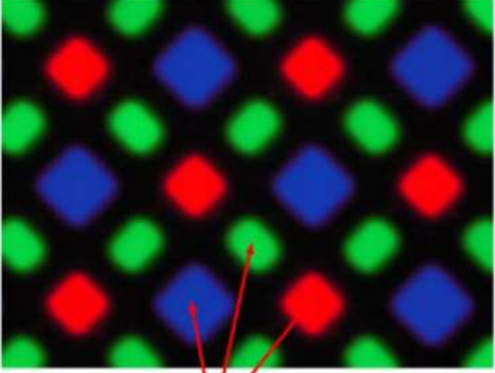
Flagship mobile devices following the Galaxy S4 and iPhone X have similarly received praise for their displays that embody the ’578 Patent. Ex. 2009, ¶290 (citing Exs. 2068-2072). For his achievements, the ’578 Patent’s named inventor, Mr. Sang-Shin Lee received an award from the Commissioner of South 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 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, ¶¶291-297. The structures suggests 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).

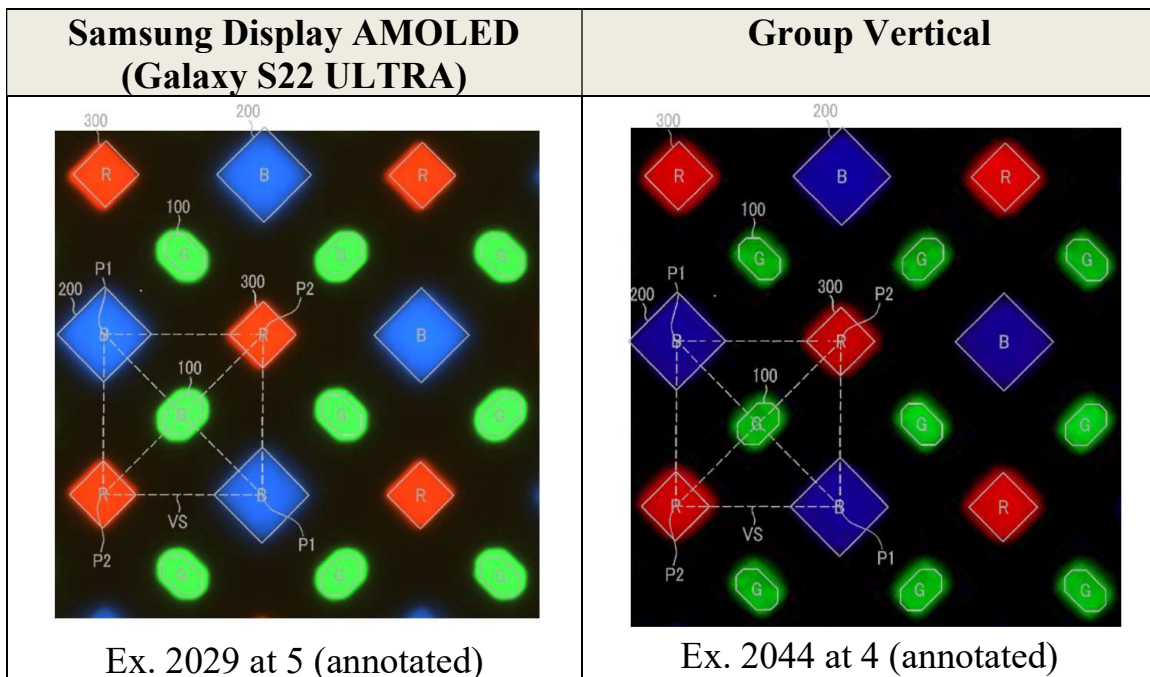
As discussed above, in 2013, Samsung Display released AMOLED displays implementing the patented Diamond Pixel arrangement to much acclaim. *See* Exs. 2009, ¶¶287, 299-300, 2013 at 3, 2026 at 2. Following Samsung Display’s success, Petitioner Mianyang BOE copied Samsung Display’s pixel arrangements to commercialize AMOLED displays for products including the iPhone 12. Ex. 2009, ¶292. 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.

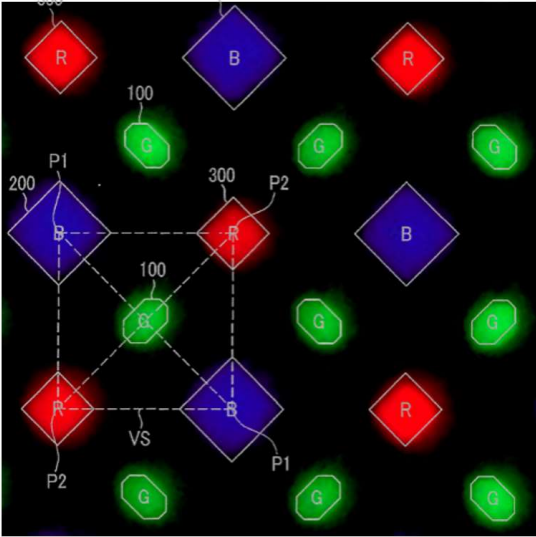
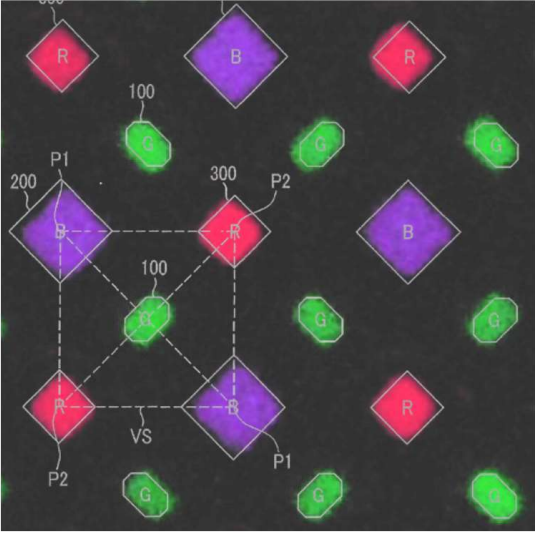
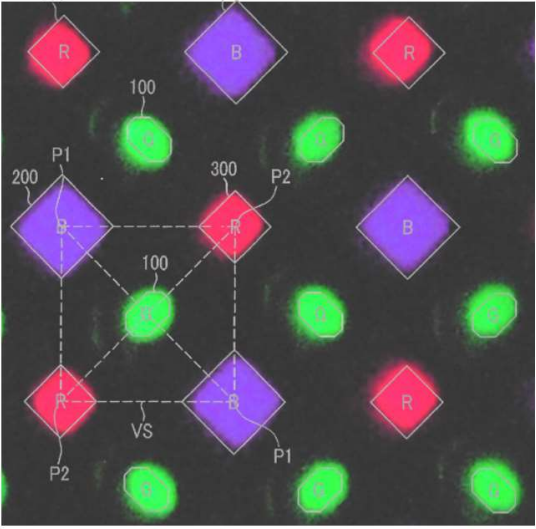
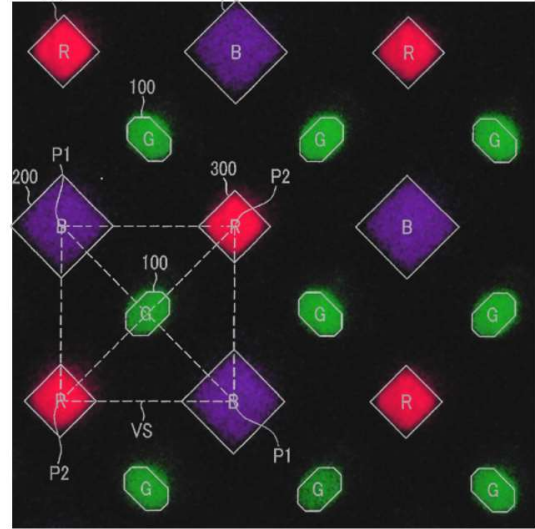
Samsung Display AMOLED (Galaxy S22 Ultra)	Mianyang BOE AMOLED (iPhone 12)
 Pixels Ex. 2029 at 5 (annotated)	 Pixels Ex. 2041 at ¶84

Widespread copying of the ’578 Patent’s inventions is further evident from samples of AMOLED displays distributed by numerous vendors of replacement AMOLED displays for mobile phones. These pixel arrangements not only infringe the challenged claims (*see, e.g.*, Ex. 2042 (chart mapping claims 1-6, 10, 12, 17-19, 21-23, 40-47, and 51-52 to Group Vertical AMOLED Display); Ex. 2043 (chart

mapping claims 1-6, 10, 12, 17-19, 21-23, 40-47, and 51-52 to Sourcely Plus AMOLED Display))), they bear such similarity to those of Samsung Display that they demonstrate copying. Ex. 2009, ¶¶293-297. *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 the '578 Patent's Figure 5 overlaid on top, showing the exact embodiment of Figure 5:



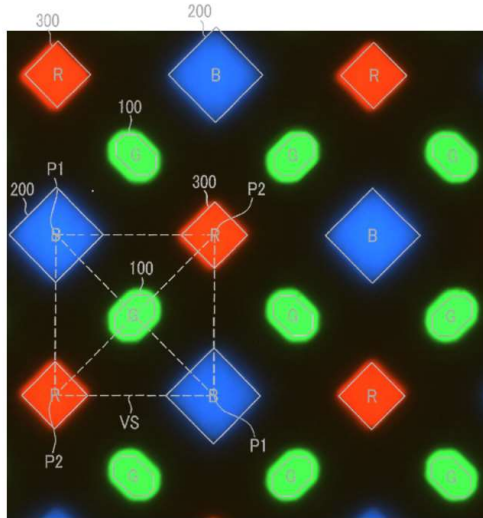
Phone LCD Parts	Sourcery Plus
 Ex. 2045 at 5 (annotated)	 Ex. 2046 at 6 (annotated)
eTech Parts	Parts4LCD
 Ex. 2047 at 6 (annotated)	 Ex. 2048 at 5 (annotated)

E. The '578 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 '578 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, ¶¶298-300. 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 ’578 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, ¶300. For example, the AMOLED display used in the Samsung Galaxy S22 Ultra product practices all challenged claims of the ’578 Patent. Ex. 2009, ¶¶301-303; Ex. 2028 (Galaxy S22 ULTRA Claim Chart). A teardown image (Ex. 2029 at 5) of the pixel arrangement obtained from a Galaxy S22 Ultra sample is reproduced below, with the ’578 Patent’s Figure 5 superimposed.



The objective evidence 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 '578 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, ¶¶304-307. 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, ¶¶304-307; *see e.g.* '578 Patent, claims 1, 23, 40, 42, 45, 47, 51, 52 (pixels that are arranged along first, second, third, or fourth

directions, forming first, second, third, or fourth lines, and/or forming a virtual quadrangle); claims 17, 23, 42 (first, second, and third pixels having different areas); claims 1, 5, 22, 40-45, 51-52 (requiring certain distances between pixels); claims 1, 6, 19, 46 (requiring pixels to emit different color lights or red, blue, or green lights); and claims 12, 40, 43, 45-47, 51-52 (requiring pixels to have certain shapes, *e.g.*, “polygonal,” “first pixel has two elongated sides . . . and two connection portions that connect the two elongated sides to each other at respective ends”). These novel pixel arrangement structures allowed Samsung Display to overcome manufacturing and design obstacles to attain higher-resolution and higher brightness AMOLED displays that relate to the sensitive light-emitting organic layers of OLEDs. *See, e.g.*, ’578 Patent, 1:46-2:3, 5:30-36, 6:46-60, 7:27-43, 8:10-16, 8:53-59; Ex. 2009, ¶¶304-307.

A pixel arrangement having the unique advantages of the ’578 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.

VIII. 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 13,998 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