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Ultra-Low Power/ High Brightness OLED Microdisplays for Connected Eyewear

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ABSTRACT

Augmented and Mixed Reality (AR, MR) markets are in their early stages and still groping to find the best display technology. Due to its compactness, power efficiency and superior image quality, AMOLED microdisplays have a leading role to play if they overcome their current limitations for high brightness.

1 Introduction

Microdisplays are widely used in head mounted displays (HMDs), electronic viewfinders (EVF) and other near-to-the-eye visualization systems. An overview about the different technologies and applications can be found in [1]. Emissive type microdisplays based on OLEDs have been strongly increasing their market share for these applications. More recently, OLED microdisplays start to enter the emergent market of wearable Augmented Reality (AR). This includes products like connected glasses or HMDs for Augmented or Mixed Reality, as well as helmet-based Head-Up-Displays, or display overlays in traditional optical systems like e.g., rangefinders or scopes.

A major challenge for these applications is the required high brightness on display level in the range of 2000-20 000 cd/m², depending on the specific application, combined with a very low power consumption and high compactness of the overall system. While monochrome or even two colors (Red & Green) OLED microdisplays comply very well with these requirements, the situation is more complicated when full color is required.

In this presentation, we will perform a comparison in terms of performance and feasibility of different architectures for full color microdisplays, in terms of OLED stack and subpixel arrangements, taking into account specific micro-display related constraints e.g. from the CMOS active matrix or from manufacturing.

2 Introduction to Microdisplays & Applications

Microoled has always been driven by product innovation to deliver the best display performances and accompany its customers on the road of world premieres from the first OLED viewfinder integrated in a high-end consumer camera in 2012, to the first full see-trough connected glasses with an overall weight of 35 grams and 12 hours of operating time in 2020 [2], [4]. Our well-established OLED microdisplay manufacturing line delivers a large family of microdisplays from 0.38” to 0.61” with the latest 0.20” displays dedicated to AR applications (Figure 1: Microoled displays family) .

3 Connected Eyewear – Definition & Requirements

While the term metaverse is getting more and more widespread, one must understand the characteristics behind the terms Virtual Reality, Augmented Reality, Mixed Reality, and other Smart Eyewear. Display requirements for each application are specific with quite some distance from most of the currently commercialized near-to-the-eye products. We will explain why Microoled is targeting the AR market for Connected Eyewear and why it is important for Microdisplay manufacturers to consider not only the display performance itself but the complete system to design displays accordingly. It is critical to understand the new AR-specific metrics that will be discussed in this part to develop an optimized display.

4 AMOLED Solutions for Connected Eyewear

4.1 Comparison of Microdisplay technologies

Among the microdisplay technologies, transmissive and reflective types are more mature and affordable from a manufacturing point of view compared to the emissive types. This latter holds interests thanks to its compactness, high power-efficiency, fast response and of course high contrast. If LED-based microdisplays are a trending research topic due to its potential to deliver a luminance of 10^6 cd/m² which would be a game-changer in the microdisplay field many challenges are yet to be solved. For instance, scalability towards high pixel density with a good pixel-to-pixel uniformity to ensure image quality still needs to be proven. Manufacturing costs are still too high because of the cost of the LED wafers and the complex fabrication process with a hybridization step, and therefore a completely new manufacturing process has to be developed. In this light OLED microdisplays appear to be a more mature technology with moderate costs since it is compatible with common semiconductor equipment.

4.2 Approaches and limitations for high-brightness AMOLED microdisplay

Because of its nature, AMOLED microdisplay technology still hold barriers to be the perfect candidate for a full color display dedicated to AR/MR applications.

We will first review the performances of current OLED configuration using three Red/Green/Blue fluorescent emitters in a single stack and approaches with phosphorescent emitters in either single or tandem (or 2-units) structures. The white fluorescent single stack usually peaks around 8 cd/A at a current density of 40 mA/cm² before color filters. For the monochrome stacks, efficiencies in the range of 60 cd/A to 110 cd/A are accessible at the same current density for a brightness ranging from the 3 000 cd/m² up to 25 000 cd/m² required by today's optical systems. We will briefly expose the current limitations from the OLED manufacturing process and from the CMOS active matrix with the example of Microoled displays (Figure 2) and then in a second time we will have a word on few current developments that could boost the OLED performances and AMOLED microdisplay adoption into AR/MR devices. One of them being the Thermally Activated Delayed Fluorescence (TADF) materials used in the Hyperfluorescence approach.

5 Focus on the Microoled Engine: Activelook

Finally, we will introduce the Activelook engine [3] that has been designed around our latest 0'2" yellow monochrome High-brightness display to maximize optical performances and energy efficiency for application in connected eyewear and other applications that require full see-trough information overlay (Figure 3). The display is based on a high-efficiency single yellow phosphorescent OLED with a typical luminance of 7 000 cd/m² as introduced earlier. Associated with a memory-type active matrix this display power consumption is of 1 to 2 mW. The optical module including the battery and the optics only weights 7g and can operate for 12 hours. This module paired with lenses using anti-reflective coating designed from and for the Yellow OLED display spectrum are a great example of a fully integrated system maximizing efficiency off all its element to deliver a best-in-class product twice awarded at CES 2021 Innovation Award Honoree in embedded technologies and in Sport & fitness with our partner Julbo.

6 Conclusions

For wider adoption, connected eyewear means glasses incorporating (almost) invisible technology. Microdisplays that enable this have to be very compact, with extremely low power consumption, high brightness, and high contrast. AMOLED Microdisplay respond to these requirements. Microoled shows that - together with a proprietary & innovative full see-through optics, - OLED Microdisplays are THE key enabler for connected eyewear.

References

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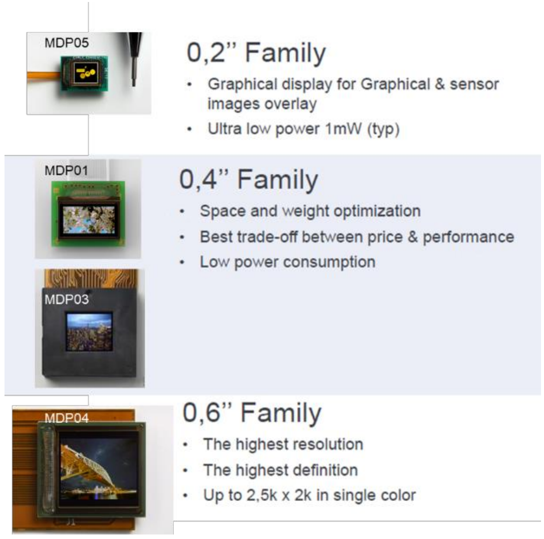

Figure 1: Microoled displays family

Figure 2: Examples of Microoled High brightness displays

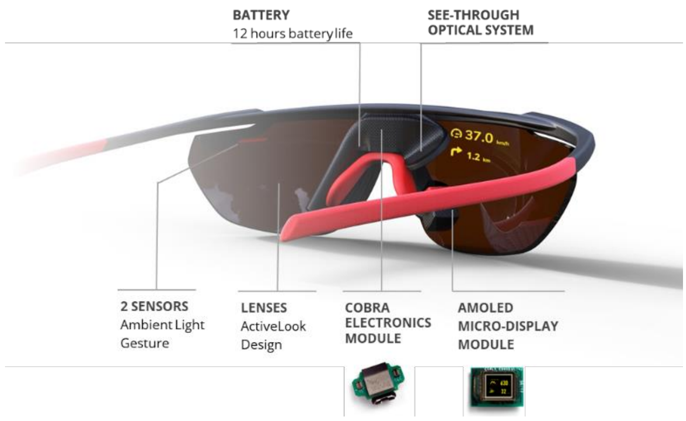

Figure 3: Microoled Activelook engine