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Catching the dream of AR for the consumer: where do we stand in terms of displays and optics in 2020?

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ABSTRACT

Over the last 18 months, lots of things happened in the AR field, specifically targeting the consumer market. As AR headsets are expected to be the next consumer electronics revolution, what has been done, what will be done and when can we expect high volumes to appear on the market?

1 INTRODUCTION

Augmented Reality (AR) and Virtual Reality (VR) have been hot topics for decades. VR has been around for the consumer for some years now, built upon off-the-shelf components. Apart from general improvements, the form factor is being worked upon and we see many developments in microdisplays, including OLED-on-Silicon and microLEDs, alongside pancake optics to be able to deliver a proper pixel density, field of view and form factor.

AR was and continues to be the dream consumer electronics companies want to make real to deliver the long-awaited revolution of replacing smartphones. But as children of the flat panel display industry, we are used to having very high-quality displays all around us. And the image quality that AR has been able to provide so far is not at this level yet. But technology has been improving on all fronts and we are seeing some progress in waveguiding optics and microLEDs that will bring new functionality.

2 TECHNOLOGICAL DEVELOPMENTS BRING A BRIGHTER FUTURE

We expect a first generation of headsets to come in soon with a 2021 milestone for reaching a significant volume sold. These will be based on conventional optics with most likely either MEMS or OLED-on-Silicon display solutions. However, for the market to really be enabled, a complete technological paradigm shift is required. In terms of optics, everything revolves around waveguiding technology. For a long time they have been improving and were fighting against the poor optical efficiency they could deliver. From less than 1% efficiency we can now see results that go an order of magnitude beyond that. So much so that, while uniformity needs to be improved, they meet the minimum requirements for Original Equipment Manufacturers (OEMs). We expect a second milestone around 2023 [1] when the big consumer electronics brands come in with a product that respects the consumer requirement trio of performance, cost and form factor (Fig. 1).

Fig. 1: Augmented reality market trends – scenario expectations for the consumer market

But one element is still missing at the moment: the display engine. Though efforts are continuing, we have not seen a microLED product yet. MicroLED microdisplays can provide what the other solutions cannot, including brightness, form factor, color and contrast. And all the OEMs are waiting for this opportunity to materialize, as we anticipate its penetration to reach 30% by 2027 (Fig. 2).

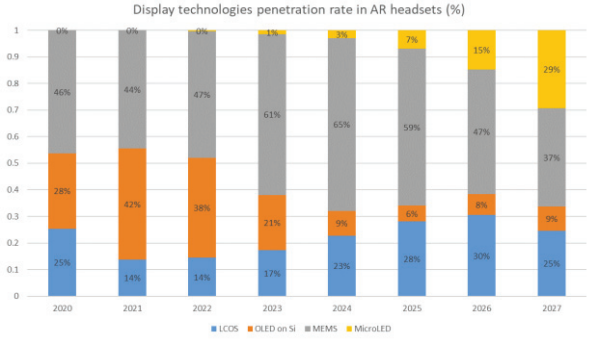

Fig. 2: Display technologies penetration rate in AR headsets

3 AN EMERGING SUPPLY CHAIN WITH KEY MANUFACTURING CHALLENGES

As it is complex to manufacture a microLED microdisplay at an acceptable cost with a proper level of performance [2], we can monitor the industry's progress. Many prototypes have been shown over the past 24 months, with different manufacturing paths including red/green/blue (RGB) native colors, color conversion and hybrid bonding (Fig. 3). In late March 2020, the

Plessey and Vuzix partnership for microLEDs in AR came to an end when Facebook signed an exclusivity deal for Plessey to supply them with microLEDs. This illustrates the interest in the technology and how the supply chain is establishing itself.

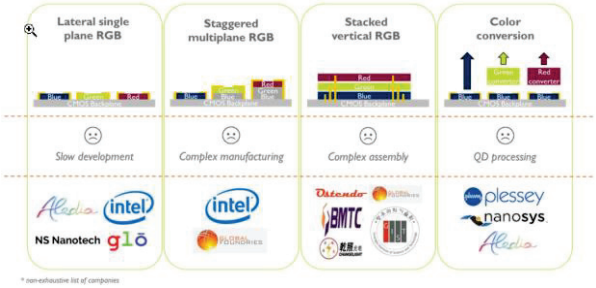

Fig. 3: Full color microLED microdisplays: architectures, challenges and players

In the meantime, we have seen lots of movement from the waveguiding optics perspective. In the past few years, we have seen investments and partnerships including Lumus with Quanta, Digilens with Foxconn, WaveOptics with Goertek and Apple with Akonia. Between reflective, diffractive, and holographic waveguides, comes the question of who is going to get the lion's share. It will all come down to performance and cost, so that every technology has its own roadmap to fight against its cons while building upon its pros (Fig. 4).

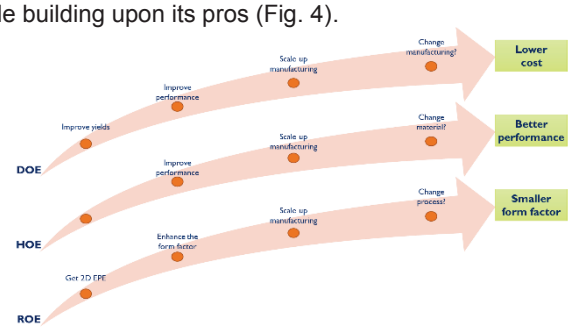

Fig. 4: Roadmaps for AR optics

And cost is very much linked to the manufacturing paths taken by the different technologies. Surface-relief grating-based waveguides have been well-known for years now, being the choice of Microsoft or Magic Leap. But poor yields linked to a complex manufacturing process based on nano-imprint lithography led to high costs. This has been improved and now WaveOptics or Dispelix can likely provide waveguides to any OEM, moving from a captive technology towards becoming openly available.

Among Apple, Facebook, Huawei and Samsung, who shall be the first to deliver a sleek design, good performance and decent cost consumer headset? There is little to no doubt that though Apple has everything in-house (Fig. 5), all major brands are close and establishing partnerships and deals with all the waveguide and microLED players to reach the consumer.

Fig. 5: Apple's vertically integrated supply chain for AR headsets

4 THE NUMBERS OF THE CONSUMER MARKET DREAM

The AR market has been mostly a professional-based market, as the performance, cost and form factor trio is hard to balance. But thanks to all the technological advancements, we can expect a 105% Compound Annual Growth Rate (CAGR) through to 2027 in volume for AR headsets (Fig. 6). And this promise of a strongly growing market has sparked the interest of many in the supply chain.

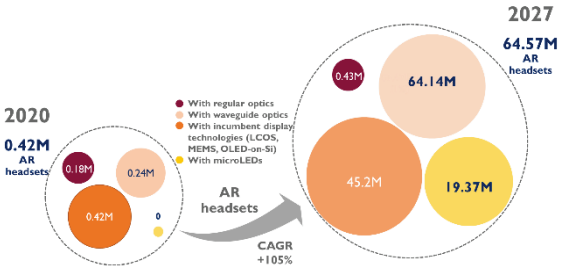

Fig. 6: AR headsets forecasts in volume.

Waveguides have improved a lot thanks to design efforts but also thanks to the push from equipment makers intensifying their efforts such as EVG and Oxford Instruments and substrate manufacturers. The glass industry has been working at providing high refractive index wafers to allow for waveguide manufacturing, trying to push and enable the market. Given the projected wafer numbers and associated revenues, were the consumer market to thrive, it would represent a non-negligible part of even the enormous glass business.

But for the consumer market to thrive, it is about more than just the hardware and providing a high-quality image in something that looks like a regular pair of glasses. If the end-result simply consists of putting a smartwatch screen in front of the eye, this is probably not compelling enough. Much like VR, there is a need for a real disruption in the use case. That is why we expect the OEMs to come in with a proper proposition to really kickstart the market. As the history of the smartwatch shows, we think the adoption curve for AR will follow the same path, with first early products maybe not providing compelling performance and use case, until a big gun jumps in. As an example, Apple seems like a good candidate for that: they have the microLED effort, the waveguide effort, the application effort with ARKit and also the 3D sensing effort. As they progressively integrate some of these technologies in their newer products, they can raise awareness about AR, preparing the consumer for when everything is ready for a headset. And perhaps we'll see that by 2023.

5 CONCLUSIONS

For AR, it is both about the optics and the display engine. The latter has been using incumbent projection technologies (LCOS, DLP) for lack of a better choice [3]. It is still bulky, not allowing for an acceptable form factor for the consumer. As OLED-on-Si cannot deliver the required brightness for a day-to-day live use case, the microLED dream continues. While microLEDs could theoretically deliver the desired level of performance with acceptable form factor, many improvements are still needed in efficiency, light extraction, driving compensation, color conversion and so on. In the meantime, the optics, which for the most part are waveguides as they provide an acceptable form factor that the consumer is asking for, have been improving steadily. Work continues on improving the performance in terms of FOV and efficiency, but it looks like an acceptable level has been reached already. Now it is all going to be about the microLEDs, and if they happen or not.

The major issue today for consumer adoption is first and foremost the use case: one can provide the best hardware in the world, but if there is no compelling application, what would be the purpose? This question is very much resolved for professional use, but not adequately for the consumer.

The first generation of headsets, coming soon, will likely provide something around a port of the common smartwatch display in front of the eyes, but we do not think that is a compelling enough use case to convince the consumers to cross the chasm. That is why we expect the OEMs to come to the party with an acceptable offer to really kickstart the market. We think the adoption curve for AR will follow a similar path to the smartwatch, with early products maybe not providing compelling enough performance and use case, until a big gun jumps in.

As an example, Apple seems like a good candidate: they are working on microLED, in waveguides, applications with ARKit, and also 3D sensing. As they progressively integrate some of these technologies in their newer products, they can raise awareness about AR, preparing the consumer for when all the building blocks will be ready for a headset. Will it be 2023?

As history showed for smartphones or smartwatches, functionalities will be enabled by technology.

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