SEEING THE WORLD IN A NEW WAY –

Welcome to Augmented Reality!

Once it was the laptop, now it's the smart phone... but watch out... there is a new kid in town as Augmented Reality looks set to be the new mobile computing platform. Evatec's Senior Product Marketing Manager, *Silvio Nigg* and Strategic Marketing Manager, *Majid Sarhangi* introduce different Smart Glasses technologies and the cost effective thin film coating solutions on 200 or 300mm required for mass market application.

AR, VR or MR?

Lets begin by reminding ourselves about the differences between all these new emerging technologies. Augmented Reality (AR) adds digital elements to a "live view", typically through a pair of smart glasses, often using a microprojector mounted on the glasses which brings additional information about the real world to the user. Virtual Reality (VR) implies a complete immersion into experiences that shut out the real world, a technology enjoyed by many teenagers and parents around the world as they spend hours using some of the latest gaming technology headsets. The Mixed Reality (MR) experience combines elements of both – live view interacting with digital objects. Microsoft's HOLOLENS™ is a technology used by Evatec's customer service department for remote support – everything from tool breakdown to training is a typical example. According to industry analysts like Yole Group (see pages 82 & 83), 2023 looks like being the start of take off as OEMs start production for professional applications in larger volumes with consumer applications driving growth later in the decade.

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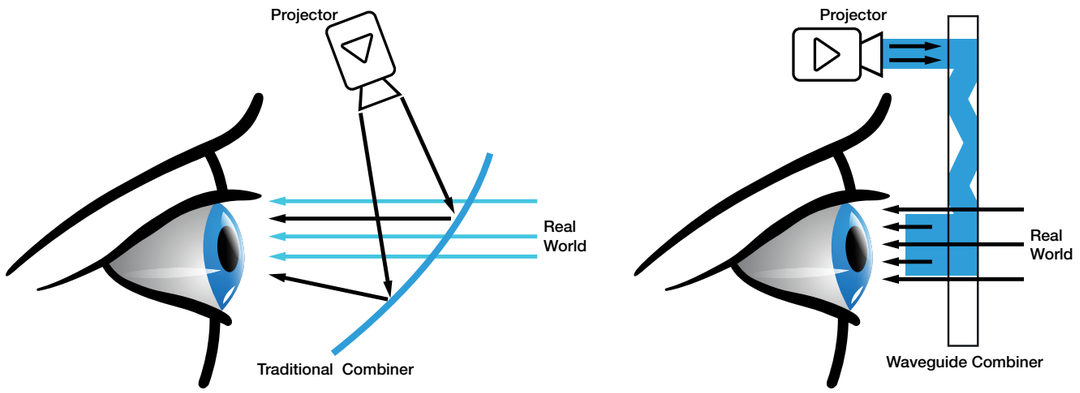


Figure 1: Comparison of traditional and waveguide combiner for Smart Glasses applications

Technologies for AR / MR

Until now the market has seen a range of different display technologies in development for AR/MR applications including "video see through" displays where the user has no direct sight, but also the more familiar "Optical see through display technology "where the user may feel more comfortable and which seems likely to be dominant. Such "see through" displays also rely on integration of a suitable combiner, but even here there is a choice of different technologies between "regular" and so called "waveguide" combiners with potential trade-offs according to image quality, physical bulk of the optics / wearability and ease of manufacture. A better image quality and larger field of view is easier to achieve in a regular combiner approach than in a waveguide solution. However, it comes with the trade-off of device becoming bulkier and pictures being less crisp and detailed. To overcome the trade-off and limitations of the regular combiner approach, waveguide solutions are becoming increasingly popular for smart glass manufactures (Figure 1).

Figure 2 illustrates two different approaches to waveguide combiner manufacturing. In so called "Reflective Waveguides" (Figure 2a), partially reflective mirrors are embedded within the lens. In Figure 2b we see a "Diffractive Waveguide" with Surface Relief Grating (SRG) and Figure 2c a "Diffractive Waveguide" with Holographic grating.

In SRG waveguide-based combiners, when the light rays from the micro projector encounter the input grating, the light dispersed is confined and moves longitudinally through the glasses due to the high Refractive Index of the glass. As the Refractive Index of glass gets higher, the light can propagate at a larger angle range by Total Internal Reflection (TIR) and hence a larger field of view is possible. At the output grating light will be diffracted out of the waveguide and released to our eyes.

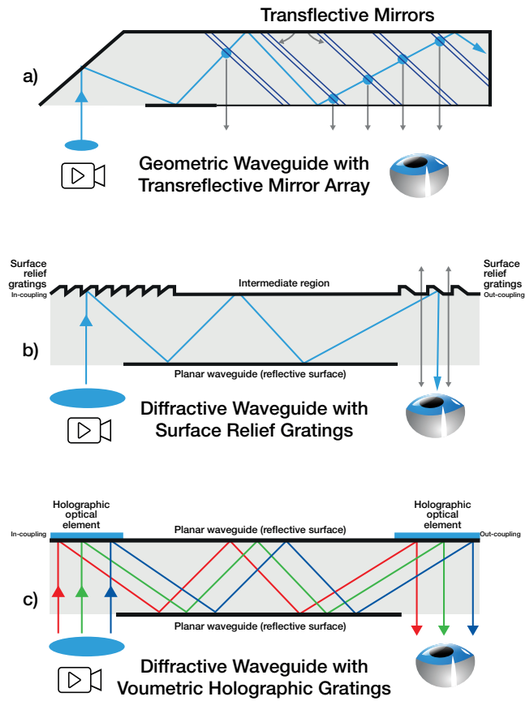


Figure 2: Categories of waveguide technologies.

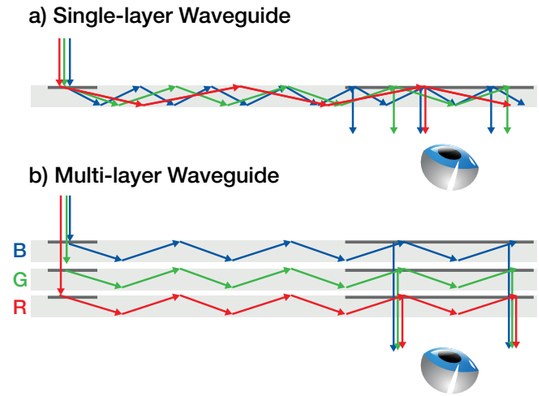
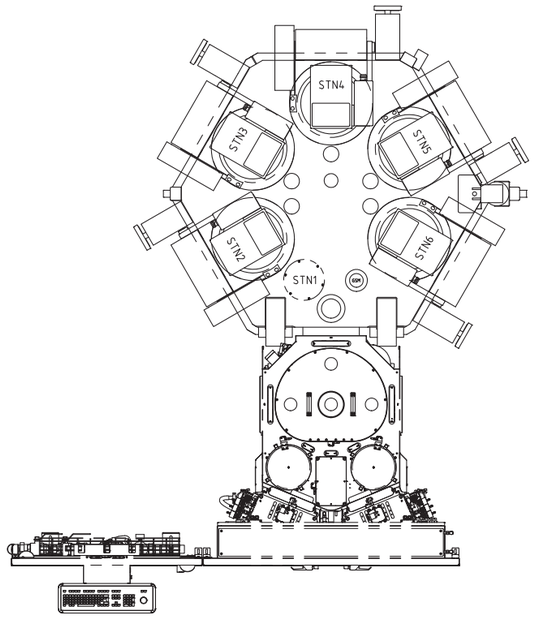


Figure 3: Comparison between Single and Multi-Layer Waveguides

Dispersion effects due to the differing wavelengths of red, green and blue have to be controlled to ensure the best colour uniformity and avoid so called "rainbow effects". The most common solution in SRGs is to use two or three layers of waveguides (Figure 3) for red, green and blue colour bands respectively, each layer having its own grating parameters optimized for one colour only.

In determining which choice of waveguide technology is the right one, and its practical implementation in the end product, manufacturers need to consider not only optical performance issues such as field of view, display resolution and colour uniformity but also more subjective factors including wearer design comfort, and the user's "sense of immersion". Overcoming any styling limitations in an image conscious world plus ease and cost of manufacture will also be paramount in enabling the expected transition from professional to consumer applications.

> "Whichever direction the industry and technology take us, it's an exciting time to be in Augmented Reality."



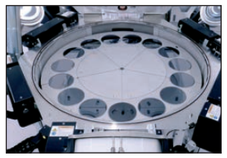


Figure 4a: Typical CLUSTERLINE® 200 BPM layout. Additional Single Process Module and or substrate flip modules could be added if required. Inset image shows the inside of a batch module.

Coatings solutions for waveguide combiners

Reflective combiners typically call for beamsplitter and antireflection coatings. The metals and dielectrics required can be deposited by evaporation or sputter to help generate high image quality and large field of views for which such combiners are known. Diffractive waveguides often call for single layer dielectric or metallic films in addition to the antireflection coatings required to achieve a wide field of view on the high index glass used.

200mm – proven performance

The need for longer term cost down looks set to drive the industry to fully automated cassette to cassette solutions. Figure 4a, shows the layout of a fully automated 200mm sputter tool equipped with batch process module enabling integration of up to 4 sputter sources and a plasma source suitable for either dielectric or metal coatings. The cassette to cassette tool also lends itself well to the potential cost savings available for a wafer level coating approach. Proven production performance with high levels of process repeatability and low particles for other existing applications in photonics and optoelectronics have shown that the tool can deliver the costs savings required for high volume production.

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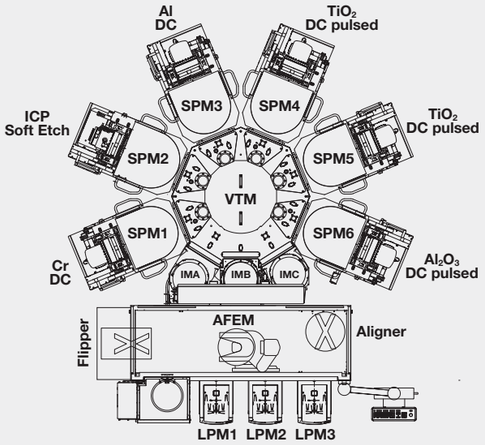


Vacuum TM

Up to 6 process modules

- ✓ PVD Sputter
- ✓ PVD Multisource
- ✓ ICP Soft Etch (arctic)
- ✓ Degasser

Drop in ports for 3 IMs

- ✓ Air-locks
- ✓ Active vacuum buffer (optional)
- ✓ HP-or Lamp Degas (optional)
- ✓ Cooler

Atmospheric Front End

- ✓ LPMs / Robot / Aligner
- ✓ Atmospheric Batch Degas (optional)
- ✓ Buffer / Wafer Flipper (optional)

Figure 4b: CLUSTERLINE® 300 configured for waveguide applications

300mm solutions are here too

For those manufacturers looking to 300mm processing already, we are excited to be able to offer a 300mm cluster tool too. A typical layout of Evatec's production proven CLUSTERLINE® 300 is shown in Figure 4b.

The single process modules can be equipped for deposition of metals or dielectrics with Front End robot and flipper station making for easy implementation of double sided coatings and cassette to cassette automation. Such tools have already proven themselves in the semiconductor and optoelectronics industries over many years and are ideal to achieve the high layer thickness uniformities, low particle levels and high quality optical films required to drive down costs on 300mm. A selection of performance results for the metal and dielectric films required in waveguide application are illustrated in Figures 5a, 5b & 5c.

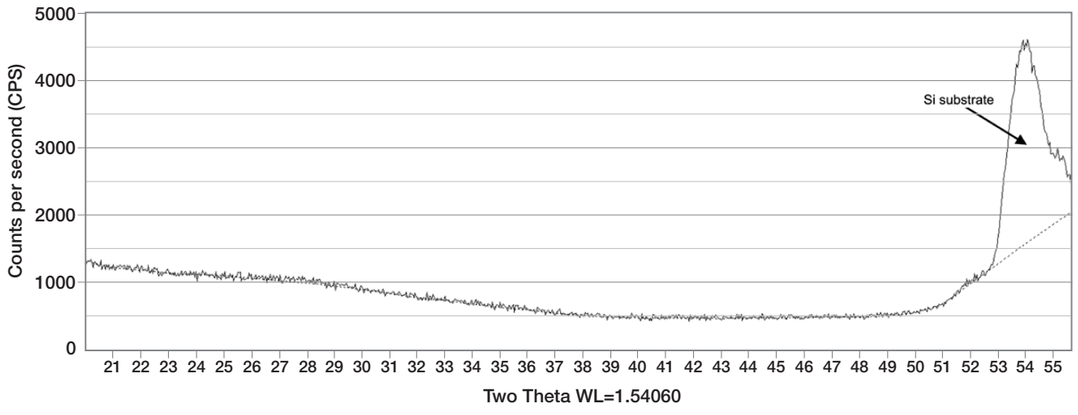


Figure 5a: Grazing Incidence x-ray diffraction (GIXRD) for a 100nm TiO_2 layer on Si substrate

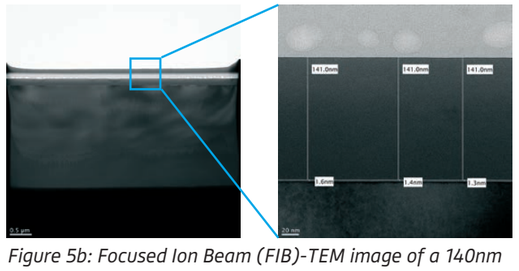


Figure 5b: Focused Ion Beam (FIB)-TEM image of a 140nm TiO_2 layer

Figure 5a: No TiO_2 peak can be observed showing layers are fully amorphous

Figure 5b: Image confirms amorphous structure for a layer deposited on CLUSTERLINE® 300

Figure 5c: Excellent particle performance for TiO_2 deposition on 300mm

Figure 5d: AR coatings on 300mm easily satisfy reflection specifications

Figure 5e: Al deposition shows good side and bottom coverage

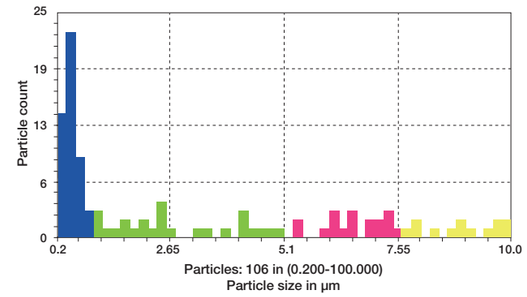


Figure 5c: Adders for a 100nm TiO_2 layer deposited on CLUSTERLINE® 300

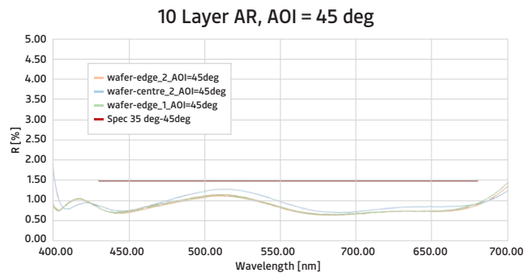
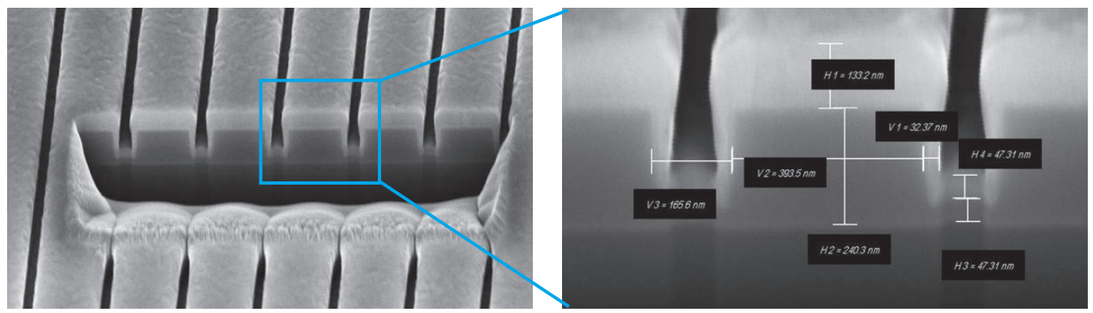


Figure 5d: Optical performance for 10 layer AR coating on 300mm



Period	~ 165 nm	Pattern Ratio (W/H)	~ 0.66
Structure Height	~ 250 nm	Coating Ratio (Side/Bottom)	~ 0.68
Bottom	47.31 nm	Coating Ratio (Side/Top)	~ 0.243
Sidewall	32.37 nm		

Figure 5e: Focused Ion Beam (FIB) SEM images of Al deposition on 300mm

Finding the right solution for you – Evatec is your partner

In the end every manufacturer is unique with their own product specifications and manufacturing fab integration needs. For some manufacturers with long experience, the flexibility and precision of evaporation remains a key advantage, but for others, the way in which sputter lends itself to full cassette to cassette automation more easily is the driver for delivering the lower manufacturing costs they need. In some cases manufacturers may prefer to work at smaller substrate sizes, where the flexible mini batch carrier handling of different form factors, or full 200mm wafer handling on Evatec's CLUSTERLINE® 200 BPM gives them complete production flexibility. In other cases, the drive to a wafer level approach on the largest substrates possible will make CLUSTERLINE® 300 the tool of choice. ◻

> “Process solutions are now ready on both 200 and 300mm according to customer needs”