Metalenses – a world of opportunity

Metalenses are tiny optical elements that can manipulate light like traditional lenses, but their small size, and "flat" architecture offers the potential for cost-effective manufacture at large scale using a "wafer level optics" approach at substrate sizes up to 12 inch. Senior Product Marketing Manager ***Dr. Clau Maissen*** explains how Evatec process know-how is helping customers deliver the sputtered layer qualities and process repeatability required for mass market applications

A technology with huge potential

Metalenses are at the forefront of optical innovation, transforming the way we manipulate light with their ultra-thin, flat structures. Unlike traditional bulky lenses, metalenses utilize nanostructured surfaces to precisely control light, offering unprecedented advantages in miniaturization and performance. This breakthrough technology is poised to revolutionize a wide range of applications, from enhancing the imaging capabilities of smartphone cameras and augmented reality glasses to advancing medical imaging devices with greater precision and clarity. Figure 1 illustrates how a traditional optical assembly can be simplified significantly using a metalense approach.

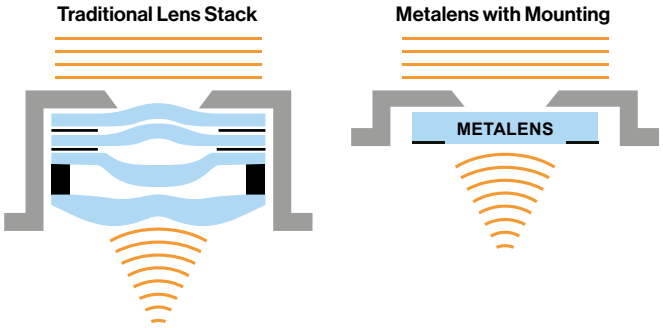


Figure 1: Metalens enable simplification

Thin film technology and wafer level optics are key

Evatec's expertise in the deposition of high-index material layers plays a crucial role in the fabrication of these advanced lenses, ensuring the uniformity and repeatability needed for high-performance optical systems. By leveraging Evatec's specialized processes, manufacturers can achieve the exacting standards required for mass-market adoption of metalenses, paving the way for a new era of optical technology.

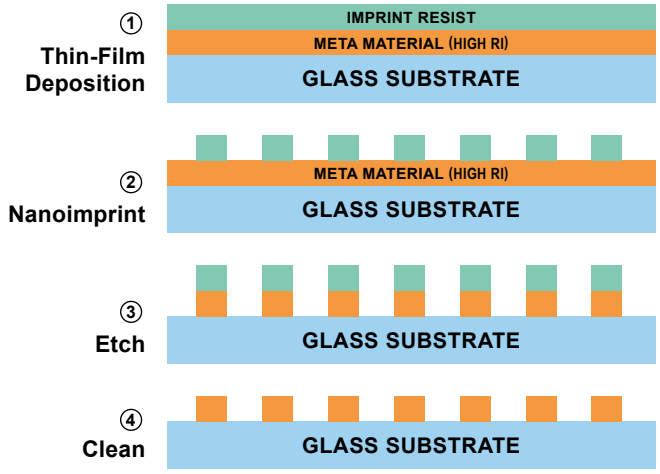


Figure 2: Example manufacturing process flow

A key advantage of metalens technology is the ability to start from a wafer. Following deposition of a high index material such as amorphous Si or metal oxides, manufacturing technologies such Nanoimprint and etch are then used to create the functional pillars "so called metaatoms" at the heart of the device. AR coatings and encapsulation layers then follow before the whole wafer is then diced to give final individual devices. Figure 2 illustrates a typical process flow.

The high index materials (e.g. amorphous hydrogenated Si for Near IR, Nb_2O_5 for visible) and pillar architectures will of course vary according to application and operating wavelength requirements. Irrespective of the application however, the ability to deposit highly uniform repeatable films of the index material up to 12 inch substrates is key.

Evatec know-how for deposition of high index materials

Evatec has long know-how in sputter deposition of high index materials on both its MSP and CLUSTERLINE® 200 BPM platforms. Use of advanced process control technologies like plasma emission monitoring ensures correct stoichiometry and high deposition rates whilst GSM optical broadband monitoring delivers precise film thickness. Typical deposition results on 8 and 12 inch substrates are shown in Figures 3a & 3b.

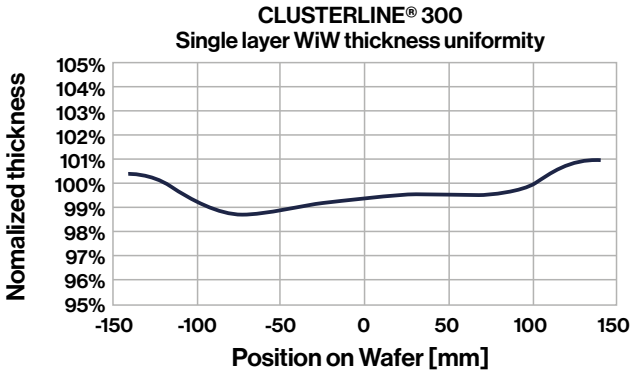


Figure 3a: aSi:H on CLUSTERLINE® 300 thickness uniformity

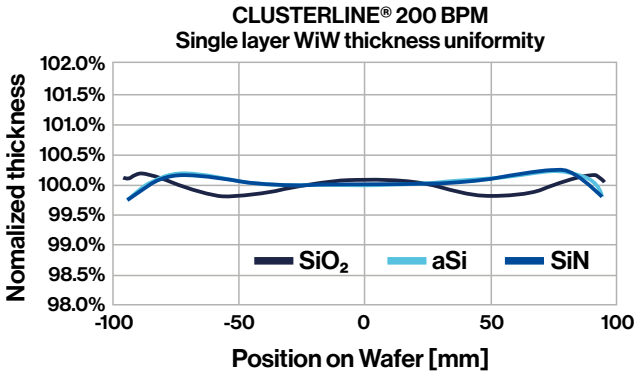


Figure 3b: SiO_2, aSi, SiN on CLUSTERLINE® 200 BPM thickness uniformity

Images in Figures 1 and 2 plus cover image courtesy of Moxtek.

Control of particles is key

Single particles can have an impact on the performance of a lens over an area up to 10x larger than the particle itself depending on the technology used to fabricate the lens. So particle control is key. Tools like Evatec's MSP or CLUSTERLINE® family which eliminate uniformity shapers from the sputter system not only enable higher deposition rates but also eliminate a significant source of particles too.

For those customers with even more demanding particle specifications the automated cassette-to-cassette handling systems of CLUSTERLINE® can improve further particle managment even more. Figure 4 illustrates typical particle data for single layer deposition on CLUSTERLINE® 300.

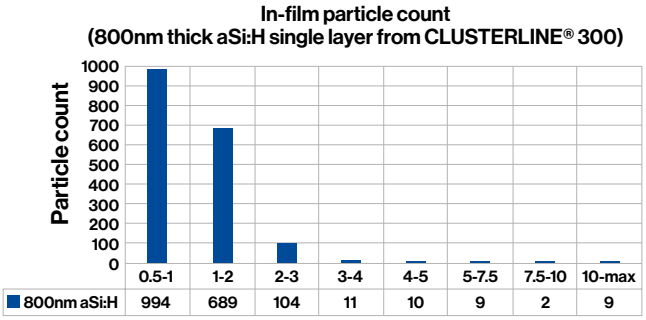


Figure 4: Particle data of single layer aSi

Want to know more?
For more information about Evatec coating solutions for metalense applications contact your local Evatec sales and service office at:
https://evatecnet.com/about-us/sales-service/

MOXTEK®

About Moxtek*

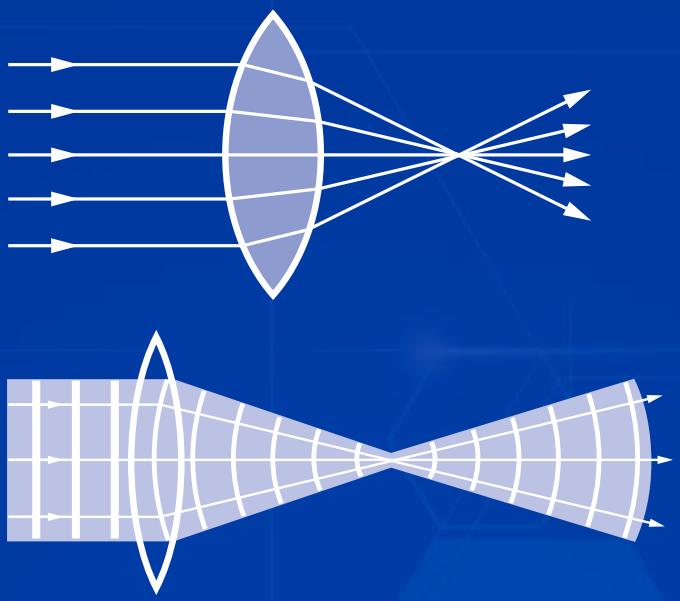
MOXTEK® is a leading developer and manufacturer of advanced nano-optical and x-ray components used in display electronics, imaging, and analytical instrumentation. Moxtek produces high volume, innovative, solution-based products that enable many new scientific discoveries and improve the quality of everyday life. Moxtek manufactures functional metasurfaces including: metalens, patterned nanostructures, Meta-Optical Elements (MOE), Diffractive Optical Elements (DOE), waveguides, photonics crystals, and biosensor arrays. Please visit their website to learn more.

For more information visit **https://moxtek.com**

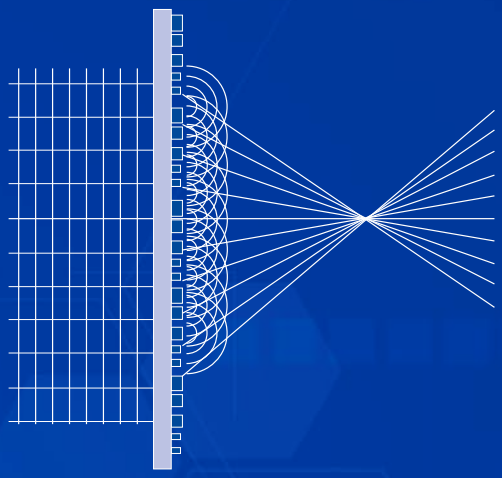
*Source: Moxtek website

SPOTLIGHT ...METALENSES

An introduction to Metalenses



Left: Conventional refractive lens: refraction at the interface between air and lens directs the light to a focal point. Another view to the same effect is: a plane wave is converted to a spherical wave.



Right: Shows a metalens. A plane wave is converted to a spherical wave via the response of nanostructures (nanoantennas) built on the surface of the substrate. The surface is a quasi-periodic structure with subwavelength dimensions.

Metalenses – Potential benefits

Benefit		
Miniaturization	✓	Metalenses allow for the creation of smaller, lighter optical devices, which is especially beneficial for applications in consumer electronics such as smartphones and AR glasses. For instance, Samsung is researching metalenses to integrate into their smartphone cameras, aiming for improved image quality and reduced lens size. Similarly, Apple is reportedly investigating the use of metalenses for future iPhones and AR glasses to achieve superior optical performance and device miniaturization .
Smaller optical packages with more functionality	✓	Meta Optical Elements (MOEs) enable the development of smaller optical packages with multiple functions , making them ideal for compact devices with advanced optical requirements. This multifunctionality is particularly advantageous in compact devices where space is at a premium.
Reduced complexity and cost of optical assemblies	✓	Metalenses simplify optical system design by reducing the number of elements required since metalenses do not suffer from spherical abberation, thereby lowering the overall cost and complexity of optical assemblies such as camera lenses. Unlike traditional lenses, metalenses are less sensitive to alignment issues, which simplifies manufacturing and assembly processes.
High Numerical Aperture (NA)	✓	Metalenses achieve high NA values, which are crucial for applications requiring high resolution, such as microscopy and high-end cameras.
Thermal stability	✓	They exhibit high thermal stability, essential for high-power laser systems and harsh environments.
Polarization control	✓	Metalenses can be engineered to control the polarization state of light, beneficial in optical communication and sensing applications .
Reduction of chromatic aberrations	✓	Chromatic aberration can be an issue with metalenses, but newer approaches have significantly reduced these aberrations. Advanced designs enable metalenses to achieve high Numerical Aperture (NA), improving image clarity and color accuracy.