Volume Manufacturing of Metalens
NIL Series Datasheet

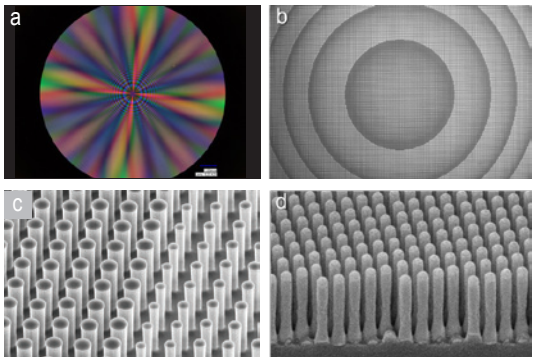

Figure 1: (a) Metalens imaged under microscope, (b) SEM view of center of metalens, (c-d) high aspect ratio Si and Nb2O5 nano-pillars, fabricated at Ø200mm wafer.

Metalens manufacturing

Moxtek manufactures high-performance metalenses for visible and IR wavelengths. Moxtek offers a full solution, including design, fabrication, and measurement capabilities. Our metalens design team can optimize the lens design to match custom applications. Our foundry service bridges the gap from research to production by offering prototyping and volume manufacturing.

Metalens benefits include reduced track length and weight in optical systems. They can have more design flexibility, added functionalities, shorter focal lengths and smaller diameters compared to traditional optics.

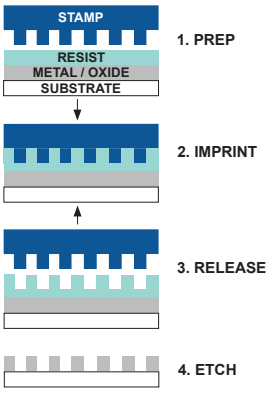

Figure 2: NIL and Etch manufacturing process

Moxtek replicates metalenses with extremely tight tolerances and high repeatability. Moxtek's manufacturing approach to high performance metalenses utilizes nanoimprint lithography (NIL) and etching (see Figure 2) into high refractive index materials to obtain high aspect ratio nanostructures. Moxtek has produced a variety of visible metalenses with different sizes, focal lengths, numerical aperture, and operating wavelengths. Building on years of expertise, Moxtek has developed reliable methods to manufacture wafer-scale visible metalenses for various emerging applications. Moxtek's metalens Overcoat™ protects against physical damage while boosting transmission. An absorptive aperture can be applied to cut down on stray light back reflections. Reflective aperture options are also available.

Advantages

- Full solution from design development to production
- Uniform lens replication over Ø200mm wafer
- Production and prototype compatible processes
- Niobium oxide (Nb2O5) for visible applications
- Silicon (α-Si) for IR applications
- Ability to replicate customer designs
- Experience with thin-film deposition, etching, and NIL
- In-house metalens modeling
- Flexibility in lens parameters
- Protective Overcoat™ enhances durability and performance
- Absorptive and reflective apertures

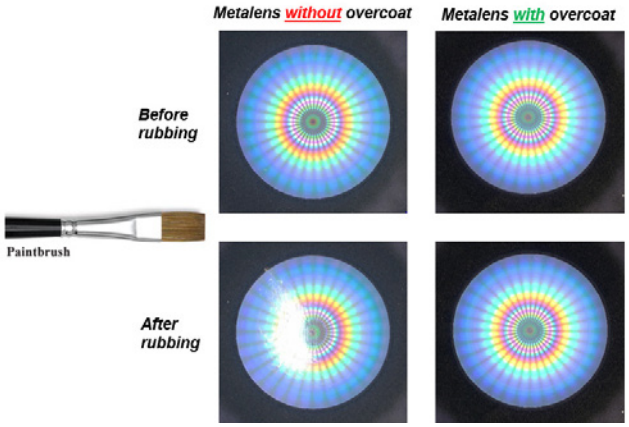

Figure 3: Overcoat™ protecting metalens nanostructures from physical abrasion.

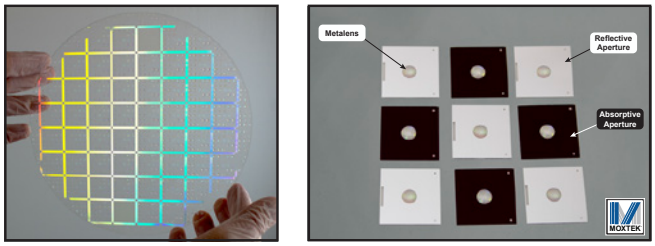

Figure 4: Full wafer metalens (left) and aperture example (right).

Moxtek has been manufacturing nanoscale structures for over 20 years. We have developed efficient methods to create e-beam masters combined with our existing NIL processing to provide a full solution approach to volume production. Moxtek can optimize the lens design to match customers applications. Moxtek offers design, fabrication, measurement, and packaging capabilities. Moxtek has production facilities in USA, Japan, and China.

Quantum Design EUROPE

Quantum Design GmbH
Breitwieserweg 9
D-64319 Pfungstadt

Please contact: Michael Foos
✆ +49 6157 80710-34, foos@qd-europe.com
Find your local contact at www.qd-europe.com

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Metrology

Production products are only as good as their metrology, therefore Moxtek has developed the capability to rapidly measure the optical performance of each lens using a Trioptics ImageMaster® HR Wafer tool (see Figure 5). Moxtek performs optical metrology on 100% of the lenses it produces, ensuring that every single lens performs to spec. Our optical characterization capabilities include Modulation Transfer Function (MTF), efficiency, EFL, distortion, relative illumination, and chromatic aberrations. We measure at visible and NIR wavelengths and will soon have 405nm and high NA measurement capabilities. Our latest measurements show excellent performance and uniformity (see Figures 6-8). The demonstrated efficiency and MTF correlates to the high-quality results shown in the macro imaging demo below (see Figures 9-10).

Figure 5: Wafer-scale automated lens measure tool: Trioptics ImageMaster® HR Wafer.

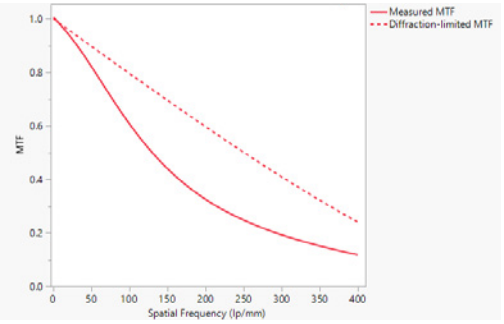

Figure 6: MTF for a Moxtek Metalens. 1mm diameter, 2.5mm focal length. Designed for 633nm wavelength.

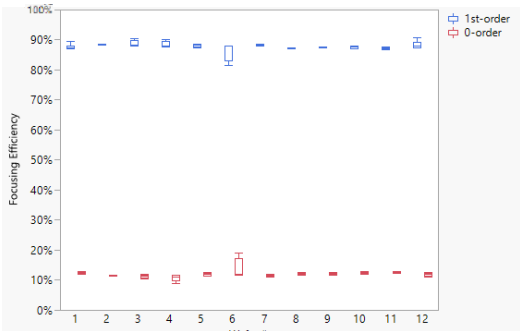

Figure 7: Moxtek metalens focusing efficiency over a 12 wafer lot, showing consistent wafer-to-wafer uniformity with near 90% efficiency.

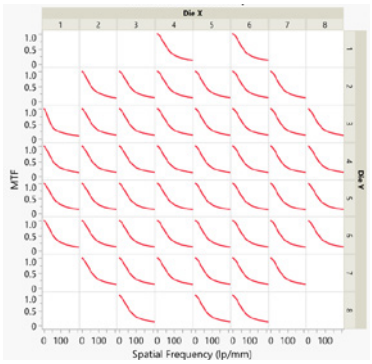

Figure 8: Measured MTF for metalenses repeated across the surface of a wafer, showing excellent edge-to-edge uniformity.

Figure 9: Metalens acting as a macro lens attachment to an iPhone11 Pro telephoto camera system.

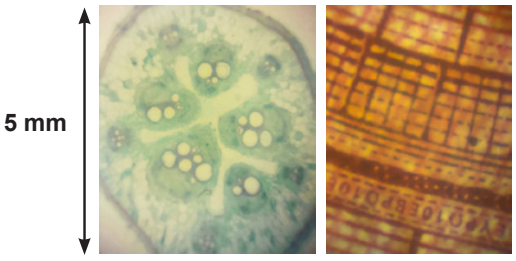

Figure 10: Imaging results of metalens attachment showing pumpkin stem (left), and euro bill (right).

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