Volume Manufacturing of Metalens

NIL Series Datasheet

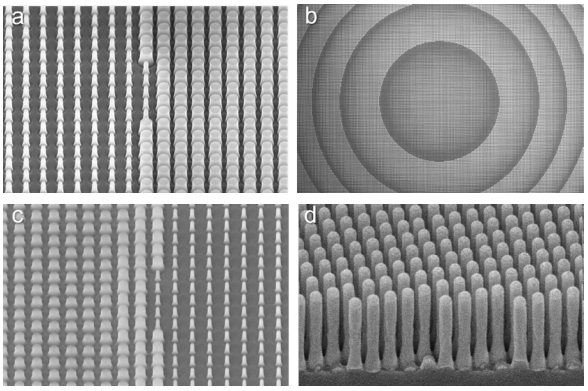

Figure 1: (a-b) SEM views of metalens nanopillar Si master, (c) NIL printed metalens nanopillars, and (d) high aspect ratio Nb2O5 nano-pillars, fabricated at Ø200mm diameter wafer-scale.

Moxtek NIL Manufacturing

Moxtek manufactures high-performance metalenses for visible and IR wavelengths. Moxtek offers a full solution, including design, fabrication, measurement, and packaging 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. Moxtek has overcome various challenges associated with scaling up visible wavelength metalens manufacturing to production volumes. We have developed efficient methods to create masters combined with our existing NIL processing to provide a full solution approach to volume production.

Moxtek replicates metalenses with extremely tight tolerances and high repeatability. Moxtek's manufacturing approach to high performance metalenses utilizes etching 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.

Moxtek Advantages

- Full solution from design development to production
- Uniform lens replication over Ø200mm wafer
- Production and prototype compatible processes
- Niobium oxide (Nb2O5) has proven beneficial in ease of deposition, uniform etching, and lower cost
- 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

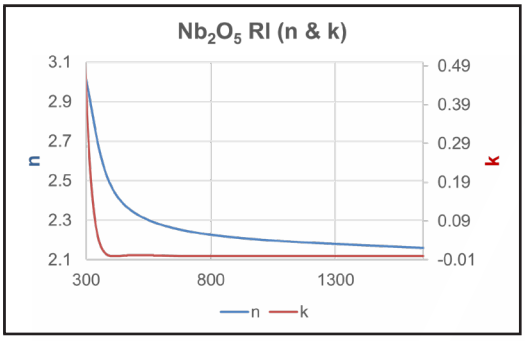

Figure 2: Niobium oxide measured index of refraction and extinction coefficient over visible and NIR wavelengths.

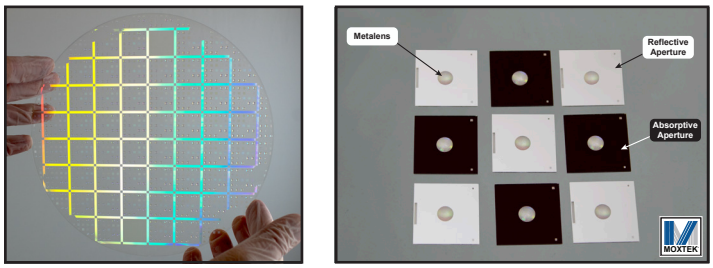

Figure 3: Full wafer metalens (left) and aperture example (right).

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.

MOXTEK®

Metrology

Production products are only as good as their metrology, therefore Moxtek fabricates blazed-grating-like test structures in parallel with the lenses. These are repeating arrays of varying pillar size that refract light at a designed angle commensurate with refraction from a portion of the lens. These blazed-grating test structures allow for simple post-fabrication metrology testing. These results, presented in Fig. 4, reveal that 800 nm tall pillars with overcoat treatment type 3 provided for the highest lens efficiency.

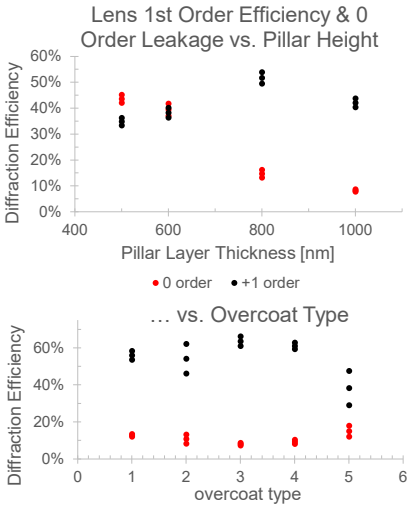

Figure 4: 1st order blaze-grating-like diffraction efficiency at 532 nm wavelength vs. pillar height and various overcoat treatments.

Additional in-line lens characterization is completed using AFM test structures of varying pillar size. Various final lens metrology was also performed using commercial and custom tool sets. Modulation Transfer Function (MTF) is presented in Fig. 5 for on-axis imaging out to 400 line pairs per mm for a 200 micron diameter, 213 microns EFL metalens, as measured by Trioptics Wafer Tester. Depth of focus was measured as 20.9µm.

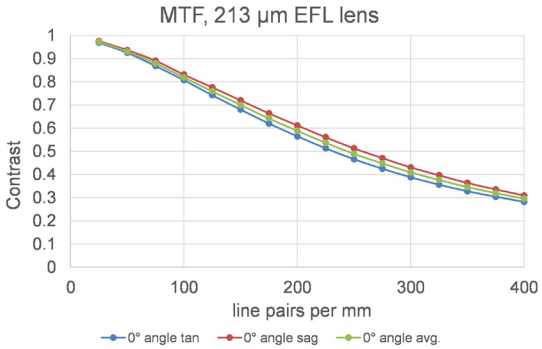

Figure 5: MTF at 532 nm wavelength for a 200 micron diameter, 213 micron EFL metalens.

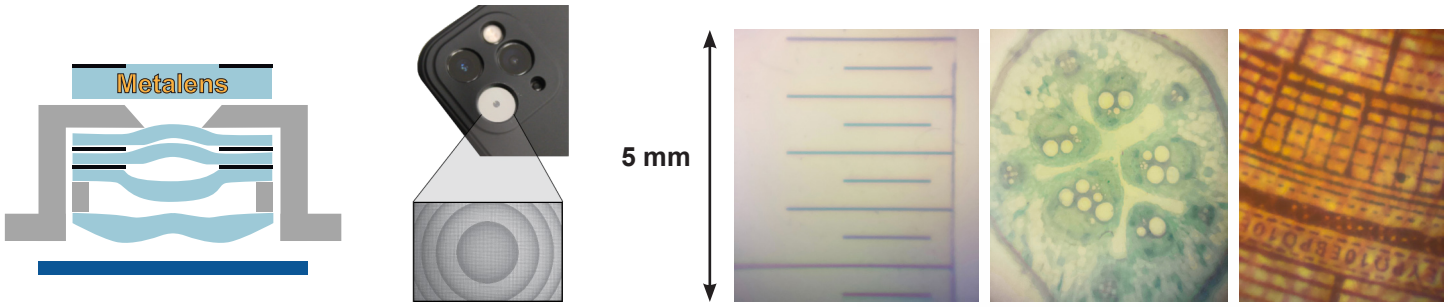

Figure 6: Imaging results of Metalens acting as a macro lens attachment to an iPhone11 Pro telephoto camera system. Transparency slide (left), pumpkin stem (center), and euro bill (right)

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