

# Visible Metalens Volume Production Line

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Moxtek has been manufacturing high volume nanostructured wire grid polarizers (WGP) for over 20 years. A few years ago, a nano imprint lithography (NIL) patterning process was brought in and released for full production on WGP. After establishing a baseline volume production NIL process running WGP, we started developing new optics products that were possible due to the advanced patterning capabilities of NIL. The most recent optics products that we have established for high volume are meta optical elements (MOE) across the visible spectrum. NIL is the key foundation for enabling visible wavelength MOE's.

Patterning subwavelength meta-atom features for the visible wavelengths has been beyond the capabilities of the high-volume deep UV lithography tools commonly used in semiconductor manufacturing. Due to this patterning barrier, NIL is proving to be the most effective path to high volume, visible wavelength MOE.

While there have been considerable advances in visible wavelength MOE's in the research laboratory space, high volume production requires different techniques. Moxtek has established a process whereby all processing is performed on tools that are currently running high volume production. Development scale MOE fabrication and production scale fabrication are unified in a single tool chain, clearing the path when switching from one to the other. Once an acceptable MOE has been established at development scale, production can be quickly ramped up to high volumes. In this paper we will detail the development methodology and show current progress. As shown in Figure 1 below the production baseline process progression over 4 months to achieve > 90% total efficiency as lot average with multiples sites > 95% total efficiency.

**Figure 1.** Total efficiency trend of visible metaoptic designed and tested at 532nm wavelength. Performance trend plots lot averages to show continuous improvement up to world class levels >90% on average. Many sites were >95%.

