Manufacturing Challenges in Bringing Visible Range Metaoptics to Market

Bradley R Williams, Mike Black, Daniel Bacon-Brown, Matthew George,
Rumyana Petrova
Moxtek, Inc.
452 West 1260 North
Orem, UT 84057
E-mail: bwillia@moxtek.com

A major road block in bringing metaoptics in the visible range to market is scaling up to volume manufacturing. A variety of research has demonstrated that flat optics built from sub wavelength nanostructures can have exceptional performance in the visible range. These devices need feature sizes that range anywhere from 300nm down to 50nm. Looking at nanoscale patterning capability, deep UV steppers and scanners have been utilized in semiconductor manufacturing to resolve very small features. These semiconductor features are more often a periodic structure, line space or hole patterns. Optical metasurfaces need to resolve closely packed large features in near proximity to sparsely packed small features. These challenging structures are not resolvable on established deep UV lithography systems. This limits the patterning options to platforms that write individual patterns such as e-beam lithography. Unfortunately these methods do not scale to volume manufacturing, so these devices are challenging to make at scale.

By utilizing Nanoimprint Lithography (NIL), patterns that have been resolved with e-beam on to a master can then be replicated many times over. The next challenge is to transfer these nanostructures into a high refractive index material. The processes needed to manufacture more established optical devices such as wire grid polarizers are most often well proven and understood from many years of practice in semiconductor manufacturing. Since the semiconductor high end lithography processes are challenged in resolving these unique metasurface features, subsequent steps such as etching the features are not well established.

For this paper we discuss the processing challenges and new developments along with processing stability and ramping to volume manufacturing. We have demonstrated a high precision NIL process that includes master making through imprint and etch. This work has enabled volume manufacturing of visible metaoptics across a full 200mm wafer.

Figure 1. Metaoptic Master: Example of closely packed large features in near proximity to sparsely packed small features.

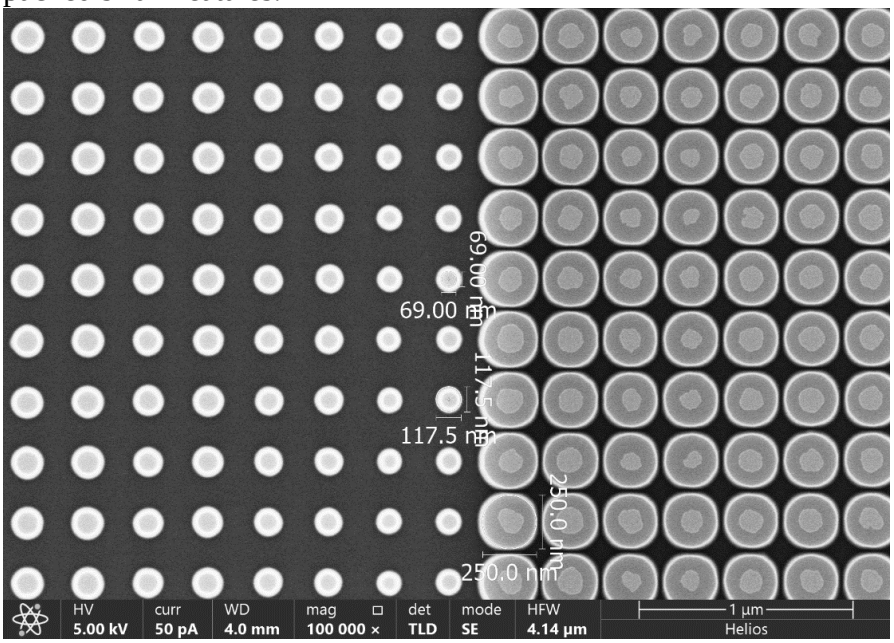

Figure 1. Metaoptic NIL Patterned

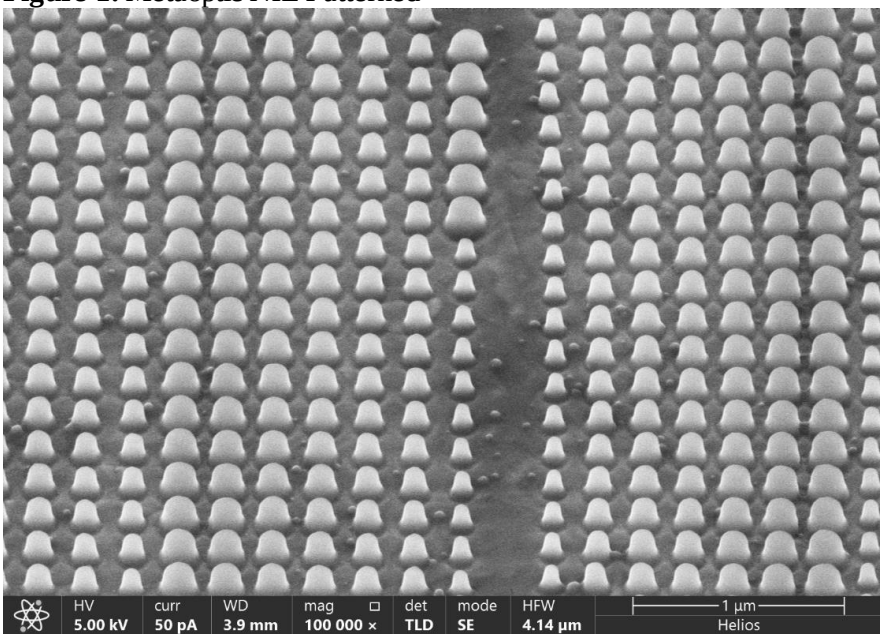

Figure 3. Metaoptic Etched in to High Refractive Index Material on Glass Substrate (Aspect Ratio >6)