Moxtek NanoStructure™ Solutions

White Paper

Authors: Brad Williams, Brian Bowers, Shaun Ogden, Hal Nielsen, Rumy Petrova

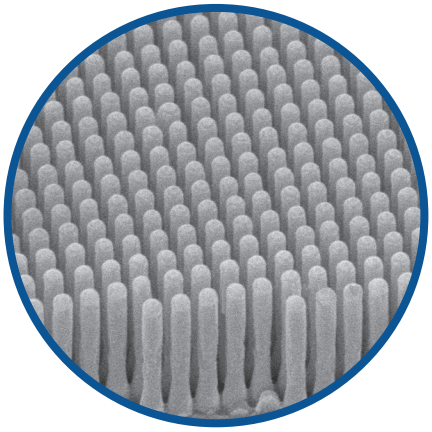

Figure 1: 800nm tall Pillars (High refractive index)

Introduction

MOXTEK has been producing functional nanostructured optical components for over 20 years. We offer high volume wafer replication of various nanostructure devices, including: microlens arrays, waveguides, patterned metasurfaces, Diffractive Optical Elements (DOEs), photonics crystals, and biosensor arrays. These devices are used for imaging, illumination, and display systems for a variety of applications including: automotive, medical/dental imaging, camera systems, and many others.

Moxtek collaborates with customers to verify designs and create solutions for high volume manufacturing. We provide options for prompt design iterations and print optimization. Moxtek uses Statistical Process Control (SPC) monitoring of post-print Critical Dimension (CD) repeatability as it is critical for quality control.

Capabilities Overview

Moxtek has a complete NIL foundry service. Our capabilities include:

- High Volume Manufacturing
- NanoImprint Lithography (NIL)
- Design Master Shuttle
- Master creation, Stamp making
- Deposition (PECVD, Sputter, ALD)
- Etching (metals, oxides low to high refractive index)
- AFM and SEM Analysis
- Optical metrology and inspection

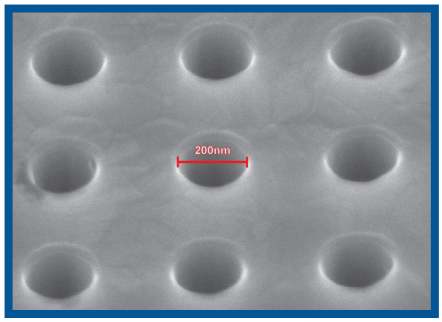

Figure 2: Nanoholes (Photonic Crystals)

Parameter	Design Constraints
Minimum CD	30nm
Master Aspect Ratio	≤ 2 (CD Height/Width)
Master Wafer Type	Silicon (Preferred)
Master Wafer Size	Ø300mm, Ø200mm (preferred) Ø150mm (acceptable)
Residual Layer Thickness	15nm < X < 25nm
Substrate Detail	Ø200mm glass/fused silica/silicon/sapphire Thickness: 0.675mm to 1.8mm
Resist Mask	Oxide-based sol gel, UV curable, or nano particle resists

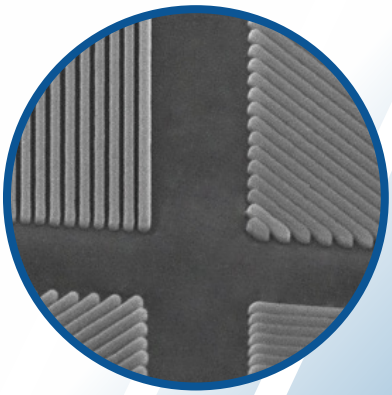

Figure 3: Pixelated Line Arrays

MOXTEK®

OPT-WP-0001 Rev A

Critical Dimensions & Defect Control

Moxtek's NIL capabilities allow for small feature sizes and high aspect ratios. Design parameters including Critical Dimension (CD) are shown in Table 1. Moxtek uses metrology tooling to verify line space patterns using our Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM). Moxtek production lines use Statistical Process Control (SPC) to monitor the printed line structure for line width and print height.

NIL replication relies on obtaining precision masters to produce stamps for mass production. This precision is critical to verify before making stamps and printing the final wafers. Moxtek's stamp and printing process allows for tight process control. Moxtek's print replication variation (σ) across a wafer for a 45nm line pattern is ~1.0nm. Figure 5 below illustrates wafer-to-wafer CD consistency using multiple stamps from the same Master. CD feature uniformity across a wafer is ± 1nm for a 80nm pillar design.

Moxtek has access to E-beam master fabrication typically processed onto silicon wafers. Moxtek also has the capability to produce many stamps from every Master used to replicate the final design. Typical stamp life is >500 prints.

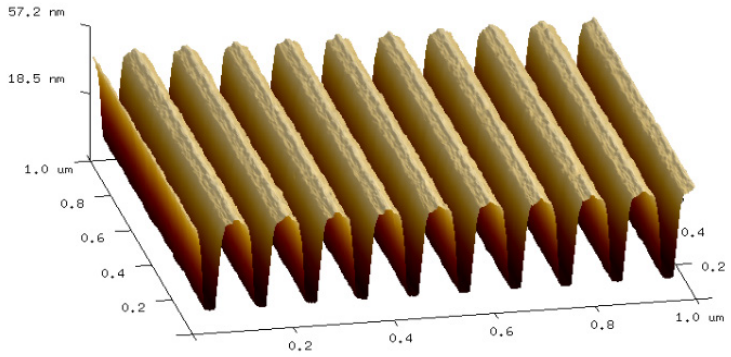

Figure 4:AFM image of a typical 300nm high precision master

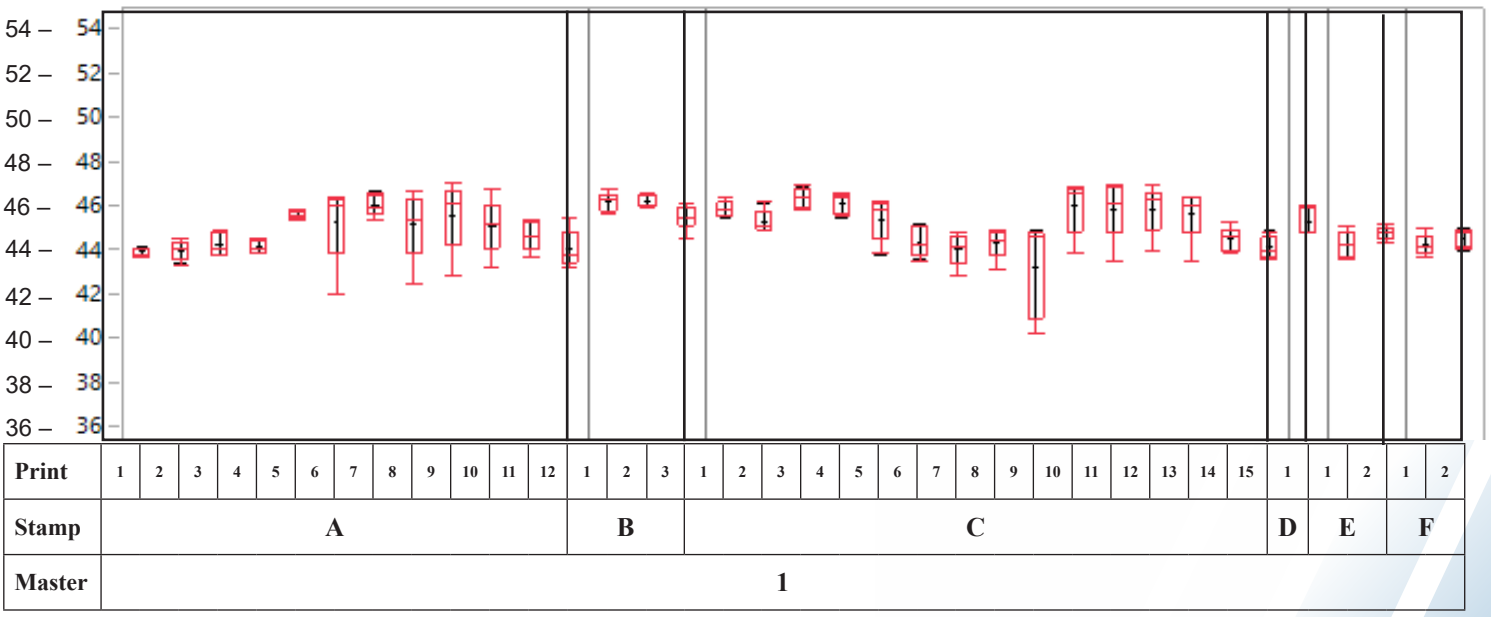

Figure 5: Mid-Point CD Repeatability (5 Sites per Wafer, 6 stamps, Same Master)

Design Master Shuttle

Moxtek offers prototyping samples on board our recurring Design Master Shuttle. This NIL Design Master Shuttle includes space for multiple, design structures which allows engineers to test several designs on a single shuttle iteration and reduce development time and cost. Moxtek can add your unique design on our next Design Master Shuttle for prototyping your optical device. These design shuttles are processed multiple times a year.

In addition to high precision masters, Moxtek has been using our own proprietary LIL processes to produce nanoscale patterns for Wire Grid Polarizers (WGPs). Our LIL process can produce periodic pillars, hole structures and pixelated polarizer arrays.

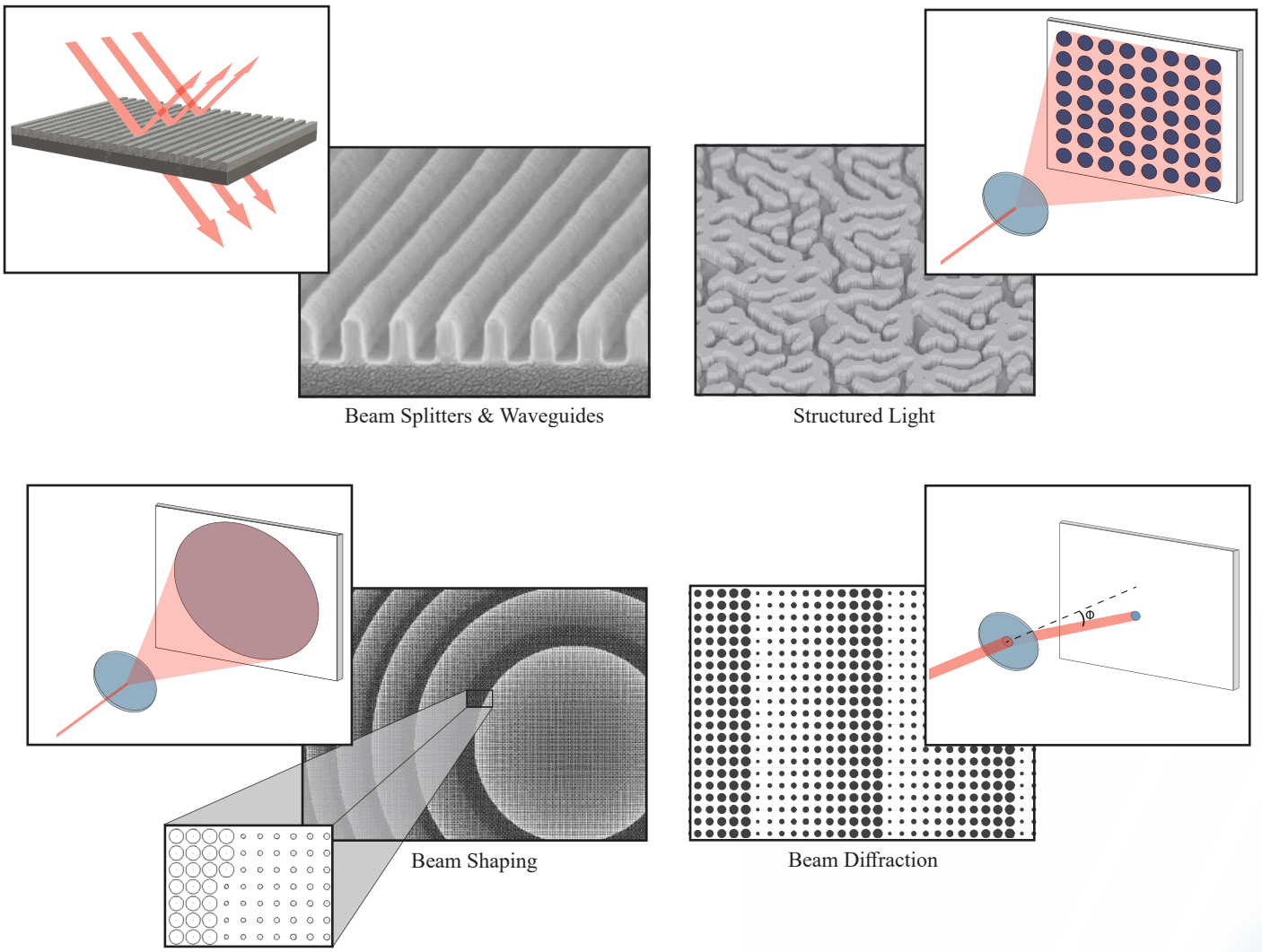

Figure 6: Examples of nanostructures processed at Moxtek and their respective applications