Volume Manufacturing of Full Wafer Nanoimprint on Wire Grid Polarizers

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Nanoimprint Lithography (NIL) has demonstrated the ability to replicate nano-structures within extremely tight tolerances. The process concept and lab sample implementation has been around for a long time. Scaling up has introduced a number of barriers that have taken some time to overcome. In this paper, we discuss the implementation of full wafer NIL in to an established Wire Grid Polarizer (WGP) manufacturing line. In doing this we have demonstrated that NIL can be utilized effectively to mass produce various nano-structures that are challenging and cost prohibitive for conventional lithography techniques.

The full wafer imprint process was released in to a 200mm wafer fabrication line that has typically produced around 160,000 wafers a year. Moxtek's has many years of expertise manufacturing nano-structures and now has include the capability of an automated Substrate Conformal Imprint Lithography (SCIL) system. Here, we present data producing Wire Grid Polarizer (WGP) as the baseline and related qualification methodology.

We have achieved stamp life well in to the 500 to 750 print ranges with some life time tests up to 1300 prints. Process control includes critical dimension (CD) measures, and remaining breakthrough thickness monitored with statistical process control (SPC). The NIL process produces CD uniformity of less than 2.5% σ on structures with CD's at 45nm (Figure 1). This precision of replication includes all variation introduced from; 1) multiple stamps, 2) wafer to wafer prints, and 3) multiple sites within the wafer. As with all NIL processing, defect reduction is a constant focus and area for improvement. With recent improvements we have brought an originally very high defect level down to 2 defects/cm^2 (Figure 2). Defect improvement is ongoing.

The goal of this paper is to demonstrate the pathway to transition optical products from lab proof of concept to full volume manufacturing. New product development projects begin with master making, which is often a significant expense. Therefore, it is important to understand critical processing information related to making good masters, especially when many thousand duplicates of identical nano-structures are made. We have developed a knowledge base on various structures and the process integration to build in to final products. The imprint process step begins with master making and ends with printed structures with SPC controlled critical dimensions. Building the product also incorporates the other more typical semiconductor type processing steps which Moxtek has mastered for many years.

Collectively, we are offering a complete NIL foundry service from master making through imprint but also all the other process steps needed to build a complete structure and finished product. See SEM/AFM in Figure 5 for more challenging printed structure. Contact Moxtek for questions.

Figure 1. CD Repeatability (6 Stamps, Same Master, 5 Sites/Wafer)

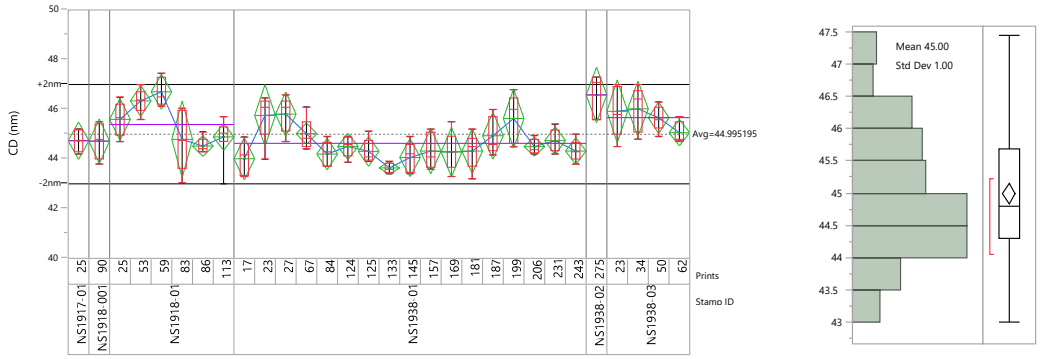

Figure 2. Active Defect Reduction

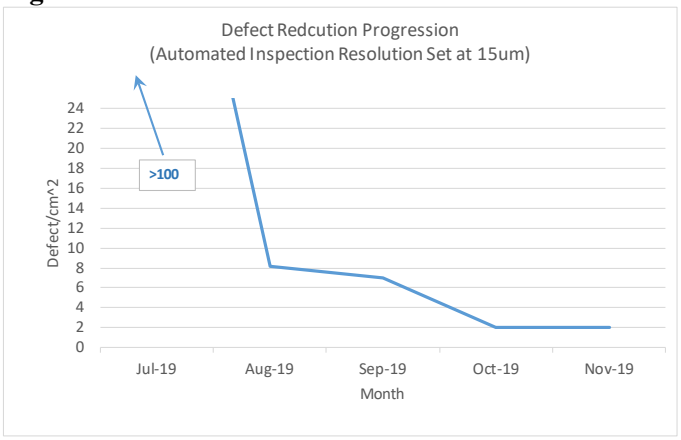

Figure 3. SEM/AFM of Printed Structures