A novel Dynamic Nano Inscribing technique for creating continuous and seamless metal and polymer nano gratings

Se Hyun Ahn*, L. Jay Guo**
**Department of Mechanical Engineering*
***Department of Electrical Engineering and Computer Science*
University of Michigan, Ann Arbor, MI 48109, USA

The increasing demands in nano-scale grating and channel structures in bio- and optics industries have stimulated many emerging technologies such as laser interference lithography, nano ruling and nanoimprint lithography. Among them, roll-to-roll based nanoimprint lithography (R2RNIL) provides greatly enhanced throughput while keeping NIL's inherent high resolution.[1] However, R2RNIL process still requires thermal or UV curing steps that are not compatible with many functional polymers and can damage bio- or sensitive organic materials. Moreover, creating large-area continuous pattern requires the same size original mold and the imprinted patterns are not truly continuous due to the presence of seam region where the two ends of the flexible mold meet on the roller.

We introduce a novel nanofabrication technique, Dynamic Nano Inscribing (DNI), for directly creating true continuous nano grating patterns in a variety of metal or polymer materials, with linewidth down to 70 nm, at extremely high speed (~10 cm/sec) at ambient environment. The principle of DNI shares similarity with room temperature nanoimprinting, but it uses the sharp edge of a tilted Si mold to directly inscribe a moving substrate and form seamless gratings patterns. Since DNI relies on the plastic deformation of the inscribed material under gradually increased pressure at a very small contacting region, continuous linear patterns on various polymers, metals or even hard materials such as ITO can be successfully created by using very low applied forces (several Newtons). Among many advantages of DNI, a prominent feature is its ability to create essentially infinitely long and continuous nano or micro grooves in straight or free curves by using only a small piece of Si mold, without causing significant damage to the mold. The gentle nature of this nanofabrication technique makes it very attractive for patterning nanostructures in materials that are sensitive to heat, UV radiation, or chemical treatment on a variety of substrates.

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[1] S. H. Ahn and L. J. Guo, Adv. Mater. 2008, 20, 2044–2049

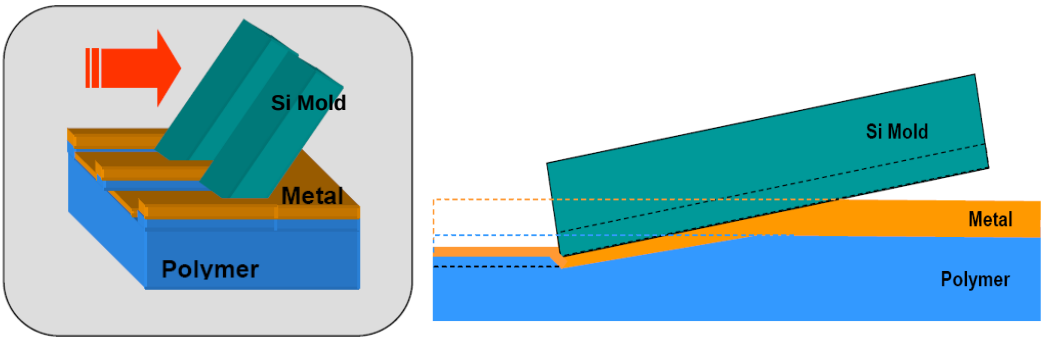

Figure 1. Schematics of DNI process for creating metal nanowire.

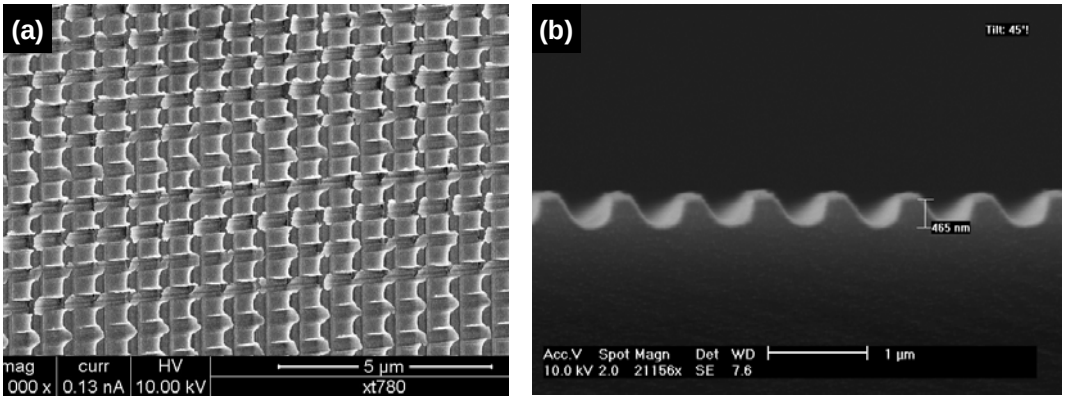

Figure 2. SEMs of (a) Square-shaped gold nano-patterns fabricated by sequential DNIs in orthogonal directions, and (b) 700 nm period gratings directly fabricated on ETFE substrate.

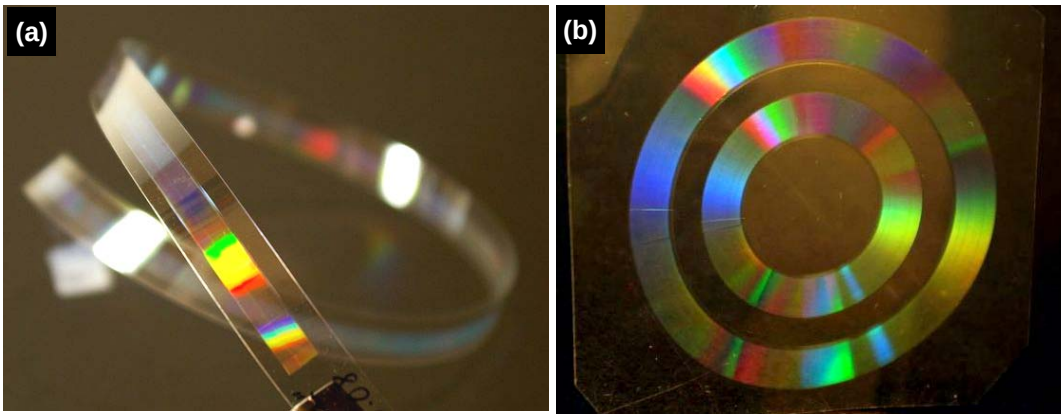

Figure 3. (a) A 22 inch long, 700 nm period, continuous nano-grating pattern directly created on a polycarbonate strip by roll-to-roll DNI process and (b) Concentric nano-gratings on ETFE film fabricated by a rotating DNI process. Outer diameter is 50 mm.