Continuous formation of nano-scale periodic patterns by localized dynamic wrinkling

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

Parallel to the development of lithographic-based nanopatterning methods, a whole different patterning approach based on ordered surface wrinkling has also been investigated in the past decade. However, the nature of nonlinear behavior in the wrinkling process not only makes it difficult to analyze theoretically but also the process difficult to control.[1] Moreover, to create well-oriented wrinkles in practically large area is still challenging because experimentally it is very difficult to apply perfect uniaxial strain to a large-size membrane, which is generally limited by the strain-generating device. In addition, patterns on a soft elastomer substrate, which is most commonly used in wrinkle inducing patterning, have very limited applications.

We present a novel nano patterning technique, Localized Dynamic Wrinkling (LDW), which continuously creates micro/nano-scale gratings in a thin metal film coated on a polymer substrate by simply sliding a flat edge of a cleaved Si wafer over the metal film. LDW shares the basic principle as the buckling (wrinkling) phenomenon of a thin and stiff layer on a compliant substrate under uniaxial stress; but the moving edge of the tilted Si wafer exerts stress to metal coated polymer along the moving direction and sequentially generates localized winkles in the metal film in a dynamic fashion. More interestingly, the period and geometry of patterned gratings can be controlled by several material and process parameters such as the thicknesses of the metal layer, the type of backing polymer substrate and the adhesion between the metal and the polymer layer. Very good agreement with a theoretical model has been obtained. Furthermore, the sequential nature of the localized wrinkle formation along the Si edge moving direction makes LDW easily applicable to high-speed, continuous roll-to-roll process. In this work, we demonstrate the fabrication of gold nano gratings linewidth from micron scale down to 150 nm on plastic substrates.

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[1] A. Schweikart and A. Fery, Microchim Acta, Vol. 165, pp. 239-263, 2009

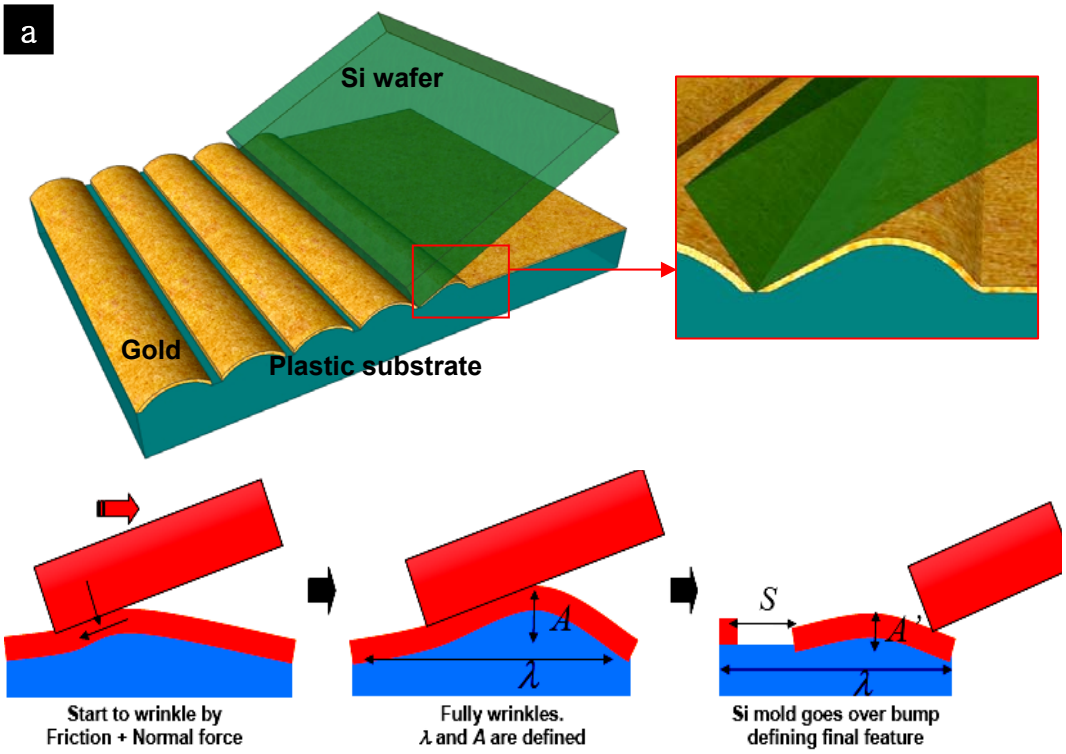

Figure 1. Schematic of LDW process to create discrete metal gratings.

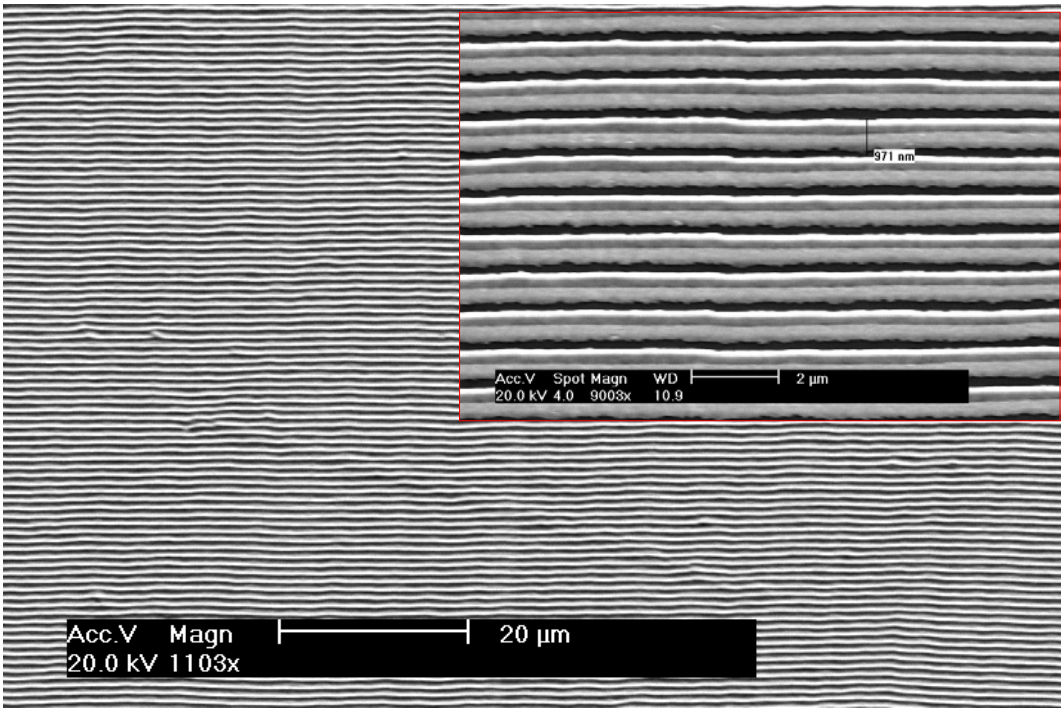

Figure 2. SEM image of 970 nm period gold grating pattern fabricated by LDW process