Development of continuous phase lithography and application to transparent conductor fabrication

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The demand for large-area, low-cost nanofabrication techniques is increasing for many applications. These applications include nanostructured self-cleaning surfaces, nanopatterned light-trapping layers and nanostructured absorbers for photovoltaic devices, wire-grid polarizers for display devices, and optical metamaterials, to name an important few. Current available fabrication techniques are still unable to meet the required performance, fabrication speed, and cost criteria for such large-area patterning applications. We report the development of a continuous fabrication technique by using a roll-type phase-shift mask, which combines some of the best features of photolithography, soft lithography, and continuous roll to roll/plate patterning technologies.[1] Sub-wavelength resolution is achieved using near-field exposure of photoresist through a roll-type phase-mask, allowing a dynamic and high throughput continuous patterning. The use of elastomeric materials for the phase-mask ensures uniform contact with the resist film and provides tolerance to nonflatness on the substrate surface.

As an application, we present the fabrication of transparent metal electrode by using the roller-based optical lithography method. The demand for transparent electrode has been soaring due to wide range applications in LCDs, touch panels, OLEDs, organic photovoltaic devices; and there has been increasing interest in finding alternatives to the most commonly used transparent oxide indium tin oxide (ITO). We present the first results of transparent conductor and its properties achieved by a recently built cylindrical phase-shift lithography prototype, which were designed to pattern on 100 mm^2 of substrate areas.

As shown in figure 6a, transmittance of mesh pattern is governed by its period while there were not notable differences according to thickness. Regardless of thickness, 10 μm periodic patterns have around 85 % of transmittance and 30 μm periodic patterns have 92 %. Also the sheet resistance of samples was measured in the range of 57 Ω to 195 Ω. In comparison with ITO, fabricated TME can be a good alternative of ITO.

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[1] B. Kobrin, E. Barnard, M. Brongersma, M. K. Kwak, L. J. Guo, "Rolling Mask" nanolithography – the pathway to large area and low cost nanofabrication," SPIE Photonics West, San Francisco, January 21-27, 2012.

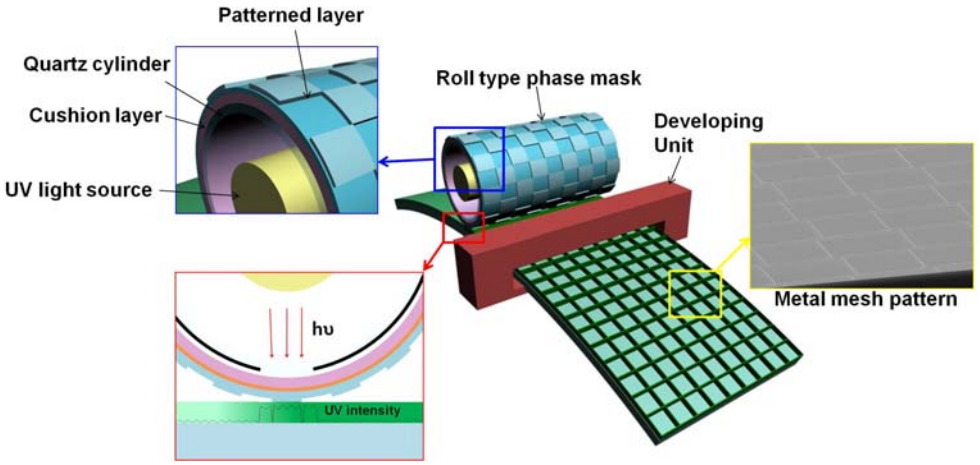

Figure 1: Roll type phaselithography: Schematic of roll type phase lithography to make submicron mesh patterns for transparent metal electrode. SEM image represents a metal mesh pattern after lithography and dry etching.

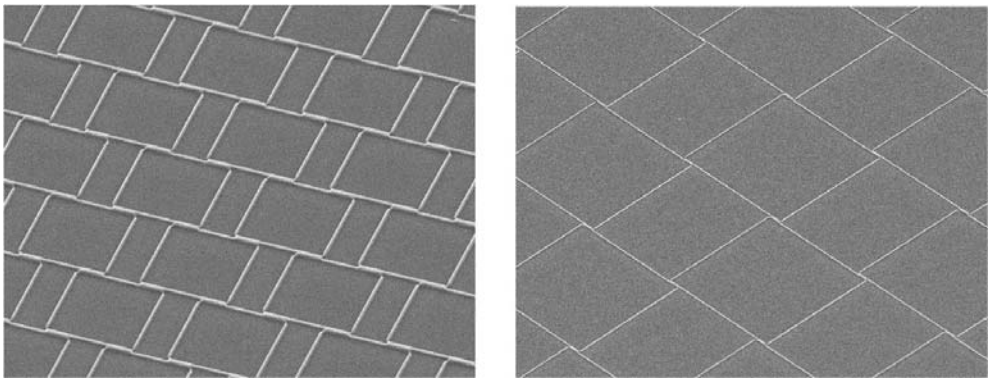

Figure 2: Fabrication results: SEM image of two different period of transparent metal eectrode.

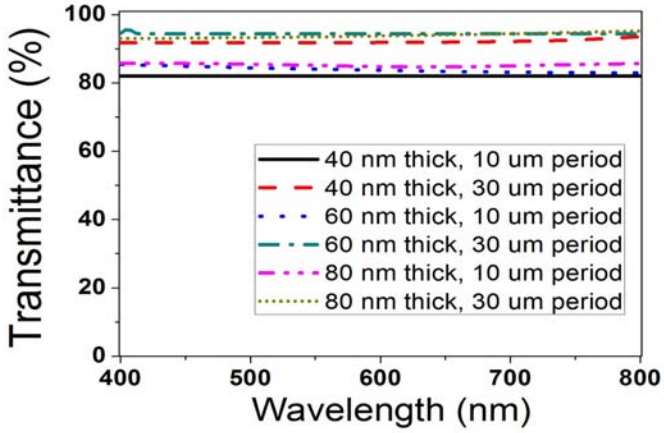

Figure 3: Performance: Transmittance values of six kinds of metal electrodes.