Metal Transfer Assisted Nanolithography on Flexible Substrate

M. G. Kang and L. Jay Guo
Department of Electrical Engineering and Computer Science
University of Michigan, Ann Arbor, MI 48109, USA

A low cost and efficient lithography technique which can produce sub-micrometer feature is essential for future plastic electronics, biotechnology, and other fields. Nanoimprint lithography[1] and nanotransfer printing[2] are potential candidates for this purpose. In this report, we demonstrate another nanolithography technique based on metal transfer printing in which transferred metal acts as a etch mask for pattern transfer to substrate. There are several advantages of this technique. First, it can be applied to plastic substrate as well as hard substrate due to low pressure and temperature used in metal transfer. Second, it can create both large (micron size and larger) and small (nm size) pattern at the same time. Third, the naturally formed undercut feature in the polymer under-layer after oxygen RIE makes the lift-off of nanoscale feature very easy.

Figure 1 shows the schematic diagram of the metal transfer assisted nanolithography. PDMS stamp with nanoscale pattern is first replicated from a nanoimprinted resist template by casting and curing. A High modulus PDMS layer is needed to replicate nanoscale features.[3] Thin metal films such as Au or Ni evaporated on the PDMS stamp is transferred onto a polymer layer on a rigid or plastic substrate through slight pressure and temperature of around the Tg of the polymer. E.g. 10 psi pressure and 95 °C were used in the case of metal-transfer onto a PMMA layer. An Oxygen RIE of the polymer underlayer further transfers the pattern to the substrate and a final metal evaporation and lift-off complete the fabrication of metal patterns on the substrate. A SEM image of the transferred Ni grating with a period of 700nm on PMMA on SiO_2 substrate is shown in Fig. 2(a). Fig. 2(b) and 2(c) show the perspective view after oxygen RIE of PMMA and a top view after lift-off of a Cr film. A 100 nm linewidth dense grating with a period of 220 nm fabricated using similar approach is shown in Fig. 2(d). This lithography can be expanded to fabricate metal dot array by transferring a second metal grating across the first transferred metal layer. For example, dot array with a size of 350 nm was successfully fabricated on PET as shown in Fig. 3. Optimization of the parameters such as temperature, pressure, choice of polymer and metal are currently underway. Upon optimization our approach could be used for fabrication of micro and nano scale pattern on plastic substrate with high throughput, high-yield and low cost.

---

[1]L. J. Guo, *Adv. Mater.*, **19**, 495, (2007)
[2]S.-H. Hur, D.-Y. Khang, C. Kocabas, J. A. Rogers, *Appl. Phys. Lett.*, **85**, 5730, (2004)
[3] C. P.-Hernandez, J.-S. Kim, L. J. Guo, and P.-F. Fu, *Adv. Mater*. **19**, 1222, (2007).

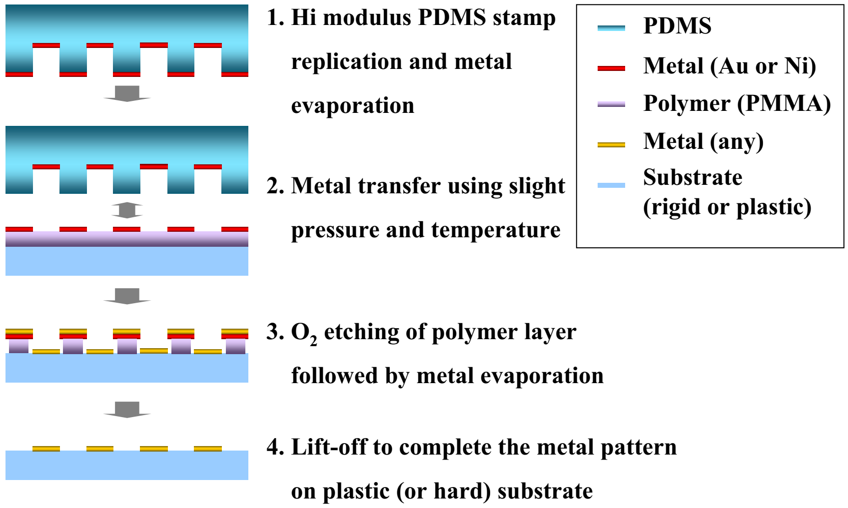

Figure 1. Schematic diagram of metal transfer assisted nanolithography

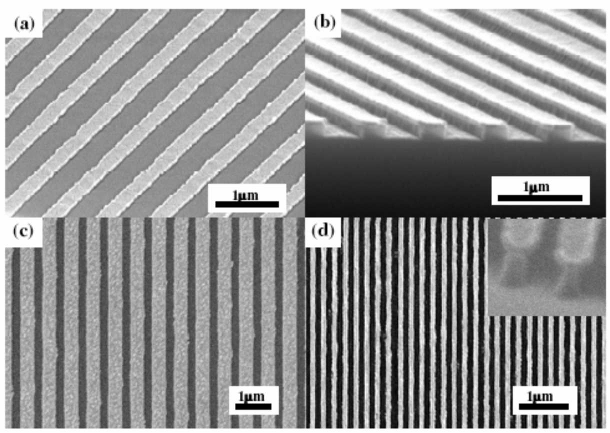

Figure 2. SEM images of (a) transferred Ni grating pattern with a period of 700 nm on PMMA on SiO_2 substrate, (b) after oxygen RIE, (c) after lift-off process of Cr film, (d) 220 nm period Cr grating on SiO_2 substrate fabricated by metal transfer assisted nanolithography and lift-off (inset is after oxygen RIE) .

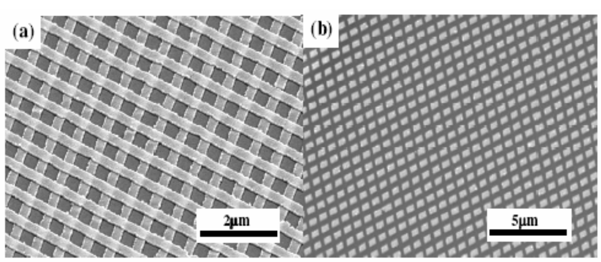

Figure 3. SEM images (a) after sequential transfer of two Au grating films on PMMA on PET substrate and (b) Au dot array on PET substrate after oxygen RIE and lift-off of the transferred Au film.