Step-and-Repeat Nanoimprinting on pre-spin coated film: from sub-15 nm metal patterning to the fabrication of a spectrometer-on-chip

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UV Nanoimprint Lithography (UV-NIL) is a very attractive technology to reproduce micro/nano-patterns over large area at low cost[1]. The Step&Repeat approach for UV-NIL allows reaching high throughput and is currently in industrial pre-production phase for various applications. Over the last few years, we have reported an attractive method combining the advantages of Step&Repeat technology and the imprinting of spin-coated films. Our process SR-NIL allows imprinting and the pattern transfer of the smallest features (sub-10 nm) reported in the literature [2,3,4]. It is also suitable to fabricate nanophotonic devices[5]. Here we present a novel process to fabricate sub-15 nm metallic nanostructures and show the full fabrication of a spectrometer-on-chip by SR-NIL.

To fabricate metallic structures by our SR-NIL, we developed a novel multi-layer PMMA/SiO_2/APS/mrUVCur resist system in order to overcome adhesion issues of the NIL resist. Sub-15 nm metallic nanostructures were successfully replicated by imprint (Fig. 1a) and metal lift-off (Fig. 1b) opening a route to fabricate plasmonic devices by SR-NIL.

To prove capabilities of our process to fabricate real and complex devices, a nanospectrometer based on Digital Planar Holography (DPH) coupled with a full optical circuitry was fabricated. Devices are sequentially imprinted with the experimental mrNIL200 resist from MicroResist[6] and transferred into Si_3N_4 waveguide core film by two plasma etching steps. Finally a SiO_2 upper cladding layer is deposited by plasma enhanced chemical vapor deposition. The spectrometer device lays on a 1.5×1 cm chip (Fig. 2). Dozens of devices were characterized to test the repeatability and the reliability of the NIL process. Optical

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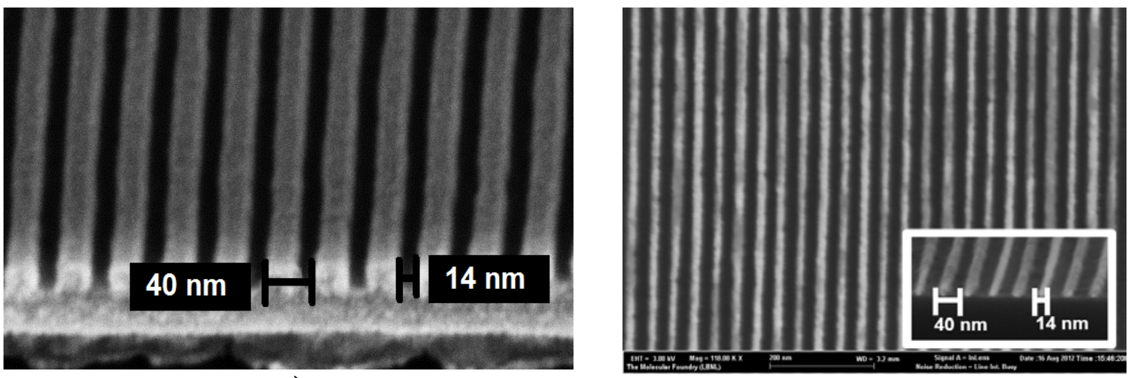
[1] J. Haisma, J. Vac. Sci. Technol. B 14 (1996), 4124
[2] C. Peroz et al., 2010 Nanotechnology 21, 445301
[3] C. Peroz et al., 2012 Nanotechnology 23, 015305
[4] S. Dhuey et al., 2013 Nanotechnology 24, 105303
[5] C. Peroz *et al.*, 2011 Microelectronic engineering 88, 2092-2095
[6] www.microresist.com

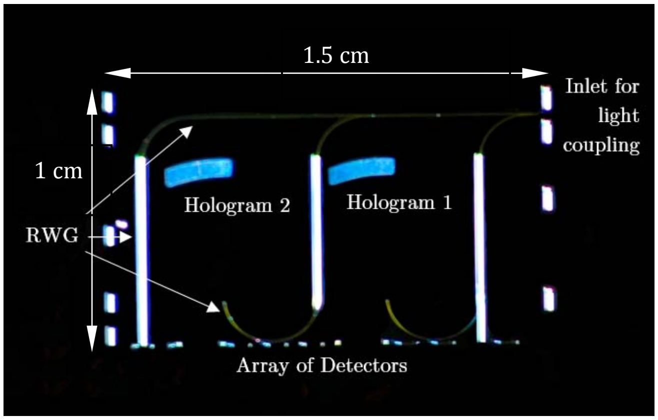
measurements of the device properties show performances comparable with electron beam lithography fabricated devices.

Results prove the flexibility and robustness of the pre-spin coated SR-NIL process and establish the new state-of-the-art for SR-NIL confirming its actual potentials towards high throughput manufacturing of nanodevices with sub-15 nm features.

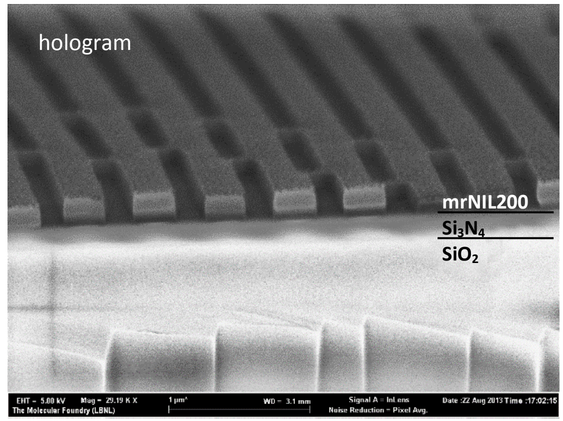


a) *b)*

Figure 1: a) Cross-section SEM picture of 40 nm gratings imprinted on PMMA(55nm) / SiO_2(15nm) / APS(5nm)/ mrUVCur (50nm) b) Cross-section SEM of a grating after lift-off of Cr(5nm)/Au(10nm) film.



a)



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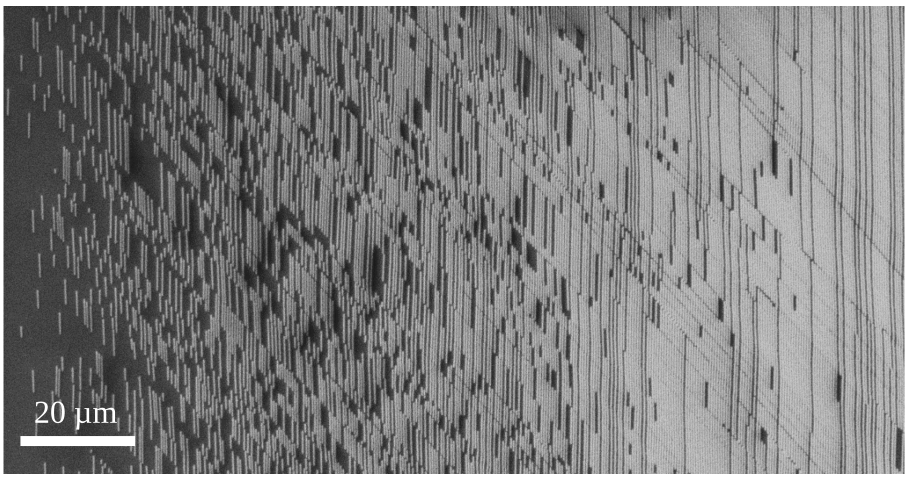

c)

<u>Figure 2:</u> a) Optical picture of the spectrometer-on-chip while a narrow red laser illuminates the input; it can be noticed how only one output channel is on due to the laser narrow band; b) SEM cross-sectional image of an imprinted hologram after residual layer etch; c) SEM image: partial view of a hologram dashes transferred into silicon nitride.