# Sub-20 nm Metal Gratings by Nanoimprint Lithography

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Metamaterials have recently exhibited a wide variety of electromagnetic characteristics impossible from naturally occurring materials.[1] To realize metamaterials in the visible range, structures with sub 50 nm patterns are needed with the requirement of a fast and repeatable process. Buzzi et al. have realized photonic structures down to 250 nm in metal with pressures of ~43500 psi.[2] In this work, we achieved 15 nm metal gratings using nanoimprint in metal (NIM) process with pressures 100 times less than previous work.

The process is shown in Figure 1. Electron beam lithography (EBL) system is used to pattern hydrogen silsesquioxane (HSQ) on a silicon (Si) wafer. The patterns are transferred to Si using reactive ion etch with $Cl_2$/Ar chemistry. Silver (Ag) is evaporated by an electron beam evaporator onto a quartz wafer. The Si mold is used to imprint the fine gratings onto the metal film using nanoimprint lithography (NIL). Due to the metal's high ductility, at temperatures over 200 °C and pressure of ~ 300 psi, the mold is successfully transferred onto the metal film.

Figure 2 shows the SEM micrograph of the metal gratings obtained by NIL. Gratings with a trench width of 15 nm are experimentally demonstrated on Ag film. The successful transfer of the mold to metal allows the realization of devices such as metal-insulator-metal structures for slot and chain waveguides. The ultra small dimension allows plasmonic confinement and propagation. NIM is a promising candidate to the realization of a cost effective method to create such structures since the mold is reusable and the structure can be imprinted multiple times and in a large scale.

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[1] V. M. Shalaev, Nat Photonics 1, 41 (2007)

[2] S. Buzzi et al., Microelectron Eng 85, 419 (2008)

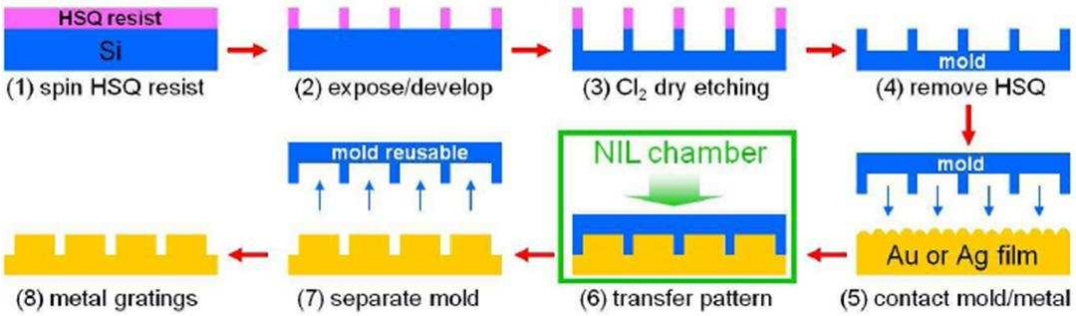


*Figure 1*: *The process flow for nanoimprint in metal (NIM) process flow.*

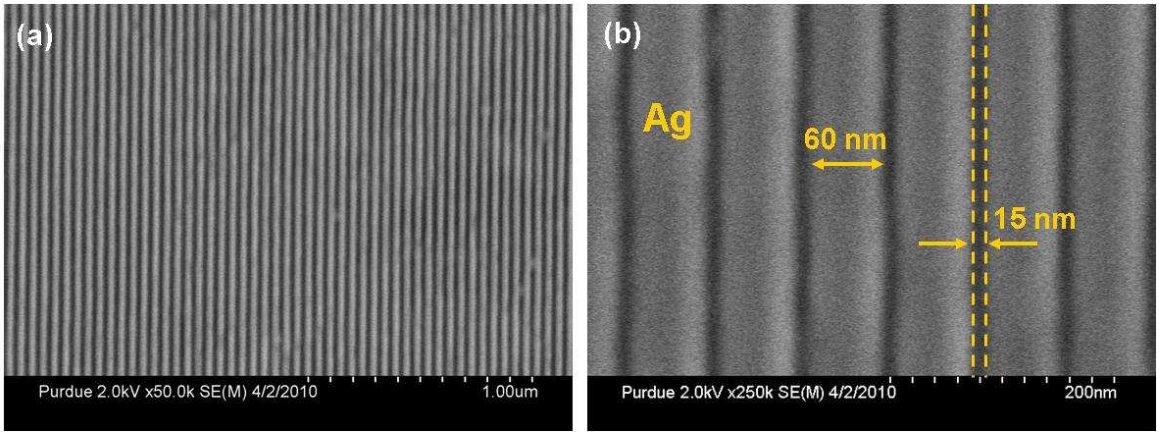


*Figure 2: SEM micrographs of patterned Ag film by NIM process.*