High-Throughput Maskless Nanolithography Using Plasmonic Lens

W. Srituravanich[1], L. Pan[2], Y. Wang[1], C. Sun[1], X. Zhang[1*], and D. Bogy[2]

[1]*NSF Nano-scale Science and Engineering Center (NSEC), University of California, Berkeley, CA 94720-1740*

[2]*Computer Mechanics Laboratory, Department of Mechanical Engineering, University of California, Berkeley, CA 94720*

Surface plasmons offer an exciting route to access short modal wavelengths while using visible/UV light illumination. Such a unique property opens up a new era in nanoscale imaging [1] and lithography [2] at resolution well beyond far-field diffraction limit. Recently, we demonstrated a new concept of lens -plasmonic lens- to generate a high resolution intense light spot by focusing surface plasmons [3]. The optical throughput has been dramatically improved by orders of magnitude in comparing with sub-wavelength apertures commonly used in obtaining sub-wavelength light spot. The proposed plasmonic lens consists of a nano-aperture surrounded by multiple through rings. By designing a proper ring period, surface plasmons can be excited on the rings and focused at the focal point in order to generate sub-wavelength light spot with high throughout. This scheme promises an exciting avenue to nanoscale lithography, ultra-high density data storage, nano-spectroscopy, bio-sensing and so on.

In this paper, we present the development of high-throughput maskless nanolithography process by scanning a plasmonic lens at extremely high speed using air bearing slider platform. We employ the scanning scheme of the air bearing slider -a mechanical element widely used in a hard disk drive- to achieve high speed scanning while precisely regulating nano-scale gap between the slider and the substrate (Fig.1). A plasmonic lens is fabricated on a metal layer that is deposited on the bottom side of a transparent slider. The experiment was conducted using a spindle to rotate the disk at 2,000 rpm equivalent to the plasmonic lens flying at the linear speed of ~10 m/s while illuminating with UV light (wavelength of 365 nm). By modulating the illumination light using high bandwidth Electro-optical Modulator synchronized with the position of the plasmonic lens, arbitrary pattern can be transferred to the substrate. The atomic force microscopy image revealed an exposure result of 120-nm line pattern below far-field diffraction limit as shown in Fig.2. This result demonstrates the potential of a high-throughput nanolithography as a candidate towards next–generation high-throughput nano-manufacturing.

* Corresponding Author, email: xiang@berkeley.edu;URL:http://xlab.me.berkeley.edu

This work was supported by NSF on Nanoscale Science and Engineering Center (NSEC) (Grant # DMI-0327077), and NSF (Grant # DMI-0218273).

References:

[1] N. Fang, H. Lee, C. Sun, and X. Zhang, Science **308**, (2005)534.

[2] W. Srituravanich, S. Durant, H. Lee, C. Sun, and X. Zhang, J. Vac. Sci. Technol. B **23**, (2005)2636.

[3] Z. W. Liu, J.M. Steele, W. Srituravanich, Y. Pikus, C. Sun, and X. Zhang, Nano Lett., **5**, (2005)1726.

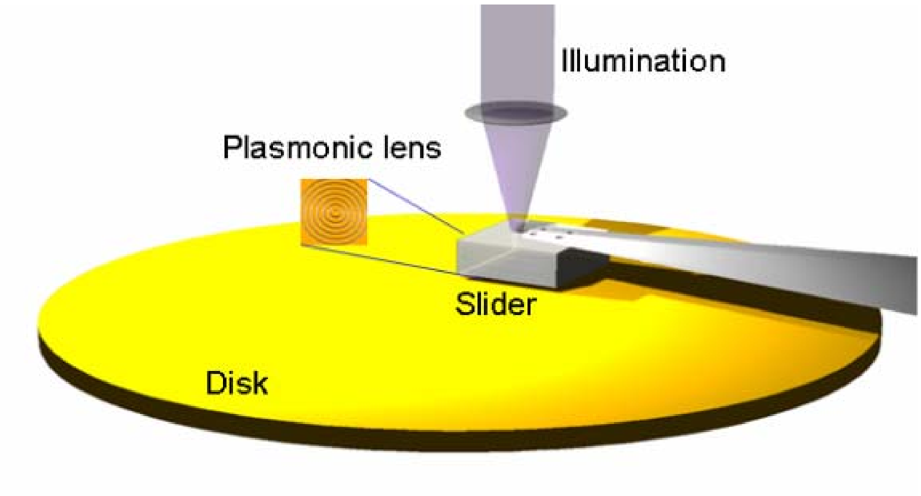

Fig 1 : Schematic of a high-throughput plasmonic lithography using an array of plasmonic lens on the air bearing slider platform.

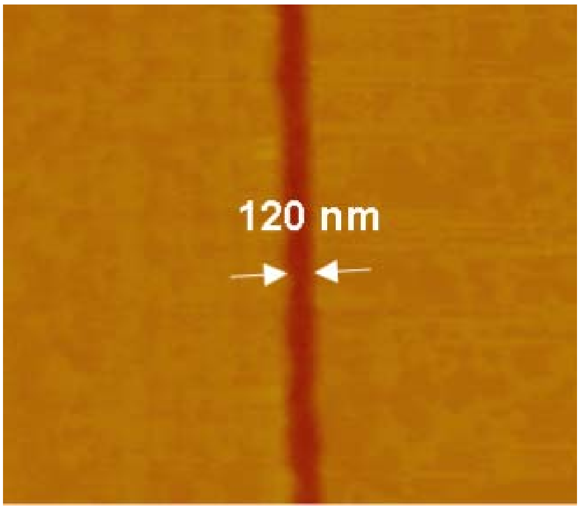

Fig 2 : AFM image of an exposure result of line pattern with 120 nm linewidth.