Optical Transmission Via Elliptically Patterned Grooves on Pyramidal Nano-aperture

Seong Soo Choi*, Myoung Jin Park, Chul-Hee Han
*Research Center for Nanobio Science, SunMoon University, Ahsan, 336-708 Korea, *sscphy2010@gmail.com*

Sung In Kim, Jung Ho Yoo, Kyoung Jin Park
National Nanofabrication Center, Daejeon City, 305-701 Korea

Yong Sang Kim
School of Electronic and Electrical Engineering, SungKyunKwan, Suwon, 440-746 Korea

Sang Hoon Han, Nam Kyou Park
School of Electrical Engineering, Seoul National University, Seoul 151-742 Korea

Recently there have been tremendous interest about plasmonic nano-focusing device for its capability for a single molecule detection device [1, 2]. We present a plasmonic nano-probe on a pyramid. The nano-apertures surrounded with periodic elliptic groove patterns on pyramid were fabricated by using a focused ion beam (FIB) technique. The optical characteristics of the fabricated nano-apertures with elliptic groove patterns on pyramids were investigated. Huge enhancement of the transmitted optical power was observed from a pyramidal aperture surrounded with an elliptically patterned grooves [Figs.1-4]. The in-phase coupling with localized surface plasmon polaritions from backward scattered surface waves through an pyramidal aperture resulted in enhancement of the optical transmittance. Optical enhancement of 10^3 fold increase though an elliptically patterned pyramidal probe even without aperture is also observed due to resonant transmission through interaction between photon modes and localized surface plasmon modes in the groove. The fabricated plasmonic nano-aperture on pyramid can be an excellent candidate for both an optical biosensor device and a nano-antenna. Furthermore, the nanopore inside a FIB-drilled aperture was fabricated on Au complex membrane diffused by electron beam irradiations with electron microprobe analysis (EPMA) and transmission electron microscopy (TEM).

[1] Y. Wang, W. Srituravanich, C. Sun, X. Zhang, Nano Lett., **8**, 3041(2008).
[2] A. J. Storm, J. H. Chen, X. S. Ling, H. W. Zandbergen, C. Dekker, Nature Materials **2**, 537 (2003).

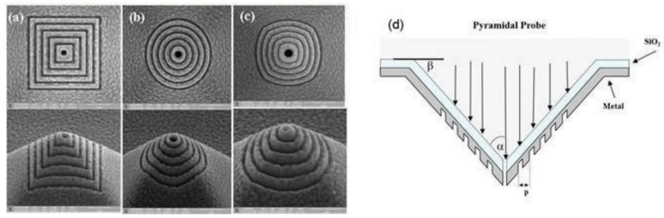

Figure 1: The rectangular, circular, and elliptic periodic groove patterns abricated by using 30 keV FIB are shown as in (a), (b), and (c), respectively. A schematics of a pyramidal probe (side view) is drawn. α and β is 35.3˚ and 54.7˚, respectively, in (d). The width, and the depth is designed to be 100 nm, and 100 nm, respectively. The pitch was varied from 250 nm to 500 nm. The aperture diameter ranging from 100 nm to 400 nm was fabricated.

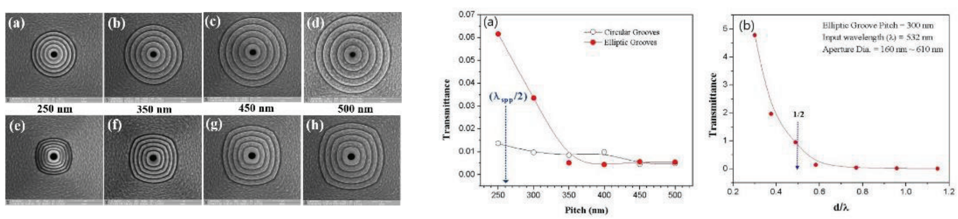

Figure 2: (left) FESEM images of resized Au nano-apertures. The electron beam was irradiated on the area, 500 nm away from the edge of the Au aperture, not directly on Au aperture. This technique would maximize energy absorption of electron beam resulted in the maximum reduction.

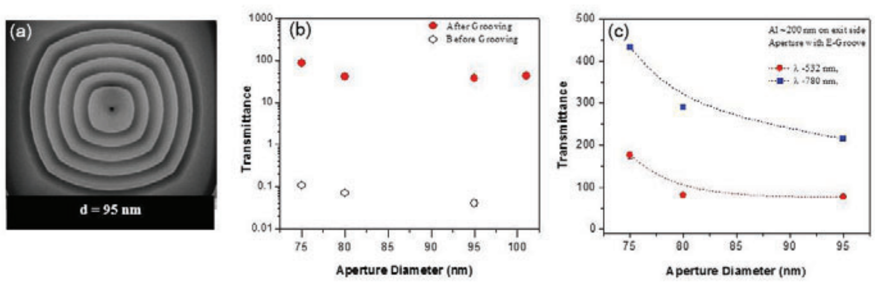

Figure 3. The pitch, width and depth for the groove patterns were 250 nm, 100 nm, and 100 nm, respectively. A SEM image for an aperture with a 95 nm diameter surrounded with elliptically patterned grooves. The depth, width, and pitch are 100 nm, 100 nm, and 250 nm, respectively

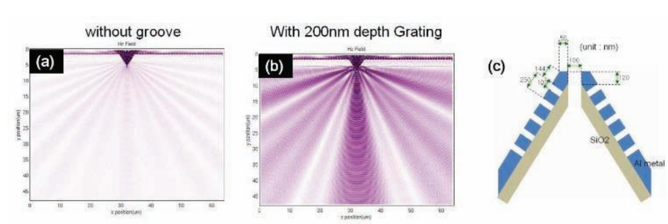

Figure 4. FDTD simulation of Hz field for the transmitted optical field through a pyramidal probe with and without grating pattern is shown. The depth of the patterns is 0 nm in (a), 25 nm in (b), and 200 nm in (c).