Concentrating Light into Nanometer Domain using Nanoscale Ridged Apertures and Its Application in Laser-based Nanomanufacturing

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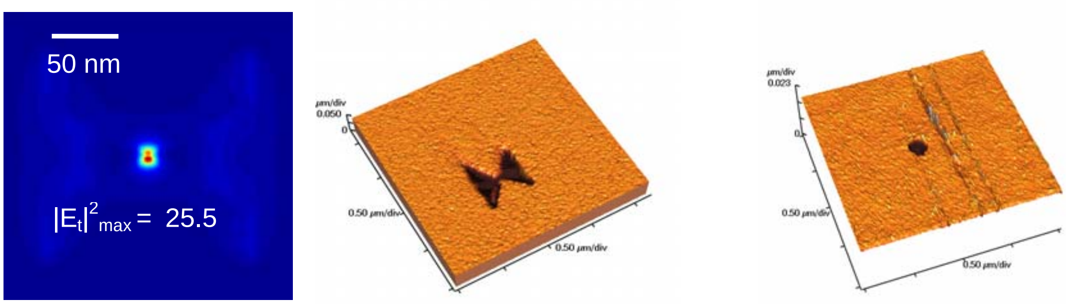
In this work, we investigate laser-based nanofabrication using high transmission nanoscale ridge apertures. The optical transmission characteristics of ridge apertures in a metal film are first numerically studied using the finite-difference time-domain (FDTD) method. We show that ridge apertures provide a drastic optical transmission enhancement compared to regularly shaped nanoscale apertures and confine the transmitted light into a nanometer domain.[1,2] The optimum field concentration and enhancement are achieved by taking advantages of the resonant effect of surface plasmon.[3]

We fabricated various ridge apertures in metal film coated on quartz substrates. These apertures are designed by FDTD calculations to obtain optimal performance and characterized using near field scanning optical microscopy (NSOM). The ridge apertures are then used as a nanoscale light source for nano-lithography. Holes with sub-100 nm dimension are produced in photoresist with visible laser illumination polarized in the field concentration direction (Fig. 1b,c). The performance of the ridge apertures is compared with that of square nanoscale apertures to demonstrate their advantages. The potentials of using these nanoscale ridge apertures for nano-lithography are demonstrated.



(a) (b) (c)

Fig. 1: (a) A properly designed ridged aperture can enhance optical transmission of visible light by 25 times and concentrated into a size of about 16 nm [3]. (b) An AFM image of fabricated ridged apertures. (c) An AFM image of a 90 nm hole produced in a lithography experiment using nano-apertures shown in (b).

1. Jin, E.X., and Xu, X., 2004, "FDTD Studies on Optical Transmission through Planar Nano-Apertures in a Metal Film," J. Journal Applied Phys., Vol. 43, pp. 407 - 417.
2. Jin, E.X., and Xu, X., 2005, "Radiation Transfer through Shaped Nanoscale Apertures," J. of Quantitative Spectroscopy and Radiative Transfer, Vol. 93, pp. 163 – 173.
3. Jin, E.X., and Xu, X., 2005, "Obtaining super resolution light spot using surface plasmon assisted sharp ridge nano-aperture," Appl. Phys. Lett. Vol. 86, pp.111106-08. Also appear in the March 21, 2005 issue of Virtual Journal of Nanoscale Science & Technology.

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