Plasmonic near-fields by nano-post arrays for super-localization microscopy

Hongki Lee and Donghyun Kim

School of Electrical and Electronic Engineering, Yonsei University, Seoul 120-749, South Korea
E-mail: kimd@yonsei.ac.kr

1. Introduction

Near-fields can be locally amplified into a subdiffraction limited region using plasmonic nanostructures [1]. Such near-field localization can be useful for biomedical imaging and sensing applications [2,3]. In this research, we present localized field distribution by plasmonic nanoaperture array structures that is measured by near-field scanning optical microscopy.

2. Results and Discussion

We have considered nano-post arrays modeled of gold on the 20-nm thick gold film, 2-nm thick chrome adhesion layer, and BK7 substrate as shown in Fig. 1(a-c). The diameter and the height of a post were 250 and 45 nm. The nano-post arrays were fabricated by e-beam lithography with a scanning electron microscope (Elphy Quantum, Raith, Dortmund, Germany) and near-field distribution of the fabricated sample was measured with a near-field scanning optical microscope (NSOM, SNLG102NTF, NT-MDT, Moscow, Russia) and a tapered fiber probe (MONO450, LovaLite, Besançon, France) whose aperture size is 70 nm in diameter. The NSOM was combined with a conventional inverted microscope system (IX73, Olympus, Tokyo, Japan) to accomplish angled illumination of nano-post arrays with a total internal reflection (TIR) microscope objective lens (UAPON 100XOTIRF, Olympus, Tokyo, Japan) using a continuous-wave solid-state laser (Sapphire 532 FP, λ = 532 nm, Coherent, California, USA).

When TM-polarized light is incident with its incident angle of 70, 65, and 70 degrees to three different arrays, the near-field was localized at one side of a nano-post with enhanced intensity over the other side, as shown in Fig. 1(d-f). The calculation was numerically performed by 3D rigorous coupled-wave analysis. We experimentally confirmed these localized near-fields using NSOM as shown in Fig. 2. Under given illumination angles, near-fields were localized on one side of each nano-post. The near-field intensity was collected and measured by the fiber probe and the photomultiplier tube (PMT). To calculate the field enhancement due to the nano-post array, we assumed that the field intensity can be mapped to the measured voltage and considered the ratio between the maximum and the minimum field intensity measured on the bare gold film. The calculated field enhancement for each period was 7.57 and 11.76, which is lower than what is expected from calculation. As we changed the direction of incident light, the localized field was induced on the opposite side of the nano-post.

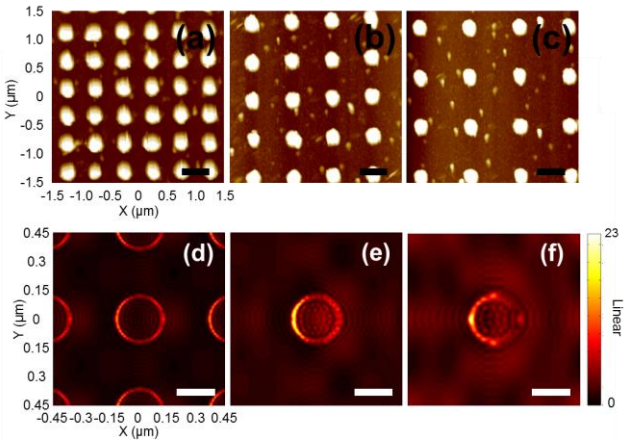

Figure 1 AFM images of fabricated gold nano-post arrays with different periods of 500, 700, and 900 nm (a-c, scale bars: 500 nm) and calculated near-field distributions at the top plane of the nano-post arrays (d-f, scale bars: 200 nm). For three periods, the peak intensities were enhanced by 13.57, 20.78, and 22.08.

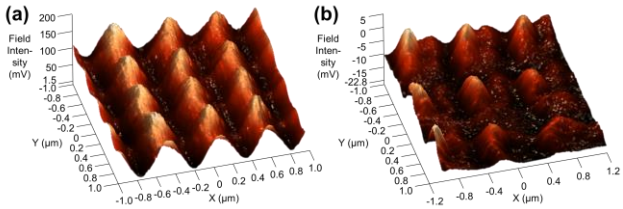

Figure 2 NSOM images of fabricated gold nano-post arrays with two periods of 500 and 700 nm (a,b) when they were illuminated with 70 and 65 degrees under TIR condition.

3. Conclusions

We have measured the field distribution created by different plasmonic nano-post arrays under the TIR condition while incident angle and the direction vary. By optimizing the structural dimension and reducing the size, we expect to be able to customize localized fields for super-localization microscopy.

References

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