In-Plane Optical Power Flow Control with Nano-Fabricated Plasmonic Structures for Micro Total Analysis Systems

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The micro total analysis systems (Micro-TAS) have been attracted to be a high sensitive sensor, ultra-fast chemical reactor, and biomedical analyzer with small number of samples[1]. The Micro-TAS contains micro-fluidic channels, reactor cells, micro pumps, micro valves, and microscopes. For the reduction of Micro-TAS equipment size and amount, we propose an optical power flow control method with nano-fabricated plasmonic structures to replace the micro pump which is the largest equipment in Micro-TAS.

In case of the analysis method with Micro-TAS, the optical microscope is widely used. In our idea, the power of the illuminated light waves through the optical analysis with microscope was used to make the analyte move one direction. Our plasmonic structures are designed to enhance the in-plane optical power flow.

The schematic of our plasmonic structure for in-plane optical power flow is shown in Figure 1. Gold (Au) was selected as the material of the eclipse-like plasmonic structure. Finite-domain Time-difference (FDTD) method was carried out to calculated the optical power flow with the eclipse-like structure. The wavelength of illumination light wave for z direction was fixed as 532 nm. The simulated optical power flow is shown in Figure 2. The estimated optical power was 10^{-21} N with 10 mW illumination[2].

To confirm the optical power with illumination, the microscopic Raman scattering measurement with coloring matter (10^{-2} M Rhodamine B, 10 μl) was performed[3]. The eclipse-like plasmonic structures were fabricated by lift-off process following the electron beam lithography. The measured mapping image is shown in Figure 3. In Figure 3 (a), the white area is related to silicon (Si) substrate. In Figure 3 (b), the white are is related to the coloring matter. From these results, the surrounded area by eclipse-like plasmonic structure shows strong enhancement of Raman scattering with large in-plane optical power.

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[1] Y. Sugii *et al.*, "Effect of korteweg stress in miscible liquid two-layer flow in a microfluidic device", Journal of Visualization, 8, 117, 2005.

[2] K. C. Neuman & S. M. Block, "Optical trapping", Review of Scientific Instruments, 75, 2787, 2004.

[3] T. Baba, R. Kometani, E. Maeda *et al.*, "Triple-walled gold surfaces with small-gaps for non-resonance surface enhanced Raman scattering of rhodamine 6G molecules", Journal of Vacuum Science and Technology B *in press*.

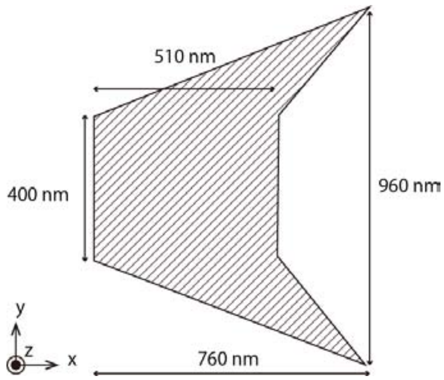

Figure 1: The schematic of our plasmonic structure for in-plane optical power flow. The eclipse-like shaped structure shows in-plane (xy plane) optical power flow with vertical light illumination (z direction).

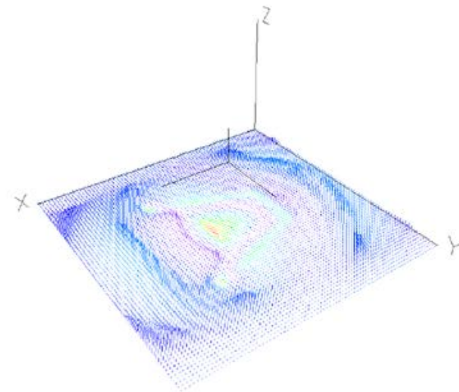

Figure 2: Calculated optical power flow through FDTD simulation. The red area is for in-plane (xy plane) optical power flow.

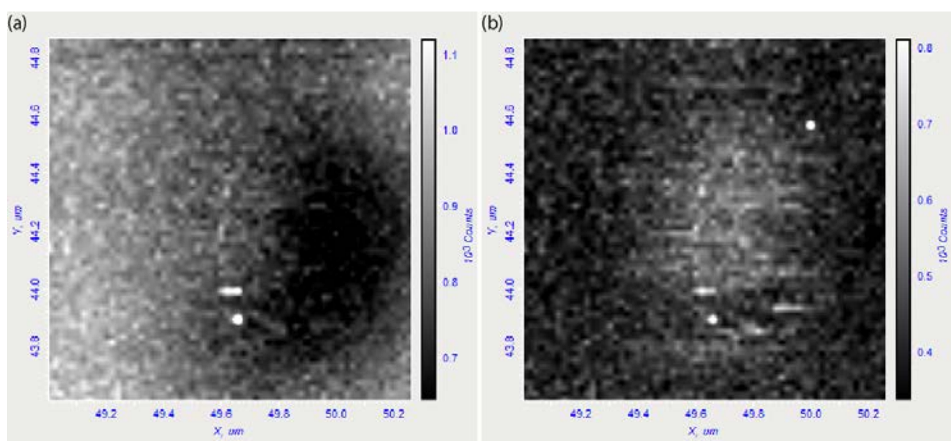

Figure 3: The Raman scattering intensity from Si and Rhodamine B in same position. The intensity mapping was performed by microscopic Raman spectrometer. (a) white: Si substrate, black: eclipse-like Au structure. (b) white: Rhodamine B, black: non resonant area.