Enhancement of fluorescence correlation using plasmonic gold dimer arrays

Hongki Lee, Gwiyeong Moon, Seongmin Im, Taehwang Son, and Donghyun Kim
School of Electrical and Electronic Engineering, Yonsei University
50 Yonsei-ro Seodaemun-gu, Seoul, Republic Korea
E-mail: kimd@yonsei.ac.kr

KEYWORDS: Surface plasmon resonance, localized surface plasmon, surface plasmon resonance microscopy, fluorescence microscopy

Plasmonic localization recently has drawn significant interests as a way to manipulate optical signal within the nanoscale area beyond diffraction limit and thereby acquire biological information with a high signal-to-noise ratio (SNR) and precision. In this work, we report fabrication of gold nanodimer arrays which were first modeled to have h_a = 20, h_f = 30, h_c = 2, l_d = 100, and l_g = 18 nm with a period Λ = 746 nm, as described in Figure 1(a,b). The scattering spectrum was quite broad with full-width-at-half-maximum of 209 nm and a peak was located at λ = 643 nm, as depicted in Figure 1(c). It was found that a fabricated sample could couple with the incident wavelength at 671 nm reasonably. Two individual gold posts of a dimer start to couple each other when the distance becomes smaller than 50 nm. The near-field calculation shows 296-time field enhancement can be achieved within a dimer gap, which is applicable to enhance SNR of fluorescence correlation spectroscopy (FCS). Within the dimer's gap, full-width-at-1/e-maximum of localized fields were found to be 70 and 30 nm in the *xz* and *yz* planes. To verify the improved SNR of molecular detection using nanodimer arrays, we have measured diffusion dynamics of 40-nm fluorescence beads in water ambiance. The maximum fluorescence intensity on dimer arrays was measured to be 1.85 times stronger than on a bare gold film. The diffusion coefficient (D) of fluorescence bead was measured to be D = 7.53 ± 0.20 μm^2/s. More interestingly, scattering intensity of surface plasmon resonance microscopy was also improved, because amplified near-field intensity enhances the intensity of leakage radiation [1]. The highest plasmon scattering intensity was measured to be S = 1714 in analog-to-digital units (ADU) while the background noise was measured to σ_N = 538 in ADU. An SNR of plasmon scattering intensity on nanodimer arrays can be calculated to be 10.1. It was shown that FCS with sub-diffraction-limited observation volume can help measure the dynamics of fluorescence molecules with high SNR.

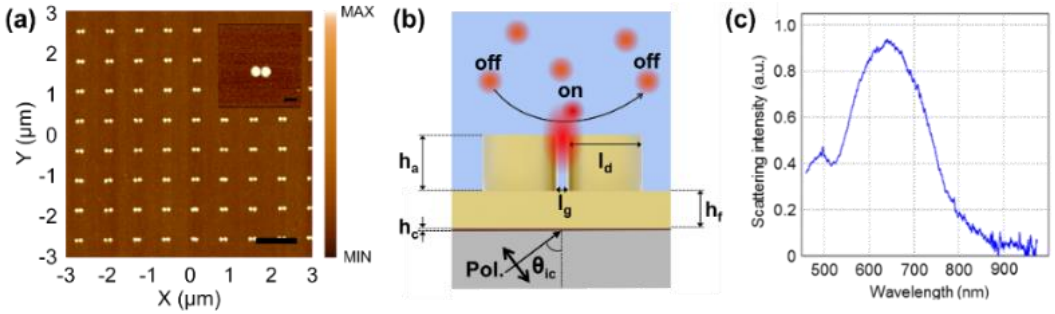

Figure 1: (a) AFM image of gold nanodimer arrays. (b) Schematic field localization by gold nanodimer arrays. (c) Experimentally measured scattering spectrum of gold nanodimer arrays.

[1] A. Hohenau, J. R. Krenn, A. Drezet, O. Mollet, S. Huant, C. Genet, B. Stein, and T. W. Ebbesen, "Surface plasmon leakage radiation microscopy at the diffraction limit," *Opt. Express* **19**, 25749-25762 (2011).