Plasmonic Nanosheet towards Biosensing Applications

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Surface plasmon resonance (SPR) is classified into the propagating surface plasmon (PSP) excited on flat metal surfaces and the local surface plasmon (LSP) excited by metal nanoparticles. It is known that fluorescence signals are enhanced by these two SPR-fields. On the other hand, fluorescence is quenched by the energy transfer to metal (FRET). Both phenomena are controlled by the distance between dyes and metals, and the degree of fluorescence enhancement is determined by the correlation. In this study, we determined the condition to achieve the maximum fluorescence enhancement by adjusting the distance of a metal nanoparticle 2D sheet and a quantum dots 2D sheet by the use of SiO$_2$ spacer layers.

The 2D sheets consisting of myristate-capped Ag nanoparticles (AgMy nanosheets) were prepared at the air-water interface and transferred onto hydrophobized gold thin films based on the Langmuir-Schaefer (LS) method [1]. The SiO$_2$ sputtered films with different thickness (0-100 nm) were deposited on the AgMy nanosheet as an insulator. TOPO-capped CdSe/CdZnS/ZnS quantum dots (QDs, $\lambda_{ex}$=638 nm) [2] were also transferred onto the SiO$_2$ films by the LS method. The layered structure is schematically shown in Fig. 1.

The result of fluorescence measurement is shown in Fig. 2. Without the SiO$_2$ layer, the fluorescence intensity of the layered QD film was lower than that of the original QDs layer, i.e., the quenching by FRET was predominant. When the SiO$_2$ thickness was increased, the fluorescence intensity of the layered QD film was higher than that of the original QDs layer, i.e., the SPR enhancement was predominant. The fluorescence intensity was maximal at the SiO$_2$ thickness of 20 nm, particularly when the LSPR absorption wavelength ($\lambda$=480 nm) was utilized for the excitation. This plasmonic nanosheet can be integrated into green or bio-devices as the creation point of enhanced LSPR field.

References
Fig. 1 Layered structure composed of AgMy and QDs nanosheets with SiO₂ spacer layer.

Fig. 2 SiO₂ thickness vs. Normalized fluorescence intensity (I/I₀).