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※支援課題名（日本語）　：制御された金ナノ構造による蛍光増強の検討
※Program　Title（in English）　: Surface plasmon-enhanced fluorescence induced by gold nanostructures
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※概要（Summary）：
We have demonstrated surface plasmon-enhanced fluorescence of Eosin Y molecules induced by gold nanostructures. Al_2O_3 films deposited by atomic layer deposition (ALD) with sub-nanometer resolution were used as the spacer layer to control the distance between molecules and the gold surface. As the thickness of the Al_2O_3 film increased, the fluorescence intensity first increased and then decreased. The highest enhancement factor is achieved with a 1 nm Al_2O_3 film. However, the trend for the fluorescence lifetime is the opposite. It first decreased and then increased. The changes in the fluorescence quantum yield were also calculated. The yield shows a similar trend to the fluorescence intensity. The competition between the surface plasmoninduced increase in the radiative decay rate and the goldinduced fluorescence quenching is responsible for the observed phenomenon. In addition, this competition strongly depends on the thickness of the spacer layer between Eosin Y molecules and the gold surface.

※実験（Experimental）：
The gold nanostructures were fabricated on glass substrates by high-resolution electron beam lithography and lift-off. Al_2O_3 films with different thicknesses were deposited onto the sample using an ALD system using trimethylaluminum (TMA) and water as the precursor as a spacer layer to control the distance between the Eosin Y molecules and the gold surface. The sample was immersed in the Eosin Y solution (2×10^{-5} mol/L) for 30min. Then, we took it out and let it dry naturally in air.

※結果と考察（Results and Discussion）：
As the thickness of the Al_2O_3 film increased, the electric field intensity and quantum yield first increased and then decreased as shown in Fig.1(b). The fluorescence lifetime shows the opposite tendency (Fig.1(a). These observed phenomenon can be explained by the competition between the surface plasmon-induced increase in the radiative decay rate and the metal-induced fluorescence quenching. Within a short distance, the quenching effect is dominant, while as the separation distance increases, the surface plasmon-induced increase in the radiative decay rate takes the domain place since it decreased much slower than the quenching effect. We have demonstrated quantitative analyses of the enhancement of fluorescence of Eosin Y on the usage of gold nanostructures fabricated by precisely controlled nanofabrication techniques and ALD coated dielectric spacer layer with sub nanometer resolution. This study not only helps to clarify the energy transfer process between excited molecules and metal but also has potential applications in the biosensing area.

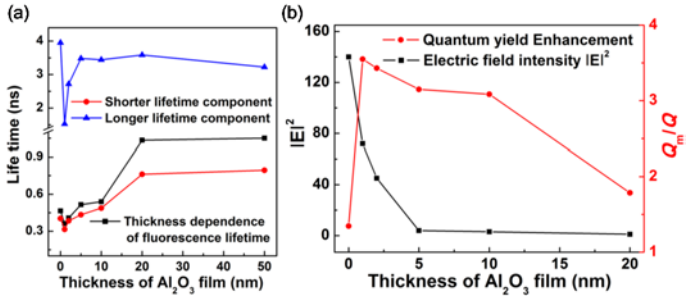

Fig. 1 (a) Dependence of the average fluorescence lifetime, longer and shorter lifetime components on the thickness of the Al_2O_3 film. (b) The dependence of electric field intensity ($|E|^2$) and quantum yield enhancement factor (Q_m/Q) on the thickness of Al_2O_3 films.

※その他・特記事項（Others）：
Fluorophores with low quantum yield and fluorescence intensity, such as DNA, whose quantum yield is as low as 10^{-4} to 10^{-5}, can be detected successfully with the help of surface plasmon-induced fluorescence enhancement. Therefore, the fluorescence and quantum yield of the fluorophore is largely enhanced, which can be applied in biosensing area.

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論文・学会発表（Publication/Presentation）：
[1] Y. Teng, K Ueno, X. Shi, D. Aoyo, J. Qiu, H. Misawa, Ann. der Physik, 524, 11, 733-740 (2012).

関連特許（Patent）：なし