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銀ナノ粒子の光捕捉を利用した表面増強ラマン散乱分光のバイオセンシング応用

Surface-enhanced Raman spectroscopy using an optical trap of Ag nanoparticles for biosensing applications

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Background

Noble metal nanoparticles exhibit extremely interesting optical responses in interaction with light. Surface-enhanced Raman spectroscopy (SERS) is an enhanced Raman scattering from molecules adsorbed on noble metal nanostructures. The enhancement factor can be as much as 10^{10} to 10^{11}, which means the technique may detect single molecules.

Not only size and shape of individual nanoparticle, but also aggregation structures are significant for sensitive SERS detection. In this work, we used an optical trapping technique to make SERS-active aggregates in colloidal Ag solution in the presence of analyte molecules. The aggregates produced by optical trapping with an IR laser beam could be fixed on a glass substrate and the SERS spectra were measured by irradiating a visible laser beam on it. We have studied optimal laser power, laser irradiation time, and NaCl concentration for each analyte molecule.

Experiments and results

Ag nanoparticles (colloid) were synthesized by chemical reduction method with citrate and tannic acids. Analyte molecules and NaCl were mixed in the Ag colloid just before the SERS measurement. We put the mixed solution into the gap between a slide and cover glasses. As shown in Figure 1, we introduce an IR laser beam (1064nm) in the solution via an objective lens (100x, NA=1.3) for optical trapping, we control the size of aggregation by the power and irradiation time of this laser beam. By focusing a laser beam near the glass surface, Aggregates of Ag nanoparticles were fixed on the glass plate. For SERS detection a visible laser beam (532nm) was irradiated on the fixed aggregates and SERS spectra were measured by a spectrometer. We used histamine, adenine and cytosine as analytes. By optimizing an IR laser power, irradiation time, and NaCl concentration, we succeeded in the detection of these molecules at 2.5 μM.

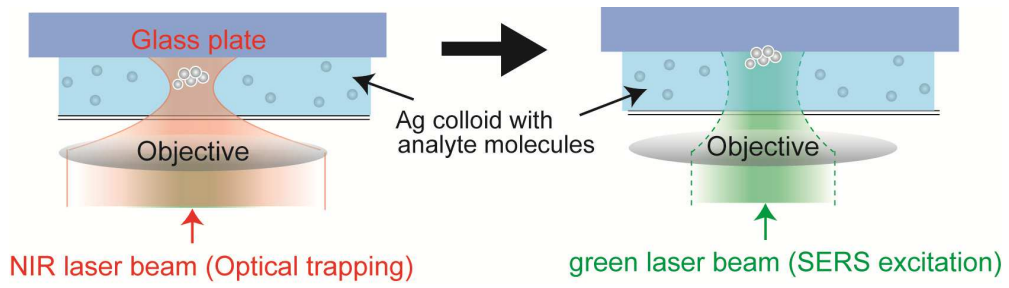

Figure1. Experimental schematic of optical trapping and SERS spectroscopy