Deposition of fluorescent nanoparticles in the gap of plasmonic nano-antennas

北海道大学電子科学研究所 [1]，熊本大学 [2]，
○(P)パン クリストフ [1]，石田 周太郎 [1]，(M1)高橋 玄太 [1]，深港 豪 [2]，笹木 敬司 [1]
RIES Hokkaido Univ. [1], Kumamoto Univ. [2],
°(P) Christophe Pin[1], Shutaro Ishida[1], (M1) Genta Takahashi[1],
Tsuyoshi Fukaminato[2], Keiji Sasaki[1]
E-mail: christophe.pin@es.hokudai.ac.jp

Precise deposition and assembly of composite materials at the nanoscale is a key challenge to achieve bottom-up fabrication of new nano-components. As they allow light confinement at the subwavelength scale, plasmonic nanogap antennas are of particular interest in order to enhance light-matter interactions at the nanoscale However, few fabrication techniques are now able to deposit and precisely position nanomaterials in the gap of such nanoantennas. We investigate here the self-driven deposition of small amount of colloidal nanoparticles in the gap of gold nano-antennas.

Orange-fluorescent dye molecules (1,4-Bis(4-diphenylaminophenyl)-2,1,3-benzothiadiazole) were used to fabricate molecular nanoparticles (about 30~50 nm in diameter) by reprecipitation process. By irradiating gold nano-antennas with different geometries using laser intensities of ~10^2 kW.cm^{-2}, nanoparticles were observed to be attracted toward the nanostructure and attached at its surface. This result was confirmed by scanning electronic microscope (SEM) observations. At high laser intensity, deposited material was found to form circular or elliptical contour shape around or on the gold structure. This may be due to a balance between attractive and repulsive thermal convection and thermophoresis forces [1]. However, at lower intensity and using short irradiation time, particles can be attracted in the nanogap of the antenna thanks to near-field optical forces. Similar experiments were reproduced using commercial fluorescent polystyrene nanobeads (46 nm average diameter) and CdSe/ZnS core-shell quantum dots in water solution. As revealed by SEM observation, deposition of few nanoparticles was achieved in the case of molecular and polymer nanoparticles, whereas quantum dots are rather observed to form aggregates. Although some quenching effect was observed during the deposition process of polystyrene nanoparticles and quantum dots, fluorescence of molecular nanoparticles was still observed after deposition. Two-photon fluorescence emission enhancement was also observed in some specific configurations.

REFERENCES:

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