Optical Trapping, Binding, and Swarming of Silica-coated Gold Nanoparticles at Glass/solution Interface

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Optical trapping, which uses a tightly focused laser beam to confine small objects, allows us to manipulate materials and explore new phenomena at the microscopic level. In a previous work, we observed a dynamic assembly of gold nanoparticles (Au NPs) at the glass/solution interface that only evolved in the direction perpendicular to the linear polarization of the trapping laser.1 This phenomenon can be explained as an evolving optical binding network through multiple trapping and scattering of Au NPs.2 All the previous studies of swarming have only been conducted using bare metallic NPs.

In this report, we present the optical trapping and assembling of silica-coated Au NPs at the glass-solution interface. The gold core contributes to the optical binding force through its high scattering, while the additional silica shell experiences gradient force as a dielectric material. By varying the thickness of the silica shell (22-100 nm), we can modify the balance between these forces and change the optical binding distance between particles in the initial stage. Furthermore, new assembling behaviors were observed using Au NPs coated with a 100 nm silica shell (Fig. 1). A single rolling assembly is formed outside the focal spot in the direction perpendicular to laser polarization. When the solvent was changed from water to dimethylformamide, the optical forces applied to the silica shell became negligible due to their similar refractive index. In this case, the dumbbell-shaped swarming returned, indicating that the optical forces arising from the silica shell play an important role in the rolling assembly.

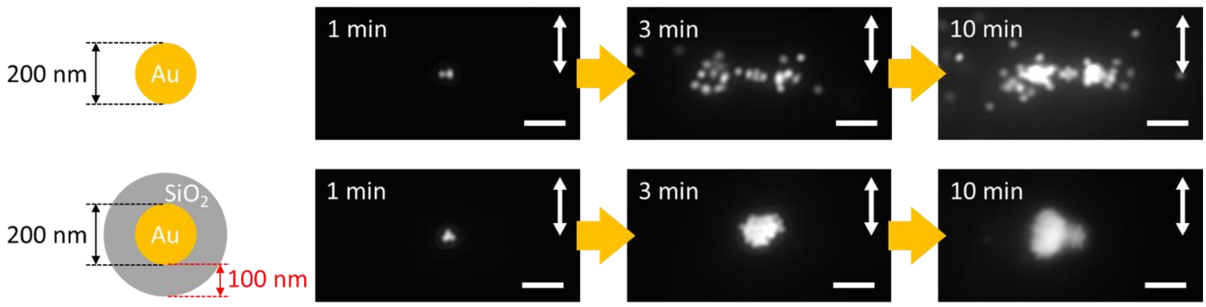

Figure 1. Comparison between the evolving process of bare Au NPs and silica-coated Au NPs. The size information is illustrated on left side. The arrows indicate the direction of linear polarization of the trapping laser. The while bars refer to 2 μm.

1. Tetsuhiro Kudo, Shang-Jan Yang, Hiroshi Masuhara, Nano Lett., 2018, 18, 5846–5853
2. Chih-Hao Huang, *et al.*, Nat. Commun., 2022, 13, 5435