Optical Trapping-induced Gold Nanoparticle Assembly and its Directional Extension outside the Irradiated Area Based on Light Scattering

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Recently, we have investigated nanoparticle assembling by optical trapping at an interface through light propagation and light scattering [1]. This assembly is organized by photons, and nanoparticles constituting the assembly are optically bound through photons in contrast to the typical molecules bound by electrons. Here, we demonstrate optical trapping and assembling of 200 nm gold (Au) nanoparticles (NPs) at glass/solution interface with tightly focused 1064 nm continuous wave laser. The assembling dynamics are monitored by the dark-field scattering images and spectroscopy. The Au NPs randomly move in the solution, and they start to assemble at the focal spot upon the laser irradiation. The NPs tend to form one-dimensional alignment perpendicular to the linear polarization in the beginning of optical trapping (Fig. 1a), which is different from the close-packed structure consisting of several Au NPs with circular polarization (Fig. 1c). We infer that inter-particle interaction involves the optical force between the separated NPs. The center-to-center distances of 200 nm NPs are near 800 nm, which is common for both linear and circular polarization and considered to be close to the laser wavelength in water. This separation corresponds to optical binding force generated by interference of light scattering of Au NPs.

After trapped for a while, the particle assembly is directionally extended outside the focal spot along the direction perpendicular to the linearly-polarized laser (Fig. 1b) in contrast to the isotropic extension by circularly-polarized laser (Fig. 1d). The extension reaches about 8 µm from the focus, which is indeed difficult to be realized under conventional trapping conditions. Extension phenomena are also observed in larger particle size (such as 250 nm and 300 nm in diameter). However, the assembly composed of 150 nm Au NPs cannot be extended outside the focal spot owing to relatively weak light scattering efficiency. The NPs are aligned due to the scattering light enhanced by surface plasmonic resonance of metallic NPs, and these aligned NPs scatter the light furthermore to extend the assembly outside the focal spot. Spectral analysis is being carried out to understand the assembling dynamics.

**Figure 1.** Dark-field scattering images of 200 nm gold nanoparticle assembly formed by (a, b) linearly- and (c, d) circularly-polarized laser trapping, respectively. The images observed (a, c) at around 10 sec and (b, d) 2 min. The directions of the polarization are indicated as arrows.