Optical binding dynamics of gold nanoparticles with linearly patterned gold nanodisks

National Yang Ming Chiao Tung Univ., Taiwan [1], Okayama Univ., Japan [2],
Hokkaido Univ., Japan [3], KU Leuven, Belgium [4], Universitat Ramon Llull, Spain[5]
○ Mu-En Li[1], Chih-Hao Huang[1], Xu Shi[3], Kosei Ueno[3], Boris Louis[4], Roger Bresolí-Obach[5],
Johan Hofkens[4], Hiroaki Misawa[1,2,3], Hiroshi Masuhara[1]
E-mail: a311654060.sc11@nycu.edu.tw

Optical trapping of colloidal nanoparticles is considered a promising approach for constructing active optical matter. Our group has reported a dynamic matter based on the optical binding between non-irradiated and irradiated gold (Au) nanoparticles (NPs) by tightly focusing a linearly polarized 1064 nm laser at glass/solution interface.[1,2] In 2024 JSAP meeting, we discussed the polarization-dependent optical trapping dynamics of Au NPs in the presence of the lithographically fabricated Au nanodisk (ND) pattern, where several specific trapping positions are observed with a displacement to the center of the beam when the laser is shifted along the alignment of the Au ND pattern.

In this report, we extend the investigation of the far-field interaction between patterned Au NDs and free NPs. Without introducing the Au ND pattern, the geometry of one to seven optically trapped Au NPs located inside the focus, and the dynamics of the eighth and ninth Au NPs fluctuate outside the irradiation area are analyzed. In contrast, characteristic trapping behaviors are observed by shifting the trap 400 nm perpendicularly to the alignment of the Au ND pattern. The least stable triangular configuration of six particles is stably formed (Fig 1. (A-vi)). Upon shifting the laser, the pentagonal configuration, which is commonly observed configuration in the absence of Au ND pattern, is recovered accompanied by the slightly suppressed rotational motion (Fig 1. (B-v)), suggesting the weakened far-field interaction between the Au NDs and NPs. These results open a new approach to prepare active optical matter based on the interaction between reconfigurable colloidal particles and designed lithographical pattern.

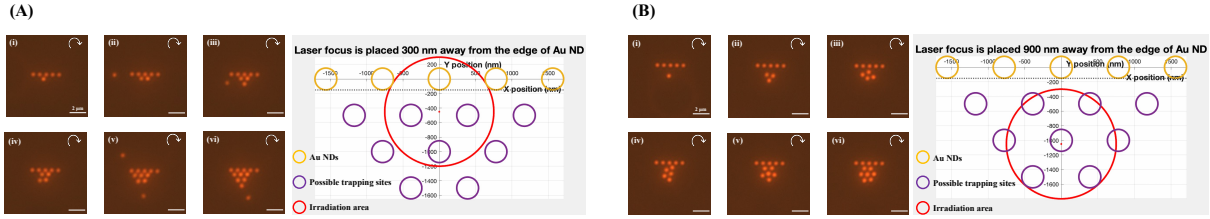

Figure 1. The representative snapshots of the evolving process of assembling 300 nm gold nanoparticles when the laser is shifted (A) 300 nm and (B) 900 nm away from the edge of the gold nanodisk. The top right angle represents the polarization direction. The illustration on the right shows the experimental scheme.

1. Huang, C.-H. *et al. Nat. Commun.,* **2022**, 13(1)
2. Huang, C. H., *et al.*, *J. Phys. Chem. C*, **2023**, *127* (38), 19044–19054.