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AFM-based optical force spectroscopy of plasmonic nanostructures

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Plasmonically-induced optical forces in the vicinity of metallic nanostructures have received considerable attention because of their applications in local positioning and manipulation of nano-objects. There have been a variety of works on nano-optical forces controlled by various geometric configurations of matallic nanostructures since the late 1990's [1-3].

Here in this study, we propose the use of our advanced atomic force microscopy (AFM) with high force sensitivity in order to quantitatively and qualitatively characterize optical forces generated between two metallic nanostructures. As schematically shown in Fig. 1(a), one of the metallic nanostructures is attached to the apex of an AFM probe while the other is immobilized on a substrate. The separation distance between the nanostructures is controllable with angstrom-scale precision by AFM, which enables us to measure both magnitude and sign (repulsive or attractive) of the plasmonically-induced optical force as a function of the distance.

Figure 1(b) shows a calculation result of force-distance curves of a two-silver-nanoparticle system with each particle diameter of 40 nm at the incident wavelength ranging from 300 nm to 700 nm. Polarization of the incident light is set parallel to the inter-particle axis, in which condition strong plasmonically-induced optical force is generated between the nanoparticles. In Fig. 1(b), the darker blue (red) color corresponds to stronger attractive (repulsive) force exerted between the nanoparticles. In the incident wavelength region between 400 nm and 450 nm, the repulsive force is dominant in the shorter distance range while the attractive force in the longer distance range. However, at the wavelength longer than 450 nm, only the attractive force is acting over the whole distance range, and it increases up to 50 pN as the distance decreases under a moderate incident laser power. Such amount of force is detectable using our advanced AFM system with force sensitivity of a few pN. Further characteristics of the plasmonically-induced optical forces will be discussed in our presentation along with some experimental results of AFM-based optical force spectroscopy.

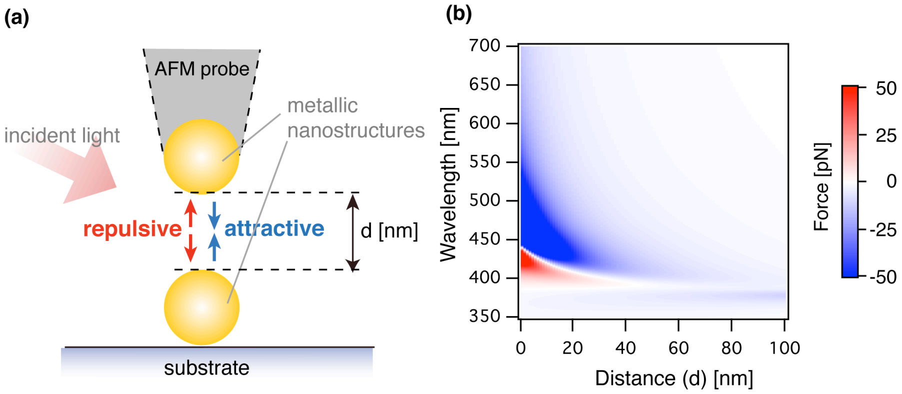

Figure 1 (a) Schematic of measuring optical forces exerted between metallic nanostructures by means of AFM-based force spectroscopy. (b) Calculated optical forces between two silver nanoparticles (40 nm in diameter) as a function of the inter-particle distance in the visible wavelength region.

References

[1] K. Okamoto and S. Kawata, Phy. Rev. Lett. **83** (1999) 4534.

[2] P. C. Chaumet, A. Rahmani, and M. Nieto-vesperinas, Phys. Rev. Lett. **88** (2002) 123601.

[3] M. L. Juan, M. Righini, and R. Quidant, Nat. Photonics **5** (2011) 349.