Optical near-field excitation in a nano-liquid droplet system

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Nano-liquid droplets are remarkable materials for transferring optical signals in a near-field regime. The newly discovered degrees of freedom involved in liquid-droplet systems, such as surface energy and entropy, have the potential for self-optimization and modulation of near-field optical interactions within nanosystems. The position and alignment of nano-liquid droplets should be optically controlled for enabling full operation of nano-optoelectronic devices that utilize optical near-fields. We have already investigated material transportation and optical near-field excitation using azobenzene molecular thin films with local polarization of optical near-fields [1-6]. Local plasmon excitation of metallic nanowires in bulk liquid crystals was demonstrated in a previous study; the liquid crystal molecules were oriented on optically controlled nanostructures of azo films [7].

In this study, we demonstrate the optical near-field excitation of water nanodroplets. The nanodroplets were self-assembled from micrometer-sized deionized water on PMMA-co-DR1 azo films and irradiated by propagating light or evanescent waves excited by a 532-nm visible laser. Nanoholes were formed around the nanodroplets owing to the photoisomerization of azo molecules [1,3]. The holes showed anisotropic shapes that clearly coincided with the polarization directions of the incident light, which irradiated the nanodroplets. In the case of evanescent wave illumination, the size of the holes is strongly dependent on the thickness of the azo molecular thin films, possibly relating to the size resonance of the optical near-field and water droplets.

Furthermore, we demonstrate the production of liquid crystal nanodroplets by means of electrospray deposition using a sharpened-metallic-wire electrode at the nanoscale. The radius and distribution of the nanodroplets were controlled by the applied voltage and by adjusting the distance between the electrodes and the samples. Rhodamine dye molecules were dispersed in the nanoparticles of nematic 5CB liquid crystals. The fluorescent spectra of the samples were blue-shifted. It is believed that this is the result of changes in the molecular aggregation states and/or modulation of near-field optical interactions in the nanoparticles of the liquid crystals. This cooperative phenomena provided by the nanodroplet system of liquid crystals will provide novel functions for nano-optoelectronic devices. We are currently investigating the optical near-field trapping of fluorescent nano-liquids and attempting to modify their distribution in nanoregions.

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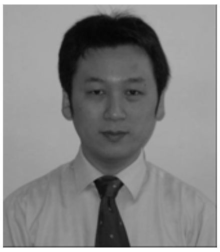

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He received BE, ME, and PhD degrees in electronics from Yamanashi University, in 1996, 1998, and 2003, respectively. He has been engaged in the research of high resolution spectroscopy and atomic spin control in optical near-fields. He is currently an Associate Professor at Niigata University. His research interests lie in the area of near-filed optical signal control using nano-structured organic material systems.