Nanophotonic droplet: all-autonomous fabrication of novel nanophotonic device by using dressed-photon technology

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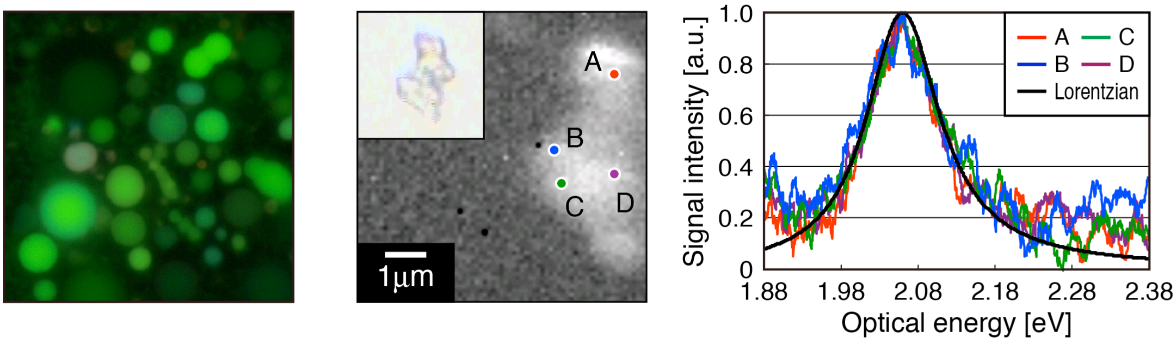
A fundamental issue in implementing practicable nanophotonic devices and systems that consist of coupled nanometric components [1] is the design and assembly of an appropriate nanometric setup using nanometric components to induce the intended optical nearfield interactions and corresponding optical far-field responses [2]. Among various fabrication technologies, which have been actively developed for realizing such devices and systems, self-assembly is one promising method of achieving mass-production of nanometric devices.

Previously, we reported an all-autonomous technique for producing *nanophotonic droplets* [3], which are coupled heterogeneous quantum dots (QDs) encapsulated by locally cured photocurable polymer. In this technique, a mixture of QDs and photocurable polymer is irradiated with incident light having a lower photon energy than the curing energy of the polymer, inducing a phonon-assisted process [4], namely, multistep excitation, which cures the polymer via excited phonon levels. Moreover, subsequent emission with higher photon energy from the incident light is occurred, and the photo-curable polymer in the surroundings is gradually cured by absorption of the emitted light to encapsulate the coupled QDs. The important point is that this process occurs only when heterogeneous QDs of similar size come close to each other [5].

In order to demonstrate basics of fabricating nanophotonic droplets, we experimentally produced nanophotonic droplets by our proposed method. Specifically, we used toluene solutions contain CdSe-QDs and ZnO-QDs, which emit visible and ultraviolet (UV) light, respectively, and UV-curable polymers. Figure 1(a) shows microscope emission images of produced nanophotonic droplets formed by irradiating the mixtures with a CW light having a wavelength of 532 nm for 30 minutes. As shown, nanophotonic droplets with extremely spherical structures were successfully obtained. The individual emission spectra of another four nanophotonic droplets A, B, C, and D indicated in Fig. 1(b) are respectively plotted in Fig. 1(c). These results evidently demonstrate the uniformity of the optical properties of the massively produced nanophotonic droplets.



(a) (b) (c)

Fig. 1. (a) SEM image microscope emission image of multiple nanophotonic droplets. Multiple four nanophotonic droplets (b) reveal similar shapes of emission spectra, which emitted from the contained CdSe-QDs. The result indicates that each nanophotonic droplet contains the same number of CdSe-QDs.

These findings show the fundamental features of our proposed method, where we can obtain a large number of nanophotonic droplets with homogeneous optical properties by using an all-autonomous fabrication process based on dressed-photon technology. Our method can be easily used in various applications where the further development of novel nanophotonic devices and nanotechnologies will be required.

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Refernces

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Naoya Tate was born in Osaka, Japan, on March 24, 1978. He received the B.E. and M.E. in physics, and Ph.D. degrees in information science from Osaka University in 2000, 2002, and 2006, respectively. From 2006 to 2007, he was a Researcher of the Core Research for Evolutional Science and Technology (CREST) at the Japan Science and Technology Agency (JST), Tokyo. In 2007, he joined Ohtsu research group, the University of Tokyo as a Project Researcher at the New Energy and Industrial Technology Development Organization (NEDO). His main field of interest is implementation of several applicative processing systems based on information photonics. Dr. Tate is a member of the Optical Society of America (OSA) and the Japan Society of Applied Physics.