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Basics of optical processing system based on nanophotonic droplets

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We have previously demonstrated a novel technique for autonomously forming a nanophotonic droplet (ND) [1–3], which is a micro-scale spherical polymer structure that contains coupled heterogeneous nanometric components, such as quantum dots (QDs) and organic dye molecules. The sort-selectivity and alignment accuracy of the nanometric components in each ND, and the related homogeneity of their optical functions, are due to a characteristic coupling and encapsulation process based on a phonon-assisted photo-curing method involving dressed-photon–phonon interactions [4]. The method only requires irradiating a mixture of components with light to induce optical near-field interactions between each component, and subsequent processes based on these interactions.

As schematically shown in Fig. 1, the basic concept of an ND enables hierarchical interconnection between the scale of nanometric optical behavior and macro-scale applications. Our recent work on the development of a system for mass-producing NDs has shown that it is possible to achieve arbitrary sizes and optical properties. Concurrently with this, we have been studying the implementation of an optical functional system that works on fundamental characteristics of NDs, as an example of a nanophotonic information system [5].

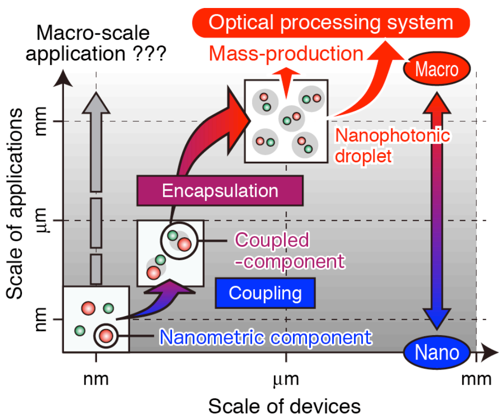

Figure 1: Basic concept of ND based on hierarchical interconnection between nano and macro scales.

Recent research in the field of *beyond von Neumann computing* [6] suggests that effective utilization of *fluctuations* in a physical setup forms an essential part of such a computing system. On the other hand, autonomy observed in the formation of NDs and the homogeneity of their optical properties are affected by fluctuations of the components in the mixture, which depend on thermal and size-resonant effects [7] of optical near-field interactions that occur when the components encounter each other. Due to such effects, the components freely float in the mixture and couple with heterogeneous components of similar size, and higher intensity interactions can be expected between them. Such behavior corresponds to a kind of solution solving in which a particular solution that satisfies appropriate conditions is sought. Figure 2 shows some results of demonstrations, indicating successive searching of a particular size of CdSe-QDs by utilizing coupling with CdS-QDs, and the subsequent increase in emission intensity. The accuracy and efficiency of such processes can be quantified with results of experimental measurements, such as optical spectrometry and small angle scattering.

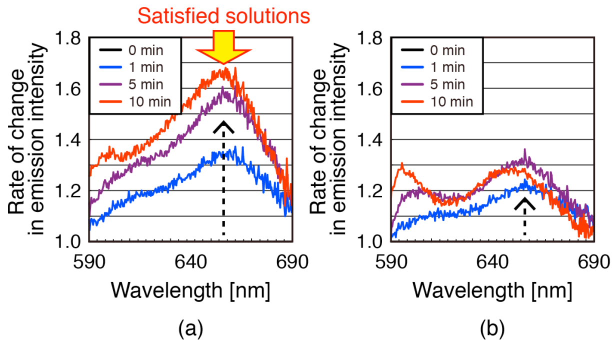

Figure 2: Rate of change of emission intensity from CdSe-QDs, (a) when coupled with CdS-QDs and (b) without CdS-QDs. The increased intensity at particular wavelengths indicates that CdSe-QDs of a particular size are successfully coupled with CdS-QDs of corresponding size.

Furthermore, while the formation process of NDs is fundamentally irreversible, more advanced processing operations can be realized by incorporating a reversible photoreaction mechanism, such as photoisomerization, into the formation process, to provide an additional control system enabling more advanced processing. These studies on NDs are expected to suggest other approaches to practical implementations of beyond von Neumann computing.

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