LIGHT PROPAGATION IN TWO-DIMENSIONAL SPHERICAL ARRAYS

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Two-dimensional (2D) ordered arrays, in which fine particles or molecules are densely packed in a highly oriented fashion, have been extensively studied as new types of nanoscale architecture.[1] Very recently, a new viewpoint of 2D array research has arisen from the field of physics, that is, the 2D array as a photonic crystal.[2]

Photonic crystals are periodic dielectric crystals in which photons behave a similar way as electrons do in semiconductors[3, 4]. 2D arrays also have the same periodic dielectric structures, i.e., periodic structures of spheres and air. Thus, it is expected that the 2D arrays may function as photonic crystals.

When we first considered the 2D array for the study of photonic crystals, we were interested in precisely how the photons behave within the array. To check this point, we tried to put the light source in the 2D array. It is easy to make this type of array if one uses the general 2D array preparation method, which makes use of capillary forces between colloidal particles. Just one thing is different: the colloidal suspension contains three different types of the particles, non-fluorescent polystyrene (PSt) ("Polybead" PSt microspheres, Polysciences, Inc.) and the others are two types of fluorescent [red (541/640 nm) and green (458/430 nm)] PSt particles ("Fluoresbrite" microspheres, Polysciences, Inc., 1 μm dia.). The fluorescent particles were expected to function as light sources in the 2D array. In this paper, we report how the photons propagate in this quasi-2D photonic crystal within both mono and triple layers using such composite-type arrays. We used a combination of phase-contrast microscopy and fluorescence microscopy. Both techniques are available in the same microscope (BX60-34-FLBD1, OLYMPUS, Japan), so that we can easily observe the same area to obtain information on both packing and light propagation.[5, 6]

Figure (a) shows a fluorescence microscopic image of a monolayer. This shows six-fold symmetric arrays of bright red and green spots forming radial patterns emanating from the fluorescent particles. Comparing the phase-contrast microscopic image and the