A Plug-In Electric Plate for Micro Assembly of Colloidal Mixtures

Inst. Nano. Sci. & Tech., Kochi Univ. of Tech., Hiroshi Frusawa
E-mail: frusawa.hiroshi@kochi-tech.ac.jp

大小コロイド粒子混合系の枯渇相分離、カーボンナノチューブとコロイド混合集積体のメゾ構造などを、簡便に短時間で観察する方法を提案する。具体的には、マニピュレータに装着された針電極対を平行に配置し、誘電泳動により擬２次元集積を行う。

1. Introduction

Mixing colloids of different sizes and shapes has served to yield a variety of mesostructures such as superlattice in binary colloids and lamellar phase of rod-colloid mixtures, as well as to enhance protein crystallization and epitaxial growth of colloidal crystals. Particularly, colloidal composites containing nanoparticles have attracted research interest due to their unique properties. In designing the nano-composites, it must be taken care that the high size asymmetry between micro- and nano-particles has tendency to bring about entropy driven demixing due to depletion attraction [1] which is, though, exploited for both protein crystallite formation and colloidal expitaxy on patterned templates. Here we propose a highthroughput screening method for the cluster formation in electrically directed colloidal mixtures between plug-in electrode needles.

2. Plug-In Style of Electric Plate

What we would like to achieve is a short time determination on demand as to whether different species of colloids mix or not. Toward this end, we introduced a parallel pair of tungsten electrode needles with tip diameter of 1 μm whose positions are controlled by two micromanipulators, respectively. Several features emerge from the simple setup. Among them, one unique point is that the electrode pair is movable independently of the sample holder, by which we can find out cluster formation in free-standing like colloidal film of micron-scale (CFM) anywhere, especially at the positions without substrate or gravity effects, in contrast to built-in styles as before [2].

3. Results

Figures 1 are optical micrographs, after 4 minutes from starting to apply the electric field, of CFM composed of carboxyl latex particle mixtures with large size ratio. As the diameter of smaller particles increase from 0.2-μm to 0.3-μm, it is observed that the segregation of larger particles becomes weaker in consistent with scanning electron microscopy images of the same samples dried.

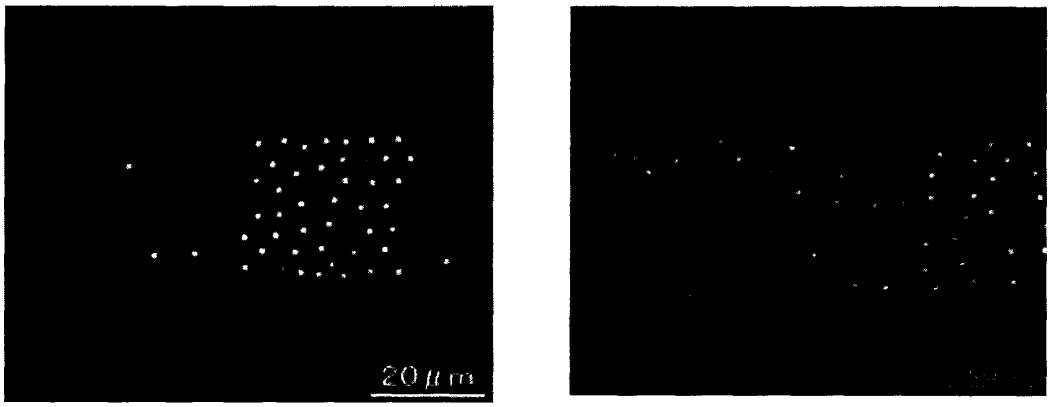

Figure 1: Optical micrographs of dielectrophoretic assembly of colloidal mixtures. Left: Strong segregation of 3-μm and 0.2-μm particles. Right: Weak segregation of 3-μm and 0.3-μm particles.

Next, we directed composite mesostructure of multi-walled carbon nanotubes and the above 3-μm colloids. Making use of known phenomena that carbon nanotubes deposit to form bundles called microwires perpendicular to electrodes [3], we get stable chains of colloids adhered along the microwiresin under the electric field of 300 kHz as shown in the left side of Fig. 2. Changing the frequency to 2MHz, on the other hand, colloids start to wander around and eventually aggregate in the middle area of CFM as seen in the right side of Fig. 2, though it remains to be explored whether the driving force is an electric one or the depletion attraction in rod-sphere mixtures.

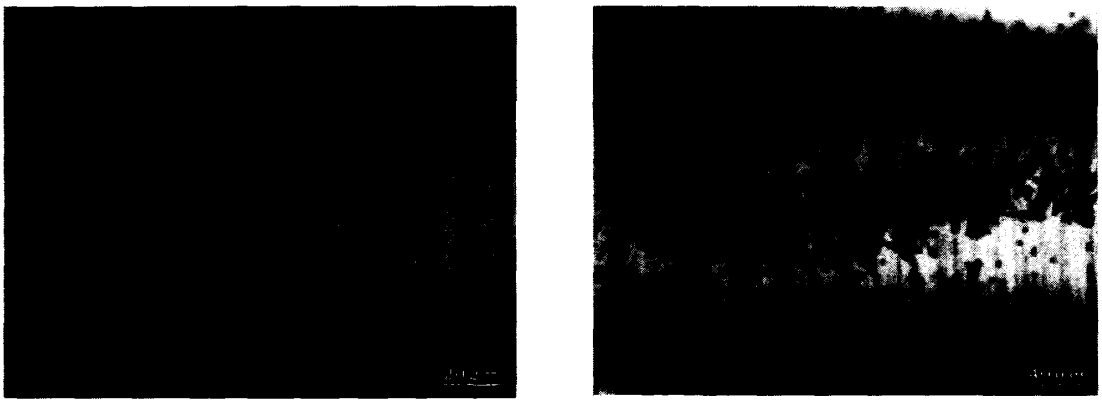

Figure 2: Optical micrographs of nano-composite of multi-walled carbon nanotubes and 3-μm colloids. Left: Colloidal chains parallel to aligned tubes under 300kHz AC field. Right: Colloidal cluster sandwiched between oriented tubes grown from both electrodes under 2 MHz AC field.

References

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