RAPID FABRICATION OF COLLOIDAL CRYSTAL ASSISTED BY ELECTROPHORETIC DEPOSITION TECHUNIQUE

Tetsuo Uchikoshi, Research Center for Functional Materials, National Institute for Materials Science, Japan;
Graduate School of Chemical Sciences and Engineering, Hokkaido University, Japan
uchikoshi.tetsuo@nims.go.jp
Thi Hoai Giang Tran, Graduate School of Chemical Sciences and Engineering, Hokkaido University, Japan
Masaki Koike, Research Center for Functional Materials, National Institute for Materials Science, Japan
Hiroshi Fudouzi, Research Center for Functional Materials, National Institute for Materials Science, Japan

Key Words: Colloidal crystal, Structural color, Polystyrene.

Colloidal crystals with tunable structural colors have potential sensing applications in a wide range of fields. One of the sensing applications is to visualize distortion of material deformation. For example, colloidal crystal films coated on polyethylene terephthalate (PET) sheets can easily and conveniently inspect structural materials for degradation. However, it usually takes several days to fabricate this sheet. From an engineering perspective, high-speed processes are important to reduce production costs. Therefore, the application of electrophoretic deposition (EPD) technique is expected as an alternative processing method.[1-2]

Polystyrene colloids (PS, ϕ203.6 nm) were prepared by standard emulsion process in an aqueous medium. The aqueous suspension was mixed with ethanol at 1:4 weight ratio. Indium tin oxide (ITO)-coated PET sheets (10×15 cm^2) were used as a conducting electrode. A stainless-steel plate was used as a counter electrode for the colloidal crystal film coating. In the EPD process, DC voltage at 4 V/cm for 5 min was applied and then the PET sheet was pulled out of the suspension at a constant speed of 3 mm/s and then dried at room temperature. After drying, the deposited film was filled with silicone elastomer to fix the particles and expand the space between the particles. Reflection spectra were measured using a small spectroscope for color evaluation. Microstructure of the colloidal crystal film was observed by SEM. A tensile test of the colloidal crystal film was carried out using an anode-oxidized black aluminum plate for strain visualization.

Figure 1 shows the surface and cross-sectional images of the colloidal crystal film. The film thickness was about 10 µm and most PS colloids are closely packed. Figure 2 shows a schematic diagram of the change in structure due to deformation. The structural color changed as the spacing decreased from d_1 to d_2 by the tensile test: Before the test, a reflection spectrum appeared near 625 nm, exhibiting red structural color. After the test, a reflection spectrum shifted to around 580 nm, exhibiting green structural color.

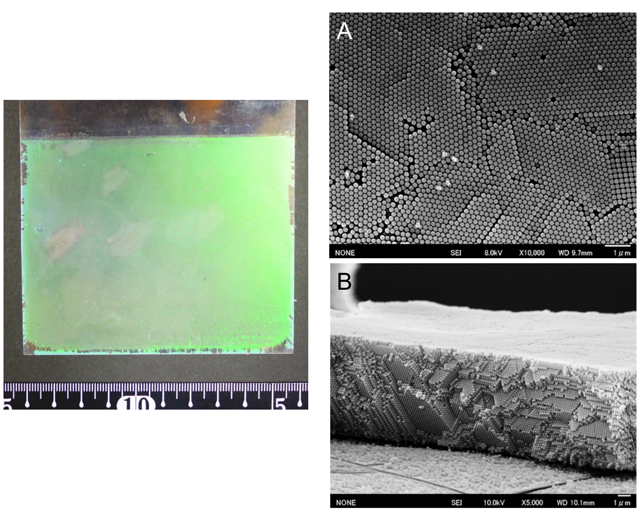

Figure 1 – Optical and SEM images of the PS film obtained on an ITO/PET sheet: A and B: Top surface, C: Cross-sectional

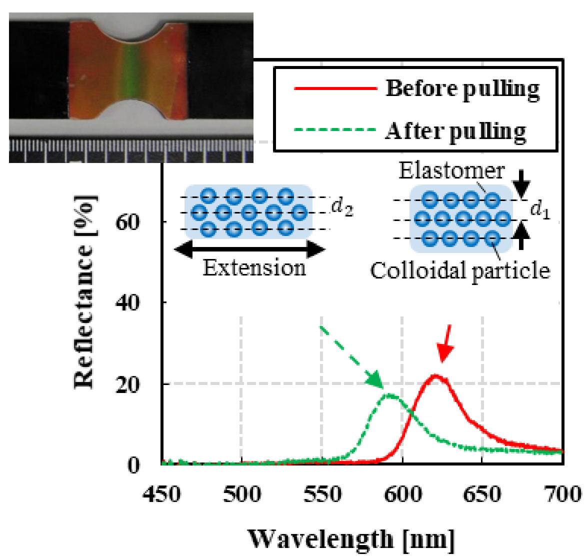

Figure 2 – Structural color change of the colloidal crystal film by a tensile test: By applying tensile stress, the color changed red to green due to the reducing lattice distance from d_1 to d_2.

[1] K. Katagiri et al., *RSC Adv.* 2018, 8, 10776.
[2] K. Katagiri *et al.*, *NPG Asia Mater.* 2017, *8*, e355.