ENLARGEMENT OF GRAINS OF SILICA COLLOIDAL CRYSTALS BY CENTRIFUGATION WITH AN INVERTED-TRIANGLE SHAPED CONTAINER

Kaori Hashimoto, Yoshihisa Suzuki*, Atsushi Mori, Shin-ichiro Yanagiya, Katsuhiro Tamura

Graduate School of Advanced technology and Science, The University of Tokushima,
2-1, Minamijosanjima, Tokushima 770-8506, Japan.
*e-mail: suzuki@chem.tokushima-u.ac.jp

Introduction

Close-packed face-centered cubic (F.C.C.) silica colloidal crystals provide templates for the creation of the inverse-opals with three dimensional (3D) full photonic band gap (PBG) [1], and they are easily fabricated by drying highly concentrated colloidal crystals [2-3].

These crystals were obtained by centrifugation [2-3, 4] and had relatively large columnar-shaped grains.

However, nucleation and enlargement of the grains can not be easily controlled in a normal flat-bottomed container by centrifugation (Fig. 1(a)). In general, several grains are nucleated on the flat bottom all at once. In addition, width of the grains which are once nucleated in the flat container becomes almost constant because of the growth competitions between adjacent grains. Elimination and widening of the grains are indispensable for enlargement of grains.

An inverted-triangle shaped container will be useful for enlargement of the grains by centrifugation. The inverted-triangle shaped container has a pointed bottom and an expanded top. The pointed bottom eliminates the nucleation of the grains. The expanded top widens the grains.

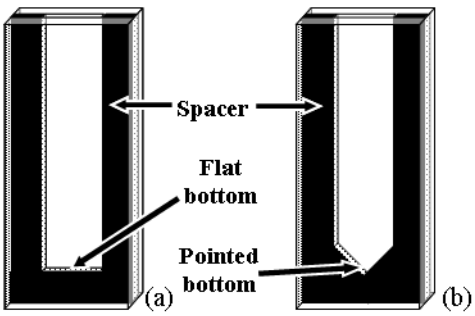

Fig. 1. Schematic illustration of a flat container (a) and an inverted-triangle shaped container (b). Containers have black spacers.

In this study, we compared the size of the grains prepared in the inverted-triangle shaped container with that in the flat container.

Experimental

The flat container has a rectangle internal-shaped spacer (width = 6 mm, thickness = 0.2 mm) (Fig. 1(a)). The inverted-triangle shaped container has an inverted-triangle internal-shaped spacer (vertical-angle = 90° , maximum width = 6 mm, thickness = 0.2 mm) between two glass slides (Fig. 1(b)). Dispersion of silica particles (diameter = 110nm, volume fraction = 0.0968, NIPPON SHOKUBAI CO. LTD.) was injected into the containers. Centrifugal acceleration 2.2 G was applied for 30 days.

We observed retardation colors of the grains using a transmitted-light polarization microscope (VANOX, OLYMPUS) [5]. Size and orientation were evaluated with the retardation colors of the grains. The retardation colors of a grain is different from that of the other grain with a different orientation.

Result and Discussion

The largest grain in the inverted-triangle container (2.65 mm x 4 mm x 0.2 mm, volume = 1.26 mm^3) was much larger than that in the flat container (0.66 mm x 3.2 mm x 0.2 mm, volume = 0.36 mm^3).

Maximum widths of the grains W_{max} in inverted-triangle shaped containers and in a flat container are shown in Fig. 2. The values of W_{max}

in a flat container were larger than that in inverted-triangle shaped containers near the bottoms of containers. This is mainly due to faster condensation of particles at the pointed bottom in the inverted-triangle shaped container, since the faster condensation results in faster nucleation of grains. The values of W_{max} in the inverted-triangle shaped containers become larger than those in the flat container when grains grow higher than 1.5 ~ 2.0 mm from bottom of containers. Crystals in the inverted-triangle shaped containers have spaces for grains to grow in a transverse direction.

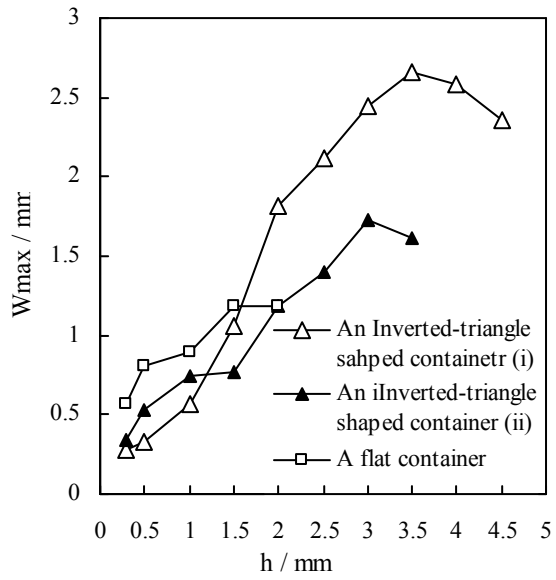

Fig. 2. The widths of the largest grains in the inverted-triangle shaped containers and the flat container. h is height of the crystals.

The number of the grains in the inverted-triangle shaped container was less than half that in the flat container.

Conclusion.

Large grains of the silica F.C.C. colloidal crystals were obtained with an inverted-triangle shaped container by centrifugation. The largest grains of the inverted-triangle shaped containers were much larger than the largest grains of a flat containers by centrifugation.

The number of the grains was eliminated by pointing the bottom of the inverted-triangle shaped container.

Grains of the inverted-triangle shaped container were widened with growth of the colloidal crystals.

Reference

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