

Experimental procedure for 2D-hexagonally ordered mesoporous alumina film:

The precursor solution was prepared according to the following procedure. Aluminum tri-*n*-butoxide (2.46 g) was added to a solution of 37 wt% hydrochloric acid (1.71 g) and absolute ethanol (4.74 g) under stirring. After 15 min of vigorous stirring, a solution of Brij 58 (1.00 g) dissolved in absolute ethanol (9.48 g) was added to this solution. Then, after stirring for another 6 h at room temperature, the clear precursor solution was spin-coated on clean silicon substrates at 23 °C and 50 % relative humidity. The spinning speed and time were fixed at 3,000 rpm and 30 s, respectively. The as-prepared thin films were then aged at -20 °C with 20 % relative humidity for 2 h. After the aging, the films were calcined in air at 400 °C for 4 h with a ramp rate of 1 °C·min⁻¹.

Figures and Figure Captions

Figure S1

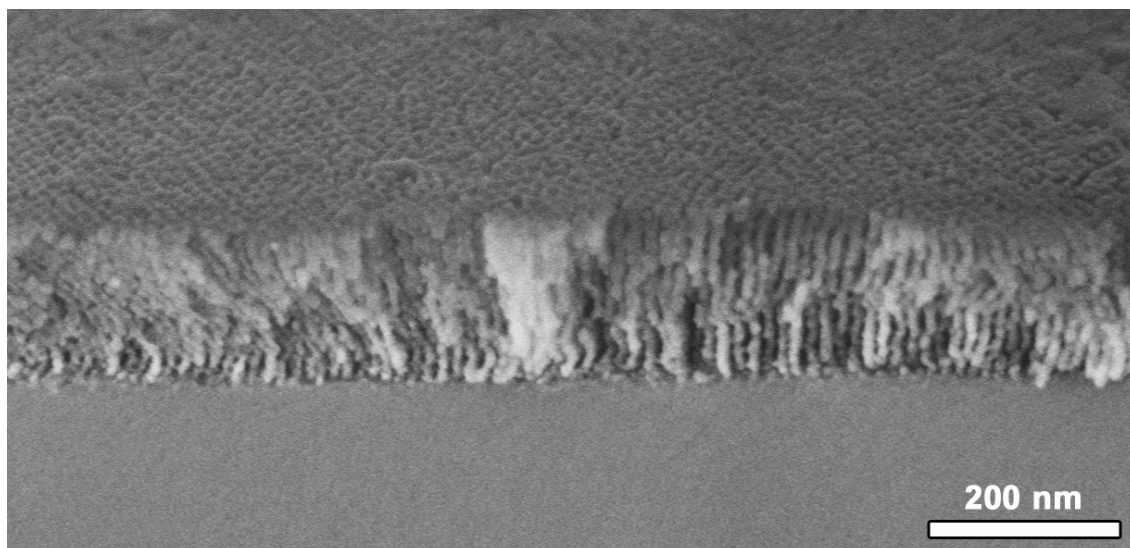


Figure S1 Cross-sectional SEM image of mesoporous alumina film with vertical mesoporosity.

Figure S2

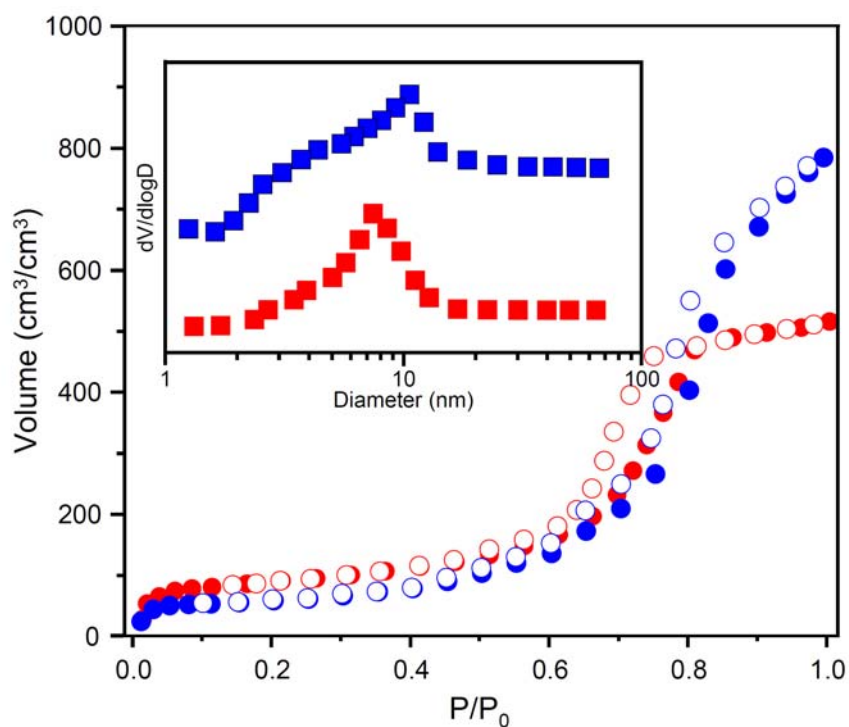


Figure S2 Nitrogen adsorption-desorption isotherm for mesoporous alumina films with cage-type mesopores (Red) and vertical mesoporosity (Blue), respectively. The pore size distribution curves calculated by BJH method are also shown as an inset image. The adsorbed volume is normalized by the film volume.

Figure S3

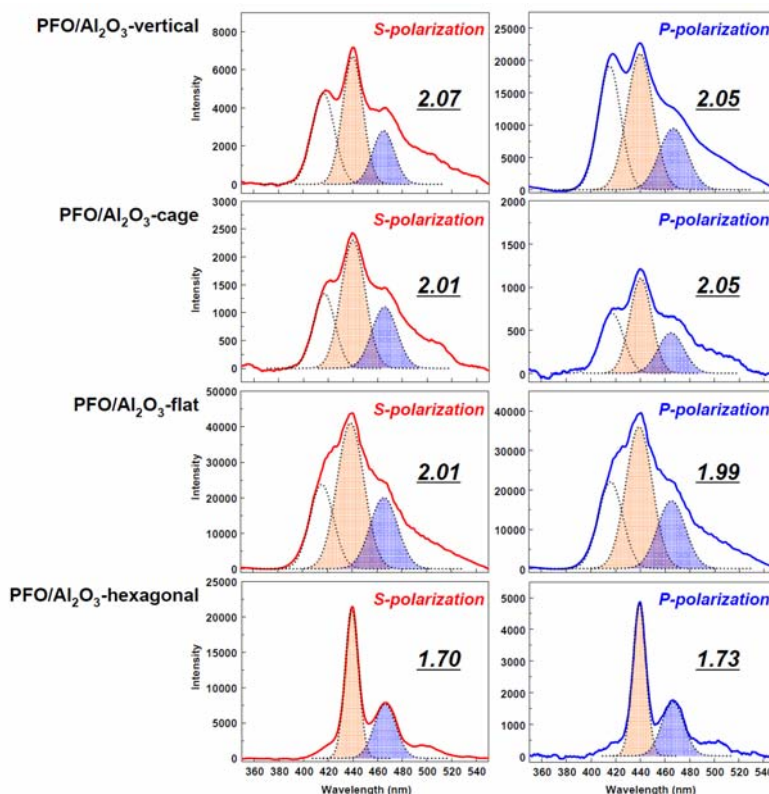


Figure S3 Relative peak areas of 0-1 band to 0-2 band for β -phase emission, calculated by peak deconvolution.

Comment on Figure S3: The band at 417 nm can be assigned to be 0-0 band for amorphous phase emission. When the PFO amorphous phase is formed, the 0-0 band for amorphous phase emission is observable. This band has no correlation with other band peaks. On the other hand, the bands at 438 nm and 466 nm can be assigned to be 0-1 and 0-2 bands for β -phase emission, respectively. The peak area for 0-1 band strongly correlates with that for 0-2 band. From calculation by waveform separations, the relative peak areas of 0-1 band to 0-2 band were almost 2 for all the films.

Figure S4

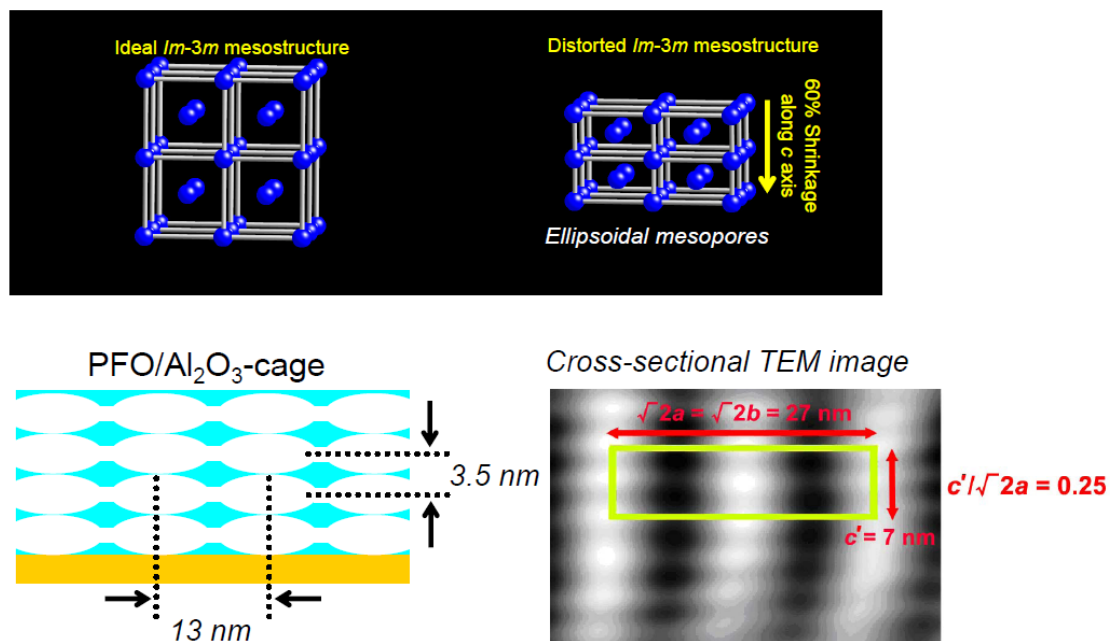


Figure S4 (Top) Illustration showing $\langle 100 \rangle$ view of distorted $Im-3m$ mesostructure. (Bottom) Illustration showing $\langle 110 \rangle$ view of distorted $Im-3m$ mesostructure and actual cross-sectional TEM image.

Figure S5

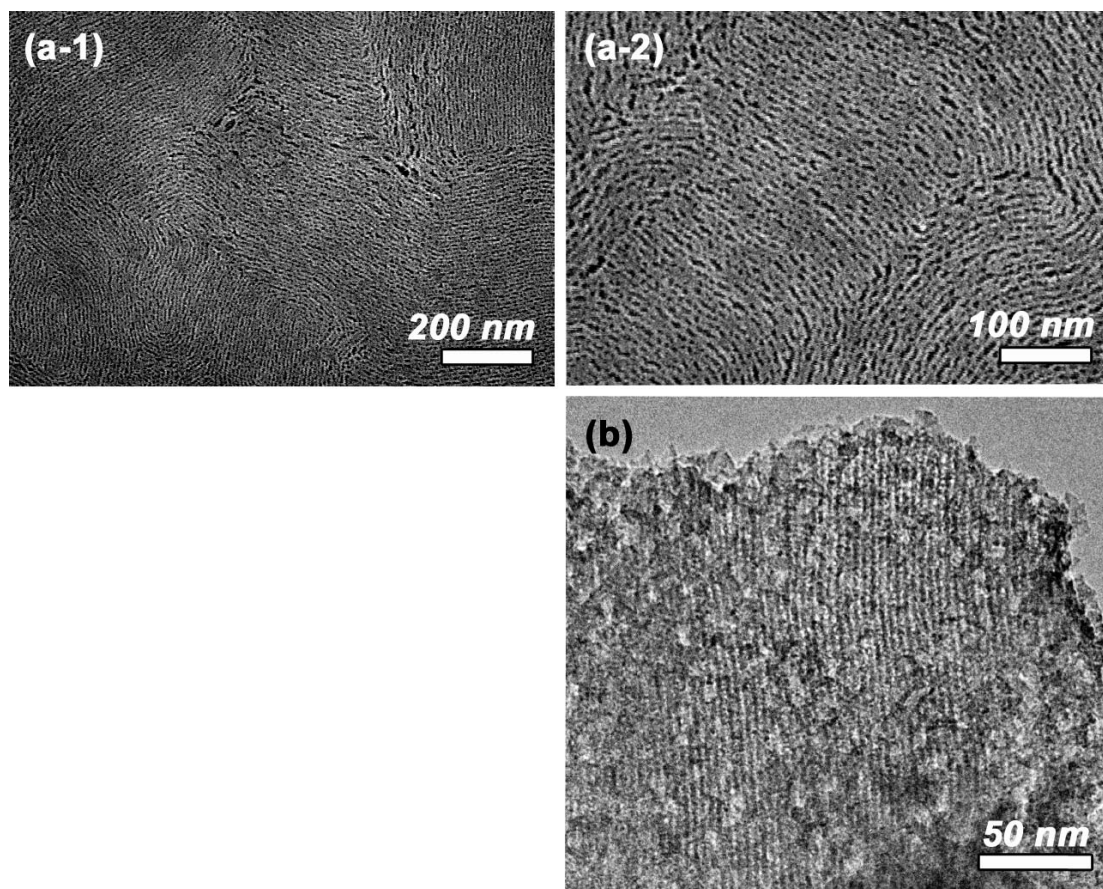


Figure S5 (a) Top-surface SEM and (b) TEM images for 2D-hexagonally ordered mesoporous alumina film prepared with Brij 58.