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Electronic Supplementary Information

High density Array of Multiferroic Nanoislands in a Large Area

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S1. Reconstruction of SrTiO3:Nb (STO:Nb) (100)

A single crystalline STO:Nb (100) (Nb: 0.5 wt%, CrysTec GmbH, Germany) was immersed in deionized (DI) water at 60 ^{o}C for 10 min. Then, it was etched by a buffered oxide etchant (BOE: JT Bakers, U.S.A.) for 40 s to increase the amount of TiO_2 in the top layer of the substrate. BOE consists of 6:1 (v/v) 40 % NH_4F in water and 49 % HF in water. After etched substrate was thoroughly rinsed with DI-water, it was thermally treated at 1000 ^{o}C for 2 h. The thermally treated sample shows terrace-like topology, while the as-received sample does not have this structure, as shown in Fig. S1. We found that this pretreatment was essential for obtaining a high density array of $BiFeO_3$ (BFO) nanoislands on the substrate. Otherwise, the array of BFO nanoislands could not be maintained.

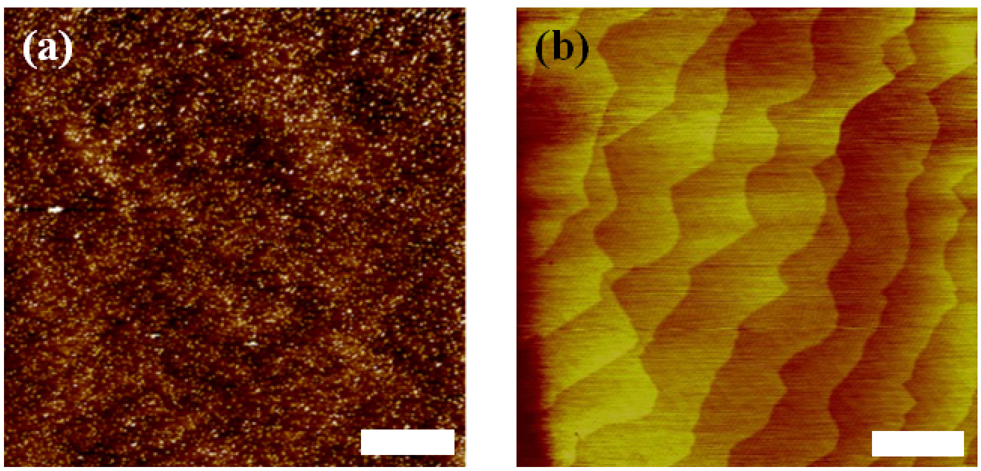

Fig S1. AFM topography images of (a) pristine and (b) thermal treated STO:Nb (100) substrate at 1000 ^{o}C for 2 h. Scale bar is 1µm.

S2. Fabrication of various sizes of BFO nanoislands by using different AAO templates

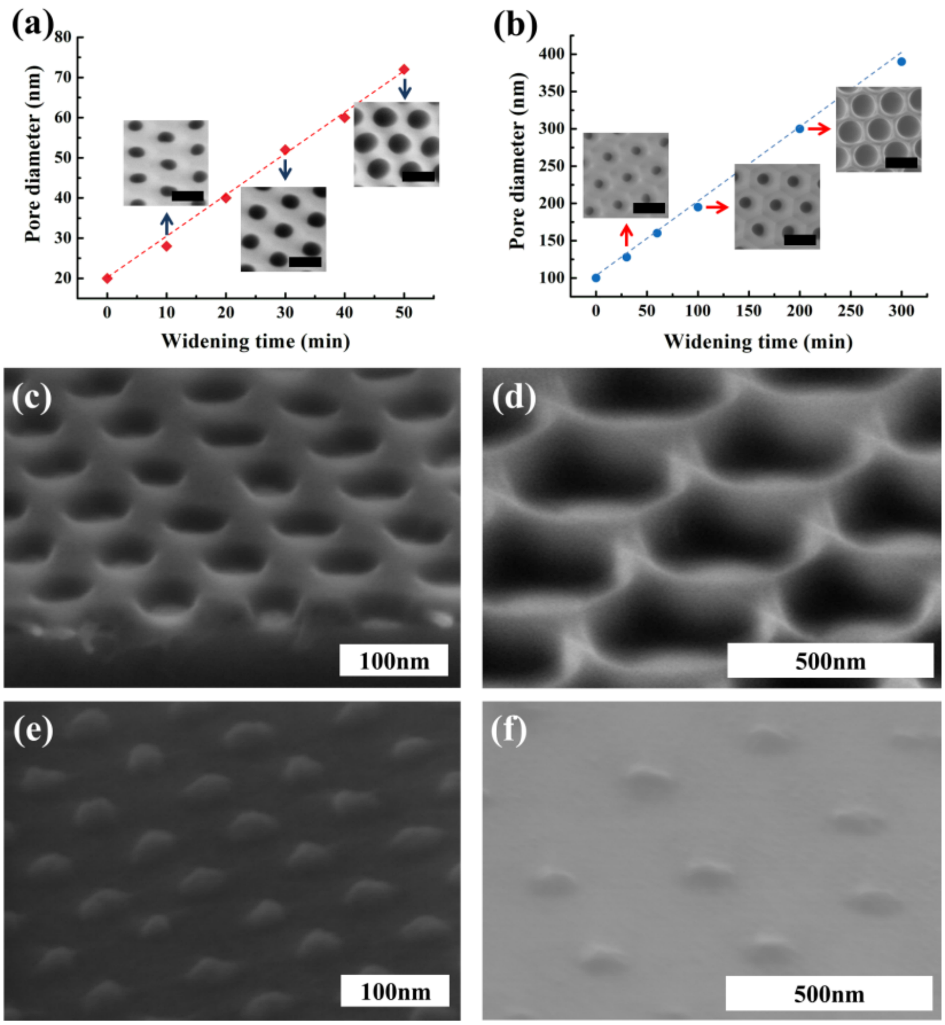

Fig S2. AAO templates with various pore size by pore widening process: (a) oxalic acid and (b) phosphoric acid. Top view SEM image of nanoporous PS templates prepared by AAO templates with two different pore sizes (30 nm (c) and 250 nm (d)). (e) High density array of BFO nanoislands using two different nanoporous PS templates.

Various pore sizes in the AAO templates are obtained by widening process (Figures S2a and S2b) and type of acid (oxalic and phosphoric acids). Figures S2c and S2d show top view SEM images of nanoporous PS templates with two different pore sizes. Using these two nanoprous PS templates, we obtained BFO nanoislands with two different sizes (Figure S2e and S2f).

S3. Floating of AAO template on PS thin film after detachment from Al substrate

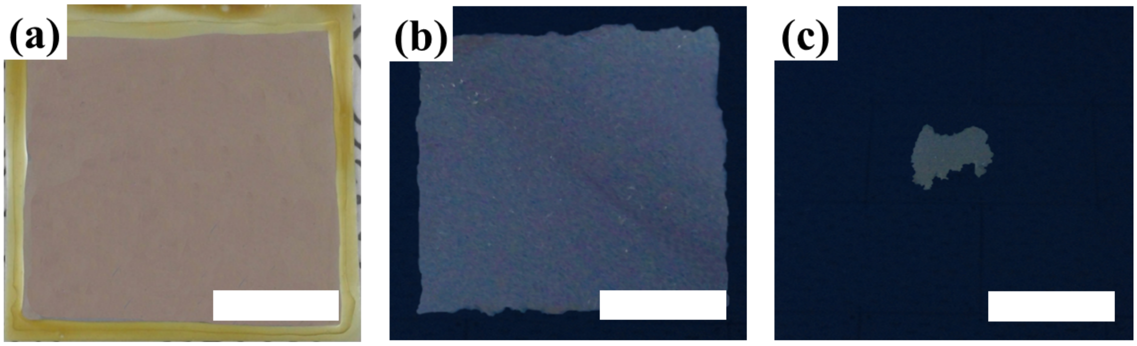

Fig. S3. (a) Image of fabricated AAO template with size of 5cm $\times$ 5 cm. Floating of AAO templates with two thicknesses (1 μm (b) and 300 nm (c)) on PS thin film after detaching from Al substrate. Scale bar is 2 cm.

When an AAO template with a large area (for instance, 5cm $\times$ 5 cm: see Fig. S3a) is detached from Al substrate and floated on PS film, it is very important to use a thick AAO template to have uniform coverage. For instance, when an AAO template with a thickness of at least 1 μm was used, it was successfully floated on PS thin film throughout the entire area (Figure S3b). But, if a thin AAO template (a thickness of 300 nm) was detached from Al substrate and floated on PS film, only small portions of the AAO template were floated on PS film because of tearing and resulting from the bubbles formed during the electrochemical detachment process (Figure S3c).

S4. Magnetization measurement of BFO nanoislands

SQUID based MPMS data of STO:Nb

To investigate the hysteresis of magnetic properties for BFO nanoislands, magnetization arising from STO:Nb(100) substrate should be subtracted. Fig. S5 shows magnetic hysteresis loops of STO:Nb (100) measured by SQUID based MPMS at room temperature**.**

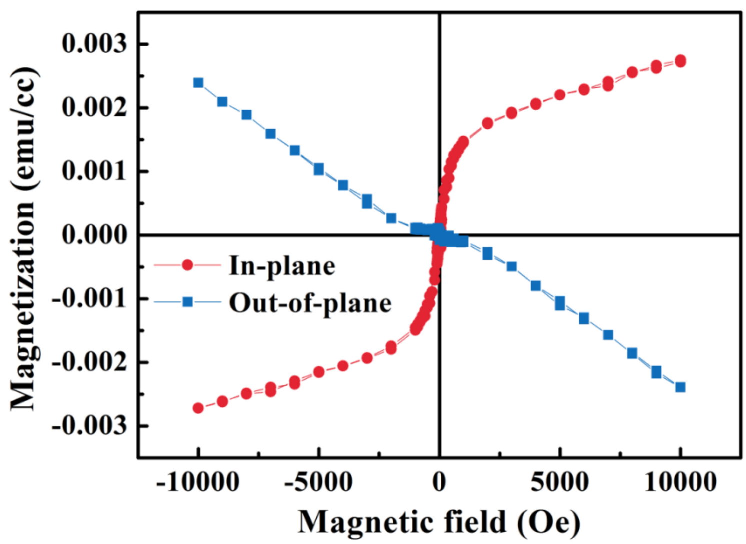

Fig. S4. Magnetic hysteresis loops of STO:Nb (100) measured by SQUID based MPMS at room temperature.