Electronic Supplementary Material (ESI) for Nanoscale.

Utilizing the anti-ferromagnetic functionality of multiferroic shell to study exchange bias in hybrid core-shell nanostructures

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Methods

All the chemicals have been purchased from Sinopharm Chemical Reagent Beijing Co., Ltd and Alfa Aesar Co. Ltd.

[ESI-1] Synthesis of $Bi_{0.87}La_{0.13}FeO_3$ (BLFO) nanotubes through sol-gel method

Chemical used:

Bismuth nitrate $Bi(NO_3)_3{\cdot}5H_2O$

Iron nitrate $Fe(NO_3)_3{\cdot}9H_2O$

Lanthanum nitrate $La(NO_3)_3.6H_2O$

2-Methoxyethanol/Ethylene glycol monomethyle ether (EGME)

The sol-gel method has been employed for the fabrication of BLFO nanotubes. The infiltration time has been optimized carefully to get unbroken and non-porous nanotubes. High purity $Bi(NO_3)_3.5H_2O$, $Fe(NO_3)_3.9H_2O$ and $La(NO_3)_3.6H_2O$ have been dissolved in ethylene glycol monomethyl ether (EGME). Few drops of nitric acid have been added to adjust pH of the sol and the concentration has been adjusted to 0.3 M followed by room temperature stirring for about 1 hour. AAO templates with pore diameter of 120 nm have been immersed into the sol for about 20 minutes to get infiltration of BLFO sol inside the pores. AAO templates having BLFO precursor have been annealed at 600˚C, 650˚C and 700˚C.

[ESI-2] Synthesis of $Co_{90}Pt_{10}$ (CoPt) nanowires through electrochemical deposition

Chemical used:

Cobalt sulfamate $Co(NH_2SO_3)_2 \cdot 4H_2O$

Diammine dinitritoplatinum $Pt(NO_2)_2(NH_3)_2$,

Diammonium hydrogen citrate $C_6H_{14}N_2O_7$

For chemical electrodeposition of CoPt nanowires, a Cu layer of 200 nm thickness was sputtered on one side of AAO template filled with BLFO nanotubes to serve as working electrode. The aqueous electrolyte composed of 0.15 M cobalt sulfamate, 0.05 M diammine dinitritoplatinum, and 0.15 M diammonium hydrogen citrate has been used for electrochemical deposition with pH around 3.5. A conventional three electrode cell has been used potentiostatically at room temperature with constant stirring during electrodeposition and a voltage of -0.1 V versus the saturated calomel electrode (SCE). Versa STAT 3 (Princeton Applied Research) was employed for electrodeposition by using Versa Studio Electrochemistry Software to control the applied potential.

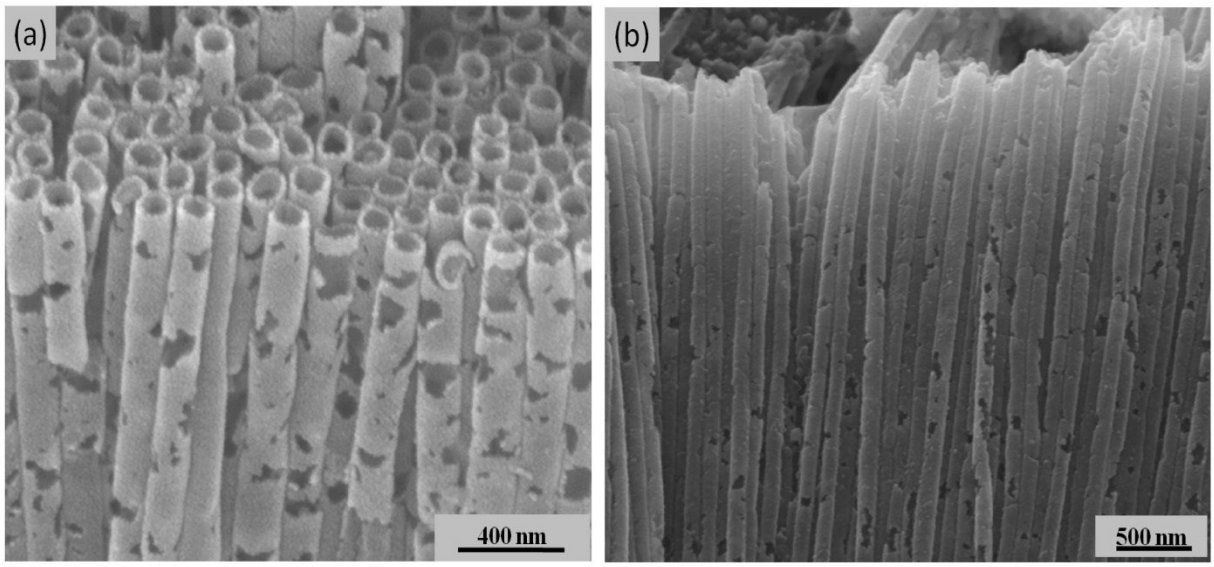

Fig. S1 SEM images of porous and broken BLFO nanotubes formed when the Infiltration of the precursor is not sufficient.

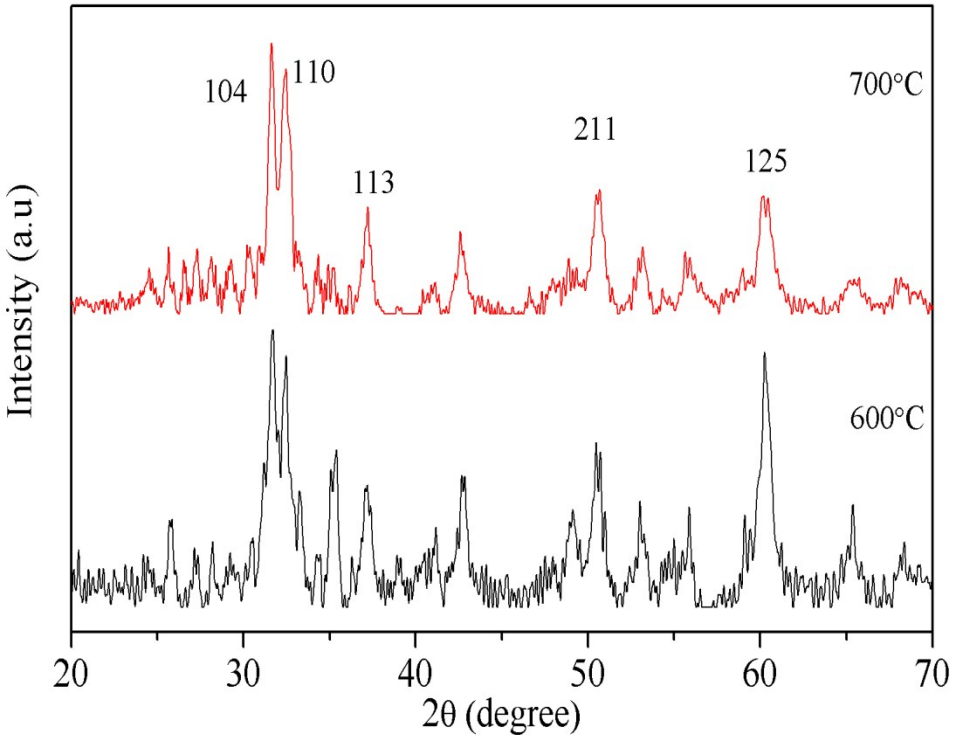

Fig. S2 XRD patterns of BFO nanotubes without La doping annealed at 600˚C and 700˚C.

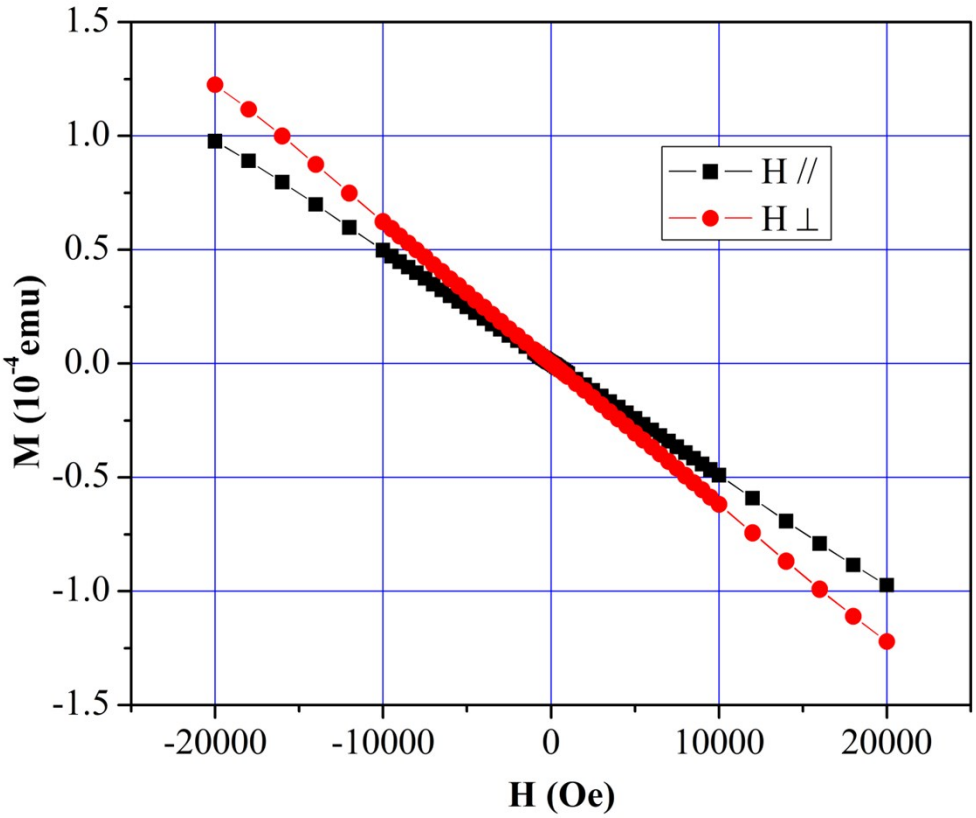

Fig. S3 M-H hysteresis loops of BLFO nanotubes measured by VSM at room temperature with applied field angle parallel and perpendicular to nanotubes' axis.

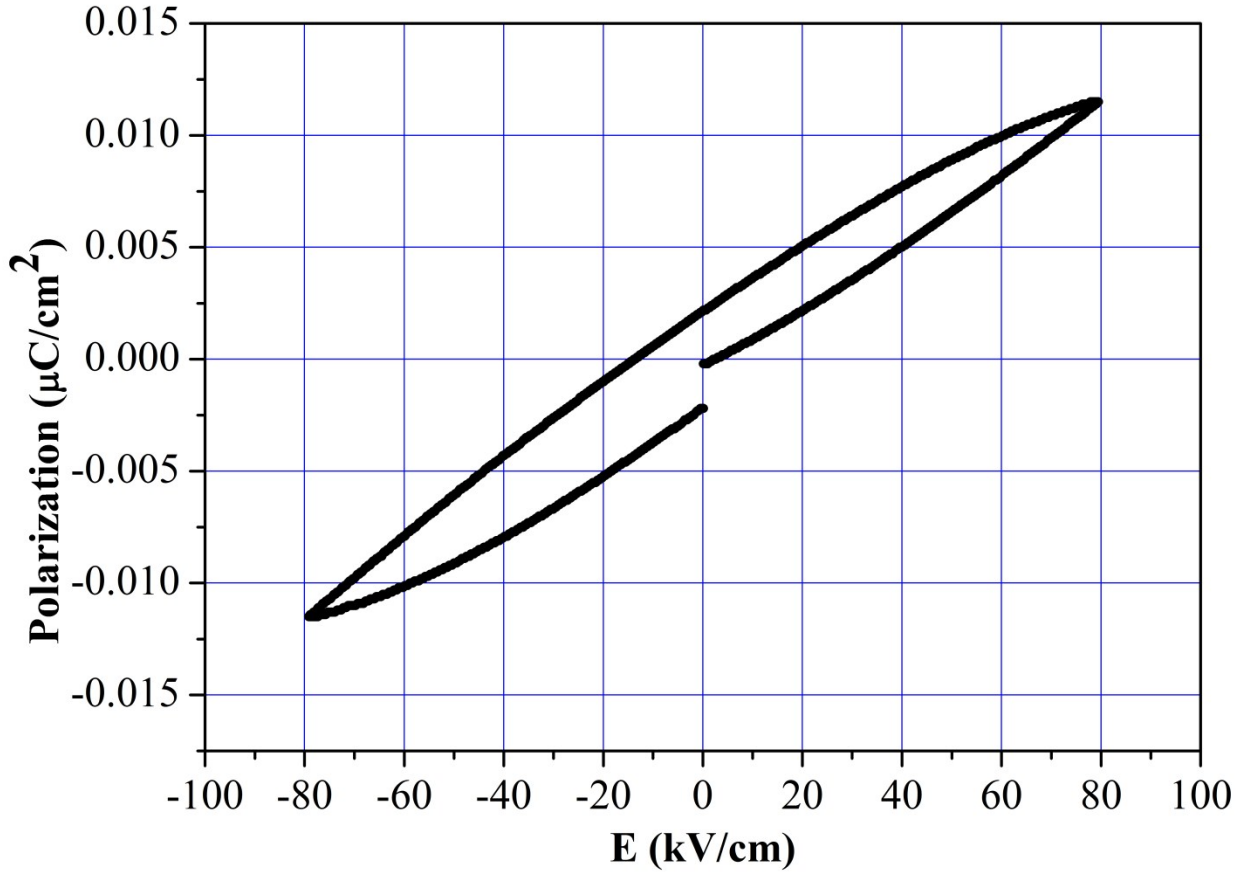

Fig. S4 Room temperature P-E loop of BFO nanotubes without La doping.