Supplementary Information

Strain-induced Electrostatic Enhancements of $BiFeO_3$ Nanowire Loops

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1. Electrospinning fabrication of $BiFeO_3$ nanowires

The synthesis of BFO nanowires by electrospinning method has been well-developed in our previous studies[1-3]. In a typical process, the BFO sol–gel precursor solution was prepared by dissolving 4 g $Bi(NO_3)_3 \cdot 5H_2O$ and 3 g $Fe(NO_3)_3 \cdot 9H_2O$ salts in 10 mL 2-methoxyethanol. The pH value of the solution was adjusted to 4 by adding ethanolamine. This mixture was magnetically stirred for 2 hours at room temperature. The polymer solution of 15 wt% was prepared by dissolving nylon-6 crystals to formic acid. The prepared BFO solution was added to this polymer solution drop by drop to obtain a homogeneous BFO precursor solution for the electrospinning process. A home-made electrospinning unit was used for the fabrication of BFO NWs. The obtained nylon-6/BFO gel was electrospun onto the $Pt/Ti/SiO_2/Si$ substrates with an applied voltage of 20 kV and feeding rate of 0.3 ml/h. The distance between the needle tip and the target was kept at 20 cm. The as-spun fibers were then dried at 100 °C for 2 h in a vacuum oven. The dried fibers were then calcinated at 600 °C in furnace for 2 h in presence of air to form BFO NWs. The product shows R3C Rhombohedral structure with XRD patterns matching JCPDS number 01-071-2494.

2. SEM characterization

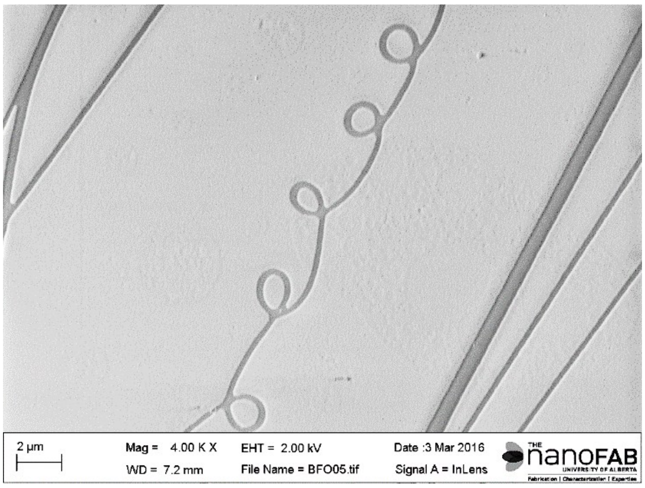

Fig. S1 SEM image of the as-prepared BFO nanowires.

3. Peakforce-KPFM (PF-KPFM) working principle

Peakforce-KPFM technique combines the PeakForce Tapping™ and frequency modulation KPFM (FM-KPFM), which offers simultaneous quantitative nanomechanical property and surface potential (*e.g.* contact potential difference V_{CPD}) mapping capability. During the KPFM lift scan, external DC and AC bias, V_{DC} and V_{AC} are applied simultaneously between the tip and sample, of which V_{AC} at frequency ω gives rise to an electric force modulation at both ω and 2ω. Accordingly, the electric force gradient $F_{el}^{'}$ can be expressed as:

$$F_{el}^{'} = \frac{\partial^2 C}{\partial z^2}\left((V_{DC} - V_{CPD})^2 + \frac{1}{2}{V_{AC}}^2\right) + \frac{\partial^2 C}{\partial z^2}(V_{DC} - V_{CPD})V_{AC}\sin{(\omega t)} + \frac{1\partial^2 C}{4\partial z^2}{V_{AC}}^2\cos{(2\omega t)},$$

where $\frac{\partial^2 C}{\partial z^2}$ is the second derivative of the capacitance, V_{CPD} is the KPFM surface potential signal, or the so-called contact potential difference. The V_{CPD} can be expressed as:

$$V_{CPD} = \frac{\varphi_{tip} - \varphi_{BFO}}{q},$$

where φ_{tip} and φ_{BFO} is the work function of AFM tip and BFO nanowire surface, q is the elementary charge, respectively. When $V_{DC} = V_{CPD}$, the modulation amplitude of the electric force gradient $F_{el}^{'}$ at ω drops to 0, enabling one to extract work function information from V_{DC}. Herein, V_{CPD} instead of φ_{BFO} is used for interpretation, since tip work function calibration is very sensitive to the atmosphere, which would lose it validity when working in an ambient environment.

References

1. Prashanthi, K.; Thundat, T. *Scanning* **2013,** 36, (2), 224-230.
2. Prashanthi, K.; Dhandharia, P.; Miriyala, N.; Gaikwad, R.; Barlage, D.; Thundat, T. *Nano Energy* **2015,** 13, 240–248.
3. Kovur, P.; Ravi, G.; Thomas, T. *Nanotechnology* **2013,** 24, (50), 505710-505710.