Electronic Supplementary Material (ESI) for Nanoscale.


Supporting Information

# Field Electron Emission of Layered $Bi_2Se_3$ Nanosheets with Atomic-Thick Sharp Edges

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## Part 1. Fabrication routing and supplement characterizations

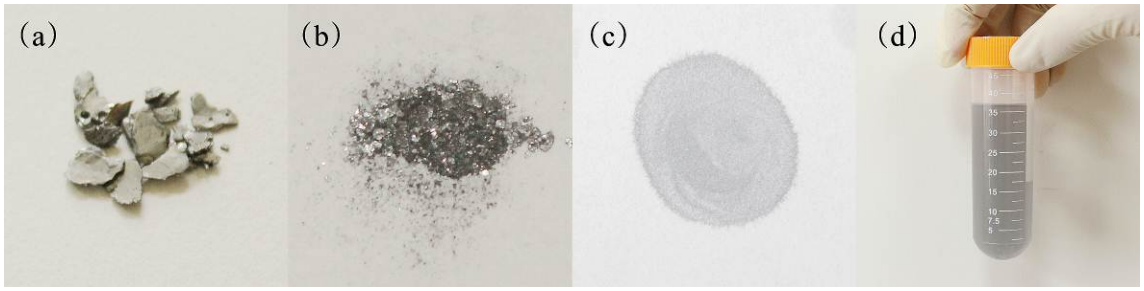


**Figure S1.** The fabrication routing of layered $Bi_2Se_3$ nanosheets dispersion. (a) Bulk $Bi_2Se_3$ crystals. (b) $Bi_2Se_3$ powders. (c) Layered $Bi_2Se_3$ nanosheet clusters. (d) Dispersion of layered $Bi_2Se_3$ nanosheets.

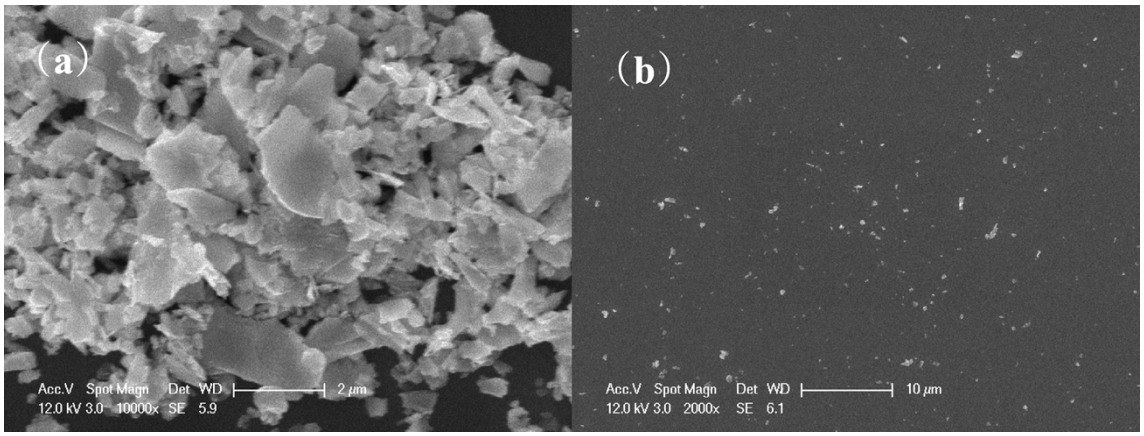


**Figure S2.** (a) SEM image of the layered $Bi_2Se_3$ nanosheet clusters. It depicts the SEM image of the hydrothermal exfoliated $Bi_2Se_3$ nanosheet clusters, which reveals that the hydrothermal intercalation and exfoliation method could turn the $Bi_2Se_3$ from bulk-size to nano-size (see

optical images from **Figure S1(a) to (c)**). (b) SEM images of the exfoliated layered $Bi_2Se_3$ nanosheets spin-coated on Si substrate at large scale.

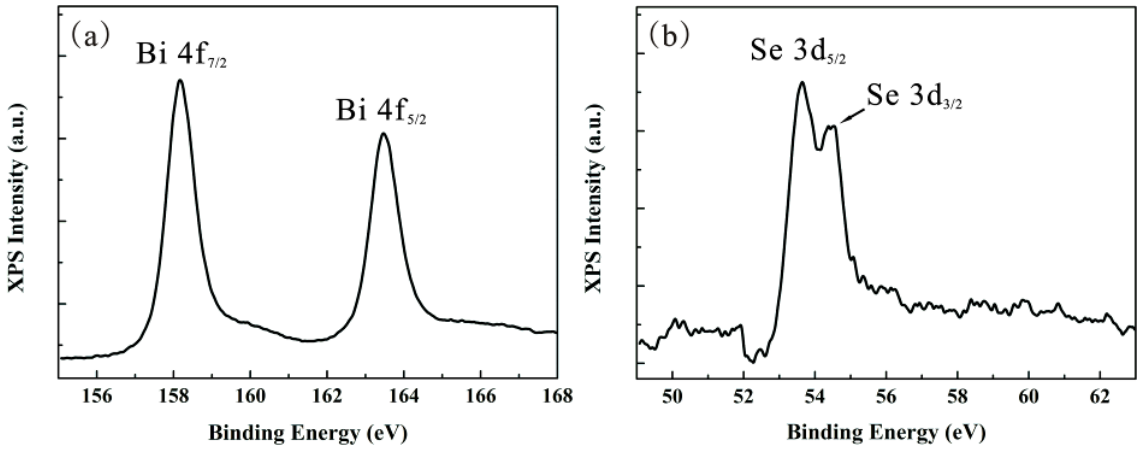


**Figure S3.** XPS spectra of $Bi_2Se_3$.(a) bismuth region (Bi4f) and (b) selenium region (Se3d).

Part 2. Field emission of carbon cloth decorated with layered $Bi_2Se_3$ nanosheets.

The samples were directly fabricated by solution-casted on the pre-clean carbon cloth.

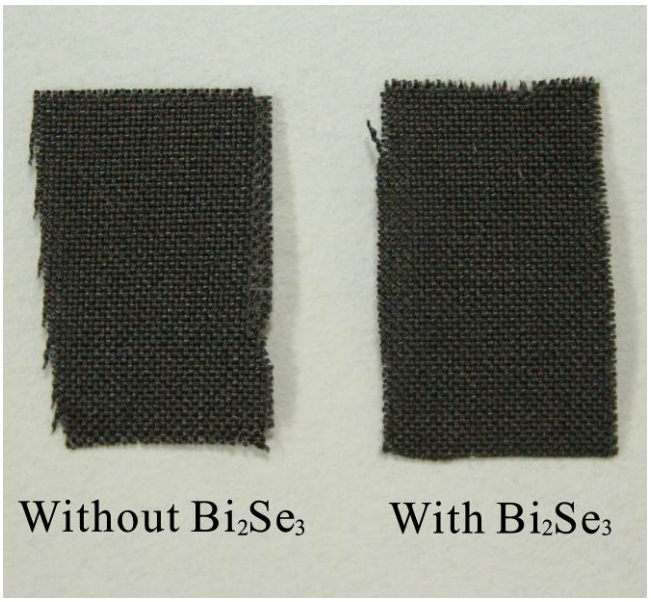


**Figure S4** Photograph of carbon cloth decorated without and with layered $Bi_2Se_3$ nanosheets, which can't be distinguished by naked eyes.

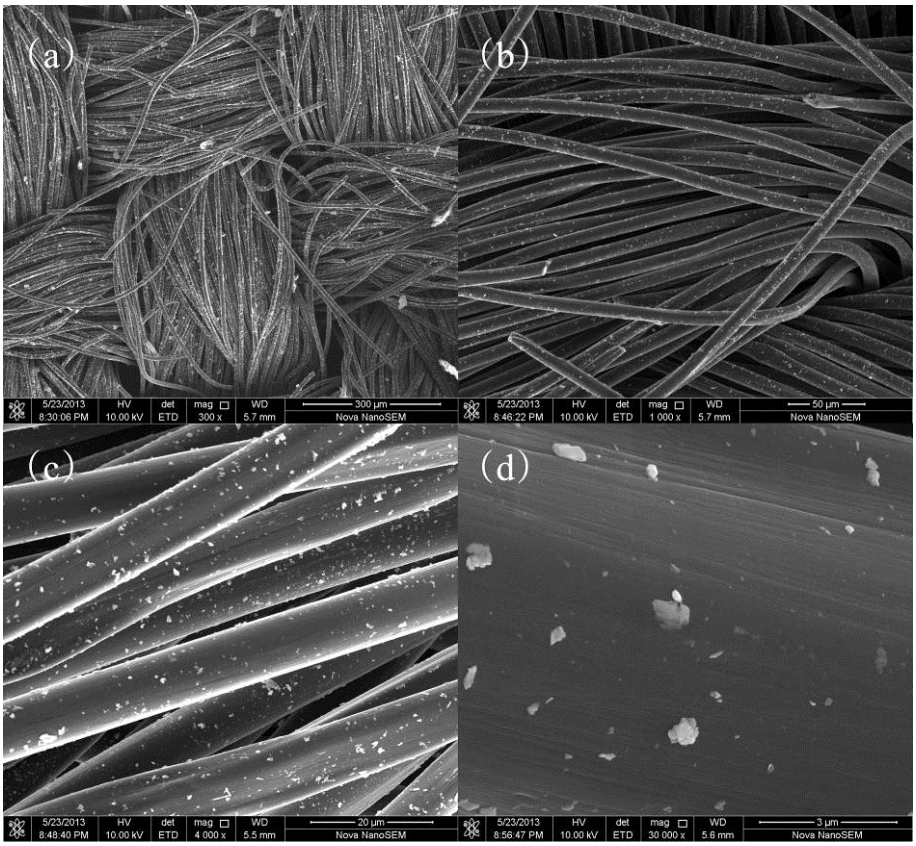


**Figure S5.** SEM images of carbon cloth decorated with layered $Bi_2Se_3$ nanosheets.

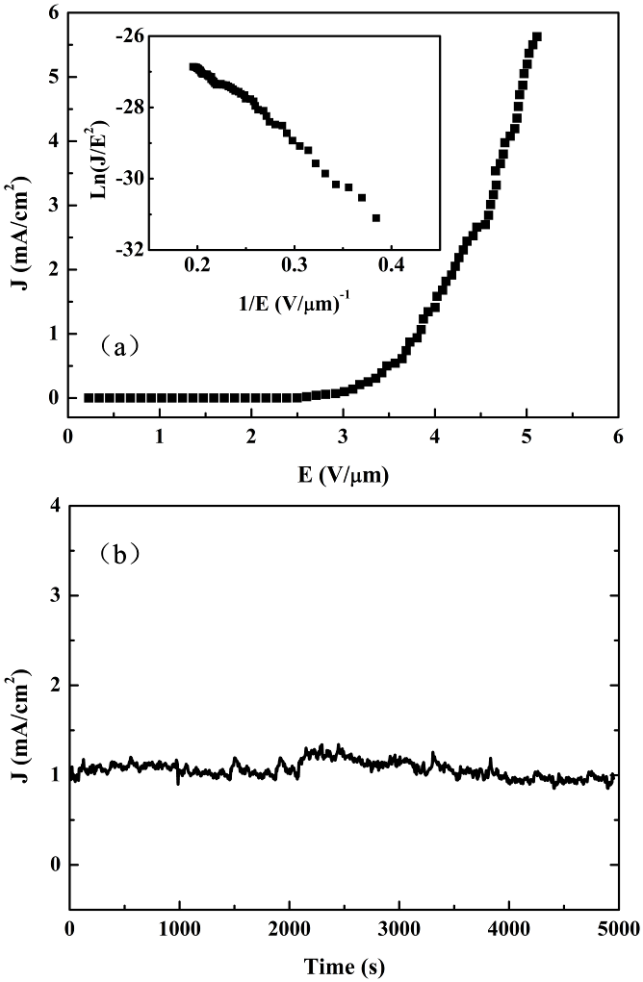


**Figure S6** (a) Typical plot of field emission current density versus electric field (J-E) of the layered $Bi_2Se_3$ nanosheets on carbon cloth. Inset is the corresponding Fowler-Nordheim (FN) plot. (b) The field emission current stability over time.

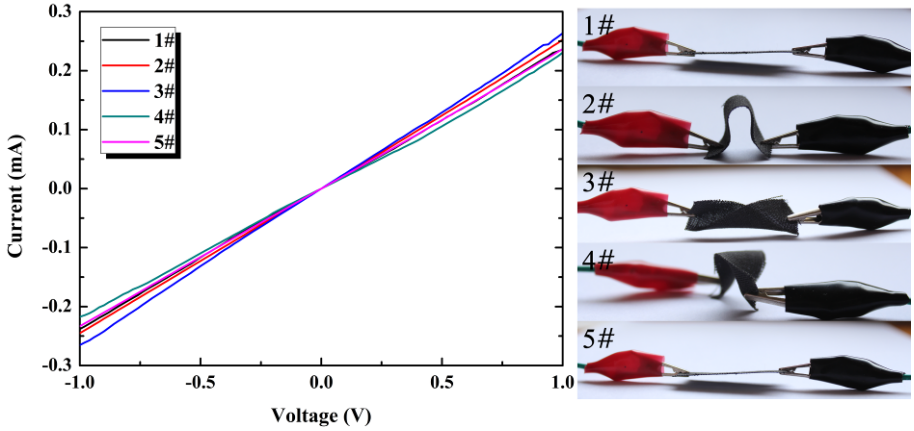


**Figure S7.** I–V curves of the sample under different bending conditions (1#-4#). 5# records the I–V curve of carbon fabric after 50 cycles of bending, which reveals the high flexibility and stability of the carbon colth with layered $Bi_2Se_3$ nanosheets on it.

Part 3. Simulation and theoretical calculation

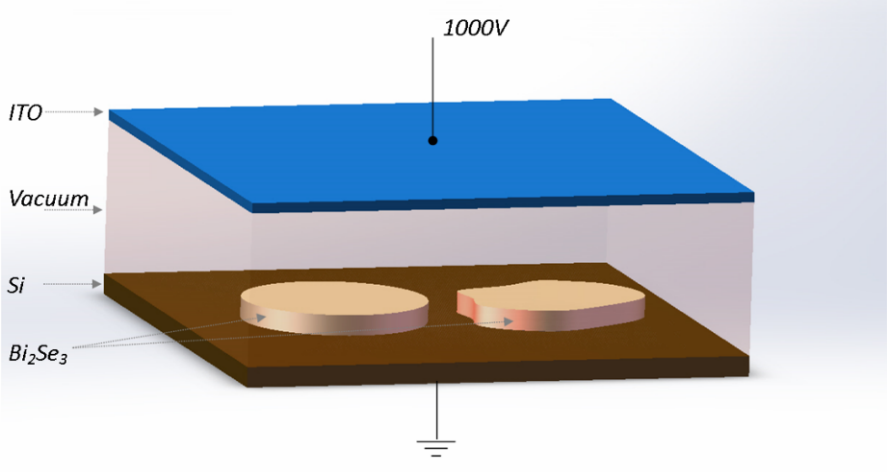


**Figure S8**. Schematic diagram of simulating electrical filed distribution.

**Table S1.** Parameters of materials in simulation

| | **Thickness** | **Permittivity** |
|---|---|---|
| **ITO** | 80 nm | 7.6 |
| **Vacuum** | 220 μm | 1.0 |
| **Si** | 400 μm | 11.7 |
| **$Bi_2Se_3$** | 5 nm | 3.7 |

The permittivity of 5 QL (~5 nm) $Bi_2Se_3$ was simulated from density functional theory. Our first principles electronic structure calculations were carried out in the projector augmented wave (PAW) framework parametrized by Perdew-Burke-Ernzerhof (PBE) of the generalized gradient approximation (GGA) [1] in the Vienna *ab initio* simulation package (VASP) [2,3]. Spin-orbit interactions (SOC) are turned on to capture the Dirac cone feature of the surface electronic states [4,5]. Fully relativistic PAW pseudo potentials acting on valence electron wave functions were used. The plane-wave kinetic energy cutoff is 400 eV and the self-consistency tolerance is $1x10^{-8}$ eV. The bulk material structure is relaxed until all force components are less than 0.001 eV/Å. The static dielectric response matrix was determined using density functional perturbation theory with local field effects. The method is explained

in Ref. [6]. One quintuple layer is defined as in Ref. [4] and the distance between slabs is 10 Å to avoid interlayer interactions. Based on these, the permittivity of 5 QL (~5 nm) $Bi_2Se_3$ in z direction was calculated as ~3.7, which is shown in **Table S1**. More details of which will be shown in our coming work.

[1] J. P. Perdew, K. Burke, and M. Ernzerhof, Phys. Rev. Lett. 77, 3865 (1996).

[2] G. Kresse and J. Hafner, Phys. Rev. B 47, 558 (1993).

[3] G. Kresse and D. Joubert, Phys. Rev. B 59, 1758 (1999).

[4] H. Zhang, C. Liu, X. Qi, X. Dai, Z. Fang, and S. Zhang, Nat. Phys. 5, 438 (2009).

[5] O. V. Yazyev, J. E. Moore, and S. G. Louie, Phys. Rev. B 105, 266806 (2010).

[6] M. Gajdos, K. Hummer, G. Kresse, J. Furthmuller and F. Bechstedt, Phys. Rev. B 73, 045112 (2006).