Supplementary information

Fabrication of Large Scale Single Crystal Bismuth Telluride (Bi$_2$Te$_3$) Nanosheet Arrays by Single Step Electrolysis Process

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Calcualtion of the bond energies of Te$^{(1)}$-Bi, Te$^{(2)}$-Bi, and Te$^{(1)}$-Te$^{(1)}$ in Bi$_2$Te$_3$:

According to the calculation results of Kaviany and co-workers, the calculated bond energies of Te$^{(1)}$-Bi, Te$^{(2)}$-Bi, and Te$^{(1)}$-Te$^{(1)}$ in Bi$_2$Te$_3$ can be obtained as shown in below.

For Te$^{(1)}$ atom: bonds with three Bi and three Te$^{(1)}$ atoms

\[ => 3 \times 0.974 + 3 \times 0.0691 = 3.1293 \text{ eV} \]

For Te$^{(2)}$ atom: bonds with six Bi atoms

\[ => 6 \times 0.5801 = 3.4806 \text{ eV} \]

For Bi atom: bonds with three Te$^{(1)}$ and three Te$^{(2)}$ atoms

\[ => 3 \times 0.974 + 3 \times 0.5801 = 4.6623 \text{ eV} \]

Existence of H$_2$Te gas during the electrolysis process

In order to prove the existence of H$_2$Te gas during the electrolysis process, we design an experiment as shown in Figure S1 (a). A Si substrate was suspended upon the electrolyte while doing the electrolysis process and the tellurium was formed by the decomposition of H$_2$Te gas$^{[1]}$. Figure S1 (b) shows the schematics of formation of H$_2$Te derived Te, and the reaction process can be visualized as below:

\[ H_2Te(g) + \frac{1}{2}O_2 \rightarrow H_2O + Te(s) \]
The H2Te derived Te was distinguished by Raman spectrum. In the Raman spectrum of H2Te derived Te, three peaks are located at 92.4, 121.6, and 141.1 cm\(^{-1}\), corresponding to optical modes of \(E_l\), \(A_1\), and \(E_u\), respectively\(^{[2]}\), as shown in Figure S1(d). These three peaks are consistent with the results from pure Te ingot. The SEM image of H2Te derived Te is shown in Figure S1(c) and reveals the blade shape.

**Figure S1.** (a) Suspended Si substrate upon the electrolyte. (b) Schematics of H2Te derived Te. (c) SEM image of H2Te derived Te. (d) Raman spectrum of Te ingot and H2Te derived Te.

**REFERENCES**
