Supporting Information

Surface Micro-Etching of Bi_2Te_3 Thermoelectric Legs Enables High-Efficiency Power Generator

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1. Sample synthesis

The p-type $(Bi,Sb)_2Te_3$ and n-type $Bi_2(Te,Se)_3$ materials were prepared according to our previous reports.[14,15] The weighed raw materials were sealed into quartz tubes, using an oxyacetylene flame under a vacuum of 5 Pa. The mixtures were then melted at 750°C for 1 hour, followed by shaking for half an hour and rapidly quenched in air. Subsequently, the p-type $(Bi,Sb)_2Te_3$ ingots were finely ground, loaded into a Ø40 mm graphite die, and sintered by spark plasma sintering for 13 minutes. The n-type $Bi_2(Te,Se)_3$ ingots were processed by zone melting at 700°C in a vertical crystal growth furnace at a rate of 20 mm/h.

2. Sandblasting and ultrasonic treatments

For the sandblasting treatment, the cut Bi_2Te_3 disk was placed on the grid of the sandblasting machine. The 220-mesh SiO_2 sand was used, the nozzle was positioned about 30 cm away from the materials, and the air pressure was maintained at approximately 0.1 MPa. Then the sandblasting was performed uniformly across the entire Bi_2Te_3 disk. After that, the residual SiO_2 sand was removed by the ultrasonic treatments. The sandblasted disk was cleaned in the ultrasonic cleaning machine for 1 minute, and the working conditions were set to 25°C and 80 W.

3. Micro-etching treatments

The reproducibility of the micro-etching process is guaranteed by the key parameters including pH value, etching temperature, etching time, and the ratio of sample and acid solution. Specifically, the pH value is monitored in real-time and stabilized in the range of 3.8 to 4.5; The etching time is fixed as 5 minutes based on comparative experiments, and the etching temperature is kept at 30°C during the etching process by thermostat. On average, each piece of Φ30 mm Bi2Te3 disk requires 50 mL of etching solution.

4. Contact resistance measurement

The contact resistance (ρ_c) measurement was conducted by using a four-probe method. The probe moved from one end of the contact metal layer to the other end across the contact interface with a tip size of 2 mm and a step size of 10 μm, while a series of voltages were recorded using an alternating current of 100 mA passing through the junctions. The ρ_c is defined as:

$$\rho_c = A \cdot \frac{V_{jump}}{I} = A \cdot R_c$$

where A is the area of the cross section, V_{jump} is the voltage jump, I is the test current and R_c is the contact resistance at the interface.

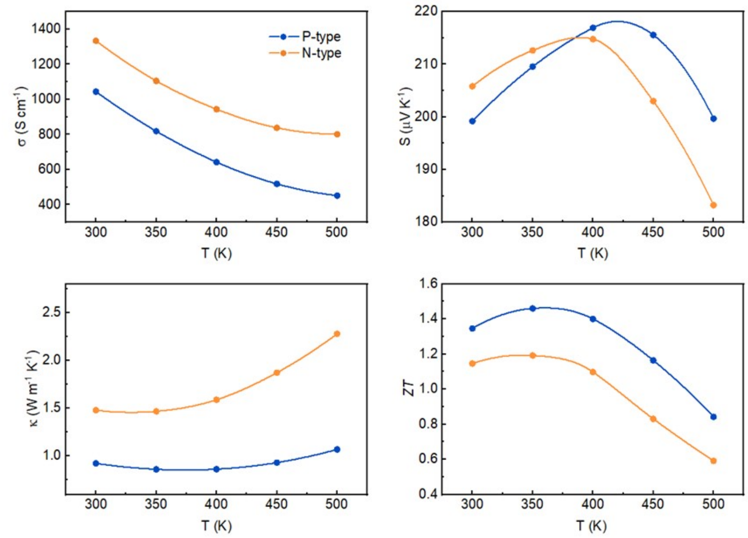

Fig. S1 The temperature dependent (a) electrical conductivity, (b) Seebeck coefficient, (c) total thermal conductivity and (d) *ZT* values for the p-type $(Bi,Sb)_2Te_3$ and n-type $Bi_2(Te,Se)_3$.

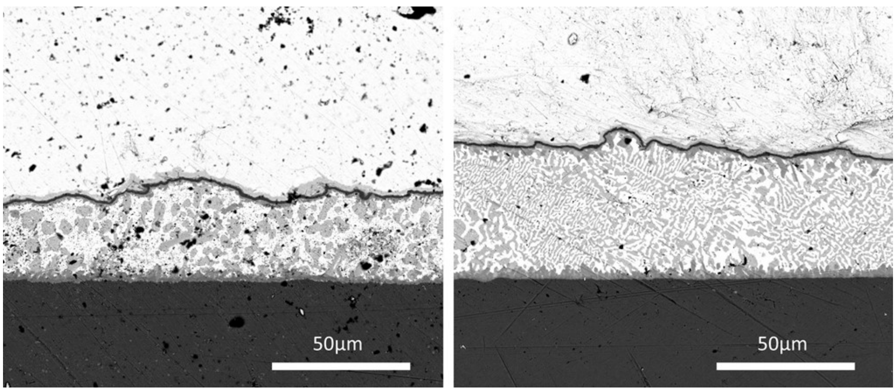

Fig. S2 The SEM image to show the solder on the (left) hot-side and (right) cold-side of Bi_2Te_3-based thermoelectric leg.

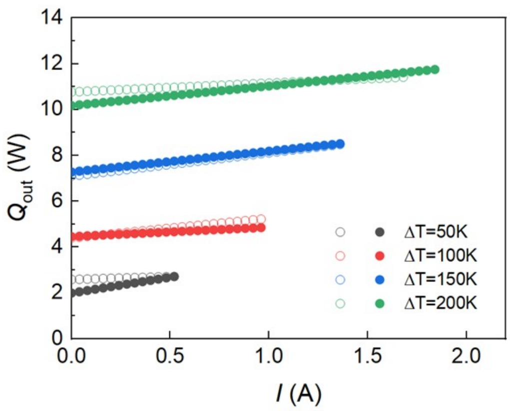

Fig. S3 The measured heat flow of the fabricated thermoelectric power generators.