Supporting Information

Interfacial friction-induced electronic excitation mechanism for tribo-tunneling current generation

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1. Schematic of Surface Potential

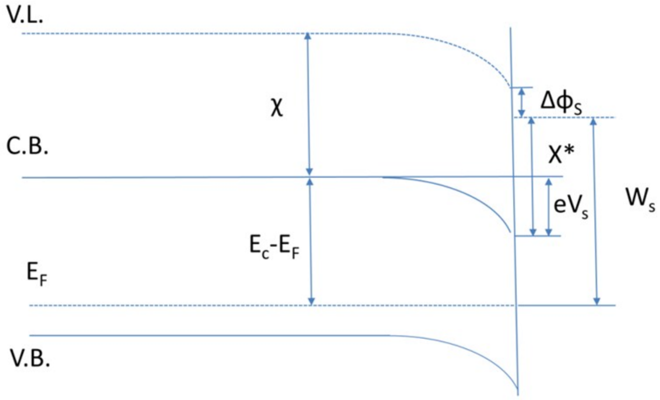

Figure S1 Schematic diagram of the electronic band structure at a semiconductor surface. Physical meanings of the symbols can be find in the main text

2. AFM cantilever calibration

All the AFM experiments were conducted with Dimension Icon (Bruker, CA). The B-doped diamond probes are purchased from AppNano, USA. The deflection sensitivity of the cantilever is determined to be 99 nm/V by force curve measurement (**Figure** S4). The spring constant k and resonance frequency f_0 of the cantilever is estimated to be ~5.4 N/m and ~97 kHz, respectively, by thermal tune method (**Figure** S5).

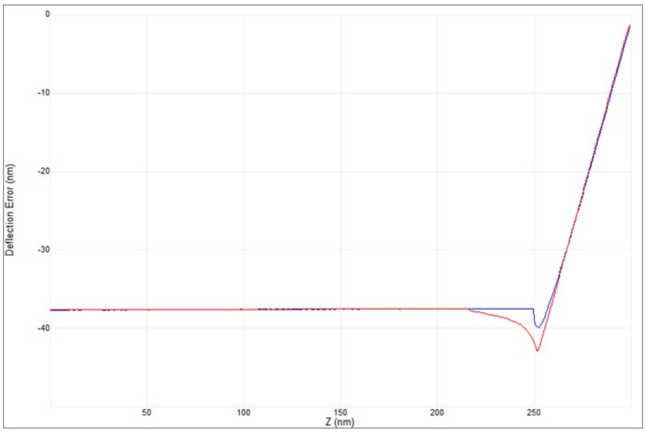

Figure S2. Force curve measurement

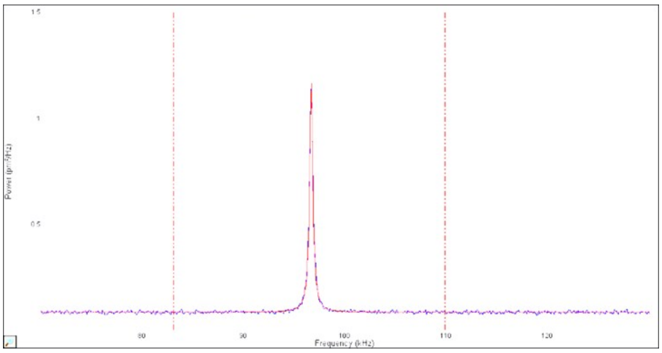

Figure S3. Thermal tune of the cantilever

3. Peakforce-CAFM measurement

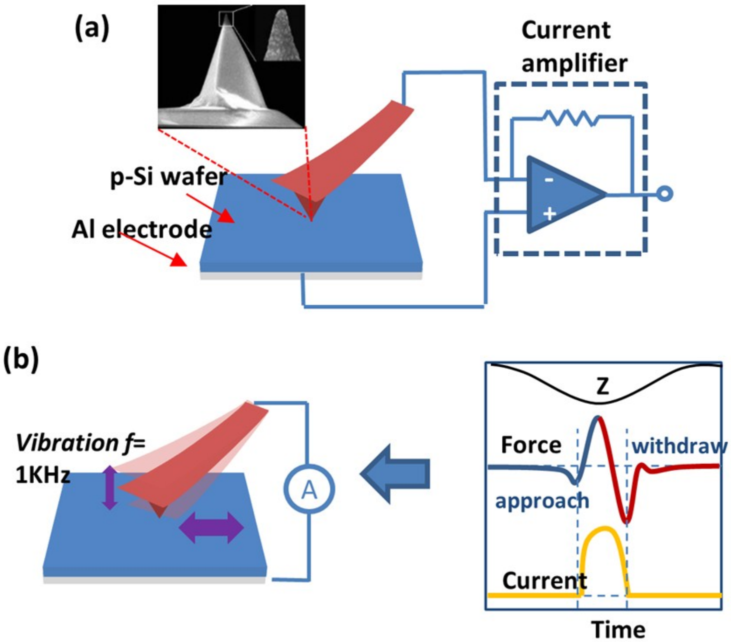

Figure S4. (a) Schematic of conductive-AFM (C-AFM) measurement. A boron-doped diamond tip is used to slide on the p-type silicon sample. (b) is the schematic of peakforce tapping mode: the AFM probe is scanned across the sample at a frequency of 1 kHz, and the feedback loop controls the maximum force on the tip (Peak force) as the setpoint for each individual cycle (top). The corresponding time-dependent tip position, force, and current in a Peakforce tapping based C-AFM mode (right).

4. Tip-sample Contact Area Estimation

In the macroscale measurement, the tip-sample contact area *A* is estimated according to the optical microscope image. In the AFM measurement, according to DMT model:

$$A = \pi\left[\frac{R}{K}(L + 2\pi R\gamma)\right]^{2/3}, \qquad \text{(S1)}$$

where *R* is AFM tip radius, *L* is the load (contact force *F*), and γ is the work of adhesion. The term $2\pi R\gamma$ can be considered as an ‘additional load’ L_{ad}, which is determined by the “pull-off” force in the force curve. *K* is the reduced Young’s modulus:

$$K = \frac{3}{4}\left(\frac{1 - v_s^2}{E_s} + \frac{1 - v_t^2}{E_t}\right), \qquad \text{(S2)}$$

where E_t and E_s are Young’s moduli and v_t and v_s are the Poisson ratios of the tip and the sample, respectively.

5. *J* and *power density* as a function of load resistance *R*

The data were collected by a Keithley 2450 SourceMeter SMU (Tektronix, USA). Unlike the high impedance in polymer-based TENGs (high resistance and capacitance), the equivalent circuit components in our case is relatively simpler, which can be approximated as a DC voltage source, an internal resistance and an external resistance connected in series. Therefore, the *J* and the *power density* can be modeled as:

$$J = J_0\, r/(R + r), \qquad \text{(S3)}$$

$$Power\ density = {J_0}^2 r^2 RA/(R + r)^2, \qquad \text{(S4)}$$

The fitting results are shown in Fig. 2d in the main text.

6. Force-dependent *A* and *J*

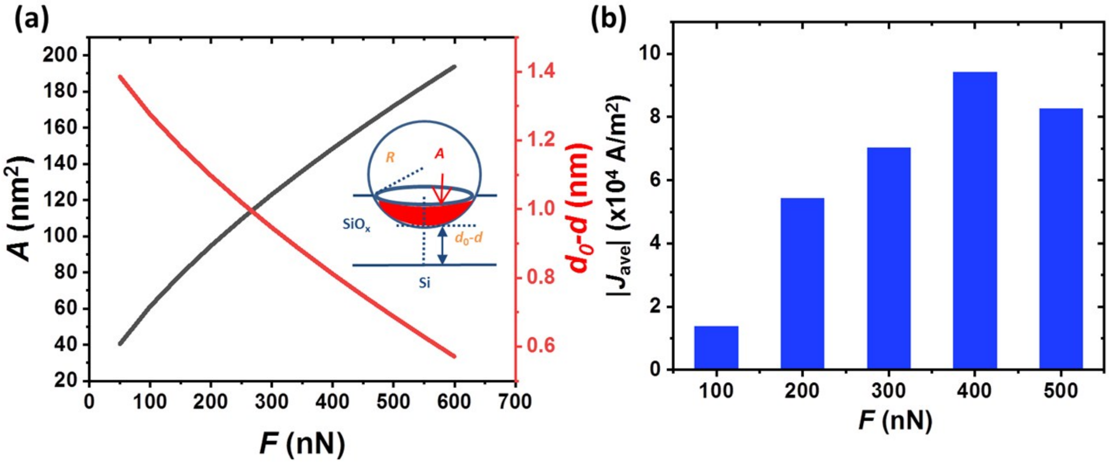

Figure S5. (a) Tip-sample contact area *A* and the effective oxide thickness (d_0-d) as a function of contact force *F*. (b) Average C-AFM current density J_{ave} as a function of contact force.