Electronic Supplementary Information (ESI) for

Fabrication of *p*-$Ni_{0.8}Cu_{0.2}WO_4$/*n*-Si heterojunction diode and 1 MHz rectifier operation

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S1. Schematic of target synthesis and deposition.

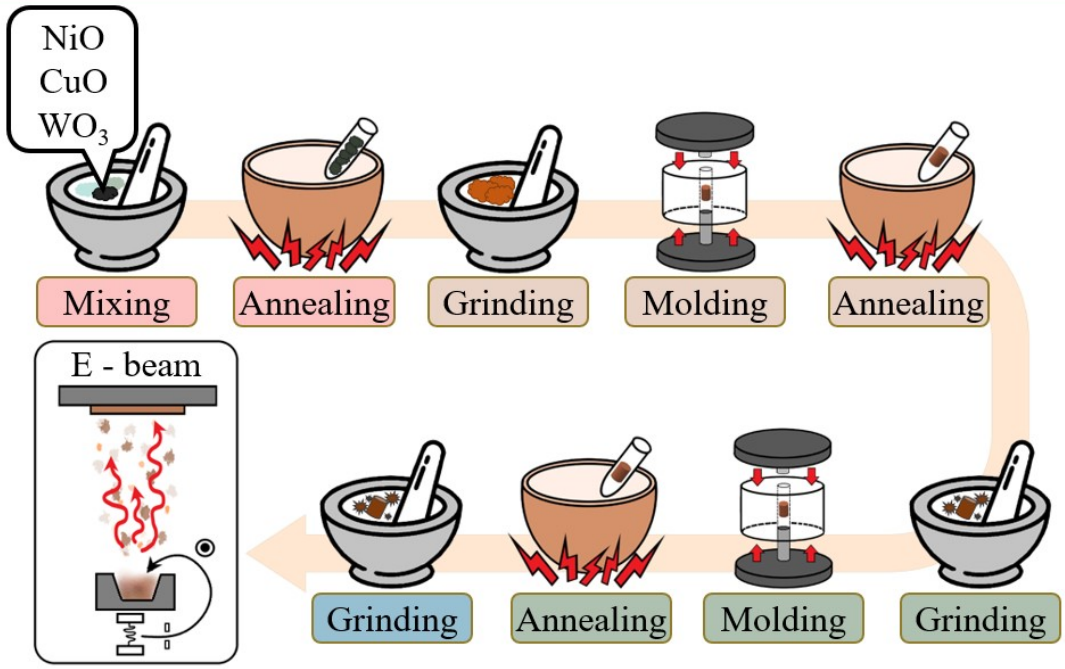

Figure S1. The schematic of $Ni_{0.8}Cu_{0.2}WO_4$ target synthesis process for e-beam evaporation.

S2. The purity of synthesized target.

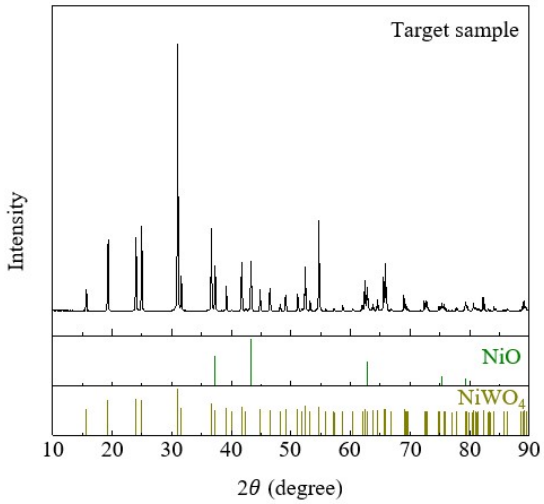

Figure S2. The powder XRD pattern for the synthesized target. All the peaks are well indexed only with $NiWO_4$ and NiO peaks without other secondary phases.

S3. The ohmic contact behaviours between *p*-$Ni_{0.8}Cu_{0.2}WO_4$ and Au.

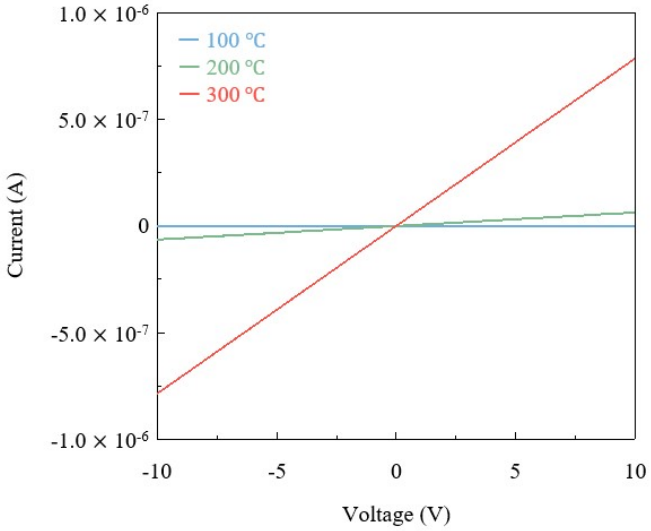

Figure S3. The I-V characteristics from Au/$Ni_{0.8}Cu_{0.2}WO_4$/Au geometry devices for 100, 200, and 300 °C deposited samples.

S4. The Raman spectrum analysis.

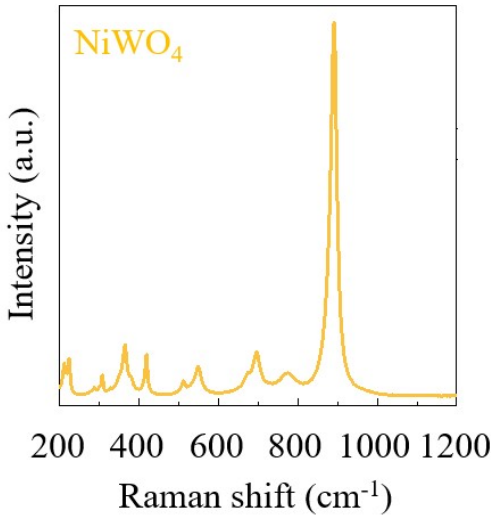

Figure S4. The Raman spectrum for the pure $NiWO_4$ sintered bulk form as referance.

S5. Optical absorption spectra of $Ni_{0.8}Cu_{0.2}WO_4$ films.

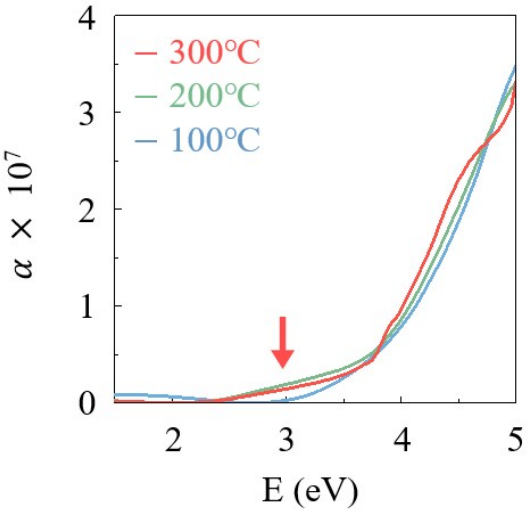

Figure S5. The absorption coefficient *vs.* optical energy (E). The shoulder peak is marked by red-arrow.

S6. Band-diagram picture for *p*-$Ni_{0.8}Cu_{0.2}WO_4$/*n*-Si heterojunction.

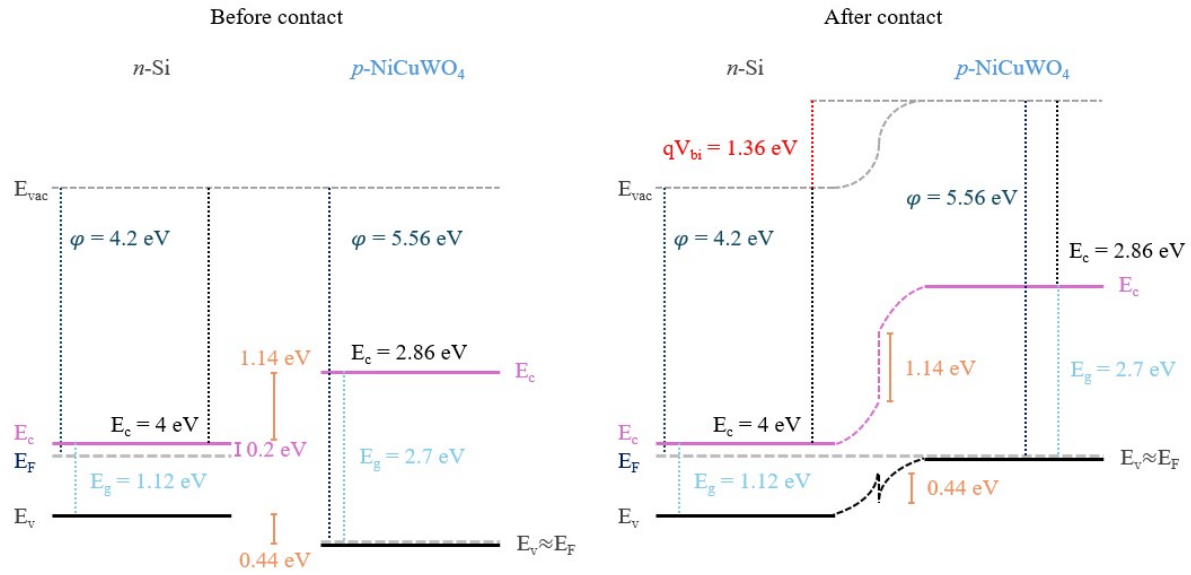

Figure S6. The schematic of band-diagram for *p*-$Ni_{0.8}Cu_{0.2}WO_4$/*n*-Si heterojunction. The band parameters for $Ni_{0.8}Cu_{0.2}WO_4$ are referred from our previous work. [*Mater. Horiz.* **11**, 6342 (2024)]

S7. The current density (*J*) – voltage (*V*) characteristics the *p*-$Ni_{0.8}Cu_{0.2}WO_4$/*n*-Si heterojunction diodes.

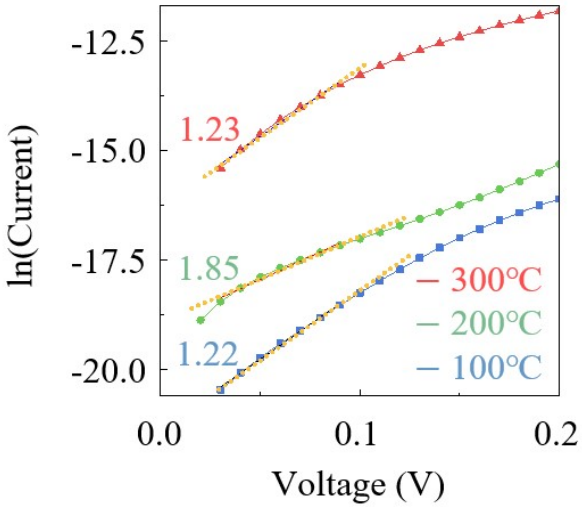

Figure S7. The ln *J* - *V* characteristics for different substrate heating temperature. The idearity factors are obtained based on following equation of $J = J_s\{\exp[qV/nkT] - 1\}$.

S8. The half-wave rectifications behavior of the *p*-$Ni_{0.8}Cu_{0.2}WO_4$/*n*-Si heterojunction diode.

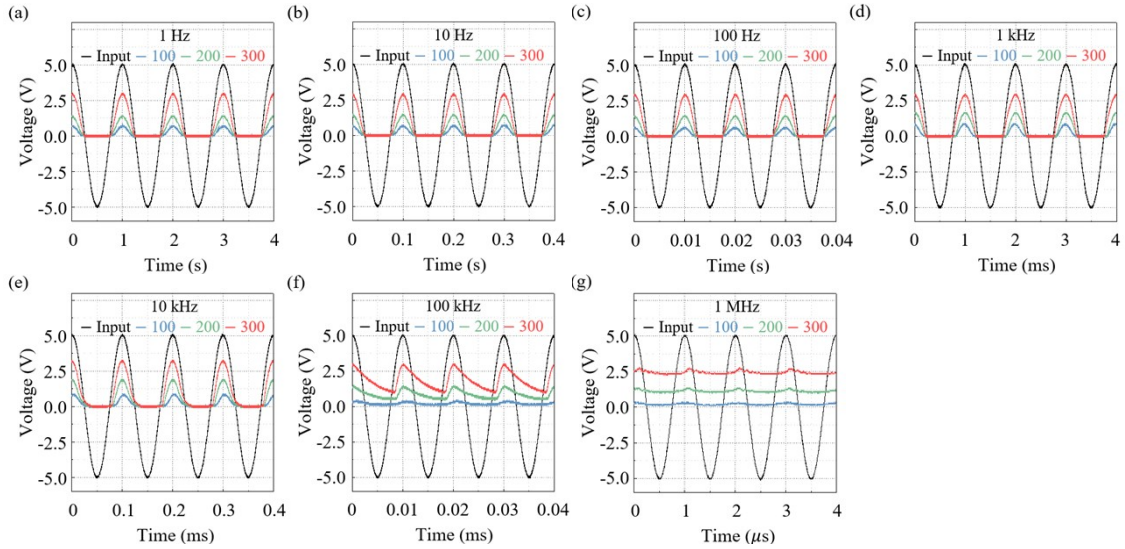

Figure S8. The output signals of the half-wave rectification circuit at (a) 1 Hz, (b) 10 Hz, (c) 100 Hz, (d) 1 kHz, (e) 10 kHz, (f) 100 kHz, and (g) 1 MHz when applying a 5 V sinusoidal AC input signal.