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Flexible Textile Direct-Current Generator Based on the Tribovoltaic Effect at Dynamic Metal-Semiconducting Polymer Interfaces

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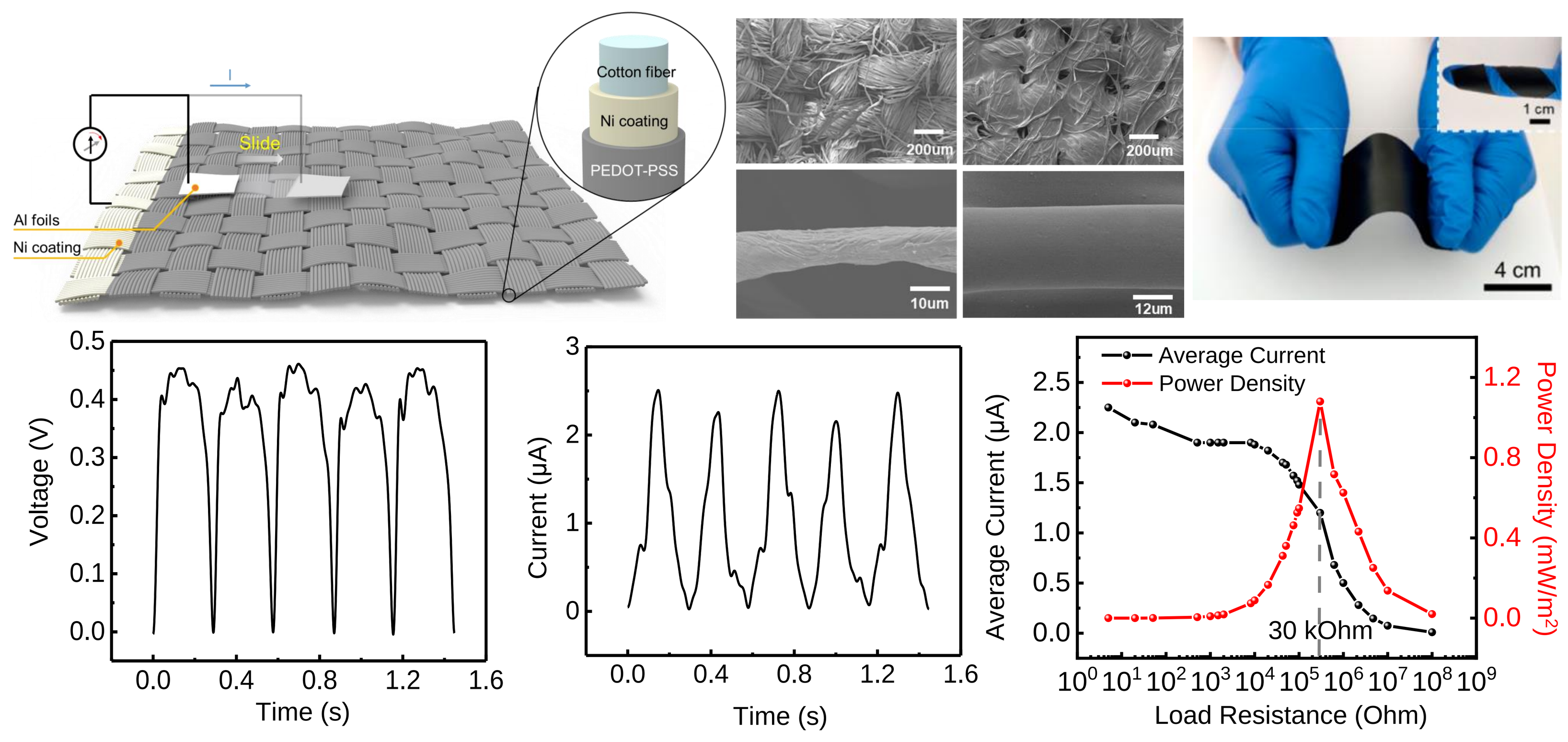
Abstract

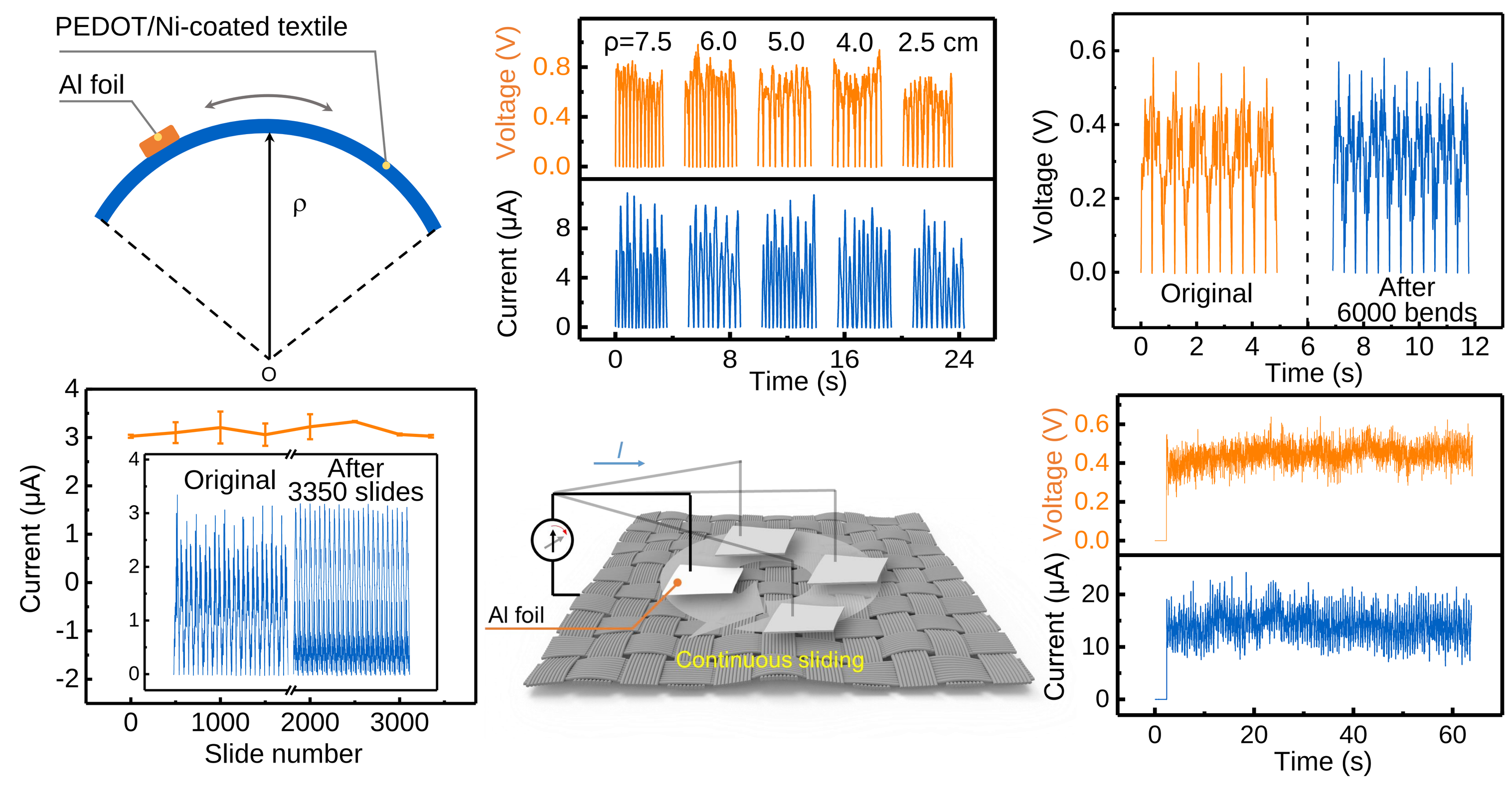
Generation of direct current (DC) from mechanical kinetic energies is crucial for realizing self-powered wearable electronics. Here, we report a flexible textile-based DC generator based on the tribovoltaic effect at a dynamic metal-semiconducting polymer interface. The tribovoltaic effect refers to a phenomenon in which an energy “quantum” is released once an atom−atom bond is formed at the dynamic interface of two contacting materials; such released “binding” energy excites electron−hole pairs at metal−semiconductor interfaces or semiconductor−semiconductor pn junctions. This textile DC generator can output a voltage of approximately 0.45−0.70 V. Seven generators in series can power an electronic watch constantly without any conditioning circuit. These findings offer an efficient strategy for harvesting mechanical energies and realizing self-powered electronics.

Structure and output of the TTDG



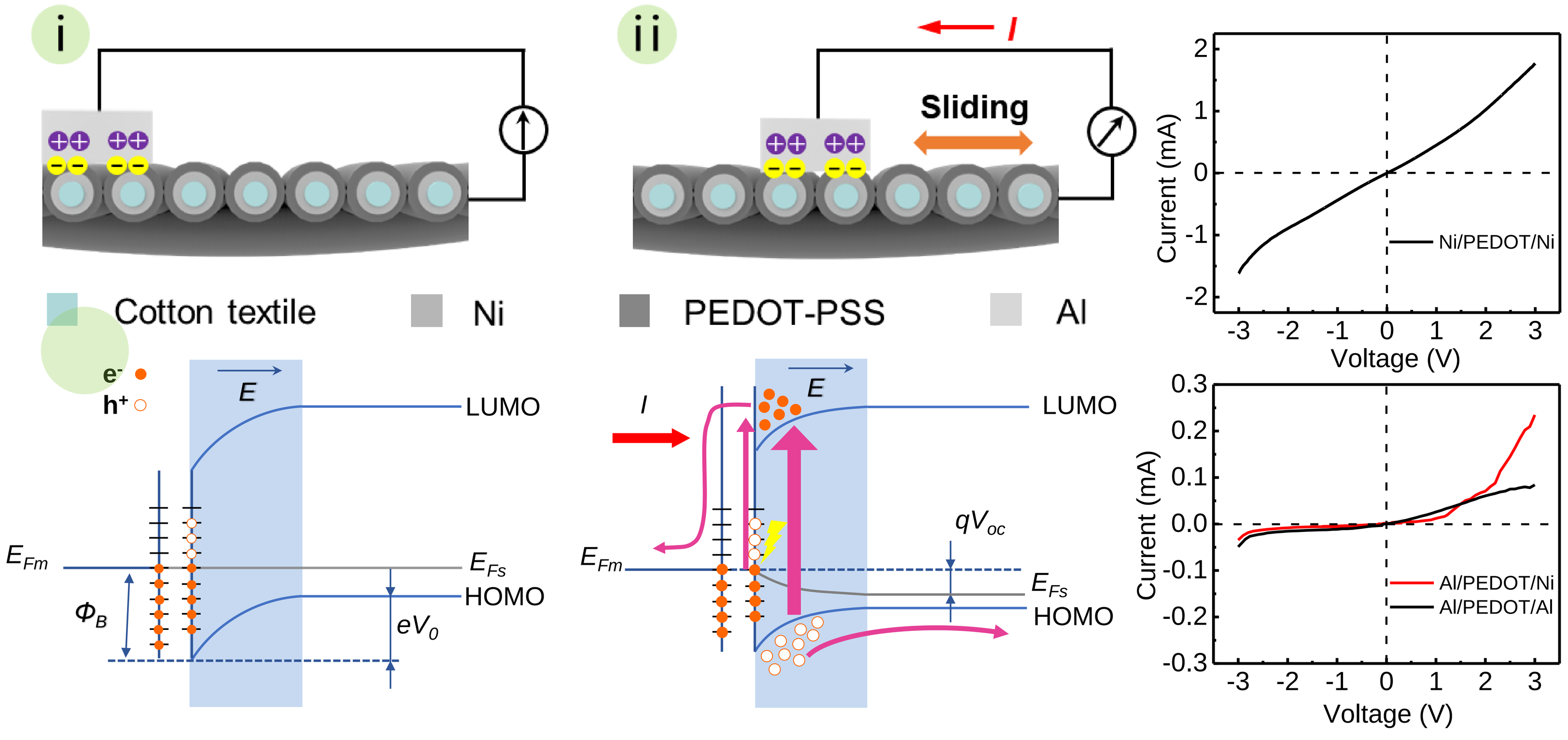
- The textile tribovoltaic DC generator (TTDG) with outstanding flexibility consists of a PEDOT- and Ni-coated textile and an Al foil slider.
- A single DC generator can output a voltage of ~0.45 V and a current of ~2.5 μA.

Flexibility and durability of the TTDG



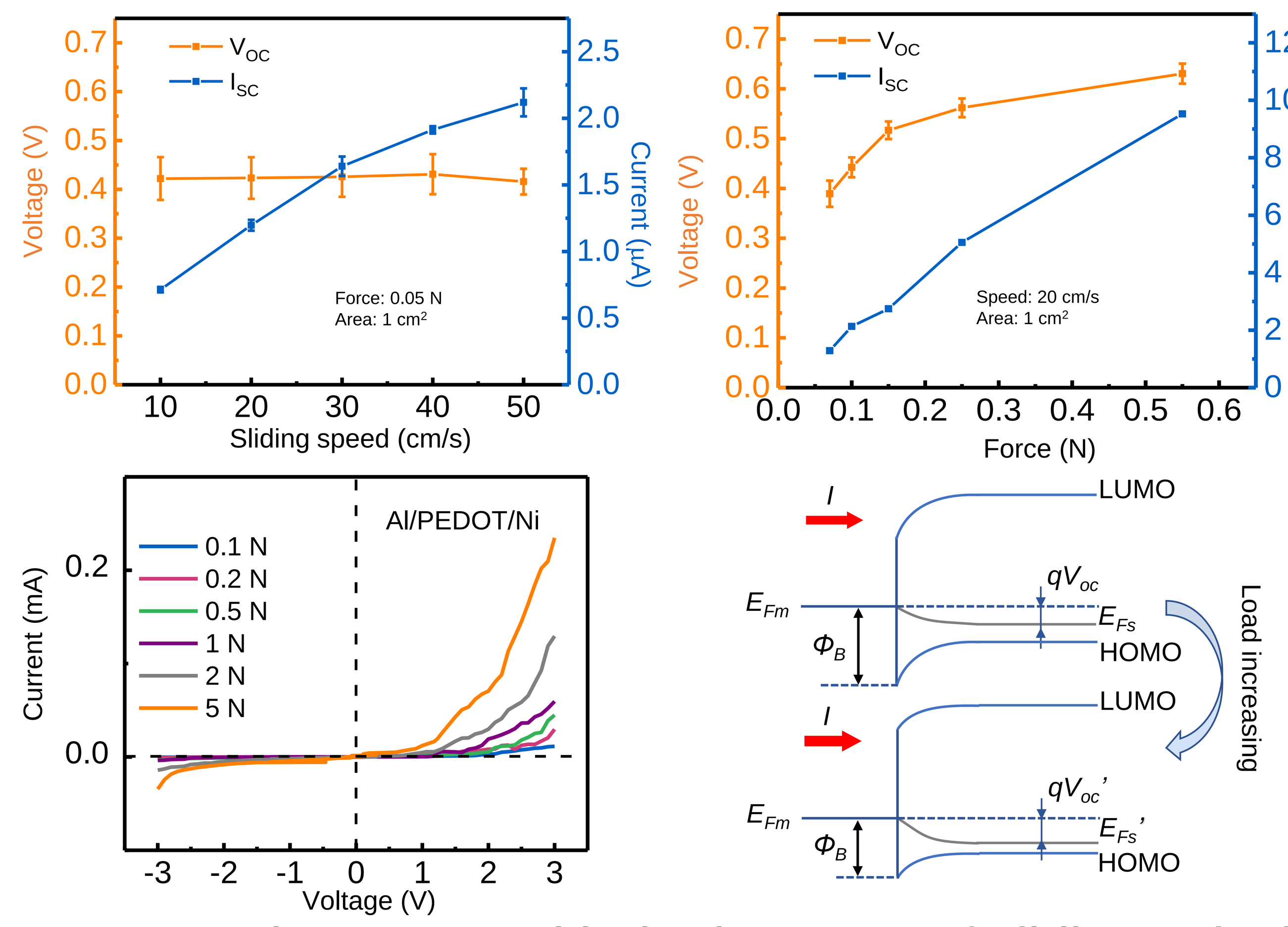
- The output V_{OC} and I_{SC} are maintained at ~0.7 V and ~10 μA, respectively with different curvature radii, confirming that the generator operates appropriately in the bending states.
- Continuous DC outputs can be achieved when the sliding motion was continuous.

Working principle of the TTDG



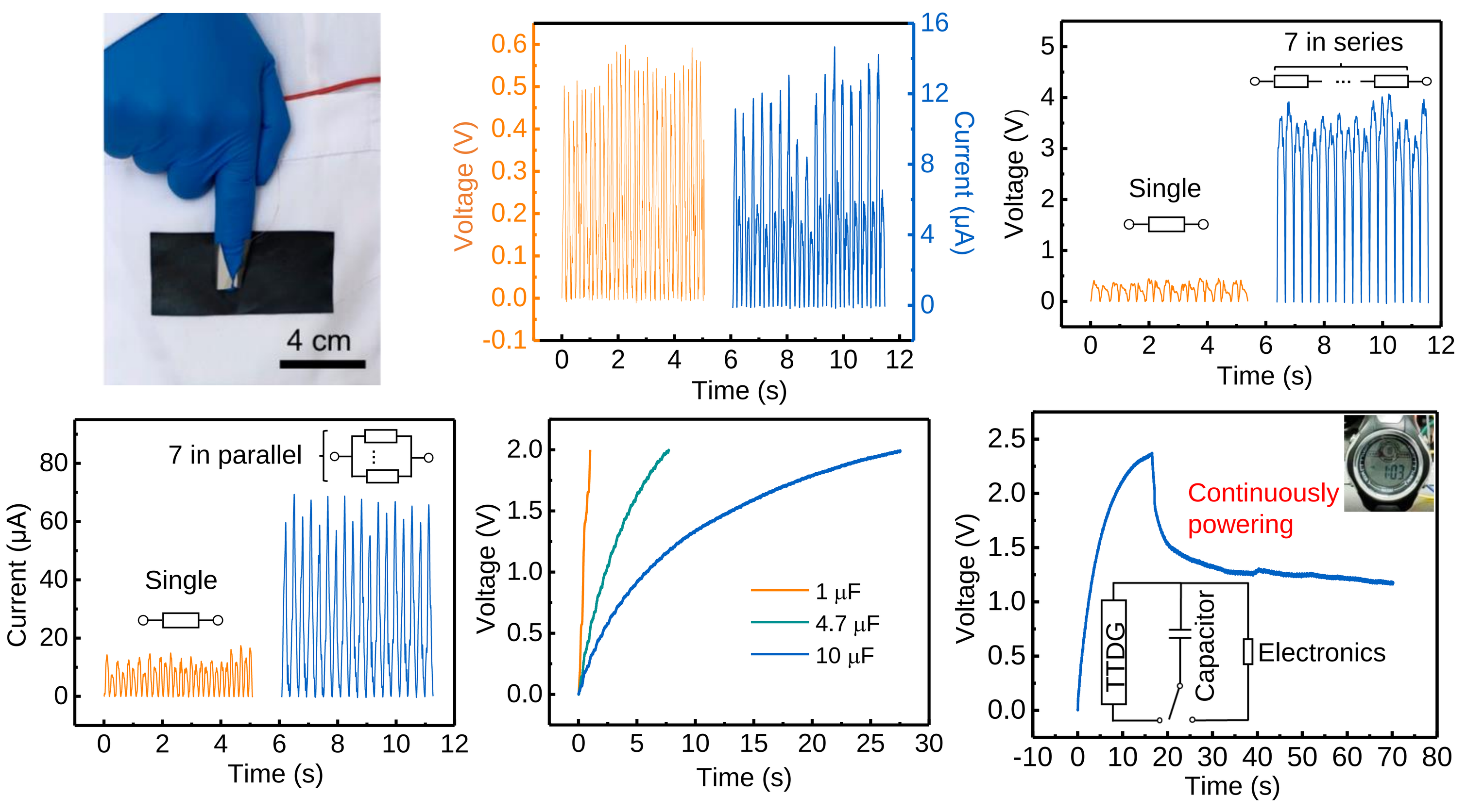
- The non-equilibrium carriers is generated in the space charge region by the friction energy at the interface due to the sliding of Al on the PEDOT, and separated in response to the built-in electric field arisen from the Schottky contact.

Influencing factors for the TTDG



- The average I_{SC} increases with the increase of sliding velocity, while the average V_{OC} maintains constant.
- The average I_{SC} of the generator increases with the increase of the load, while the V_{OC} increases gradually and reaches saturation.

Application of the TTDG in self-powered electronics



- The V_{OC} and I_{SC} was ~0.5 V and ~12 μA respectively when the generator was sewn on a lab coat, and an Al foil was attached on an index finger for rubbing PEDOT-coated textile.
- The voltage of the seven generators connected in series was sufficiently high for charging batteries, or directly powering many electronics.

Conclusion

- ✓ We realized DC electricity generation from mechanical sliding on a flexible PEDOT-coated textile with asymmetric MS interfaces.
- ✓ The dynamic Schottky interface was demonstrated to be able to absorb dissipated friction energies to generate non-equilibrium electron−hole pairs and output voltage to the external circuit. Such an effect is attributed to the tribovoltaic effect reported recently.
- ✓ Self-powered wearable electronics were achieved without conditioning circuits due to DC characteristics and low internal impedance.

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