Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information

Ultra-High Drivability, High-Mobility, Low-Voltage and High-Integration Intrinsically Stretchable Transistors

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1. Contact resistance characterization of the fabricated transistors.

The devices with a channel width of 20 μm and channel lengths range from 5 to 100 μm were characterized in the linear regime ($V_{DS} \ll V_{GS} - V_{TH}$) to derive the contact resistance between the metallic-CNTs (M-CNTs) and the semiconducting-CNTs (S-CNTs) through the Transmission Line Model (TLM). The low contact resistance 15.3 kΩ extracted from the intercept of TLM fitting curve confirms enhanced contact between M-CNTs and S-CNTs of fabricated stretchable all-carbon-nanotube transistors.

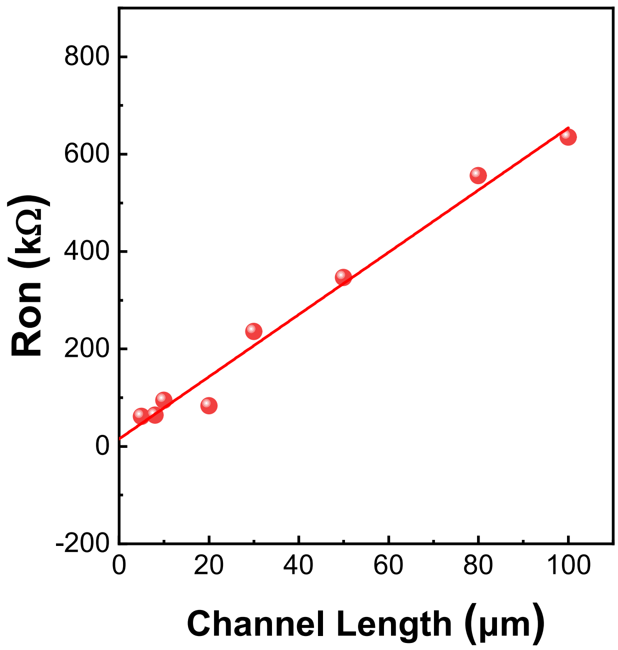

Figure S1. Plot of on-state resistance (R_{on}) with different channel lengths. Straight line is a linear fitting curve of data points with an intercept of 15.3 kΩ.

2. Transconductance characteristics of the stretchable transistors.

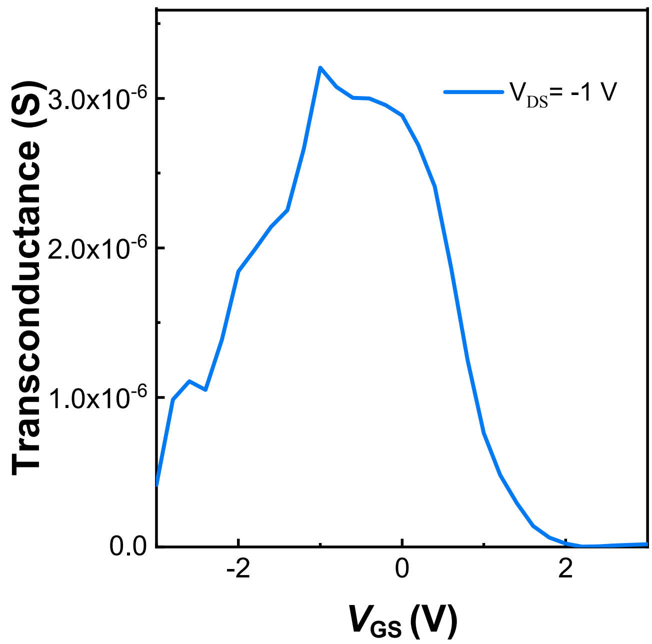

Figure S2. Transconductance of a typical transistor (W = 20 μm, L = 10 μm) versus gate voltage.

3. **Mobility extracted from devices with different channel lengths and fixed channel width of 20 μm.**

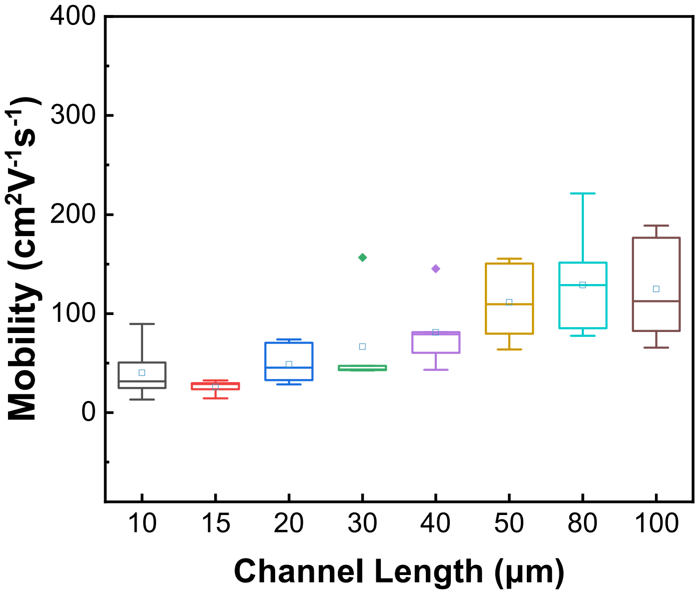

Figure S3. Mobility distribution as a function of channel length. Long-channel devices tend to have higher mobility.

4. **Electrical characterization of the stretchable transistors before and after IGZO layer etching.**

Under normal circumstances, carbon nanotubes are P-type conductance, and IGZO is N-type conductance. This stacking layer will affect the device electrical performance. Furthermore, IGZO is a hard material that can hardly be stretched. And fracture and stacking of IGZO layer during stretching will seriously affect the electrical properties of the device after stretching. Therefore, it is necessary to etch IGZO to transfer the S/D electrode and channel patterns directly onto the PUU dielectric layer. Before etching, the device shows obvious bipolarity characteristic due to the IGZO and CNT compound channel. And the current on-off ratio is low owing to the influence of different conductivity types of semiconductors. After etching, the device exhibits enhanced P-type conductance and the on-off current ratio is improved.

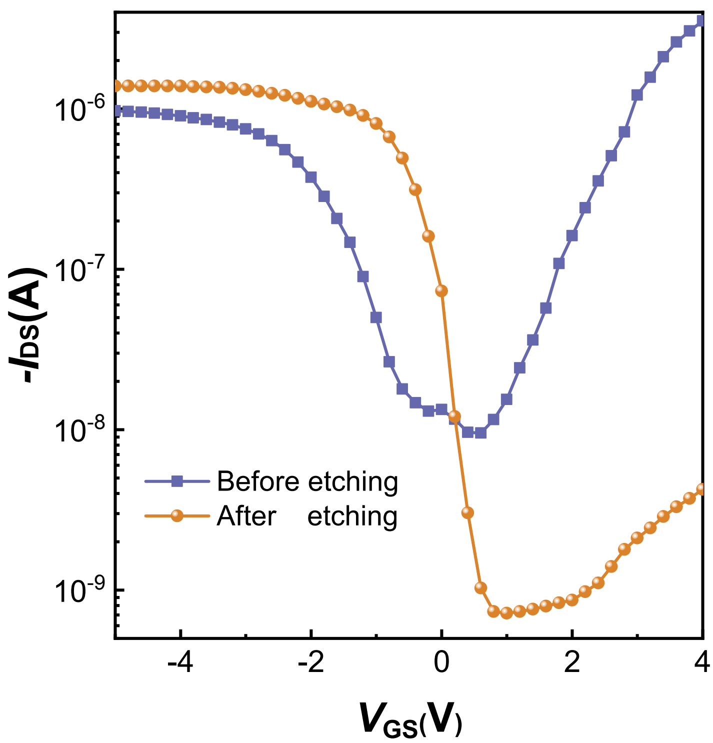

Figure S4. Transfer characteristics of a typical transistor (W= 20 µm, L= 100 µm) at -1 V drain voltage before and after IGZO etching.

5. Gate leakage current characterization under mechanical strain.

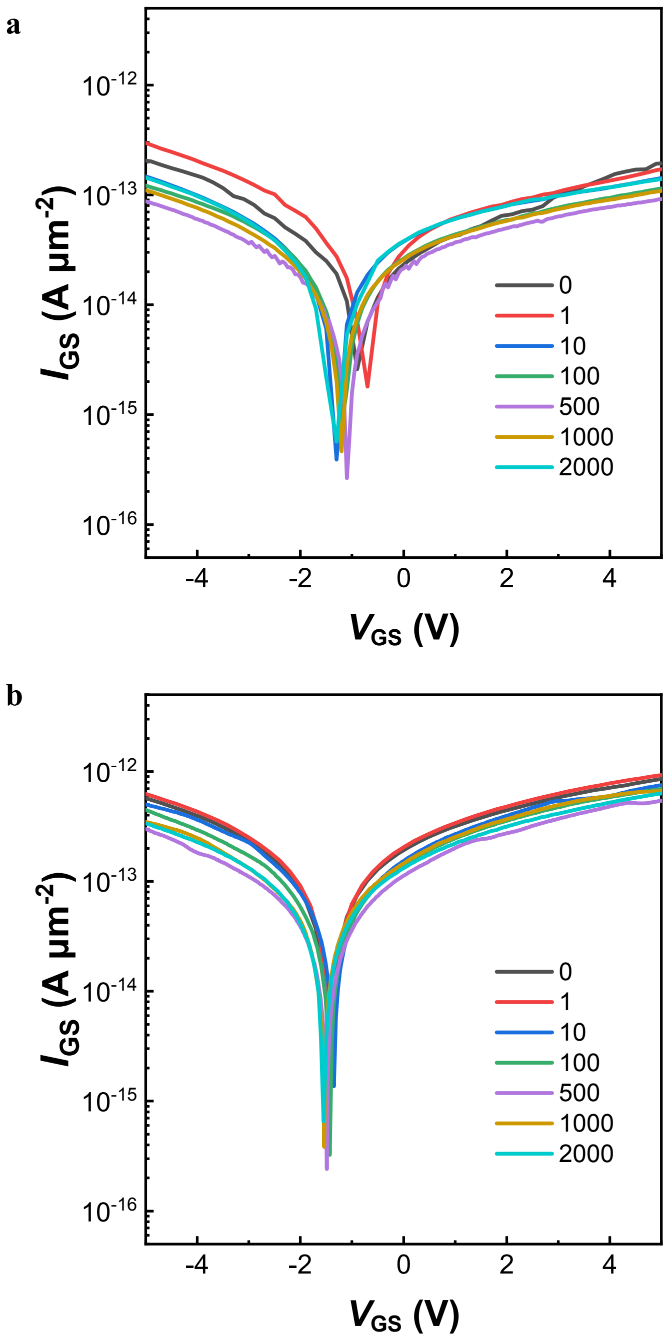

Figure S5. Gate leakage current density (I_{GS}-V_{GS}) during the test of 2000 stretch cycles under 50% strain applied along the directions (a) parallel and (b) perpendicular to the channel direction. The gate leakage currents show minor changes during the 2000 stretching cycles, indicating the mechanical stability of the PUU dielectric layer.

6. Optical microscope images of stretchable transistors before and after stretching.

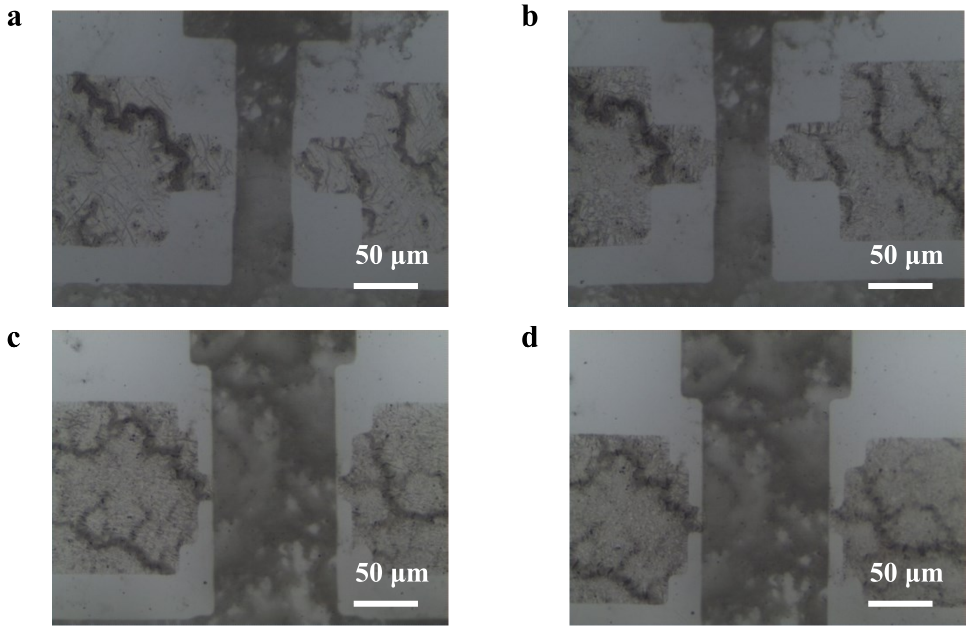

Figure S6. Optical microscope images of typical transistors before and after 2000 stretch cycles by 50 % strain. **(a, b)** Optical microscope images of the transistor (W= 20 µm, L= 40 µm) before **(a)** and after **(b)** applied 50% strain perpendicular to channel direction. **(c, d)** Optical microscope images of the transistor (W= 20 µm, L= 100 µm) before **(c)** and after **(d)** applied 50% strain parallel to channel direction.