Supporting Information for:

Local Gate Effect of Mechanically Deformed Crossed Carbon Nanotube Junction

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Methods

Device fabrication and measurement: Arrays of carbon nanotube FET devices were fabricated by patterned chemical vapor deposition (CVD) growth of single-walled carbon nanotubes (CNT) on highly degenerated silicon substrate with a 500 nm SiO_2 coating[S1], followed by electron-beam lithography and metallization, using Ti/Au (10 nm/80 nm) as contacts. The samples were then imaged with DI Nanoscope III Atomic Force Microscope (AFM). Only the devices with a single semiconducting CNT channel and a single as-grown crossed CNT junction were selected for measurements. The crossed CNT was isolated from both source and drain electrodes by AFM manipulation without disturbance to the junction. All electrical characterizations were conducted on a Keithley 4200 Semiconductor Characterization System.

AFM manipulation: The AFM operations were performed on a DI Nanoscope III AFM with customized control software. The radius of the AFM tips (NSC-11 Si_3N_4 coated probes from µmash, force constant 50 N/m) is 20 nm. In practice, the radius of the AFM tips may increase to 40-50 nm due to wear-out in the imaging and manipulation process, estimated from the cross section analysis of the surface features. The topological image of the crossed CNT junction was first captured in Tapping Mode, and the scanning size was gradually decreased with the CNT junction always at the center to reach a 500 nm x 500 nm window. Before AFM manipulation, the image scan would continue for at least 30 minutes to correct in real-time any error introduced by the drifting of the scanning tube. Then the AFM tip was brought right on top of the start point of the manipulation, vibration of the AFM tip shut off by external controller, feedback turned off, and the tip was directed to go through the predefined path. In the case of pressing at the crossed junction, this would be moving down along the z-axis at the center of the image, holding position for one second, and then back to imaging height. The z movement was defined according to calibrated force curve and the desired setpoint. In the end, the vibration and feedback was turned back on, and the AFM was switched back to the imaging mode.

Reference

S1. Kong, J.; Soh, H. T.; Cassell, A. M.; Quate, C. F.; Dai, H. J. *Nature* **1998,** 395, 878-881.

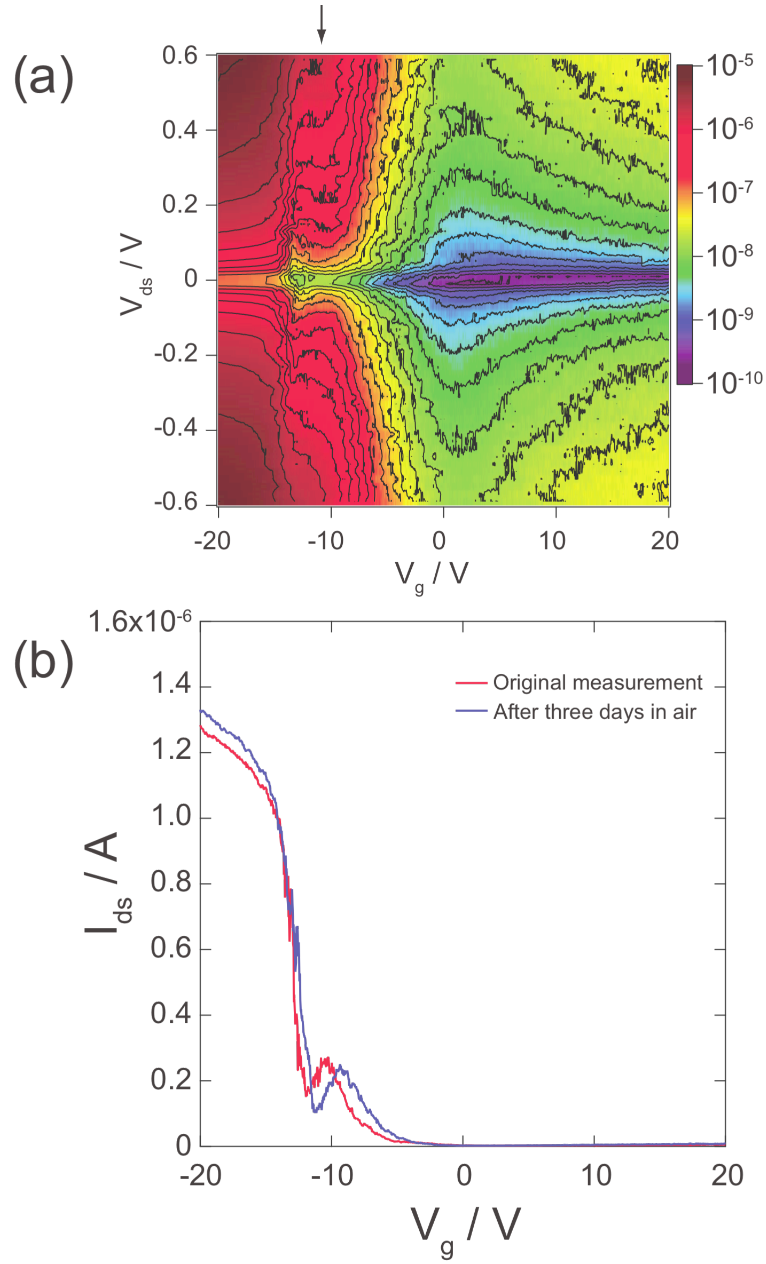

Figure S1. The transitional transconductance modulation at different source-drain bias and its long-term stability. (a) I_{ds}-V_{ds}-V_g map obtained by scanning V_g from -20 V to 20 V when varying V_{ds} from -0.6 V to 0.6 V. The current is plotted in log scale. The arrow marks the transitional peak, which holds a stable position for V_{ds} between -0.4 V and 0.4 V, but become less significant at higher V_{ds}. The current map is reproducible when only V_{ds}<1 V was applied. (b) The modulation feature is stable in ambient environment. The measurement three days (blue trace) after the original one (red trace) shows only a small shift.

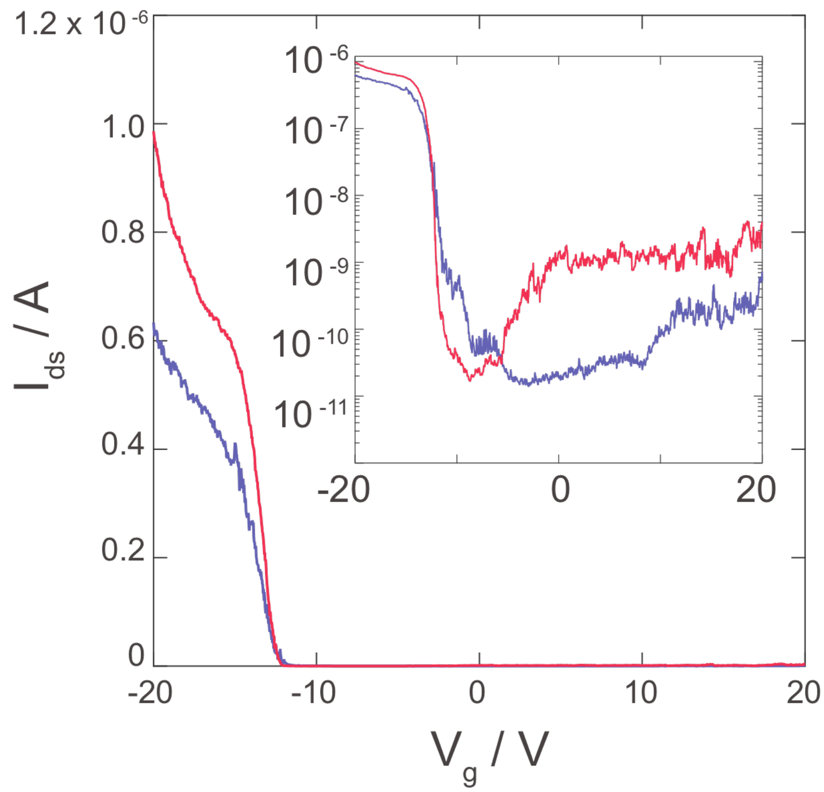

Figure S2. Control experiment of the device that has a single 3 nm diameter CNT with no crossed junction. Red trace: I_{ds}-V_g of the original device. Blue trace: after pressing at the middle point of the CNT at >0.3 GPa pressure. Inset: the same data with log scale. The V_g was scanned from -20 V to 20 V.

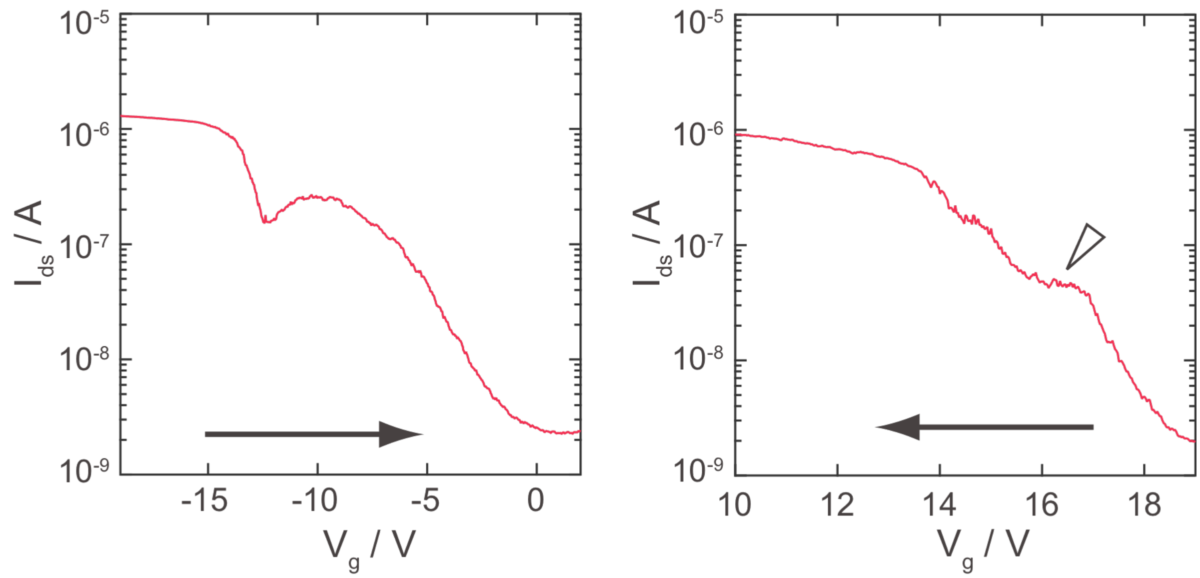

Figure S3. Comparison of I_{ds}-V_g with opposite scan directions. Left: V_g scans from -20 V to 20 V. Right: V_g scans from 20 V to -20 V. The modulation of transconductance is much less obvious for the latter case with only a brief transitional step as marked by the hollow triangle.