Supporting Information

Synergistic effects of doping and thermal treatment on organic semiconducting nanowires

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Experimental Procedures:

Sample Preparation: Highly-doped silicon wafers and thermally-grown SiO_2 (100 nm) were used as gate electrodes and gate dielectrics, respectively. A thermal evaporator was used to deposit Ti (3 nm) and Au (30 nm) on the Si/SiO_2 substrate for the source and drain electrodes with interdigitated structure. The channel length was 20 μm.

P3HT (Regioregularity~90%, Mw~79,000, Aldrich) and PEO (Mw~400,000, Aldrich) were used to prepare 70:30 (w/w) blend solutions of P3HT:PEO. F4-TCNQ (Aldrich) was added as a dopant at 0.1, 0.5, 1, 2 wt% ratios to P3HT. Trichloroethylene and chlorobenzene were mixed in appropriate ratio and the mixture was used as the co-solvent of the P3HT:PEO blend solution. P3HT NW was printed using an our homebuilt ONP system consisted of syringe (Hamilton), syringe pump (NanoNC), micrometer, high voltage generator (NanoNC), collector, linear motor stage (Yaskawa) and also another similar ONP system (Enjet Inc.). The blended P3HT:PEO solution was injected into the syringe and metal nozzle (32G) at a feed rate of 200 $nl \cdot min^{-1}$. Tip-to-collector distance was set at 5-8 mm and 1.5-2 kV was applied to the metal nozzle. While the collector moved in a zigzag motion, ten strands of P3HT NWs doped with F4-TCNQ were fabricated and aligned on the substrate. The NW FETs were thermally annealed at 100, 150, or 200 °C for 1 h in vacuum.

Characterization: NW morphology was observed by scanning electron microscopy using a Jeol JSM-7401F at an acceleration voltage of 5 kV and by transmission electron microscopy imaging using a JEOL JEM-2200FS (with Cs-corrector) (National Institute for Nanomaterials Technology, Korea) at an acceleration voltage of 200 kV without staining. Photoluminescence spectra were measured using a JASCO FP-6500. Ultraviolet absorption spectra were recorded

using an ultraviolet-visible spectrophotometer (S-3100, Scinco). Electrical measurements of FETs were conducted under nitrogen atmosphere at room temperature using an I–V tester (Keithley 4200, Keithley Instruments Inc.). PL decays of P3HT NWs were investigated by a Time-Correlated Single Photon Counting (TCSPC) measurement using a PicoHarp 300 TCSPC module (PicoQuant GmbH) and a picosecond pulsed laser head (LDH-P-C-405B, PicoQuant), with 405 nm excitation wavelength, ~150 fs pulse width driven by a PDL800-D (PicoQuant) laser driver at 40 MHz repetition rate as excitation source. The PL emission was spectrally resolved by using a monochromator (SP-2155, Acton) and an MCP-PMT (R3809U-50, Hamamatsu) was used for ultrafast detection at 650 nm emission wavelength.

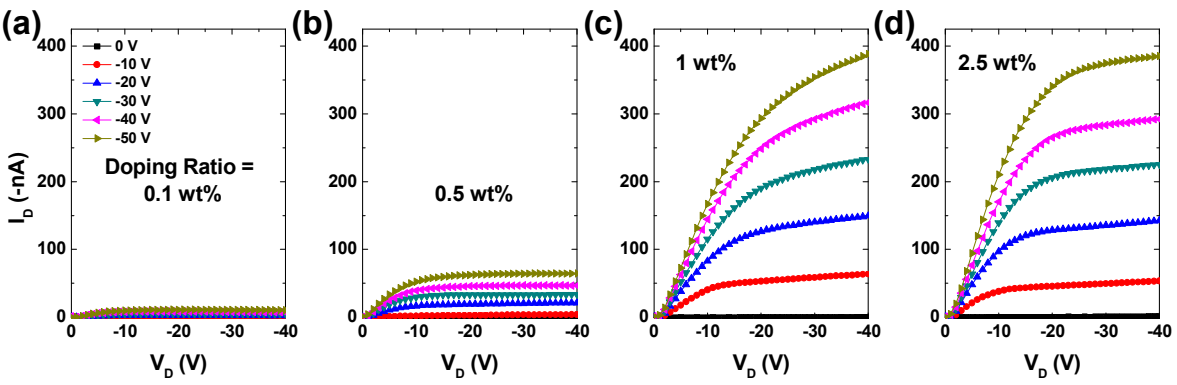

Figure S1. Output characteristics (I_D-V_D) of F4-TCNQ doped P3HT NW FETs with the doping ratios of (a) 0.1, (b) 0.5, (c) 1, and (d) 2.5 wt% after thermal annealing.

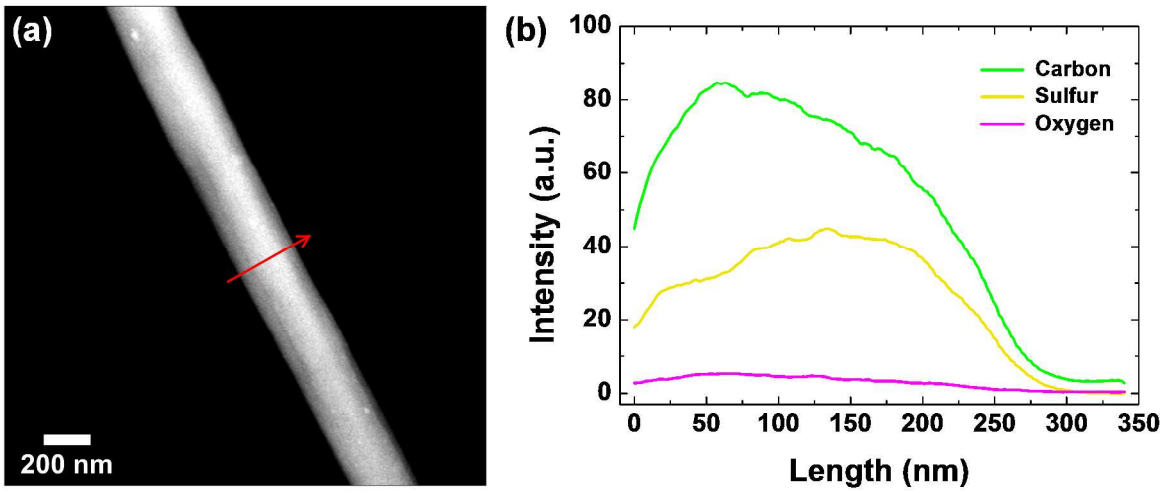

Figure S2. (a) Transmission electron microscope image of an undoped P3HT NW after thermal annealing. (b) Energy-dispersive X-ray spectroscopy graph of carbon, sulfur, and oxygen atoms along red arrow in (a).

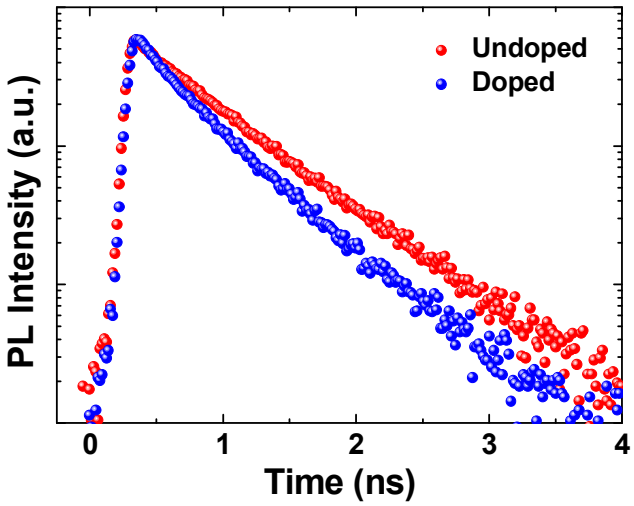

Figure S3. PL decay curves for undoped and 1 wt% F4-TCNQ doped P3HT NWs after annealing.

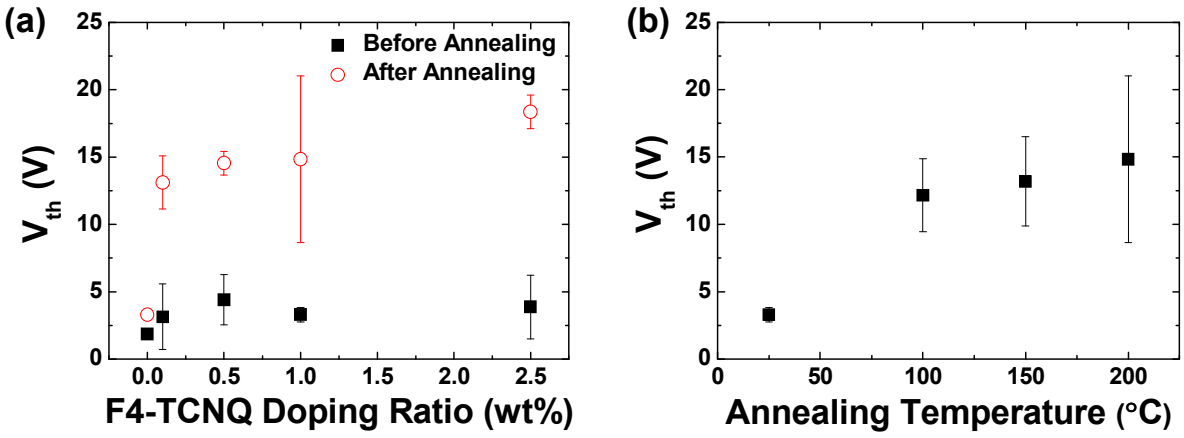

Figure S4. (a) Threshold voltages (V_{th}) of F4-TCNQ doped P3HT NW FETs before (close square) and after (open circle) annealing. (b) Threshold voltages (V_{th}) of 1 wt% F4-TCNQ doped P3HT NW FETs with different annealing temperatures.