Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Experimental section

Material: All chemicals were purchased from chemical suppliers and used without further purification. SWCNHs were produced by Carbonium s.r.l., Padova (Italy) by direct graphite evaporation in Ar flow, according to a patented method1717 and used without further purification. SWCNH films of several thicknesses were prepared onto glass substrates by spin coating. Different thicknesses were achieved by varying the amount of spin coated SWCNHs dispersions (3.6 mg mL^{-1} in *o*-dichlorobenzene). After each layer deposition, the sample was left at a heated state (140 °C) to allow solvent evaporation.

Doping of films: The thin films were p-doped by submersion in a solution of triethyloxonium hexachloroantimonate (OA) in dichloroethane (DCE). The doping level was modified either by varying concentrations and/or exposure durations (Table S1).

Table S1. Details of the p-doping experiment.

Concentration of OA ($mg \cdot mL^{-1}$)	Doping time (min)	Doping rate ($mg \cdot min \cdot mL^{-1}$)	Conductivity ($S \cdot cm^{-1}$)	Seebeck coefficient ($\mu V \cdot K^{-1}$)
0	0	0	3.62	42.91
0.003	2	0.006	5.26	40.52
0.03	5	0.15	9.28	38.66
3	0.5	1.5	15.29	33.58
3	10	30	17.64	29.33

The n-type doping of SWCNHs films was achieved by submersion in a solution of bis(pentamethylcyclopentadienyl) cobalt(II) in toluene (doping rate 4.8 $mg \cdot min \cdot mL^{-1}$). The procedure was performed in a glovebox under inert conditions. The air-free holder was used to transport the samples out of the glovebox when necessary.

Seebeck coefficient and resistivity measurements: The Seebeck coefficient was determined using a custom-built apparatus designed to implement the Method of Four Coefficients. The Seebeck voltage is measured at four different temperature gradients, all near 298 ± 3 K. The thermopower is determined *via* linear fit on a plot of Seebeck voltage vs. temperature difference, and is corrected for the built-in thermopowers associated with the indium pads and copper blocks. The Seebeck measurement has been calibrated by measuring the temperature-dependent thermopower of an n-type Bi_2Se_3 NIST standard, as discussed previously.[40] The sheet resistance of the thin films is measured using a linear four-point probe setup. The sheet resistance values were first converted to resistivity with the film thickness measured by profilometry, and finally to conductivity.

Raman experiments were performed using Horiba Jobin Yvon LabRAM Aramis confocal Raman microscope with an excitation wavelength of 532 nm. The spot size was about 1 μm using an

Olympus LMPlanFl 100, NA 0.80 objective in backscattering geometry. The sample was spin coated onto a glass substrate.