Vanishing Hysteresis in Carbon Nanotube Transistors Embedded in Boron Nitride / Polytetrafluoroethylene Heterolayers

Sandeep Kumar,[1,2] Daghan Dagli,[1,2] Simone Dehm[1], Chittaranjan Das,[5] Li Wei[4], Yuan Chen[4], Frank Hennrich[3], and Ralph Krupke[1,2,3]

[1] Institute of Nanotechnology, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

[2] Institute of Materials Science, Technische Universität Darmstadt, 76021 Karlsruhe, Germany

[3] Institute of Quantum Materials and Technology, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

[4] School of Chemical and Biomolecular Engineering, The University of Sydney, NSW 2006, Australia

[5] Institute of Applied Materials, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

Supplementary Material

Figure S1: Characteristics of reference devices fabricated on Si/SiO_2 without h-BN and PTFE

Figure S2: Optical image of grown h-BN

Figure S3: SEM images of grown h-BN

Table S1: Comparison of hysteresis in this work to previous literature for CNT transistors

License: CC BY 4.0 International - Creative Commons, Attribution

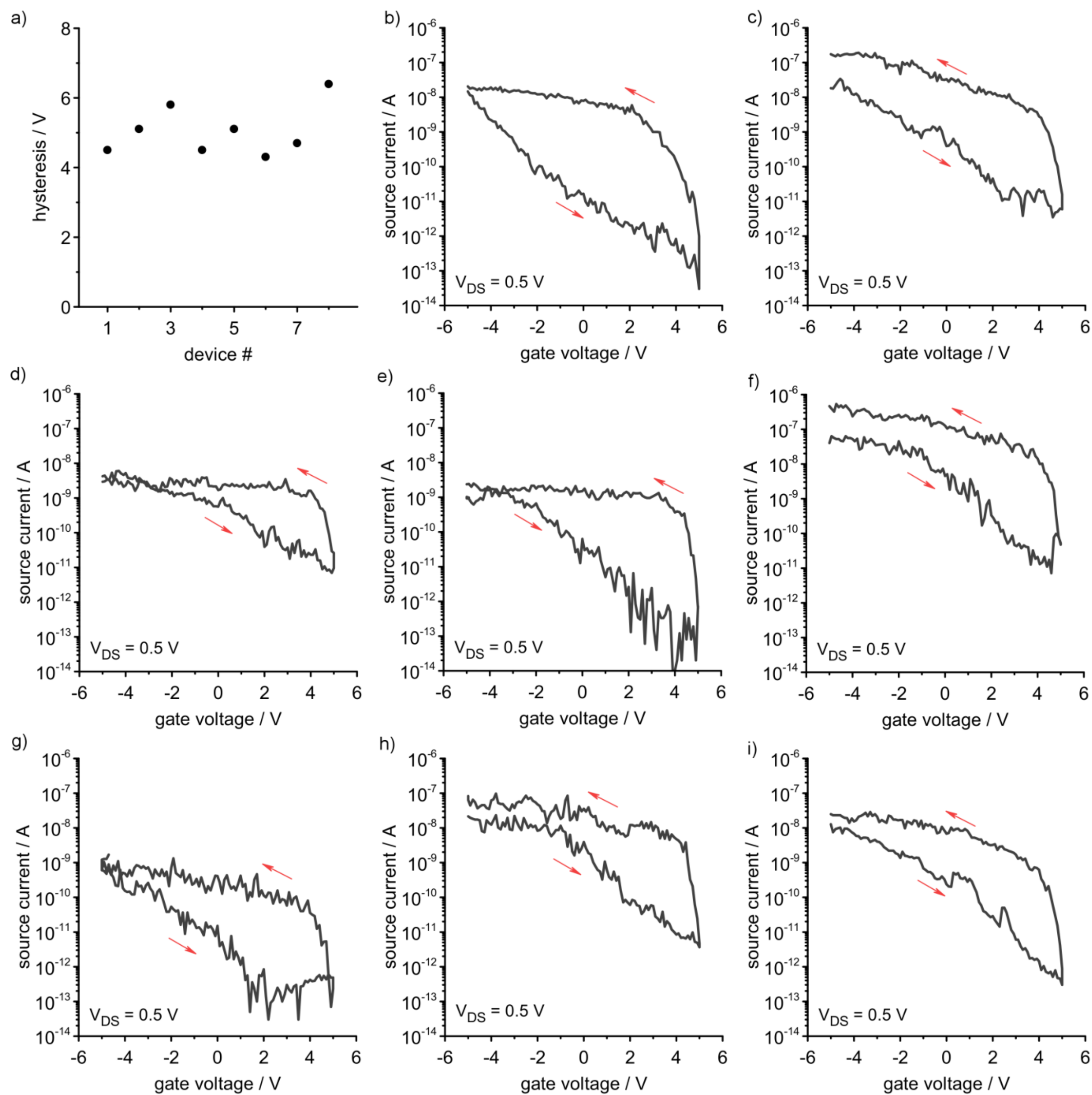

Figure S1: (a) Hysteresis in transconductance curves for SWNCT devices on Si/SiO2 without h-BN and PTFE encapsulation. (b-i) The corresponding transconductance curves were measured after vacuum annealing and are hence comparable to the h-BN supported devices prior Teflon coating.

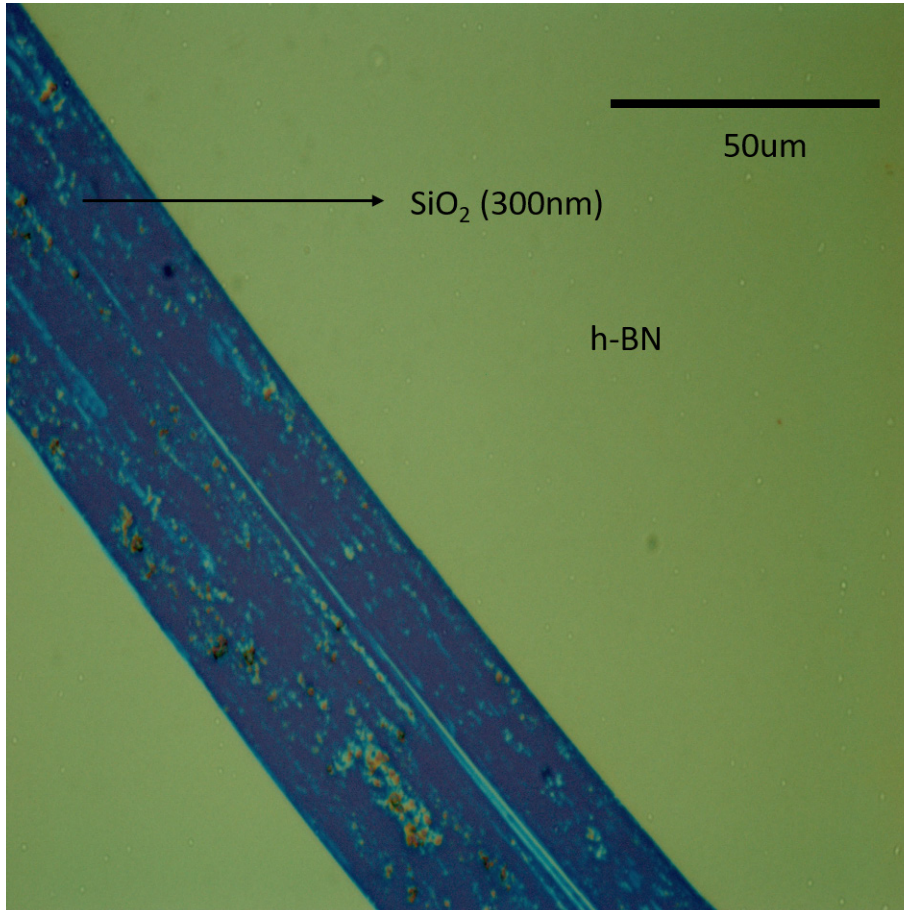

Figure S2: Optical image of 80 nm thick h-BN grown on 300nm SiO_2

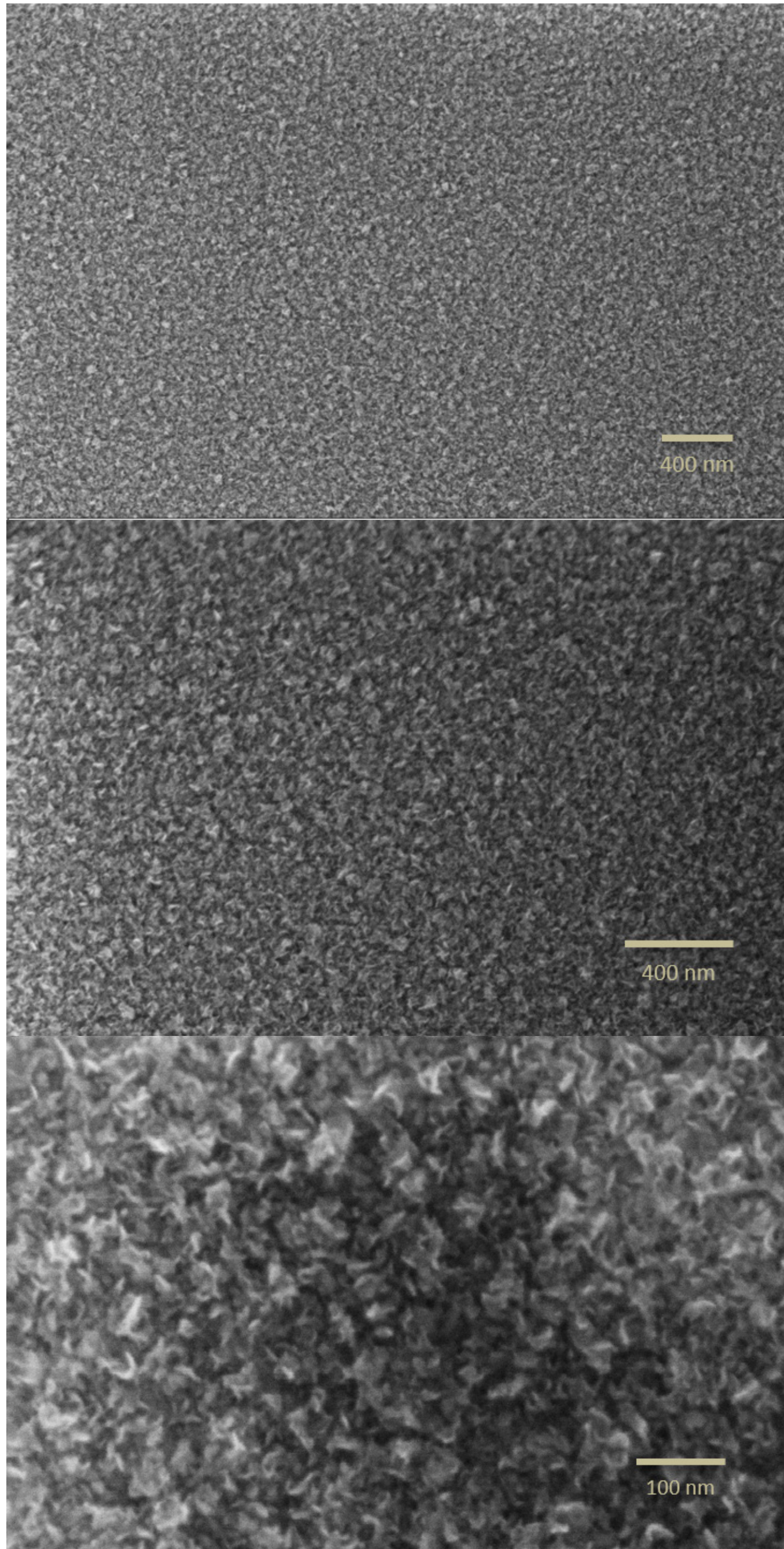

Figure S3: SEM images of 80nm thick h-BN on 300nm h-BN at different magnifications.

Gate sweep window (Electric field)	Hysteresis in V	Dielectric thickness	Effective Dielectric constant	CNT Condition	DOI
-3 to 3 (3.14 MV/m)	2.2	SiO_2-500nm Air-200nm	SiO_2+air = 2.13	Suspended (CNT on top of electrodes)	10.1103/PhysRevB.86.115444 (ref 5)
-5 to 5 (2 MV/m)	<0.1	SiO_2 – 50nm	SiO_2 =3.9	PTFE encapsulation Dielectric Surface passivation (Electrodes on top of CNT film)	10.1021/am5013326 (ref 17)
-10 to 10 (16.7 MV/m)	5	SiO_2-200nm Parylene-100nm	SiO_2+ Parylene (3.15) = 3.61	Hydrophobic film on dielectric (CNT on top of electrodes)	10.1002/adma.201004640 (ref 6)
-1 to 1 (16.7 MV/m)	0.1	SiO_2-4nm SAM-2nm	3.3	SAM on SiO2(Electrodes on top of CNTs)	10.1021/nl061534m (ref 8)
-10 to 10 (80 MV/m)	8	SiO_2-100nm	SiO_2 =3.9	PMMA passivation on top of CNT (Electrodes on top of CNT)	10.1143/JJAP.45.5501 (ref 14)
-5 to 5 (5.55 MV/m)	0.5	ZrO_2-90nm	ZrO_2 =10	PVDF-TrFE passivation on top of CNT (CNT film on top of electrodes)	10.1063/1.4895069 (ref 15)
-1.5 to 3 (10 MV/m)	0.3	TiO_2-30nm	TiO_2 =22	TiO2 top gate (Electrodes on top of CNT film)	10.1021/acsnano.7b01164 (ref 16)
-5 to 5 (0.263 MV/m)	0.1	h-BN-80nm SiO_2- 300nm	h-BN = 3.29 h-BN+SiO_2= 3.75	PTFE + h-BN (CNT on top of electrodes)	This work

Table S1: Comparison of the hysteresis in this work to the literature