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Supplemental Information

Breakdown Current Density in BN-Capped Quasi-1D $TaSe_3$ Metallic Nanowires: Prospects of Interconnect Applications

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I. Materials Characterization

The samples for x-ray diffraction (XRD) were prepared by grinding $TaSe_3$ crystals in a mortar and pestle before pressing into an aluminum mount. Data were collected on a Bruker D8-Advance (Co-Kα radiation) diffractometer from 10-80 2θ at a rate of 0.1 s per step at 40 mA,

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40 kV. For SEM/EDS and EPMA analyses, crystals were mounted on double-sided carbon tape. SEM images were acquired with an FEI Inspect F field emission gun scanning electron microscope operated at 20 keV, with an EDAX energy dispersive spectroscopy attachment. EPMA data were collected wtih a JEOL JXA 8600 Superprobe instrument.

II. Optical Microscopy

High-quality $TaSe_3$ crystals were prepared by the chemical vapor transport (CVT) method using iodine. Figure S1 is an optical microscopy image of the synthesized $TaSe_3$ crystals before chemical and mechanical exfoliation.

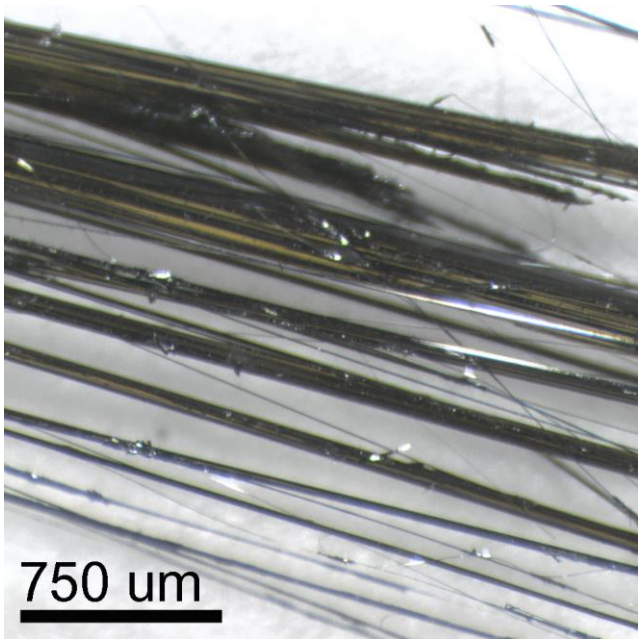

Figure S1: Optical microscopy image of $TaSe_3$ crystals.

III. Transmission Electron Microscopy

Transmission electron microscopy and electron diffraction were performed on a FEI Tecnai12 TEM at the Central Facility for Advanced Microscopy and Microanalysis at UC Riverside.

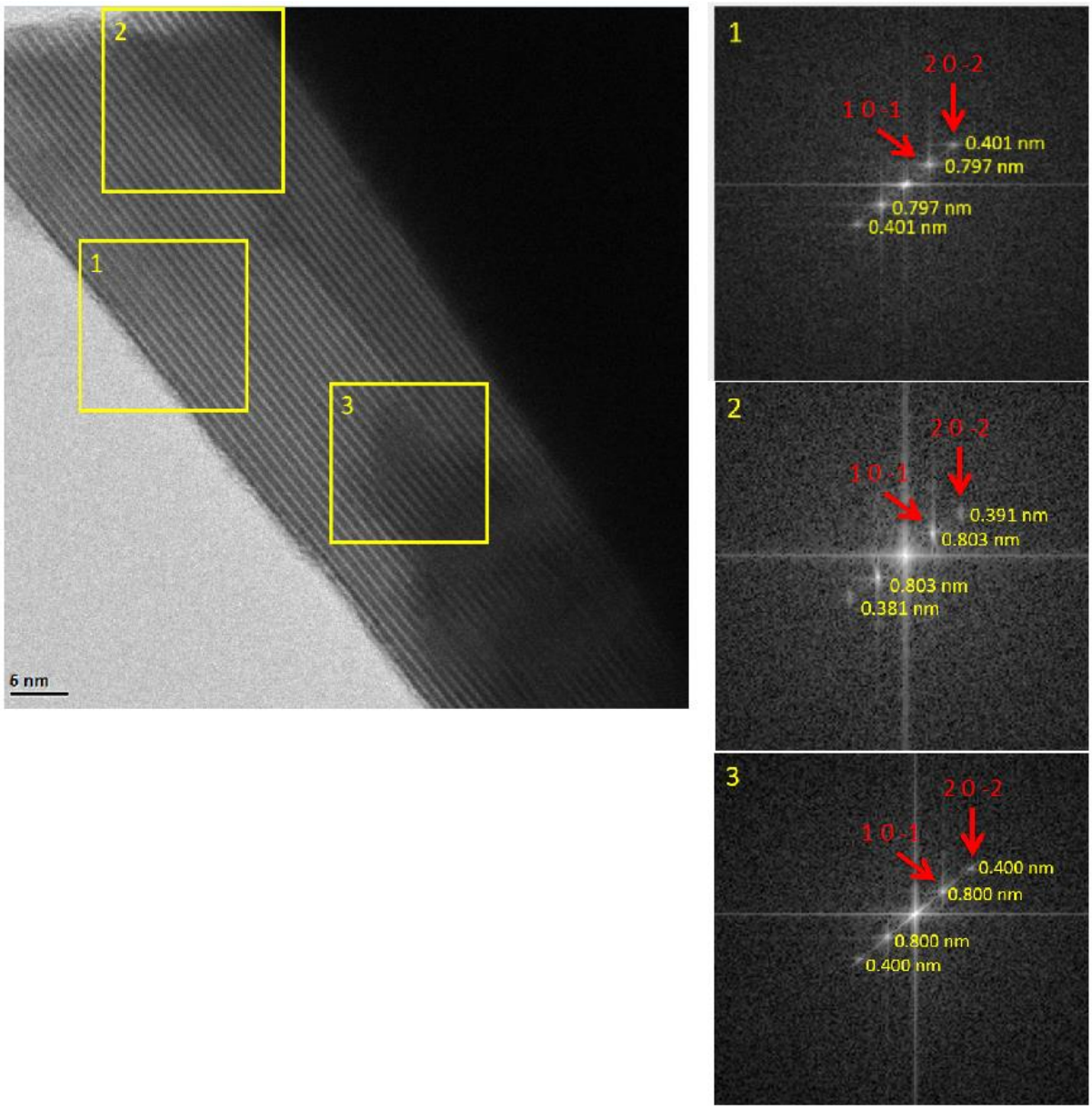

Figure S2: FFT analysis for the HRTEM image in Figure 1(c). Spots were matched using d-spacing values for the monoclinic $TaSe_3$ structure (below).

Table S1: Values for the d-spacing of the monoclinic $TaSe_3$ structure.

monoclinic $TaSe_3$					
d-spacing[Å]	**2θ**	**rel. I [%]**	**h**	**k**	**l**
9.9859	8.848	3.15	1	0	0
9.4358	9.365	8.85	0	0	1
8.0801	10.941	100.00	1	0	-1
6.0631	14.598	1.87	1	0	1
5.0342	17.603	20.60	2	0	-1
4.9930	17.750	32.57	2	0	0
4.8186	18.398	34.57	1	0	2
4.71793	18.7924	14.93	0	0	2
4.04007	21.9818	2.60	2	0	-2
3.97683	22.3358	4.06	2	0	1
3.86795	22.9730	29.93	1	0	2
3.45741	25.7450	13.02	3	0	-1
3.32864	26.7591	0.09	3	0	0
3.29879	27.0058	0.16	1	1	0
3.27740	27.1854	0.96	0	1	1
3.27416	27.2128	0.13	1	0	-3
3.20778	27.7871	4.55	-1	1	1
3.16988	28.1262	1.48	3	0	-2
3.14528	28.3507	4.40	0	0	3
3.07820	28.9820	0.27	2	0	-3
3.03154	29.4380	1.89	2	0	2
3.02795	29.4737	7.74	1	1	1
2.89503	30.8598	2.40	3	0	1
2.87095	31.1252	0.52	-2	1	1
2.86324	31.2112	5.52	2	1	0
2.82917	31.5968	97.78	-1	1	2
2.80836	31.8370	3.79	0	1	2
2.78487	32.1129	0.04	1	0	-3
2.69338	33.2348	0.17	3	0	-3

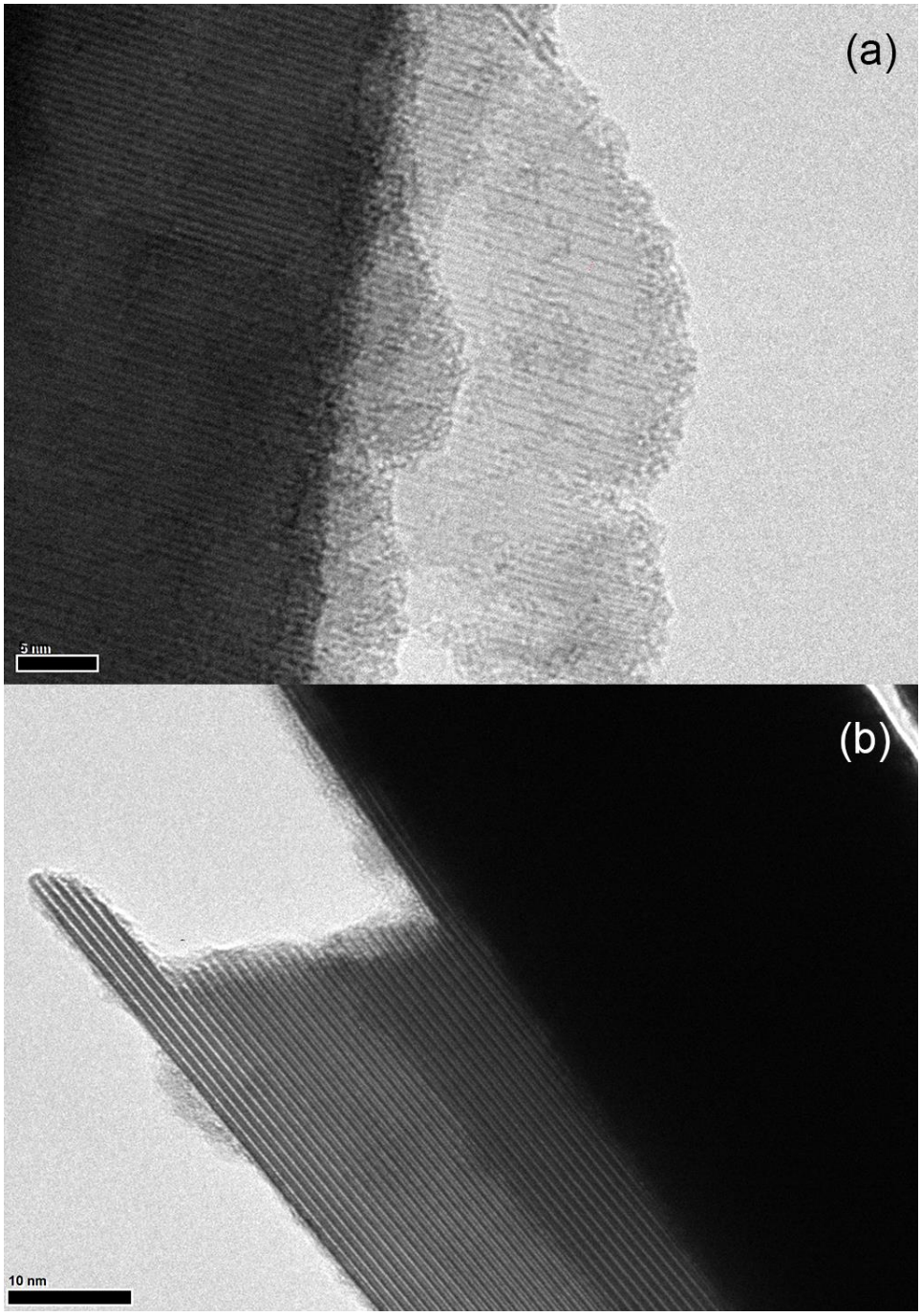

Figure S3: Additional TEM images of quasi-1D $TaSe_3$ nanowires after chemical exfoliation.

IV. Analysis of Elemental Composition

Table S2: Data on the elemental composition of CVT-grown $TaSe_3$ crystals are summarized below.

		Experimental weight %			Experimental atomic %	
	Theoretical weight %	EPMA	EDS	Theoretical atomic %	EPMA	EDS
Se	56.70	55.12	54.94	75.00	73.47	74.08
Ta	43.30	43.13	45.06	25.00	26.53	25.92
Total weight %	100.0	98.25	100.0	-	-	-
Se/Ta	-	-	-	3.00	2.77	2.86

V. Atomic Force Microscopy

Figure S4 illustrates AFM characterization of the current breakdown point in $TaSe_3$ nanowire.

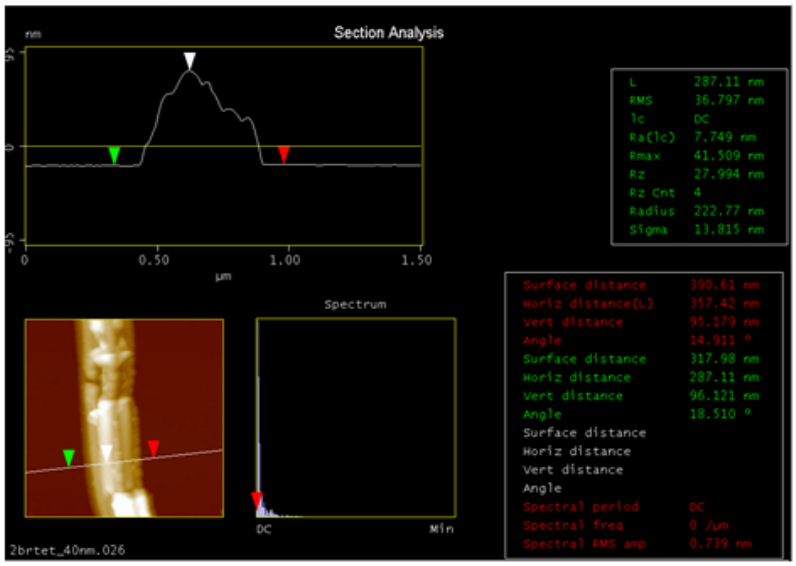

Figure S4: Representative AFM image of the breakdown point in $TaSe_3$ nanowire.

VI. Device Fabrication

In order to prevent material oxidation, $TaSe_3$ nanowires were capped immediately after being mechanically exfoliated. The fabricated heterostructures were spin coated with a positive resist polymethyl methacrylate (PMMA) and heated two times. Patterning of the assembled stacks was accomplished by electron beam lithography (EBL) (LEO Supra). In order to expose $TaSe_3$ material covered by h-BN, the assembled stacks were selectively etched with sulfur hexafluoride (SF6) gas on an inductively coupled plasma system (Oxford Plasmalab). Time of ICP treatment with 50 sccm of SF6 varied from 20 sec to 180 sec depending on hBN thickness and each time was adjusted gradually. Total of about fifty h-BN capped and not capped prototypes were fabricated within the scope of this work. Optical microscopy image in Figure S5 show a representative h-BN capped $TaSe_3$ nanowire device.

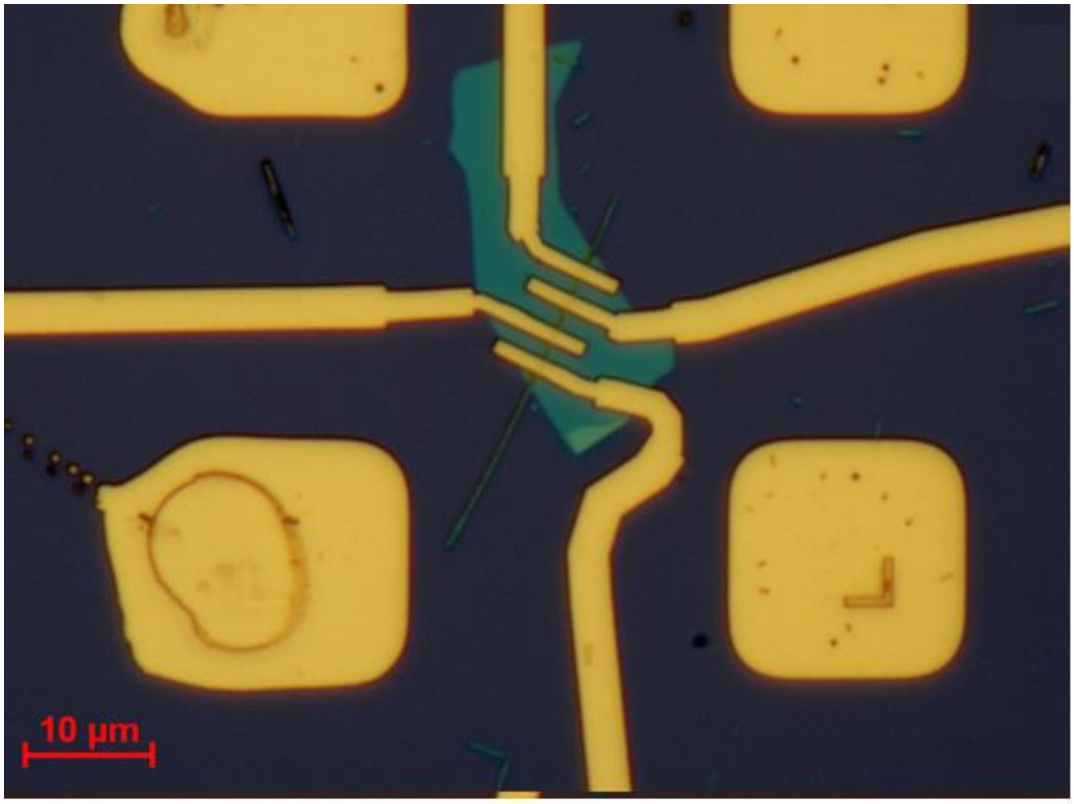

Figure S5: Optical microscopy images of quasi-1D $TaSe_3$ nanowire capped with h-BN layer.

VII. Scanning Electron Microscopy

The SEM inspection confirmed significantly lower roughness of a $TaSe_3$ metallic nanowires in comparison with the deposited metal contacts (see Figure S6). Roughness estimated by AFM was in the range from 0.2 nm to 0.5 nm.

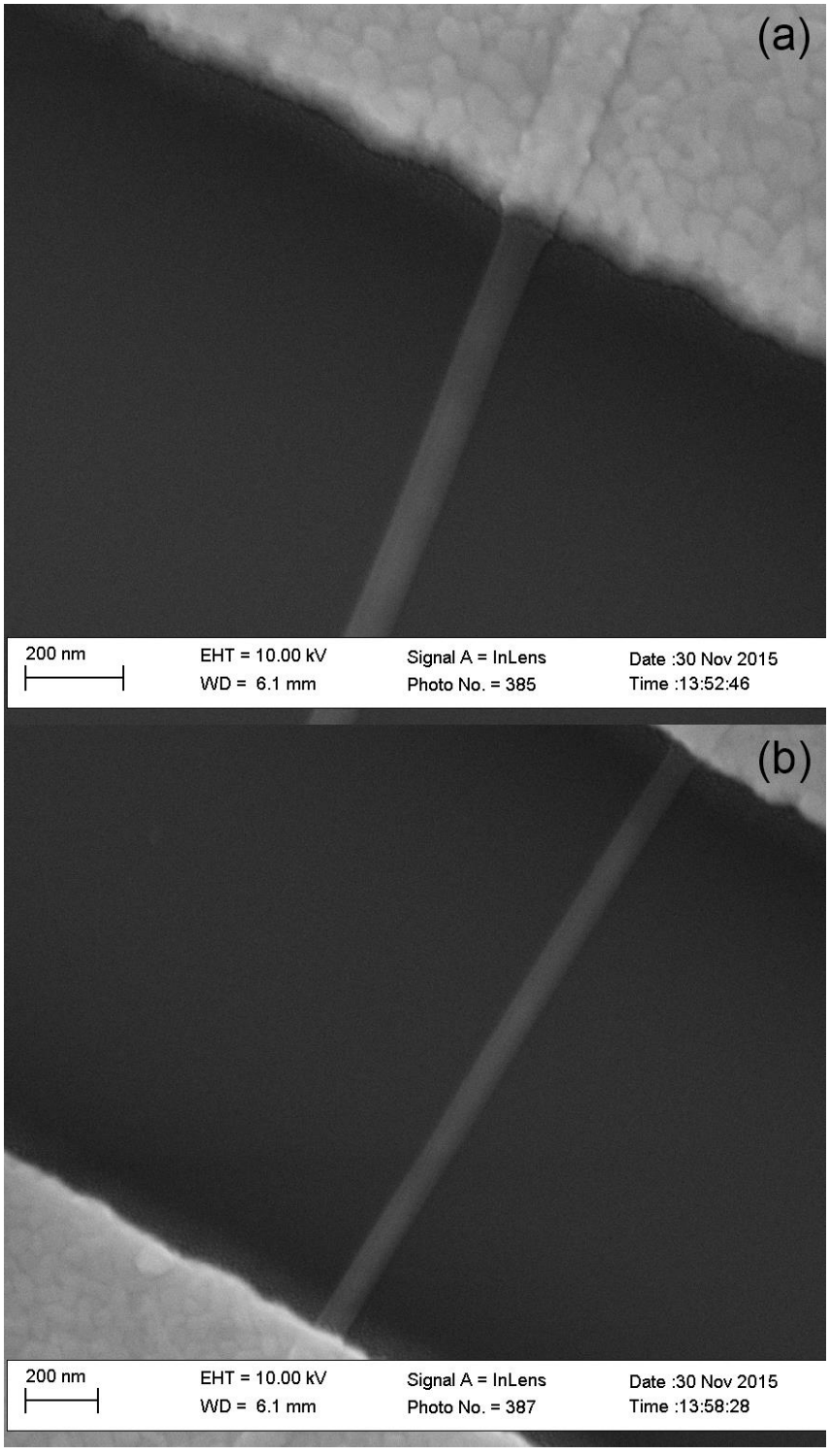

Figure S6: SEM images of representative quasi-1D $TaSe_3$ nanowires.