Supplementary Information

Achieving Wide-Range Steep Slope in SnS_2 Negative Capacitance Transistors through Its Isolated Band Structure and Thermionic Emission Enhancement via Bi Contacts

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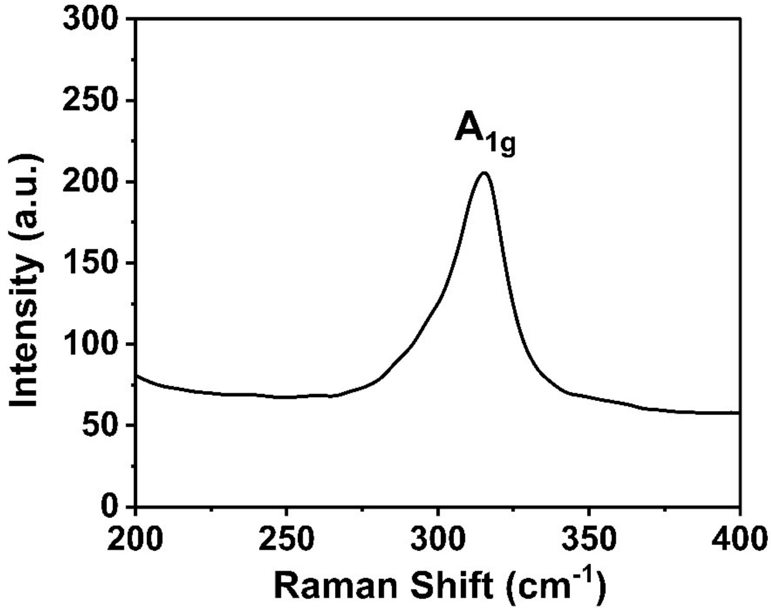

Fig. S1 Raman spectra of the SnS_2 flake. Characteristic Raman mode (A_{1g}) can be identified and compared based on their peak positions and relative intensities.

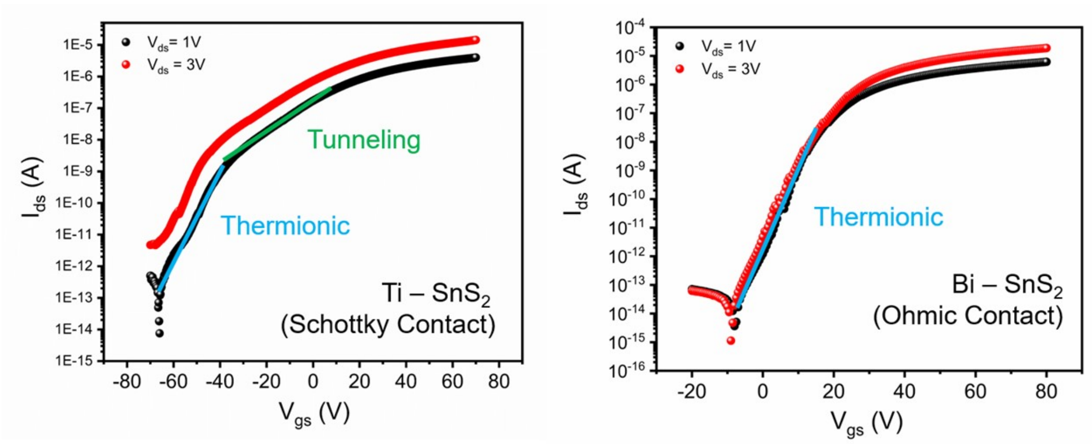

Fig. S2 I-V transfer curves of Ti-SnS_2 (Schottky contact) and Bi-SnS_2 (Ohmic contact) FETs fabricated on a 200nm SiO_2/P^{++} Si substrate.

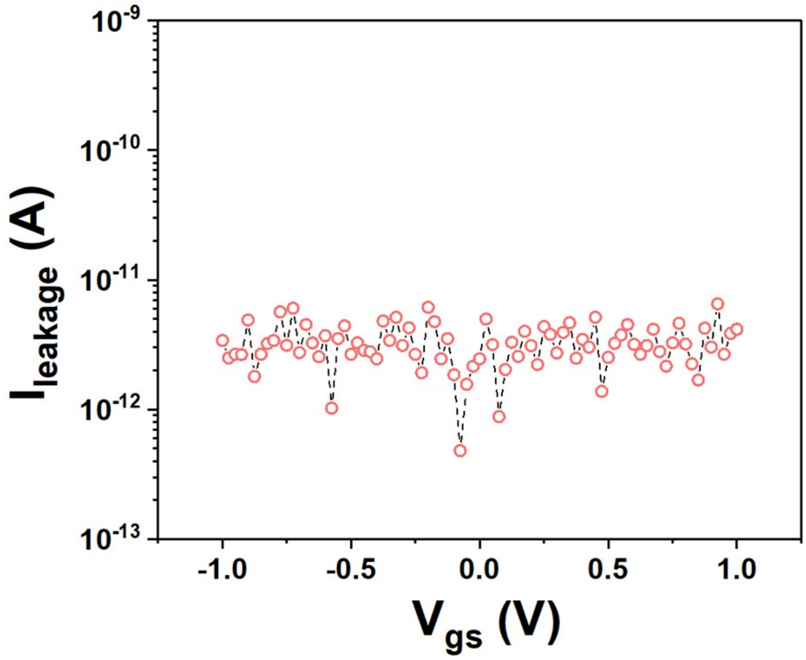

Fig. S3 Gate leakage current-voltage characteristics of the La:HfO_2/HfO_2 gate stack.

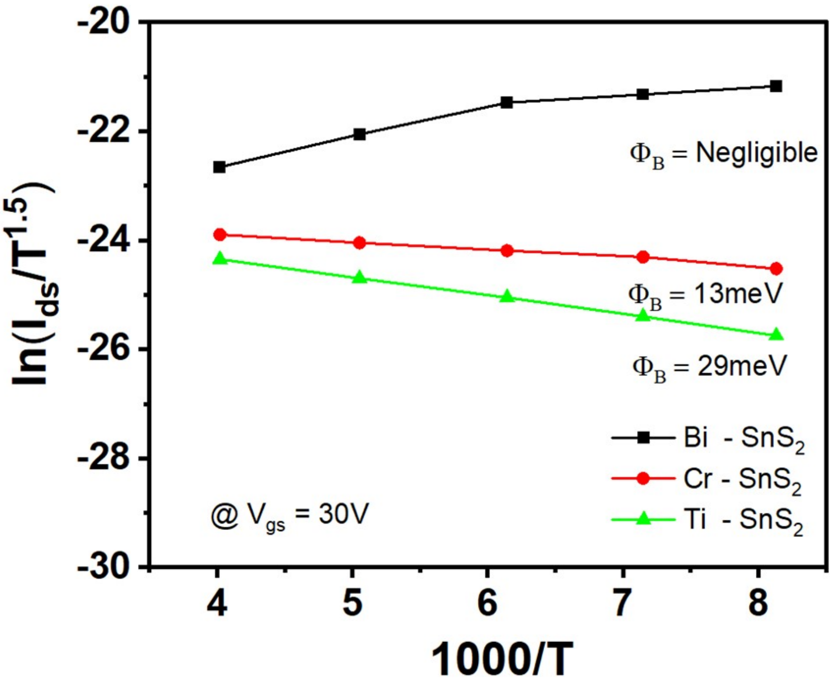

Fig. S4 Arrhenius plots for SnS_2 devices with different metal contacts (Bi, Cr, Ti). Temperature-dependent I–V measurements were used to extract activation energies, showing the contact behavior of each metal.

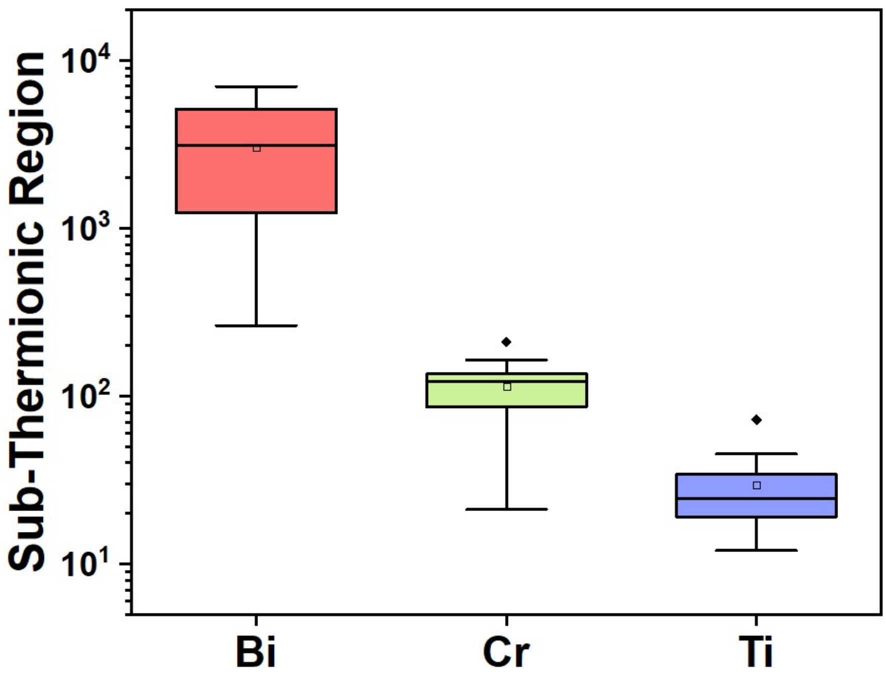

Fig. S5 Statistical summary of the sub-60 mV/dec region width for 15 NCFETs with each contact metal (Bi, Cr, Ti).

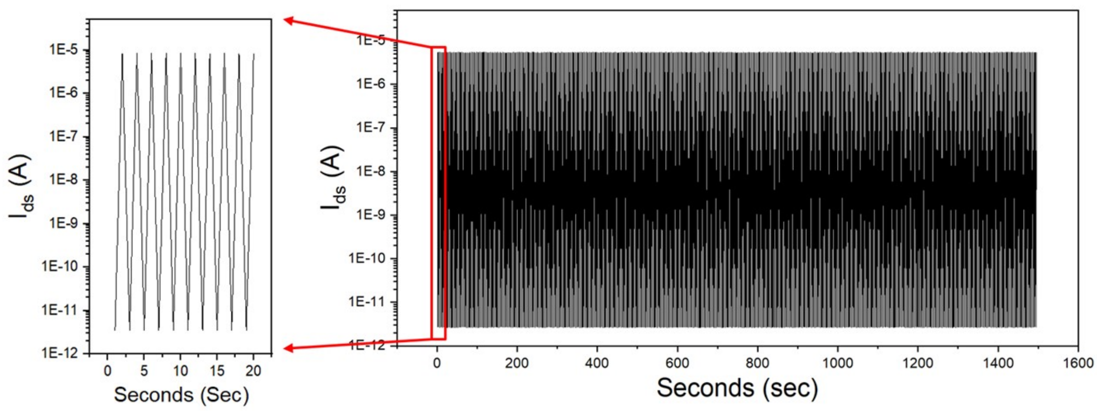

Fig. S6 Repeated switching test results of the SnS_2 transistor.

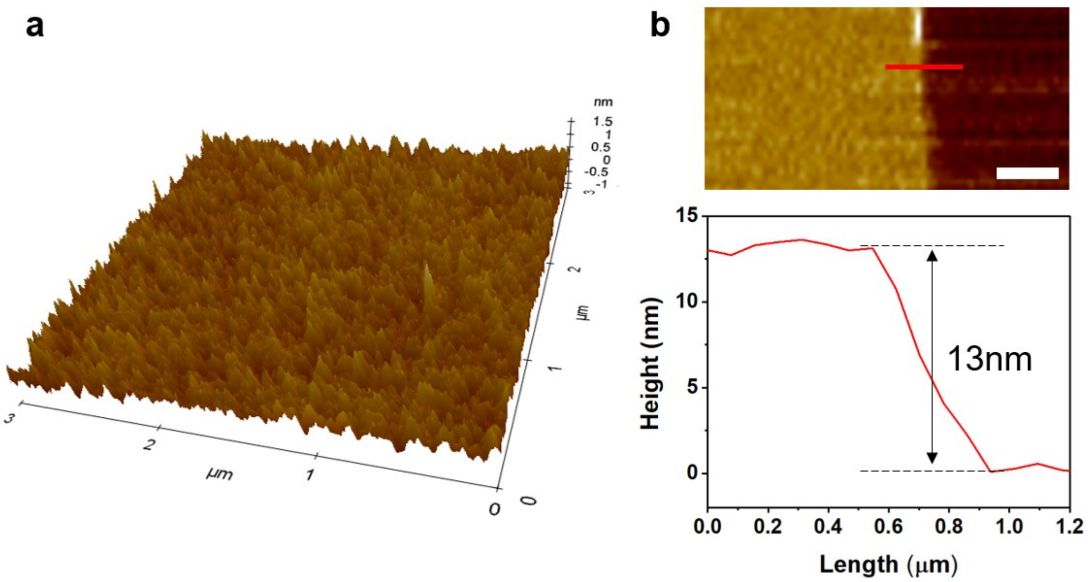

Fig. S7 Images of the negative capacitor (HfO_2/La:HfO_2): (a) surface AFM image (RMS roughness: 0.26 nm) and (b) thickness of the negative capacitor.

Table S1. Comparison of TMD-Based NCFETs with Hysteresis-Free Characteristics

Channel	Gate structure	Contact Electrode	SS_{min} (mV/dec)		V_{ds} (V)	Sub-thermionic Region (A)	On/Off	Ref
			Forward	Reverse				
MoS_2	$H_{0.5}Z_{0.5}O$ /Al_2O_3	Ni	57.6	52.3	0.1	10^{-12}~10^{-9}	>10^7	1
MoS_2	$H_{0.5}Z_{0.5}O$ /Al_2O_3	Cr/Au	17.6	25.5	0.1	10^{-13}~10^{-10}	>10^7	2
WSe_2	$H_{0.5}Z_{0.5}O$ /Al_2O_3	Pt	44	18	0.1	10^{-12}~10^{-11}	>10^5	3
MoS_2	$H_{0.5}Z_{0.5}O$ /HfO_2	Ti/Au	29.2	35.3	0.1	10^{-11}~10^{-10}	>10^4	4
MoS_2	P(VDF-TrFE)/AlO_x	LiF/Au	28		0.5	10^{-13}~10^{-9}	>10^7	5
Te	$CuInP_2S_6$/h-BN	Au	54	36	0.1	10^{-13}~10^{-12}	>10^6	6
SnS_2	La:HfO_2/HfO_2	Bi	34	39	0.1	10^{-11}~10^{-7}	>10^6	This work

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