Supplementary Information

Natively oxidized 2D $NbSe_2$ enables ultralow-power electrical switching

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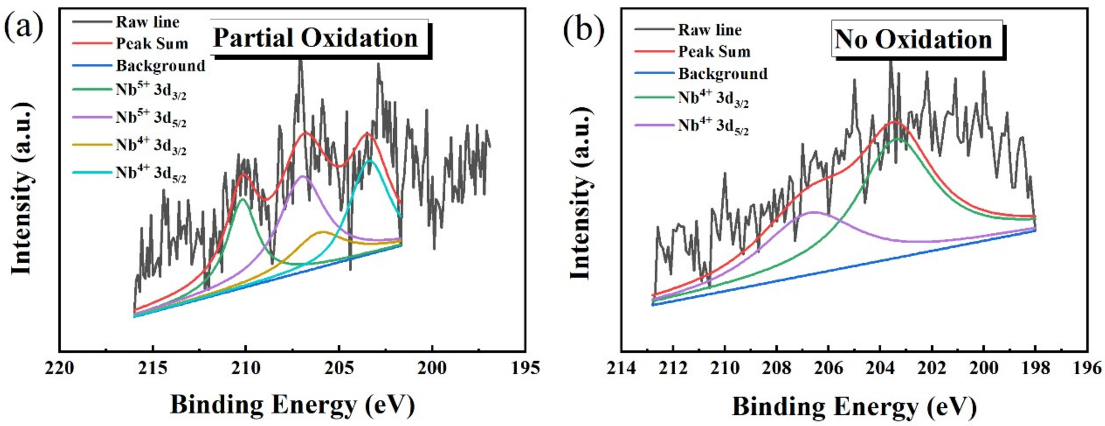

Fig. S1 XPS spectra for binding energies of $NbSe_2$ films. (a) In the partially oxidized sample, both Nb^{4+} and Nb^{5+} exhibit $3d_{5/2}$ and $3d_{3/2}$ peak positions. (b) In the non-oxidation sample, only the $3d_{5/2}$ and $3d_{3/2}$ peak positions of Nb^{4+} exist.

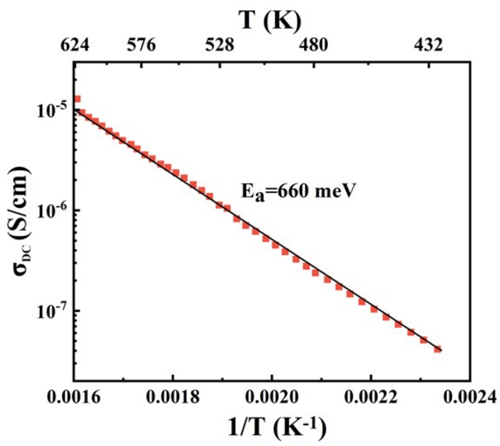

Fig. S2 Logarithm of the conductance of single crystal α-Nb_2O_5 as a function of 1/T[1]

Calculation of the functional layer resistance in devices

The calculation process is as follows:

As shown in **Fig. S2**, the relationship between resistivity and temperature in the graph can be expressed in the following equation form:

$$\lg \sigma = k \times \frac{1}{T} + b$$

Substitute the coordinates of two points into the analytical equation of a straight line:

(0.0016, -5), (0.0022, -7)

The analytical expression of the equation is obtained as:

$$\lg \sigma = -3.33 \times 10^3 \times \frac{1}{T} + 0.33$$

Set T to room temperature (T=298.15 K), the obtained result is:

$$\lg \sigma = -10.84$$

$$\sigma = 10^{-10.84}\ S/cm$$

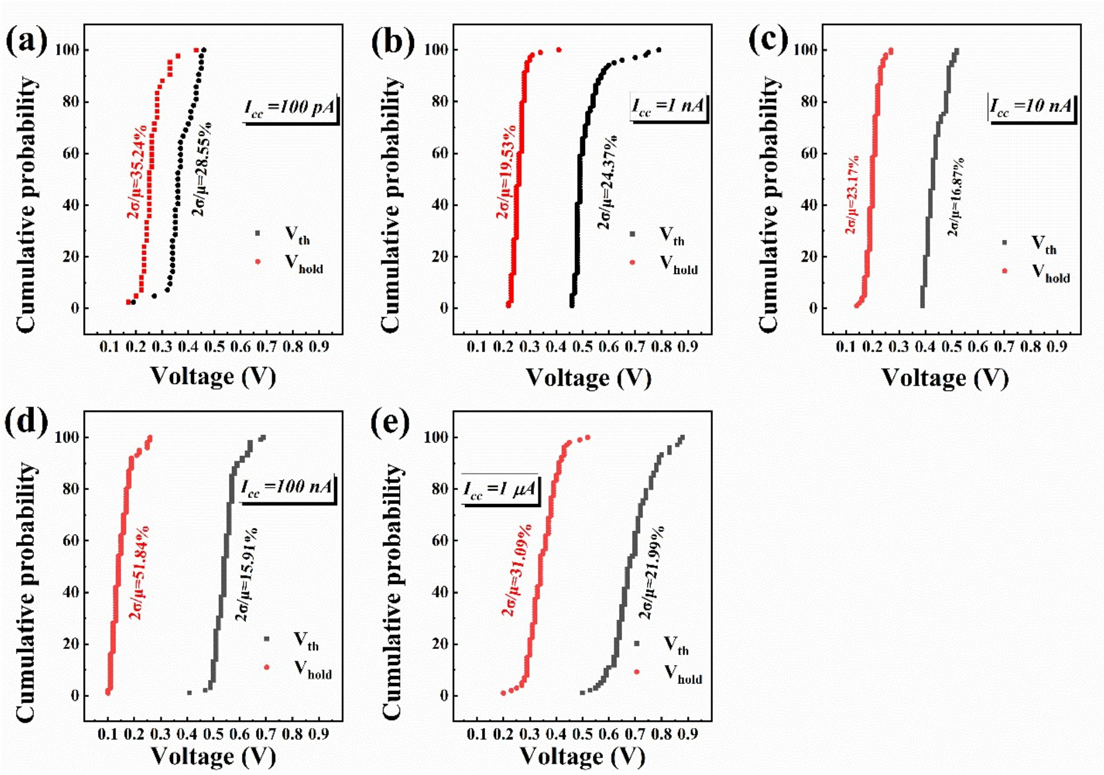

Fig. S3 The cumulative probability distribution of the device's threshold voltage and holding voltage under different compliance currents.

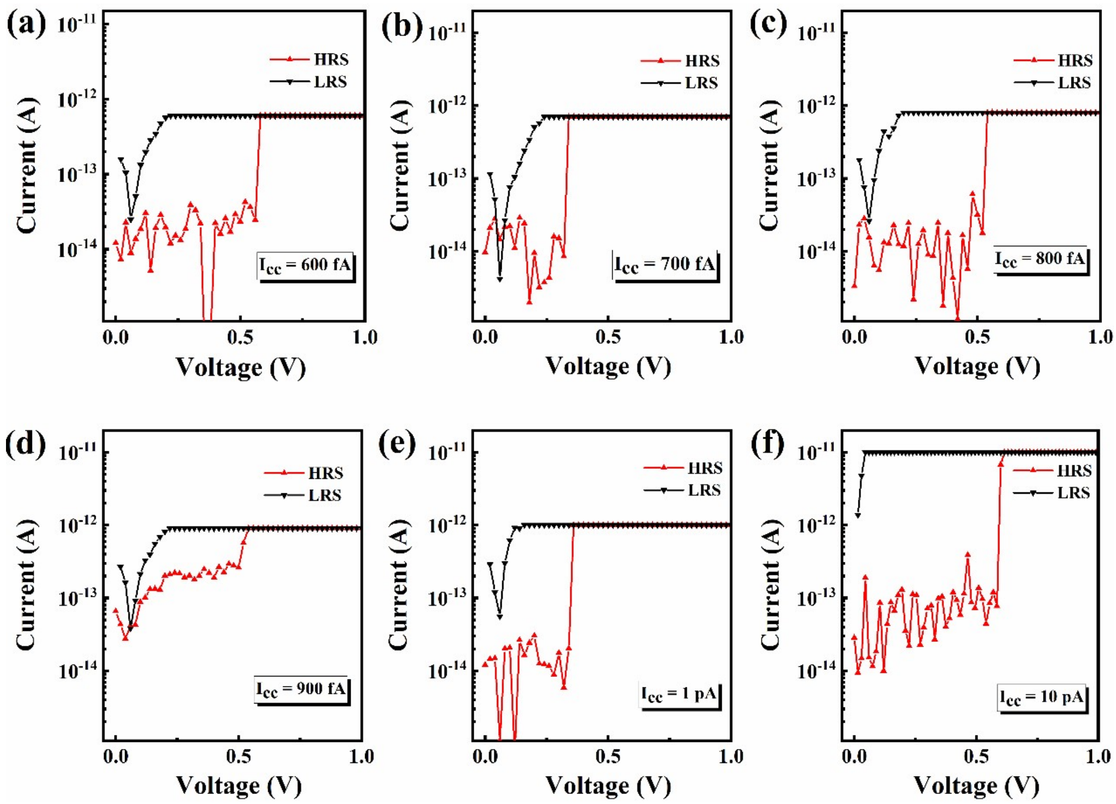

Fig. S4 The DC characteristics of the device under six different compliance currents, from 600 fA to 10 pA with the bias at 1 V.

Table S1 Comparison for similar work that utilized 2D materials or similar compounds to achieve low power consumption and high endurance.

Materials	U_{set} (V)	W_{set} (J)	Endurance	Data
DG/SiO_2	0.675	3.5×10^{-11}	10^5	Zhao[2]
Nb_2O_5/NbO_2	1.5	3.3×10^{-11}	10^6	Kim[3]
AgGeSe/Al_2O_3	0.5	1.5×10^{-15}	10^5	Tian[4]
$TiSe_2$/TiO_2/$TiSe_2$	0.845	2.39×10^{-16}	10^2	Xiong[5]
$HfSe_xO_y$/$HfSe_2$	2.5	1.6×10^{-16}	40	Liu[6]
$NbSe_2$/NbO_x	1	/	20	Kim[7]
Ti: NbO_2	2.5	2.5×10^{-18}	~10^5	Jeon[8]
pV3D3/MLG	3	>9×10^{-14}	100	Jang[9]
HfO_x	3.5	3.5×10^{-13}	120	Wang[10]
BN/SiO_2	1.3	1.3×10^{-11}	2×10^4	Ranjan[11]
$NbSe_2$/Nb_2O_5	**0.5**	**6.3×10^{-19}**	**10^6**	**This Work**

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