

• Supplementary File •

High-temperature optoelectronic synaptic devices based on 4H-SiC

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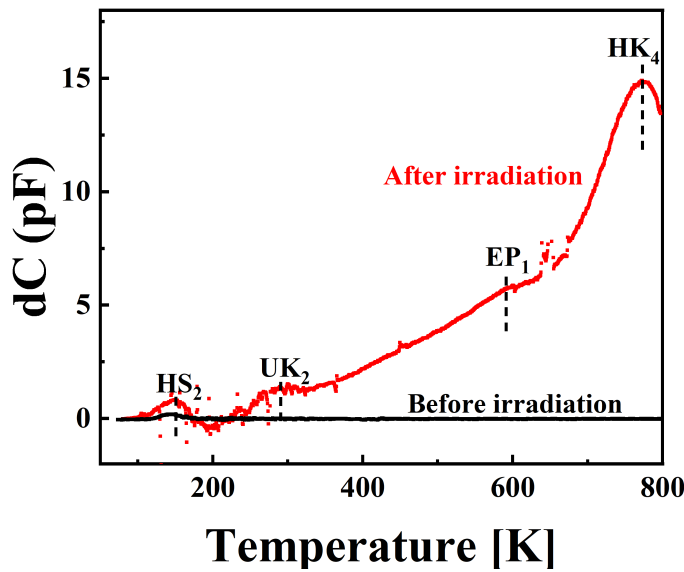


Figure 1 DLTS results of the 4H-SiC sample before and after electron irradiation.

The black curve indicates an obviously low level of defect signal intensity. After irradiation, there is a substantial increase in signal intensity (shown by the red curve) particularly evident in the high-temperature range. The capacitance change can be calculated utilizing the following function:

$$N_t = 2N_D \frac{dC(U_B - U_R)}{C(U_1 - U_2)}$$

Where N_t , N_D , C , U_B , and U_R represent the trap concentration, doping concentration, the capacitance of the Schottky barrier diode, the built-in potential of junction, and the reverse bias. U_1 and U_2 represent the excitation pulse during test. During DLTS test, N_t is proportional to N_D . After irradiation, the primary defects observed in p-type 4H-SiC in our experiments are HK_4 [1]. Its concentration is $\sim 5 \times 10^{16} \text{ cm}^{-3}$, significantly higher than the majority-carrier concentration ($\sim 10^{11} \text{ cm}^{-3}$). Other identified defects have also been marked in Figure S1.

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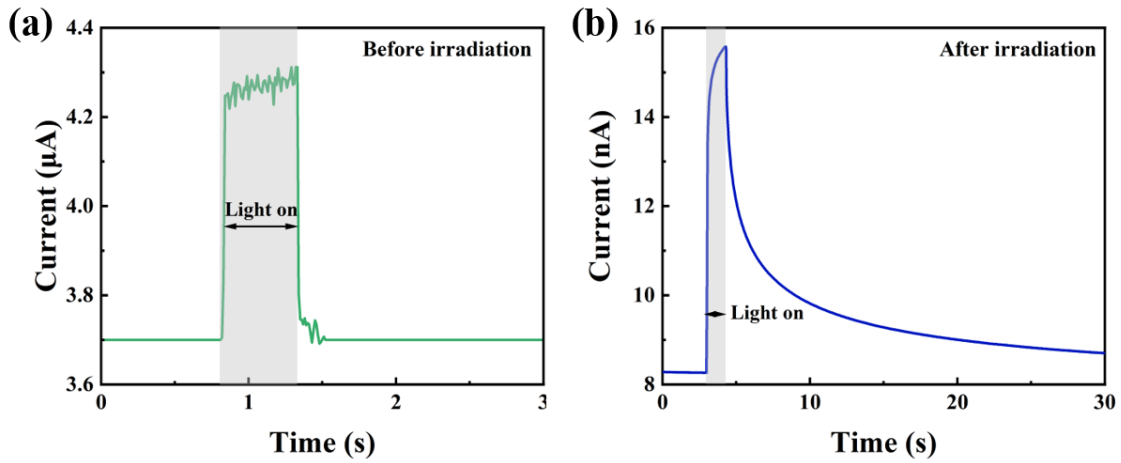


Figure 2 Photocurrent simulated by a single pulse (a) before irradiation and (b) after irradiation.

This measurement is based on two Ohmic electrodes (Al/Ti/Ni) on the same side. The excitation wavelength is 325 nm, which is often used for the intrinsic excitation of 4H-SiC. The 4H-SiC sample exhibits a much slower photoconductive decay after irradiation than before it, proving that the electron irradiation increased the photoconductive lifetime of 4H-SiC.

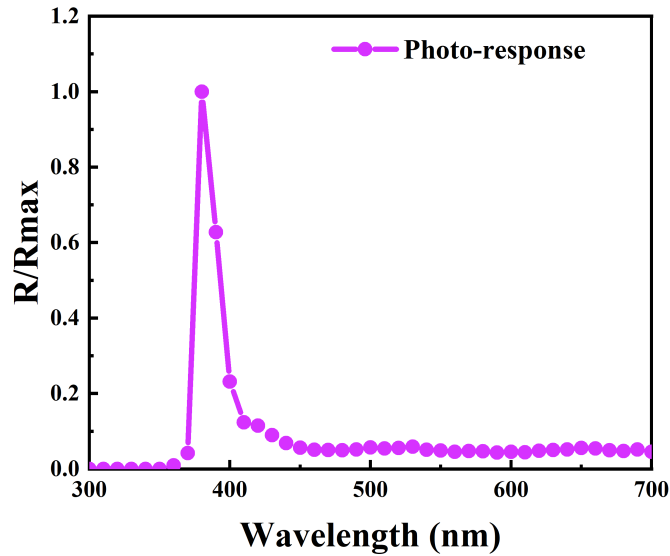


Figure 3 Normalized photoresponse of a 4H-SiC synaptic device.

The photoresponsivity (R) is calculated by dividing the optical power to EPSC. R_{\max} represents the maximum value of R .

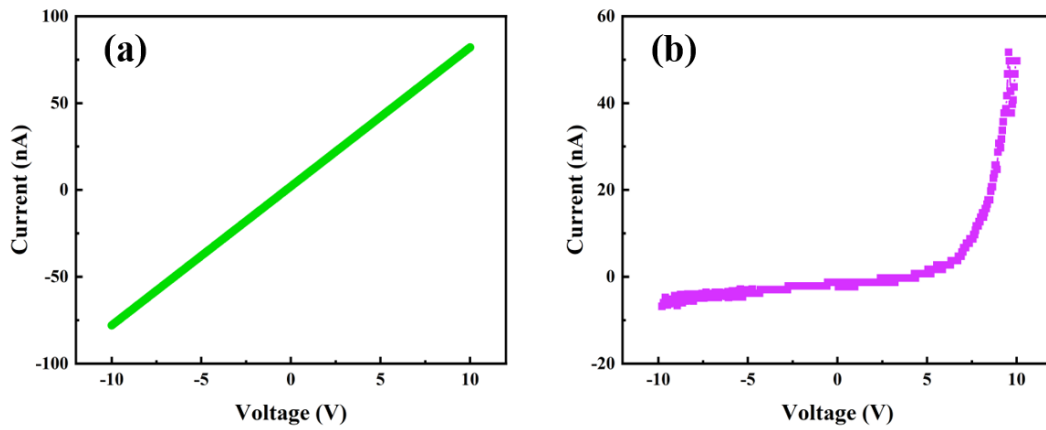


Figure 4 (a) I-V curve obtained by using two top Ohmic electrodes (Al/Ti/Ni); (b) the I-V curve obtained by using an ohmic electrode and the Schottky electrode (Ti/Au).

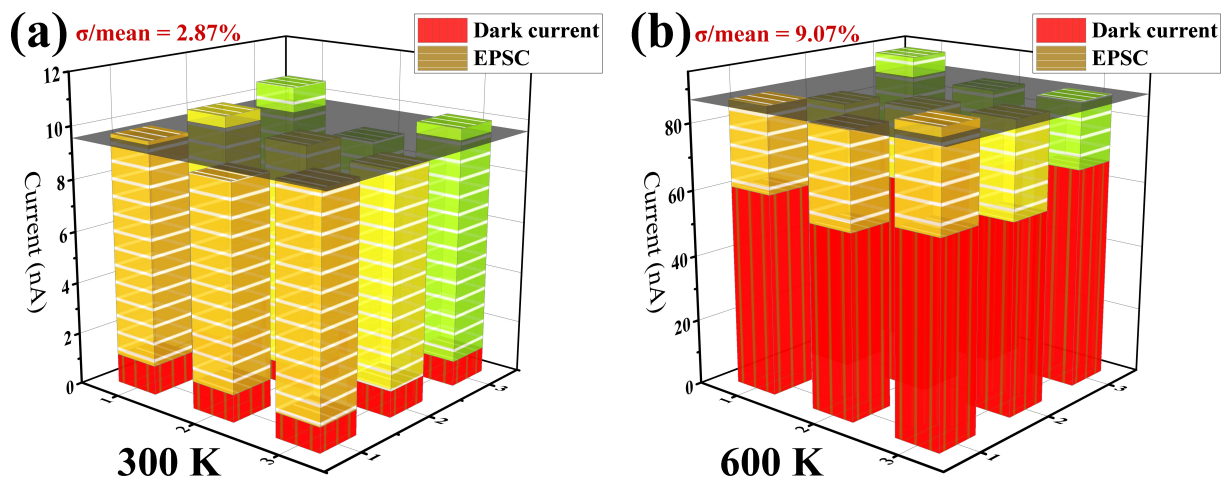


Figure 5 Three-dimensional stacked bar charts of the dark current and EPSC for the array at (a) 300 K and (b) 600 K.

The bottom red portion in each bar chart represents the dark current, while the upper yellow part represents EPSC. As a consequence, the total height of each bar is equal to the operating current (light current), which is the sum of dark current and EPSC. The transparent gray plane above each chart indicates the average operating current for the nine devices in an array. The consistency of device operating currents is represented by the root mean square divided by the mean value (σ / min).

The wavelength of the optical pulses is 405 nm. The energy density is 0.1 mw/cm². The bias voltage applied to the Ohmic electrodes is -1.0 V.

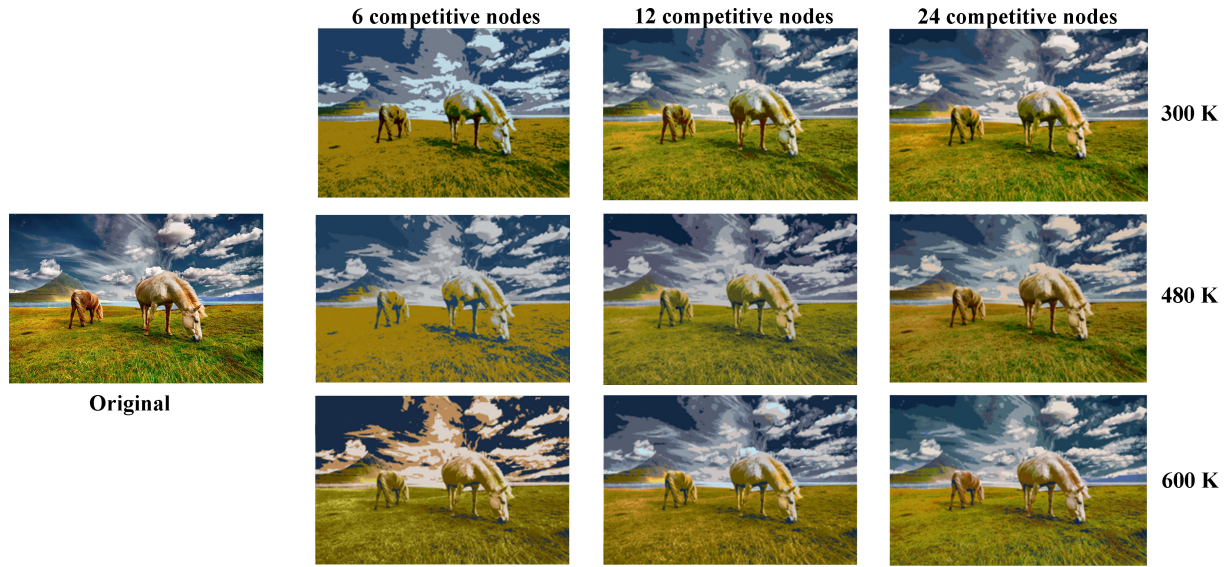


Figure 6 Visual result of color quantization.

The image on the left is the input. The images on the right are output results obtained at 300 K, 480 K, and 600 K, respectively.

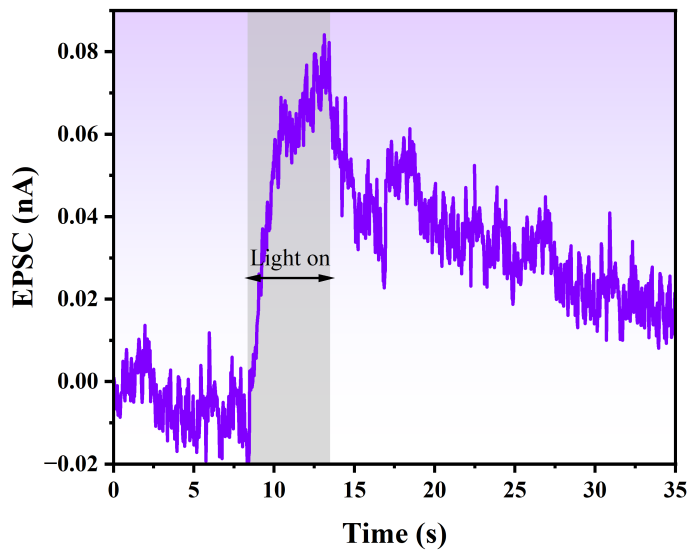


Figure 7 EPSC of the 4H-SiC device stimulated by an optical pulse with a low power density at 600 K.

The wavelength of the optical pulse is 405 nm. The optical power density is $6 \mu\text{W}/\text{cm}^2$. The bias applied to the Ohmic electrode is -1.0 V.

Table 1 Summary of some representative optoelectronic synaptic devices

Active material	Light wavelength (nm)	Power density (mW/cm ²)	Synaptic functionalities	Working temperature (K)	Ref.
AlGa _N /Ga _N	375	0.0008	STP	473	[2]
ScN	Xe-arc lamp	-	STP/LTP/STDP	400	[3]
DPPD _{TT} /MI	400	0.00056	STP/LTP	448	[4]
MoO _x	365	15	STP/LTP	340	[5]
4H-SiC	405	0.006	STP/LTP	600	This work

References

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