

RESEARCH AREA 1 - Superconductors and Innovative materials for Energy and Environment - 2023

Self-powered CNT-Si photodetector with tuneable photocurrent

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ADVANCED ELECTRONIC MATERIALS (WILEY)

A photodetector with bias-tuneable current is realized by adding a film of single-walled carbon nanotubes (CNT), forming a CNT/Si₃N₄/Si capacitor, to a prefabricated Pt-Ti/Si₃N₄/Si metal-insulator-semiconductor (MIS) diode. Electrical characterization of the entire device is performed to extract the temperature-dependent ideality factor and Schottky barrier height in the framework of the thermionic emission theory. The CNT/Si3N4/Si capacitor increases the reverse current of the parallel Pt-Ti/Si₃N₄/Si MIS diode by adding a Fowler-Nordheim tunnelling current at high reverse voltage bias. This feature endows the photodetector with two different photocurrent levels, photoresponsivity up to 370 mA/W and external quantum efficiency up to 50% at 950 nm wavelength. The device also shows a different photoresponse when light is focused on the CNT/Si₃N₄/Si region or around the Pt-Ti/Si₃N₄/Si structure. The photodetector can also be used as an optoelectronic Boolean logic device, in which the applied voltage bias and the incident light are the two input signals, and the photocurrent is the output. Furthermore, light generates a photocurrent at zero voltage and a photovoltage at zero current, making the device a self-powered photodetector.



Fig. 1: Cross-section of the device under study.



x (Vbias)	y (Light on)	$x \oplus y$
-8V <v<-6v< td=""><td>MIS capacitor</td><td>0</td></v<-6v<>	MIS capacitor	0
-8V <v<-6v< td=""><td>MIS diode</td><td>1</td></v<-6v<>	MIS diode	1
-14V <v<-12v< td=""><td>MIS capacitor</td><td>1</td></v<-12v<>	MIS capacitor	1
-14V <v<-12v< td=""><td>MIS diode</td><td>0</td></v<-12v<>	MIS diode	0

Fig.2: CNT-Si device IV characteristics under illumination on the MIS diode (green curve) and the MIS capacitor (red curve). Table shows that CNT-Si device suitable for optoelectronic Boolean logic application, working as a XOR.

