A Flexible Solar-blind Ultraviolet Photodetector Based on Carbon Dots

Keyang Zhang
School of Electronic Science and Engineering
Southeast University
Nanjing, China

Abstract—With the update and iteration of intelligent devices, there are more demands for flexible and foldable functions of devices. Therefore, flexible materials as substrates are a promising research direction for solar-blind ultraviolet (UV) photodetectors (PDs). At the same time, carbon dots (CDs) are also widely concerned due to their excellent optical performance. In this work, a flexible solar-blind UV PD based on CDs is fabricated on a low-cost using polydimethylsiloxane (PDMS) and polyethylene terephthalate (PET) as substrates, respectively. Under the same fabrication and bending test conditions, the device based on PET substrate shows better performance, that is, it has more stable operating current and lower loss caused by bending. The device based on PET exhibits extraordinary detectivity of $1.76 \times 10^9$ Jones without bending and $1.68 \times 10^9$ Jones at the bending strain of 0.2% at 10V. The results show that flexible solar-blind UV PDs are of great significance for the realization of wearable functions.

Keywords-Solar-blind ultraviolet photodetector, carbon dots, flexibility

INTRODUCTION

With the update and iteration of intelligent devices, there are more demands for flexible and foldable functions of devices. Therefore, flexible materials as substrates are a promising research direction for solar-blind ultraviolet (UV) photodetectors (PDs). At the same time, carbon dots (CDs) are also widely concerned due to their excellent optical performance. In this work, a flexible solar-blind UV PD based on CDs is fabricated on a low-cost using polydimethylsiloxane (PDMS) and polyethylene terephthalate (PET) as substrates, respectively. Under the same fabrication and bending test conditions, the device based on PET substrate shows better performance, that is, it has more stable operating current and lower loss caused by bending. The device based on PET exhibits extraordinary detectivity of $1.76 \times 10^9$ Jones without bending and $1.68 \times 10^9$ Jones at the bending strain of 0.2% at 10V. The results show that flexible solar-blind UV PDs are of great significance for the realization of wearable functions.
The substrate was prepared by mixing 5g of the CDs solution and 0.5g of the curing agent into the 10ml obtained solution. Then the CDs solution prepared above was processed using ultrasonic wave for 30 min and subsequently centrifuged at 10000 rpm for 30 min to remove precipitates and bulky graphite fragments. The obtained mixture was stirred with a glass rod until there are small bubbles. After that, CDs solution was poured into the mold, which was made by mixing 5g of the PDMS stock solution and 0.5g of the curing agent into 9ml distilled water. The mixture was stirred for about 10 minutes until there no bubbles appeared. Finally, the mold was peeled from the mold and cut into 2 cm long and 1 cm wide pieces. The CDs are as photosensitive layer material, and PDMS and PVA are used to form a film. Another device was prepared by using a mandrel method. Moreover, the CDs are as substrate material respectively. The device was annealed at 50° C for 10 mins to allow the CDs to be evenly distributed and the morphology is basically quasi-spherical. The inset in Fig. 2 shows the TEM image of CDs, in which the CDs are almost no absorption peak at 230nm in blind wavelength range and it's much smaller than the substrate thickness. In this work, three different CD substrates were used to fabricate the devices. The active photosensitive layer of CDs was spin coated onto the substrate at 500rpm, and for another 30 seconds at 2,000 rpm. After that, Al electrodes were vacuum thermal evaporation as electrode material, for 10 seconds. Then, the active sensor was made by spin coating a thin film with thickness of 200 nm. PDMS is an almost no reflective material, in which using distilled water with a distance of 2 cm. The static potential of 60 V, provided by a direct current power supply, was vertically inserted in the distilled water with a distance of 2 cm. The CDs are as raw material. Such CDs exhibit a strong absorption in visible wavelength range, which makes it an excellent optical properties. Electrochemical method was proposed to manufacture CDs with graphite rods (10 cm in length and 0.6 cm in diameter) as raw material. Such CDs exhibit a strong absorption in visible wavelength range, which makes it an excellent optical properties.

### EXPERIMENTS

**II. EXPERIMENTS**

**III. RESULTS AND DISCUSSION**

The bending performance of flexible device is tested by various photoelectric tests including spectral analysis. The electrical performance is estimated by various photoelectric tests. The electrical performance is estimated by various photoelectric tests. The electrical performance is estimated by various photoelectric tests. The electrical performance is estimated by various photoelectric tests.
is observed at about 230nm, which is due to a typical π-π* transition of C=C. Apparently, the absorption range covers from 200 nm to 600 nm. As the wavelength approaches to the shorter wavelength range, higher absorption value will be observed.

Both the photo current and dark current increase with the bending strain. For the device based on PET, the dark current is about 1.6x10^-9 A, and the photo current is 1.2x10^-8 A. Thus the switching ratio of generated current under 254 nm illumination is about 0.9. For the device based on PDMS substrate, the dark current decreases to 2nA, which further decreases to 29% of that of the device without bending. At the bending strain of 0.3%, the device current is 4nA in the dark and 6nA with the light source turned on. Thus photo current and the dark current increase with the bending strain.

Moreover, it can be found that CD absorption spectrum shows such low symmetry, indicating that a good ohmic contact forms between the CDs and the Al electrode. The sweep bias was varied from −30 V to 30 V. The I-V curve is generally linear and has a good V curve comparison of devices based on PDMS and PET substrates. It is easy to see that the photodetection performance of the flexible device with PDMS substrate is better. As the substrate can only work under the condition with small bending strain without any bending. It can be seen that the device with PDMS as the substrate is better.

In comparison, the larger the switching ratio, the greater the difference between the generated current under the same condition is. It can be seen that the device current is 4nA in the dark and 6nA with the light source turned on. Thus photo current and the dark current increase with the bending strain. For the device based on PET, the dark current is about 1.6x10^-8 A, and the photo current is 1.2x10^-7 A. Thus the switching ratio of generated current under 254 nm illumination is about 0.9. As the wavelength

The I-T curve under different bending strains at 10V for a PDMS substrate based flexible photodetector. The photo detector using the device based flexible devices based on the PET substrate are similar to those of 0.3%, the device current is 4nA in the dark and 6nA with the light source turned on. Thus photo current and the dark current increase with the bending strain. For the device based on PET, the dark current is about 1.6x10^-8 A, and the photo current is 1.2x10^-7 A. Thus the switching ratio of generated current under 254 nm illumination is about 0.9. As the wavelength
Device based on PET substrate under bending strain of 0%, 0.2%, 0.3%, and 0.6% exhibit different detectivity. The dark current, photo current, and responsivity of the device are studied more deeply below.

Through the I-V curves of the two devices, it can be seen that the detectivity is greatly improved compared with the device based on PDMS substrate. The obtained photo current generated by the device is about 7nA in the dark, and the device generated a current of about 8nA without the light source and increases to 10.4nA when the light source is turned on. The obtained photo current is 0.9nA, decreasing to 81% when the bending strain is 0.2%, the detectivity was 1.68×10⁻¹¹ Jones, which decreased slightly. When the bending strain is 0.6%, the detectivity is 1.34×10⁻¹¹ Jones, which has a large decrease, but it is still in a high order. It indicates that the device has a good ability to detect weak signals when the bending strain varies from 0% to 0.6%, which means it can carry out detection work normally.

CONCLUSION

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