LD-O-2

Flexible infrared detector

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Currently, e-textile is a popular area of research due to its ability to satisfy many needs of users [1]. Moreover, due to the rapid spread of fiber optic communication networks, it is necessary to develop highly efficient and fast photodetectors operating in the infrared (IR) range of radiation [2].

One of the main problems of the current IR detection technology is the low efficiency and the fact that the predominantly used sensing elements are based on crystalline epitaxial materials, which require rigid and brittle lattice-matched substrates such as CdZeTe, GaAs, InAs and InP. Therefore, these materials cannot be bent or compressed.

The TiS_2 band gap lies in the range from 0.2 to 0.9 eV, which indicates its dependence on the structure and the possibility of absorbing radiation in the IR spectral range [3]. TiS_2 in monolayer and few-layer forms is a transparent material that can be used in e-textiles [3]. In addition, the manufacturing process of devices based on transition metal dichalcogenides is mainly carried out by mechanical exfoliation.

The aim of this work is to solve the problems mentioned above by developing a flexible broadband IR photodetector based on a new promising TiS_2 material.

In this work, a comparative analysis of photodetectors based on TiS_2 nanosheets and on TiS_2 nanosheets functionalized with silver nitrate has been carried out. TiS_2 nanosheets were synthesized by chemical vapor transport technique following by 1 h ultrasonication treatment. The obtained solution was deposited between interdigitated electrodes fabricated on the surface of a flexible substrate using a dielectrophoresis process. Polyethylene terephthalate was used as the flexible substrate material. The characteristics of the fabricated photodetectors were determined by illuminating them with laser radiation with a wavelength of 1064 nm and a tunable power. A significant effect of silver nitrate particles scattered in the volume of the photodetector sensitive material on its efficiency is observed. The superiority of the photodetector based on TiS_2 nanosheets functionalized with silver nitrate is demonstrated. This photodetector demonstrates a significant response for the all used radiation powers (11.6, 19.6, 51, 100, and 150 mW), shows fast response (0.23 s) and recovery (0.49 s) times, coupled with high sensitivity (259840.34 A/W), quantum efficiency (303404.67 A/W·nm) and detectivity ($3.1 \cdot 10^{13}$ Jones) at an incident radiation power of 11.6 mW. The results obtained in this study can be used for the development and optimization of modern optoelectronic devices.

[1] Abid, P. Sehrawat, C.M. Julien, S.S. Islam, WS_2 quantum dots on e-textile as a wearable UV photodetector: how well reduced graphene oxide can serve as a carrier transport medium, ACS Applied Material Interfaces, 12, pp. 39730–39744, (2020).
[2] L. Colace, G. Masini, F. Galluzzi, G. Assanto, G. Capellini, L.Di Gaspare, E. Palange, F. Evangelisti, Metal–semiconductor–metal near-infrared light detector based on epitaxial Ge/Si, Applied Physics Letters, 72, pp. 3175-3177, (1998).
[3] P.C. Sherrell, K. Sharda, C. Grotta, J. Ranalli, M.S. Sokolikova, F.M. Pesci, P. Palczynski, V.L. Bemmer, C. Mattevi, Thickness-dependent characterization of chemically exfoliated TiS_2 nanosheets, ACS Omega, 3, pp. 8655-8662, (2018).