IR jautrio pagerinimas GeSn fotodioduose lazerinio atkaitinimo pagalba

IR Sensitivity Enhancement in GeSn Photodiodes by Laser Annealing

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Photo-detection in the near-infrared is commonly performed by Ge or InGaAs-based photodetectors. Further extension of the detection range to the mid-infrared region can be performed by germanium-tin (GeSn) material which shows promising characteristics and is fully compatible with silicon electronics as can be directly grown on silicon substrates. In this study, we focused on the optoelectronic properties of the photodiodes prepared by using 200 nm thick $Ge_{0.95}Sn_{0.05}$ epitaxial layers on Ge/n-Si substrate with aluminium contacts. Photodiodes were formed on non-irradiated and Nd:YAG laser irradiated $Ge_{0.95}Sn_{0.05}$ layers. The samples were irradiated by pulsed Nd:YAG laser with 61.5-259.2 MW/cm^2 intensity. The photodiodes were characterized by using short laser pulses with the wavelength in 2.0-2.6 μm range. The laser-irradiated diode was found more sensitive in the long wavelength range due to laser induced Sn atoms redistribution providing formation of graded bandgap structure. Sub-millisecond photocurrent relaxation in the diodes revealed their suitability for image sensors. Our findings open the perspective for improving the photo-sensitivity of GeSn alloys in the mid-infrared by pulsed laser processing [1].

In Fig. 1 responsivity spectral dependencies of the photodiodes with different laser irradiation are provided. It is evident that the laser irradiation extends the photosensitivity to longer wavelengths by 250 nm, revealing a positive impact of laser irradiation at low intensities. Further increase of the laser annealing induces a strong Sn accumulation into a thin surface layer, and a drop of efficiency is observed at longer wavelengths, since Sn-enriched surface layer is suspected to have stronger non-radiative losses, as evidenced by faster photocurrent relaxation decay and faster recombination of carriers investigated by pump-probe. XRD 2-theta peak broadening explains the Sn redistribution and arising relaxation, which increased the concentration of dislocation defects from 2×10^8 cm^{-2} to ~10^9 cm^{-2}. Photocurrent dependencies on laser power showed a slight reduction of the photocurrent with laser irradiation. Rather low photo-responsivity is explained mainly by the weak absorption in the layer due to its indirect bandgap. Similar values of 33 mA/W [2] and 24 mA/W [3] at 2000 nm were obtained in conventional GeSn photodiodes.

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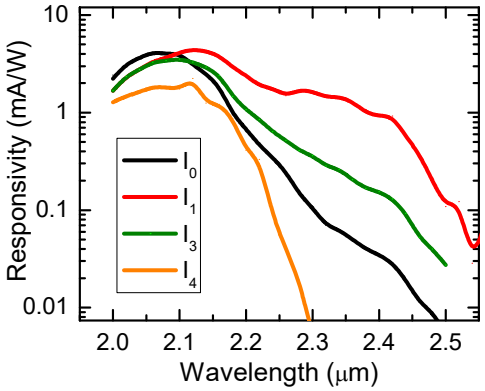

Fig. 1. Responsivity spectral dependences of the photodiodes with different laser irradiation [1].

Keywords: photodiode, infrared, laser annealing, GeSn.

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