Portable Mid-infrared Spectrometer Integrating High-Speed Group IV Detector

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Developing compact and portable sensing devices capable of operating at room temperature in the mid-infrared (MIR) range can profoundly impact a range of applications including machine vision, gas monitoring, and biosensing, to name a few. Current state-of-the-art devices utilize photodetectors based on compound semiconductors such as InGaAs, PbS or even MCT. However, these semiconductors typically require operation at low temperatures and, consequently, the use of cooling systems, thereby reducing their portability and increasing their cost.

To address these challenges, Germanium-Tin (GeSn) semiconductors have been proposed as a promising platform for scalable MIR devices thanks to their compatibility with silicon processing. By increasing the Sn content in Ge lattice, the bandgap of the resulting alloy gradually to cover the entire MIR spectrum thus making GeSn semiconductors an excellent choice for MIR photodetectors (PDs). With this perspective, here we demonstrate the fabrication and the integration of GeSn photodiodes into a portable MIR single-detector spectrometer based on the use of a Digital Micromirror Device (DMD). GeSn PDs were fabricated on silicon wafers, exhibiting a high broadband operation at room temperature with a cutoff wavelength of 2.6 µm and a bandwidth up to 7.5 GHz, as detailed in [1]. Photodiodes, with diameters of 160 and 120 µm, were connected to the p and n sides of the detector and integrated into an industrial photodetector packaging through specific wire-bonding. This custom photodetector was then incorporated into a Texas Instruments NIR-Scan NANO spectrometer. To optimize the signal alignment, a SLS201LM light source was collimated at the spectrometer entrance. Performance comparisons between industrial InGaAs, industrial germanium, and the custom GeSn PDs were conducted using 2 different SWIR light sources. Our results demonstrate that the GeSn PD exhibits superior sensitivity in the NIR range below 1 µm and outperforms the InGaAs photodetector at wavelengths above 1.5 µm.

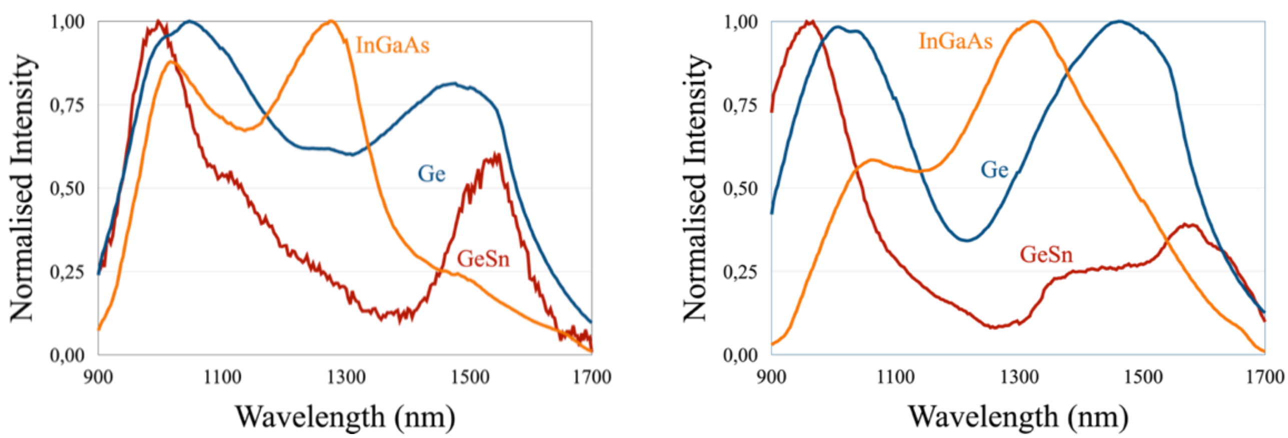

Fig. 1. Normalized spectra of the SLS201LM (left) and NIR (right) light source acquired with a GeSn, Ge and InGaAs detectors respectively.

References

[1] M.Atalla *et al*, ACS Photonics, **9**, 1425 (2022)