Ge-on-Si dual-band detectors for solvents recognition

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Light sensing beyond the visible spectra has always played an important role in scientific advances. By connecting two photodiodes in a back-to-back configuration, creating a dual-band detector, it is possible to sense in two different spectral bands depending on the semiconductor bandgap and applied voltage bias [1].

Dual-band photodiodes based on Group IV materials such as silicon (Si) and germanium (Ge) can cover the visible (VIS) and near infrared (NIR) ranges ($\lambda = 400 - 1100$ nm) and short-wave infrared (SWIR) ranges ($\lambda = 800 - 1600$ nm), respectively, allowing the detector to collect independently information from the SWIR/VIS-NIR ranges (see Figure 1 a, b). The open-circuit voltage of this system, $V_{OC} = V_T \ln\left(\frac{I_{ph}^{Ge}}{I_{ph}^{Si}}\frac{I_0^{Si}}{I_0^{Ge}}\right)$, is achieved when the produced photocurrent goes to zero and since $I_0^{Ge} >> I_0^{Si}$, the open-circuit voltage is rather insensitive to small variations of this ratio and is mainly dominated by variations on I_{ph}^{Ge}/I_{ph}^{Si} [2]. We exploit this feature to acquire the diffuse reflectance of a set of solvents which are perfectly transparent in the VIS range but show distinctive absorption bands in the IR, enabling the discrimination of different solutions with a resolution of a few mV on V_{OC}.

In summary, we have demonstrated the use of a compact and scalable dual-band detector capable of identifying different substances without any mechanical or dispersive element thus reducing the necessity of complex optical assemblies to cover broad light spectra or the need for different detectors.

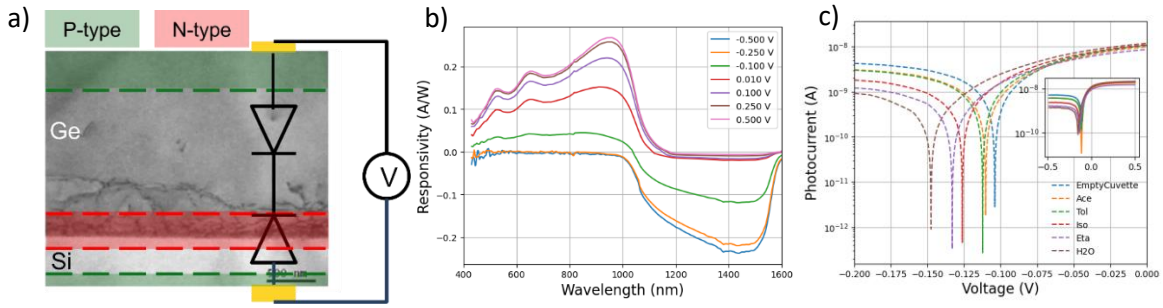

Figure 1- (a) Schematic representation of the dual-band detector (b) Device responsivity measured for several voltage bias (c) photocurrent-voltage curves for the different solvents in measure.

[1] Simola, E. T.; De Iacovo, A.; Frigerio, J.; Ballabio, A.; Fabbri, A.; Isella, G.; Colace, L. Voltage-tunable dual-band Ge/Si photodetector operating in VIS and NIR spectral range. Optics express 2019, 27, 8529–8539

[2] Nouchi, R. Extraction of the Schottky parameters in metal-semiconductor-metal diodes from a single current-voltage measurement. Journal of Applied Physics 2014, 116,184505.