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SWIRGe - Micrometer-scale pulsed laser melting for the direct fabrication of infrared photodetector on Ge-on-Si substrates through ex-situ incorporation of deposited metallic elements

Detection in the near and short-wave infrared (NIR and SWIR) has attracted a renewed attention in the past decade due to its potentialities in material recognition and sensing applications. As compared to visible (VIS), IR light is more suitable for flame detection, night and machine vision applications, not only because of the larger overlap with black-body or night-glow radiation, but also for its superior tolerance to dusty/foggy environments. Currently, the cut off wavelength of NIR/SWIR photonics is limited by the direct energy gap of Ge (≈1500nm). However, the possibility of extending the Ge absorption in the SWIR range has been recently demonstrated thanks to the incorporation in Ge of other group IV elements such as Sn, Pb or chalcogens. In fact, the introduction of such atoms in Ge lattice above their solubility limit modifies the Ge band-structure, leading to a crossover from indirect to direct bandgap and strong increase of carrier mobility. Currently, several strategies are being pursued to produce these materials. However, limitations in standard non-equilibrium growth techniques lead to the formation of poor-quality alloys, that are not suitable to obtain the desired material properties, such as SWIR sensitivity. This project aims to adopt pulsed laser melting (PLM) to overcome solubility limitations and fabricate Ge-based alloys by ex-situ incorporation of metallic elements deposited directly on Ge substrates by sputtering. In addition, this project aims to go beyond the fabrication of high-quality (super-saturated or hyper-doped) alloys, and develop an innovative approach to fabricate SWIR photodetectors. In fact, the used of laser custom-designed shadow masks for the laser allows to obtain a lateral selectivity of the processed regions (few µm). This paves the way for the direct laser writing of devices on Ge-on-Si substrates, creating also a new industrial standard for the micro-fabrication of SWIR photodetectors.