Micro-SPAD arrays based 3D epitaxial growth

The single photon avalanche diode (SPAD) is a robust solid-state detector based on a semiconductor junction reverse-biased above its breakdown voltage, working in the so-called “Geiger mode”: a single photon triggers a macroscopic avalanche current through positive-feedback impact ionization. Therefore, at every photon arrival the SPAD outputs a high-level current pulse that can be easily detected by a read-out circuitry. Silicon SPAD sensitivity is limited by its band-gap (1.12 eV) and smaller band-gap semiconductors, sensitive to near-infrared (NIR) and mid-infrared (MIR) photons, suffer by high noise (i.e. carrier generation due to thermal or tunneling effects, augmented by the high electric field required for avalanche triggering).

We aim at achieving the NIR/MIR single-photon sensitivity thanks to 3D hetero-epitaxy a novel deposition method that allows the monolithic integration of a layer of hetero-epitaxial micro-crystals on silicon wafers (see Fig. 1). The idea is letting each micro-crystal act as a micro-SPAD within more complex single-photon detectors assembly. A schematic representation of micro-SPAD array exploiting germanium for the absorption of NIR photons and silicon for avalanche multiplication is shown in Fig. 2.

Skills acquired during the thesis work:

- Epitaxial growth of semiconductors by LEPECVD
- Micro-fabrication techniques (UV lithography, plasma etching, e-beam evaporation of metals)
- Scanning electron microscopy and atomic force microscopy imaging
- Electrical and photocurrent measurements

List of selected publications:
