Master thesis Project

Selective area growth of GeSn infrared photonic devices

Developing all-group IV semiconductor infrared light emitters and detectors is an attractive approach towards the monolithic integration of photonics and electronics on the same platform.[1] This long sought- for silicon photonics has recently gained revived interest motivated by pressing needs for ultrafast data transfer and low-power electronics. With this perspective, direct bandgap GeSn semiconductors have been attracting great interest for a Si-compatible processing. Over the last decade, tremendous progress was made in the epitaxial growth of GeSn semiconductors grown on a Si wafer, resulting in a direct band gap material (*i.e.* high efficiency for the optical emission) when the incorporation of Sn increases above ~9 at.%. Photodetectors, lasers, and LEDs operating from short-wave infrared (SWIR: 1.5-3 µm) to mid-wave infrared (MWIR: 3-8 µm) are now available using direct band gap GeSn semiconductors.[2,3] However, GeSn material quality is the main limiting factor in the efficiency of optoelectronic devices. The growth of GeSn is commonly performed on Si using Ge as an interlayer, and the resulting lattice-mismatch with the Ge/Si substrate leads to compressive strain in GeSn. When the critical thickness is exceeded, plastic relaxation takes place and structural defects are formed in GeSn. Defects are a source of nonradiative recombination and largely contribute to the dark current of GeSn photonic devices, in turn strongly reducing efficiency.

The goal of this internship is to overcome the boundaries of the current epitaxial growth of GeSn by developing selective area growth (SAG) from patterned SiO_2 trenches on a Si wafer. The SAG has proven to be a highly valuable approach for the integration of III-V semiconductors on Si,[4] with similar results that are now being explored in Ge.[5] By tailoring the dimensions of SiO_2 trenches that are patterned using electron beam lithography, the student will develop the SAG of GeSn and evaluate its structural properties using a variety of characterization techniques down to the atomic-level.

For more information on this topic please read these recent publications (available on demand):

[1]. O. Moutanabbir *et al.*, Appl Phys Lett. 118, 110502 (2021).
[2] M.R.M. Atalla *et al.*, ACS Photonics 9 (2022). [3] Y. Zhou *et al.*, Phot. Res. 10 (2022). [4] Y. De Koninck *et al.*, https://www.researchsquare.com/article/rs-3187756/v1 (2023).
[5]. S. P. Ramanandan *et al.*, Nano Lett. 22 (2022).

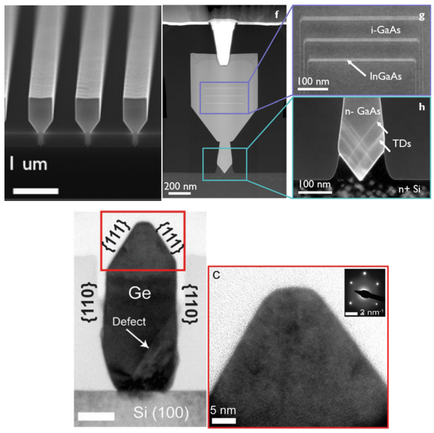

Figure: SAG of III-V (a)[4] and Ge (b)[5] semiconductors on a Si wafer.

Possible collaborations and networking. Collaborations with CEA-Leti, Canada (Polytechnique Montréal), Singapore (Nanyang Technological University), for atomic-level characterization of materials and optoelectronic measurements of the infrared photonic devices.

Possible extension as a PhD. Yes.

Required skills. Interest in performing collaborative experiments in the lab (materials growth, fabrication of photonic devices, optoelectronic measurements), background in solid-state physics.

Starting date. Spring 2024.

Contact. Simone Assali (IRIG/PHELIQS, Grenoble).

APPLY NOW!

To apply for this position, send your application (including CV) by e-mail to: simone.assali@cea.fr.

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