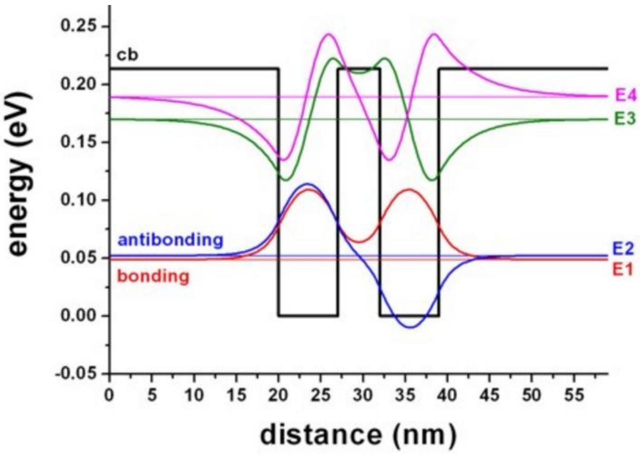
Germanium quantum wells for silicon photonics

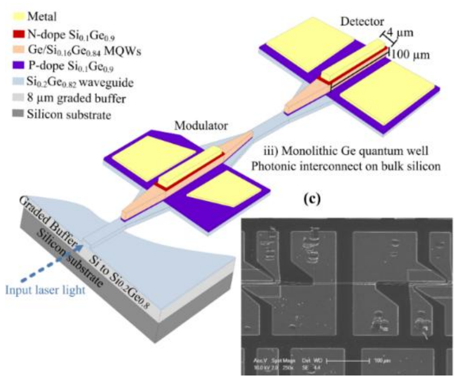
Silicon photonics addresses the study and the technological application of silicon as an optical medium for generation, transmission, modulation and detection of light. It has been envisioned that silicon photonics will solve the interconnect bottleneck of CMOS technology, by the on-chip integration of silicon based optical interconnects with standard electronic elements. This technology has already shown its tremendous potential for data communications in server farms and data storage centers, thanks to the huge investments placed by big players such as Intel and IBM. Nevertheless, on-chip applications require an higher level of integration and extremely low power consumptions. It has been envisioned that germanium, thanks to its photonic properties and its compatibility with CMOS technology, will pave a new path through on-chip applications of silicon photonics. In particular, Ge rich quantum wells, thanks to the Quantum Confined Stark Effect, are very promising for the realization of modulators and photodetectors with power consumptions of the order of 1 fJ/bit.



In this framework, our research group is working on the development of a new material platform for silicon photonics based on Ge/SiGe quantum wells and SiGe based passive optical circuitry, in particular:

- Symmetric and asymmetric coupled quantum wells for modulation and basic physics
- Doped quantum wells for light generation
- Waveguide integrated quantum wells for non linear optics
- Compositionally graded silicon-germanium waveguides for telecom wavelengths

The thesis activity will be focused on the epitaxial growth of Ge/SiGe quantum wells by LEPECVD (Low-energy plasma-enhanced chemical vapor deposition) and the material characterization by high resolution X-ray diffraction, atomic force microscopy and defect etching. The samples will be processed into p-i-n vertically illuminated photodiodes by standard nano-fabrication techniques such as optical litography and plasma etching. The fabricated photodiodes will be used to perform photocurrent spectroscopy measurements. Skills aquired during the thesis work:



- Epitaxial growth of semiconductors by LEPECVD
- Micro-fabrication techniques (UV lithography, plasma etching, e-beam evaporation of metals)
- High resolution X-Ray diffraction measurements
- Atomic Force microscopy measurements

- Photocurrent spectroscopy
- Modelling using k-dot-p bandstructure calculations implemented in Nextnano++

List of selected publications:

J. Frigerio, V. Vakarin, P. Chaisakul, M. Ferretto, D. Chrastina, X. Le Roux, L. Vivien, G. Isella, and D. Marris-Morini: Giant electro-optic effect in Ge/SiGe coupled quantum wells, Sci. Reports 5, 15398 (2015).

P. Chaisakul, D. Marris-Morini, J. Frigerio, D. Chrastina, M.-S. Rouifed, S. Cecchi, P. Crozat, G. Isella, and L. Vivien: Integrated germanium optical interconnects on silicon substrates, Nature Photonics 8, 482 (2014).

D. Marris-Morini, P. Chaisakul, M.-S. Rouifed, J. Frigerio, D. Chrastina, G. Isella, S. Edmond, X. Le Roux, J.-R. Coudevylle, and L. Vivien: Towards low energy consumption integrated photonic circuits based on Ge/SiGe quantum wells, Nanophotonics 2, 279 (2013).