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Photonic integrated circuits with phase change materials

Semester/Master project

(Section: Microengineering – Physics – Electric Engineering)

Reconfigurable Silicon Integrated Photonic Circuits (PICs) enable the construction of increasingly complex optical networks on a chip. Of particular interest are non-volatile photonic components [1]: a finite actuation pulse toggles their state, with no further action required to maintain the desired state. Integrating chalcogenide phase change materials (PCM) on silicon photonic can provide this functionality, since these alloys have extremely different optical properties in crystalline or amorphous solid states, with state transitions possible with nanosecond-duration heat pulses.

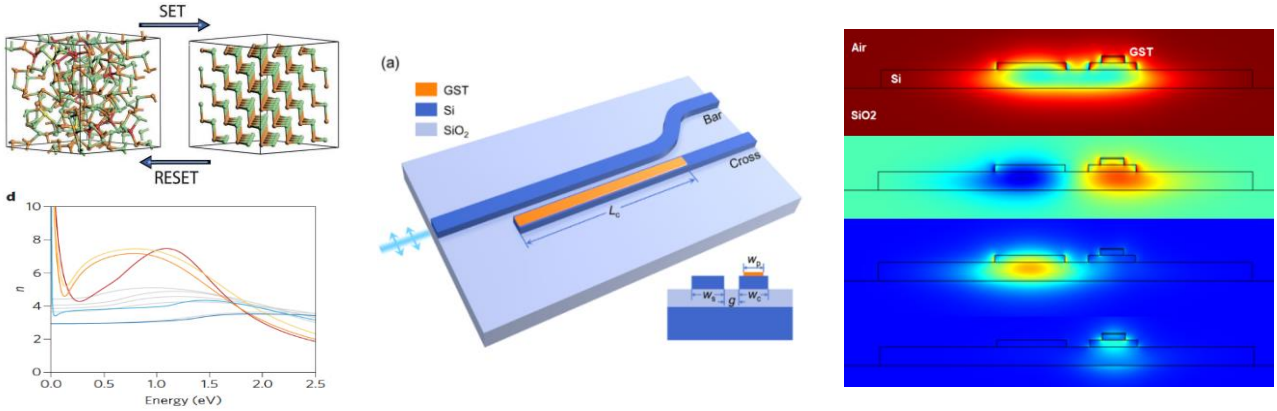

Figure 1 : *Left: PCM atomic bonds and refractive index in amorphous (gray) and crystalline (orange-red) states for some GeSbTe alloys [1]. Center: example of non-volatile tunable directional coupler [2]. Right: Simulated modes for coupled silicon waveguides with PCM in amorphous and crystalline state.*

Our recent research has aimed at designing PCM optical integrated components and developing a process flow for their fabrication at the CMi using the DUV Stepper as the only lithography method. This will allow demonstrating scalable PCM-PICs, apt for reliable and straightforward production with integrated electrical actuation.

A crucial step for the manufacture of PCM PICs is the careful design of the exposure reticle, the mask used by the DUV Stepper. In this project you will contribute to the construction of a complex multi-layer DUV Stepper reticle layout for the realization of a wide range of prototype optical components and their parametric variations. Furthermore, optical and thermals aspects of some components may still need to be evaluated using 2D/3D COMSOL models.

Through this project, the student will get involved in the field of innovative integrated photonic circuits and phase change materials, and they will gain experience in hands-on aspects of PICs design, simulation and fabrication. This work will be carried out in tight collaboration with Prof. Villanueva's ANEMS lab.

Project components:

- Study of a fabrication process flow for integrated photonics with PCM based on the DUV Stepper.
- Realization of a DUV stepper reticle layout for a PICs prototype, using dedicated software.
  - Code-automated component generation and layout assembly with GUI commercial tools.
  - Fabrication of a reticle at CMi (photolithography).
- Modelling, analysis and design of photonic components with PCM materials:
  - Thermal transient simulation,
  - Optical simulation.

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