PhD subject

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Optoelectronic devices based on carbon nanotubes

The realization of integrated light sources in silicon, as well as the on-chip integration on silicon platform of all optical functions (emission, routing, modulation, detection…) are still an object of investigation. Most approaches considered today, rely on a wide variety of materials deposited or grown on silicon. These include III/V, Germanium, colloidal quantum dots, graphene, chalcogenides (for their nonlinear properties), etc. These approaches have advantages to offer a range of physical effects to emit, modulate and detect light on chip. However, none has the capability to exhibit efficient emission, modulation and detection at the same time, leading to heterogeneous integration of photonic functionalities. In this context, we are carrying out work aimed at exploiting the optoelectronic properties of single-walled semiconducting carbon nanotubes (s-SWNTs) as active optical material for Si photonics. Indeed, s-SWNT is a direct bandgap material exhibiting room-temperature electro- and photo-luminescence, light modulation based on Kerr effect and detection in the visible and near-infrared wavelength range. Recent advances in solution processing and wafer-scale selective deposition have opened a new path towards the realization of on-chip light sources for the Si photonic platform, based on the use of s-SWNTs.

Recent experiments have shown the demonstration of resonant-enhancement of the photoluminescence emission from a s-SWNT network from 2-D hollow-core Si photonics microcavities, ring resonators, nanobeam cavities and micro-disks. The purpose was to exploit the strong evanescent field, the small mode volume and the high quality factors of these microcavities to yield narrowband light emission with high off-resonance rejection.

The objective of the PhD work will be to develop a new type of electrical-pumped circuits based on carbon nanotubes integrated in silicon and silicon nitride photonics platforms. The PhD student will perform the design, the fabrication and characterization in close collaboration with our partners (CEA/LICSEN, CEA/LETI, STMicroelectronics, Univ. Florence, Dreden Univ.). The candidate will be fully involved in the optical and electrical simulations and in the characterization using integrated optical benches and Raman spectrometers.

The research activity will include:

- **Theoretical study and electro/optical simulations** (using commercial software) to evaluate the key metrics for tuning the optical properties of the waveguide modes

- DC and high-speed **experimental characterizations** of optoelectronic devices based Carbon nanotubes

During the PhD, the student will be actively involved in the current research activity of the group, collaborating with PhD students, postdocs and researchers of different research backgrounds and nationalities.

VALUED QUALITIES IN THE STUDENT

- Curiosity for novel research experiences and fields.
- Creativity and pro-activity in the search for innovative solutions and approaches.
- Attractness in experiments and simulations.
- Capability to communicate and share results in a multidisciplinary and multi-nationality environment.

BIBLIOGRAPHY RELATED TO THE TOPIC

- M. Balestrieri et al., Polarizationn-sensitive single-wall carbon nanotubes all-in-one photodetecting and emitting device working at 1.55µm, Adv. Funct. Mater., 1702341 (2017)
- Thi Hong Cam Hoang et al. Narrow-linewidth carbon nanotube emission in silicon hollow-core photonic crystal cavity, Optics Letters Vol. 42, Issue 11, pp. 2228-2231 (2017)
- E. Durán-Valdeiglesias et al., Integration of carbon nanotubes in silicon strip and slot waveguide micro-ring resonators, IEEE Transactions on Nanotechnology 15(4), 583-589 (2016).
- F. La China et al., Near-field imaging of single walled carbon nanotubes emitting in the telecom wavelength range, J. Appl. Phys. 120(12), 123110 (2016)

Funding of the PhD: Application to the ED EOBE grant.