Direct band gap Ge-based laser sources for silicon photonics

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http://www.agence-nationale-recherche.fr/projet-anr/?tx_lwmsuivibilan_pi2%5BCODE%5D=ANR-17-CE24-0015

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The objective of the project is to develop direct band gap group IV laser sources operating at room temperature. This goal will rely on recent innovation and merging technologies allowing to reach direct band gap in Ge-based material.

Research context :

The main missing element that would allow to fully exploit the technology of silicon photonics is a full-CMOS laser source. For that purpose the best choice of gain material would be a group-IV element like Si or Ge. Unfortunately these main group-IV elements players in the microelectronics industry, are penalized for the emission of photons by the indirect nature of their electronic band structure. Currently the semiconductor laser sources are mainly made from III-V elements whose integration on silicon turns out to be complex, for reasons of chemical incompatibilities between III-V and IV-IV, and of manufacturing cost. In recent years several research groups have succeed to turn the band structure of germanium into direct band gap through the application of tensile mechanical stress or by alloying of Ge with tin. It is also possible to combine both strain and alloying to obtain direct band gap materials. C2N has pioneered tensile strain engineering on Ge photonic devices like resonant microdisk cavities. This allowed researchers from C2N to obtain laser effect in pure tensile strained Ge cavities, where Ge exhibits a direct band gap. It turns out that the alloying of Ge with tin and the application of tensile stress increase the directness of the band structure, this would allow to reach laser effect up to room temperature, while previous demonstration were performed at cryogenic temperature. Secondly both alloying with tin and tensile strain reduce the band gap of the materials and the operating wavelengths can thus be extended from 2 µm to 5 µm in depending on the tin composition and the applied stress. At these wavelength one could envision labs-on-chip spectroscopy for gas sensing and air monitoring with integrated group IV photonic circuits.

Profile and skills required :

Basics in Material science and engineering, optics and light-matter interaction, clean-room processing

The candidate will be involved in electro-optical experimental analysis of the devices and the fabrication in the clean room of the C2N research center.

- *Germanium microlasers on metallic pedestals*
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-*Direct band gap germanium microdisks obtained with silicon nitride stressor layers*
M. El Kurdi, M. Prost, A. Ghrib, S. Sauvage, X. Checoury, G. Beaudoin, I. Sagnes, G. Picardi, R. Ossikovski, and P. Boucaud, ACS photonics 3, 443 (2016)
-*Light emission from strained germanium*
P. Boucaud, M. El Kurdi, S. Sauvage, M. de Kersauson, A. Ghrib and X. Checoury
Nature Photonics 7, 162 (2013)
-*All-Around SiN Stressor for High and Homogeneous Tensile Strain in Germanium Microdisk Cavities*
A. Ghrib, M. El Kurdi, M. Prost, S. Sauvage, X. Checoury, G. Beaudoin, M. Chaigneau, R. Ossikovski, I. Sagnes, and P. Boucaud, Advanced Optical Materials 3, 353 (2015)