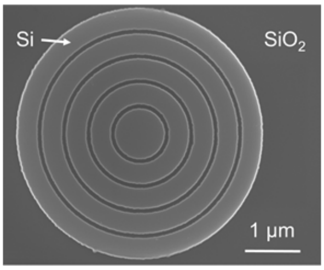
Master thesis Project

A deterministic source of single photons on a silicon chip

Applications of quantum photonics to quantum communications and quantum simulation or computing require a scalable, compact and low-cost technology for future widespread deployment. The silicon-on-insulator (SOI) platform is a highly attractive in this context, offering the possibility to implement a large panel of integrated devices for the coherent manipulation, encoding and detection of single photons. However, the lack of a source able to emit a well defined single photon increases the complexity and limits the performances of quantum photonic chips. The recent observation of photon antibunching for isolated color centers in implanted silicon, such as the G center [1] or the W center [2] is a game changing advance. It shows that the spontaneous emission of such a color center can be used to generate one and only one photon on demand. In view of practical applications, single photons must be prepared in a well defined quantum state. As shown for other single photon emitters such as quantum dots, this can be achieved by embedding the emitter inside an optical cavity, so as to harness quantum cavity effects and tailor spontaneous emission. In a highly encouraging preliminary experiment, we observed a strong enhancement of the zero-phonon emission of G centers embedded in SOI microrings [3].



In this context, this Master project will extend these studies to cavities containing a <u>single</u> color center. We will combine a single W center and a "Bull-eye" cavity such as the one shown in the figure. This choice is motivated by the high quantum efficiency of W centers and by the highly directive radiation pattern of Bull-eye cavities, enabling highly efficient off-chip collection in a normal-incidence geometry. We will then characterize fully the properties of these novel single-mode single photon sources, by measuring their efficiency, the purity and the degree of indistinguishability of emitted single photons.

The host team at CEA-PHELIQS has contributed to the first demonstrations of single photon emission by single color centers in silicon [1,2] and reported also the first observation of spontaneous emission enhancement for color centers in a SOI cavity [3]. These pioneering results provide solid ground for the Master project, which could be continued as a PhD project.

[1] W. Redjem et al, Nature Electron. 3, 738 (2020), A. Durand et al, Phys. Rev. Lett. 126, 083602 (2021) ; [2] Y. Baron et al, ACS Photonics 9, 2337 (2022) ; [3] B. Lefaucher et al, Appl. Phys. Lett. 122, 061109 (2023)

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