Direct growth and in-situ EBL integration of high-quality single InGaAs quantum dots emitting at the telecom bands on a CMOS-compatible silicon substrate

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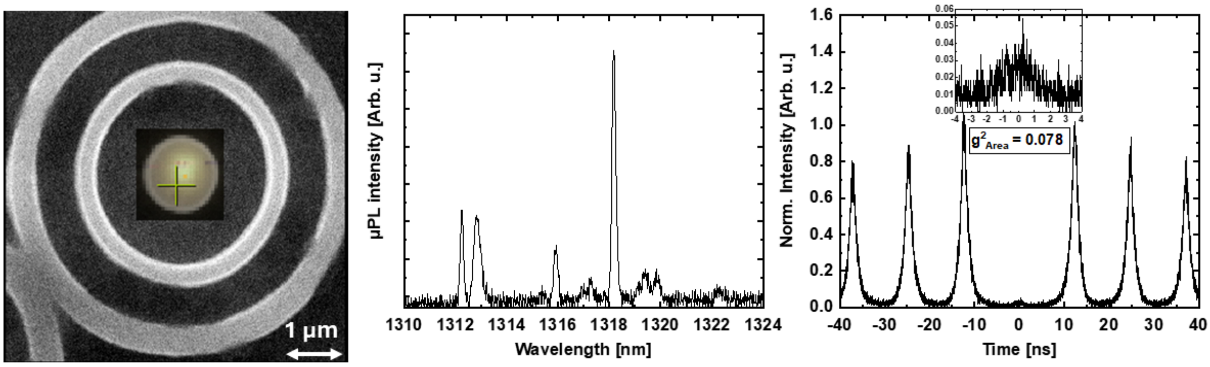
For over two decades, the integration of light sources onto the silicon (Si) platform has garnered significant interest in both scientific and industrial communities. Despite Si's cost-effectiveness and extensive use in semiconductor technology, its indirect bandgap constrains its potential for optoelectronic applications. One approach for fabricating Si-compatible optoelectronic devices involves complex wafer-bonding techniques. Alternatively, direct growth of III-V materials, offering excellent optical properties, on Si is more appealing but challenging due to factors such as lattice mismatch, differences in thermal expansion coefficients, Si surface reactivity, and dislocation formation.

While conventional silicon photonics with classical light sources have made significant advancements, progress in silicon-compatible quantum photonics has been hindered by difficulties in achieving direct and high-quality growth of single quantum emitters on Si. Despite advances in post-growth integration of quantum dots (QDs) on Si, process complexity limits scalability and cost-effectiveness. Particularly promising quantum emitters are Stranski-Krastanov (SK) grown InGaAs/GaAs QDs on GaAs or InP substrates, offering exceptional quantum optical properties suitable for quantum information technology applications like quantum key distribution (QKD) and boson sampling.

This work presents the direct growth of high-quality, single-photon-emitting InGaAs/GaAs QDs on a Si (001) substrate using a GaP buffer layer [1] as an initial step for the subsequent growth of III/V materials on Si. These quantum emitters exhibit optical characteristics comparable to QDs on GaAs substrates [2], including high multi-photon suppression, with emission of indistinguishable photons from 900 nm up to the telecom bands. Furthermore, we integrate the QDs into a circular Bragg grating (CBG) using in-situ electron beam lithography (EBL), significantly improving the extraction efficiency. Our work paves the way for advanced and economically viable quantum photonics in conjunction with CMOS technologies.



[1] K. Volz et. al., J. Cryst. Growth 315, 37–47 (2011).
[2] I. Limame et. al. arXiv:2311.14849 (2023)