Heterogeneous Quantum Integrated Photonics with InAs Quantum Dots

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Heterogeneous integration enables the creation of photonic circuits with highly optimized performance, offering a great potential for applications in quantum photonics. Such an approach allows functional circuit elements based on disparate materials with complementary desirable optical properties to be incorporated onto a single photonic chip. Recently, a number of photonic integration architectures allowing direct integration of III-V semiconductor quantum dot-based single-photon sources onto silicon or silicon nitride on-chip waveguides have been demonstrated [1-4]. Such architectures simultaneouly benefit from the low propagation losses and functional nonlinearities offered by silicon or silicon nitride waveguides, and the high single-photon flux made available by the quantum dot sources, which can be deterministically triggered, potentially at very high rates. These two features – high on-chip single-photon flux and low-loss linear optic elements – are crucial for a variety of single-photon based photonic quantum simulation, sensing and communication tasks. We have recently demonstrated a heterogeneous integration plaform based on wafer bonding that allows the creation of GaAs nanophotonic structures containing InAs quantum dots, coupled with high efficiency to stoichiometric Si_3N_4 on-chip waveguides. Our technique allows independent, flexible, high-resolution and scalable tailoring of both GaAs and Si_3N_4 photonic circuit elements with precise and repeatable, sub-50 nm alignment, all defined strictly by lithography in a single process run. We have demonstrated efficient and pure single-photon emission into the Si_3N_4 waveguides, and the ablity to control quantum dot radiative rates in GaAs nanophotonic cavities [4]. This presentation will focus on further development of our platform, towards demonstration of features such as electrostatic control of quantum dot linewidths and Stark-shift tuning of emission wavelength, resonant on-chip excitation, large Purcell enhancement and strong coupling through small mode-volume cavities. Our platform offers great flexibility in implementing all such features through mature micro/nanofabrication techniques.

References

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