Quantum playground with semiconductor quantum emitters

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Solid-state quantum emitters, such as semiconductor quantum dots and crystal color centers confine electrons in a nanoscale size, resulting in quantized energy levels as electrons confined in atoms. These artificial atoms provide versatile quantum resources, including photonic and spin qubits, without the need for complex trapping systems. However, their solid-state environment also introduces challenges, including interactions with phonons and charge fluctuations, limited light-extraction efficiency, and spectral inhomogeneity.

Over the past decade, remarkable advances in quantum material growth, nanophotonic integration, coherent control techniques, and high-efficiency single-photon detection have transformed these emitters into leading platforms for quantum light sources, quantum memories, and applications ranging from quantum communications to quantum sensing. In particular, the integration of quantum emitters with photonic cavities and waveguides has enabled efficient light-matter interfaces and scalable quantum interactions among multiple photons and emitters.

Given these advances in performance and scalability, solid-state quantum emitters are now transitioning from individual quantum devices to fully integrated quantum systems implemented on photonic integrated circuits and optical fiber platforms. This evolution paves the way for practical quantum technologies in which quantum generation, manipulation, transmission, and detection are seamlessly integrated within real-world photonic architectures.

In this talk, I will present recent progress in scalable integrated quantum photonics, highlight emerging opportunities enabled by solid-state quantum emitters, and discuss the key challenges toward realizing practical quantum photonic technologies.

References

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