

Generation and control of quantum emitters in solid-state defect system

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Quantum emitters (QEs) in solid-state crystals have attracted strong interest for quantum technologies such as cryptography, computation, teleportation, and metrology. They can be broadly classified into excitonic defects in semiconductor-like hosts such as quantum dots, and atomic defects in wide-bandgap materials like diamond. In this talk, we present the generation and control of both classes of QEs and their applications.

Atomically thin transition metal dichalcogenides (TMDCs) have emerged as promising hosts for quantum light sources, operating at the ultimate limit of few-atom thickness. Approaches include naturally occurring defects and strain-induced confinement in monolayer semiconductors. Nevertheless, several challenges remain: First, precise polarization control of QEs and efficient QE–cavity integration for Purcell enhancement [1, 2]. Second, deterministic, electrically driven QEs via strain engineering [3]. To address these issues, we will introduce experimental approaches that establish key methods for overcoming these obstacles.

In parallel, spin states of QEs in wide-bandgap materials offer a pathway to quantum networking. Silicon carbide (SiC), hosting various optically active defects, is particularly promising for on-chip quantum photonics. Silicon vacancies (V_{Si}) in SiC exhibit excellent optical coherence at cryogenic temperatures, millisecond spin coherence times, and compatibility with nanophotonic structures. We demonstrate coherent spin-state control using pulsed microwaves, and integration of V_{Si} into cavities enabling Purcell enhancement ($F_p \sim 48$) and improvement in the optical stability of the spin-preserving resonant optical transitions relative to the radiation-limited value [4]. The results highlight the potential of nanophotonic structures for advancing quantum networking technologies and emphasize the importance of optimizing emitter–cavity interactions for efficient quantum photonic applications.

- [1] So et al., Nano Letters 21, 1546-1554 (2021).
- [2] Lee et al., Science Advances 10, eadn7210 (2024)
- [3] So et al., Science Advances 7, eabj3176 (2021).
- [4] So et al., Nano Letters 24, 11669 (2024)