Nanoengineered Transition Metal Dichalcogenides Platform for Quantum Photonics: Generation, detection, and interference of single photons

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Transition metal dichalcogenides (TMDs) have attracted significant attention as a unique excitonic and photonic platform for nano- and quantum photonics. One remarkable feature of TMDs is their easy exfoliation via the scotch tape, thanks to their van der Waals stacking nature. This feature opens the door to assembling and stacking various TMD materials to possess new properties and integrating them into other photonic platforms. Additionally, TMD mono- and bilayers can yield single photons through strain- and defect-engineering, ranging in visible [1] and telecom [2] wavelengths. Integrating these TMD quantum emitters with photonic nanostructures and cavities promises efficient single-photon generation [3-5]. In addition to monolayers, multilayer TMDs possess exceptional optical properties, e.g., high index ($n \geq 4$) and low loss ($k \leq 10^{-4}$) [6], despite their indirect bandgap. These exceptional optical properties combined with optimized nanostructuring offer new possibilities to exploit multilayer TMDs in developing novel photonic components [7-8] for fully integrated quantum photonic circuits.

In the first part of my talk, I will present our recent advancements in fabricating highly polarized mono- and bilayer TMD single photon emitters through strain engineering [9]. This technique allows precise control over the polarization of these quantum emitters, a crucial step in their integration into desired photonic cavities for developing efficient single-photon sources. Our fabricated quantum emitters not only feature a high degree of single photon purity but also exhibit narrow zero-phonon lines with visible phonon sidebands [10]. This provides crucial details on the exciton-phonon coupling of the system and allows us to predict exciton preparation under different excitation schemes [11]. Moreover, we have explored experimentally various optical excitation schemes [10], including quasi- and resonant excitations, to understand their impact on single photon characteristics and the stability of emission lines, especially when compared to above-band excitation.

In the last part of my talk, I will discuss our ongoing research activities in developing on-chip TMD photonic components such as nanobeam cavities, on-chip beam splitters, and waveguides, harnessing the unique properties of nanoengineered multilayer TMD materials. These novel photonic components combined with our TMD quantum emitters could be a promising platform for realizing fully integrated quantum photonic circuits in future scalable quantum information technology.

References

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