Tunable van der Waals Materials as Building Blocks for Quantum Nanoptoelectronics

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The understanding of the properties of two-dimensional (2D) van der Waals (vdW) materials has posed significant challenges to researchers in the field of quantum nano-optoelectronics. These materials, with their unique nanoscale crystalline structure and resulting physical properties, hold immense potential as versatile building blocks for various applications, such as nanophotonics and quantum computing. However, effectively harnessing these properties requires in-depth characterization, made possible through recent advancements in fabrication methods and characterization techniques such as transmission electron microscopy combined with artificial intelligence algorithms. In this talk, I will present recent findings focused on unravelling the core properties of vdW materials for nanotechnology applications. One key aspect of my research is the development of a novel strategy for fabricating position-controlled Mo/MoS_2 core-shell nanopillars, enabling significant nonlinear optical processes driven by the MoS_2 shell [1]. This breakthrough allows for the precise localization of nonlinear signals, which is a critical requirement for nanophotonics. Additionally, I will delve into the quantification of the interplay between strain fields, thickness, and bandgap energy in twisted WS_2 nanostructures. By utilizing advanced techniques [3], we gain insights into how local strain influences the bandgap energy, providing valuable knowledge for designing functional devices such as quantum emitters. Lastly, I will explore local collective excitations in one-dimensional (1D) MoS_2, showcasing how this configuration provides a new platform to tune excitonic/plasmonic resonances and bandgap energy, distinct from planar configurations. Through these investigations, we aim to enhance our understanding of the fundamental properties of vdW materials, opening new avenues for their application in nanotechnology.

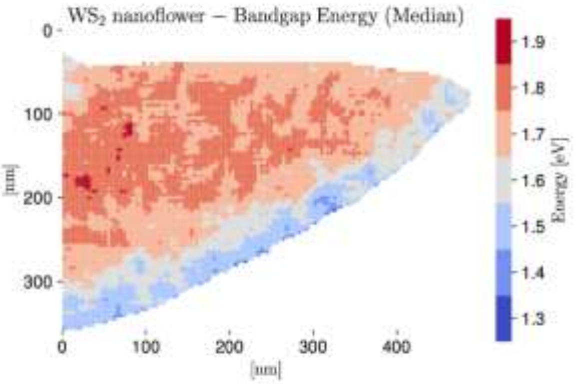

Figure 1: Spatially resolved determination of the bandgap of WS_2 nanostructures.

References

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