STEVENS
INSTITUTE OF TECHNOLOGY
1870

Ph.D. DISSERTATION DEFENSE

Candidate: Yuxing Liu
Degree: Doctor of Philosophy
School/Department: Charles V. Schaefer, Jr. School of Engineering and Science / Physics

Date: Wednesday, May 6th, 2026
Time/Location: 2:00 p.m. / Burchard 430
Title: Coherence and Spin Control of Quantum Emitters in 2D Materials

Chairperson: Dr. Stefan Strauf, Department of Physics, School of Engineering & Sciences

Committee Members:
Dr. Ting Yu, Department of Physics, School of Engineering & Sciences
Dr. Xiaofeng Qian, Department of Physics, School of Engineering & Sciences
Dr. Annie Xian Zhang , Department of Mechanical Engineering, School of Engineering & Sciences

ABSTRACT

My dissertation focuses on two complementary pathways towards solid-state qubits in Van der Waal's materials: The first approach prolongs exciton dephasing in monolayer Tungsten Diselenide (WSe_2) quantum emitters by geometric strain confinement. The second approach involves the development of spin-active defect centers in hexagonal Boron Nitride (hBN) by oxygen-annealing and controls the spin states via optically detected magnetic resonance (ODMR) spectroscopy.

Within the first part of the work, I demonstrate that introducing quasi one-dimensional (1D) strain folds on top of a zero-dimensional (0D) confinement potential in monolayer WSe_2 extends the dephasing time (T_2) of excitons by up to 7-fold. This approach realized T_2 times with an average value of 15 ps and a best case up to 25 ps, which represents the longest coherence time reported for strain-induced quantum emitters in WSe_2. In addition, a polarization statistic on over 200 single-photon emitters reveals a strong correlation between emission dipole orientation and the orientation of the on-chip engineered 1D strain channels. This correlation further confirms that the added strain folds reshape the excitonic confinement landscape beyond the original 0D localization.

The second part of this dissertation presents a comprehensive study correlating the spectral class of oxygen-annealed hBN quantum emitters with their spin properties. Through ODMR screening of 158 color centers that were individually identified, it was established that about 9 % of the broadband Type I emitters display coexistence of S = 1 and S = 1 / 2 spin transitions. In contrast, none of the narrowband Type II emitters showed any measurable spin signatures, thereby resolving an open question posed in earlier purely optical studies. These measurements were conducted using a home-built pulsed ODMR setup that I designed, implemented and programmed, consisting of an FPGA timing controller, an integrated RF signal chain and a pulsed laser driver. This unique setup enabled complete time-resolved characterization of each spin-active emitter from spin initialization to spin manipulation and spin readout. In this way, I determined the spin–lattice relaxation times T_1, the spin coherence time T_2 as well as the zero-field-splitting energies (D, E) for this novel oxygen-induced defect system and furthermore observed coherent Rabi oscillations for these spin active centers in hBN.

Collectively, these findings in my thesis work revealed 1D strain confinement as a previously unexploited method for prolonging T_2 and established the first direct link between spectral class and spin activity in oxygen-annealed hBN, advancing both platforms toward viable qubit implementations in van der Waals materials.