RICE QUANTUM GROUP MEETING SEMINAR SERIES

Engineering of single-photon emission from buried perovskite quantum dots in solid matrix

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Hao Zhang is a postdoctoral researcher in Chemical and Biomolecular Engineering at Rice University. He received his B.S. in photoelectric information science and engineering from University of Science and Technology of China (USTC) in 2018, and his PhD in applied physics from Rice University in 2024. He works with Professor Aditya D. Mohite in his research group of Material Physics for Energy Management, affiliated with the chemical and biomolecular engineering (CHBE) department. His current research focuses on revealing the photo-physics of perovskites and 2D materials using optical spectroscopies and advanced X-ray and electron diffraction techniques, towards future opto-electronic applications.

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ABSTRACT

Single photon emitter (SPE) sources are considered fundamental building blocks for next-generation quantum technologies with requirement of high brightness, indistinguishability, photon purity, and scalable fabrication. Achieving these properties in solid-state materials is challenging due to interactions with phonons, dark states, impurities, and dielectric fluctuations, causing spectral diffusion over tens to hundreds of microseconds. In this work, we demonstrate a novel material platform of halide perovskite-based quantum emitters, by embedding perovskite quantum dots (PQDs) into the wide-bandgap 3D perovskite matrix using one-step solution-processed synthesis technique. Spectroscopic characterizations reveal the quantum nature of light emission from the buried PQDs, as well as rich exciton fine structures such as triplets and singlets with assistance of magneto-spectroscopy. We observe SPEs with resolution-limited linewidths below 130 μeV, accompanied with photon-antibunching ($g^2(0) = 0.1$), no blinking or spectral diffusion for tens of minutes, and a high photon count rate of 10^4/s. The ultrasharp linewidth allows for the direct observation of the exciton fine structure (dark and triplet excitons) and their dynamics under a magnetic field. Furthermore, we have firstly demonstrated the capability of electrical-driven single-photon emission in perovskite by sandwiching the system between electron-transport and hole-transport layers. Our results may pave the pathway of on-chip integration of low-cost single-photon sources for quantum optical systems..

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