Workshop on MBE for Emerging Emitter Technologies
Room Tamaya ABC - Session WME1-SuM

Quantum-Dot based Single Photon Emitters I

Moderator: Richard Mirin, National Institute of Standards and Technology

8:00am **WME1-SuM-1 Welcome & Opening Remarks**,

8:15am **WME1-SuM-2 Invited Paper**, ***Edo Waks***, University of Maryland **INVITED**

8:45am **WME1-SuM-4 Low Noise Epitaxial Quantum Dots for Photonic Quantum Technologies**, ***Alisa Javadi***, University of Oklahoma **INVITED**

Efficient generation and detection of coherent single photons are key to advances in photonic quantum technologies such as quantum computation, quantum simulation, and quantum communication. Among many quantum emitters, semiconductor quantum dots are promising due to their deterministic and high-rate single-photon emission and the possibility of integration into nanostructures. However, poor quantum coherence between single photons created by independent emitters poses a major roadblock. I will discuss our recent work on achieving near-unity two-photon interference visibilities from two separate GaAs quantum dots [1,2]. This high visibility (~93%) is achieved under rigorous conditions: there is no Purcell enhancement, no temporal post-selection, no narrow spectral-filtering, nor frequency stabilization. One key component is the heterostructure, an n-i-p diode using material of excellent quality. The quantum dot charge is locked via Coulomb blockade; within a charging plateau, the exact emission frequency can be tuned via the bias applied to the gate; the charge noise is very low. A second key component is the quantum dot itself: the relatively large size confers multiple benefits such as larger oscillator strength and lower susceptibility to spin noise. This level of interference visibility from independent GaAs QDs is a first of its kind and matches the performance achieved in trapped ions and cold atoms, the seemingly most identical emitters. These results highlight the advantage of high-quality epitaxial quantum dots as a versatile choice for generating identical photons from multiple emitters.

[1] L. Zhai *et al*., Nature Nanotechnology **17**, 829 (2022).

[2] L. Zhai *et al.*, Nature Communications **11**, 4745 (2020).

9:15am **WME1-SuM-6 Growth and Characterization of Epitaxial InAs Quantum Dots for Efficient and Pure Single Photon Sources**, ***Kevin Silverman***, NIST - Boulder **INVITED**

Epitaxial quantum dots (QDs) grown by molecular beam epitaxy (MBE) currently serve as the backbone of the world's best performing single photon sources. Therefore, they are poised to play an important role in emerging quantum information systems, and in particular, quantum networking applications. To meet metrics of photon purity, indistinguishability, and efficiency excellent crystal quality, careful design, and precise control of QD density and shape is necessary. In this presentation, we will discuss the optical and electrical characterization needed to prove that an epitaxial QD device can meet these demands. In contrast to conventional optoelectronic devices, photoluminescence characterization (even at cryogenic temperatures) is insufficient for this purpose. We will explain the need for precision, cryogenic, resonant measurements and how results can directly feedback to improvements in growth conditions and device design. Depending on the intended application, charge noise and/or spin noise could be the major factor effecting performance. These two concerns can be separated with different spectroscopic methods and have different physical mechanisms. We will then discuss some of our latest research into improving InAs epitaxial single photon sources including the addition of Phosphorus based materials and monolithic microcavities for enhancing collection efficiency into a single mode fiber.

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