# Quantum Information Science and Technology with Quantum Dots

Quantum mechanics offers the opportunity for completely new ways of encoding and processing information in future quantum devices of unprecedented power. Development of quantum computers is a highly ambitious technological pursuit that can provide dramatic payoffs for the Department of Defense, including the ability to break codes that are fundamentally unbreakable with ordinary computers. In the NRL Electronics Science and Technology Division (ESTD), a multidisciplinary group of experts in materials fabrication, spectroscopy, and theory is establishing the scientific basis for practical solid-state quantum information technologies using semiconductor quantum dots (QDs). Quantum dots are nanometer-sized crystals so small that their properties are governed by the laws of quantum mechanics. Over the past decade, ESTD has made key advances in understanding and developing quantum dot systems to be used as the quantum bits of information for future quantum information technologies. These will be the basis for secure communications and real-time processing of large arrays of information needed by the Navy and Department of Defense in the 21st-century battlefield environment.

Since 2005, this team has published more than 35 papers in *Science*, *Nature* (journals), and *Physical Review Letters*, with over 1600 citations. Key contributions of the ESTD team include:

**Quantum dot growth and device fabrication** (1)

- Engineering of orbital and spin energy levels of QDs
- Engineering of multi-qubit structures with stacked QDs
- Deterministic control of QD position with nanometer precision
- Incorporation of dots into electrical and photonic devices

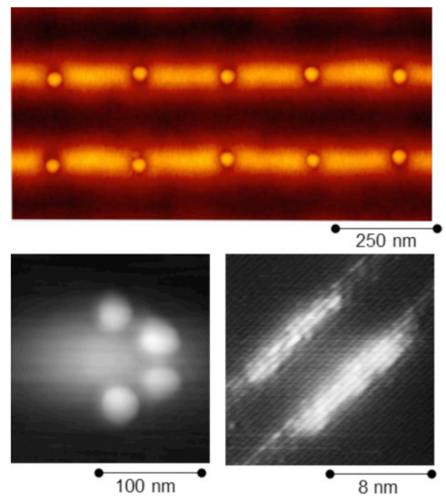
**Quantum control and entanglement** (2)

- Design and implementation of quantum logic gates of spins using laser pulses
- Identification, modeling, and mitigation of loss and decoherence due to interaction with QD nuclear spins
- First demonstration of ultrafast entanglement control of two spin qubits in QDs

**Quantum nanophotonics** (3)

- Integration of QD qubits into photonic crystal circuits
- Conversion of quantum information between solid-state and photonic qubits
- Design of entangled multiphoton “cluster” states from QDs
- First demonstration of quantum gates on a spin qubit coupled to a nanocavity

(1)

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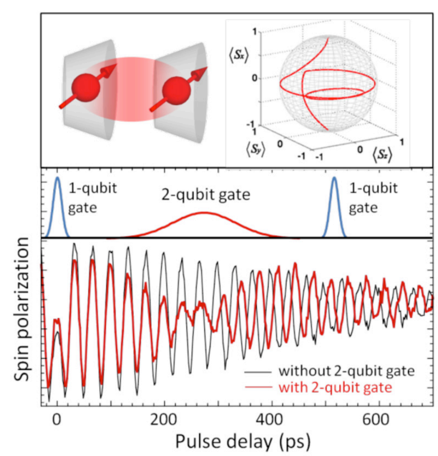


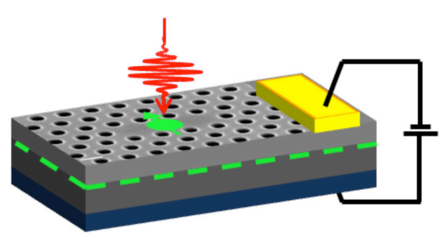

(3)