Research Spotlight Forum

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6.4.19 Quantum Information Sciences

Semiconductor-Based Quantum Computing at Sandia

PRESENTED BY:

Steven M. Rinaldi

Manager, Dept 5226

smrinal@sandia.gov, (505) 844-2153

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About our Semiconductor Qubit Program

- A Brief Bio:
  - PhD in semiclassical laser theory; research activities have spanned lasers/optics, nonlinear optics, critical infrastructure protection, cyber security, and most recently quantum computing
  - Project Manager, AQUARIUS Grand Challenge LDRD, 2011-2013 (adiabatic quantum computing)
  - Project Manager, Quantum Information Science & Technology (QIST), 2013-present – our portfolio of projects using quantum dots/donors in Si-MOS
- Current activities in semiconductor-based quantum computing:
  - P donors and dots in Si-MOS systems – electron spin qubits, hybrid donor-dot systems
  - Automation of qubit tune-up (see Andy Mounce's work)
  - Cyrogenic amplifiers
  - Hole spin qubits in Ge
  - Coupling electron spin qubits to waveguides – information transfer, quantum networks
- Group interests: How do we make increasingly better qubits in Si-MOS systems? How do we begin coupling multiple qubits?

Keywords:

Electron spin qubits, hole spin qubits, donor-based qubits, quantum dots, Si-MOS and semiconductor qubits

CURRENT WORK IN QUANTUM INFORMATION SCIENCES

- QIST – electron spins and donor nuclei in Si
  - Device theory, modeling – e.g., noise models, valley splitting
  - Fabrication - employing MESA as well as CINT capabilities
  - Experimentation – 1- and 2-qubit operations, hybrid donor-dot qubit, understanding noise, cyroamplification, automation, …
  - Analysis – gate set tomography, fidelities, lifetimes
- Hole Spin Qubits in Strained Ge Quantum Well Heterostructures
  - Develop the groundwork for hole-based single spin qubits in Ge/SiGe
  - Demonstrate hole spin qubits in Ge/SiGe
  - Identify dominant decoherence mechanisms for hole based qubits
- Strain in Si-Based Devices
  - Evaluating strain effects in Si-based quantum devices (e.g., fab, CTE mismatches)
- Device Fabrication
  - Providing fabrication services to several universities

FUNDING SOURCES

Multiple sources over the years

- LDRD: two Grand Challenge LDRDS and multiple traditional LDRDs
- Sponsored Research (ARO): multiple projects, including most recently fab, strain modeling, QIST

Many years experience with collaborative efforts:

- Universities – supported multiple student PhDs, masters degrees
- Device fabrication
- CRADAs

RESEARCH NEEDS

We are seeking to build relationships with universities

- Staffing opportunities – we are hiring (undergrad, PhD), particularly students with expertise in cryogenics/experimentation and theory of Si-based qubits
  - See Art Fischer, Steve Rinaldi
- Potential partnering opportunities – LDRDs, BAAs
- If you have thoughts and good ideas, let's talk!