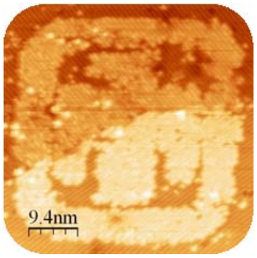
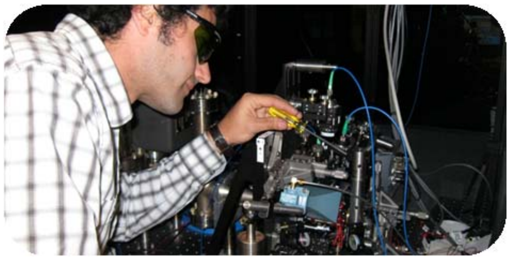
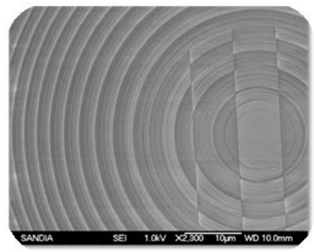
SAND2012-4335P

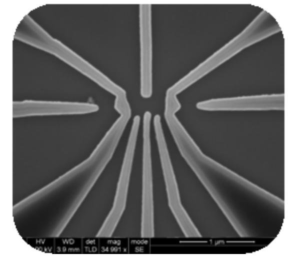
Exceptional service in the national interest

Sandia National Laboratories







# Quantum Computing Research

## *Advancing the Frontiers of Science and Engineering*

### Problem

Despite the extraordinary computational power of massively parallel supercomputers, there are some computational problems that are beyond their capabilities. For example, certain problems involving factoring integers into primes, searching through unstructured databases, and analyzing quantum effects. These types of problems fall into the quantum computing arena.

### Why It Matters

Quantum computers promise to take computing to its ultimate quantum-coherent limit, just as lasers did for light. Although they will not replace conventional computers, they have the potential to revolutionize technologies like simulation, sensing, energy capture, and nanoscale device fabrication. Advances made through scientific research will increase U.S. national security and competitiveness.

### Sandia's Approach

Sandia is leveraging its expertise in materials, fabrication, electronics, and computing to develop integrated methods for harnessing the fundamental units of quantum information processing (aka quantum bits or "qubits"). This approach is advancing multiple qubit technologies, including silicon quantum dots, laser-trapped cesium atoms, and electromagnetically trapped ytterbium ions.

An additional approach Sandia researchers are taking is in the area of adiabatic architecture. Qubits are more vulnerable than ordinary bits to environmental influences like noise. An adiabatic approach, one that keeps the system in its lowest-energy configuration, is predicted to dramatically improve robustness. Sandia is expanding the theoretical knowledge base of this proposed architecture and testing its properties with several qubit technologies.

### Research Accomplishments

Investments in quantum information sciences at Sandia have resulted in a number of recent achievements.

- First-ever demonstration of a robust functional ion trap.
- Demonstration of the basic electrostatic components of a silicon double quantum dot in which electrons can be confined.
- Demonstration of atomic-scale silicon lithography.
- First-ever fabrication of diffractive optical elements for cesium trapping and control, and first ever trapping of three separated cesium atoms.
- Operation of Sandia's first quantum device that processes information stored in a cesium atom laser cooled to 100 microkelvin.

### Collaborations and Funding

*Collaborations:* University of New Mexico, University of Wisconsin, Los Alamos National Laboratory, and NASA.
*Funding:* Laboratory Directed Research and Development and Other Federal Agencies.

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2012-XXXXP

Sandia National Laboratories