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Sandia QIS Capabilities

Sandia National Laboratories has developed a broad set of capabilities in quantum information science (QIS), including elements of quantum computing, quantum communications, and quantum sensing. The Sandia QIS program is built atop unique DOE investments at the laboratories, including the MESA microelectronics fabrication facility, the Center for Integrated Nanotechnologies (CINT) facilities (joint with LANL), the Ion Beam Laboratory, and ASC High Performance Computing (HPC) facilities. Sandia has invested $75 M of LDRD funding over 12 years to develop unique, differentiating capabilities that leverage these DOE infrastructure investments.

Sandia is pursuing the application of quantum technologies to novel materials, including a search for Majorana fermions and the development of materials with topological properties, that leverage existing quantum capabilities that include semiconductor fabrication, atomic-scale lithography, and low temperature device measurement.

In quantum computing, Sandia has developed working qubits in three different technologies, trapped ion, trapped atom, and semiconductors. The silicon qubit capability is enabled by the MESA fab facility and e-beam and STM lithography capabilities at CINT to build quantum dot, donor atom, and hybrid donor-dot qubits. This capability also enables fabrication of nanoelectronic structures, low-temperature amplifiers and charge sensors, and post-Moore's law computing devices.

The Ion Trap Foundry was seeded with funding from IARPA/MQCO, and uses the MEMS capability in the MESA fab to create the world's best ion microtraps with qubits, supplying traps to 14 groups around the world, including world leading groups such as those at NIST, University of Maryland, Duke, and Innsbruck.

The trapped atom capability uses diffractive optical elements to create high-quality and reproducible optical traps. In addition to being used for quantum information processing, this capability is also the foundation for a mature program in quantum sensing using atom interferometry. Among other applications of this technology is improved brain imaging using magnetoencephalography.

In addition to qubit hardware development, Sandia has a broad range of modeling and characterization capabilities to support hardware development. Sandia has developed an open-source Gate Set Tomography capability for characterization, validation, and verification of quantum devices that is in use worldwide. Sandia has also developed modeling capabilities for trapped-ion and semiconductor qubits, including the open-source QCAD capability for quantum dot and nanoelectronic devices.

In quantum communications, Sandia has developed world-leading quantum communications and QKD technologies, including a secure chip-based QKD device, single-photon sources and detectors, and protocols to support digital signatures, distributed computing and sensing, and time synchronization. Many of these capabilities also reside at the DOE/BES CINT User facility.

In the sensing area, Sandia has numerous investments in cold atom based magnetic field sensing for, among other applications, improved brain imaging using magnetoencephalography. Starting in October, we will be launching a new LDRD grand challenge in the area of cold atom based precision space and time measurement.

Sandia has a multidisciplinary, integrated cross-laboratory team for quantum information science, engineering, and integration that is available to the DOE community.

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