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Silicon enhancement mode nanostructures for quantum computing

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Development of silicon, enhancement mode nanostructures for solid-state quantum computing will be described. A primary motivation of this research is the recent unprecedented manipulation of single electron spins in GaAs quantum dots, which has been used to demonstrate a quantum bit [1]. Long spin decoherence times are predicted possible in silicon qubits. This talk will focus on silicon enhancement mode quantum dot structures that emulate the GaAs lateral quantum dot qubit [1] but use an enhancement mode field effect transistor (FET) structure. One critical concern for silicon quantum dots that use oxides as insulators in the FET structure is that defects in the metal oxide semiconductor (MOS) stack can produce both detrimental electrostatic and paramagnetic effects on the qubit. Understanding the implications of defects in the Si MOS system is also relevant for other qubit architectures that have nearby dielectric passivated surfaces. Stable, lithographically defined, single-period Coulomb-blockade and single-electron charge sensing in a quantum dot nanostructure using a MOS stack will be presented. A combination of characterization of defects, modeling and consideration of modified approaches that incorporate SiGe or donors provides guidance about the enhancement mode MOS approach for future qubits and quantum circuit micro-architecture. [1] J. Petta et al., Science 309, 2180 (2005) We wish to acknowledge the research funding support provided by the laboratory directed research and development (LDRD) program at Sandia National Laboratories and the Laboratory of Physical Sciences. Sandia National Labs is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.