Quantum Device Development Using Ion Beams

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Ion implantation at low fluences is being used to fabricate a variety of silicon-based quantum devices in the Centre for Quantum Computation and Communication Technology (CQC2T) in Australia [1]. Recent breakthroughs include coherent manipulation of an individual electron spin qubit bound to a phosphorus donor atom in natural silicon with single-shot read-out [2], single-shot read-out of the nuclear spin of a single 31P atom with very high readout fidelity and operation of the single nuclear spin as a qubit [3] and observation of the optical excitation of a single erbium atom implanted in the channel of a silicon transistor [4]. In this presentation we will describe the extremely important contribution of ion beam analysis in the development of these quantum devices. Ion beam induced charge mapping is used to study the construction zones where the quantum devices will be fabricated and to check that the detector structures that are engineered into the chip to provide single ion detection functionality are working properly. Due to the fact that low energy ions produce a relatively small number of electron-hole pairs when they enter the substrate, to push single ion detection to low energies in the 5 – 15 keV energy range we are working on the development of avalanche detector structures which provide some level of multiplication of charge when an ion enters the material. We will describe beam pulsing experiments that are used to study the performance of the avalanche detectors when operated in Geiger mode.

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