Erbium Implanted Silicon for Quantum Technologies

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Erbium is an attractive optically-addressable spin-centre for applications in quantum technologies including quantum memories, repeaters, and quantum computers.[1] The features that make Er in Si particularly attractive for applications in quantum technologies include the fact that it possesses spin states with low decoherence rates, optical addressable transitions to interface solid-state qubits with flying qubits, and a potentially scalable device engineering platform. While early ion implantation studies of Er:Si focussed on implantation of Er at relatively high fluences for possible applications in optical amplification and lasing, more recently research has generally been concerned with low fluence implants to produce populations of relatively isolated spin-centres suitable for quantum computing applications.[2-4] Er is a heavy ion that creates considerable damage upon implantation into Si and deep level transient spectroscopy, DLTS, offers a sensitive method of exploring the defect evolution and damage recovery that occurs during subsequent thermal processing and hence is well-suited and directly relevant to this low-fluence implant regime. DLTS studies of Er implanted Si have highlighted the fact that the dense collision cascades of these heavy ions produce strain in the lattice that tends to broaden and distort the DLTS features when compared with DLTS spectra for lighter ions. [5, 6] Defects can also be projected well beyond the projected range of the ions. The defects produced by heavy ion implantation are also stable up to higher temperatures than those introduced by electron irradiation and low mass ions and this can be an important consideration for quantum devices fabrication since in some cases available thermal budgets for removal of the implantation damage are quite limited and it is possible that detectable levels of electrically active defects are still present in the devices in their fully-processed state. [1, 2, 4] While most studies have focussed on Er implantation of n-type Si there have been fewer studies of p-type Si and this has been a particular focus of our recent research since many of the Er implanted FinFET devices in our quantum measurement program have B-doped channels. In this presentation, a broad introduction to the attributes of Er in Si for quantum device development will be given along with details of how the companion DLTS studies are used to complement the quantum device development and measurement programs.

References:

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