**Information Collection of Er:Si**

**General Comments:**

Implanted Er3+ in Si has shown comparable spin coherence times in low magnetic fields to Er substitutional dopants [21], but it can occupy a large variety of possible sites in silicon, and the properties of these sites, even for ensembles, are not well known.

the shielding of their 4f shell electrons offers an atomic scale barrier to decoherence

Combining the shielding of RE f-electrons with the low nuclear spin and processing pedigree of silicon offers a novel system in which to implement quantum technologies.

Knowledge of rare-earth ion symmetry is important in maximizing the number of optically active centers and for quantum technology applications where local symmetry can be used to control decoherence.

indirect electronic band gap of Si: a poor light emitter due to fast non-radiative decay dominating over slower radiative routes.

Dislocation engineering by boron implantation can be used to inhibit non-radiative decay paths and allow band edge photoluminescence (PL) and electroluminescence (EL) from Si. -> Similarly applied to REI

The atomic shielding of the f-shell electrons in REs means that the effect of the host crystal field on their energy levels is weaker when compared with transition metal ions or bismuth.

Because of the low number of optically active ions in implanted samples compared to bulk doped samples, measuring the crystal field splitting from absorption measurements in implanted samples is extremely difficult. PL spectra can often be detected, but are inherently weak because above band gap excitation is required, and this only penetrates the first few hundred nm from the sample’s surface. Therefore, various peaks in the crystal field split spectra can be undetected or unresolved.

Since silicon, and in particular isotopically pure 28Si, have low nuclear spin we expect the decoherence time to be significantly improved…

**Papers and main conclusions:**

[Crystal field analysis of Dy and Tm implanted silicon for photonic and quantum technologies](https://opg.optica.org/DirectPDFAccess/2A5F2CF5-F353-4BB8-95020907B384DC69_304756/oe-22-24-29292.pdf?da=1&id=304756&seq=0&mobile=no)

In this work we report for the first time crystal field analysis of the PL from Dy and Tm ions implanted into Si which is used to determine symmetry and structural parameters.

determine that the symmetry of the Dy and Tm ions in the silicon lattice is tetragonal for both ions.

Extended X-ray absorption fine structure (EXAFS) measurements of Er-implanted, high O impurity Czochralski-grown Si, which exhibit strong PL at 1.54 μm, show Er is six-fold coordinated to oxygen.

Strong PL can also be observed from Er and O co-implanted Si [9]. By contrast, in low O impurity FZ Si, no PL was observed and Er was coordinated with 12 Si atoms.

Contradictions: Rutherford backscattering (RBS) measurements have indicated that Er implanted in Si is

located [10], and is not located [11], at an interstitial site. (Contradiction: substitutional or interstitial?)

Other RBS and PL measurements indicate that when annealed at over 800°C, 80% of Er occupies substitutional sites with tetrahedral symmetry.

The emission channelling technique indicates that Er in FZ Si occupies tetrahedral interstitial sites [15], and first-principles calculations indicate that the lowest energy configuration of Er in Si is Er3+ at a tetrahedral interstitial site.

[Electron paramagnetic resonance of erbium doped silicon](https://aip.scitation.org/doi/pdf/10.1063/1.117127)

Electron paramagnetic resonance (EPR) spectra of Er and O co-implanted Si indicate two Er3+ centers having monoclinic C1h symmetry and trigonal symmetry.

[Sub-megahertz homogeneous linewidth for Er in Si via in situ single photon detection](https://arxiv.org/pdf/2108.07090.pdf)

Studied the optical properties of a resonantly excited trivalent Er ensemble in Si accessed via in situ single photon detection. Show highly efficient detection of 70 excitation frequencies, of which 63 resonances have not been observed in literature.