**Literature review of Er:Si**

Outline:

Review of past research (PL, EPR, EXAFS)

Review of recent research (spectroscopy, optical lifetime, coherence measurements)

mention T center in Si, Er in molecules, CaWO4/GaN

Aspects: centers, symmetry, energy level structure, electronic states

Should add numbers of references later

Should add more details later

**Motivation**

Erbium in silicon was explored extensively in the beginning of twentieth century, with the interest of building a silicon-based on-chip optical source. As a poor photonic material, silicon suffers from fast non-radiative decay dominating over slower radiative routes, and indirect bandgap (band edge luminescence at 1.1 μm). It was hoped that implanting optical active centers into this material will allow photoluminescence at specific wavelengths determined by the rare-earth optical transitions. Er3+ was chosen for its direct 4I13/2 → 4I15/2 transition at 1532 nm falling in the telecom band, which is convenient for optical fiber links in modern communication.

There have been considerable experimental researches towards this platform. To begin with, a major problem facing researchers was the relatively low solubility of erbium in crystalline silicon. This problem was solved by enhancing the equilibrium concentration by co-doping with impurities such as oxygen, carbon, nitrogen and fluorine. In experiments, co-implanting Er with O significantly increases the photoluminescence and leads to sharp lines in EPR spectroscopy. In later parts of this review, I will mainly discuss about erbium and oxygen co-doped silicon.

**Electronic structure of Er and O co-doped silicon**

However, ion implantation also suffers from the disadvantage of introducing significant damage to the matrix. High temperature annealing can recover the majority of this damage and initiate the formation of Er–O clusters, but at the cost of producing aggregates of rare-earth ions or forming optically inactive silicides.

In practice, incorporating erbium into an interstitial site is more strongly preferred than a substitutional site, as the interstitial sites are predicted to be more stable from the estimations of the bonding mismatch between the rare earth ion and the covalent semiconductor.

**Unsolved puzzles**

**Recent Quantum researches**

The forbidden 4f-4f intra-shell transitions of erbium become weakly allowed in the presence of crystal field, which result in sharp optical transitions with high quantum efficiency. In the case of semiconductor, like Si, however,

References:

<https://uchicago.box.com/s/kmxa15p3v75gyemtdwthzj49pyue1m1p>

[1] A J Kenyon 2005 Semicond. Sci. Technol. 20 R65

[2]