

Electron paramagnetic resonance (EPR) spectroscopic study of nuclear waste glasses

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Joint ICTP-IAEA International School on Nuclear Waste Vitrification

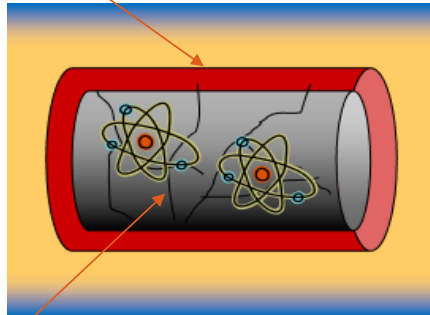


Outline

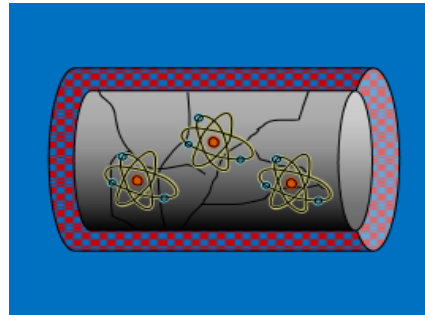
- ❑ Introduction – Ageing of HLW nuclear waste form
- ❑ Introduction – Radiation damage
- ❑ EPR – Theory and experimental
- ❑ EPR on gamma irradiated samples – Data and results
- ❑ Thermal annealing
- ❑ Summary
- ❑ Further work

Introduction – Ageing of HLW Nuclear Waste Form

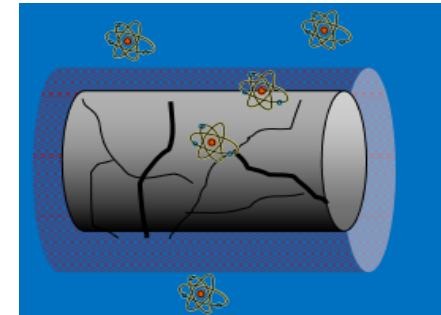
Metallic container



Container Corrosion



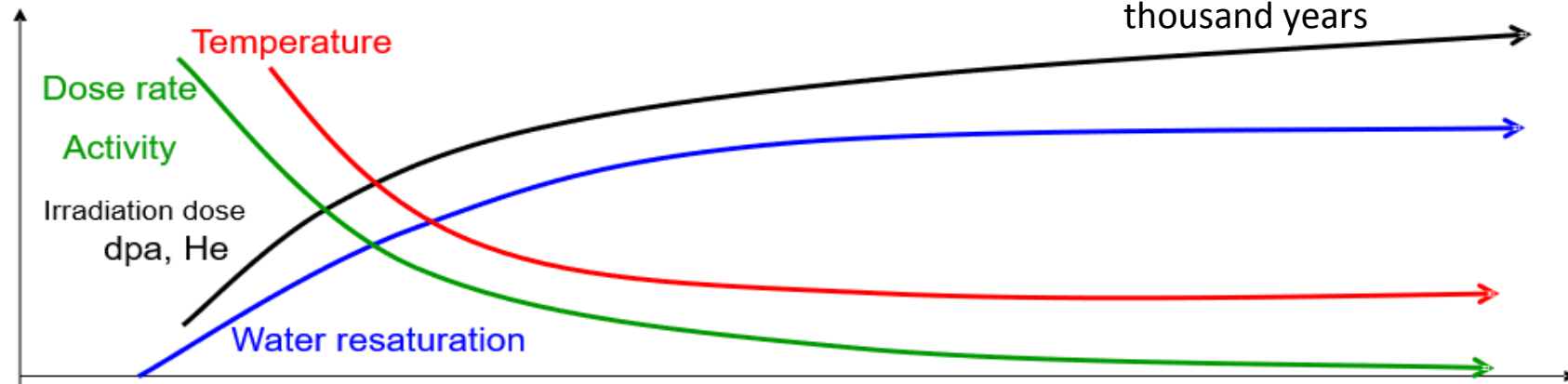
Leaching and RN release



Glass

Hundred to thousand years

Thousand to hundred of thousand years



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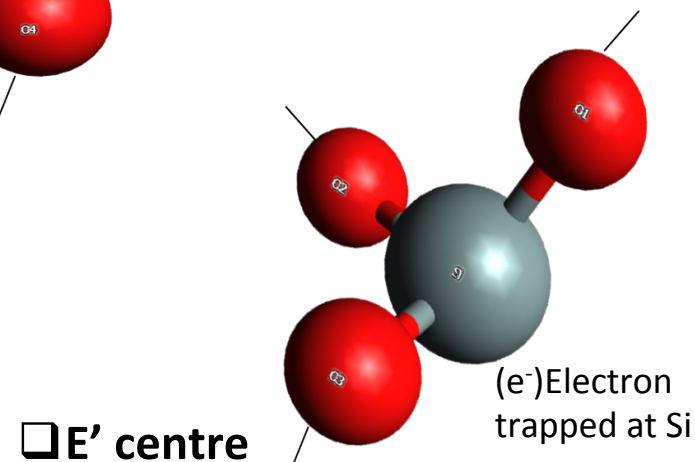
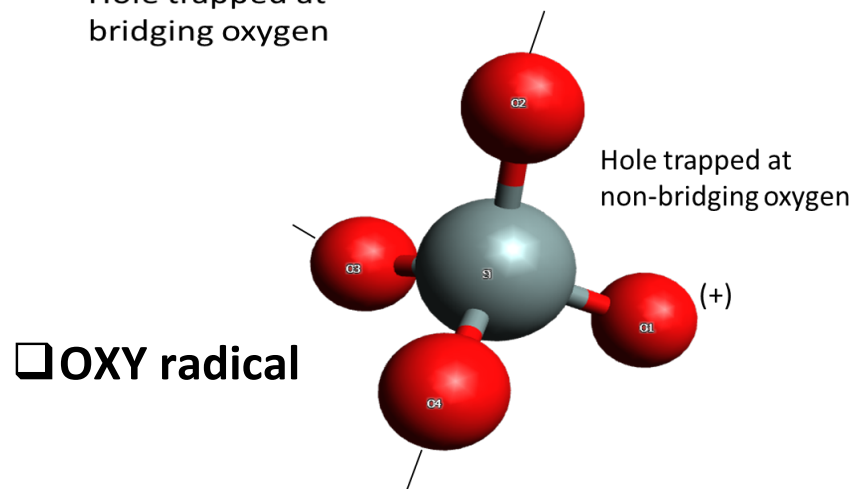
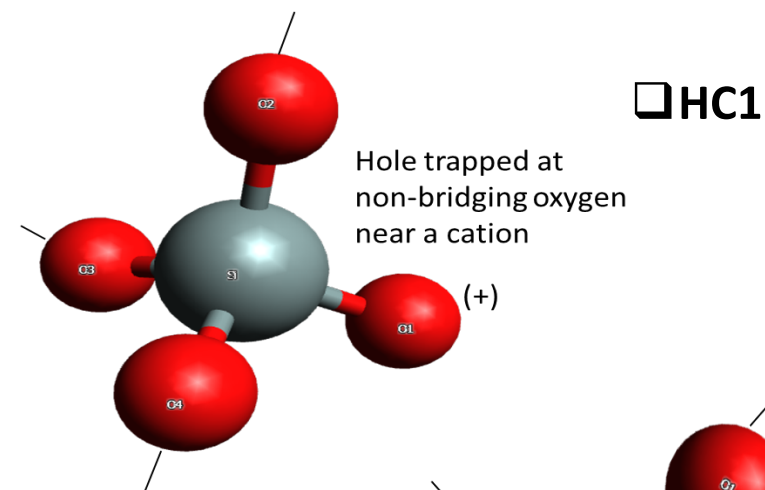
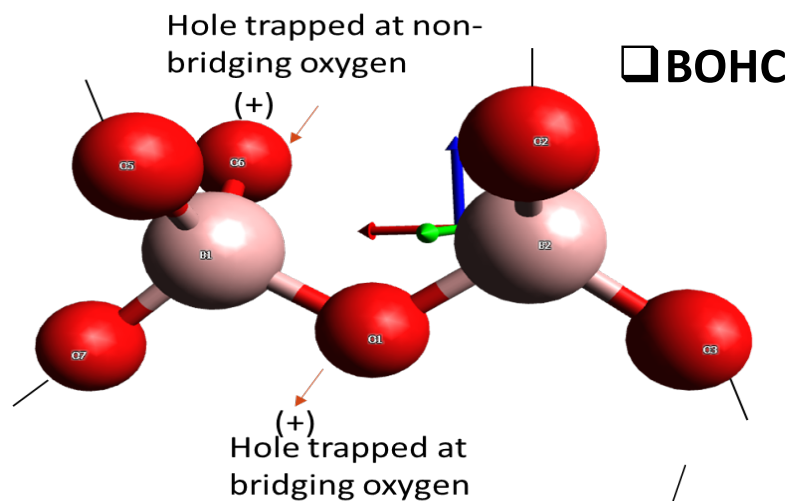
Radiation Interaction with Matter

- ❑ Interaction of radiation- energy transfer, formation of lattice defects
- ❑ Production of phonons, excitons, plasmons, secondary electrons, heating of material
- ❑ Photon irradiations create damage mainly by **electronic excitation-causing bond breaking**
- ❑ Covalent and ionic bond rupture
- ❑ Valence changes
- ❑ Significant changes in ionic mobility
- ❑ Phase separation
- ❑ Density and volume changes

(Nordlund et al., 2018)

(Ewing, Weber & Clinard, 1995) (Weber, 2014)

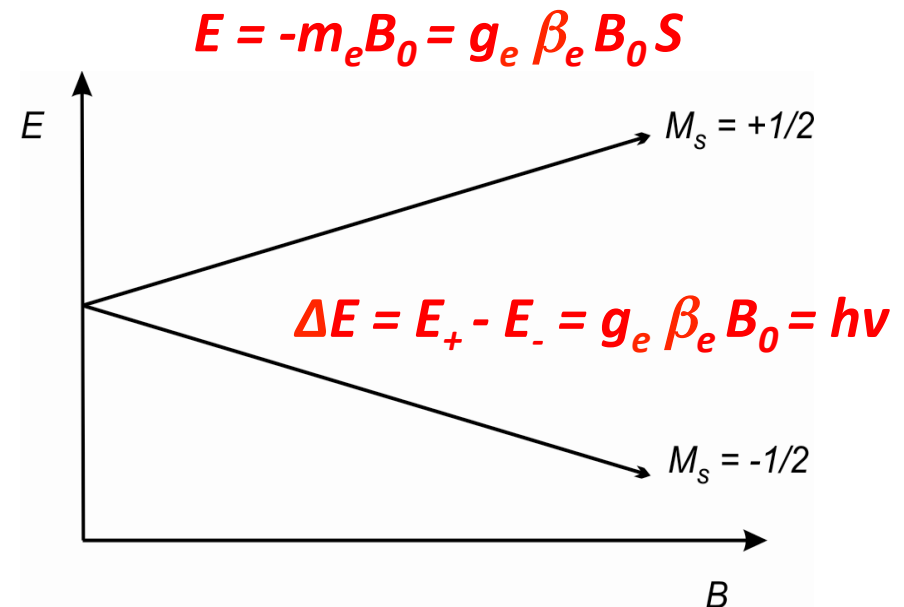
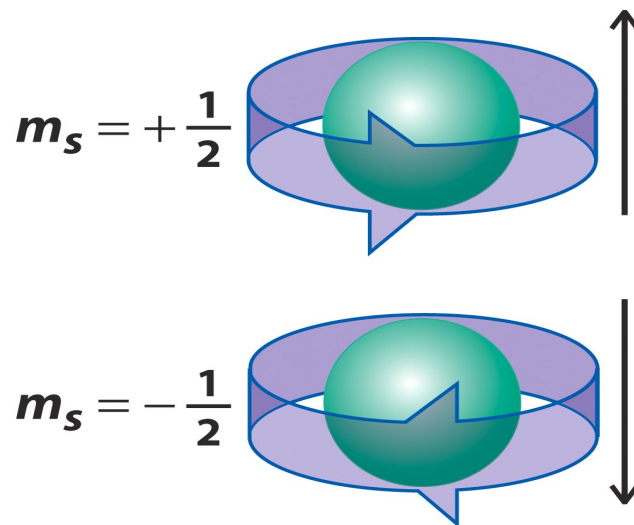
Introduction – Radiation Defects



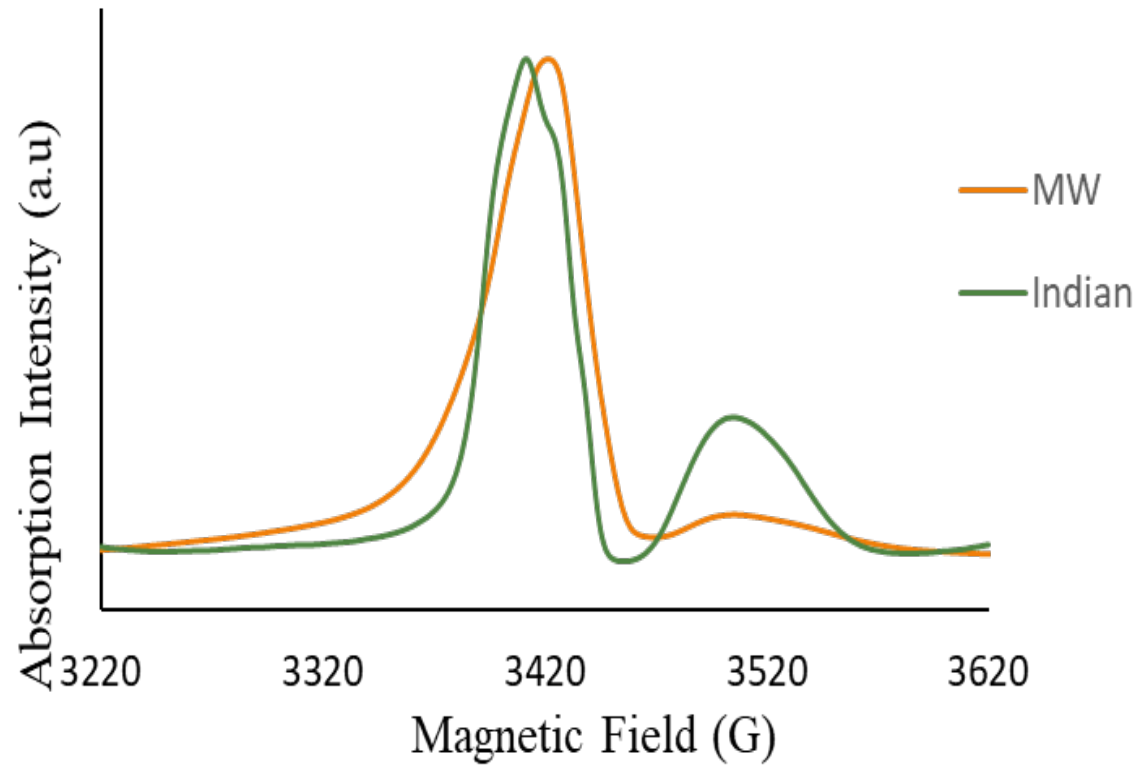
EPR – Theory and Experimental

- ❑ Electron spins on its own axis – spin angular momentum
- ❑ And around the nucleus in an orbit - orbital angular momentum.

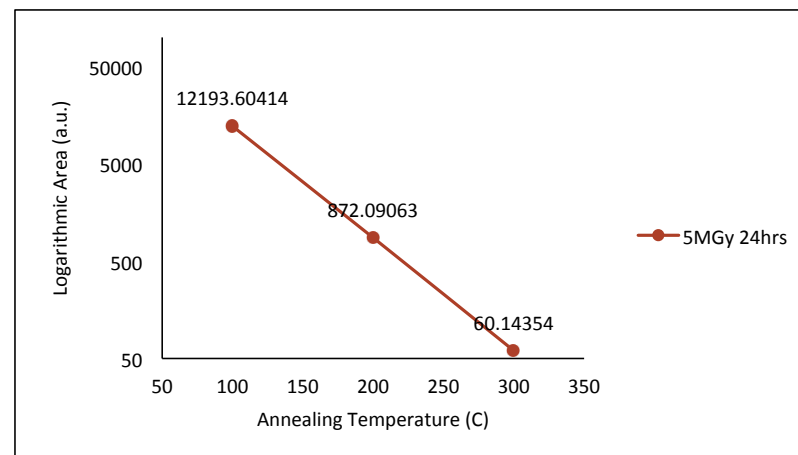
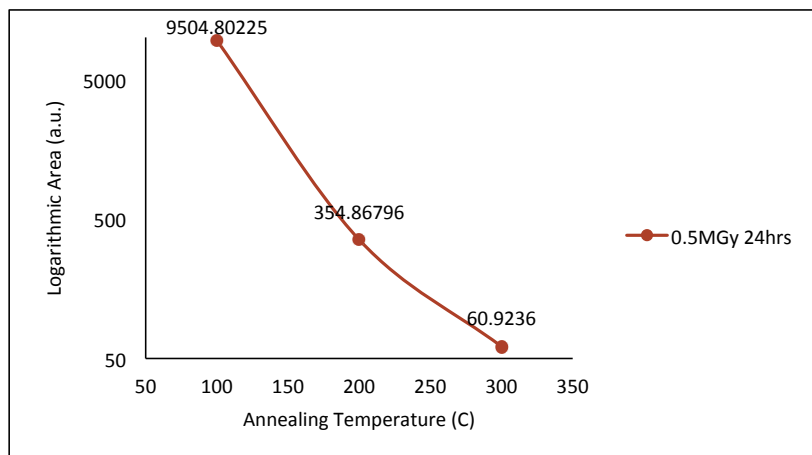
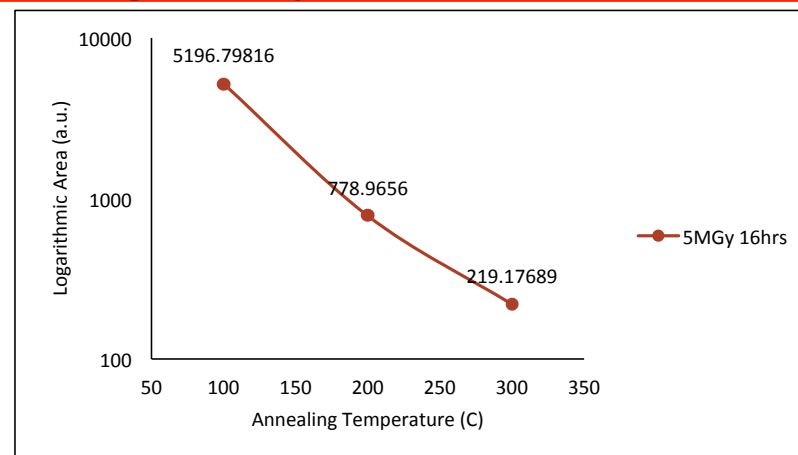
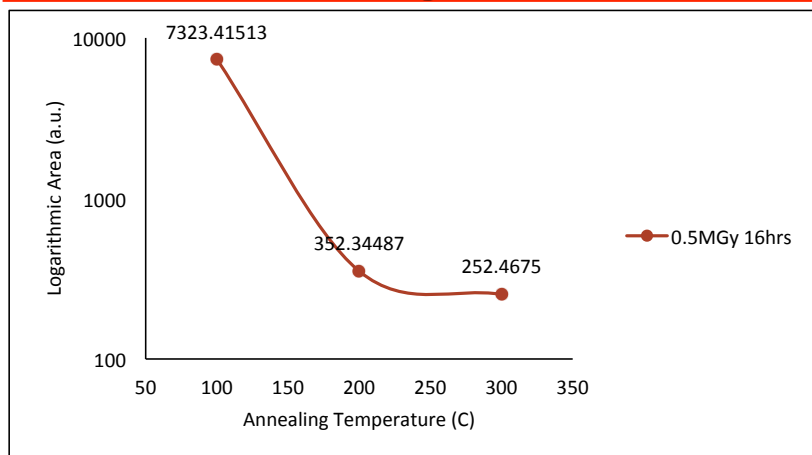
Unpaired electrons possess a magnetic moment which acts like a tiny bar magnet.



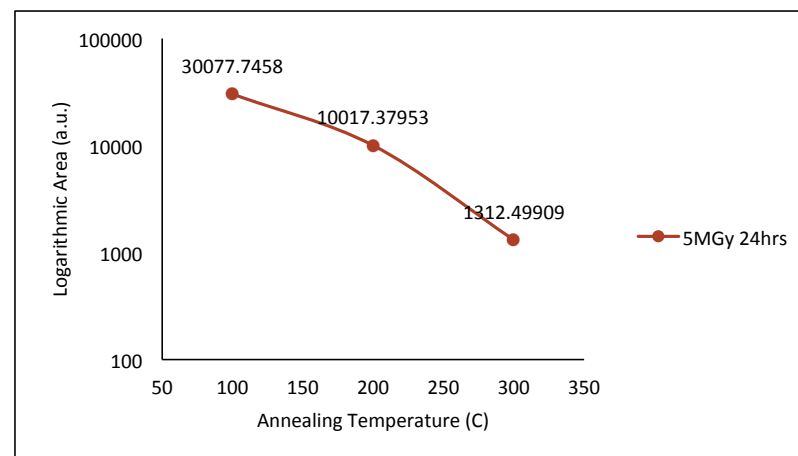
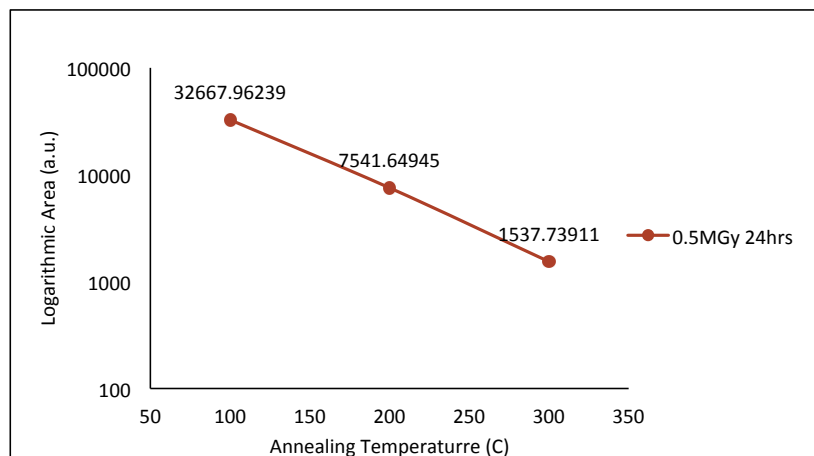
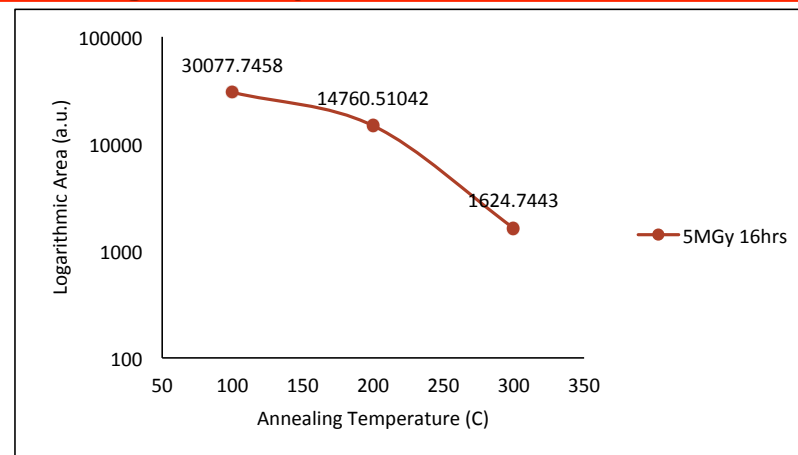
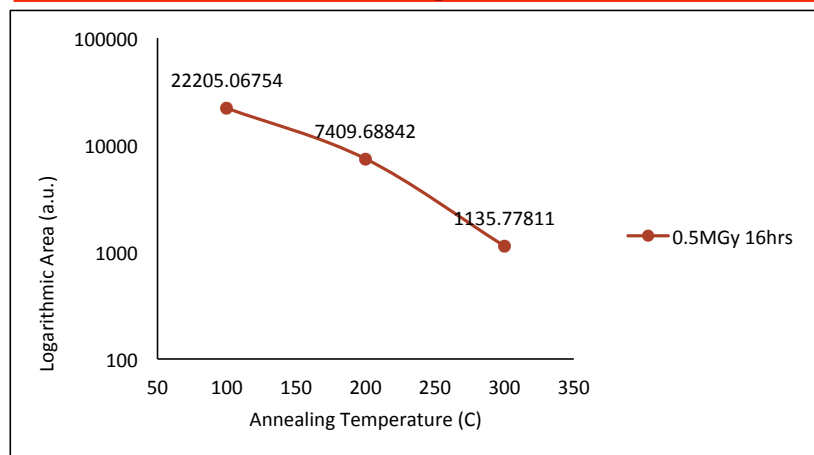
Integral/Area



Integral/Area vs. Annealing Temperature



Integral/Area vs. Annealing Temperature



Results and Summary

- ❑ Gamma radiation induced defects identified in the Indian and MW base glasses.
- ❑ Most of the defects disappear by the recombination of electron and hole on annealing except the oxy radical.
- ❑ The area under the integration curve for EPR signals decreases on annealing.
- ❑ There is difference in the UV-Vis absorption intensity but no changes in the band position suggesting same defect formations. (quantification is required).

Further Work

- ❑ Identification of the unidentified defects.
- ❑ Quantification of the defect centres and relation with dose.
- ❑ Thermal annealing at 400 degree Celsius.
- ❑ Study of the structure of the all the defect centres with simulations possibly.

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Thank you for listening! Any questions?

