Radiation Damage Studies at Materials Science Group

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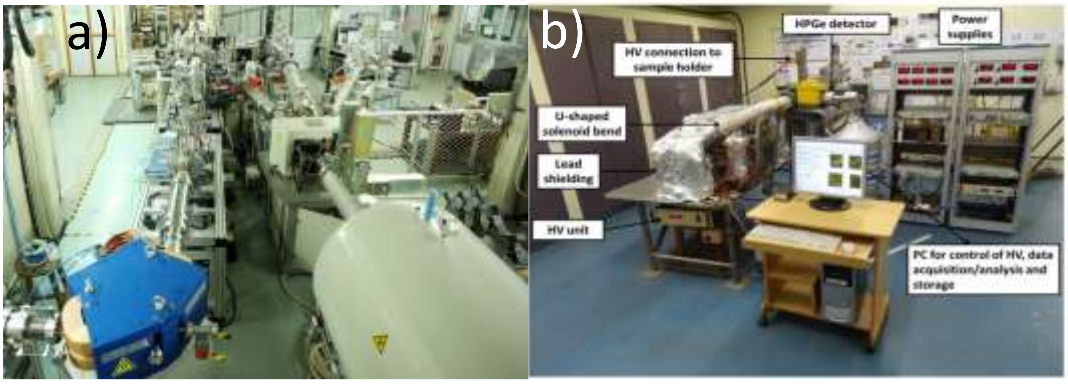

Fig. 1 a) Ion irradiation and characterization facilities b) Positron Annihilation Spectroscopy (PAS) setup

Defects and damage studies in materials are an important core activity of Materials Science Group (MSG). 1.7 MV Tandetron accelerator is being effectively utilized to study the radiation effects in reactor materials using heavy ions, giving the defect production rate of up to five orders of magnitude higher than reactor irradiation effects, providing a test bed for simulating the condition of both thermal and fast reactor.

The irradiation damage studies in D9 (titanium-modified, 316 stainless steel) alloys have given crucial insight into the importance of Ti to C ratio on the void swelling behaviour. Oxide dispersion strengthened (ODS) steels are the candidate material for future fast and fission reactors due to their better radiation resistance. The Density Functional Theory (DFT) simulations along with Transmission Electron Microscopy (TEM) and Positron Annihilation Spectroscopy (PAS) have shown that in comparison to Al, Zr containing ODS steels give rise to finer distribution of particles along with high number densities and the onset of the defect production is also at higher dose of 150 dpa as compared to the corresponding dose of 100 dpa for Al containing ODS steels. Nanocrystalline Ni, which is a coating material for molten salt reactor upon irradiation with 14 MeV Ni ions, shows that void-denuded zone at the surface is absent. The interaction of O solute with defects and the effect of grain size in FeCr alloy is studied using ion-channelling, high-resolution Rutherford back-scattering (HRBS) and DFT. RBS and Channeling are done to study the irradiation-induced recovery of defects in 3C-SiC. The defects produced by 200 keV Si ions were found to be annealed by irradiating 14 MeV Si ions. PAS has been used extensively to study vacancy defects, voids and their evolution with annealing temperature in Indian reduced activation ferritic martensitic (INRAFM) steels for both fission and fusion reactor applications and high entropy alloys. Besides providing the comprehension of the experimental results, the computational activity at MSG plays a key role in understating defects energetics and calculation of binding energies in bcc Fe, bcc U and U_3Si_2 using DFT. The random network structures of glass are modelled using *ab-initio* Molecular Dynamics (MD) and Monte Carlo methods for IPG envisaged as powerful tools for the studies on the retention and stability of IPG after insertion of Cs and Pu for waste immobilization applications. The displacement cascades are studied in $Y_2Ti_2O_7$, $Y_2Ti_2O_5$ and $Gd_2Zr_2O_7$ to understand the basic processes in defect production using MD simulations. MSG equipped with a dual ion beam facility (400 kV ion accelerator for He ions and 1.7 MV Tandetron accelerator for heavy metal ion irradiation) for simulating nearly the radiation damage conditions in the reactor and powerful characterization tools, including PAS (variable low energy DC beam and upcoming pulsed beam of positrons), HRBS/ Channeling, SEM, TEM along with the computational modeling would contribute significantly in providing greater insights to devise strategies for defects studies in the materials of interest for current and future reactors.