Notification No: 549/2023

Date of Award: 16-11-2023

Name of the Scholar: Zara Aftab

Name of the Supervisor: Prof. Lekha Nair

Name of the Department/Centre: Department of Physics, JMI.

Topic of Research: Radiation processing of metal films: structural and morphological transformation on the nanoscale.

Findings

The interaction between incident ions and a solid occurs at the expense of the energy each incident ion. The ion slows down because it loses a certain amount of energy and momentum in each encounter with the atoms of the material along its path and eventually comes to rest- if not backscattered out of the target- and is implanted within the target at a certain depth. In between collisions with the target and coming to rest, various processes may occur in the target, such as sputtering, dewetting, interface mixing, ion beam induced reactivity, and crystallographical changes such as amorphisation and enhanced crystallinity. When films grown on dissimilar substrates are irradiated, dewetting and sputtering may lead to the formation of nanostructures in a self organised process, driven by surface energy minimisation. These large scale consequences follow the immediate atomic effects (on the sub femto-second time scale) such as ionisation, followed by a Coulomb explosion, collision cascades, and electronic and lattice thermal spikes, which cannot be directly observed; but theoretical work has made considerable progress in developing an understanding of how the process unfolds. Controlled variations in the film thickness, incident ion energy, ion fluence and ion species can be used to tailor the shape, size and distribution of nanostructures, and there is a need to understand and characterise the physical processes that drive these changes.

We have done a series of systematic experiments to investigate the self organised morphological and structural changes on a range of metal films grown on single crystal silicon substrates using ions in the keV and MeV energy ranges. The materials that we have chosen-Aluminium (Al), Indium (In) and Copper (Cu)- are elements which have atomic numbers which show large variations in energy transfer from incident ions, as determined from Monte Carlo calculations using SRIM software. They also have widely varying physical properties, which could affect the evolution of the material following ion impact. These films were irradiated with medium energy and high energy ions to study the incident ion energy, ion species and ion fluence dependence of ion induced modifications of the various target materials. The beam induced structural changes will be analysed with characterisation techniques including AFM, SEM, RBS and XRD.