# Evolution of Crystalline Phases and Diffusion of Elements in Ion Beam Irradiation Synthesized Cosmic Dust Analogues

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Laboratory astrophysics has become increasingly important to explore the evolution of cosmic dusts. Generation of experimental data for both diffusion of elements and crystalline phase modification due to conditions in the stellar winds of AGB stars is crucial to develop models for the growth of crystalline grains in amorphous silicate cosmic dust.

A new synthesis process is presented for experimentally simulating modifications in cosmic dust grains utilizing multiple ion beam irradiation techniques. Olivine type cosmic silicate dust analogues were prepared via implantation of 20-80 keV $Fe^-$, $Mg^-$, and $O^-$ ions into silicon and quartz wafers. The olivine type analogues, $Mg_{2x}Fe_{2(1-x)}SiO_4$ (x: mixing ratio), had an average mixing ratio of 0.5, 0.7, and 0.9. The analogues were subsequently irradiated with energetic $He^+$ ions (~600 keV) to induce growth centers and improvement of the crystalline phase. Prior to the ion implantation and irradiation, Monte-Carlo based ion-solid interaction codes were used to model the dynamic redistribution of the target layers. The samples were then thermally annealed in laboratory conditions appropriate for the system of interest, M-class stellar winds, at temperatures ranging from 850-1100 K.

The elemental depth profiles and diffusion are measured utilizing Rutherford Backscattering Spectrometry (RBS) and X-ray Photoelectron Spectroscopy (XPS) in the samples before and after thermal annealing. X-ray diffraction (XRD) technique was employed for identification of various phases in crystalline minerals in post irradiated and annealed analogues. Theoretical solid state diffusion rates were calculated and compared to the experimentally observed rates. In this presentation the modification of crystalline phase as a function of ion beam stopping force, and thermally induced elemental diffusion will be reported in the formed silicate dust analogues.