Ionoluminescence Studies in Certain Silicates

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Researchers exploited energetic ion beams in different ways in the field of materials science. Its effect on the materials depends on the ion energy, fluence and ion species. When an energetic ion penetrates a solid material, it loses its energy mainly by two nearly independent processes: (i) elastic collision with the nuclei known as nuclear energy loss which dominates at an energy of few KeV/amu and (ii) inelastic collisions of the highly charged projectile ion with the atomic electrons of the matter known as electronic energy loss which dominates at an energy of about 1 MeV/amu or more. Ionoluminescence also known as *Ion beam induced luminescence* (IBIL) is a technique used for material analysis and defect studies. Light emitted from the target material caused by energetic ions is analyzed with a fiber optics based spectrophotometer. Since visible light results from outer shell transitions, it gives information about the nature of chemical bonds in materials and also IBIL is sensitive to the local chemical environment of compounds and trace substitutes and to the microstructures of the network. Energetic ion beams can be applied for characterization and materials modification. Also, it is possible to reach higher electronic levels because of the amount of ion energy supplied during irradiation (order of MeV) whereas, it is not possible with other techniques.

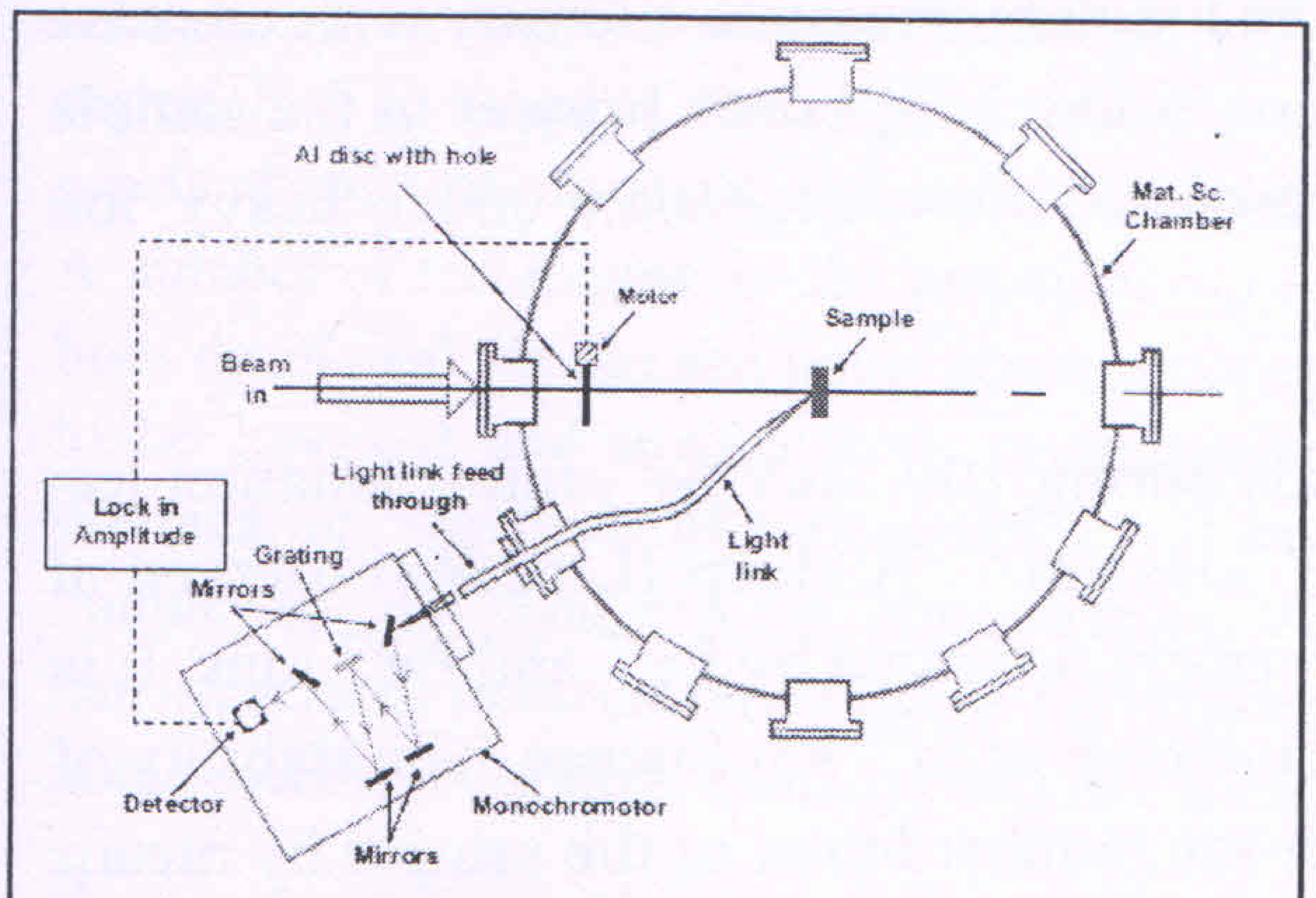
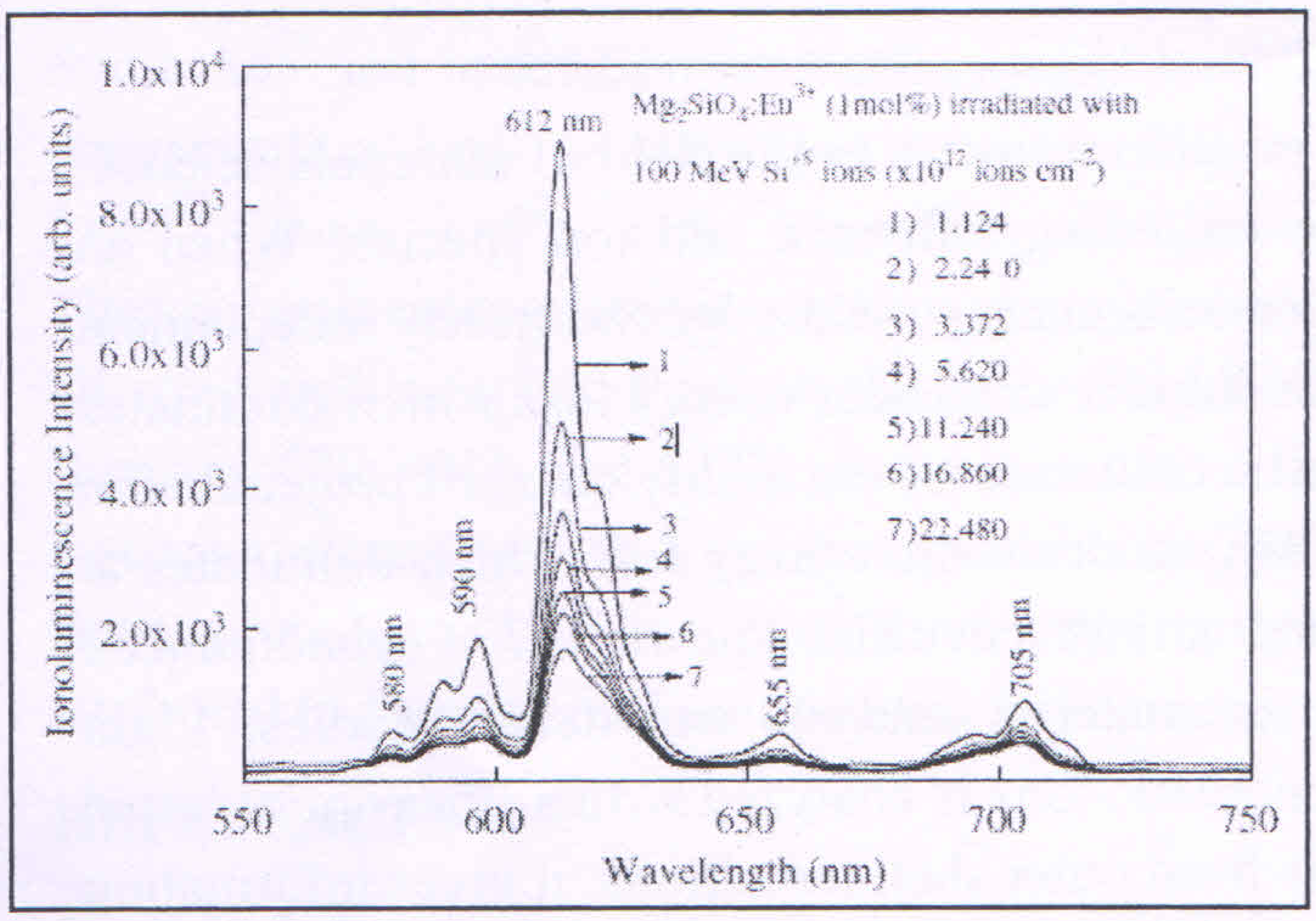


Fig. . Schematic experimental setup for online Ionoluminescence studies.

Combustion synthesized pure and rare earth doped Mg_2SiO_4 samples were made into pellets of 8 mm diameter and ~ 1 mm of thickness using an homemade pelletizer. The samples were bombarded with energetic swift Si^{8+} ions at room temperature using 15UD pelletron accelerator at Inter University Accelerator Centre (IUAC), New Delhi, India. The ion beam was scanned over 5 ×5 mm^{-2} area of the sample using a magnetic scanner with a beam current of 1.5 pnA. The detailed Ionoluminescence setup used is discussed elsewhere and its schematic diagram is shown in the above figure.

Nanoparticles of pure and Eu^{3+} doped Mg_2SiO_4 have been prepared by the solution combustion technique and the grain size estimated by PXRD is found to be in the range 40–50 nm.

Ionoluminescence (IL) of $Mg_2SiO_4:Eu^{3+}$ pellets bombarded with 100MeV Si^{8+} ions with fluencies in the range 1.124 – 22.48 $\times 10^{12}$ ions cm^{-2}. Is shown in the figure below. Five prominent IL bands with peaks at 580 nm, 590 nm, 612 nm, 655 nm and 705 nm are recorded. These characteristic emissions are attributed to the luminescence centers activated by Eu^{3+} cations. It is found that IL intensity decreases rapidly in the beginning. Later on, the intensity decreases slowly with further increase of ion fluence. The reduction in the ionoluminescence intensity with increase of ion fluence might be attributed to degradation of Si–O(ν3) and Si–O(2ν3) bonds present in the sample. The red emission with peak at 612 nm is due to characteristic emission of $^5D_0$-$^7F_2$ of the Eu^{3+} cations.



Ionoluminescence (IL) of nanocrystalline $Mg_2SiO_4:Dy^{3+}$ pellet samples bombarded with 100 MeV Si^{+8} ions with fluences in the range (1.124 - 22.480) × 10^{12} ions cm^{-2} revealed two prominent IL bands with peaks at ~480 nm and ~580 nm and a weak band with peak at ~670 nm. The characteristic peaks are attributed to luminescence centers activated by Dy^{+3} ions due to the transitions $^4F_{9/2}$-$^6H_{15/2}$, $^6H_{13/2}$ and $^6H_{11/2}$. It is found that IL intensity initially decreases rapidly and then continuous to decrease slowly with further increase in ion fluence. The reduction in the Ionoluminescence intensity with increase of ion fluence might be attributed to degradation of Si-O (2ν3) bonds present in the sample and/or due to lattice disorder produced by dense electronic excitation under heavy ion irradiation.

Ionoluminescence of kyanite single crystals during 100 MeV Si^{8+} ion irradiation has been studied in the fluence range 1.87–7.50$\times 10^{11}$ ions cm^{-2}. A sharp IL peaks observed at 689 and 706 nm were attributed to luminescence centers activated by Fe^{2+} and Fe^{3+} ions. It is observed that the IL peak intensity increases with increase of Si^{8+} ion fluence. The stability of the chemical species were studied before and after ion bombardment of the sample by means of FT-IR spectroscopy and the results are presented.

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