

Etch-pit morphology of tracks caused by swift heavy ions in natural dark mica

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Ion tracks in solids can be visualized by appropriate etching. During the etching procedure, size and depth of the etch pits grow linearly with time. Their shape is mainly controlled by the crystal structure. For example, in muscovite, ion tracks have a rhombic cross-section after HF etching, whereas in polycarbonate etch pits are circular after NaOH etching.

Natural phlogopite (dark mica) may contain fission tracks and alpha-recoil tracks (ART) as latent radiation damage. HF can be used to make them visible by optical, scanning electron and scanning force microscopy (SEM, SFM). ART, generated by collisions of the recoil nuclei with the lattice atoms, provide etch pits, which are triangular at the surface, whereas the fission tracks, created via electronic energy loss (dE/dx), have hexagonal etch pits.

After ion irradiation of phlogopite in the electronic dE/dx regime, the etch pits are triangular below 5.7 keV/nm and hexagonal above 8.8 keV/nm in shape. To examine more precisely the shape transition and its relation to the radiation damage, phlogopite from the Kerguelen Islands (French territory, Indian Ocean) was first annealed (500 °C, 3.5 h) and subsequently irradiated at GSI with ^{58}Ni (kinetic energy ~ 81 MeV), dE/dx amounting to 10.4 keV/nm (according to SRIM 2000). Using polyethylene terephthalate (PET) foils of seven different thicknesses as a degrader, dE/dx in the sample could be reduced stepwise to 2.4 keV/nm. The irradiated samples were etched with 4% HF at room temperature and afterwards imaged with SEM and SFM. It was observed that the triangles relate to the octahedral sites (represented by OH, O, Fe, Mg and other ions) and the hexagons to the SiO_4 -tetrahedral positions in the tetrahedral sheet. We interpret our findings as evidence that the dE/dx -dependent etch-pit morphologies are controlled by the lattice structure.