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Pb^+ irradiation of synthetic zircon ($ZrSiO_4$): Infrared spectroscopic investigation

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Abstract

The structural variations of synthetic zircon ($ZrSiO_4$) single crystals irradiated at room temperature by 280 keV Pb^+ ions (with fluences up to 1×10^{15} ions/cm^2) were investigated using infrared (IR) spectroscopy. Like metamict zircon whose crystal structure is damaged and amorphized by naturally occurring α-decay events, the Pb^+-irradiated zircon crystals show a dramatic decrease in reflectivity. However, no significant decrease in wavenumbers of the stretching vibrations of SiO_4 tetrahedra in zircon was detected. The Pb^+-implanted zircon exhibits new IR bands, indicating irradiation-induced new vibrations or domains, clusters or phases in addition to SiO_2 and ZrO_2. IR features consistent with those of Pb silicates (with a divalent state, i.e., Pb^{2+}) are also found in the irradiated sample. This finding implies that some of the radiogenic Pb in natural zircon might not actually reside in the zircon lattice or in $ZrSiO_4$ phases, but form new local domains or clusters. Infrared bands of OH-stretching vibrations were also detected in the irradiated synthetic zircon, which was originally free from OH features prior to the irradiation. These results indicate that H can easily diffuse into the irradiated layer or into irradiated-induced phases to form OH or and hydrous species after the irradiated material is damaged. The type and content of hydrous species vary with irradiation fluences.

Keywords: Infrared spectrum, zircon, irradiation, lead silicate, Pb, amorphization, OH species