First Results of in-situ Raman measurements of ion-irradiated calcite*

Sebastian Dedera1#, Ulrich A. Glasmacher1, Michael Burchard1, Markus Bender2, Daniel Severin2, Christina Trautmann2,3

1Institute of Earth Sciences, University of Heidelberg, 2GSI Darmstadt, 3Technische Universität Darmstadt

Raman spectroscopy, as a tool to determine specific modifications of minerals exposed to accelerated ions or natural radioactive decay, is widely used in geoscience and materials research. As described in the same scientific report [1], an online and in-situ Raman system was attached to the spectroscopy chamber of the M3-beamline at the UNILAC.

To test the performance of the Raman systems and display beam-induced changes, calcite (CaCO3) crystals from Chihuahua, Mexico were chosen for the first experiments, because calcite and its fluence-dependent changes in Raman spectra are known from earlier off-line experiments [2,3].

The irradiation of a calcite crystal was performed with 4.8 MeV/u Au ions (2 Hz, pulse length 1.2 ms). After calibration, alignment and focusing of the Raman system, the calcite crystal was exposed to the ion beam in steps from 1×10^9 ions/cm^2 up to a fluence of 1×10^12 ions/cm^2. After each irradiation step, Raman spectra were recorded with 20 s acquisition time with 3 repetitions.

The Raman spectra of irradiated calcite show four major changes (Fig. 1). With increasing fluence, the bands at 156 and 284 cm^-1 decrease in intensity, but they are still visible at 1×10^12 ions/cm^2. Above 2×10^10 ions/cm^2, a new band appears at 437 cm^-1. Its intensity grows with increasing fluence and reaches a maximum at 5×10^11 ions/cm^2. Worth mentioning is also that the width of the band at 1087 cm^-1 gets broader with increasing fluence starting at 5×10^11 ions/cm^2.

In conclusion, the first results of the new online Raman system at the M3 beamline are very promising. The system operates well and the results for calcite are in quality and quantity agreeable with results known from off-line measurements [2,3]. The setup provides a powerful tool to monitor structural changes of a given material before, during, and after the irradiation with swift heavy ions. A more detailed analysis of the obtained data is in progress.


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Sebastian.Dedera@geow.uni-heidelberg.de

Figure 1: Raman spectra of calcite recorded during irradiation with 4.8 MeV/u Au ions at the new online Raman system of the M3-beamline.