Validation of the Diamond Detectors for the Super Fragment Separator beam diagnostics

M. Alfonsi[1], C. Nociforo[1], M. Kiš[1], M. Träger[1], J. Galvis Tarquino[1], T. Blatz[1], C. Karagiannis[1],

[1] GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

The Super Fragment Separator [1, 2] at the FAIR accelerator complex adopts Chemical Vapor Deposition diamond detectors as radiation-hard, high particle rate counters. Their role is to monitor and optimize the beam transmission for beams with ions rates up to 10^7 ions/spill, and to calibrate the other beam diagnostics devices that are in duty at higher beam intensities. The target vacuum chamber [3] hosts a 7×7 mm^2 single crystal diamond and a 25×25 mm^2 polycrystalline diamond: they are required to detect crossing particles with a high efficiency ($> 98\%$) in the case of heavy ion species (Ar to U), and for several years in an environment in which they can potentially accumulate, due to the proximity of the target, a dose of few MGy per year.

Laboratory measurements and beam test campaigns were arranged in the past years for the validation of the proposed sensors, in particular for the case of the polycrystalline technology [4, 5]. Here we report the outcome of the irradiation of a sensor based on a 20×20 mm^2 polycrystalline diamond produced by Element Six, with high intensity 1 GeV/nucleon Pb and U beams at GSI (Darmstadt). The detector signal shape characteristics and the ion counting efficiency have been monitored by interleaving periods of low ions rates, to evaluate possible damages or performance degradation during and after a total bombardment of about 10^{12} heavy ions. In the same campaign, the ion counting efficiency of other smaller samples based on different production methods were measured: we report here also the findings for a 5×5 mm^2 heteroepitaxial diamond grown on iridium, provided by the University of Augsburg, which might represent an alternative to the polycrystalline diamonds.

References

[1] H. Geissel *et al.*, "The Super-FRS project at GSI", Nucl. Inst. and Meth. B **204** (2003) 71, https://doi.org/10.1016/S0168-583X(02)01893-1

[2] M. Winkler *et al.*, "The status of the Super-FRS in-flight facility at FAIR", Nucl. Inst. and Meth. B **266** (2008) 4183, https://doi.org/10.1016/j.nimb.2008.05.073

[3] L. Orona *et al.*, "Super-FRS Target Area Remote Handling: Scenario and Development", International Journal of Advanced Robotic Systems **10** (2013) 386, https://doi.org/10.5772/57073

[4] S. Schlemme *et al.*, "Long-term exposure of a polycrystalline diamond detector irradiated by 62 MeV/nucleon carbon beams", Diamond and Related Materials **99** (2019) 107536 https://doi.org/10.1016/j.diamond.2019.107536

[5] F. Schirru *et al.*, "Evaluation of the counting efficiency of a pcCVD diamond detector irradiated by 62MeV/nucl. carbon beams", JINST **15** (2020) C04040 https://doi.org/10.1088/1748-0221/15/04/C04040