

Latent track radius of PTFE irradiated with high energy ion beam

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Polytetrafluoroethylene (PTFE) shows an outstanding combination of chemical and physical properties such as excellent chemical and electric resistance, thermal stability, and low friction coefficient, therefore it is a very useful material for hi-tech applications. However due to its high chemical stability, it is not possible to determine the ion track radius in PTFE irradiated foils by the standard technique of chemical etching. Hence the aim of this work is to estimate the latent ion track radius in PTFE from different ion beams studying the induced chemical modifications.

PTFE films (50 μm thick, Enflo Canada Ltd.) were irradiated with C, Xe, U and Au ions up to energies of 1.5 GeV and fluences of 1×10^{13} ions/cm² at the accelerator UNILAC at the GSI in Darmstadt, Germany. The irradiations were performed at cryo ($T = 23\text{K}$) and room temperature. The sample analysis was performed during and after the irradiation period. The in-situ setup allowed infrared spectroscopy (FTIR) and residual gas analysis (RGA). After irradiation the samples were investigated by FTIR, UV absorption spectroscopy and X-Ray diffraction (XRD).

Mass spectra recorded during room temperature ion irradiation show outgassing of several fragments, with CF and CF₃ being the most dominant species. During the cryo-irradiation almost no fragment was observed. Small fragments were frozen in the sample and outgassed above 150 K after sample heating. The FTIR analysis shows a decrease in the absorption intensity of the bands assigned to the CF₂ bonds, evidencing scission of the main polymer chain. The CF₂ degradation is accompanied by the formation of the CF₃ terminal and side group. In addition, we observed double bond formation and cross linked structures, see figure. The internal double bond formation is an indication of C–F bond scission. Normally, this scission is unlikely due to the higher stability of the C–F bonds, but the observed increase in the intensity of the respective absorption peaks reveals that this process plays a significant role in the degradation induced by swift heavy ions. The UV spectroscopy and XRD analysis show a decrease in the light absorption at wavelengths about 400 nm that may be related with the observed decrease in the material crystallinity.

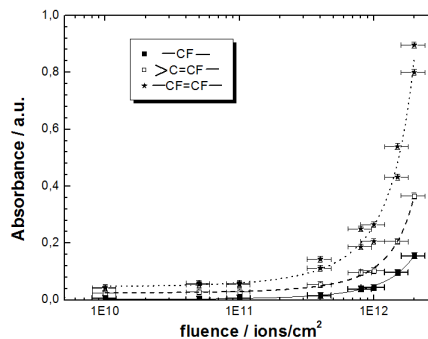


Figure: Increase in the intensity of IR absorption peaks from PTFE spectra when irradiated with 1.3 GeV U ions at room temperature.

Fitting an exponential curve to the IR absorption intensity data as a function of the ion beam fluence and assuming a cylindrical track structure results in an average value of $5,7 \pm 1,0$ nm for the PTFE track radius. The good data agreement with the exponential fit leads us to the conclusion that the double bonds and the cross-linked structures probably follow a one-hit process of ion track creation.