Contribution of electronic excitation and nuclear mechanisms in ion induced hardening of LiF crystals

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A study of radiation damage in LiF crystals under irradiation with MeV energy ions, from ^{12}C to ^{132}Xe, at 300K temperatures , depending on the ion energy, energy loss is presented. For light ions (^{12}C, ^{14}N) at low fluences, it is mainly color centers that are created. Increasing the fluence leads to the overlapping of tracks and the formation of more complex color centers, defect aggregates and dislocations. For ions with an energy loss above a threshold value (dE/dx = 10 keV/nm) the tracks exhibit a core damage region, surrounded by a halo which mainly contains single color centers. In this case, ion-induced nanostructuring is observed.

Formation of dislocations is acknowledged by an increase of hardness of LiF crystals. The depth profiles of indentation hardness have been studied. The results show a joint contribution of electronic excitation and nuclear (impact) mechanisms in ion-induced hardening. The damage via electronic excitations is responsible for hardening in the major part of the ion range whereas the impact mechanism plays a dominant role in a narrow zone at the end of the ion range where nuclear energy loss displays a maximum. The relative contribution of impact mechanism becomes important at low energies of ions (52 MeV, Fig.1) and high fluence irradiations (10^{13}-10^{14} ion/cm^2). The variation of hardness along the ion trajectory is consistent with changes of the dislocation structure, revealed by chemical etching.

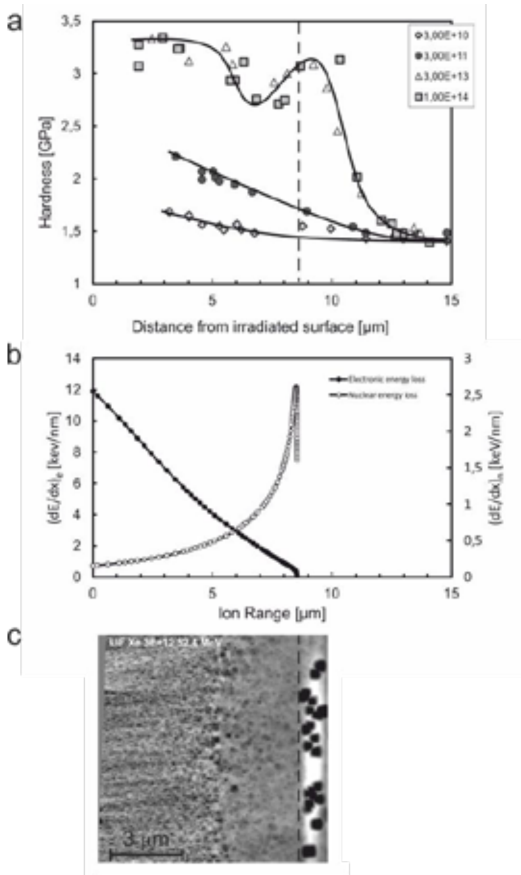

Figure 1. (a) Depth profile of hardness of LiF irradiated with 52 MeV Xe ions at different fluences; (b) Energy loss of 52 MeV Xe ions in LiF, (c) Structure of LiF irradiated with 3x10^{12} Xe/cm^2. AFM image from cleaved cross-section (profile) . Size 5x5 μm.