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Ion beam modification of dielectric materials in the electronic excitation regime: Cumulative and exciton models



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ABSTRACT

Main experimental evidences and theoretical models, currently used to describe the modification of dielectric materials by swift-heavy ion (SHI) beams, operating in the electronic stopping regime, are reviewed. The emphasis is on the interplay and synergy between point defects and amorphous tracks. This implies a change of focus from purely thermal approaches to those based on the generation and accumulation of irradiation-induced defects followed by some type of lattice collapse and structural change. To that end special attention has been paid to experiments performed at electronic stopping powers around the threshold value for track formation. In particular, approaches based on the non-radiative decay of self-trapped excitons (STEs) have been more extensively discussed. The discussion is illustrated by dealing in some detail a few specific materials such as alkali halides (NaCl), SiO₂ and LiNbO₃ where STEs are, or very likely, ascertained. The review stresses the connection between the SHI-induced effects and those caused by femtosecond laser pulse irradiations. Moreover, electronic effects on SiO₂ materials are discussed due to their technological relevance and because they offer an example of the interplay between thermal and excitonic effects. Finally, the potential of SHI irradiation for various technologies, with particular emphasis on photonics, is discussed.

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1. General introduction

Light ions (mostly H and He) with energies in the MeV range are now a standard tool for the analysis and characterization of materials, components and devices [1,2], including objects of archaeological or artistic relevance [3,4], as well as biological [5], and environmental [6] samples. On the other hand, ion bombardment, together with ion implantation, offers a universal procedure

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