Progress in Materials Science 76 (2016) 1–58

Contents lists available at ScienceDirect

Progress in Materials Science

journal homepage: www.elsevier.com/locate/pmatsci

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

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ARTICLE INFO

Article history:
Received 31 December 2014
Received in revised form 28 May 2015
Accepted 26 June 2015
Available online 8 September 2015

Keywords:
Ion beams
Electronic excitation processes
Materials modification
Irradiation damage
Ion tracks
Excitonic models

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), SiO_2 and $LiNbO_3$ 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 SiO_2 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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http://dx.doi.org/10.1016/j.pmatsci.2015.06.002
0079-6425/

Contents

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