PROTON BRAGG-CURVE IMAGING BY RADIOPHOTOLUMINESCENCE OF LITHIUM FLUORIDE THIN FILM RADIATION SENSORS

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Passive solid state radiation detectors based on the visible radiophotoluminescence of colour centres in lithium fluoride thin films grown on silicon substrates are investigated for imaging of full proton Bragg curves by fluorescence microscopy.
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1. Introduction

Solid state detectors based on radiophotoluminescence (RPL) in insulating materials (glasses, crystals, films) can be generally used in radiation imaging and dosimetry.
Passive radiation detectors based on RPL should feature high spatial resolution, long-term stability against fading and non-destructive reading capability. Lithium fluoride (LiF) is of particular interest due to the excellent thermal and optical stabilities of radiation-induced colour centres (CCs).
Novel radiation sensors utilising the visible RPL of such atomic-scale aggregate point defects are being utilised for advanced diagnostics of proton beams [1]. Recently, excellent results were obtained for imaging and full reconstruction of entire Bragg curves in LiF crystals [2] at proton energies up to 27 MeV in a wide range of doses by fluorescence microscopy. Here we investigate the opportunity to extend this approach to LiF thin film radiation sensors.

2. Experimental

Optically transparent LiF thin films thermally evaporated on glass and Si(100) substrates were used for advanced diagnostics of proton beams of energies from 1.4 [3] up to 27 MeV produced by the linear accelerator TOP-IMPLART (Oncological Therapy with Protons - Intensity Modulated Proton Linear Accelerator for RadioTherapy), under development at ENEA C.R. Frascati for protontherapy. Proton irradiation induces the local formation of CCs, such as the F_3^+ and F_2 defects, which are optically active in the green-red spectral range under blue-light pumping [1]. After high-dose irradiating a LiF film grown on Si(100) substrate with the cut edge perpendicular to the proton beam, the latent two-dimensional (2-D) fluorescence image of the CC distribution generated in the polycrystalline layer was detected in a fluorescence microscope, as shown in Fig.1.

3. Results

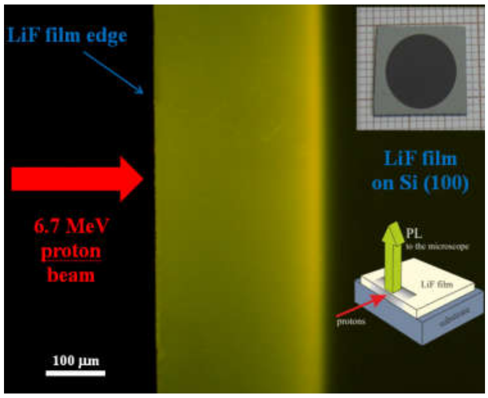

Fig. 1 Visible RPL image of the top surface of a 0.8 µm thick LiF film grown on a Si(100) substrate and irradiated by a 6.7 MeV proton beam after cleavage, acquired at a fluorescence microscope.

A simple defect formation model that takes into account the energy released in the material together with the saturation of CC concentration at high doses in crystals [1] has been applied to reconstruct the depth profile of the energy released by protons along their path in LiF films from 2-D fluorescence images. The results are presented and discussed with the aim of highlighting some quantitative aspects of the RPL behaviour of CCs hosted in a polycrystalline LiF matrix [4] grown on a reflective substrate [3], which can be relevant for proton-beam imaging and dosimetry.

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