ENHANCED PHOTOLUMINESCENCE OF RADIATION-INDUCED COLOUR CENTRES IN LiF FILM DETECTORS

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Enhancement of the visible photoluminescence of colour centres induced by soft X-rays in LiF film imaging detectors was studied to investigate the effects of reflective substrates.
Keywords: film imaging detectors, photoluminescence.

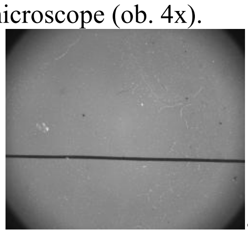
1. Introduction

Stable colour centres (CCs), such as F_2 and F_3^+ aggregate electronic defects (two electrons bound to two and three close anion vacancies, respectively), can be induced in lithium fluoride (LiF) crystals and thin films by irradiation with ionising radiations. The F_2 and F_3^+ defects possess almost overlapping absorption bands, located at about 450 nm and under optical pumping in this spectral region they emit broad photoluminescence (PL) bands peaked at 678 nm and at 541 nm, respectively. Their peculiar spectral features have been proposed and studied for photonic devices [1], X-ray imaging detectors [2], proton beam sensors and dosimeters [3,4]. Polycrystalline LiF thin films assure great versatility as radiation sensors because they can be grown by thermal evaporation, in controlled experimental conditions, on different substrates, tailoring the appropriate geometry, size and thickness. Vertical multilayer structures used as substrates for LiF film detectors can be used to increase the collection efficiency of the PL signal emitted by CCs during the reading process [5] and, consequently, the sensitivity of these detectors. In this work we present the optical characterization of CCs induced in LiF thin films grown on different substrates (glass, Si, Al on glass, Al on Si) by using soft X-rays emitted by a laser plasma source. Substrate-enhanced PL intensity was observed and investigated.

2. Experimental and results

At the Micro- and Nano-structures Laboratory, ENEA C.R. Frascati, polycrystalline LiF films, about 1 μm thick, were grown by thermal evaporation on different substrates: glass, Si(100), Al films (200 nm thick) grown on glass and on Si(100) substrates. The LiF films were irradiated at Tor Vergata University with a soft X-ray laser plasma source [6] based on a Nd:YAG/Glass laser system (pulse duration = 15 ns, wavelength = 1064 nm) focused on a copper target in a vacuum chamber.

The reading method of LiF imaging detectors is based on the detection of the PL emitted by radiation-induced CCs. Figure 1 reports the PL images of two LiF films of the same thickness grown on glass coated with an Al film (a) and glass (b) substrates irradiated in the same conditions (X-ray fluence = 12 μJ/cm^2) and detected by a wide-field fluorescence microscope (ob. 4x).


a)


b)

Fig. 1 PL images (4.2×3.5 mm^2) acquired by a wide-field fluorescence microscope of two LiF films of the same thickness grown on glass coated with an Al film (a) and glass (b) substrates irradiated in the same conditions.

The fluorescence images show that PL intensity of irradiated LiF film deposited on an Al coated substrate is much higher than that of LiF film on glass substrate. The darker lines in the images are the shadows of a human hair placed in direct contact with LiF films during the X-ray irradiations as reference absorption contrast objects. The effects of the reflective substrate properties on the enhancement of the visible photoluminescence of the radiation-induced F_2 and F_3^+ was investigated by optical spectroscopy, conventional and confocal fluorescence microscopy.

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