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TecHea Photonics for Health TOPIMPLART

Enhanced colour-centre photoluminescence in LiF films for proton beam detectors

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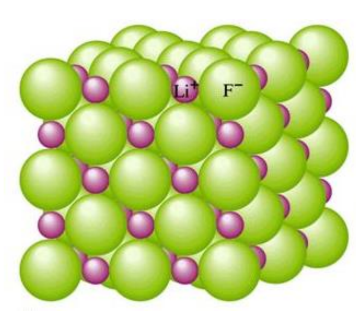
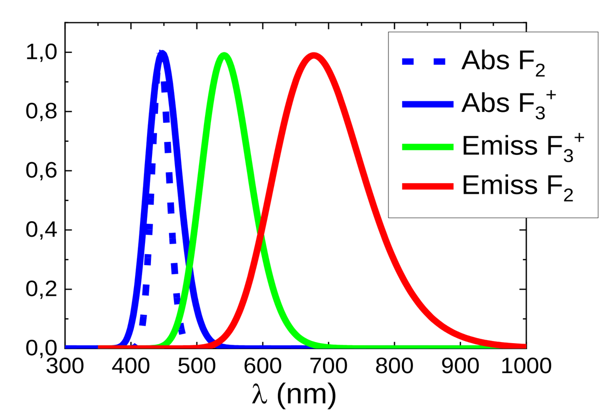
Luminescence properties of radiation-induced colour centres in lithium fluoride (LiF) have been deeply investigated in the last two decades for their successful use in radiation imaging sensors and, more recently, as detectors and dosimeters, even at low dose values. The material sensitivity to ionizing radiations (X-rays, γ-rays, electrons, protons, neutrons, etc.), combined with the high efficiency of visible photoluminescence emitted by F_2 and F_3^+ colour centres, allows indeed for the optical readout of these LiF-based detectors, which also offer high intrinsic spatial resolution, wide dynamic range and large field of view. Their use for advanced diagnostics of proton beams, produced by the TOP-IMPLART linear accelerator for oncological radiotherapy under development at ENEA Frascati Research Centre, is under test at different proton energies [1, 2].

Photoluminescence of colour centres created by ionizing radiation

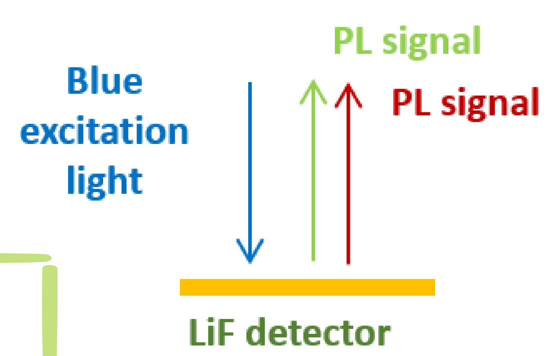
- F_2 (two anion vacancies with two bound electrons) and F_3^+ (three anion vacancies with two bound electrons) centres created by radiation



- Photoluminescence from F_2 and F_3^+, excited with blue light, is emitted with broad spectrum consisting of two bands: 670 nm band related to F_2 centres and 525 nm band related to F_3^+ centres



Visible photoluminescence (PL) for optical readout of LiF detectors



Growth & Characterization of LiF thin films

Growth by thermal evaporation @ Photonics Micro and Nanostructures Laboratory of ENEA C.R. Frascati [3].

Controlled deposition conditions

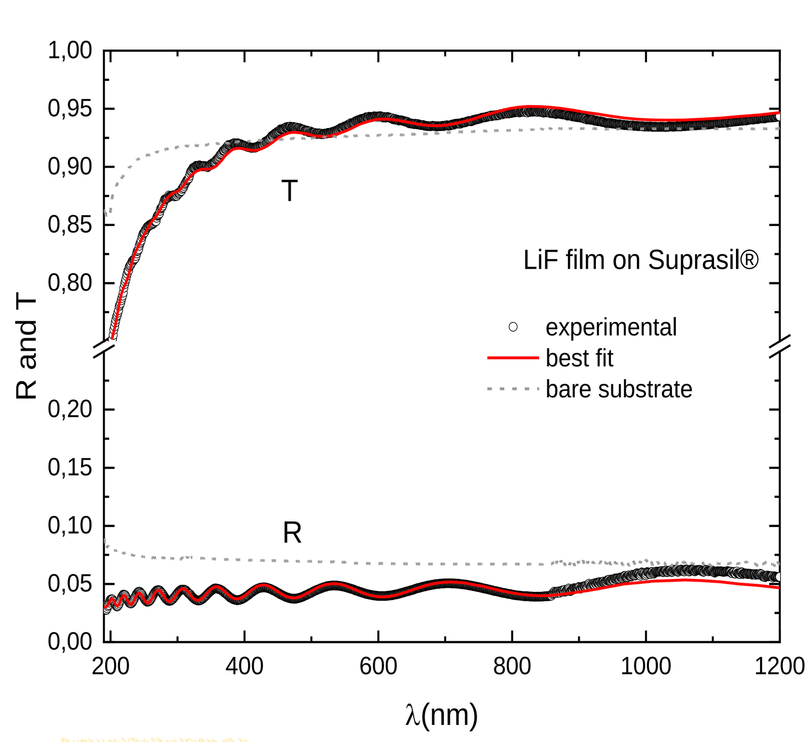
- Pressure P<10^{-3} Pa
- Rotating Substrate-holder: 22 rpm
- Nominal thickness: t_{nom}= 300 nm, 600 nm, 900 nm
- Substrate temperature: T_s=300°C
- Nature of substrate: Suprasil®, glass, Si(100)

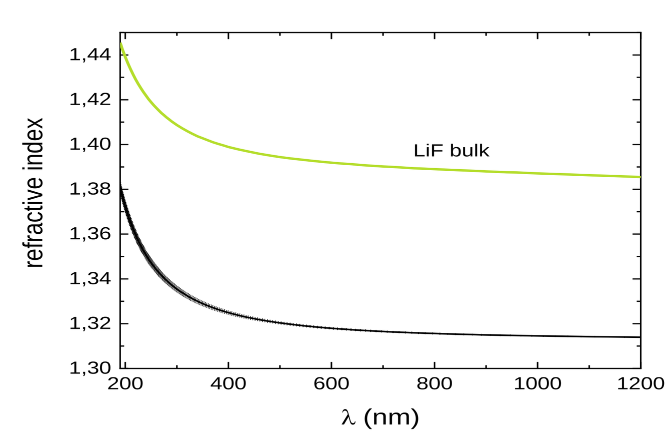
Characterization of optical and morphological properties

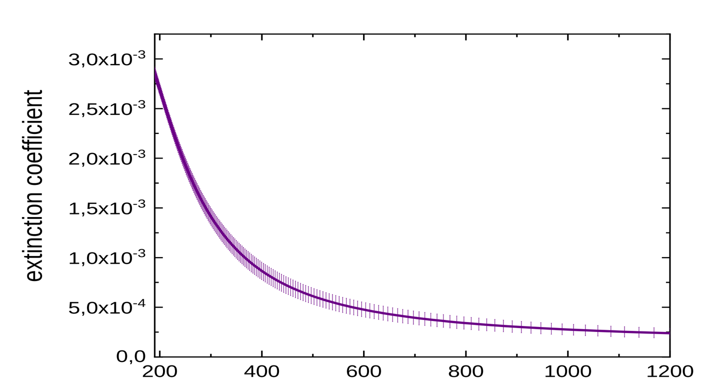
- UV-Vis-NIR spectrophotometry
- Atomic Force Microscopy (AFM)
- Optical Microscopy in Fluorescence Mode

Optical and morphological properties of LiF films

UV-Vis-NIR spectrophotometry

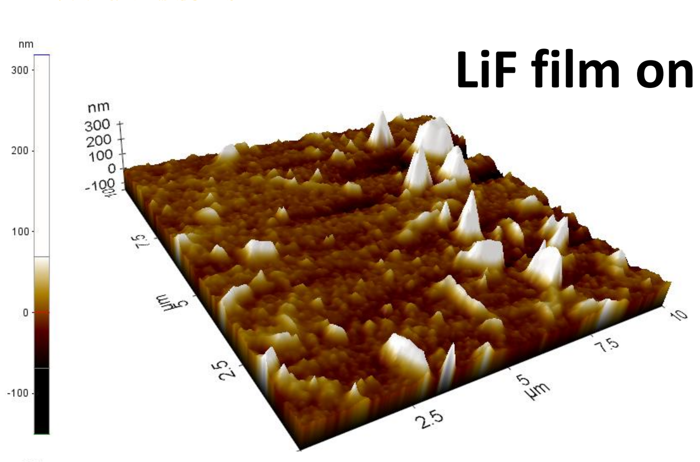




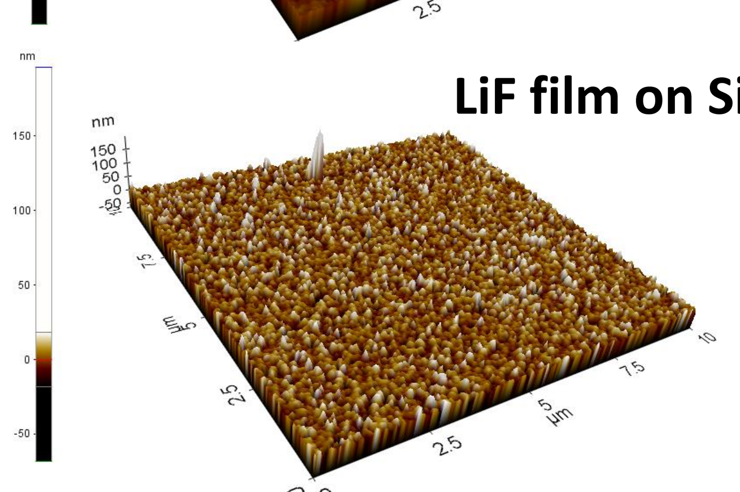


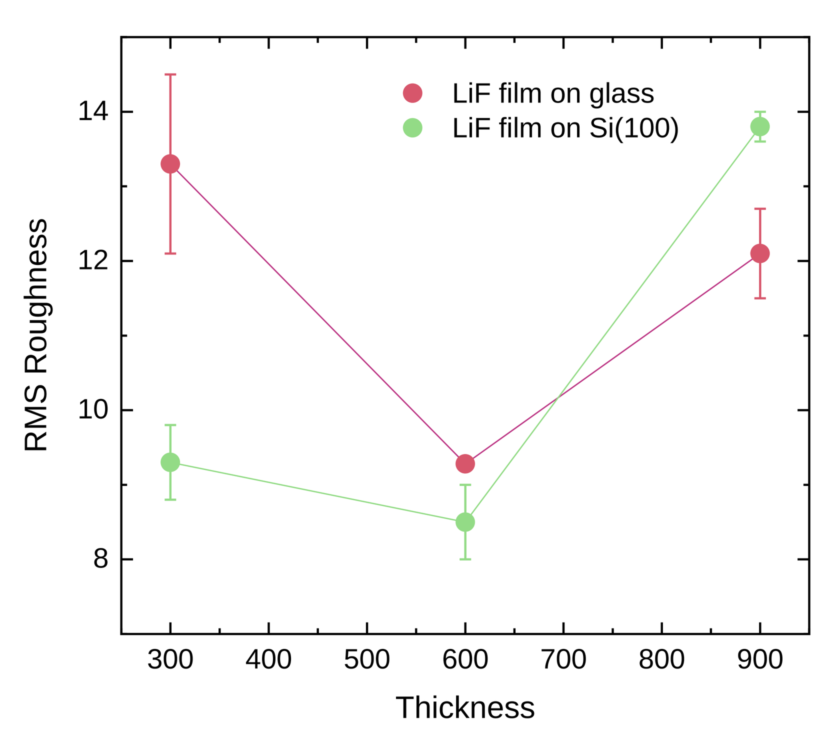
AFM

LiF film on Glass



LiF film on Si(100)



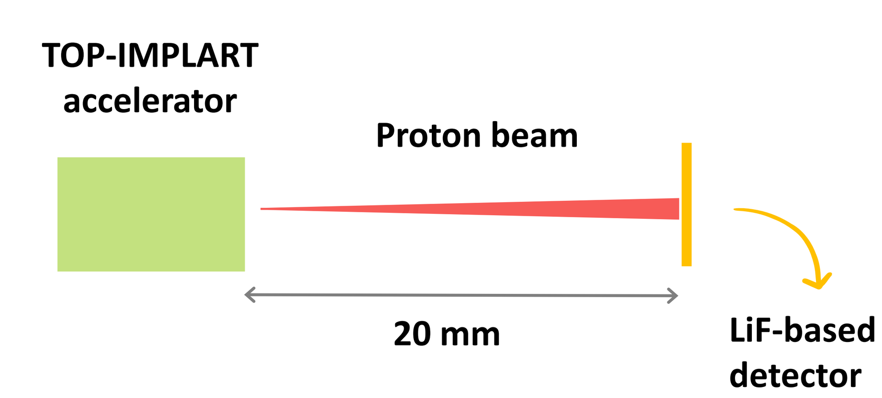


PL response of LiF films

Proton Irradiation @ TOP-IMPLART

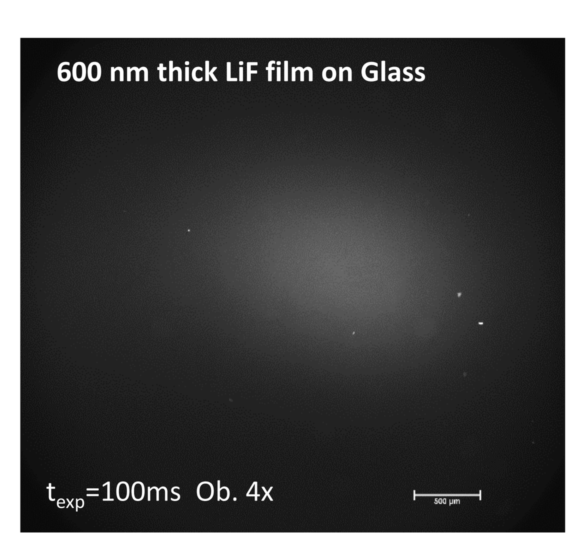
E = 35 MeV

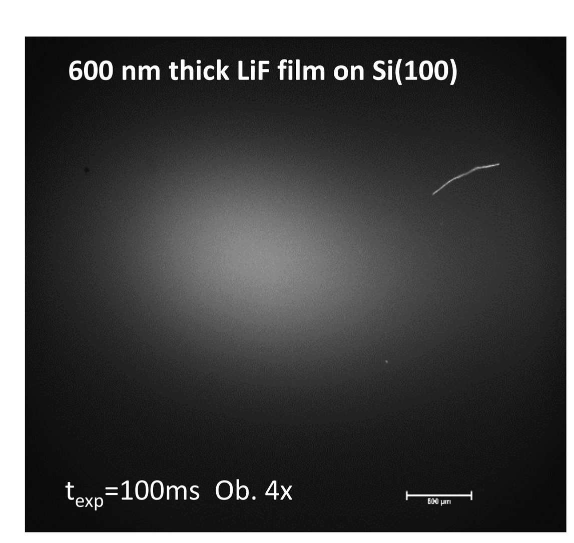
Dose = 10^4 Gy

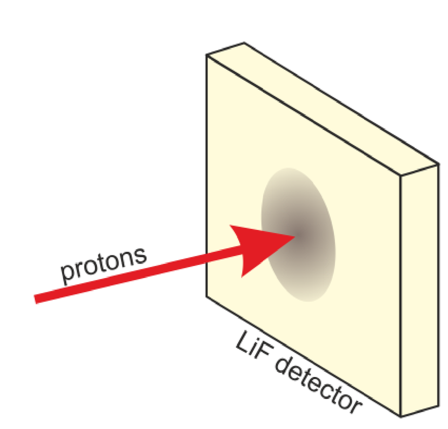


Optical Fluorescence Microscopy

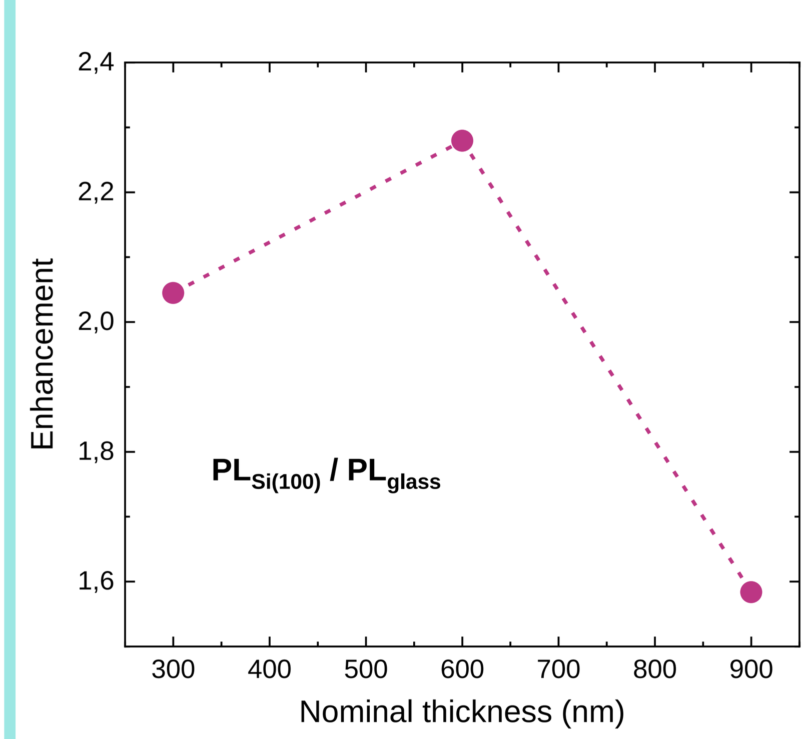
(Nikon Eclipse 80-i, Hg lamp, 4x objective, Andor Neo s-CMOS camera)







Brighter spots for LiF films grown on Si(100) than on glass



$$Enhancement = \frac{PL\ LiF\ on\ Si}{PL\ LiF\ on\ Glass}$$

PL enhancement for LiF thin films grown on Si(100) by a factor 2

[1] M.A. Vincenti et al., Optical Materials 119, 111376 (2021)
[2] M. Piccinini et al., Appl. Phys. Lett. 106, 261108 (2015)
[3] M.A. Vincenti et al., ENEA Technical Report RT/2011/19/ENEA

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