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Improvement of light extraction from scintillators due to the surface modification in microscale using Xe-PFIB

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Positron Emission Tomography (PET) and detectors in High Energy Physics (HEP) both use scintillating crystals and face similar problems when it comes to light extraction. A large fraction of light produced in the crystals is trapped inside the crystal due to total internal reflection caused by their high refraction index. In previous works[1,2] we already showed the light extraction improvement of several LYSO crystals covered with Photonic Crystals structures (PhC) using Gallium Focused Ion Beam (Ga-FIB). However the use of Ga-FIB seems to be particularly problematic for structuration of materials for optical applications since it brings about amorphization of a sample's surface and the implantation of Ga ions to a depth of several dozen nanometers (depending on the acceleration voltage). The Ga implantation causes the metallization of implanted layer inducing surface conductivity and changing the surface reflection as well as introducing chemical Ga-compounds. Xenon Plasma Focused Ion Beam (Xe-PFIB) has many advantages over widely used Ga-FIB e.g. more than 20x higher milling speed, high-precision final cuts, no Ga implantation and others. Therefore we use Xe-PFIB for structuration of crystals without metallization of the surface.
In this work we show the enhancement of LYSO scintillator's surface by micro-structuration using Xe-PFIB which results in the improvement of light extraction. Together with created surface micro-pattern we show the results of spectroscopic measurements as well as the results of computer simulations of light extraction from LYSO crystal within Finite Difference Time Domain (FDTD) method.

References:

[1] Modrzynski P, Gotszalk T, Knapitsch A, Kunicki P, Lecoq P, Moczala M, et al. Light Extraction from Scintillating Crystals Enhanced by Photonic Crystal Structures Patterned by Focused Ion Beam. IEEE Trans Nucl Sci 2016;63:644–8. doi:10.1109/TNS.2015.2494368.

[2] Knapitsch A, Auffray E, Barbastathis G, Chevalier C, Hsieh CH, Kim JG, et al. Large Scale Production of Photonic Crystals on Scintillators. IEEE Trans Nucl Sci 2016;63:639–43. doi:10.1109/TNS.2016.2535328.

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