Contribution ID: **93** Type: **Oral presentation**

Consequences of Ca co-doping in YAlO_3:Ce single crystals

Thursday 21 September 2017 12:00 (15 minutes)

Point defects play a relevant role in the scintillation process since they can act as traps for free carriers, created by the interaction of ionizing radiation with the scintillator, slowing down the carriers migration toward the radiative recombination centres. The competition which arises between charge trapping and recombination is ultimately responsible for the degradation of the scintillator performance with a reduction of light yield, the presence of rise time and long scintillation time decays - or even afterglow - and luminescence sensitization.[1] The defect impact on the scintillation process is well established and several strategies have been proposed to reduce the concentration of traps or their relevance upon the scintillation economy.[2] Co-doping with Ca or Mg in cerium doped garnets and silicates has proven itself as a very effective strategy to improve scintillation timing and light yield performances of these matrices. The detected improvements have been related to the partial oxidation of cerium ions to their tetravalent form induced by the presence of the co-dopant. Although Ce^{4+} is not photoluminescent by itself, it can still take part in the scintillation process by temporarily capturing an electron, thus becoming trivalent and able to give rise to the typical Ce^{3+} luminescence.
In this contribution we will discuss the applicability of Ca co-doping in order to improve the scintillation characteristics of $YAlO_3$:Ce (YAP:Ce) single crystal grown by Czochralski method. Four different Ca concentrations (from 0 to 500 ppm) combined with two cerium contents differing by one order of magnitude have been considered.[3] The optical properties of these samples have been studied by means of optical absorption (OA), steady state and sub-nanosecond time resolved photo- (PL) and radio-luminescence (RL). OA data showed a clear increase in absorption in the UV region as a function of Ca content and related to the Ca-induced Ce^{4+} ions presence alongside regular 3+ ones. Steady state PL and RL data evidenced a rather clear reduction in the luminescence intensity related to reabsorption of the emitted light as well as energy transfer phenomena occurring from Ce^{3+} to Ce^{4+} ions. Time resolved RL profiles showed an acceleration of the main Ce^{3+} luminescence decay coupled with a reduction in the contribution of long scintillation tails by increasing the Ca content; in weakly Ce doped samples, the observed scintillation decay improvements are also accompanied by a clear acceleration in the luminescence rise time. TSL results evidenced a reduction in carrier capture probability at defect sites. All these improvement are, however, accompanied by a substantial reduction in scintillation light yield. The obtained data clearly suggest that Ca co-doping is not a useful strategy to improve YAP:Ce crystal scintillation properties, but they also give valuable information on the applicability of this strategy on other matrices and activator ions. Moreover they also provide further insights in the understanding of charge carrier migration and trapping role on the scintillation time response.
This work has been supported by the H2020 project INTELUM (GA no.644260)
[1] Moretti et al. JPhysChemC 118(2014)9670
[2] Nikl et al. AdvOptMater 3(2015)463
[3] Moretti et al. ChemPhysChem 18(2017)493

Primary author: Dr MORETTI, Federico (Institut Lumière Matière UMR55306 Université Claude Bernard Lyon 1-CNRS, France; Department of Materials Science, University of Milano-Bicocca, Italy)

Co-authors: Dr HOVHANNESYAN, Karine (Institute for Physical Research National Achademy of Sciences, Ashtarak, Armenia); Dr DERDZYAN, Marina (Institute for Physical Research National Academy of Sciences, Ashtarak, Armenia); Dr BIZARRI, Gregory (Lawrence Berkeley National Laboratory, Berkeley (CA), USA); Dr BOURRET, Edith (Lawrence Berkeley National Laboratory); Prof. PETROSYAN, Ashot (Institute for Physical Research); Prof. DUJARDIN, Christophe (Institut Lumière Matière, UMR5306 Université Lyon 1-CNRS)

Presenter: Dr MORETTI, Federico (Institut Lumière Matière UMR55306 Université Claude Bernard Lyon 1-CNRS, France; Department of Materials Science, University of Milano-Bicocca, Italy)

Session Classification: Characterization

Track Classification: S12_Characterization 2 (Orals)