1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: Development of Novel Semiconductor Scintillators

1.1. Project goals

1.1.1. To develop one or more semiconductor scintillators displaying a scintillation yield of about 15000 ph/MeV

1.1.2. To study and describe mechanisms of scintillation light production in semiconductor scintillators

1.2. Outline

The term „scintillation" is used to describe a phenomenon of light flash production inside a sample when excited by ionizing radiation. Materials exhibiting scintillations are termed „scintillators". From year to year the area of scintillator applications extends its limits, thus larger volumes of scintillation materials are needed and new requirements emerge. This increasing demand motivates scientific studies and growth technology development. For tens of years special emphasis has been put on insulating crystals, both based on intrinsic emissions (e.g. CWO or BGO) and activated with rare-earth ions (e.g. LSO:Ce, $LaBr_3$:Ce, GAGG:Ce or LuYAG:Pr). No wonder that scintillation mechanisms in insulators are relatively well known and described. On the contrary, very little is known about scintillation light production in semiconductors, even though semiconductor scintillators clearly receive a rapidly growing interest, defining a new promising class of materials in the present-day scintillator market.

The project is based on a close collaboration with Leibniz-Institut für Kristallzüchtung (IKZ) in Berlin, which will be responsible for preparation of bulk single crystals of semiconductor scintillators. One of them is β-Ga_2O_3 (pure and codoped with various elements), which has already been recognized as a very promising material for scintillation detection [1-3]. The scintillation yield of the β-Ga_2O_3 crystals from the newest generation does not exceed the level of 8000 ph/MeV, hence there is still plenty of room for improvement. The other compounds are still under development and cannot be revealed here.

1.3. Work plan

Each series of crystals will be immediately characterized in Toruń: their scintillation properties in response to X-rays (radioluminescence) and gamma radiation (pulse height spectra, scintillation time profiles) will be evaluated, as well as low and high temperature thermoluminescence will be measured to shed light on the distribution of defect levels inside the material. These results will provide a feedback for further growth series. In this way, by choosing optimal growth conditions and crystal components, a scintillation yield value of 15000 ph/MeV is likely to be achieved. This is an enumerable goal of the project, nevertheless some other objectives are also defined, including the investigation of light production mechanisms in semiconductor scintillators, which have not been well recognized so far.

1.4. Literature

[1] M. Makowski et al., *Opt. Mater. Express* **9** (2019) 3738

[2] Z. Galazka et al., *J. Alloys Compd.* **818** (2020) 152842

[3] W. Drozdowski et al., *Opt. Mater.* **105** (2020) 109856

1.5. Required initial knowledge and skills of the PhD candidate

The candidate is expected to have a theoretical background in solid state physics and spectroscopy on academic level, as well as to have sufficient expertise in data analysis. Some programming skills (preferably Python) are welcome. Basic knowledge in electronics is also desired, since the student will carry on measurements using various experimental setups, all of them full of electronic items and devices.

1.6. Expected development of the PhD candidate's knowledge and skills

The student will master several experimental techniques used to study scintillation properties, as well as he/she will learn the fundamentals of scintillator-related physics. He/she will improve his/her skills in programming, data analysis and drawing conclusions from data.