Project name: New dosimetry materials

Travel/Event Report
25.09.2012 - 01.10.2012/28.10.2013

General information

Name of the rapporteur	Name of the rapporteur's organisation
Vitali Nagirnyi	Institute of Physics, University of Tartu
Type of research (nanotechnology/health care/chemistry etc.)	**Name of the research facility**
Physics	SUPERLUMI, DORIS III, DESY
Date of the measurement, duration	**Location of the event**
29.09.2012 - 01.10.2012, 48 hours	DESY, Hamburg
National Industrial Liaison Officer from rapporteur's country participating in the measurement	
Mikhail Danilkin, LUMIFOR	

Description of the project

Research description (short summary as written in the application)
Our company is specialised in developing and producing dosimetry materials for various applications. The important parameters of such materials are high sensitivity, tissue equivalency, low fading, linear dose response, etc. In this respect the borate crystals (lithium tetra- and triborate, $Li_2B_4O_7$ and LiB_3O_5) are promising materials because of their chemical stability and a low minimum detectable dose. The most important property of lithium borates regarding their use in personnel dosimetry is their effective atomic number equivalent to that of human tissue. Cationic and anionic dopants have an important effect on the TL response and properties of lithium tetraborate host and allow materials engineering in a desired way. In our R&D of new and improved dosimetry materials, we use laboratory based methods in collaboration with scientists from University of Tartu. These include optical spectroscopy methods (luminescence and absorption measurements in UV – visible range), thermoluminescence spectroscopy and electron paramagnetic resonance methods for evaluation of charge carrier trap properties (energetic depths, frequency factors) and geometric configuration of luminescence and trapping centres, respectively. However, borates have energy gaps larger than 6 eV, which means that VUV photons are needed in order to investigate both the host properties and the states related to defects and dopants, which are located in the energy gap. Recently, we have identified that Be and Mn ions facilitate hole trapping and energy transfer to recombination centres. The main goal of the project is to investigate energy transfer, recombination and trapping processes in $Li_2B_4O_7$ with various cation and anion dopants using luminescence and reflection spectroscopy. This work is well suited for such a dedicated luminescence setup as SUPERLUMI (Strahl I) at DORIS, HASYLAB at DESY in Hamburg. The expected amount of beam-time is ca 2 days to make spectroscopic investigation of 6 powder/ceramic samples at room and low temperature. We appreciate assistance and consultations in sample preparation, during measurements (if possible, because LUMIFOR has strong background in chemistry, but not in luminescence spectroscopy) and possibly in data analysis. This help can be most conveniently delivered by scientists from Institute of

Physics, University of Tartu, who are experts in such kind of studies (e.g., V. Nagirnyi, E. Feldbach).

Summary of activities (experiments performed, beam-time used, preliminary overview of results, next steps and other relevant information)

Ceramics of $Li_2B_4O_7$:Mn, $Li_2B_4O_7$:Mn,Be, and $Li_2B_4O_7$:Mn,Cu were studied by the means of luminescence spectroscopy under excitation in VUV spectral region. This material has high potential in application for tissue-equivalent dosimetry. The spectral characteristics of Mn^{2+} and Cu^{+} related emissions were compared to those observed in the recombination luminescence (phosphorescence, thermally and optically stimulated luminescence) observed in the ceramics irradiated by ionizing radiation. It was shown that the emission of Mn^{2+} centres dominated in the thermoluminescence spectra of the low-temperature and dosimetric high-temperature glow peaks in the irradiated samples. This allowed to give arguments in favour of hole mobility being responsible for the dosimetric thermoluminescence peak at 490 K in $Li_2B_4O_7$:Mn. The co-doping of $Li_2B_4O_7$:Mn with Cu^{+} was shown to increase the sensitivity of the material to ionizing radiation.

In addition, the electron paramagnetic resonance study of the selected ceramics was performed at the home institution, which gave a valuable information on the structure of the centres participating in luminescent recombinations.

Based on the results obtained, recommendations were given to LUMIFOR on optimization of the impurity content and ceramics treatment in order to increase the performance of the dosimetric material studied.

How would you describe cooperation and assistance from national contact points while preparing and carrying out the research at large scale facilities?

The experiment at the SUPERLUMI station has been well settled since long and all the measurements went very smoothly. The staff was very helpful and we had no any problem with preparing and carrying out the research, neither with accommodation.

Other personal remarks

We are grateful to ScienceLink for giving as an opportunity to perform our studies at a unique luminescence setup SUPERLUMI, one of the best in the world.

Annexes

Annexes
(list of annexes; meeting minutes, graphical illustrations, tables and other supplementary data)