



2023 Master internship at University of Gdańsk



TITLE: Optical characterization of infrared phosphors for fiber communication and bioimaging applications

LAB & PEOPLE

- Name of the hosting lab: Condensed Matter Spectroscopy Division / Institute of Experimental Physics
- General activities of the lab: materials science, solid state spectroscopy
- Website: cmsd.ug.edu.pl
- Number of staff / PhD: 9
- Supervisor name and contact: Sebastian Mahlik, sebastian.mahlik@ug.edu.pl; Tadeusz Leśniewski, tadeusz.lesniewski@ug.edu.pl

TOPIC OF THE INTERNSHIP

- Scientific context of the internship (max 20 lines)

The student will take part in research regarding infrared emitting phosphors (materials converting visible light into infrared). Such phosphors, working on the principle of photoluminescence, absorb photons of higher energy (visible light) and in turn emit photons of infrared light. Infrared emitting phosphors find numerous applications in optical sensing, chemical analysis, bioimaging, machine vision, optical communication, and night-vision surveillance, due to the unique features of infrared light, including invisibility to the naked eye, exceptional penetrating capability, and low biological tissue-related absorption and scattering.

Currently, a great effort is made to find infrared phosphors with desired properties: specified emission spectrum, high quantum efficiency (ratio between number of emitted photons to the number of absorbed photons), good stability of emission under elevated temperature. This can be obtained by choosing the correct chemical composition of the material (so called crystalline host) and activating the material – introducing to the host a small amount of different chemical element. These elements (dopants) form isolated optical centres in the crystal which are responsible for absorbing and emitting infrared light.

Keywords: infrared phosphor, pc-LED, Cr³⁺, Cr⁴⁺, Ni²⁺, spectroscopy, fiber communication, bioimaging

Bibliography :

[1] Mu-Huai Fang, Zhen Bao, Wen-Tse Huang, and Ru-Shi Liu *Evolutionary Generation of*

Tasks and duties entrusted to the student:

During the internship, the student will evaluate (under supervision of staff members of the laboratory) the optical properties of phosphor samples obtained through international collaboration with National Taiwan University (NTU). The student's work will be related to phosphors belonging to one of the following groups:

- phosphors based on yttrium aluminum garnet structure (YAG) activated with chromium ($\text{Cr}^{3+}/\text{Cr}^{4+}$)
- phosphors based on MgGa_2O_4 spinel compound, activated with chromium (Cr^{3+}) and nickel (Ni^{2+})

The samples will be characterized by the following standard spectroscopic methods: emission/excitation/reflectance spectra, and luminescence decay. Whenever needed the student will be encouraged to participate advanced spectroscopic methods, such as time-resolved emission spectroscopy, or high pressure spectroscopy

The student's results will then be used as feedback to the NTU group to improve on the synthesis procedures or chemical composition of next iterations of phosphor samples.

If successful, the student will have a chance to evaluate the performance of secondary structures manufactured in NTU based on the selected phosphor samples, namely crystalline optical fibers based on $\text{YAG}:\text{Cr}^{3+}/\text{Cr}^{4+}$ for optical communication or $\text{MgGa}_2\text{O}_4:\text{Cr}^{3+}/\text{Ni}^{2+}$ spinel nanoparticles embedded in mesoporous silica intended for bioimaging applications.

Skills to be acquired or developed:

- a) practical skills and experience in optical spectroscopy methods: photoluminescence, photoluminescence excitation, and diffuse reflectance spectra, quantum yield measurement
- b) obtaining theoretical background for luminescence processes in the solid state
- c) opportunity to acquire skills in advanced spectroscopic methods: time resolved emission spectroscopy using streak cameras, high pressure spectroscopy in diamond anvil cells
- d) opportunity to acquire skills in structural characterization methods : X-ray powder diffraction, Raman spectroscopy
- e) opportunity to acquire basic skills and experience in cryogenic measurements, vacuum technology, inorganic synthesis

PROFILE OF THE DESIRED STUDENT

- Minimum level of study required: Graduate

- Field(s) of study: Physics, Chemistry, Materials science, Materials engineering, Nanotechnology, or related

- Scientific skills : Some experience with optical measurements or materials characterization. Experience with optical spectroscopy will be advantageous
- Language skills required : fluent English in writing and speaking

THE INTERNSHIP ASSIGNMENT:

Desired duration of the internship (in months): 6

Desired Starting date of the mission: January-December 2024

Indicative weekly schedule: *35h / week*

Remuneration ?

Erasmus grant : could be asked to your own university

Internship agreement: *an internship agreement will be signed.*

To SEA-EU students:

*If you're interested please send your CV and letter of motivation to : **Sebastian Mahlik**, sebastian.mahlik@ug.edu.pl or **Tadeusz Leśniewski**, tadeusz.lesniewski@ug.edu.pl before the date 30/09/2024.*