Ceramic texturing for the next generation of luminescent monolithic materials and functional layers

Summary

Motivated by the recent progress in the nanophotonics, photovoltaic and biophotonics applications and the increasing demand for cost-effective and easy-to-use point-of-care platforms, tailoring the emission in luminescence materials has a great scientific interest. These luminescent materials have been synthesized mostly in powder-form, formed by a matrix (host) doped with activators which can be a transition metal or rare earth (RE) ions that act as emitting centers. For practical applications, luminescent particles are incorporated to form thick or thin films. Therefore, the development of monolithic luminescent glass-ceramics and -ceramics by a single and cost-efficient process supported by robust moisture and thermal stability is highly desirable. Recently, we demonstrate that luminescent properties layers depends on random orientation or/and by epitaxial growth. In this context, one of the breakthroughs in this project is the understanding of luminescence in monolithic layers on several surfaces by modulation their crystalline orientation.

Research field:	Mechanical engineering
Supervisors:	Prof. Dr. Irina Hussainova Rocio Estefania Rojas Hernandez
Availability:	This position is available.
Offered by:	School of Engineering Department of Mechanical and Industrial Engineering
Application deadline:	Applications are accepted between September 01, 2020 00:00 and October 02, 2020 23:59 (Europe/Zurich)

Description

The doctoral student will be based on the laboratory's of Department of Mechanical and Industrial Engineering site and will integrate in our team.

Project Background

The approaches that will carry out in this project are particularly applicable to the development of luminescent glass-ceramics and ceramics, which belong to an emerging class of photonic materials that compete with "single crystal technology" in a wide range of optical applications. These new glass-ceramics and ceramics offer many advantages, including large-scale shaping and production, and tolerate higher levels of active ion doping than single crystals, which improves optical performance. Mainly, luminescent materials have been synthesized mostly in powder-form, formed by a matrix (host) doped with activators which can be a transition metal or rare earth (RE) ions that act as emitting centers. However, the efficient emission of light is limited due to the strong absorption and the scattering by the particles. This, alongside the drawbacks regarding the thermal stability and aging degradation of the luminescent particles embedded in a polymer matrix, led the attention to the development of luminescent bulk and glass-ceramics and ceramic layers.

Different strategies are proposed to design the luminescent bulk and glass-ceramics layers, including the embedding of luminescent particles in glass matrix or the direct synthesis of the layer by employing a solution or ink directly by sol-gel or/ and screen printing routes or the monolithic bulk by SPS. For all synthesis routes, we are seeking new compositions and structures (at both the unit-cell and microscopic level) to develop materials with superior properties, opting for aluminates and aluminosilicate matrices.

Objective

The objective of the project is to expand the range of known luminescent glass-ceramic and ceramics by two main strategies: a. dispersion of phosphors particles within the bulk glassy matrix and b. direct synthesis of the luminescent layers. The new materials will be characterized structurally (from the unit cell to the micro scale) and physically, to understand the link between structure and properties, allowing their performance to be optimized.

The thesis work will consist of a first experimental and methodological part that will make it possible to identify new glass and glass-ceramic compositions to tailor the emission in the visible and/or infrared regions. The second part of the work will focus on the structural characterization of the ceramic materials obtained: crystallographic characterization of the structure at the unit-cell level by X-ray diffraction and the use of electron microscopy to study the nature

and morphology of the crystals, grain boundaries, or the presence of residual phases. The study of microstructure/luminescence correlation during the synthesis processes should make it possible to optimize the synthesis parameters (e.g. composition, annealing conditions) to obtain high-quality materials and improved properties. The laboratory has a wide range of multi-scale characterization techniques that can be used in-situ (HTXRD, SEM, ...) and numerous spectroscopic methods (UV-VIS, Luminescence characterization, Raman) to determine the structural characteristics of the synthesized glass- ceramics, as well as mechanical characterization. We have collaborations with HR-TEM, Coupling confocal Raman and AFM facilities, allowing us to carry out highly detailed structural characterizations. Finally, the functional ceramics obtained will be optically characterized within the framework of collaborations.
This thesis will allow the candidate to acquire expertise in the field of luminescent materials, for the synthesis of new crystalline materials with emerging optical properties. Depending on the candidate's profile, he or she may prefer an emphasis on innovative synthesis methods, structure- and luminescent characterization. The project benefits from established national and international collaborations for specific physical property measurements, advanced structure, and time-resolved luminescence spectroscopy methods.

Responsibilities and tasks:
PhD student has a responsibility to communicate their research, to collaborate with others members of the team. Doctoral student has a responsibility to behave honestly and ethically in the course of their research. The research student is expected to adopt a professional approach, including good timekeeping, observing deadlines, reading and responding to communications from the supervisory team and other members of the University and taking responsibility for their own skills and career development.
The main duties of doctoral students are to devote themselves to their research studies. The work task include the development of inorganic luminescent materials (synthesis, characterisation and modification). Interpreting research specifications and developing a work plan that satisfies requirements. Conducting desktop research, and using books, journal articles, newspaper sources, questionnaires, surveys, polls, and interviews to gather data. Analyzing and interpreting experimental results.

Qualifications
The applicants should fulfill the following requirements:

- Applicants should have a degree in a relevant subject (e.g. Chemistry, Physics, Materials Science), completed Masters research project in solid-state science, and demonstrate a desire to learn more about the field.
- Cross-disciplinary applications are welcome.
- Strong experience in nanofabrication via chemical routes is desirable.
- Preference will be given to candidates that evidence:
  - Background in manufacturing processes from laboratory to pilot scale,
  - Background in properties correlation with materials nano and microstructure;
  - Strong capacity to work in a team and individually.
- Experience in either non-linear effects or programming is a plus, but not required.

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