Stimulus-responsive luminescent ceramics

Summary

The proposed topic focuses on bridging the gap in current stimulus-responsive luminescence mechanism by utilizing the thermo-mechano-opto effect of ceramics. Given the abundant transitions and the stress-responsive ability of ferro and piezoelectric ceramics, multi-activator-doped ferro/piezoelectric materials are promising candidates for multifunctional detection based on luminescence characteristics. The project aims at fabricating translucent and /or transparent ceramics and tandem designs combined with ferroelectric and luminescent materials. The multidimensional scheme will use the intensity, wavelength and bi-temporal multiplexing.

Research field:	Production and materials engineering, robotics, transport and logistics
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 January 01, 2025 00:00 and January 24, 2025 23:59 (Europe/Zurich)

Description

The research

The project focuses on bridging the gap in current **stimulus-responsive luminescence** mechanism by utilizing the **thermo-mechano-opto effect of ceramics**. The technology proposed host a rich set of attractive features such as high strain sensing, encoded logic function, direct visualization and good adaptivity to the local structure, from which we hope it will enable new opportunities for designing next generation of opto-electronic devices. One of the latest trends in next generation **nano and micro-opto-electronics technology** is to develop **multidimensional stimulus** sensing, actuators and storage devices. Nevertheless, the exploitation of all-in-one materials with multimode and multicolor luminescence capacities is still immature. Given the abundant transitions and the stress-responsive ability of ferro and piezoelectric ceramics, **multi-activator-doped ferro/piezoelectric** materials are promising candidates for **multifunctional detection based on luminescence characteristics**.

One of the strategies is to incorporate photo-stimulated luminescence particles in glasses. However, the incident light is partially scattered and absorbed by color centers, resulting in the weakening of light intensity when passing through a material and thus decreasing the optical transmittance. So, there is an urge to develop a bulk translucent/transparent medium. From the view of practical applications, the development of high-performance transparent ferroelectric ceramics still faces significant challenges related to their synthesis. For that reason, the aim is to consolidate the ferroelectric ceramic that can couple luminescence features to provide multifunctional response by the integration of bi-temporal, tunable (emission and excitation wavelength).

Different approaches to control the luminescence characteristics are going to be applied by a pressing issue in materials engineering for the use of non-toxic and non-critical materials, which is essential for the development of environmentally sustainable technologies.

The goal of this PhD project is to develop new synthesis approaches that allows consolidate the expected ceramics. Specifically, the project should carry out synthesis, consolidation and sintering by using reactive and non-reactive sintering; exploring the polymorphs stabilization to increase the transparency of the determining the encoding features through lifetime experiments and temperature-dependent steady-state luminescence.

Responsibilities and (foreseen) tasks

- Manufacturing translucent/ transparent bulk ceramics and fabrication of multi-stacking systems, i.e. synthesis, consolidation and sintering of undoped and doped systems;
- Optimization of process parameters;
- Exploring the interface process and understanding the transparency features and couple luminescence mechanism in the tandem structures;
- Characterization of the produced materials (structural, microstructural and optical properties);

- Assessment of the potential methodological and technical risks, provide timely dissemination and secure exploitation of results, provide public engagement and outreach;
- Contribute to the organization of research and practitioner workshops where project findings are presented

Applicants should fulfil the following requirements:

- a master's degree in Materials Sciences or Chemistry (preferably in ceramics; materials chemistry; and powder metallurgy)
- experience in materials microstructural (optical microscopy, SEM, XRD etc) and optical characterization
- a clear interest in the topic of the position
- excellent command of English
- strong and demonstrable writing and analytical skills
- capacity to work both as an independent researcher and as part of an international team
- capacity and willingness to provide assistance in organizational tasks relevant to the project

The following experience is beneficial:

- Experimental and/or theoretical knowledge in luminescent materials and processes
- Experience/ knowledge of the storage capacity of the optical medium
- Experience with optical and scanning electron microscopy
- Previous experience with information storage devices, optical data storage technology.

The candidate should submit a research plan for the topic, including the overall research and data collection strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

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About the department

The department of Mechanical and Industrial engineering focuses on the engineering side of self-driving vehicles, developing new material systems and coatings and additive manufacturing developments. The curriculums on Bachelor, Masters and Doctor level have hundreds of graduates each year.

The Materials Engineering Research Centre in our department brings together leading scientists and PhD students to form a vibrant and collaborative environment for research into materials engineering. The centre has expertise in materials (particularly powder materials, thin and thick coatings, materials characterization), materials technologies (powder metallurgy, surface engineering, joining technology etc.) and related industrial applications.

We also provide engineering services for industry and our partners, starting with modelling and finishing with production optimization. TalTech houses state-of-the-art powder metallurgy and additive manufacturing laboratories, plus laser, optical, metrology and chemical labs and equipment – the ideal environment for world-class materials development.

Additional information

For further information, please contact Dr. Rocio Rojas (rocio.rojas@taltech.ee) and/or Prof. Irina Hussainova (Irina.hussainova@taltech.ee) or visit https://taltech.ee/en/department-mechanical-and-industrial-engineering

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