

# High-entropy ceramic based composites

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## Summary

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*The proposed PhD project focuses on developing new ceramic-ceramic and ceramic-metal composites where ceramic phase utilizes high-entropy phenomenon. The work assumes both theoretical (phase modelling, etc.), as well as practical (synthesis of materials, characterisation, wear testing, etc.) tasks. The project addresses the following research questions: What are the most promising chemical combinations and what are the basis for selection of high-entropy ceramics with metals, oxides/nitrides and covalent carbides that can be effectively utilised in ceramic composites? How to improve the understanding of the microstructure evolution, phase formation and composition of high-entropy ceramic based composites. The PhD project will be carried out in collaboration with The Fraunhofer Institute for Ceramic Technologies and Systems IKTS (Germany).*

Research field:	Production and materials engineering, robotics, transport and logistics
Supervisors:	Dr. Marek Tarraste Dr. Lutz-Michael Berger
Availability:	This position is available.
Offered by:	School of Engineering Department of Mechanical and Industrial Engineering
Application deadline:	Applications are accepted between October 01, 2022 00:00 and October 23, 2022 23:59 (Europe/Zurich)

## Description

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Ever ongoing technological advancements are enabled by materials research and engineering. New material systems with enhanced properties (stronger, tougher, lighter, more wear resistant, etc.) capable of performing at even higher temperatures and extreme conditions are constantly needed. The advent of high-entropy alloys in 2004 opened the possibilities to expand the high-entropy design also to other materials such as ceramics (oxides, carbides, nitrides, borides etc.). Employing new high-entropy based phases in ceramic composites can yield improved properties and increase serviceability. In addition, this opens the door for a wider range of chemical compositions and can help to reduce the dependency on a few key chemical elements.

The goal of this PhD project is to identify advantageous high-entropy phases to be employed in ceramic composites and develop suitable material synthesis methods. Throughout his/her studies, the PhD candidate will employ various powder metallurgical technologies and characterisation methods. Additionally, the PhD candidate must co-author at least three scientific papers on the topic of the doctoral thesis, whereas two of which must be published in Q1 and/or Q2 (SCImago) journals. The PhD student is also expected to spend at least one semester at a research centre outside Estonia (through Erasmus+ or another program) during his/her study. Apart from that, the PhD student should be ready to supervise bachelor and/or master student(s), as well as to take part in other teaching activities.

### Supervisors

Main supervisor: Dr. Marek Tarraste (TalTech)

Co-supervisor: Dr.-Ing. Lutz-Michael Berger (Fraunhofer Institute for Ceramic Technologies and Systems)

### Applicants should fulfil the following requirements:

- MSc. or an analogous degree in mechanical or chemical engineering
- Adequate understanding of how microstructure features like grain size, etc., and phase composition of a material affect its properties
- Is competent in phase diagrams, and can describe the microstructure formation on their base
- 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:

- Previous experience working with ceramic materials and/or powder metallurgy
- Experience with optical and scanning electron microscopy
- Experience with x-ray diffraction analysis
- Knowledge of ThermoCalc® or any other thermodynamic software

**We offer:**

- Excellent opportunities for performing high quality research during 4-year PhD position
- An informal and inclusive international working environment, green campus approach, a flexible schedule and modern office facilities located in Tallinn.
- Individual development and training opportunities.
- Opportunities for conference visits, research stays and networking with universities and research centres

**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 characterisation), materials technologies (powder metallurgy, surface engineering, joining technology etc.) and related industrial applications.

**Additional information**

For further information, please contact Marek Tarraste [marek.tarraste@taltech.ee](mailto:marek.tarraste@taltech.ee) or visit <https://taltech.ee/en/department-mechanical-and-industrial-engineering>



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