Hector Fellow Academy

Doctoral Position on Solid-State Elastocaloric Cooling

Job description:

In Germany, refrigeration comprises 20% of total electricity consumption. Cooling on a small scale, such as that needed for electronic chips, lab-on-chip systems, typically relies on miniaturization-compatible thermoelectric cooling, which, unfortunately, tend to be inefficient. Conversely, cooling on a larger scale, such as for air conditioning and refrigeration, is commonly achieved through conventional vapor compression cooling. However, these systems utilize gaseous refrigerants that can easily escape into the environment, contributing to global warming potential.

A promising alternative to traditional cooling methods is elastocaloric cooling, which leverages stress-induced temperature changes, particularly in superelastic shape memory alloys. Unlike conventional methods, elastocaloric cooling poses no environmental risk associated with refrigerant leakage, as it utilizes solid-state materials. Moreover, it boasts high potential efficiency, with material efficiency approaching the thermodynamic maximum limit. Recognizing its potential, the U.S. Department of Energy and subsequently the EU Commission have identified elastocaloric cooling as the most promising non-vapor-compression technology for future cooling applications.

This PhD position will develop a next-generation high-performance elastocaloric cooling device using microfluidics-based shape memory alloys. Our goal is to upscale the cooling capacity of the device, transitioning from microwatts (mW) to several hundred watts (100 W), while simultaneously enhancing temperature lift to unlock new avenues for sustainable cooling application. This interdisciplinary work is at the interface of materials science, engineering and microtechnology. The project holds particular relevance for various applications, encompassing battery thermal management in electric vehicles, the cooling of critical electronic components, as well as ensuring the safe transport of perishable goods.

The PhD thesis includes the following tasks:

- Characterization of superelastic shape memory alloys (mechanical, thermal, fatigue life)
- Modelling, design and simulation (FEM multiphysics, lumped element modelling)
- Rapid prototyping (optical lithography, 3D printing, laser technology)
- Development, characterization and control of cooling demonstrator variants
- Simulation-based design optimization

In executing this position, the host institute is equipped with an expansive array of state-of-the-art facilities, including a 600 m² clean room, advanced rapid prototyping capabilities like lithography, 3D printing and laser cutting, construction and connection technology labs, as well as various metrology laboratories. A high level of support is provided to ensure that the project progresses seamlessly within the specified timeline. The position is within the ZEco Thermal Lab of Dr. Jingyuan Xu.

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This PhD position is funded by the Hector Fellow Academy (HFA). As a recipient of this funding, the PhD student will have the invaluable opportunity to engage in various enriching activities within the HFA, including participation in the yearly symposium, in the networking and training events, and in an annual management module of the Hector School. For more information, please see: https://hector-fellow-academy.de/en/young-scientist-support/.

Personal qualification

- MSc in the mechanical engineering field or a related field
- In-depth knowledge of mechanical engineering, thermodynamics, heat transfer, microsystems technology
- Experience in CAD, Lumped element modelling and/or FEM simulation and/or MATLAB programming, thermal characterization, mechanical testing
- High proficiency in spoken and written English
- Excellent degree at master's level (HFA criteria: ≤ 1.7 MSc final grade)

Keywords

Elastocaloric cooling; Shape memory alloys; Solid-state cooling; Cooling and Heating; Energy

Contract duration

Four years of funding (3+1, three years with the possibility to extend for one year

Location

Institute of Microstructure Technology/ Karlsruhe Institute of Technology/ Karlsruhe

Starting date

July 2024 or later

Technical contact person

For further information, please contact Dr. Jingyuan Xu, email: jingyuan.xu@kit.edu.

How to apply

Please apply via the HFA application portal.

Application Deadline

March 31, 2024

Enquiries

For questions related to the application process, please contact the Hector Fellow Academy Office: application@hector-fellow-academy.de or check the HFA website https://hector-fellow-academy.de/en/

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