# Open Position for PhD Candidate (m / f / d):
# Analytical electron microscopy of beam sensitive materials

There is an opening for a PhD candidate researcher position in the new research group **MNM** (microscopy of nanoscale structures & mechanisms) guided by Dr. Yolita Eggeler, which is part of the central laboratory for electron microscopy (**LEM**) at KIT.

**MNM** uses high-resolution analytical scanning and transmission electron microscopy (SEM and TEM) to identify new material structures. We explore elementary processes which govern microstructural evolution during material processing. We are interested in the evolution of nano- and microstructures in functional (magnetic materials) and structural materials (high temperature materials, high entropy alloys). We work on the new materials, which are engineered on the atomic and nano scale (e.g. by 3D nanoprinting) in the Cluster of Excellence 3D Matter Made to Order (3DMM2O). MNM is in close contact with other material researchers at KIT and with material scientists from universities and research institutions in Germany and abroad.

**As of November 2020, we are looking for a PhD candidate (m / f / d)** who fits well into our team. The research aims at establishing new techniques to characterize the nanostructure of SURMOFs beam sensitive materials.

## Project Description / Scope

Advanced SEM and TEM techniques (high-resolution analytics and *in situ* experiments) are the central experimental characterization techniques. Metal-organic frameworks (MOFs) consist of metal ions or clusters (nodes) connected by organic ligands (linkers). They represent a subclass of molecular materials that self-assemble to ordered three dimensional (3D) crystalline structures, with superlattices consisting of large unit cells that incorporate a high density of pores [1]. This highly porous MOF structure makes them versatile and their properties can be exploited in many applications. Thus they can be used as permeable systems for gas separation processes, to name but one example [2]. However, for the processing of gas permeable thin-film membranes, the classical MOF synthesis routes (painting or doctor blading) are prejudicial, because they promote the formation of pin-holes in the thin film [3].

To overcome this issue, surface anchored MOFs referred to as SURMOFs have been developed [3]. SURMOF synthesis is based on a liquid phase epitaxial (LPE) layer-by-layer (LBL) deposition procedure. Sample thicknesses can be precisely set and the process can be well controlled on the molecular scale [3,4]. The parameters which govern SURMOF synthesis are well understood and their potential macroscopic properties are well appreciated [4–6]. In contrast, little is known about their nanostructure and there is a need to explore crystalline homogeneity within individual nanodomains (nanograins), the nature of internal interfaces which separate nanodomains (nanograin boundaries) and the types of structural defects (1 and 2 dimensional defects like dislocations and planar faults) within crystalline domains. Most importantly there is a need to explore, how these defects, which represent key elements of the SURMOF nanostructure, affect functional SURMOF properties.

An atomistic understanding of nanostructures (down to the sub-nm scale) is essential when aiming at designing new SURMOF materials with novel properties. In principle, high-resolution transmission electron microscopy (HRTEM) and advanced scanning transmission electron microscopy (ASTEM) have the power to provide this information [7]. However, the application of electron microscopy to explore SURMOFs is not straightforward, because these materials are electron beam sensitive. High energy electrons can destroy bonds and damage the structure, a phenomenon known as knock-on damage [8]. Therefore, it is necessary to experimentally tailor SURMOF electron microscopy (EM) analysis towards optimizing electron dose, which allows retrieving the required information by keeping the risk of knock-on damage at a minimum.

The project combines and draws on different areas of expertise, including materials processing (synthesis by the dipping method), assessment of different layer thicknesses and chemical distribution, and in particular advanced SEM and TEM techniques (including high resolution TEM, high resolution TEM spectroscopy and in situ TEM). The topic is not only scientifically interesting but also technologically important.

The research will be carried out in close collaboration with KIT's Institute of Functional Interfaces (IFG) and is embedded in the Cluster of Excellence 3DMM2O, a joint research project by KIT and Heidelberg University. In addition to the scientific day-to-day running of the project, the position allows to present results at international conferences, and close interactions with the 3DMM2O scientists. It also involves participating in the HEiKA Graduate School on Functional Materials as well as training and supervising students and guest scientists.

## Requirements

We are looking for highly motivated graduates with a **master degree in the fields, physics, materials science, chemistry, mechanical engineering, or related fields.** (Please make sure that the master degree is equivalent to a German master degree). We are looking for someone with a **background in transmission electron microscopy (TEM**), which can be in form of a dedicated class or/and hands on experience. For data evaluation we are also seeking for someone with experiences in applied **coding** (Python / Matlab, etc.**)**.

The candidate should have **very good English and/or German communication and scientific writing skills**. We seek for someone with a **keen interest in advanced materials topics** and interest in being an active member of the new MNM team. The position offers the opportunity to gain advanced hands on experience in powerful characterization techniques, and, at the same time, to widen one's outlook and acquire technological expertise in an important area. It allows to work independently with advanced students and to contribute to the formation of a new dynamic and interdisciplinary research group.

## Funding

A scientific staff position (f/m/d) with a remuneration of **0.65 E13** is offered to candidates who aim for a doctoral degree (German PhD degree). Funding is secured **for 3 years** and can be extended if required. The position also allows taking part in advanced training courses offered by KIT for young scientists (f/m/d).

We strive to fill the jobs with female and male employees as evenly as possible and would be particularly happy to receive applications from young female researchers. With appropriate suitability, severely disabled people are given priority.

## Application Procedure

Please hand in your **application using the HEiKA Graduate School application portal (https://functionalmaterials.applicationportal.org/home.html)** by **October 30, 2020.** Your application should include a cover letter explaining motivation, curriculum vitae, diplomas, pdf copy of your master's thesis (preliminary versions welcome) and other relevant documents, if applicable (please use "Other documents" for the upload). Please contact Dr. Yolita Eggeler (E-Mail: yolita.eggeler@kit.edu), if you have questions about the project, the possibilities of your development or the type of work and the MNM in general.

More information is available on the homepage: www.lem.kit.edu.


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7. Schröder, R. R. Advances in electron microscopy: A qualitative view of instrumentation development for macromolecular imaging and tomography. *Arch. Biochem. Biophys.* **581**, 25–38 (2015).
8. Zhang, D. *et al.* Atomic-resolution transmission electron microscopy of electron beam–sensitive crystalline materials. *Science (80-. ).* **359**, 675–679 (2018).