FLAIR Colloquium

# Thursday, 12. December 2024, 16:00
# Room R4/23, Building L6|01

**Zoom-Link**

## Thermo-Iono-Electronic (TIE) Materials: Unified View of Ceramic Gas-Transporting Membranes and Thermoelectric Materials and Recent Performance improvements through Texturing

**Prof. Dr. Armin Feldhoff**

**Institute of Physical Chemistry and Electrochemistry,**
**Leibniz University Hannover**

### Abstract

In addition to ionic and/or electric charge carriers, it is proposed to consider entropy as further basic quantity being transported through a thermo-ionic-electronic (TIE) material. Conversion of energy is easily understood as the loading of energy from entropy current (thermal energy) to ionic current or electronic current (both electrochemical energy). Analogies between the Soret coefficient, the Seebeck coefficient and the ionic transfer number become evident. The latter plays an important role in the context of the mixed ionic-electronic conductor (MIEC), which can be considered as TIE under isothermal conditions. If the TIE is simultaneously placed in gradients of temperature and electrochemical potential (ionic and/or electronic), currents of entropy, ionic charge carriers, and electronic charge carriers are observed (i.e. Soret diffusion or thermoelectrics). In the basic transport equation, the TIE material appears as tensor, which is a major advantage over the concept of the so-called thermodynamics of irreversible processes. The role of energy and its conversion is easily understood by the flux of entropy, ionic charge carriers, and electronic charge carriers at their respective local potentials, which are the temperature, the ionic electrochemical potential, and the electronic electrochemical potential.

An overview of the activities of our group in the context of the subsets of TIE materials, MIEC for oxygen-transporting membranes (OTMs) and thermoelectric (TE) materials is given with some emphasize on the utilization of anisotropic transport properties in layered oxide systems (e.g. $La_2NiO_{4+\delta}$ and $Ca_3Co_4O_{9-\delta}$) in (nano)structured bulk ceramics with texture. Together with our cooperation partners, we have applied a variety of techniques for ceramic texturing, including electrospinning of nanofibers and nanoribbons, spark plasma sintering (SPS), spark plasma texturing (SPT), magnetic grain alignment, and crystal facet engineering via reverse microemulsion synthesis. Substantial performance improvements were realized.

### Speaker

Prof. Armin Feldhoff is head of the Electron Microscopy Laboratory at the Institute of Physical Chemistry and Electrochemistry of the Leibniz University Hannover and holds the venia legendi for Physical Chemistry. His research interests are in thermo-iono-electric (TIE) materials for energy conversion and chemical separation. His activities link materials synthesis with the microstructure, as obtained by scanning and transmission electron microscopy as well as x-ray diffraction, and functionality. Aim is always a knowledge-based approach to bring new functionality into materials and devices.