# TUT 1: Tutorial: Thermoelectricity - The Quest for a High Figure of Merit (TT)

The search for and the investigation of novel materials with excellent thermoelectric properties, i.e., a high "figure of merit", has been a hot topic recently, in particular, in view of numerous technological applications. For example, a greater efficiency would generate brand new possibilities in the field of power engineering, by using directly the waste heat in combustion engines while lowering $CO_2$ emissions at the same time, or in energy self-sufficient sensors. In this Tutorial, after an introduction into the basic theoretical concepts, measurements at the nanoscale will be discussed, as well as applications in power generators.

Organizers: Ulrich Eckern (Uni Augsburg), Claudia Felser (MPI CPfS Dresden)

Time: Sunday 16:00–18:25 Location: HSZ 304

**Tutorial** TUT 1.1 Sun 16:00 HSZ 304

**Thermoelectric Effects: Basic Aspects, Boltzmann Theory, Onsager Relations** — •Arthur Ernst — Max-Planck-Institut für Mikrostrukturphysik, Halle — Wilhelm-Ostwald-Institut für Physikalische und Theoretische Chemie, Universität Leipzig

Thermoelectric phenomena which involve the conversion between thermal and electrical energy and provide a method of heating and cooling materials are expected to play an important role in meeting the energy challenge of the future. In my talk I shall present basic aspects of the microscopic theory for thermoelectricity. First, I discuss the basic definition of the thermoelectric heat. Then I present a short overview of non-equilibrium thermodynamics and the microscopic theory of the electronic transport. Further I review several approaches to describe thermoelectric properties, present the state of the art in the understanding the thermoelectric phenomena, and conclude my talk with some remarks on future prospects of the field.

**5 min. break**

**Tutorial** TUT 1.2 Sun 16:50 HSZ 304

**Thermal Transport Measurements at the Nanoscale** — •Saskia F. Fischer — AG Neue Materialien, Humboldt-Universität zu Berlin, 10099 Berlin

In this tutorial first an introduction to measurements of the electrical conductivity, the thermopower and the thermal conductance will be given. All three material parameters are required to determine the thermoelectric figure of merit. However, the measurement techniques which are successfully applied to bulk materials often cannot be transferred to nanoscale materials such as individual ultra-thin films, flakes or nanowires. On behalf of particular examples, I will discuss measurement techniques for such nanomaterials. In particular, the application of a micro-machined platform for the full ZT-characterization allowing as well for the investigation of the crystal structure and chemical composition of a single nanowire will be demonstrated. If time allows, an outlook to thermal transport in low-dimensional charge carrier systems and the determination of the charge carrier temperature via noise thermometry will be given.

**5 min. break**

**Tutorial** TUT 1.3 Sun 17:40 HSZ 304

**High Temperature Thermoelectric Power Generators: Materials and Devices** — •Anke Weidenkaff[1,2] and Wenjie Xie[2] — [1]Empa, 8600 Dübendorf, Switzerland — [2]Institut für Materialwissenschaft, Universität Stuttgart, 70174 Stuttgart, Germany

With a thermoelectric converter heat can be directly converted into electricity. A broad application of thermoelectric converters in future energy technologies requires the development of thermoelectric active, stable, low cost and sustainable materials. Suitable candidates are being selected among novel materials according to their temperature dependent $ZT$ (thermoelectric figure of merit) values, and their compatibility factors to produce well performing thermoelectric converters, delivering a high power output. Theses converters are tested under ambient air at temperatures of $T > 900$ °C and applied in an exhaust gas stream of a custom made hybrid vehicle, concentrated solar thermal converters, metal casting furnaces and solid oxide fuel cells. The lectures will provide an overview on the development of novel perovskite-type and Heusler materials gaining importance for future energy technologies