DS 35: Thermoelectric Thin Films and Nanostructures II

Time: Thursday 15:15–17:00 Location: GER 38

Topical Talk DS 35.1 Thu 15:15 GER 38

Nanotechnological thin film concepts for new thermoelectric materials — •Harald Böttner — Fraunhofer Institut Physikalische Messtechnik Heidenhofstr.8 79108 Freiburg

Thermoelectric converters are multitalented: they cool or generate electricity and do so silently, without maintenance and in particular with extreme reliability. But: all thermoelectric applications depend mainly on the material quality, in the field of thermoelectric defined by the well known Z (thermoelectric figure of merit). It is the main goal for the material development to enhance Z for ZT (T = absolute temperature) values above the critical number of 1. For modern concepts, to achieve e.g. ZT values to up 2, the internal structure of thermoelectric semiconductors is based on different nanoconcepts. Here we will give an overview over different concepts and technological procedures as well as the typical materials involved. We will focus on thin films nanoconcepts which, particularly, deal with the approach to reduce the thermal conductivity keeping high electrical conductivity, mainly as superlattices. The survey will cover the preparation via PVD methods like thermal evaporation MBE, sputter-techniques and chemical routes for structural self organizing thermoelectric material. The impact of those nanoscale layers stacks on the performance on thermoelectric devices will be discussed and compared to bulk like thin film devices.

Topical Talk DS 35.2 Thu 15:45 GER 38

Nanostructured layered thermoelectric oxides — •Anke Weidenkaff[1], Myriam Aguirre[1], Petr Tomes[1], Stefan Ebbinghaus[2], and Rosa Robert[1] — [1]Empa — [2]Uni Halle

Heat from e.g. solar insolation could be used to provide electricity if the direct thermoelectric energy conversion, i.e. the transformation of heat into electricity becomes fast and highly efficient. For the realisation of an innovative ceramic thermoelectric converter, stable p- and n- type thermoelectric oxides are developed to be tested in Thermoelectric Oxide Modules (TOM). A very promising approach to reduce the thermal conductivity, which is leading to very high theoretical values of ZT, is to increase the amount of grain boundaries by producing nano-scaled semiconductor thermoelectric materials. Suitable candidates are perovskite-type materials. Tailor-made materials with various compositions are chosen and synthesized by chimie douce methods. The power factor is improved by appropriate variations of the composition and the crystallographic structure.

DS 35.3 Thu 16:15 GER 38

Complete thermoelectric characterization of thin films — •Jan D. König — Fraunhofer IPM; Heidenhofstr. 8; 79110 Freiburg; Germany

An enhancement of the thermoelectric performance is needed for a wider use of thermoelectricity. The developments of nanostructured materials such as thin film superlattices have shown a considerable increase of the thermoelectric figure of merit. Such developments are based on the measured values of the physical transport properties and naturally on the accuracy of the measurement itself! So it is necessary to have a closer look on the commonly used thermoelectric measuring techniques and on new cross-plane thermopower and electrical conductivity measuring techniques for thin films. Some comments on standard thermopower and electrical conductivity measurements in the in-plane directions are given. The advantage and disadvantage of the 3Omega methode and the TDTR-methode will be investigated. The Völklein methode will be discussed exemplary as a bridge method to determine the in-plane thermal conductivity. The most challenging problems are the measurement of the cross-plane electrical conductivity and thermopower. The complexity of such measurements are illustrated at some principle approaches. These considerations will give a better understanding of the complexity of thermoelectric measurement techniques for thin films and should be a guideline for an accurate measurement of the thermoelectric properties for material development and verification of the theoretical nanoconcepts for an enhancement of the thermoelectric performance.

DS 35.4 Thu 16:30 GER 38

Thermoelectric properties of $FeSb_2$ thin films — •Peijie Sun[1], Niels Oeschler[1], Ye Sun[2], Simon Johnsen[2], Bo B. Iversen[2], and Frank Stelich[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Department of Chemistry, University of Aarhus, Denmark

$FeSb_2$ is a strongly correlated, narrow-gap semiconductor showing the largest thermoelectric power factor ($> 2000\ \mu W/K^2cm$) so far known at low temperatures [1]. The enhanced thermoelectricity is believed to result from a large electronic contribution from the narrow and correlated bands. However, the large thermal conductivity (> 300 W/Km in single crystals) prevents the realization of a high dimensionless figure of merit ZT for practical electronic cooling application in the cryogenic temperature range. The thermal conductivity might be largely reduced by introducing nanometer-scale internal structures to selectively scatter propagating phonons. In this work, we successfully deposited thin films of $FeSb_2$ by sputtering techniques on various substrates. Thermoelectric properties of the thin films will be presented in comparison to those of the bulk system.

[1] A. Bentien et al, Europhys. Lett. 80 (2007) 17008.

DS 35.5 Thu 16:45 GER 38

Investigation of thermoelectric properties of bismuth telluride thin films after controlled heat treatment — •Katrin Rothe[1,2], Matthias Stordeur[3], Frank Heyroth[1], Hartmut S. Leipner[1], and Bernd Engers[2] — [1]Interdisziplinäres Zentrum für Materialwissenschaften der Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]angaris GmbH, Halle, Germany — [3]HTC, Hallesche Str. 50 06122 Halle, Germany

Thermoelectric (TE) devices of bulk materials have been widely used for power generation or cooling systems based on the Seebeck and Peltier effect. For TE modules bismuth telluride compounds at room temperature are already used for instance in aerospace or sensor systems. Here, TE modules are the only alternative to get a power supply of the components. However, for low dimensional applications the development and further investigations of thin thermoelectric films are necessary. Here, we present a method to enhance the thermoelectric properties of thin film by a fast thermal treatment. Thin films of bismuth telluride were prepared by DC magnetron sputter deposition at different substrate temperatures. The enhancement of the power factor ($S^2\sigma$) depends on the temperature of the substrate and on the thermal treatment. The inner structure, the morphology and chemical composition were investigated by XRD, FESEM and EDX.