DS 42: Thermoelectric materials IV: Glass, sintered materials (Focused session – Organizers: Meyer, Heiliger)

Time: Friday 11:30–13:00 Location: H 2032

Topical Talk DS 42.1 Fri 11:30 H 2032

Employing laterally nanostructured ZnO-based thin-films as model systems for studying interface effects in themoelectrics — •Peter J. Klar — I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany

The morphology of the interface between two materials has a major impact on the transport properties across this interface. Interface properties at different length scales ranging from the atomic to the micrometer scale affect phonons and electrons differently. Controlling these effects allows one to tune and optimize the thermoelectric properties of materials. Laterally nanostructured thin-films offer the advantage that the interfaces between its constituents are easily accessible by local probes such as electron microscopy, micro-Raman and micro-photoluminescence spectroscopy as well as local transport measurements, which allows one to correlate the interface structure with global and local transport properties and thus to establish structure-property relationships. In particular, the controlled fabrication of interfaces of different morphology by self-aligned patterning combining lithographic steps, etching steps, and rf-sputtering will be introduced. Examples of the impact of the interface structure on the transport properties and the correlation between their global and local properties will be discussed for various series of laterally nanostructured ZnO thin-films. The results suggest that in many nanostructured thermoelectrics the impact of diffusion, band bending or percolation on thermoelectric properties is more significant than that of density of states changes and confinement anticipated at reduced dimensions.

DS 42.2 Fri 12:00 H 2032

Glass-ceramics as high-temperature thermoelectric materials — •Julian Lingner[1,2], Matthias Jost[1,2], Gerhard Jakob[1], and Martin Letz[2] — [1]Johannes Gutenberg-Universität Mainz — [2]Schott AG Mainz

The research on thermoelectric materials has progressed enormously over the last years and is still growing because of the global demand for eco-sensitive energy conversion. Innovative approaches like bulk-nanostructuring helped to increase the efficiency of the investigated materials. Especially the high temperature segment of thermoelectric materials seems to promise good yields concerning power generation because the efficiency is proportional to the temperature. Therefore it is important to find suitable materials in this regime. SiGe has been known to be a high-temperature thermoeletric but has the limited availability of Ge as a big disadvantage. This presentation focuses on a new material class for high temperatures in thermoelectrics - glass-ceramics. In a glass-ceramic, a certain crystal structure is embedded in a glass-matrix leading to many new properties of the material. Especially the possibility to induce small crystallites, the pore-free surface combined with the high-temperature durability of this material class support this approach. Measurements of different systems of glass-ceramic thermoelectric materials are presented.

DS 42.3 Fri 12:15 H 2032

$Ca_3Co_4O_9$ based ceramics and glass-ceramics as high temperature stable oxide thermoelectrics — •Matthias Jost[1,2], Julian Lingner[1,2], Martin Letz[2], and Gerhard Jakob[1] — [1]Johannes-Gutenberg Universität, Institut für Physik, Staudinger Weg 7, Mainz D-55128 — [2]Schott AG, Hattenbergstraße 10, Mainz D-55122

Oxidic thermoelectric materials are a good alternative to the now more common thermoelectric materials, such as PbTe, SiGe, BiSb or Bi_2Te_3, because of their thermal stability, chemical stability, low toxic level and good availability of the raw materials. In our presentation, we will give a brief review about the determined thermoelectric properties of our $Ca_3Co_4O_9$ ceramics and $Ca_3Co_4O_9$ glass-ceramics. $Ca_3Co_4O_9$ ceramics were first discussed by Ryoji Funahashi in 1999. The ceramics have been processed using conventional sintering. Therefor we mixed $CaCO_3$ and CoO powders. The mixture was ground, calcined, pulverized, and pressed into pellets. These pellets were cold isostatically pressed and after that sintered at different temperatures. The glass was melted in a platin-iridium crucible, casted into a steel mold, quenched and cooled down in an annealing lehr. After that, it was ceramized in an infrared-furnace. The ceramics/glass-ceramics were examined by X-ray diffraction and samples were prepared out of the pellets/glass-ceramic-blocks. Electrical conductivity, thermal resistivity and the Seebeck coefficient of these samples were measured for different temperatures and from these values ZT were calculated.

DS 42.4 Fri 12:30 H 2032

Nanocrystalline Diamond as Thermoelectric Material — •Nicolas Wöhrl[1], Markus Engenhorst[2], Gabi Schierning[2], and Volker Buck[1] — [1]University Duisburg-Essen and CeNIDE, Faculty of Physics, Duisburg, Germany — [2]University Duisburg-Essen and CeNIDE, Faculty of Engineering, Duisburg, Germany

The thermoelectric effect directly converts temperature differences into electric voltage and vice versa. The thermoelectric material has to have a high electrical conductivity because a high internal resistance will reduce the efficiency of the generator and a low thermal conductivity. Thus one promising way to design good thermoelectric materials is to manipulate phonons and electrons at the nanoscale making nanostructuring a possible way to achieve these materials. Introducing defects that scatter phonons but not electrons at the same degree can decrease the thermal conductivity without appreciably affecting the power factor. Another strategy is to scatter phonons at interfaces, leading to the use of nanostructured materials consisting of thin-film superlattices or mixed composite structures. Nanocrystalline diamond films were deposited by microwave-plasma CVD from an Ar/H2/CH4 plasma with admixtures of trialkylborane to obtain p-type semiconducting diamond and results shown here are indicating that nanostructured diamond films are a promising material for thermoelectric applications. Thermal conductivity lower than 10 W/mK and Seebeck coefficients above 50 μV/K were achieved.

DS 42.5 Fri 12:45 H 2032

Laser sintering of nanoparticles - morphologic and thermoelectric aspects — •Benedikt Stoib[1], Tim Langmann[1], Martin S. Brandt[1], Nils Petermann[2], Hartmut Wiggers[2], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 4, 85748 Garching — [2]Institut für Verbrennung und Gasdynamik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg

Bottom-up fabrication of nanoscale thermoelectrics in most cases requires annealing to improve the otherwise insufficient electrical performance. We apply a high-intensity short-pulse laser treatment to spin-coated films of crystalline nanoparticles, grown by plasma decomposition of silane and/or germane in a microwave reactor. The resulting films with sub-micrometer thickness are highly suited as a model system to systematically study the influence of Si/Ge ratio, doping, defects and grain size on the thermoelectrical potential of SiGe-based thin films. The morphology is discussed with special emphasis on porosity and its influence on macroscopic conductivity. The interdiffusion between nanoparticles of different composition during the partial melting is studied by Raman spectroscopy. The thermopower of the films indicates little variation of the Seebeck coefficient with respect to the morphological properties of the thin films.