DS 20: Focus Session: Organic-based Hybrid Thermoelectrics I

Waste heat at moderate temperatures of around 100°C constitutes an energy source of enormous potential for recuperative technologies such as themoelectrics. By their inherently low thermal conductivity, possibility for p- and n-type doping, sustainability as well as low-cost processing, organic semiconductors have entered the focus of interests in recent years. In addition, the strong electron-phonon interaction in this material class results in a wealth of new phenomena ranging from phonon-drag effects to electronic correlations. However, a comprehensive picture of the microscopic mechanisms governing the thermoelectric properties as well as advanced hybrid material concepts are necessary to further enhance their thermoelectric figure-of-merit and, thereby, to pave the way towards first technologically relevant implementations.

This focus session aims for bringing together material scientists, chemists and physicists working in the fields of material synthesis, thin film preparation, doping of organic semiconductors, in-depth thermoelectrical characterizations as well as theoretical modelling. Only the concerted approach by the various disciplines will allow for a successful transformation of academic research into technologically relevant applications. Thus, this focus session will also provide a suited platform for an intense informational exchange as well as for initiating possible future collaborations between the participating groups.

Organizers: Manfred Albrecht (Universität Augsburg), Wolfgang Brütting (Universität Augsburg), Jens Pflaum (Universität Würzburg)

Time: Wednesday 9:30–11:00 Location: CHE 89

Invited Talk DS 20.1 Wed 9:30 CHE 89

Progress and challenges of organic and hybrid based thermoelectrics — •Mariano Campoy-Quiles — Institute of Materials Science of Barcelona (ICMAB-CSIC)

Heat is a ubiquitous source of energy. About half of the energy that the sun delivers to the Earth is in the form of infrared radiation. Moreover, two/thirds of the energy produced for human consumption is lost in the form of heat. In this scenario, solid state heat-to-electricity converters, i.e. thermoelectrics, have strong potential to harvest part of this untapped diluted energy source. Widespread use of thermoelectric generators has been thus far elusive due to the relatively high cost of the technology, and the fact that most thermoelectric materials operating at low temperatures are based on non-abundant or toxic materials. Solution processed carbon based materials are currently being investigated as a very promising alternative for low-cost, low temperature thermoelectrics. In this talk I will describe the progress and challenges for three carbon based systems: highly doped conjugated polymers, carbon nanotubes, and composites thereof. I will focus on our current understanding of what governs the main material thermoelectric properties, namely electrical conductivity, Seebeck coefficient and thermal conductivity.

DS 20.2 Wed 10:00 CHE 89

FFT-based Integrated Transient Thermoelectric Measurement Setup for Thin Films — •Karthikeyan Manga Loganathan[1,2,3], Guodong Li[1,2], Vineeth Kumar Bandari[1,2,3], Feng Zhu[1,2,3], and Oliver G. Schmidt[1,2,3] — [1]Material Systems for Nanoelectronics, Chemnitz University of Technology, Chemnitz, Germany — [2]Institute for Integrative Nanosciences, Leibniz IFW Dresden, Dresden, Germany — [3]Center for Materials, Architectures and Integration of Nanomembranes (MAIN), Chemnitz University of Technology, Chemnitz, Germany

Characterization of thin films for their thermoelectric figures of merit (zT) has been constantly met with the challenges in effectively measuring their thermal conductivity (k), electrical conductivity (σ) & Seebeck coefficient (S) coherently along the same plane. The author's work introduces a novel FFT-based measurement technique that independently measures the above parameters coherently along cross-plane direction for thin films with thicknesses as low as 50 nm. The technique incorporates FFT into the traditional transient measurement strategies of recording second and third harmonic voltage drops from the material in response to AC heating, established by David Cahill et al. [Phys. Rev. B, 1994]. This allows for the simultaneous measurement of the thin film's k and S in the cross-plane direction. The merits of this technique include enhanced ease, efficiency and accuracy of measurement of k, σ & S. The technique has been further employed to characterize organic materials and 2D multilayers such as CuPc, PEDOT, MoS2 and SnS2 for their cross-plane thermoelectric parameters.

Invited Talk DS 20.3 Wed 10:15 CHE 89

Thermoelectric microdevices - challenges and perspectives — •Gabi Schierning — IFW Dresden, Dresden, Germany

Next generation electronic devices require intelligent thermal management strategies in order to remove high density heat fluxes from the active electronic components or to harvest small amounts of energy for low-power electronics. Hence, hardware solutions for a smart and efficient thermal management are sought for. Micro-scale thermoelectric coolers (TEC) are therefore developed as one part of the thermal management. To fabricate these micro-scale TECs, we developed a fabrication technology such that tellurium-based compound semiconductors with decent thermoelectric performance at room temperature are deposited by electrochemical deposition combined with structuring by photolithographic processing. Current and temperature dependent cooling performances, transient cooling response, cooling cycling, and long-term stability under constant current of these micro-devices will be shown. Challenges that will be discussed are i) to integrate high figure-of-merit materials into the fabrication process, ii) to integrate the devices into real electronic circuitry, iii) to operate and characterize such devices as thermoelectric micro-harvesting devices rather than as micro cooling devices.

DS 20.4 Wed 10:45 CHE 89

Orgaic/inorganic hybrid composites for near-room temperature thermoelectric applications — •Rodrigo Rubio-Govea[1,2], Katherine Mazzio[1,2], and Simone Raoux[1,2,3] — [1]Institute for Nanospectroscopy, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Straße 15, 12489, Berlin, Germany — [2]Energy Materials In-Situ Laboratory Berlin (EMIL), Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Straße 15, 12489, Berlin, Germany — [3]Department of Physics, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489, Berlin, Germany

Hybrid organic/inorganic materials for thermoelectric application have received great attention in the last two decades due to the possibility of enhancing their performance. This is done by combining the intrinsic low thermal conductivity of the organic constituents and the high Seebeck coefficient and electrical conductivity of inorganic materials, making it possible to achieve high power factors and thermoelectric figures of merit. In this work we report the synthesis of hybrid composites consisting of chalcogenide-based nanowires and poly(3,4-ethylenedioxythiophene):polystyrene sulfonate and investigate how to control the thermoelectric properties based on the synthetic conditions. We found that it is possible to change the characteristics of the composite, including changing the majority charge carrier from p-type to n-type by engineering the composition of the inorganic component. We demonstrate an n-type composite with a power factor of 21.47 uWm-1K-2 and a zT value of 0.06 at 200 °C