DS 33: Thermoelectric Thin Films and Nanostructures I

Time: Thursday 10:30–12:00 Location: GER 38

Topical Talk DS 33.1 Thu 10:30 GER 38

Preparation and Charakterisierung von thermoelektrischen Nanodrähten — •Friedemann Völklein[1], Reinhard Neumann[2], Sven Müller[2], Oliver Picht[2], Heiko Reith[1] und Matthias Schmitt[1] — [1]Institut für Mikrotechnologien, FH Wiesbaden, Am Brückweg 26, D-65428 Rüsselsheim, Germa — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, D-64291 Darmstadt, Germany

Thermoelectrische Nanodrähte werden bei GSI Darmstadt durch Ionenspur-Technologie und elektrochemische Abscheidung hergestellt. Die thermoelektrischen Eigenschaften von Bismuth- und V/VI-Verbindungshalbleiter-Nanodrähten als Funktion der Kristallstruktur, der Zusammensetzung und der Draht-Abmessungen werden untersucht, um Modelle des Ladungs- und Wärmetransports in niederdimensionalen thermoelektrischen Materialien zu entwickeln. Microchips zur Messung der elektrischen und thermischen Leitfähigkeit und des Seebeck- Koeffizienten von einzelnen Nanodrähten wurden entwickelt und erfolgreich getestet. Diese Messungen gestatten die Bestimmung der thermoelektrischen Effektivität ZT und damit die Prüfung theoretischer Voraussagen hinsichtlich einer Steigerung von ZT in niederdimensionalen Thermoelektrika als Folge von Quantum-Size Effekten bzw. verstärkter Phononen-Streuung.

DS 33.2 Thu 11:00 GER 38

Thermoelectric transport in periodic 1D stacks of InAs/GaAs quantum dots — •Vladimir M. Fomin[1,2,3] and Peter Kratzer[1] — [1]Fachbereich Physik and Center for Nanointegration (CeNIDE), Universität Duisburg-Essen, Germany — [2]TFVS, Departement Fysica, Universiteit Antwerpen, Belgium — [3]PMS, Department of Theoretical Physics, State University of Moldova, Chişinău, Moldova

Superlattices (SLs) of InAs/GaAs quantum dots (QDs) are presently of interest for possible thermoelectric applications. Due to the quantum confinement of electrons and phonons, such SLs are expected to provide an improved figure-of-merit. The present work is aimed at the investigation of a periodic 1D stack of InAs quantum disks in GaAs. Electron minibands for a 3D SL of InAs/GaAs QDs are calculated using the tight-binding approach. The essential features of the obtained minibands, e.g. the distribution of the probability density in the xy-plane, can be understood within the Kronig-Penney model of a periodic 1D stack of quantum disks. Solution of the dispersion relation for acoustic phonons in a 1D SL with the parameters of the 3D SL of InAs/GaAs QDs confirms the accuracy of a model of an effective medium. Using the obtained electron wave functions and the phonon fields, the relaxation time is calculated and the electric and thermoelectric coefficients for a periodic 1D stack of InAs/GaAs quantum disks are analyzed as a function of their geometric characteristics. V.F. acknowledges the support by the ESF through Exchange Grant No. 2157 within the activity 'Arrays of Quantum Dots and Josephson Junctions'.

DS 33.3 Thu 11:15 GER 38

Fabrication of Si and Si-Ge nanopillars for the investigation of thermoelectric properties — •Nadine Geyer[1], Bodo Fuhrmann[2], Manfred Reiche[1], Trung-Kien Nguyen-Duc[1], Silko Grimm[1], Hartmut S. Leipner[2], and Peter Werner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle/Saale — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Heinrich-Damerow-Str. 4, 06120 Halle/Saale

A renewed interest in thermoelectric materials appeared in the last decade through the search for environment-friendly methods of power generation and the implementation of new concepts of nanotechnology due to the prospect of much higher conversion efficiency. Si nanopillars (NPs) and Si NPs containing a Si-Ge superlattice are expected to have superior thermoelectric properties (figure of merit ZT). Here, we report on the synthesis of the Si and the Si-Ge NPs with diameters below 25 nm. Starting from Si-Ge multilayer structures grown by MBE and combining lithography and metal-assisted chemical etching techniques, hexagonally ordered, vertically aligned Si and Si-Ge NPs were obtained, whose diameter, density and length can be controlled by localized etching. The morphology, the inner structure and the chemical composition were investigated by SEM, TEM and EDX. Future steps will be to investigate the thermoelectric properties of these etched Si and Si NPs containing a Si-Ge superlattice.

DS 33.4 Thu 11:30 GER 38

Thermoelectric properties of thin films made from doped Si and Ge nanoparticles — •Konrad Schönleber[1], Robert Lechner[1], Roland Dietmüller[1], Martin S. Brandt[1], Hartmut Wiggers[2], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching — [2]Institut für Verbrennungs- und Gasdynamik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg

We investigate the applicability of doped Si and Ge nanoparticles for future thermoelectronic devices. The nanoparticles are prepared by plasma decomposition of silane or germane in a microwave reactor and have average sizes between 5 and 50 nm, depending on the preparation conditions. The particles can be doped n- or p-type by phosphorus or boron, respectively. Thin films are prepared by dissolving the particles in a suitable solvent such as ethanol, followed by spin coating. Kapton, silicon, or glass are used as substrates. The doping level and alloy composition of the particle films can be varied by mixing highly doped with undoped and Si with Ge particles, respectively As-deposited films are highly resistive, even at high doping levels and after removal of the native oxide shell surrounding the nanoparticles by HF treatment. In order to obtain sufficiently high conductivity levels for thermoelectric energy conversion, the films are treated with pulsed high energy laser. Electrical and thermal conductivities as well as Seebeck coefficients will be presented as a function of doping level, alloy composition, and laser treatment parameters.

DS 33.5 Thu 11:45 GER 38

Potential & Seebeck Microprobe – Imaging of electrical and thermoelectric materials properties on the microscale — •Pawel Ziolkowski[1], Gabriele Karpinski[1], Dieter Platzek[2], Christian Stiewe[1], Ralf Hassdorf[1], and Eckhard Müller[1] — [1]German Aerospace Center (DLR), Institute of Materials Research, 51170 Cologne — [2]Physics Technology – Development and Consulting (PANCO), 56218 Mülheim-Kärlich

Recent developments turned the Potential & Seebeck Microprobe (PSM) into a powerful tool for electrical functional materials characterisation. A wide spectrum of applications has been demonstrated including thermoelectric cobalt antimonide and bismuth telluride thin films as well as nanostructured thick films. The principle involves a heated probe tip positioned at the surface of a sample coupled to a heat sink. The sample is scanned by mechanically touching and again lift-off from the surface at each position. The tip is heating up the sample in a microvicinity, forming a locally focused temperature gradient. By several measuring circuits, thermovoltages and the temperature drop over the gradient region are recorded, yielding the local Seebeck coefficient. With an electrical current feedthrough, the potential profile over the sample is monitored. Microresolving images both of the Seebeck coefficient and the potential obtained in a single run provide information on functional effects of the distribution of chemical components, phases, alloy constituents, or dopants. The method is particularly helpful in studying functionally segmented or graded materials and suitable for low resistivity materials due to its high-sensitive signal detection limit.