DS 16: Focus Session: Sensoric Micro and Nano-systems II

Time: Tuesday 14:00–16:15 Location: CHE 89

Invited Talk DS 16.1 Tue 14:00 CHE 89

Carbon Wonderland from an Engineering Perspective — •Franz Kreupl, Stefan Kapser, and Sebastian Hübner — TUM, Department of Hybrid Electronic Systems, Munich, Germany

A fresh look on carbon-based materials like carbon nanotubes (CNTs) or graphene in microelectronic applications will be given. Graphene has just passed the peak of inflated expectations and is heading towards the trough of disillusionment from where CNTs are just recovering. In contrast to short scale SWCNTs, graphene nanoribbons - even with bandgap - are not promising candidates for a better transistor. However, interconnects made of multi-layer graphene show promise in a wide range of applications. Through-Silicon-Vias (TSV), capacitors, metal gate, diodes, membranes, memories and sensors will be discussed. These applications are heavily based on the direct deposition methods which we have developed over the past decade.

DS 16.2 Tue 14:30 CHE 89

Fabrication and characterization of nano-crystalline graphite/graphene membranes — •Andreas Geworski, Yuri Koval, and Paul Müller — Department of Physics and Interdisciplinary Center for Molecular Materials, Universität Erlangen

The newly emerging field of carbon-based micro electro-mechanical systems (C-MEMS) tries to utilize the diverse properties of carbon and to push the performance of MEMS devices further. We have developed a method to fabricate suspended micro and nano structures made of nanocrystalline graphite/graphene. The preparation includes low-energy ion irradiation and electron beam lithography at different electron energies. Two different polymers were used as precursors for the membrane fabrication: novolac and poly(methyl methacrylate) (PMMA). Both materials demonstrate similar results except for the thickness of the membranes, which is smaller for PMMA. The thickness of the nanocrystalline suspended membranes can be varied between 2 and 100 nm by process parameters. The membranes show outstanding thermal properties and stay intact even at more than 3000^{o}C in vacuum. A fine adjustment of the electrical conductivity of the membranes can be performed by an additional ion irradiation [1]. A sheet conductance as high as 10^{-3} S can be achieved. The conductance of the membranes can be varied by a gate electrode [2]. An integration of electrostatic actuation and field effect transistor effect opens a pathway for novel devices. [1] Y. Koval, I. Lazareva, P. Müller, Synthetic Metals 161 (2011) 528. [2] Y. Koval, I. Lazareva, P. Müller, Phys. Stat. Solidi (B) 248 (2011) 299.

DS 16.3 Tue 14:45 CHE 89

Abnormal Thermal Transport in Two-dimensional Silicon — •Ming Hu — Institute of Mineral Engineering, Division of Materials Science and Engineering, Faculty of Georesources and Materials Engineering, RWTH Aachen University, 52064 Aachen, Germany — Aachen Institute for Advanced Study in Computational Engineering Science (AICES), RWTH Aachen University, 52062 Aachen, Germany

Silicene, the silicon equivalent of graphene, has recently attracted significant attention because it has graphene-like electronic structures including the presence of the Dirac cone at the Fermi level and because of its compatibility with mature Si-based electronics. In this presentation, first I will describe my recent atomistic simulation on thermal transport of atomically thin two-dimensional silicon (silicene). We found that silicene has extremely low thermal conductivity, which is about 20 times smaller than bulk Si and two orders of magnitude less than that of its carbon counterpart graphene. Second, I will present the effect of strain on the thermal conductivity of this novel 2-D material. We discovered that, contrary to its counterpart of graphene and despite the similarity of their honeycomb lattice structure, silicene exhibits an anomalous thermal response to tensile strain. Finally, I will demonstrate the effect of length and impurity on the thermal transport of silicene, which makes silicene very promising for thermoelectrics. Our findings provide a guide of how to modulate the thermal transport properties of two-dimensional Si with nanoengineering and may be of use in tuning their electronic and optical properties for electronic, thermoelectric, photovoltaic, and opto-electronic applications.

DS 16.4 Tue 15:00 CHE 89

Magnetoresistive Emulsion Analyzer — •Gungun Lin[1], Larysa Baraban[2,3], Luyang Han[1], Daniil Karnaushenko[1], Denys Makarov[1], Gianaurelio Cuniberti[2,3], and Oliver.G. Schmidt[1] — [1]Leibniz Institute for Solid State and Materials Research, Dresden, Germany — [2]Institute for Materials Science and Max Bergmann Center of Biomaterials, TU Dresden, Germany — [3]Center for Advancing Electronics Dresden (cfaed), TU Dresden, Germany

A substantial part of nanomedicine focuses on drug design and employing magnetic nanomaterials with multifunctional polymers, lipids or proteins. High-throughput drug discovery requires a tool which is able to analyze, manipulate, and sort objects containing known doses of magnetic nanoparticles associated with medications. A promising route relies on the implementation of magnetically-labeled biochemical species combining magnetoresistive sensors. In-flow detection based on magnetoresistive sensors has been demonstrated recently, representing first steps towards the integration of magnetic sensor elements into fluidic channels. However, up to date, progress is restrained to the mere sensing and counting of magnetic objects. Advanced and quantitative analysis, which is the main advantage of e.g. optical flow cytometry, has not been explored so far with magnetic sensors. Apart from detection and analysis, sorting of species is invaluable in diagnostic devices. We report a magnetoresistive emulsion analyzer which is capable of detection, multiparametric analysis and sorting of ferrofluid droplets. The device offers important complementarity to conventional optical approaches involving ferrofluids, and paves the way to the development of novel compact tools for diagnostics and nanomedicine.

DS 16.5 Tue 15:15 CHE 89

Building Blocks of a Micro and Nano Scale Tensile Testing Platform: Design, Technology, Numerical Simulation and Optimization — •Peter Meszmer, Karla Hiller, Raul David Rodriguez, Daniel May, Alexey Shaporin, Dietrich R. T. Zahn, Jan Mehner, and Bernhard Wunderle — Technische Universität Chemnitz, Germany

The presented tensile testing system targets to characterize functional sensor subcomponents such as CNTs, smart tubes, membrane structures, nanowires and their respective interconnections under thermomechanical loads to enable reliability predictions. The platform consists of three parts besides the specimen: actuator, force sensor and displacement sensor, integrated into a singe chip.

The thermal actuator is designed to ensure electrical insulation against the other components of the platform, passively heated using a thin aluminum meander, thus enabling the integration of all components, providing a travel range of up to $1\mu m$.

The displacement sensor is based on capacitive sensing, providing a resolution of $4fF$ and a sensitivity of $3\frac{fF}{nm}$.

The MEMS force sensor is based on the piezoresistive effect, capable of measuring nano-Newton sized forces mapped onto a micro-Volt scale and able to measure continuously while different loads are applied to the specimen.

All components are fabricated using SOI wafers processed by a BDRIE method, provide electrical readout and drive, are optimized using numerical methods providing experimentally verified results.

DS 16.6 Tue 15:30 CHE 89

Rolled-up antenna for on-chip aplication — •Dmitriy D. Karnaushenko, Daniil Karnaushenko, Denys Makarov, and Oliver G. Schmidt — Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstraße 20, Dresden, Germany.

One of the severe limitations of the conventional inter- or intra-chip communication is the emergent parasitic reactance and resistance associated with interconnects at high frequencies, which prohibits further miniaturization of the functional elements. This issue can be overcome by wireless transceivers integrated directly on a chip [1]. The latter requires development of compact antennas with tunable emitting characteristics.

To achieve this goal, we realized helical antennas using rolled-up nanotechnology allowing straightforward on-chip integration. First, we performed full scale modeling to understand the impact of geometrical parameters on the antenna performance (gain, resonance frequency, directivity). Relying on the results of the simulations, we applied thin film deposition and lithography techniques to determine various 2D sample layouts, which are then successfully rolled-up into a 3D helical antenna. Measurements of the return loss characteristics up to 20 GHz demonstrate that the rolled-up antenna reveals better performance than the initial planar structure. Experimental data agrees well with the result of the simulations.

[1] T. Kikkawa, Microelectronic Eng. 88, 767 (2011).

DS 16.7 Tue 15:45 CHE 89

Multifunctional nanomembranes as sensitive optical sensors in compact MEMS devices — •Stefan M. Harazim[1], Vladimir Bolaños[1], Christian Helke[3], Tom Enderlein[3], Thomas Otto[2], Thomas Gessner[2,3], and Oliver G. Schmidt[1,4] — [1]IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [2]Fraunhofer ENAS, Technologie-Campus 3, 09126 Chemnitz, Germany — [3]TU Chemnitz, Zentrum für Mikrotechnologien, Reichenhainer Str. 70, 09126 Chemnitz, Germany — [4]TU Chemnitz, Material Systems for Nanoelectronics, Reichenhainer Str. 70, 09107 Chemnitz, Germany

Point of care (PoC) diagnostic is a method to test biological samples directly where the patient is. This method offers, compared to the slow and large stationary laboratory, the most spatial flexibility and is very efficient if not preservable, quickly perishable samples have to be analyzed. Micro-electro-mechanical systems (MEMS), especially Lab-on-a-Chip (LoC) systems, could be utilized to include all required process steps, starting from the sample preparation up to the analysis of the recorded data. Furthermore, if it is possible to develop a sensor and actuator technology, providing a broad spectrum of biomedical applications, that enables the fabrication of low cost and fast operational one-time analysis tools, a huge leap towards PoC diagnostic is done. Herein, we present the fabrication and microfluidic integration in a LoC system of easy and fast to fabricate multifunctional nanomembranes. The refractrometric sensor capabilities, signal stability, complete devices with sensitivities of up to 880 nm/refractive index unit (RIU), reliability and other key parameters of the device will be presented.

DS 16.8 Tue 16:00 CHE 89

Predicting the performance of all-metal AFM tips — •E. Sheremet[1], R.D. Rodriguez[1], V. Kolchuzhin[2], V. Desale[1], K. Bhattacharya[1], J. Mehner[2], S. Schulze[3], M. Hietschold[3], and D.R.T. Zahn[1] — [1]Semiconductor Physics, — [2]Microsystems and Precision Engineering, — [3]Solid Surfaces Analysis Group. Technische Universität Chemnitz, D-09107 Chemnitz, Germany

Atomic force microscopy (AFM) is one of the most common tools for nanoscale characterization. The quality of the information and the spatial resolution that can be achieved in the measurements are largely determined by the AFM tip used. Many applications, such as electrical AFM and tip-enhanced Raman spectroscopy (TERS), require metallic tips, which are normally prepared by covering Si or Si_3N_4 tips with a thin metal layer. Unfortunately, the coating readily goes away upon contact with the sample [1]. We developed all-metal gold and silver AFM tips [2], which provide much more robust performance. However, unconventional materials and shape of the cantilevers and tips makes it necessary to develop a model of their dynamical properties. We statistically analyzed custom-made gold and silver tips in order to develop a parametrical model which can predict their performance in AFM. The tips are simulated by the finite element method and the validity of the model is confirmed by comparing the simulated and measured tip resonance spectra. The model is then analyzed in order to extract empirical parametric quantities predicting the tip performance.

[1] S.S. Kharintsev, et al. Nanotechnol. 18, 315502 (2007).
[2] R.D. Rodriguez, et al. Rev. Sci. Instrum. 83, 123708 (2012).