MM 16: Functional materials III: Sensors and Actuators

Time: Monday 15:45–17:45 Location: TC 010

MM 16.1 Mon 15:45 TC 010

Modified diamondoids for sensing applications — Frank Maier, Ganesh Sivaraman, Bibek Adhikari, and •Maria Fyta — Institute for Computational Physics, University of Stuttgart, Germany

Diamondoids are tiny diamond-like cages which are hydrogen terminated and can occur in various sizes and with a diverse type of modifications giving rise to novel bionanotechnological applications. In this work, based on quantum-mechanical calculations we study the effect of doping and functionalization of diamondoids on their structural characteristics and electronic properties. For this, we use different dopants and atomic groups and focus on the band-gap variations and the influence of the molecular orbitals in the case of the lower diamondoids, adamantane up to heptamantane. At a second step, we turn to the functionalized diamondoids and use these as probes to sense DNA molecules. Modified diamondoids can form hydrogen bonded complexes to DNA nucleobases tuning their electronic properties. Accordingly, we have observed that these small modified diamond-like cages are able to distinguish between small and large DNA nucleobases based on a difference up to 1 eV in the electronic band-gaps of the respective complexes. We discuss the possibility to sequence DNA through diamondoid-functionalized nanopores using quantum transport measurements. In the end, we discuss the theoretical stability of another class of diamondoids formed by nitrogen and boron instead of carbon and their relevance to nanotechnological applications.

MM 16.2 Mon 16:00 TC 010

Nanoporous gold as strain-sensing material — •Charlotte Stenner[1], Lihua Shao[1,2], Nadiia Mameka[3], and Jörg Weissmüller[1,3] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology, Hamburg, Germany — [2]Beijing Institute of Nanoenergy and Nanoscience, Chinese Academy of Sciences, Beijing, China — [3]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Due to a large surface-to-volume ratio, nanoporous metals are predestined for exploiting their surface properties in schemes for novel functional materials. Here, we report an electrochemical sensor based on nanoporous gold (npg) for strain detection. Npg imbibed with electrolyte was inspected as a hybrid material, in which the metal acted as an electrode. Since the mechanical deformation of a planar gold electrode has a strong impact on its potential E [1], an applied strain is expected to cause potential variations that can be measured in npg.

In our experiments, macroscopic bulk samples of npg are cyclically strained in a dynamical mechanical analyzer (DMA). The material shows a robust and sensitive response of the potential to cyclic variation of strain. With higher strain amplitude and smaller pore size, the potential response is increased. Additionally, another strategy was employed, where a charge variation was measured at constant potential. Via this method the electrochemical signals were obtained in different potential regimes, as the double-layer and oxygen-adsorption region. [1] M. Smetanin, et al., Phys. Chem. Chem. Phys. 13 (2011) 17313

MM 16.3 Mon 16:15 TC 010

Shapeable magnetic sensorics — •Denys Makarov, Michael Melzer, Daniil Karnaushenko, Ingolf Mönch, Gungun Lin, and Oliver G. Schmidt — Institute for Integrative Nanosciences, IFW Dresden, 01069 Dresden, Germany

Magnetic sensor elements are usually fabricated on rigid wafer supports and provided as IC-chip packages with defined shape and size. In order to explore advanced application fields imposed by the novel trend of printable, flexible, and stretchable high-speed electronics [1], functional magnetic elements have to feature the same compliant mechanical properties. Magnetic nanomembranes have the potential to fulfill these demanding requirements of being reshapeable on demand after their preparation. We developed the technology platform allowing us to fabricate high-performance shapeable, namely, flexible [2,3], printable [4] and even stretchable [5] magnetic sensorics. These novel magnetoelectronics can be printed onto a variety of materials including regular paper [4], rolled up into a compact tubular architectures for applications in fluidics [3], as well as be stretched up to 270% without degrading in performance. These unique mechanical properties enable applications of the novel magnetic sensing devices in medical diagnostics and functional implants, safety and health care monitoring, e-mobility, flexible and low-cost consumer electronics, soft robotics as well as artificial skins. [1] J. A. Rogers et al., Nature 477, 45 (2011). [2] Y.-F. Chen et al., Adv. Mater. 20, 3224 (2008). [3] G. Lin et al., Lab Chip 14, 4050 (2014). [4] D. Karnaushenko et al., Adv. Mater. 24, 4518 (2012). [5] M. Melzer et al., Nano Lett. 11, 2522 (2011).

MM 16.4 Mon 16:30 TC 010

Wearable magnetic field sensors for flexible electronics — •Gilbert Santiago Cañon Bermudez, Daniil Karnaushenko, Michael Melzer, Ingolf Mönch, Denys Makarov, and Oliver G. Schmidt — Institute for Integrative Nanosciences, IFW Dresden, Dresden, Germany

The recent rapid advance and eagerness of portable consumer electronics stimulate the development of functional elements towards being lightweight, flexible, and even wearable[1]. Next generation flexible appliances aim to become fully autonomous and will require ultra-thin and flexible navigation modules, body tracking and relative position monitoring systems which frequently rely on Hall effect sensors. Unfortunately, conventional semiconductor-based Hall sensors are about 400 um thick and rigid, limiting their direct applicability in flexible electronics. To overcome this limitation of conventional technologies, we introduce a novel platform relying on the smart combination of inorganic Bismuth nanomembranes and polymeric foils, which allow us to fabricate highly flexible Hall effect sensorics[2]. Our experiments demonstrate that these flexible devices can be reliably bent or wrapped around the wrist to realize interactive devices for wearable electronics. Alternatively, thin and bendable Hall sensors are of great interest for the rapidly developing market of eMobility, where the performance of eMotor designs could be greatly enhanced.

[1] J. A. Rogers et al., Nature 2011, 477, 45.
[2] M. Melzer et al., Adv. Mat. (2014) in press.

15 min. break

MM 16.5 Mon 17:00 TC 010

Compact rolled-up antenna for implants applications — •Dmitriy D. Karnaushenko, Daniil Karnaushenko, Denys Makarov, and Oliver G. Schmidt — Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstraße 20, Dresden

Smart implants were suggested as an efficient tool to monitor physiological processes in the human body, which is crucial especially after, e.g. chirurgical treatment. Compactness of the implants is highly desirable to minimize discomfort during and after implantation. If the length of the device is about 5 mm and diameter of less than 0.5 mm, it can be readily implanted using standard medical syringes. In this spirit, the rolled-up technology [1] was developed to realize multifunctional and compact 3D tubular devices by self-assembly starting from a planar layout. High-performance compact rolled-up active electronics, energy storage, magnetic field and fluidic sensors are already used to acquire and process the data [2,3]. However, the antenna element allowing the communication of the data to an external device, e.g. smartphone or personal computer, is missing. Here, we realized rolled-up helical antenna operating in the Industry-Scientific-Medical (ISM) radio band at 5.8 GHz. With a total length of 5.5 mm it is about 5 times smaller than the conventional dipole antenna. The transmission and receiving signals between rolled-up antennas and the communication between a rolled-up antenna and a smartphone is demonstrated highlighting its applicability for medical implant applications. [1] O. Schmidt et al., Nature 410, 168 (2001). [2] D. Grimm et al., Nano Lett. 13, 213 (2013). [3] I. Moench et al., ACS Nano 9, 7436 (2011).

MM 16.6 Mon 17:15 TC 010

Deformation characteristics and phase transitions in Fe_7Pd_3 thin films — •Alina J. Bischoff[1,2] and Stefan G. Mayr[1,2,3] — [1]Leibniz-Institut für Oberflächenmodifizierung, Leipzig — [2]Translationszentrum für Regenerative Medizin, Leipzig — [3]Fakultät für Physik und Geowissenschaften, Universität Leipzig

Ferromagnetic shape memory alloys are a captivating class of smart functional materials and very promising candidates for miniaturized actuation devices featuring reversible strains of several percent due to the reorientation of twin variants in the martensite phase caused by

an applied external magnetic field. In this context the ferromagnetic shape memory alloy Fe_7Pd_3 is of particular interest because of its high ductility, low brittleness, and corrosion resistance enabling the use of this alloy in micromedicine.

Within an in situ study, we explore the mechanical properties of martensite and austenite freestanding Fe_7Pd_3 thin films, while monitoring changes in the surface relief as measured by scanning electron microscopy. This allows to establish correlations between structural changes and mechanical respose.

MM 16.7 Mon 17:30 TC 010

Density functional investigations on the effect of Ni excess in binary Ni-Ti shape memory alloys — •Ingo Opahle[1], Jan Frenzel[2], André Wieczorek[2], Burkhard Maass[2], Gunther Eggeler[2], and Ralf Drautz[1] — [1]ICAMS, Ruhr-Universität Bochum, Bochum, Germany — [2]Institut für Werkstoffe, Ruhr-Universität Bochum, Bochum, Germany

The martensite start temperature M_s of binary Ni-Ti shape memory alloys depends strongly on the alloy composition and decreases by about 100 K within 1 at.% of excess Ni. We present density functional calculations for binary Ni-Ti alloys close to the stoichiometric composition. In agreement with experimental results it is shown that the heat of transformation ΔH decreases as the Ni concentration increases, which in turn results in a lower martensite start temperature. The strong decrease of ΔH is caused by a stabilization of the B2 austenite phase by structural relaxations around Ni antisite atoms together with a gradual destabilization of the B19' martensite phase. In contrast, contributions from the valence electron count or magnetism are shown to be unable to explain the experimentally observed changes in M_s.