MM 13: Non-equilibrium Phenomena in Materials Induced by Electrical and Magnetic Fields 3

Time: Tuesday 10:15–13:00 Location: H45

Topical Talk MM 13.1 Tue 10:15 H45

Supercompatibility in ceramic micropillars of lanthanum niobate — •Olivia A. Graeve and Hamed Hosseini-Toudeshki — University of California San Diego, La Jolla, CA, USA

Superelastic materials represent a distinct family of compounds with the ability to manifest reversible deformation in response to an applied stress. Generally, superelastic materials are metallic in nature, and only very few ceramics have been shown to fully or partially display this response. Here, we describe exceptional superelasticity and enhanced reversibility on micropillars of $LaNbO_4$ ceramic in response to compressive stresses up to 1100 MPa without fracture. The micropillars were prepared by focused ion beam machining from specimens consolidated by spark plasma sintering. The material response to stress is consistent with the theory of supercompatibility (cofactor theory) that has been reported to address the enhanced reversibility and low-hysteresis behavior (i.e., improved superelasticity) of certain shape memory metallic alloys. This makes $LaNbO_4$ a unique addition to the germane family of smart materials for applications as long-lived actuators impacting the automotive, energy and aerospace sectors, among many other technologically significant fields, especially in extreme conditions (i.e., higher temperatures or pressures) under which ceramics excel compared to metals.

Topical Talk MM 13.2 Tue 10:45 H45

X-Ray Spectro(micro)scopy as analytics for field assisted deposition processes — •David N. Mueller — Peter Grünberg Institut, Forschungszentrum Jülich

X-Ray absorption spectroscopy (XAS) is element specific, sensitive to the electronic structure around the Fermi level, and provides information about the short-range order in a material, and can be tuned to be surface sensitive. It therefore represents a versatile tool to assess the impact of external fields during synthesis of functional materials on the structure property relations required for optimizing functionalization. Providing spatial resolution on the sub micrometer scale with X-Ray photoemission electron microscopy (XPEEM) additionally allows identification of phase inhomogeneities and their peculiarities with respect to chemistry and structure.

In this presentation, we will use 3d transition metal based oxides of varying complexity to showcase how XAS and XPEEM can give valuable insights into the atomic and electronic structure and how those can be improved towards use in e. g. catalysis by using external fields during synthesis. It will furthermore be discussed how numerical methods such as principal component analysis can help analyzing spectromicroscopic data to unambiguously identify subtle lateral inhomogeneities in the spectroscopic signatures, providing information about phase formation and decomposition processes.

MM 13.3 Tue 11:15 H45

Magnetic Field-assisted Chemical Vapor Deposition of MgFe2O4 Films for Photoelectrochemical Water Splitting — Hyenkwon Lee[1], •Ziyaad Talha Aytuna[1], Aman Bhadrwaj[1], Michael Wilhelm[1], Khan Le[1], Benjamin May[2], David Müller[2], and Sanjay Mathur[1] — [1]Greinstraße 6, 50939 Köln — [2]Wilhelm-Johnen-Straße, 52438 Jülich

Single-phase magnesium ferrite films (MgFe2O4) were grown by magnetic field-assisted chemical vapor deposition (CVD) of mixed-metal precursor [MgFe2(OtBu)8] as a function of the applied field strength (B = 0.0, 0.5 and 1.0 T). The formation of monophase MgFe2O4 deposits was confirmed by X-ray diffraction and photoelectron spectroscopy. The cross-sectional analysis (FIB-SEM) of the film revealed an increased densification and crystal growth, upon application of the magnetic field when compared to zero-field deposition. The MgFe2O4 films deposited under zero-field and field-assisted conditions were used as electrodes in a photoelectrochemical (PEC) water-splitting reaction. All the three samples showed a stable performance and photocurrent values, however, the photocurrent was found to gradually decrease with increasing applied magnetic field (0 T: 5.74 μA/cm2, 0.5 T 2.33 μA/cm2, and 1 T: 1.33 μA/cm2 at 1.23 V (vs. RHE)), which is possibly due to change in absorption properties and crystal orientation, decreasing photo absorption intensity provided by the UV-vis results and the latter being evident in the disappearance of (220) peak in MgFe2O4 films grown under the influence of the external magnetic field.

15 min. break

MM 13.4 Tue 11:45 H45

PECVD carbon-coated electrospun vanadium pentoxide nanofibers as cathode material for photoresponsive batteries — •Michael Wilhelm, Ruth Adam, Aman Bhardwaj, and Sanjay Mathur — University of Cologne, Cologne, Germany

Harvesting and converting sunlight as the most sustainable energy source on earth is still challenging. Photo-rechargeable batteries represent a synergistic concept that integrates both energy harvesting and energy storage modalities based on dual-functional materials. Vanadium pentoxide nanofibers (VNF) as photoresponsive material was synthesized by electric field-assisted spinning technique and used as dual-action cathode material for photo-rechargeable lithium-ion batteries. A high discharge capacity was delivered, which could be increased under light illumination confirming the photoresponsive behavior. To minimize side reactions and to increase the stability of the electrodes, the VNF were carbon-coated by plasma-enhanced chemical vapor deposition (PECVD). Long-term stability tests showed that besides being a conductive shell, the carbon coating is also essential in retaining the structural instability of VNF. Higher capacity retention upon cycling compared to the non-carbon-coated VNF (after 300 cycles: 43.85 % capacity retention VNF and 61.13 % capacity retention for carbon-coated VNF). Further, the rechargeability of the material by light was demonstrated by illuminating with a UV lamp and afterward discharging the electrode material in the dark which delivered a photoconversion efficiency of 4.24 % for VNF and 5.07 % for carbon-coated VNF.

MM 13.5 Tue 12:00 H45

Structure and Morphology Engineering of Hexagonal Boron Nitride (h-BN) using Magnetic Field assisted CVD — •Anja Sutorius, Michael Wilhelm, Khan Lê, Ziyaad Aytuna, and Sanjay Mathur — University of Cologne, Cologne, Germany

The aim for two dimensional materials namely graphene, MoS2 and borophene has become a high interest due to their amazing properties (e.g. conductivity, flexibility, dimensionality) and demand for innovative electronic device applications. The large band gap material h-BN catches the attention of latest research due to its non-toxicity, environmentally friendly and chemical stability as well as its dielectric properties. The commonly preparation of h-BN often requires a gas phase deposition on catalytic metals at very high temperatures and is despite intense research very challenging. A new opportunity is provided using an external magnetic field during synthesis. Precursor molecules like amino borane (NH3BH3) or dimethyl amino borane (CH3)2NBH2 and h-BN itself exhibit a charge distribution and thus can be influenced by an applied field. Here, we would like to report about the thin film formation of h-BN with and without an external magnetic field on a variety of substrates ranging from catalytic metal substrates to non-catalytic dielectric silicon substrates. Results from infrared and x-ray photoelectron spectroscopy, as well as transmission and scanning microscopy.

MM 13.6 Tue 12:15 H45

Nanocrystalline CoCrFeNiGax (x = 0.5, 1.0) high entropy alloys: structural and magnetic features — •Natalia Shkodich, Marina Spasova, and Michael Farle — Faculty of Physics and Center of Nanointegration (CENIDE), University of Duisburg-Essen, Duisburg, 47057 Germany

Nanocrystalline single fcc phase CoCrFeNiGax (x = 0.5, 1.0) high entropy alloy (HEA) powder particles with good structural and compositional homogeneity were successfully fabricated by high energy ball milling (HEBM). Characterization by XRD, SEM/EDX, and TEM/EDX shows that the fcc phase with the refined microstructure of nanosized grains (~10 nm) could be obtained after 190 min of HEBM at 900 rpm. We used HEBM powders to fabricate homogeneous nanocrystalline bulk HEAs by spark plasma sintering (SPS). SPS at 1073 K of the CoCrFeNiGa0.5 HEA powder increases the crystallinity of the fcc phase, while for the equiatomic CoCrFeNiGa powder a partial transformation of the fcc into the bcc phase is observed. The nanocrystalline

HEA CoCrFeNiGax (x = 0.5, 1.0) powders show a paramagnetic behavior at room temperature and a Curie temperature (Tc) is of 127K-130K. After SPS, the CoCrFeNiGa bulk material is ferromagnetic up to Tc =775K. Its saturation magnetization Ms (300K) increases by a factor of 10 as compared to the HEA powder. The SPS of the CoCrFeNiGa0.5 HEA powder, however, does not change its paramagnetic nature at ambient temperature. This work has been supported by the Deutsche Forschungsgemeinschaft (DFG) within CRC/TRR 270, project S01 (project ID 405553726).

Topical Talk MM 13.7 Tue 12:30 H45

Field-assisted processing of magnetic materials — •Fernando Maccari and Oliver Gutfleisch — Technical University of Darmstadt, 64287 Darmstadt, Germany

Optimization of materials requires a precise control of processing parameters to achieve a desired combination of phases and microstructural features. The application of an external fields during synthesis, going beyond the classical use of only temperature and time, can be used as additional degree of freedom to promote densification, solid state phase transformation, intermetallic compounds and precipitates formation. This combination opens new possibilities to obtain highly tailored microstructures and improved properties.

Focusing on magnetic materials, this talk will provide an overview on how different length scales can be manipulated using external magnetic and electric field assisted processing techniques to create materials with enhanced functional properties. Aspects related to induced magnetic anisotropy and phase formation in soft and hard magnetic materials will be covered. Additionally, field driven coupled magnetic and phase transition is going to be addressed and exemplified in ferromagnetic shape memory Ni-Mn-Ga Heusler compound.