MM 27: Topical Session: Interface-dominated phenomena - Nanoporous Metals

Time: Tuesday 14:15–15:30 Location: IFW A

MM 27.1 Tue 14:15 IFW A

Precipitation in nanoporous Au-Ni — •Maowen Liu[1], Lukas Lührs[1], and Jörg Weissmüller[1,2] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology — [2]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht

The vacancies formed during dealloying process play a critical role in the preparation of nanoporous metals. In order to obtain a detailed understanding of the vacancy distribution in nanoporous metals, the precipitation behavior, which can reflect the vacancy migration and is closely related to the void distribution, was investigated. In the present work, Au-Ni alloy, a typical immiscible binary alloy, was selected for the study of precipitation. The precipitation behavior in nanoporous Au-Ni during dealloying and subsequent heat treatment was investigated using a transmission electron microscopy equipped with an energy dispersive X-ray spectroscopy. The results reveal that parts of Ni atoms tend to aggregate as nanoscale clusters in the nanoporous alloy during dealloying process. After heat treatment, more Ni precipitates appear in the ligaments. It is speculated that the Ni clusters and some small voids formed during dealloying process provide nuclei for the subsequent precipitates.

MM 27.2 Tue 14:30 IFW A

Hybrid Materials Made from Nanoporous Metals and Electrically Conductive Polymers as Electro-Chemo-Mechanical Actuators — •Benedikt Roschning[1] and Weissmüller Jörg[1,2] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology, Hamburg, Germany — [2]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Nanoporous metals can be used as functional materials like sensors or actuators, due to their high intrinsic, externally accessible surface. The mechanism is based on surface stress variations as a consequence of an applied electrical potential. This stress variation acts on the underlying bulk atoms, resulting in actuation, scaling with the feature size. The environmental stability and structural coarsening due to surface diffusion restricts the materials choice to noble metals like gold or platinum and are still an issue in terms of long-term stability. Another class of electro-chemo-mechanical actuators are conductive polymers. Their actuation is caused by the incorporation of co-ions between the polymer chains for charge balancing. Within thin films, fast ion exchange is possible, but the stiffness of the underlying substrate limits the effect of actuation. A combination of both approaches, the coating of the intrinsic surface area of nanoporous metals with electrically conductive polymers, leads to superior electrochemical and actuatoric properties. Within this contribution, we address manufacturing approaches, the electrochemical properties as well as the underlying mechanisms for actuation.

MM 27.3 Tue 14:45 IFW A

Coarsening of nanoscale metal networks and their connectivity evolution via kinetic Monte Carlo simulations — •Yong Li[1,2], Bao-Nam Dinh Ngo[2], Jürgen Markmann[2,1], and Jörg Weissmüller[1,2] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology, Hamburg, Germany — [2]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Nanoporous gold made by dealloying takes the form of a network assembled from nanoscale struts or "ligaments". It has been emphasized that the connectivity of the networks is decisive for their mechanical behavior. The relevant experimental observations lead to apparently contradictory conclusions on how the connectivity evolves during coarsening. Here, we study the microstructure evolution of nanoscale metal network structures due to surface diffusion during annealing, using large-scale on-lattice kinetic Monte Carlo simulation and spinodal-like initial microstructures. Our results [Y. Li et al., Phys Rev Mater 3 (2019) 076001.] confirm the classical time exponent $t^{1/4}$ for the size evolution. They also reveal that the degree of surface faceting does not affect the growth kinetics or the evolution of connectivity. The initial connectivity, as described by a scaled topological genus, depends on the solid fraction, φ, of the microstructure. Furthermore, networks with $\varphi \geqslant 0.30$ undergo a self-similar coarsening and maintain their connectivity, whereas networks with $\varphi < 0.30$ lose their connectivity during coarsening and will eventually disintegrate into isolated clusters.

MM 27.4 Tue 15:00 IFW A

Electrochemically driven actuation and change in Young's modulus of nanoporous metal-conductive polymer actuator under external load — •Jie Li[1], Jürgen Markmann[1,2], Jörg Weissmüller[1,2], and Nadiia Mameka[1] — [1]Helmholtz-Zentrum Geesthacht, Institute of Materials Research, Materials Mechanics — [2]Hamburg University of Technology, Institute of Materials Physics and Technology

Nanoporous (np-) metals made by dealloying may be considered as promising low-voltage electro- and chemo-mechanical actuators with a good combination of actuation strain, stiffness and strength [1]. The actuation performance of np metals can be further improved by electrodeposition of conductive polymers on the pore surface [2]. Here, we study hybrid electroactuator from np Au and polypyrrole (PPy). Upon electric charging in an aqueous electrolyte, the material exhibits actuation as well as large modulation in stiffness. We point out that the stiffness change can strongly affect the actuation efficiency-as described by the maximum work density-particularly when the actuator operates under external mechanical load [3]. We employ a dynamic mechanical analysis with an electrochemical control to study the impact of the applied load on the actuation and the Young's modulus variation. The conditions under which the np Au/PPy actuator shows enlarged actuation amplitudes along with enhanced elastic response will be discussed. [1] L.-H. Shao et al., *RSC Nanoscience-Nanotechnology* 2012, **22**, 137. [2] K. Wang et al, *Sens Actuator B Chem*, 2017, **248**, 622. [3] L.-Z. Liu et al, *Phys Rev Mat*, 2019, **3**, 066001.

MM 27.5 Tue 15:15 IFW A

Nanoporous gold with controlled surface morphology — •Stefan Berger[1], Lingzhi Liu[1,2], Jürgen Markmann[3,1], and Jörg Weissmüller[1,3] — [1]Institut für Werkstoffforschung, Werkstoffmechanik, Helmholtz-Zentrum Geesthacht — [2]Chinese Academy of Sciences, Institute of Metal Research, Shenyang National Laboratory for Materials Science — [3]Institut für Werkstoffphysik und Werkstofftechnologie, Technische Universität Hamburg

Nanoporous gold is a nanostructured material with a high specific surface area. The large surface of the nano sized gold structures make the material interesting for applications like catalysis and sensing. Investigations of the catalytic behaviour of gold have shown surface dynamics and surface reconstructions. Based on these findings, we present a method to control the surface morphology by annealing in different gaseous environments. Surface morphology investigations by electron microscopy are presented to classify different faceting behaviour. We show that oxygen is a strong driver for faceting and that high index surfaces appear on gold nano ligaments, when treated in oxygen containing environments. A Oxygen free reducing environment in carbon monoxide in contrast will produce more roughed surfaces with only low index facets. A controlled surface morphology might help to further tune the surface properties, which have a great impact on the bulk properties of nanoporous materials.