MM 61: Nanomaterials - I

Time: Thursday 15:45–17:15 Location: IFW D

MM 61.1 Thu 15:45 IFW D

Nanoporous Copper-Nickel – Macroscopic bodies of a strong and deformable nanoporous base metal by dealloying — •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

Owing to their very large surface area to volume ratio, nanoporous metals made by dealloying in aqueous solutions promise significant functionalization. Potential applications arise as actuators, sensors, catalysts or structural materials with tunable mechanical properties. An obvious require-ment for a materials competitive ability in these fields is affordability. In addition, deformability is required to avoid premature failure upon exposure to stress concentrations or to designed mechanical load. So far, macroscopic samples of nanoporous metals with a high surface area and deformability have been limited to precious, and thereby costly, metals such as Au, Pd and Pt.

Here we present nanoporous Copper-Nickel (npCN), a nanoporous base metal that can be made in macroscopic dimensions (> several mm in size) and shows significant deformability. Fabricated through dealloying in aqueous media, npCN exhibits a uniform, bicontinous network structure with feature sizes that can be controlled from 13 to 40 nm through thermal annealing. Continuous com-pression tests find ductile deformation behavior accompanied with a high strength compared to other nanoporous base metals as well as macroporous Cu- and Ni-foams with similar solid fraction.

MM 61.2 Thu 16:00 IFW D

Elastic and plastic behavior of nanoporous gold under applied electrochemical potential — •Yijuan Wu[1], Jürgen Markmann[1,2], and Erica Lilleodden[1,3] — [1]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany — [2]Institute of Materials Physics and Technology, Hamburg University of Technology, Hamburg, Germany — [3]Institute of Advanced Ceramics, Hamburg University of Technology, Hamburg, Germany

The elastic and plastic behavior of nanoporous gold (NPG) under electrochemical potential control at the microscale was investigated by in situ compression testing in an electrolyte using a modified nanoindenter and a novel multiple load function. It was found that the potential dependent flow stress of NPG micropillars showed the same trend as corresponding results of NPG at the macroscale: significant increase at positive potential due to surface coverage of an OH- monolayer and reversible modulation with varying potentials. However, the elastic modulus is insensitive to the applied potential, which is in good agreement with corresponding results from in situ macro-compression experiments, but different to reported results of in situ dynamic mechanical analysis (DMA)

MM 61.3 Thu 16:15 IFW D

Impact of the precursor alloy composition on the mechanical properties of nanoporous gold — •Birthe Zandersons[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

Due to its chemical stability and the tunable structure size from a few to several hundred nanometers, nanoporous gold (NPG) is an attractive model system for small-scale material behavior. Its mechanical properties have been investigated over many years. Clear distinctions in stiffness and strength caused by variations of the solid fraction have been reported. Yet, a systematic investigation is still missing. Therefore, we systematically dealloyed AuAg alloys with Au amounts between 20 and 35 at.% electrochemically in 1 M $HClO_4$ or via free corrosion in concentrated HNO_3. Compression tests with continuous loading and with load/ unload protocols explored the stress-strain behavior and Young's modulus. We confirm a significant depending of the mechanical performance on the master alloy compositions and validate an impact of the topological genus.

MM 61.4 Thu 16:30 IFW D

In-depth porosimetry of pore evolution in low-k thin films — •Ahmed G. Attallah[1], Maciej Oskar Liedke[1], Nicole Koehler[2], Maik Butterling[1], Eric Hirschmann[1], Stefan E. Schulz[2], Ramona Ecke[2], and Andreas Wagner[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiation Physics, 01328 Dresden, Germany — [2]Center for Microtechnologies, Chemnitz University of Technology, 09126 Chemnitz, Germany

The development of the porous structure in low-k materials after conducting a thermal in-situ and ex-situ curing processes will be shown. Such a study has been performed by using positron annihilation spectroscopies (Lifetime and Doppler Broadening) and Fourier-transform infrared spectroscopy. The goal of this work is to take a closer look at the kinetics of the template removal which, in addition to the chemical structure of the matrix-template mixture, defines the created porosity. Positron lifetime shows that template decomposition starts at 473K and complete removal is accomplished at 723K. Additionally, it reveals template agglomeration and diffusion to the surface by creating channels that would affect the mechanical stability and the k-value. Definite curing temperature ranges for different processes (moisture removal, SiO_x network cross-linking, porogen decomposition) has been figured out by Doppler broadening spectroscopy during in-situ curing. Also, it shows a pore interconnectivity onset at 673K. Fourier-transform infrared spectroscopy results help for understanding the network changes during curing and confirmed positron results for template removal.

MM 61.5 Thu 16:45 IFW D

Scalable Structural Coloring Based on the Photonic Bandgap of Ordered Nanoporous Array — •Yudie Huang, Fanzhou Lv, Jiaxu Chen, Zhihang Wang, Shiyao Jia, Yi Wang, and Wenxin Wang — Harbin Engineering University , Harbin, China

Full structural coloring within the range of visible light has been fabricated through various methods due to the distinguished features of high saturation, durability and unfading. However, the reported prepared samples do not exhibit superior saturation compared to the natural structural color materials. Because of broad and multi-peaks surrounding profiles are existing in reflective ranges that obstruct the coloring saturation. Bandgap-assisted structural coloring based on sharp and less reflective peaks is highly recommended. Besides, color over a considerable spectral range remains stable. Here, we present a scalable and vivid structural coloring approach to acquire color with a more pure hue. (1) designing a metal-dielectric-metal structure system to narrow the reflect peaks. (2) regulating the parameters of the nanoporous array to reduce the number of reflectivity peaks and achieve bright and pure hue. The reflective peaks of nanoarray are adjusted and concentrated towards the position of photonic bandgap caused by highly ordered dielectric arrangement. (3) owing to the used fabrication method, the area of structural color presentation is sufficiently large to serve as commercial applications. Therefore, this scalable and vivid structural coloring proposal has promising application prospects in human daily life.

MM 61.6 Thu 17:00 IFW D

Atom Probe Tomography of Mesoporous Silica — •Kuan Meng, Patrick Stender, and Guido Schmitz — Stuttgart University, Germany

In order to visualize the porous structure of desiccant silica gel (orange) with atom probe tomography, the FIB cryogenic technique was used to prepare a solid tip sample by filling the pore with water vapor absorption and then freezing. In an attempt to understand the measurement result, this work was split into three parts of investigation in pure bulk silica as the pore wall material, pure water as the filler and the water-filled silica gel like a water-absorbed sponge respectively. In the first part, silica was thermally oxidized from silicon wafer and the tip samples were prepared with FIB Lift-Out technique. Its evaporation field was determined by measuring the Si/SiO2 interface in normal, vertical and reverse geometries. Moreover, the interface was found not flat. Secondly, water was measured by preparing an ice tip with the FIB cryogenic method. Despite the uncommon ring-like patterns in the detector view, the crystal ice peaks were found in the mass spectrum. Thirdly, a quasi-porous structure network was visualized in the case of the water-filled silica gel, revealing a promising future in the field of APT measurement for porous materials.