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Mechanical behaviour of nanoporous gold can be controlled by surface modification

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Sustainable use of energy resources often asks for innovative intelligent materials with adjustable response to in-service changes of requirements in material parameters. Nanoporous metals are proved to be suitable candidates due to unique structural morphology with large effective surface area and penetrability for surface functionalization.

Our study highlights a smart hybrid material based on nanoporous gold in an aqueous electrolyte whose stiffness and strength are reversibly tuned by external stimuli. The tunability of these effective mechanical properties is realized via application of electric potentials to the large gold-electrolyte interface of the material, and consequent control of the surface state through electrical polarization and adsorption. The experiments are implemented *in situ* under environmental control in a dynamic mechanical analyzer and a mechanical testing device. Novel and interesting findings in the mechanics of a nanoporous metal have been revealed.

First, the effective elastic modulus varies reversibly with the electrode potential by up to 10% [1]. We find that adsorption of oxygen species as well as a simple excess of electrons on the surface increase the stiffness while oxygen desorption/electron depletion reduces it. Since the electrochemical modification affects the material exclusively at its surface, the changes in the effective elastic response unambiguously testify to the surface excess elasticity phenomena in nanomaterials.

Second, *in situ* compression tests in electrolyte suggest a similar effect of the electrode potential on the flow stress, where the relative variation reached 100%. The implications of microstructural size and electrochemical environment on these aspects of the material's mechanical behavior also was analyzed and will be discussed. The observations point towards (potential-dependent) surface tension as the most relevant parameter in controlling the plasticity of nanoporous gold.

Keywords: nanoporous; surface tension; surface stresss; surface excess elasticity

[1] N.Mameka et al., Act. Mat. 76, 272 (2014)