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Nanoporous metals have recently attracted considerable interest fueled by potential sensor and actuator applications. From a material science point of view, one of the key issues in this context is the synthesis of nanoporous metals with both high tensile and compressive strength. Nanoporous gold (np-Au) has been suggested as a candidate material for this application due to its monolithic character. The material can be synthesized by electrochemically-driven dealloying of Ag-Au alloys, and exhibits an open sponge-like structure of interconnecting ligaments with a typical pore size distribution on the nanometer length scale. However, besides the observation of a ductile-brittle transition very little is known about the mechanical behavior of this material.

Here, we present our results regarding the mechanical properties and the fracture behavior of np-Au. Depth-sensing nanoindentation reveals that the yield strength of np-Au is almost one order of magnitude higher than the value predicted by scaling laws developed for macroscopic open-cell foams. The unexpectedly high value of the yield strength indicates the presence of a distinct size effect of the mechanical properties due to the sub-micron dimensions of the ligaments, thus potentially opening a door to a new class of high yield strength – low density materials. The failure mechanism of np-Au under tensile stress was evaluated by microscopic examination of fracture surfaces using scanning electron microscopy. On a macroscopic level, np-Au is a very brittle material. However, microscopically np-Au is very ductile as ligaments strained by as much as 200% can be observed in the vicinity of crack tips. Cell-size effects on the microscopic failure mechanism were studied by annealing experiments whereby increasing the typical pore size/ligament diameter from ~100 nm to ~1µm.

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