Mesoscale Priority Research Direction

Elastic Properties for Mesoporous Structures under Extreme Conditions

Opportunity

The mechanical properties of materials containing structures and pores with mesoscopic dimensions are of practical importance to the development of high-strength, low-weight materials. While the mechanical properties of constituent materials may be known, the mechanical properties of various nano/meso/microporous structures—including aerogels, foams, and engineered lattices—are relatively unexplored and the microscopic mechanisms determining the emergent strength of the bulk form are not well understood.

Approach

X-ray or neutron scattering techniques are appropriate for these kinds of measurements. Small angle scattering is appropriate for studying the pore sizes, diffraction for interatomic spacing and strain, and radiography for determining macroscopic dimensions. A challenge going forward is to establish the synchronous application of these techniques. The application of pressure would allow a continuous tuning of pore size and mechanical properties, providing a controlled environment to understand strengthening mechanisms in these mesoporous materials.

Meso Challenge

Dimensions of the structure, which can range from the nanometer to micrometer scale, affect the *effective* bulk elastic properties. Although strong, nanoporous materials have been reported, the dependences of mechanical properties on pore size, shape, and distribution are largely untested, as is the performance of such materials as a function of pressure, temperature, and chemical environments.

Impact

Knowledge of mechanical properties of mesoporous materials will be essential to basic understanding of the mechanisms responsible for strength. Complex, multi-scale modeling is necessary to computationally predict the behavior of mesoporous materials, and this characterization will provide essential benchmarks for the emergent strength of these materials, which is dependent on physical parameters that cover a wide swath of length scales from the atomic to the mesoscopic.

References:

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