METALLIC GLASSES AS ADVANCED STRUCTURAL MATERIALS: SYNTHESIS, FRACTURE STRENGTHS, AND TOUGHNESS

S. J. Poon

1Department of Physics, University of Virginia, USA

Alloys based on one or more of the refractory Fe, Co, Ni, Ta, and W elements form the strongest bulk metallic glasses (BMG). As noted in amorphous steel alloys, the ductility and toughness of metallic glasses can be improved by chemically tuning the elastic moduli and therefore the Poisson’s ratio. The latter material parameters are determined by the amorphous structure and chemical bonding. Mechanical characterizations are performed to obtain the hardness, fracture strengths, and toughness. Deformation behavior is interrogated on the microscopic level to understand intrinsic and extrinsic effects. A high-throughput approach based on effective medium model is developed to accelerate the selection of prospective metallic glass composition with potentially favorable intrinsic mechanical properties. By employing this search method, Ni-based BMG compositions with high absolute densities exceeding 11 g/cm³ were identified and synthesized via compaction of alloy powders using spark plasma sintering (SPS). Optimization of SPS via selection of sintering temperature, uniaxial load pressure, and powder radii ratios yielded samples with relative densities of nearly 100% and hardness values in excess of 12.5 GPa without cracking. This demonstrates the capability of SPS in the fabrication of high hardness and high density metallic glasses in large quantities.


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Presenting author’s email: sjp9x@eservices.virginia.edu