Superelastic Shape Memory Ceramic Particles
Technology #16922

Applications

Superelastic shape memory ceramics (SMCs) exhibit a combination of high strength, large recoverable strain, large energy damping, and are light weight. These features are useful as an energy-damping layer for armor systems or as an energy absorber for automobiles, sports equipment, and aerospace applications.

Problem Addressed

Zirconia has a well-studied martensitic transformation between tetragonal (austenite) and monoclinic (martensite) phases with associated shear strains of up to 16%. However, the mismatch stresses in the polycrystalline zirconia prevents the shape memory and superelastic behavior and induces brittle fracture failure in the material. This technology solves the cracking problem by creating small-volume ceramics with few crystals in particle form, such that they have a large free surface area and few grain boundaries to enable robust superelasticity properties.

Technology

SMC particles can be prepared in large scale by a solid-state sintering method modified with polymers containing rich aromatic rings, or a spray drying method. The crystal structure of the particles is controlled by using a fast sintering scheme and the particle size distribution is controlled by tuning the precursor viscosity, inlet temperature, and gas pressure. The resulting samples exhibit highly repeatable superelasticity with cycling over one hundred times at strains up to 7% compared to regular polycrystalline zirconia that cracks at strains of 1-2% and after only a few cycles. Additionally, these ceramics can withstand very large stresses (~0.5-3GPa) and reversibly damp mechanical energy up to ~40MJ/m$^3$, which is much higher than that of shape memory alloys, fiber-reinforced composites, or rubbers. The SMC particles can be used as a filler in composites with polymer, metal or ceramics as matrix to enhance their energy absorbance or used alone as a powder compact for impact energy damping. Figure 1 shows the working mechanism of the SMC particles.

Advantages

- Highly reliable and repeatable
- Up-scalable, time-saving, and cost-effective
- Enhances energy damping/absorbance efficiency

Categories For This Invention:

Materials
Micro & Nanotech
Shape Memory Alloy Structures
Intellectual Property:
Superelastic shape memory ceramic particles and the preparation therefore
PCT
2017-139706
Shape memory ceramic particles and structures formed thereof
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Publications:
Shape Memory and Superelastic Ceramics at Small Scales
Science
September 27, 2013
Granular Shape Memory Ceramic Packings
Acta Materialia
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External Links:
Schuh Group
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