TMS Submission

February 2011
San Diego, CA

Title
Temperature-Sensitive Shape Memory Polymer Based Acoustic Metamaterials

Abstract

Shape-memory polymer (SMP) acoustic metamaterials are dynamic composites containing local sonic resonators with variable stiffness coatings that change controllably as a function of temperature. The resonators absorb incident sound waves in specific frequency ranges. Modeling: we use multiple scattering theory to describe viscoelastic wave propagation through the composites to demonstrate negative effective mass density and a frequency band gap that moves with changing temperature. Sound transmission through the material is an order of magnitude less than predicted by the conventional mass-density law. Experimental: we synthesize several versatile acrylic SMP coatings around 5 to 15 mm lead and tungsten balls to create materials with tunable resonant frequencies. We can adjust the glass transition temperature (between about -20 ˚C and 80 ˚C) and stiffness in the rubbery regime (between about 300 KPa and 20 MPa). Dynamic mechanical analysis and impedance tube tests are used to confirm the predicted temperature-sensitive sound attenuation.

Form 1:

Abstract

Shape-memory polymer (SMP) acoustic metamaterials are dynamic composites containing local sonic resonators with variable stiffness coatings that change controllably as a function of temperature. Modeling: we use multiple scattering theory to describe viscoelastic wave propagation through the material to demonstrate negative effective mass and a moving frequency band gap as a function of temperature. Experimental: we synthesize several versatile SMP coatings around 5 to 15 mm lead and tungsten balls to create temperature-sensitive metamaterials that behave differently .

We can adjust the glass transition temperature (between about -20 ˚C and 80 ˚C) and stiffness in the rubbery regime (between about 300 KPa and 20 MPa) through synthesis of acrylate copolymers. Characterization: dynamic mechanical analysis and impedance tube tests are used to confirm the predicted band gap structure over a variety of temperatures (and thus stiffnesses). We create materials that attenuate specific frequencies at specific temperatures.