The anisotropic response of magneto-sensitive elastomer composites with permanently magnetized inclusions

P. Ponte Castañeda, L. Dorfmann and G. deBotton

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Abstract

Magneto-sensitive composites change their shape and properties in response to magnetic stimulation. Among the various classes of smart materials, in which non-mechanical excitation fields are used to induce mechanical deformations, the class of magneto-sensitive composites is an outstanding one. These composites undergo large deformations, extract large forces, their response time is short, they can be remotely activated, and their manufacturing is relatively simple. Consequently, they can be used in variety of applications such as switches, sensors, actuators and manipulators, vibration isolation, and energy harvesting devices. Moreover, the fact that permanently magnetized inclusions are available may result in a unique response, which is yet to be explored. However, the constitutive description of these materials, where geometrically nonlinear deformations of heterogeneous and anisotropic materials on top of inherently nonlinear magneto-mechanical coupling must be accounted for, is quite complicated.

We wish to exploit possible procedures and advance a framework for tackling the non-trivial aspects associated with magneto-sensitive composites. At the scientific level we will be using and developing modern homogenization techniques in the context of a most demanding application. The unique class of magneto-sensitive composites with permanently magnetized inclusions will be explored together with the role of the inclusions spatial arrangement. Analytical results will be compared with corresponding numerical simulations that incorporate simultaneous solutions of magnetic and elastic problems. The goal is to bring relevant data from the microscopic level up to the macroscopic one in terms of anisotropic energy-density functions that will be made available and implemented numerically for both the scientific and the engineering communities.

Keywords: Magneto-sensitive solids, Magneto elastic, Composites, Finite elasticity, Smart materials, Constitutive relations, Active materials, Magnetostriction