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Effect of particle shape on magnetic field-induced rubber-like behavior of Ni-Mn-Ga particles/silicone composites

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Abstract

Single crystal of ferromagnetic shape memory alloy, Ni-Mn-Ga, exhibits 6% of magnetic field-induced strain. Therefore, it is promising as the magneto-driven actuator material. However, the magnetic field or mechanical stress applied in the orthogonal direction is necessary to reset bulk single crystal into original shape. Ni-Mn-Ga particles/polymer composite is an alternative solution to avoid an application of the extra fields to single crystal supported by the concept of release of the accumulated stress in polymer matrix to trigger a reversible deformation of composite during removal of the magnetic field. The objective of this study is to clarify the effect of embedded particle shape on the recovery deformation of Ni-Mn-Ga particles/silicone composites by using finite element method (FEM) and to investigate local stress distribution in polymer matrix between spherical and rectangular shape particles so as to provide the guidelines for design/optimization of the magnetostrain active Ni-Mn-Ga particles/polymer composites. The case studies of simulation are divided into an isolated particle, a pair of particles which are positioned parallel and perpendicular to applied magnetic field direction. Simulation results reveal that in case of 200 μm of inter-particle distance in the pair of spherical particles aligned perpendicularly to the applied field, the polymer layer between particles generates 0.35 MPa of the recovery stress which is lower than stress concentration in matrix with rectangular particles, in similar condition and arrangement. Moreover, the stress concentration in matrix in the case of pair of spherical particles is lower than 0.4 MPa of isolated rectangular particle which is insufficient to restore the deformation of embedded Ni-Mn-Ga particles during removal of the magnetic field.

Keywords*:* Ferromagnetic shape memory alloys, Ni-Mn-Ga/polymer composites, Finite element method