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題目(和文)	Ni-Mn-Ga/シリコーン複合材料の巨視的および微視的変形挙動に関する研究
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論文要約

Since ferromagnetic shape memory alloy, Ni-Mn-Ga, exhibits 5.8% large magnetic field induced strain at high frequency response in martensitic phase of bulk single crystal, it is promising candidate of smart actuator materials. Nevertheless, the difficulty and time-consuming process of single crystal results in concerned issue of practical using. Ni-Mn-Ga/polymer composite is one of alternative solutions to this issue. To fabricate the composite, in this study, the brittleness at grain boundaries of Ni-Mn-Ga polycrystalline is enhanced by addition of bismuth and individual grains (hereafter referred to particles) are embedded in stiffness-match-matrix; silicone rubber, which soft enough to permit particles to deform by applied field. However, the apparent magnetostrain of composite is too small in ~ppm order.

In this thesis, an original idea of "interaction of particles" is proposed to be dominant cause of low apparent strain of composite. Interaction of particles originates from back stress generated by matrix during applied magnetic field to deform composite and results in difference in deformation of individual particles. Back stress in matrix is not in proportional to original matrix stiffness and depends on location. As a results, apparent effective stiffness and strain of composite changes. The dominant factors effected on back stress are particle configurations and inter-particle distance.

Since interaction of particles leads to different deformation of particles, firstly, the deformation of embedded particles is necessary to be clarified. Compression test is carried out to obtain high resolution of 3D images. Three cases of particle configurations; isolate, pair and group of particle, are selected. Isolated particle can deform as single crystal due to no nearest neighbor particles. However, deformation of particles in pair and group is suppressed due to particle interaction. As a results, it can be considered that matrix generates inhomogeneous stress field depending on local configurations.

Second, stress distribution in matrix is quantitatively determined by finite element method (FEM). Simulation cases are divided in stress and magnetic field applied to composite with one isolated particle and two configurations of particles; particles//field and particles⊥field. Isolated particle composite can deform as non-existence of nearby particle. The configuration of particles⊥field has strong interaction of particles due to stress concentration generated in matrix to constrain deformation of particles. Stress concentration decreases as inter-particle distance increases. However, particles//field has low interaction of particles due to no horizontal nearby particles. Therefore, matrix generates low stress concentration in particles//field. In conclusion, particles should align in chain with field applied parallel to chain to obtain large apparent magnetostrain of composite.

30vo% Ni-Mn-Ga/silicone composite is fabricated with particles aligned in chains to evaluate macroscopic deformation of composite under magnetic field. Composite exhibits large strain up to 3.8% and 1.7% of tensile and compressive strain, respectively, when 0.8T of magnetic field is applied perpendicular to chains. In addition, deformation of composite is reversible due to back stress generated in matrix after removal of magnetic field. This suggests the novel solutions for development of actuators using Ni-Mn-Ga/polymer composite

In summary, local configuration of particles and direction of applied field are the dominant factors resulting in inhomogeneous stress field in matrix and leading to the change in apparent strain of Ni-Mn-Ga/silicone composite. This original assumption is validated in this doctoral thesis by the evaluation of deformation of individual particles and stress distribution in matrix using X-ray μCT and FEM, respectively. The guidance to design deformable Ni-Mn-Ga/polymer composite to be used as magnetic driven actuators is proposed. Furthermore, large macroscopic strain of composite is demonstrated in this thesis. The design criteria obtained in this study could be valuable contribution to engineering field.