Effect of heat treatment on the magnetostrictive properties of giant magnetostrictive material with different volume fraction of RE phase

Jong Chul Kim*[1], Oh Yeoul Kwon[1], Do Hyung Kim and Zin Hyung Lee[1]

[1] Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology, 373-1, Guseong-Dong, Yuseong-Gu, Daejeon, 305-701, Korea

*Corresponding author: e-mail: forjckim@kaist.ac.kr, Phone: +82 42 869 3361, Fax: +82 42 869 3310

Abstract

Terfenol-D has giant magnetostriction at room temperature and produces comparable strains at considerably lower magnetic fields and these outstanding properties have been shown to offer a great potential for a variety of transducer and actuator applications.

It has been considered that the heat treatment of Terfenol-D above eutectic temperature significantly improved the magnetostrictive properties because of a relief or redistribution of residual stresses produced by localized melting near second phase. In this experiment, however, as the volume fraction of RE phase was increased up to 10 %, the second phase was extracted from the specimens during heat treatment, this behavior considerably affected the magnetostrictive properties. Therefore, we discussed the effect of heat treatment with different volume fraction of RE phase.

All specimens with different composition ($Tb_{0.3}Dy_{0.7}Fe_y$, y=1.4, 1.5, 1.7) were prepared by directional solidification and machined into a cylindrical shape. The heat treatment was preceded at 1000 ℃ for 3 hours in sealed quartz tube at 710 torr. It was shown that the maximum magnetostriction was increased according to increment of y value in as grown specimens, on the contrary the increment rate of magnetostriction was decreased with respect to increase of y value after heat treatment. It means that the effectiveness of heat treatment was improved as the volume fraction of RE phase increased. It is proposed here that the reason for this behaviour is due to the Young's modulus change of second phase. Specimens with containing RE phase could be regarded as a composite because the magnetic properties of Laves phase and RE phase were significantly different. According to the magnetostriction theory of composite[1], the magnetostriction depends on the volume fraction of second phase and its modulus, as both of which are increased, the magnetostriction is decreased. During heat treatment the second phase leaked out and pores substituted the site of second phase, consequently the Young's modulus was decreased. Therefore, the effects of volume fraction of second phase and the amount of extracted second phase on magnetostriction at heat treatment were estimated.

References

[1] Y. Chen et al., Appl. Phys. letters, 74(8) (1999) 1159.