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Effects of Particle Shape on Magnetostrictive Properties of Polymer-bonded Fe-Co Based Alloy Composites

KIST S. M. Na*, and S. H. Lim
Kyungsung Univ. K. H. Shin

Fe-Co 계 합금 복합체에서 분말 형상이 자기변형 특성에 미치는 영향

한국과학기술연구원 나석민*, 임상호
경성대학교 신광호

Introduction

Polymer-bonded composites of rare earth based alloys were reported to show good magnetostrictive characteristics both in static and dynamic conditions [1,2]. Compared with conventional transition metal alloys, rare earth alloys such as Terfenol-D possess a very large magnetostriction [3] but they are considered to be rather expensive for general applications. In this sense, transition metal alloys with a moderate magnitude of magnetostriction and a cheap material cost can find advantages over rare earth alloys in commercial applications. One important problem of polymer-bonded composites of transition metal alloys which needs to be addressed is a large shape anisotropy, if the particle shape is not properly controlled. This is because transition metal alloys have much higher saturation magnetization than rare earth alloys. The existence of a large anisotropy is of course harmful to magnetostrictive properties, particularly at low fields. It is therefore important to examine the effects of the particle shape on magnetostrictive properties. In this work, the spherical and flake-type powders are considered.

Experiments

Ingots of an arc melted $Fe_{36}Co_{62}Ge_2$ alloy were pulverized into coarse powders of several mm. These powders were then ball-milled for 8 hrs with a SPEX 8000 mixer/mill to obtain flake-type powders. Spherical powders of $Fe_{52}Co_{48}$ alloy were obtained by using an atomization technique. These powders were then mixed with a phenol-type binder, the amount of which was varied from 3 to 15 wt.%. The mixed powders were compacted at a pressure from 0.25 to 0.75 GPa. Composites with high mechanical strength were finally obtained by curing at 150°C. The shape of the composites was rectangular with dimensions 3.5 mm × 3.5 mm × 10 mm. Magnetostriction was measured by using a strain gage method with a maximum applied field of 4.3 kOe.

Results and Discussion

The results for the morphology of the present powders, which were observed by scanning electron microscopy, are shown in Fig. 1. It is clearly seen that, in the case of spherical powders, the size distribution is very uniform and the average particles diameter is approximately 125 ㎛. The size of flake-type powders is irregular but the thickness is rather uniform being in the range of 3~5 ㎛. A small shape anisotropy is expected in flake-type powders if in-plane field is applied. Furthermore, this flake shape has another advantage of increasing the packing density of composites if compaction is done suitably. X-ray diffraction results indicate that the microstructure of both powders consists of a single crystalline bcc phase. One important point to notice, however, is that, in case of flake-type powders, the surface is surprisingly parallel to the (200) crystallographic plane rather than the close-packed (110) plane. Although the reason for this unexpected observation is not clearly understood, this crystallographic texture is beneficial to magnetostrictive properties. This is because magnetostriction in the <100> directions (λ_{100}) is largest *and* the (200) plane has more <100> directions than the (110) plane. Specifically, there are four <100> directions in the (200) plane as principal axes whilst two <100> and two <110> directions in the case of the (110) plane.

Typical results for $\lambda_{||}$ (magnetostriction measured in the length direction) are shown in Fig.2 for the composites fabricated by using sperical and flake-type powders. Although direct comparison between the two results may not be possible, the alloy composition and fabrication parameters being not identical to each other, it is clear that the composites fabricated with flake-type powders exhibit much better magnetostrictive properties (particularly at low fields) than those fabricated with sperical powders. A magnetostriction of 103 ppm (at 4.3 kOe) obtained for flake-type powders is considered to be fairly large.

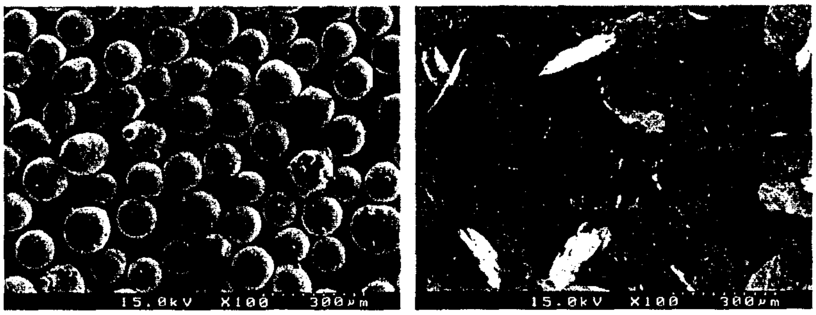

Fig. 1 The morphology of spherical and flake-type powders, observed by scanning electron microscopy

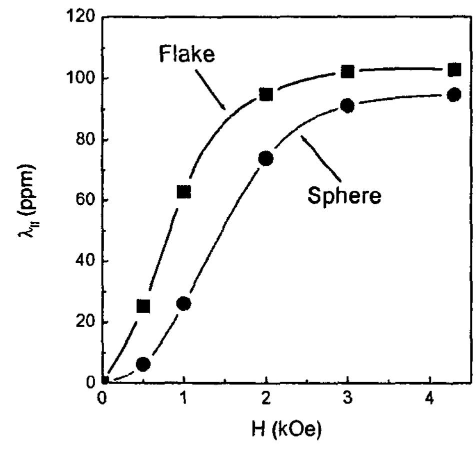

Fig. 2 $_{||}$-H plots of the Fe-Co based alloy composites

References

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