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INFLUENCE OF ION IMPLANTATION ON SURFACE MAGNETIC PROPERTIES OF AMORPHOUS Fe—B RIBBONS[1])

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The influence of N^+ implantation in as-quenched and preannealed $Fe_{85}B_{15}$ metallic glass was investigated by means of Kerr magnetooptical hysteresisgraph which gives information from an about 30—50 nm thick surface layer [1]. The implanted ions penetrate about 100—150 nm into the ribbon depending on the accelerating voltage. The coercive force of the surface layer depends significantly on the dose of the implanted N^+. The heat treatment before or after the N^+ implantation contributes to the change of the coercive force too.

I. INTRODUCTION

It has been recognized in recent years that the surface magnetic properties of metallic glasses play an important role in modifying the bulk magnetic properties [2, 3]. Surface crystallization and the stability of the amorphous phase after partial irradiation has also become a widely investigated subject. The work reported here was undertaken to examine the effect of N^+ implantation on the coercive force.

II. EXPERIMENTAL

All the samples we used were produced by the melt-spin method and had a thickness of about 40 μm. The amorphism of the samples was checked by X-ray diffraction. In order to eliminate the quenched-in stresses they were preannealed at $T = 150\,°C$ for 0.5 h in an Ar protecting atmosphere. The first batch of samples was irradiated by different doses after the preannealing treatment. The second batch of samples was annealed at higher temperatures before the implantation of a dose $\sigma = 10^{17}\,N^+/cm^2$ with N^+ ions in an N_2 protecting

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atmosphere for 0.5 h. The third batch of samples was annealed in an Ar protecting atmosphere for 0.5 h after implantation. The ions to be implanted were accelerated up to a 100 keV energy and the temperature during implantation was not higher than $T = 80\,°C$. The annealing temperature was always below the crystallization temperature of the $Fe_{85}B_{15}$ alloy [5].

III. RESULTS AND DISCUSSION

The H_c of the pre-annealed and N^+ implanted samples remains constant up to a dose of about $\sigma_0 = 4 \times 10^{16}\,N^+/cm^2$ (Fig. 1). Above σ_0 the coercive force increases significantly with the dose. According to X-ray and CEMS investigations α-Fe crystals were formed in the surface of these high dose implanted $\sigma > \sigma_0$ samples. There was no sign of a crystalline phase.

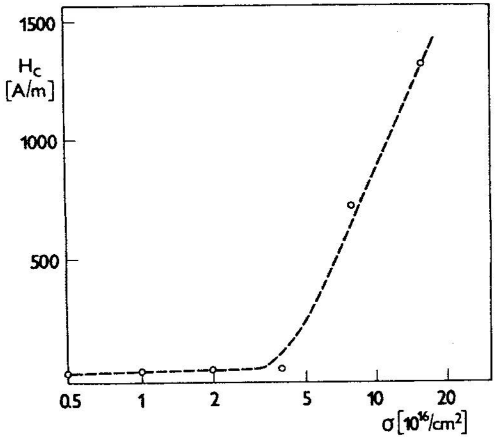

Fig. 1. Dose dependence of H_c. The pre-annealed $Fe_{85}B_{15}$ samples were implanted with $E = 100$ keV N^+ ions, $T_{impl} = 80\,°C$.

The increase of the H_c is attributed to the appearance of α-Fe microcrystals which inhibit the domain wall motion through magnetostriction. It is believed that this crystallization is caused by the decrease of the B-atoms concentration due to their preferred sputtering during the implantation. A crystalline Fe_3B phase could not be formed because it is continuously amorphised by the implanted N^+ ions.

Pre-annealings at higher temperatures cause also an increase in H_c which is relatively small up to $T = 390\,°C$ (Fig. 2). Although the N^+ implantation strongly enhanced the H_c of the sample surface layer, bulk investigation did not show any systematic difference between implanted and unimplanted samples.

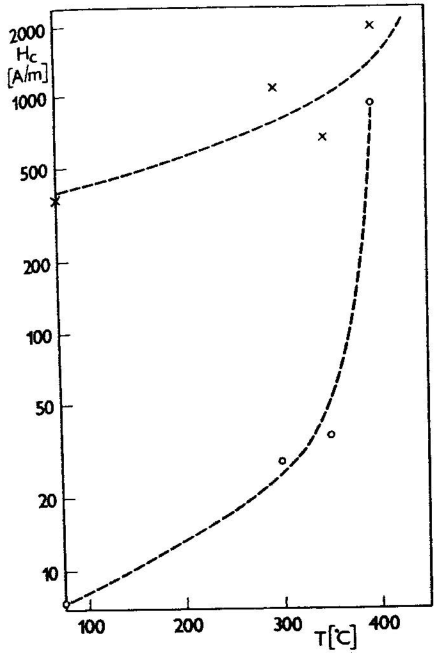

Fig. 2. ○ The effect of pre-annealing in N_2 protecting atmosphere on H_c, $t_{annealing} = 0.5$ h
× The effect of N^+ implantation on pre-annealed samples. $E = 100$ keV, $T_{impl} = 80\,°C$, $\sigma = 10^{17}\,N^+/cm^2$.

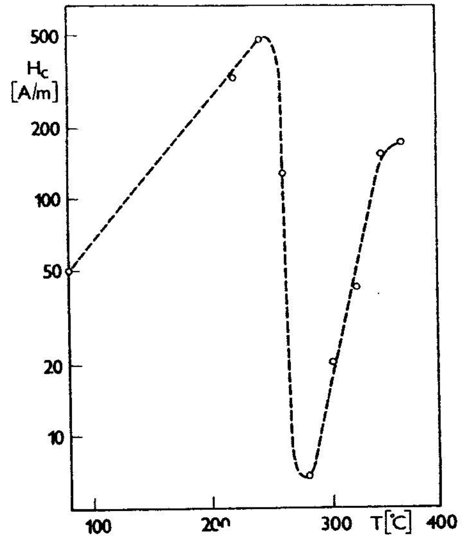

Fig. 3. The effect of annealing after implantation. The implantation parameters: $E = 100$ keV, $T_{impl} = 80\,°C$, $\sigma = 4 \times 10^{16}\,N^+/cm^2$, $t_{annealing} = 0.5$ h.

The effect of annealing after implantation can be seen in Fig. 3. At low annealing temperatures $T \lesssim 260\,°C$ and increased H_c can be seen with a maximum at $T \simeq 250\,°C$. Between 260 °C—320 °C H_c decreases with a minimum at $T \simeq 270\,°C$. Above $T \simeq 320\,°C$ the heat treatments increase H_c again. It is assumed that the implantation destabilized surface [4] and the annealing results in the redundant iron crystallizing into α-Fe and consequently in rising the H_c. At higher temperatures relaxation processes can also occur and they lead to the reduction of internal stresses.

The rising of H_c at temperatures $T > 270\,°C$ is attributed to pre-crystallization and to the influence of implantation.

IV. CONCLUSIONS

The increasing of H_c as an effect of N^+ implantation is attributed to α-Fe microcrystals formed in the surface above a certain dose. The implantation enhanced H_c can be effectively reduced by post-annealing treatments.

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ВЛИЯНИЕ ИОННОЙ ИМПЛАНАТАЦИИ НА ПОВЕРХНОСТНЫЕ МАГНИТНЫЕ СВОЙСТВА АМОРФНЫХ Fe—B ЛЕНТ

При использовании керровского магнитооптического гистерезиграфа [1] было исследовано влияние N^+ имплантации на $Fe_{85}B_{15}$ металлические стекла. Имплантированные ионы проникают только на глубину 100—150 nm в ленту, глубина проникновения зависит от ускоряющего напряжения. Поэтому влияние на коэрцитивную силу, обусловленное ионами, может быть изучено более точно, чем в объемных исследованиях. Наши исследования дают информацию из поверхностного слоя толщиной 30—50 nm.