TEMPERATURE DEPENDENCE OF RESISTIVITY IN AMORPHOUS Nd—Co—B THIN FILMS[1])

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Temperature dependences of resistivity in amorphous thin films prepared from the $Nd_2Co_{14}B$ compound have been studied in the temperature range from 77 up to about 775 K. The changes in resistivity and its temperature coeficient that reflect the structural relaxation and crystallization process of the amorphous metal are briefly reviewed. Thermally activated changes in the structure of the films are considered.

I. INTRODUCTION

Ternary rare earth-transition metal-boron compounds are of great interest as the high coercive field and very high energy product prefer them as materials for permanent magnets (e.g. [1]). On the other hand, their physical behaviour observed makes them very interesting from the scientific aspect [2]. Recently, studies of magnetic properties of thin films prepared in crystalline form [3] as well as in the amorphous one [4] from those compounds have been reported. The latter exhibits a strong dependence of its magnetic properties on heating.

In this paper we attempt to determine the state of the as-deposited film structure and its changes on annealing, on the basis of the heat treatment dependence of the resistivity and the temperature coefficient of resistivity (TCR).

II. METHOD

The amorphous thin films were prepared by flash evaporation technique in ultra-high vacuum of about 10^{-7} Pa, as described elsewhere [4]. Some of the samples were protected by a SiO layer immediately deposited.

The measurements on heating were performed in a vacuum furnace at about 10^{-4} to 10^{-6} Pa. The average heating rate was 3.5 K/min. Below room temperature the samples were measured in a LN-cryostat.

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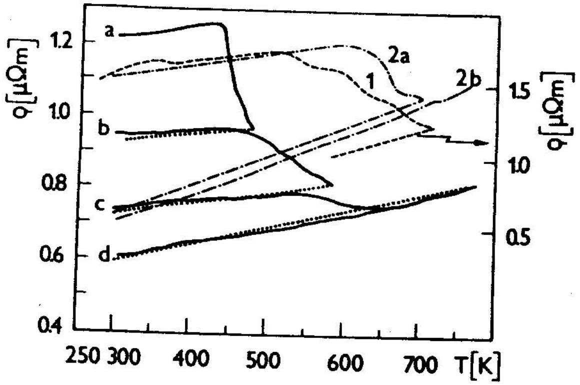

Fig. 1. Temperature dependences of resistivity: curves a, b, c and d represent sample No 1.1 on heating to 480, 575, 675 and 775 K, respectively; curves 1 and 2a, 2b represent samples No. 3.1 and 3.5.

Table 1

List of the resistivities a .d TCR's found at 77 and 300 K in as-deposited and heat treated amorphous $Nd_{12}Co_{82}B_6$ thin films.

Sample	treatment	$\varrho(77)$ [μΩm]	$\varrho(300)$ [μΩm]	$\alpha(77)$ 10^3[1/K]	$\alpha(300)$ 10^3[1/K]
1.1 $d = 50$ nm	as-deposited	—	1.22	—	0.24
	heated to 480 K	—	0.93	—	0.24
	heated to 575 K	—	0.72	—	0.59
	heated to 675	—	0.60	—	0.91
	heated to 775	—	0.58	—	1.22
1.5 $d = 50$ nm SiO coated	as-deposited	2.44	2.48	0.07	0.09
	heated to 480 K	—	2.23	—	0.30
	heated to 575 K	1.67	1.87	0.48	0.56
	heated to 535 K	—	1.82	—	0.63
2.5 $d = 17$ nm SiO coated	as-deposited	1.31	1.33	0.07	0.10
	heated to 475	1.23	1.26	0.08	0.16
	heated to 525	—	1.16	—	0.40
3.1 $d = 100$ nm	as-deposited	—	1.45	—	0.74
	heated to 750 K	—	0.71	—	1.23
3.5 $d = 100$ nm SiO coated	as-deposited	1.02	1.09	0.25	0.29
	heated to 475 K	—	1.11	—	0.35
	heated to 700 K	—	0.73	—	1.05
	heated to 760 K	—	0.65	—	2.53

III. RESULTS

In Fig. 1 representative temperature dependences of resistivity, $\varrho(T)$, are shown. The sample No 1.1 was heated gradually to 480 (curve a), 575 (b), 675 (c) and 775 K (d). The first strong drop in resistance began before it reached 450 K. In spite of the high reduction in ϱ, TCR remained constant (Table 1). The effects of further heatings are presented in Table 1. $\varrho(T)$ for the SiO coated sample No 3.1 (curve 1) is the same in character as for the sample No 1.1 but it is shifted towards higher temperatures. However, the final values of $\varrho(300)$ and $\alpha(300)$ are very close. This suggests that the structures of both as-deposited samples are the same and change similarly, though the samples differ in thickness.

The curve 2a, representing SiO coated sample No 3.5 is rather smooth. Up to 600 K there occurs no irreversible relaxation. In fact, this sample could have been exposed to a slight elevated temperature at previous magnetic measurements. During heating up to 700 K crystallization took place in the film. High TCR and the reversible curve 2b confirmed this supposition.

The ϱ dependence on T in the range of 77 to 300 K reveals a linear character.

IV. CONCLUSIONS

The study of temperature dependences of resistivity in amorphous $Nd_{12}Co_{82}B_6$ alloy thin films revealed that the as-deposited films are rather completely amorphous. The heating of those films caused a gradual irreversible structural relaxation the threshold temperatures of which may depend on the thickness and or of the SiO coating.

A previously relaxed sample exhibits only one decrease of resistance, above 600 K. This is certainly due to crystallization, confirmed by a very high rise in TCR. That effect suggests that simultaneously with relaxation the nuclei of crystallization arose as well.

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ТЕМПЕРАТУРНАЯ ЗАВИСИМОСТЬ УДЕЛЬНОГО СОПРОТИВЛЕНИЯ В АМОРФНЫХ Nd—Co—B ТОНКИХ ФИЛЬМАХ

В работе изучается температурная зависимость удельного сопротивления в аморфных тонких фильмах, приготовленных из $Nd_2Co_{14}B$ соединений в темпертурном диапазоне от 77° до 775° К. Рассматриваются изменения удельного сопротивления и его температурных коэффициентов, которые отражают структуральную релаксацию и процесс кристаллизации аморфных металлов. Учитываются изменения в структуре пленок, обусловленные температурой.