acta phys. slov. 36 (1986), No. 5

INFLUENCE OF THICKNESS ON MAGNETIC PHASE TRANSITIONS IN THIN DYSPROSIUM FILMS[1])

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Electrical resistance of thin dysprosium films has been studied in the temperature range from 4.2 K to 300 K. The decrease of the Néel temperature with decreasing thickness has been observed in these films of a thickness of 26 nm to 350 nm.

ВЛИЯНИЕ ТОЛЩИНЫ ТОНКИХ ДИСПРОЗИЕВЫХ ПЛЕНОК НА МАГНИТНЫЕ ФАЗОВЫЕ ПЕРЕХОДЫ

В работе исследуется температурная зависимость удельного электрического сопротивления тонких пленок из диспрозия в диапазоне температур от 4,2 K до 300 K. В интервале толщин 26 – 30 нм при уменьшении толщины пленок температура Нееля понижается.

I. INTRODUCTION

Dysprosium is a very interesting rare earth metal with two magnetic phase transitions [1]. Being paramagnetic at room temperature, it orders antiferromagnetically below the Néel temperature $T_N = 179$ K and ferromagnetically below the Curie temperature $T_c = 85$ K. The papers of Kaul et al. [2] and Cadim and Al Bassam [3] studied only the size effect of thin dysprosium films; mainly the papers [4, 5] dealing with some thin dysprosium films at low temperatures stimulated us to study the temperature behaviour of these films at low temperatures.

II. EXPERIMENTAL METHOD

Thin dysprosium films were prepared by vacuum evaporation of the bulk material (99.98 % pure) onto pre-cleaned glass substrates in a high vacuum coating

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[1]) Contribution presented at the 7th Conference on Magnetism, KOŠICE, June 5—8, 1984.

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unit with the vacuum $\sim 1.3 \times 10^{-4}$ Pa. They were protected by evaporation of a sufficient layer of SiO. Electrical contacts were made by evaporation of Ag onto glass substrates; thin silver wires were cemented in appropriate positions by means of silver paint DOTITE 550. The method of measuring temperature dependences of electrical resistance is described elsewhere [6, 7].

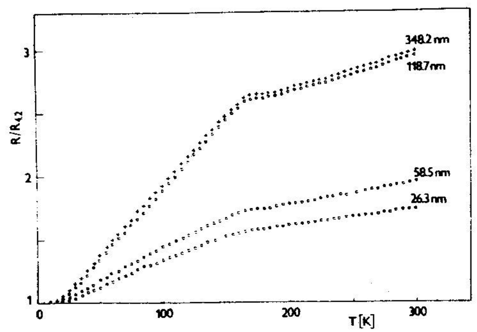

Fig. 1. Resistance ratio $R/R_{4.2}$ as a function of temperature for four thin films.

III. EXPERIMENTAL RESULTS AND DISCUSSION

We have studied thin dysprosium films in the thickness range from 26 nm to 350 nm. Four typical temperature dependences of the electrical resistance of these

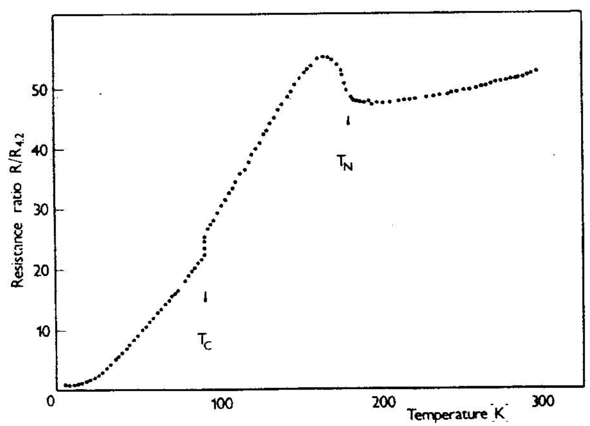

Fig. 2. Resistance ratio $R/R_{4.2}$ as a function of temperature for bulk dysprosium.

films are illustrated in Fig. 1. The temperature behaviour of the electrical resistance of bulk dysprosium is illustrated in Fig. 2 for comparison. Two magnetic phase transitions are clearly seen in this figure. The values of $T_c = 92 \pm 0.05$ K and $T_N = 180.5 \pm 0.05$ K were estimated using the mathematical method described in [8]. As we can see from Fig. 1 the onset of the antiferromagnetic spin ordering is less pronounced on thin films than on the bulk sample. The T_N values of our films estimated by the method [8] are shown in Fig. 3 as thickness dependence of T_N. Residual resistance ratio (RRR) of our films decreased with thickness from the value of 3.0 (for 348.2 nm) to 1.8 (for 26.3 nm); the bulk value of RRR was 52.

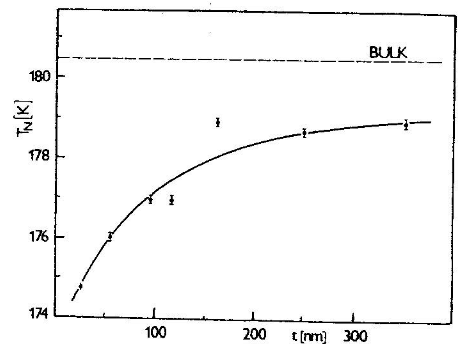

Fig. 3. Thickness dependence of the Néel temperature for dysprosium thin films.

The decrease of T_N with decreasing thickness was observed also in [4]. According to [9] the decrease of T_N could be explained by internal stresses arising in thin films during their preparation. Another possible explanation could be differences in the impurities in our Dy films. The authors [10] studied the electrical resistivity of bulk Dy samples and observed the lowest Curie point value for the sample with highest residual resistivity and vice versa. We have observed increasing residual resistivity with decreasing film thickness.

The antiferromagnetic to ferromagnetic phase transitions were not observed on our $R_{vs.}T$ dependences for thinner films (see Fig. 1). We conclude that the observed thickness behaviour of T_N of our thin dysprosium films could be explained by both above mentioned reasons.

ACKNOWLEDGEMENTS

The authors thank to Dr. Š. Jánoš for helpful discussions and to M. Fedorová and J. Jančíková for their help in some measurements.

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Received January 4th, 1985
Revised version received January 14th, 1986