acta phys. slov. 35 (1985), No. 4—5

THE INFLUENCE OF THE MAGNETIC FIELD ON THE THERMAL CAPACITY OF THE ALLOY $Gd_{1-x}Y_x$[1])

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The contribution presents results of experiments with temperature dependences of the specific heat of a Gd sample and of four samples of the alloy $Gd_{1-x}Y_x$ (for $x = 0.055$; 0.075; 0,102 and 0.22) in the temperature range from 4.2 to 40 K in the high magnetic field up to 3.5 T. The paper determines particular contributions to the thermal capacity of the above mentioned samples.

ВЛИЯНИЕ МАГНИТНОГО ПОЛЯ НА ТЕПЛОЕМКОСТЬ СПЛАВА ТИПА $Gd_{1-x}Y_x$

Экспериментально установлена температурная зависимость удельной теплоемкости образца из гадолиния и четырех образцов сплава типа $Gd_{1-x}Y_x$ (при $x =$ 0.555; 0,075; 0,102 и 0,22) в диапазоне температур от 4,2 до 40 K в сильном магнитном поле с индукцией, меньшей, чем 3,5 T. В работе определены также отдельные составляющие теплоемкости вышеуказанных образцов.

I. INTRODUCTION

The experimental study of specific heat was carried out on the sample acquired in the Physical-Technical Institute of Low Temperature of the Ukrainian Academy of Sciences in Kharkov.

The specific heat of the starting material Gd with different purities was studied and published in several papers [1—3]. The main part of impurities is created by Gd_2O_3, the contribution of which into the thermal capacity masks the effects associated with Gd of high purity in the liquid helium temperature range. The following samples, which were the object of our investigation contained the nonmagnetic ingredient of Y between 5.5 and 22 at. %.

[1]) Contribution presented at the 7th Conference on Magnetism, KOŠICE, June 5—8, 1984.
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All the samples were cut in rectangular shape of dimensions $2.5 \times 3.3 \times 25$ mm^3 and their mass kept within the interval between 1.450 and 1.875 g.

II. METHOD AND RESULTS

The temperature dependence of the thermal capacity was determined by a modified Nernst method, when the pulse-heated microcalorimeter was separated adiabatically from the surrounding environment and was enclosed in an isothermic cover. The thermal capacity is given by the relation $C_p = \Delta Q/\Delta T$, where ΔQ is the heating pulse in J and ΔT is the temperature increase in K, determined by extrapolation.

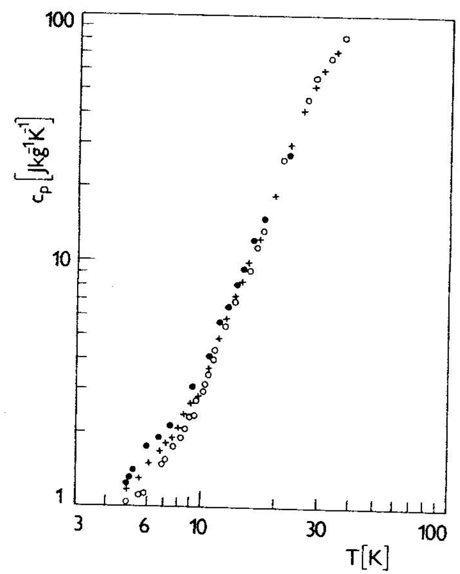

Fig. 1. Temperature dependence of the specific heat of the $Gd_{1-x}Y_x$ samples (● Gd, + $GdY_{0.102}$, ○ $GdY_{0.22}$).

In our case the microcalorimeter was placed in a stationary cryostat [4], the bottom of which, indluding the sample, was shifted into the hollow of a superconducting magnet mage by the Oxford Instruments. The calibrated Allen-Bradley thermometer of 270 Ω, 1/8 W was used as a temperature sensing device for the microcalorimeter.

Using the empirical formula [5] it was necessary to measure the temperature value respecting the dependence of the calibration characteristics of the Allen-Bradley sensor on the external magnetic field.

The graphical representation of the temperature dependences of the specific heat of the samples $Gd_{1-x}Y_x$ is shown in Fig. 1. The maximum relative error in the determination of the specific heat reached a value of 4 %.

III. DISCUSSION

First the thermal capacity of Gd_2O_3 was substracted from the thermal capacity of all the five samples [6]. The content of Gd_2O_3 in the sample was determined on the basis of an analysis to 0.5 %. Then we determined electronic and phonon contributions from the dependence C_p/T on T^2 to specific heat in the temperature interval 4.2 to 20 K. It means that the coefficients γ and β (Table 1) were specified from the known relation for the specific heat of metallic materials

$$C_p(T) = \gamma T + \beta T^3 .$$

The influence of the high magnetic field of the flux density 3.5 T was established in the sample $GdY_{0.22}$ and the given coefficients for the temperature dependence of specific heat are $\gamma = 13.4$ mJ/mol K^2 and $\beta = 0.314$ mJ/mol K^4.

Table 1

Electronic and lattice specific heat coefficients for the alloy $Gd_{1-x}Y_x$

sample	γ [mJ/mol K^2]	β [mJ/mol K^4]
Gd	23.5	0.363
Gd $Y_{0.055}$	23.2	0.315
Gd $Y_{0.075}$	21.4	0.328
Gd $Y_{0.102}$	16.5	0.341
Gd $Y_{0.22}$	12.7	0.309

Judging from the obtained results it is possible to deduce that the differences in thermal capacity between the measurement in the magnetic field and outside the magnetic field in the temperature region 4.2 to 20 K are statistically unimportant and occur in the range of measurement errors.

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Received October 30th, 1984
Revised version received December 21th, 1984