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CALORIMETRIC STUDIES OF SUPERCONDUCTING $(La_{1-x}Th_x)NiC_2$ ($x = 0.1$–0.9)

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Heat capacity measurements between approximately 0.4 and 12 K have been carried out on $(La_{1-x}Th_x)NiC_2$ ($x = 0.1$–0.9) as an extension to an earlier study on the superconducting transitions in this Ni-containing system. The transition temperature T_c values corroborate with the previous results from electrical and magnetic measurements. The thermodynamically-based calorimetric data further assure the bulk nature of the observed transitions, even though the highly-reactive-thorium-induced minor phases in the samples cause difficulties in deriving the electronic heat capacity coefficient γ. A T_c peak of 7.9 K near $x = 0.5$ is suggested phenomenologically to be at least partly due to the minimum in inter-planar lattice parameter c of the orthorhombic structure. © 1997 Elsevier Science Ltd

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1. INTRODUCTION

Following an earlier work on $LaNiC_2$ [1] Lee and Zeng [2] have reported recently superconducting transitions in a series of pseudoternary $(La_{1-x}Th_x)NiC_2$. The fact that superconductivity prevails in these compounds as well as in several R–Ni-borocarbides (R = Y or rare earth) opens an interesting area for research, since Ni usually has an adverse effect on the occurrence of superconductivity. Experimentally, the arc-melted samples used by Lee and Zeng [2] were characterized by electrical resistance and magnetization measurements. Realizing the strong reactivity of thorium with the environment, its inclusion in the samples raises concern over the interpretation of experimental data from such measurements. In general, electrical measurements are vulnerable to small amounts of superconducting minor phase, which could form a continuous network at grain boundaries leading to a zero resistance, while magnetic measurements are susceptible to the shielding effect. In contrast, thermodynamics-based calorimetry is recognized generally as the only conclusive technique in determining the bulk nature of an observed superconducting transition. Consequently, this report describes the heat capacities of the $(La_{1-x}Th_x)NiC_2$ series ($x = 0.1$–0.9).

2. EXPERIMENTAL

A thermal-relaxation micro-calorimeter was employed on mg-size specimens cut from the samples used in the previous work of Lee and Zeng [2]. For measurements between approximately 0.4 and 12 K, each specimen was thermally anchored to a tiny sapphire chip on which thin films of germanium and nickel-chromium alloy were deposited to serve as temperature sensor and Joule heating element, respectively. Temperature scale was based on a precalibrated germanium thermometer. The chip was thermally linked by four Au–Cu alloy wires to a temperature-regulated copper block. Following each heat pulse, the specimen temperature relaxation rate was monitored to yield the time constant τ. The heat capacity value was then calculated from $C = k\tau$, where k is the thermal conductance of the Au–Cu wires. The heat capacity of the sapphire disk with attached thermometer and heater was separately measured for addenda correction.

3. RESULTS AND DISCUSSION

The experimental data in terms of C vs T are shown in Fig. 1. Superconducting transitions are recognizable in