Magnetic and Superconducting Properties of $R_{1-x}Nd_xNi_2B_2C$ (R=Y and Er) Systems

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Abstract

We investigated Nd concentration dependence of the superconducting transition temperature, T_C, and magnetic transition temperature, T_N, for the $R_{1-x}Nd_xNi_2B_2C$ (R=Y and Er) systems. T_C and T_N curves against x for the R=Er system cross over at the substitution concentration x ∼0.165, for which T_N = 5 K, but T_C could not be observed. In the meanwhile, T_C and T_N curves for the R=Y system did not cross over. The phase diagram, (T_C, T_N) against Nd concentration x, for the $R_{1-x}Nd_xNi_2B_2C$ systems are given and discussed.

Key words: magnetism and superconductivity, borocarbite

1. Introduction

The recent discovery of superconductivity in borocarbide intermetallic compounds YNi_2B_2C[1] [2] and RNi_2B_2C (R=Lu, Tm, Er, Ho, and Dy)[3] has attracted a great deal of attention because of the coexistence of superconductivity and local magnetic moment ordering. Thus, one can expect an interesting intersecting point between the superconducting transition temperature, $T_C(x)$, and the magnetic ordering temperature, $T_N(x)$, curves at some Gd or Nd concentration, x_C, in $R_{1-x}R'_xNi_2B_2C$ (R=Y and Er, R'=Gd or Nd) system. Schmidt and Braun [4] investigated the superconductivity and magnetism in the system $R(Ni_{1-x}Co_x)_2B_2C$. According to them, $Er(Ni_{1-x}Co_x)_2B_2C$ system the most interesting feature is the fact if T_C reaches the temperature range of the antiferromagetic transition T_N=5.8K, reentrant behavior occurs similar to that observed in $HoNi_2B_2C$. Cao *et al.* investigated the reentrant behavior in $Ho_{1-x}Nd_xNi_2B_2C$ system. They pointed out that the Nd substitution for Ho in $Ho_{1-x}Nd_xNi_2B_2C$ has the similar effect to break Cooper-pairs as the magnetic field does [5]. Mori *et al.* investigated the phase diagram,(T_C, T_N) against Gd concentration, x, for $Tm_{1-x}Gd_xNi_2B_2C$ system[6]. T_C, T_N and T'_N curves cross over at the substitution concentration x=0.23, for which T_C=3.7 K. But T_N and T'_N have been suppressed.

In this study, we report the variations of T_C and T_N against x in the $Y_{1-x}Nd_xNi_2B_2C$ and $Er_{1-x}Nd_xNi_2B_2C$ systems. Thereby we study the coexistence of superconductivity and magnetic order and the interaction between them.

2. Experimental

Polycrystalline samples of $Y_{1-x}Nd_xNi_2B_2C$ (x=0∼1) and $Er_{1-x}Nd_xNi_2B_2C$ (x=0∼0.2) were prepared by a standard arc melting method using a tungsten electrode under an argon atmosphere. Thus obtained samples were examined by powder X-ray diffraction experiment (XRD) and almost shown the single phase. The samples were cut to rectangular for measurements of electrical resistivity and were measured using

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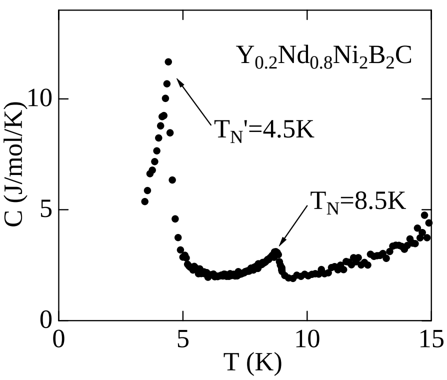

Fig. 1. Specific heat, C, *vs*. temperature for the sample of $Y_{0.2}Nd_{0.8}Ni_2B_2C$.

a standard four-probe technique in the temperature range from 1.8 K to 280 K, and the magnetization measurement was done using a Quantum Designed superconducting interference device magnetometer (SQUID) in the temperature range from 2 K to 300 K. The specific heat was measured by an adiabatic heat-pulse method in the temperature range from 3 K to 15 K.

3. Results and discussion

Figure 1 shows the specific heat variation against temperature for the sample of $Y_{0.2}Nd_{0.8}Ni_2B_2C$. As can be seen in Fig. 1, two magnetic transition peaks are found at $T_N = 8.5$ K and $T'_N = 4.5$ K. T_N and T'_N were also found in the measurement of the magnetization. T_C, T_N and T'_N as a function of Nd concentration, x, in $Y_{1-x}Nd_xNi_2B_2C$ (x=0∼1) were determined by the electrical resistivity and the magnetization measurements, which are shown in Fig. 2, where the dot lines are guides to the eye. The superconductivity is greatly depressed by Nd substitution and magnetic ordering is also depressed by increasing Y concentration. The interesting point is in the concentration range from x=0.4 to x=0.5, where the superconducting and the magnetic ordering states do not appear but the paramagnetic state. It was not found that both superconducting and magnetic ordering transitions simultaneously occur at the same temperature.

Figure 3 shows the phase diagram of T_C and T_N against Nd concentration, x, in $Er_{1-x}Nd_xNi_2B_2C$ (x=0∼0.2). T_C decreases with increasing x, indicating that superconductivity is depressed by Nd substitution for Er. T_N also decreases with increasing x, but the values of T_N did not change so much. T_C curve intersects with T_N curve around $x \sim 0.165$. T_N was observed but T_C was not observed for the sample of x = 0.165 and 0.175. In the case of $Tm_{1-x}Gd_xNi_2B_2C$ [6], T_C curve intersects with T_N curve at x=0.23, at which T_C was observed but T_N was not observed.

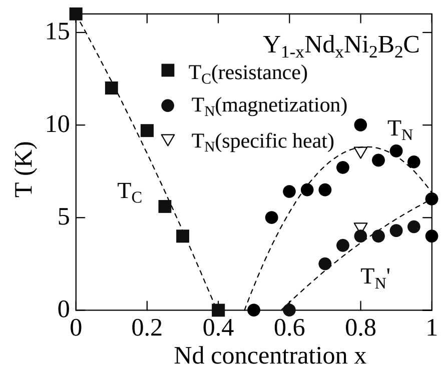

Fig. 2. Phase diagram of T_C, T_N and T'_N against x for $Y_{1-x}Nd_xNi_2B_2C$ system.

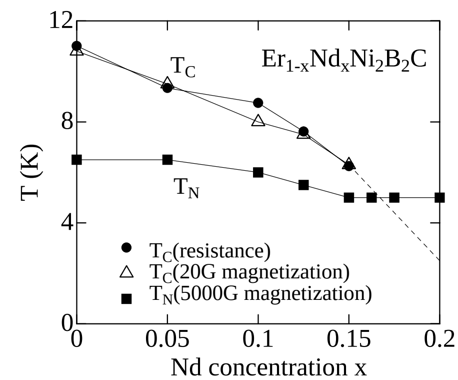

Fig. 3. Phase diagram of T_C and T_N against x for $Er_{1-x}Nd_xNi_2B_2C$ system.

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