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Syntheses of new rare-earth rhodium borocarbides

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Abstract

Single crystals of a new quaternary compound, $ErRh_2B_2C$, were obtained by the flux growth method using molten copper as a flux. The extracted crystals show golden-coloured luster and a maximum size of approximately $1 \times 1 \times 0.02$ mm^3. This compound has tetragonal symmetry and appeared to be a derivative of the $ThCr_2Si_2$-type; the lattice parameters are $a = 0.36848(2)$ nm and $c = 1.05520(3)$ nm. The electrical resistivity parallel to the a-b plane of the crystal decreases with decreasing temperature. The residual resistance ratio ρ (273 K)/ρ (1.5 K) is 1.38. No superconductivity was observed down to 1.5 K. The search for similar types of new compounds was performed using the arc-melting synthetic method. The new quaternary RRh_2B_2C compounds are obtained for R = La − Er (except Eu) and Y. The phase stability of RRh_2B_2C was discussed.
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Keywords: $ErRh_2B_2C$; $ThCr_2Si_2$-type compound; Single crystal; Flux growth; Electric properties

Introduction

Studies have accelerated on R-M-B-C (R = rare earth element, M = transition element), encouraged by reports on borocarbides composed of four elements such as Y−Ni−B−C and Y−Pd−B−C; these compounds show high superconducting transition temperatures [1,2]. Although it is recognised that there are many interesting compounds among such quaternary systems in terms of the coexistence of magnetism and superconductivity, etc., efforts to systematically search for such compounds still seem to be insufficient.

This study is an attempt to synthesise new borocarbides in the system of Er−Rh−B−C using a molten metal flux growth method and aims to synthesise compounds directly as single crystals. As a result, the new compound $ErRh_2B_2C$ is obtained. The crystal

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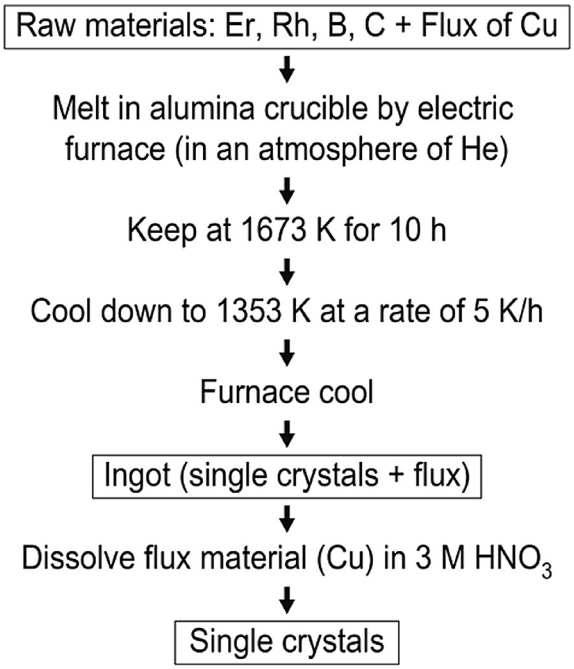

Fig. 1. The growth procedure of the single crystals of quaternary borocarbide in the Er–Rh–B–C system by the flux method using molten Cu as a flux.

structure and electronic properties of the new compound are analysed extensively using the arc-melting synthetic method. The phase stability of the new borocarbides is determined.

Experimental details

The materials used in the flux growth experiment were erbium (block, 99.9% pure), rhodium (powder, 99.96%), boron (agglomerate, 99.86%) and carbon (block, 99.999%). For one weight part of each solute, 10 weight parts of Cu (block, 99.999%) were used as a flux. The mixture of the solute and flux was placed into a high purity alumina crucible. Purified He gas flowed into the furnace at a rate of 200 mL/min and protected the atmosphere against oxidation. The mixture of the raw materials and flux was heated to 1673 K at a rate of 400 K/h and was held at that temperature for 10 h. The solution was cooled to 1353 K at a rate of 5 K/h and then furnace cooled. The extracted crystals were separated by dissolving Cu in dilute nitric acid. Fig. 1 shows the growth procedure of the single crystals of the quaternary borocarbides in the Er–Rh–B–C system by the flux growth method using molten Cu as a flux. Fig. 2 shows the schematic arrangement of the growth apparatus and vertical temperature distribution of the solution. To search for new compounds, arc-melting syntheses were carried out. The starting materials for the arc-melting syntheses were lanthanide metals (block, 99.9%), rhodium (powder, 99.9%), crystalline boron (powder, 99.86%) and carbon (powder, 99.999%). These elements were mixed in an atomic ratio of 1: 1: 1: 1, 1: 2: 2: 1 and 1: 3: 3: 1 and were arc-melted under a 1 atm argon atmosphere on a water-cooled copper hearth. The solidified button was

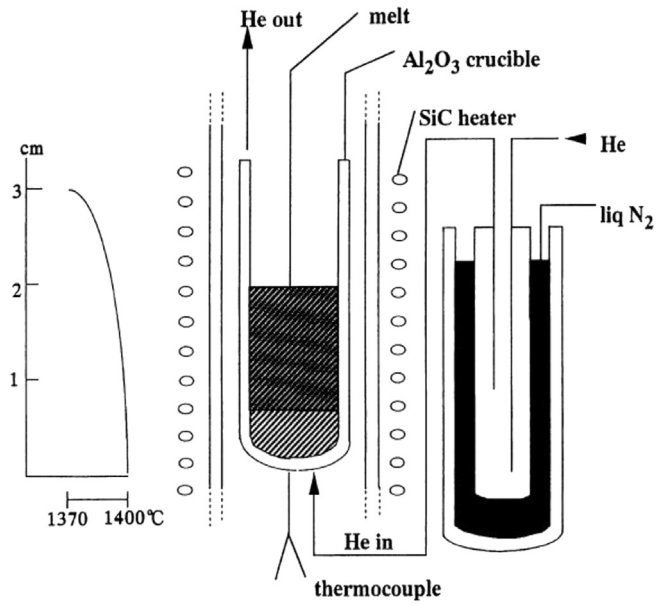

Fig. 2. The geometrical arrangement of the growth furnace and vertical temperature distribution of the solution.

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