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Superconducting and Normal State Properties in the Ternary Silicide NbIrSi, TaIrSi and NbPtSi

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Abstract

The polycrystalline NbIrSi, TaIrSi and NbPtSi with an orthorhombic structure (space group *Pnma*) were synthesized by an arc-melting method. Electrical resistivity $\rho(T)$ measurement in three compounds were performed from 0.28 to 300 K. $\rho(T)$ of NbIrSi indicates typical metallic behavior with no superconducting transition down to 0.28 K. Superconducting-like behavior is observed around 0.5 K in TaIrSi, but zero resistivity cannot be observed down to 0.28 K. $\rho(T)$ of NbPtSi shows superconductivity at 1.24 K. From $\rho(T)$ in several magnetic fields, the upper critical field $\mu_0 H_{c2}(0)$ of NbPtSi is obtained to be 1.15 T.

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Keywords: NbIrSi; TaIrSi; NbPtSi; superconductivity

1. Introduction

The ternary equiatomic compounds *TrTr*'X(*Tr*, *Tr*' = transition metals; X = P, As, Si) are known as a group of superconductors with relatively high superconducting transition temperature T_c (ex. MoRuP, T_c = 15 K) [1]. These compounds crystallize in two structures; a hexagonal-Fe_2P structure and an orthorhombic-Co_2P structure. Previous reports show that *TrTr*'X compounds with the hexagonal structure generally have much higher T_c (T_c > 10 K) than

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those with an orthorhombic structure (T_c < 5 K) [2-4]. However, ternary rhodium silicide ZrRhSi [5] shows superconductivity at T_c = 10 K even in an orthorhombic structure. The report makes us motivated to discover a new high-T_c superconductor among *TrTr*'X compounds with an orthorhombic structure. Recently, we discovered a new superconductor of TiIrSi (T_c = 1.3 K) with an orthorhombic structure [6]. We expect to discover a new superconductor among Ir-based compounds. In addition, because TaPtSi is known as superconductor with T_c = 3.5 K with the orthorhombic structure [7], we also focus on Pt-based compounds to discover a new superconductor.

In this study, we performed the electrical resistivity $\rho(T)$ measurements of polycrystalline NbIrSi, TaIrSi and NbPtSi. We observed gradual decrease around 0.5 K in $\rho(T)$ of TaIrSi, and superconductivity at T_c = 1.24 K in $\rho(T)$ of NbPtSi. The upper critical field $\mu_0 H_{c2}(0)$ of NbPtSi is obtained to be 1.15 T.

2. Experimental Details

Polycrystalline samples of NbIrSi, TaIrSi and NbPtSi were synthesized by an arc-melting method. A stoichiometric composition of 1 : 1 : 1 = Nb (99.9%, grain) / Ta (99.9%, wire) : Ir (99.9%, powder) / Pt (99.9%, wire) : Si (99.999%, bulk) was melted by an arc-furnace in argon atmosphere on a water-cooled-copper hearth. The ingots were turned over and remelted several times to ensure homogeneity. The obtained samples show metallic luster.

The crystal structure of polycrystalline samples was examined by the powder X-ray diffraction (XRD) using conventional X-ray spectrometer equipped with Cu Kα radiation and a graphite monochrometer (RAD-2X, Rigaku). The intensity data were collected over a 2θ range of 10 - 90° with a step width of 0.01° at room temperature.

Temperature dependence of electrical resistivity $\rho(T)$ was measured by a standard dc-four-terminal method with a current source (Model 6221, Keithley) and a nano voltmeter (Model 2182, Keithley) from 0.28 to 300 K using a ^{3}He refrigerator (Heliox-VL, Oxford Instruments) equipped with a superconducting magnet (Oxford Instruments). Electrical leads were made by gold-wires (ϕ = 25 μm) spot-welded to a polished surface of the specimen.

3. Results and Discussion

3.1. X-ray Diffraction

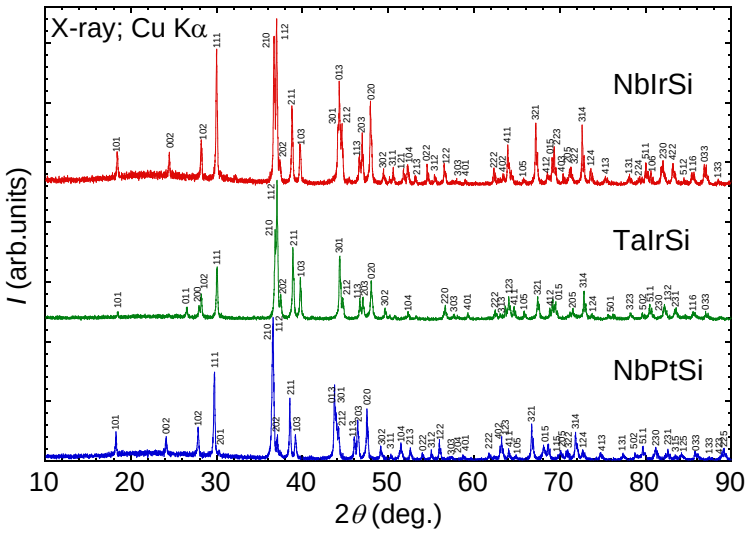

Fig. 1. Powder X-ray diffraction patterns of NbIrSi, TaIrSi and NbPtSi at room temperature.

Figure 1 shows powder-XRD patterns of the polycrystalline NbIrSi, TaIrSi and NbPtSi. The obtained patterns can be indexed as an orthorhombic structure of the space group of *Pnma*. Impurity phase is not detected in the