Electronic Structure of Condensed Matter

Electronic states of Cu-3d electrons in concentrated amorphous Gd-Cu alloys

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Introduction

The Cu metal seems to have played sometimes fascinating and important roles in solid state physics. Over 30 years long-term’s research of Rare Earth (RE)-Transition metal (TM) alloys, the Cu metal has lured the researchers to use it in order to isolate the magnetic exchange interaction of RE alone [1]. The magnetic isolation of RE can provide a clear clue to understanding the role of magnetic electrons of RE (4f, 5s, 5d and 6s). However, these attempts do not seem to have born fruitful information about the electronic states of RE, since the sample in Cu-rich content did not saturate and showed spin-glass like behavior.

In 1994, Tanaka et al. have tried to elucidate the electronic states of Cu and Gd for Gd₆₇Cu₃₃ amorphous alloy [2, 3] by means of magnetic Compton profile (MCP) method [4] and have found that the magnetic moment of the sample was described dominantly by that of 4f electrons of Gd and that the contribution of spin-polarization of s, p-like electrons was more suppressed than that of pure Gd metal.

In this report, for the Gd-Cu samples in much richer content of Gd, we examine mainly the effects of strong molecular field from Gd upon Cu-3d electrons employing the MCP measurement.

Experimental

The amorphous alloys of GdₓCu₃₀₋ₓ (x=67, 70 at%) were quenched from the melt employing a single roller system. The MCP measurements were carried out at the AR-NE1 beamline. Circularly polarized X-rays emitted from an elliptical multi-pole wiggler were monochromatized and focused on the sample by a single channel-cut bent Si crystal. The energy of incident X-rays were tuned to be 135 keV in order to avoid the effects of some kinds of fluorescence and to obtain a good quality of MCP signals. The sample was cooled by a closed-type refrigerator and the temperature of the sample was held to be 10K and 110K. The magnetic field applied on the sample was 1 Tesla and partly 2 Tesla for 110K, which are large enough to saturate the sample. The Curie temperature of the sample was about 145K.

Results and Discussion

Figure 1 shows the experimentally obtained MCP of amorphous Gd₆₇Cu₃₃ alloy at 10K under the magnetic field of 1 Tesla, together with the calculation result. The open circles are the experimental results and the solid line is the calculated MCP of atomic 4f electrons of Gd employing the relativistic Hartree-Fock method [5]. The most parts of experimental results of MCP (Pz>2.5) can be described by the calculated 4f electrons of Gd and this result shows that the 3d electrons of Cu does not contribute to the magnetic moment of the sample and are magnetically inactive.

References


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Fig. 1. Magnetic Compton Profile of Gd₆₇Cu₃₃ amorphous all

The open circles are the experimental results and the solid line calculated result for 4f electrons of Gd.