Investigation of Ni magnetic moment in Ni_2Gd Laves phase through MCP

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Introduction

Vast amounts of papers have been published in the investigation of magnetic properties of transition metal-rare earth (TM-RE) alloys in both crystalline and non-crystalline ones. Through every side of investigation, many interesting results were discovered and some important pictures have been established. One of these pictures is the vanishment of magnetic moment of the Ni when the RE content increases and reaches to the Laves phase[1]. However there have been no decisive evidences for this phenomenon. If the Ni possesses a magnetic moment of about 0.2 (μ_B) which corresponds to the value of Ni magnetic moment of Ni_3Gd, the Ni_2Gd behaves like a ferromagnetism and shows such as Curie Weiss law since the Gd magnetic moment is predominantly greater than that of the Ni. The assumption that the Ni retains a magnetic moment is consistent with the ever-known experimental facts. In this report, we examine whether the Ni does retain a magnetic moment or not in the Ni_2Gd Laves phase through the magnetic Compton Profile (MCP) [2].

Experimental

The polycrystalline Ni_2Gd Laves phase was prepared from Gd metal of 99.9% purity and Ni metal of 99.999% purity by arch-melting under an Argon atmosphere. The ingots obtained were annealed for three days at 900 degrees and X-ray powder diffraction at room temperature showed only reflections of a cubic C15 $MgCu_2$ type crystal structure. The obtained ingots consisted of fairly large single crystalline grains, which shows the high quality of these polycrystalline samples.

The MCP of the Ni_2Gd was measured at the AR-NE1 beamline. Circularly polarized X-ray from an elliptical multi-pole wiggler was monochromized and focused by a single channel-cut bent Si crystal. The energy of incident X-ray employed was 135 keV. The magnetization direction of the sample was reversed applying magnetic field of 1T by a superconducting magnet and the sample was cooled at 30K during the measurement.

Results and Discussions

The experimental results of the MCP obtained are shown in Fig.1 together with the analytical ones. The open circles are the experimentally obtained MCP data and the experimental ones apparently seem to be the MCP of 4f electrons of Gd calculated by Biggs et al [3]. The fitting of the calculated MCP of 4f electrons to the experimental one was carried out in the region of $|P_Z| \geq 5$ (solid line) since the MCP of 3d electrons of Ni (dotted line) [3] can affect on the profile of the experimental result in $|P_Z| \leq 5$. From the figure, it can be seen that the calculated MCP of 4f electrons of Gd fails to reproduce the experimental result. In order to explain this discrepancy, the calculated MCP of 3d electrons of Ni was taken into consideration. Considering that the magnetic structure of Ni-Gd system is ferrimagnetism [4], we subtract the MCP of calculated 3d from that of 4f. The result is shown in the figure by the one dotted line and it can reproduce the experimental result fairly well in $|P_Z| \geq 2$. The gap in $|P_Z| \leq 2$ corresponds to the s, p electrons contribution. This result implies that the Ni does retain the magnetic moment even in the concentration of Ni_2Gd Laves phase.

References

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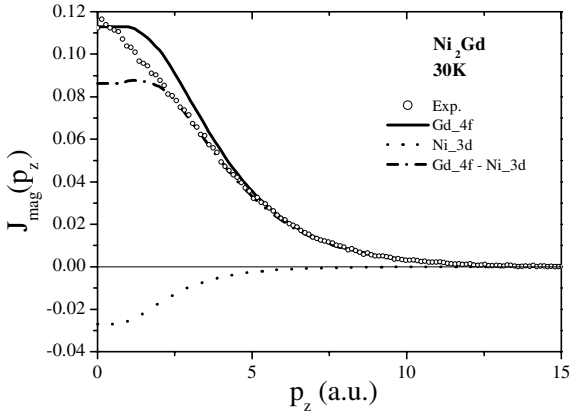

Fig.1 The MCP of Ni_2Gd Laves phase at 30K. Open circles are the experimental results and the solid, dotted and one dotted lines are the calculated 4f of Gd, 3d of Ni and subtracted MCP.

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