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Mössbauer study of iron ordering in mixed valence system $LuFe_2O_4$

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Single crystalline $LuFe_2O_4$ was grown by the floating zone method. The crystallographic and magnetic properties of the sample were measured using x-ray diffractometer (XRD), Mössbauer spectroscopy, and vibrating sample magnetometer (VSM). The crystal structure was found to be a two-dimensional layered-type rhombohedral with space group *R3-mh*. The magnetic Curie temperature (T_C) was determined to be 250 K from the *M-T* curve and Mössbauer spectra. Just below T_C, the magnetic moment has large value and shows a abrupt change in *M-T* curve. The Mössbauer spectra have been taken at various temperatures ranging from 4.2 to 370 K. We confirmed that the charge ordering of Fe^{3+} and Fe^{2+} ions was begun below 350 K, magnetic superstructure of the different ionic state was formed around 320 K. The isomer shift value of Fe^{2+} doublet increases with decreasing temperature from 320 to 235 K. At low temperature, Mössbauer spectra consisted of four sextets with magnetic ordering.

1 Introduction

$LuFe_2O_4$ belongs to a class of layered materials, generally expressed by RFe_2O_4 (R: rare earth metal) [1]. $LuFe_2O_4$ has shown charge ordering on triangular plane, spontaneous polarization, and sequential phase transition scheme associated with the charge ordering in the mixed valence system [2–4].
It is noted that the average valence of Fe ion is $Fe^{2.5+}$, which means Fe^{2+} and Fe^{3+} ions occupy the equivalent hexagonal site with equal density. N. Ikeda et al. [5] reported that the effect of spontaneous polarization was observed in $LuFe_2O_4$ by the ordering of the Fe^{2+} and Fe^{3+} ions. They form a superstructure with the magnetic spin ordering that supports an electric polarization, consisting of distributed electrons of polar symmetry.

In this paper, we have studied properties of $LuFe_2O_4$ by the x-ray diffraction (XRD), the temperature dependence of zero-field cooled magnetization curves, and the Mössbauer spectroscopy measurements.