Ferromagnetism in $^{57}$Fe-doped cupric oxide

Young Ran Park¹, Kwang Joo Kim¹*, Seung-li Choi¹, Jung Han Lee¹, Hee Jung Lee¹, Chul Sung Kim², and Jae Yun Park³

¹ Department of Physics, Konkuk University, Seoul 143-701, Korea
² Department of Physics, Kookmin University, Seoul 136-702, Korea
³ Department of Materials Science and Engineering, University of Incheon, Incheon 402-749, Korea

Received 11 May 2007, revised 18 October 2007, accepted 18 October 2007
Published online 12 December 2007

PACS 75.30.Hx, 75.50.Pp, 76.80.+y

Ferromagnetic properties were observed at room temperature for $^{57}$Fe-doped cupric oxide (CuO) film and powder samples. Mössbauer spectroscopy measurements on the Fe$_{0.02}$Cu$_{0.98}$O samples revealed that the octahedral Cu$^{2+}$ sites are mostly substituted by Fe$^{3+}$ ions. Both ferromagnetic and paramagnetic Fe$^{3+}$ signals were detected. The Fe$_{0.02}$Cu$_{0.98}$O samples were found to be ferromagnetic even above the Néel temperature of CuO. A carrier localized around oxygen vacancy can mediate a ferromagnetic coupling among neighboring Fe$^{3+}$ ions. Additional Li doping into Fe$_{0.02}$Cu$_{0.98}$O resulted in an increase of the ferromagnetic strength. Unpaired $s^1$ electron in interstitial Li atom is likely to mediate a ferromagnetic coupling between neighboring spins.

© 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

1 Introduction

In the present work, $^{57}$Fe-doped Cupric oxide (CuO) thin film and powder samples have been prepared by a sol-gel method as an effort to find out new diluted magnetic semiconductor with high Curie temperature. It has been reported that Fe doping in CuO caused an increase in the magnetic susceptibility [1], but no ferromagnetism has been observed yet at room temperature. On the other hand, we report room-temperature ferromagnetism in the present $^{57}$Fe-doped CuO samples. The magnetic properties of the samples are investigated and possible mechanism for the observed ferromagnetism is discussed.

2 Experiments

The present $^{57}$Fe-doped CuO samples were prepared by a sol-gel method. The precursor solution was prepared by dissolving copper acetate monohydrate, (C$_2$H$_3$O$_2$)$_2$Cu·H$_2$O, into a solvent at 90 °C for 2 h. The solvent consists of a mixture of 2-methoxyethanol and monoethanolamine. The molar ratio of 2-methoxyethanol to copper acetate monohydrate was kept at 1.0 with the concentration of (C$_2$H$_3$O$_2$)$_2$Cu·H$_2$O in the precursor solution being 1.5 mol/l. The impurity doping was achieved by dissolving metallic $^{57}$Fe and Li acetate (LiC$_2$H$_3$O$_2$) in diluted HNO$_3$. The amount of doping is denoted as the fraction (at. %) of number of impurity atoms to the sum of those of Cu and impurity atoms in the precursor solution. For the film preparation, the substrates, Al$_2$O$_3$(0001), were spin-coated by the precursor solution with 3000 rpm for 20 sec at room temperature to make precursor films. The resultant precursor films were post-annealed in air. For preparing powder samples, the precursor solution was dried and then the precipitated powders were annealed in air.

* Corresponding author: e-mail: kjkim@konkuk.ac.kr, Phone: +82-2-450-3085, Fax: +82-2-3436-5361

© 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim