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Journal of Solid State Chemistry 175 (2003) 366–371
JOURNAL OF SOLID STATE CHEMISTRY
http://elsevier.com/locate/jssc

New ferromagnets of $Sr_8ARe_3Cu_4O_{24}$ (A = Sr, Ca) with an ordered perovskite structure

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Received 20 February 2003; received in revised form 12 May 2003; accepted 6 June 2003

Abstract

New phases $Sr_8ARe_3Cu_4O_{24}$ (A = Sr,Ca) were discovered under high-pressure/high-temperature condition. X-ray powder diffraction and electron diffraction studies for these phases indicated that they have an ordered perovskite-type structure with cubic lattices of ~8 Å. They showed ferromagnetism at room temperature when they were synthesized under high-oxygen-pressure condition. The Ca-containing phase has a very high T_c of 440 K with a spontaneous magnetization of ~1 μ_B/f.u.

Keywords: Ferromagnetism; Cuprates; Ordered perovskite; Crystal structure; Rietveld analysis

1. Introduction

Perovskite oxides have a general formula of ABO_3 in which the A-site is occupied by a large-size electropositive cation while the B-site by a small transition metal ion. The B-sites are not always occupied by one kind of cations but sometimes by two or more kinds of cations in an ordered way. Thus far, a huge number of ordered perovskites have been prepared and reported [1]. Recently, ordered double perovskites, A_2FeMO_6 (A = Ca,Sr,Ba; M = Mo,Re), have attracted many a researcher's attention because of their interesting physical properties. The Ba- and Sr-analogues of this family are ferromagnetic metals, and a polycrystalline ceramic sample of the Sr-analogues show magnetoresistance even at room temperature and under a low magnetic field [2–4]. These interesting properties originate from their half-metallic (single-spin) characters [2–3]. On the other hand, a Ca-analogue of Ca_2FeReO_6 is known to be an insulating ferromagnet with quite high T_c of 538 K [5]. (See Ref. [6] and references therein for further details of magnetism in the A_2FeMO_6 double perovskites.)

Our original idea of the present study was to prepare an ordered double perovskite, Sr_2CuReO_6, which has not been reported as fas as we know. Generally speaking, high-pressure condition is favorable to stabilize a perovskite-type ABO_3 oxide because it is composed of cubic closest packing of A and O atoms. In the present study, we carried out phase search experiments under a high pressure of 6 GPa for Sr–Re–Cu–O and Sr–Ca–Re–Cu–O systems, expecting a new perovskite material. Indeed, we have discovered new ordered perovskites $Sr_8ARe_3Cu_4O_{24}$ (A = Sr, Ca) though they are not double perovskites but their B-site cations are ordered in a different way. Interestingly, these phases show ferromagnetism at room temperature when they are prepared under high-oxygen-pressure condition. Their structural and magnetic properties are presented.

2. Experimental

SrO_2, ReO_3 (99.9%), CuO (99.9%), Sr_2CuO_3 and $SrCuO_2$ were used as starting materials for the Sr–Re–Cu–O samples, while SrO_2, ReO_3, CaO, CuO, Sr_2CuO_3 and $SrCuO_2$ for the Sr–Ca–Re–Cu–O samples. SrO_2 was prepared through a wet process [7] and CaO by a

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0022-4596/$ - see front matter © 2003 Elsevier Inc. All rights reserved.
doi:10.1016/S0022-4596(03)00334-7