Solid State Chemistry -Solid State Chemistry-

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Alexei Belik NIMS, Japan, 6 November 2001

Scope of Research

Novel inorganic materials that have new, useful or exotic features such as superconductivity, ferromagnetism and quantum spin ground state are synthesized by novel methods. Recent topics are:

· High-T_c superconducting copper oxides with higher T_c or J_c.
· Perovskite-based compounds with unusual magnetic and electronic properties.
· Low-dimensional spin system showing dramatic quantum effects.

Research Activities (Year 2001)

Presentations

Epitaxial films of perovskite-type oxides containing 3d transition metal ions in unusually high valence states, Terashima T, Hayashi N, Takano M, The 2nd International Workshop on Novel Quantum Phenomena in Transition Metal Oxides, 25 August.

Material search and single crystal growth at high pressures of several GPa -0,1,2,3 dimensional compounds, Azuma, M, Takano M, Spring Meeting, Phys. Soc. Jpn., 29 March.

Single crystal growth of transition metal oxides at high pressures of several G Pa, Azuma M, Saito T, Takano M et al., AIRAPT, 24 July.

Pressure induced structural transition of spin ladder compound $SrCu_2O_3$, Azuma M, Yoshida H, Takano M, et al., AIRAPT, 26 July.

Grants

Terashima T, Preparation and properties of epitaxial thin films of oxides containing transition-metal ions in unusually high-valence states, Priority Area Grants from the Ministry of Education, Science, Culture and Sport of Japan, 1 April 2000 - 31 March 2003.

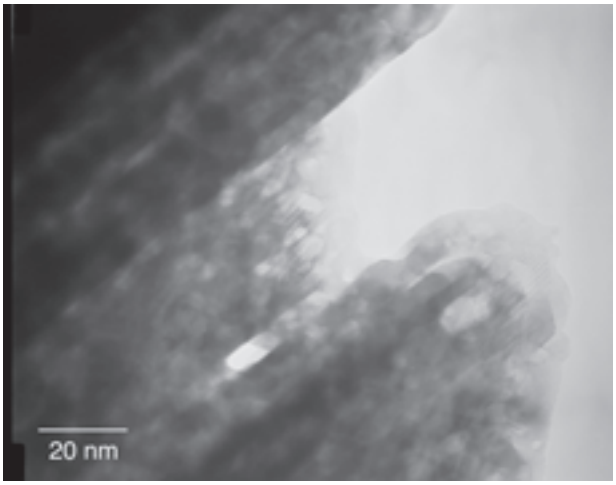
Azuma M, Physical properties of oxychloride superconductor crystals grown at high pressures. Grant-in-Aid for Scientific Research (B) (2), 1 April 2001 - 31 March 2003.

Azuma M, Exploration of photo-functions in strongly correlated electron systems of transition metal oxides, PRESTO, 1 December 2001 - 31 November 2004.

Topics

Na_xCoO_2 with nano-sized pores

A series of studies of oxides containing "late" 3d transition metals (M's) in high valence states like Fe^{4+}, Fe^{6+}, Co^{4+}, Ni^{3+}, and Cu^{3+} are in progress. The d levels of these ions are very deep because their effective nuclear charges are high, and this makes the metal-oxygen bond strongly covalent. As a result, oxides containing tight M -O- M networks like perovskites show metallic conductivity, ferromagnetism, superconductivity, high thermoelectric performance, and other intriguing properties which are dominated by oxygen p-hole character. Usually these oxides are prepared under strongly oxidizing atmospheres such as an oxygen pressure of a few GPa for $CaFeO_3$, typically, generated with a costly apparatus. However, we have noticed very recently that a novel brucite-like oxide, $Co^{4+}O_2$, can be obtained with a simple flux method under mild conditions of ambient pressure and a relatively low temperature of about 600°C. Shown in the photo are the particles thus obtained. Of particular interest is the presence of nano-sized pores (~10 nm in diameter), which might find applications in the future.



Pressure induced structural transition of $SrCu_2O_3$

$SrCu_2O_3$ is a well-known compound as typical example of quantum spin ladder synthesized at 4 GPa [1]. On the course of X-ray diffraction (XRD) study at high pressure with the aim of single crystal growth, an unexpected pressure induced structural transition at room temperature was found.

The figure shows the structures of $SrCu_2O_3$ at ambient and high pressures refined by Rietveld analysis of powder XRD data taken with a diamond anvil cell and synchrotron radiation X-ray. The structure of the high-pressure phase was similar to that of $CaCu_2O_3$. Application of an external pressure had the same effect as "chemical pressure", substitution of smaller Ca ions for Sr ions.

1. M. Azuma, Z. Hiroi, M. Takano, K. Ishida and Y. Kitaoka, Phys. Rev. Lett., **73** (1994) 3463.