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

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 GPa, Azuma M., Saito T., Takano M. et al., AIPART, 24 July.

Pressure induced structural transition of spin ladder compound SrCu$_2$O$_3$, Azuma M., Yoshida H., Takano M., et al., AIPART, 26 July.

Grants


Na$_2$CoO$_2$ 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$_2$O$_3$

SrCu$_2$O$_3$ 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$_2$O$_3$ 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$_2$O$_3$. Application of an external pressure had the same effect as “chemical pressure”, substitution of smaller Ca ions for Sr ions.