T_CSUH Bi-Weekly Seminar

Texas Center for Superconductivity at the University of Houston

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at the University of Houston

Oxygen Diffusion and Surface Exchange in Mixed Conducting Metal Oxides

Friday, September 28, 2007
Room 102, University of Houston Science Center
12:00 noon – 1:00 p.m.

Abstract

The performance of many energy conversion and storage devices depend on the properties of mixed electronic-ionic conducting materials. Mixed or ambipolar conductors simultaneously transport ions and electrons and provide the critical interface between chemical and electrical energy in devices such as fuel cells and batteries. Enhancements in storage capacity, reversibility, power density and life all require new materials and a better understanding of the fundamentals of ambipolar conductivity. In this presentation, I will describe some recent results for a remarkable new class of oxygen ion mixed conductors with potential applications in fuel cells and ion transport membranes.

We have shown that mixed-conducting non-stoichiometric perovskite oxides with ordered A site cations have remarkably high oxygen ion conductivity and surface reaction rates for oxygen exchange relative to conventional materials. Subsequent to our own studies, two other groups have demonstrated comparably high oxygen diffusion in similar compounds confirming that this class of compounds represents a significant enhancement in the achievable rates of oxygen diffusion in mixed conducting oxides.

In $PrBaCo_2O_{5+x}$ (PBCO), a representative example of this class of compounds, the barium and praseodymium cations are located in planes that alternate along the c axis; oxygen vacancies occur only in the ab plane containing the Pr^{3+} cations. The oxygen diffusion coefficient measured in $PrBaCo_2O_{5+x}$ as a function of temperature surpasses the diffusion coefficients of the compounds $La_{0.5}Sr_{0.5}CoO_{3-x}$ and La_2NiO_{4+x} which are among the highest of the known mixed conducting oxides.

The surface exchange coefficient for oxygen exchange has been measured on thin films of $PrBaCo_2O_{5+x}$ by electrical conductivity relaxation and by oxygen-isotope exchange and depth profiling. Microstructural studies indicate that the PBCO films, prepared by pulsed laser deposition, have excellent single-crystal quality and epitaxial nature. The measurements reveal that the PBCO films have high electronic conductivity and more rapid surface exchange kinetics than those of other perovskites.

Reasons for the high oxide ion diffusion and surface exchange coefficients and the relation to the high electronic conductivity and diffusion pathways will be discussed together with the potential use of the compounds as electrodes for oxygen reduction in fuel cells and as membranes for oxygen separation.

Bio

Dr. A. J. Jacobson received a B.A. in Chemistry from St. Catherine's College, Oxford in 1966, and M.A., and D.Phil. degrees in Chemistry from New College, Oxford in 1969. He continued at Oxford doing post-doctoral research in the Inorganic Chemistry Laboratory until 1970 when he was appointed as Fellow and Tutor in Chemistry, Keble College, and Departmental Demonstrator in Inorganic Chemistry. In 1976, Dr. Jacobson moved to the United States to take up a position in the Corporate Research Laboratories of Exxon Research and Engineering Company. While at Exxon he worked in a number of research areas including lithium batteries, intercalation chemistry, zeolites, and heterogeneous oxidation and hydrotreating catalysis. In 1991, he left Exxon and joined the faculty of the University of Houston as Robert A. Welch Chair of Science and Professor of Chemistry. While at the University of Houston he has been Associate Director of the Texas Center for Superconductivity, Director, NSF Materials Research Science and Engineering Center and is currently Director of the Texas Center for Superconductivity. Dr. Jacobson was a Member of the National Materials Advisory Board (2000-2003) and was the U.S. Editor for Solid State Ionics (1999-2004). He is currently Associate Editor of Solid State Ionics and Materials Research Bulletin and on the Editorial Advisory Boards of Journal of Solid State Chemistry, Progress in Solid State Chemistry and Solid State Sciences. Dr. Jacobson's current research interests are in inorganic solid-state synthesis and in solid-state ionics related to ion transport membranes and fuel cells. He has published 373 papers and 46 patents.

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