Carnegie Mellon
Materials Science and Engineering Seminar Series

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"*Doping Strategies towards a Ceria-Based Electrolyte with Higher Ionic Conductivity*"

Friday, September 28, 2007
11:00 A.M. Seminar in Hamerschlag B131

It is well known that in oxides with the fluorite structure (AO_2) such as ZrO_2 or CeO_2, the incorporation of aliovalent cation dopants (usually, divalent or trivalent) leads to the formation of oxygen vacancies which in turn results in an increase in ionic conductivity. For example in the case of trivalent dopant cation (D_2O_3), the mass-action reaction equation can be seen as

$$D_2O_3 \xrightarrow{2AO_2} 2D'_A + 2O^{\times}_O + V^{\bullet\bullet}_O$$

At low dopant concentrations the conductivity increases with increasing dopant concentration. However, it is experimentally observed that the conductivity reaches a maximum at dopant concentrations of about 16-20 mol% depending on the type of dopant, an effect often attributed to defect association. To enhance the ionic conductivity of the electrolyte, co-dopant strategies for the CeO_2 system are currently being investigated. Doped electrolyte materials were synthesized, with the selection of dopants being based on ionic radius and polarizibility to maximize oxygen vacancy concentration without forming defect associates or vacancy ordering. Dopants were also selected using the concept of effective atomic number proposed by N. Skorodumova, S. Simak and coworkers. The bulk ionic conductivity of the different doped ceria compositions was measured as a function of temperature using electrochemical impedance spectroscopy. In this seminar the overall impact of the dopants on the conductivity of ceria based electrolytes will be revised. The potential of these new electrolytes for intermediate temperature solid oxide fuel cell (SOFC) applications will be discussed.

$$D_2O_3 \xrightarrow{2AO_2} 2D'_A + 2O^{\times}_O + V^{\bullet\bullet}_O$$

Dr. Juan C. Nino received his B.Sc. in Mechanical Engineering in 1997 from Los Andes University in Bogotá, COLOMBIA. He was a Lecturer in the Colombian School of Engineering from 1997 to 1998, before joining The Pennsylvania State University, where he received his Ph.D. in Materials Science and Engineering in 2002. He did a post-doc in ferroelectric thin films at the Materials Research Institute in State College, PA and he joined the MSE department at University of Florida in Gainesville in Fall 2003 as an Assistant Professor.

The main interest of NRG (Nino Research Group) is the investigation of fundamental structure-property-processing-performance relationships governing energy-related materials systems, with emphasis on electronic and nuclear materials. As these fundamental materials relationships are identified, verified and/or postulated, they are used towards the rational design and development of new and improved materials with properties tailored toward specific applications. Current research is concentrated in five main areas: (a) co-doping strategies for ionic conductivity enhancement in electrolytes for low temperature solid oxide fuel cells (SOFCs); (b) structure-property relationships in dielectric ceramics for capacitive applications and microwave communication devices; (c) synthesis and optimization of composite oxides for inert matrix fuel systems for nuclear reactors; (d) crystallographic design and synthesis of high temperature proton exchange membranes; and (e) novel semiconductor materials for gamma-ray detection.