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Research Seminar

When: February 10, 2022
Time: 12:00 p.m.
Location: CBLL-16

Study of Magnetic, Electrical, Eletrocatalytic and Pseudocapactive Properties of Ruddlesden Popper Oxides

Abstract

Oxide materials derived from perovskites have been studied for a wide range of applications, such as solar cells, batteries, catalysts, and capacitors. The Ruddlesden popper (RP) oxides are perovskite derived oxides with the general formula $A_{n-1}A'_2B_nO_{3n+1}$ where n = 1, 2, 3 etc. The crystal structure of the RP materials is comprised of alternating A'_2O_2 layers and stacks of BO_6 octahedra throughout the material. The number of octahedral layers is denoted by n. In the RP structure, the A and A' sites are often occupied by a lanthanide, alkaline earth metal, or a mix of those, while there are transition metals at the B-site. For RP oxides, functional properties are often affected by changes to the A and B site metals, which change the electronic band structure.[1, 2] Therefore, investigating material performance with A-site and B-site variations could lead to the discovery of new supercapacitors, catalysts for water electrolysis, etc. Two n=2, RP materials $Sr_2LaCoMnO_7$ and $Sr_2LaFeMnO_7$ were synthesized by changing the B-site cation using solid-state synthesis method.[3] Functional property variations of RP oxides were demonstrated by varying the B-site cation. Magnetic transition temperature can be shifted significantly by changing the B-site cation from Fe^{3+} to Co^{3+}. In addition, charge transport properties can be enhanced. Furthermore, the change in the B-site cation helps to improve the electrocatalytic activity toward hydrogen-evolution reaction (HER) and oxygen-evolution reactions (OER). $Sr_2LaCoMnO_7$ shows significantly enhanced catalytic activity for both HER and OER. Next, the RP materials $Sr_2LaMn_2O_7$ and $Ca_2LaMn_2O_7$ were prepared by changing the A-site cation with Mn at the B-site. The A-site modifications changed the structural properties of RP materials, causing functional properties to be changed. The electrical, magnetic, and electrocatalytic properties of $Sr_2LaMn_2O_7$ are considerably improved with the change of the A-site from Ca to Sr which was associated with a transition to a higher symmetry. Furthermore, the pseudocapacitance activity generated by oxide ion intercalation was examined.[4] Therefore, the changes in A-site and B-sites in bi-layered RP oxides and subsequent structural properties lead to systematic transformation of functional properties.

References

1. Chen, A.; Zhang, X.; Zhang, Z.; Yao, S.; Zhou, Z., Band engineering of two-dimensional Ruddlesden–Popper perovskites for solar utilization: the relationship between chemical components and electronic properties. *J. Mater. Chem. A* **2019,** *7* (18), 11530-11536.
2. Sun, R.; Qin, X.-y.; Li, L. L.; Li, D.-D.; Zhang, J.; Wang, Q., Transport and thermoelectric properties of n-type Ruddlesden–Popper phase $(Sr_{1-x}Gd_x)_3(Ti_{1-y}Ta_y)_2O_7$ oxides. *J. Phys. D: Appl. Phys* **2012,** *45*, 415401.
3. Kananke-Gamage, C. C. W.; Ramezanipour, F., Variation of the electrocatalytic activity of isostructural oxides $Sr_2LaFeMnO_7$ and $Sr_2LaCoMnO_7$ for hydrogen and oxygen-evolution reactions. *Dalton Trans.* **2021,** *50* (40), 14196-14206.
4. Karki, S. B.; Ramezanipour, F., Pseudocapacitive Energy Storage and Electrocatalytic Hydrogen-Evolution Activity of Defect-Ordered Perovskites $Sr_xCa_{3-x}GaMn_2O_8$ (x = 0 and 1). *ACS Appl. Energy Mater.* **2020,** *3* (11), 10983-10992.