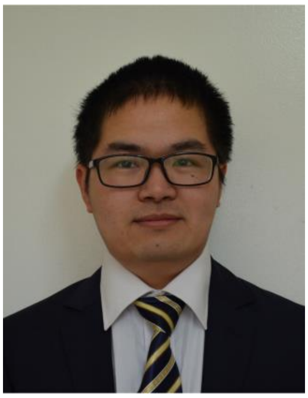
Curriculum Vitae



Personal Information:

Name: Xiubing HUANG **Date of Birth:** October, 1985

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Present Address: Research Center for Materials Science
Nagoya University, Nagoya, Japan

Research Field: materials chemistry, nanomaterials, catalysis

Education Background:

1) PhD (09/2011-06/2015): Advanced Materials, School of Chemistry, University of St Andrews, UK

Supervisor: Prof. John T.S. Irvine

2) ME (09/2008-06/2011): Materials Physics and Chemistry, School of Materials Science and Engineering, University of Science and Technology Beijing, China

Supervisor: Prof. Ge Wang

3) BE (09/2004-07/2008): Materials Chemistry, School of Materials Science and Engineering, University of Science and Technology Beijing, China

Research Experience:

1). Postdoctoral researcher: 07/2015 to present (Nagoya University, Japan)

Research Topic: ***Preparation and Characterization of Novel Selective Oxidation Catalysts based on CeO_2-related Nanomaterials***

- Synthesize transition-metals (e.g., Mn, Cr, Fe, Rh, Pd, Pt) doped/deposited CeO_2 nanocrystals and investigate their catalytic activity in selective oxidation with high conversation and selectivity at low temperatures; Investigate the synergetic effect of doping elements on the phase stability, oxygen mobility and catalytic activity using advanced nano-XAFS techniques.

2). PhD: 09/2011 to 05/2015 (University of St Andrews, UK)

Thesis title: ***Transition-Metal Based Oxides for Oxygen Storage and Energy-Related Applications***

- **Synthesis of transition-metals doped CeO_2 nanocrystals with enhanced oxygen storage**
  - Prepare various transition-metals (e.g., Cr, Mn, Co, Cu) doped CeO_2 nanocrystals (such as nanorod and nanocube) via a hydrothermal method and investigate the effect of synthesis conditions (e.g., transition-metal species, amount, hydrothermal temperature) on the nanocrystal formation.
  - Evaluate their oxygen storage capacity, reversibility and thermal stability under alternating oxidative (i.e., air) and reductive (i.e., 5%H_2/Ar) atmospheres.

- **Synthesis of nanocrystals coated β-MnO_2 nanorods**
  - ➢ Synthesize nanocrystalline metal oxides (e.g., CeO_2, SnO_2) coated β-MnO_2 nanorods and evaluate their oxygen storage capacity and energy-related applications, such as methane oxidation.
- **Synthesis of hierarchical nanostructured perovskite and layered-perovskite oxides**
  - ➢ Prepare hierarchically nanostructured perovskite oxides (e.g., $La_{0.6}Ca_{0.4}M_xFe_{1-x}O_{3-\delta}$ (M = Mn or Co)) via a facile citrate-modified evaporation-induced self-assembly method, and evaluate their oxygen storage capacity and thermal stability under various atmospheres.
  - ➢ Synthesize hierarchically nanoporous layered perovskite oxides (e.g., $La_{1.7}Ca_{0.3}M_xCu_{1-x}O_{4-\delta}$ (M = Fe, Co, Ni, Cu)) and evaluate their electrochemical performance as cathode materials for intermediate-temperature solid oxide fuel cells (IT-SOFCs).
- **Synthesis of CeO_2-modified crednerite $CuMnO_2$ composites**
  - ➢ Prepare delafossite-type $CuFeO_2$ and crednerite-type $CuMnO_2$ as oxygen storage materials.
  - ➢ Investigate the effect of CeO_2 modification on the oxygen storage capacity and thermal stability.
- **Synthesis of brownmillerite-type oxides based on Ca_2AlMnO_5**
  - ➢ Prepare brownmillerite-type oxides as oxygen storage materials, such as Ca_2AlMnO_5.
  - ➢ Investigate the effect of doping in the A-site or B-site on their structure and oxygen storage capacity, such as $Ca_2Al_{1-x}Ga_xMnO_5$, AA'$AlMnO_5$ (A and A' = Mg, Ca, Sr).

3). Master’s degree: 09/2008 to 07/2011 (University of Science and Technology Beijing, China)

Research topic: ***Synthesis of Composites and Investigation of Their Catalytic Properties***

- **Synthesis of mesoporous composites based on silica (e.g., SBA-15) with high catalytic activity**
  - ➢ Prepare mesoporous composites (e.g., Ag/SBA-15, etc.) using a double-solvent technique (e.g., *n*-hexane and precursor aqueous solution) and evaluate the catalytic properties for alkene oxidation.
- **Synthesis of magnetically recyclable catalysts and investigation of their catalytic applications**
  - ➢ Synthesize Fe_3O_4 microspheres supported core-shell catalysts, including the synthesis of Fe_3O_4@SiO_2@TiO_2@polyaniline photocatalyst for photodegradation of methylene blue under visible light and Fe_3O_4@SiO_2@Poly(4-vinylpyridine)-Mo(VI) for alkene epoxidation.

Qualifications:

- Master professional knowledge relating to nanomaterials synthesis, solid state chemistry, catalysis;
- Have experience in sample preparation, testing and analysis in catalysis, Li-ion battery, SOFC;
- Have experience in the operation and/or analysis of TGA, HRTEM, GC-MS, FESEM, FT-IR, UV-Vis, N_2 adsorption/desorption, XRD, glovebox, electrochemical workstation, etc;
- Have a good command of both spoken and written English.

List of Publications

1. **Xiubing Huang**, Guixia Zhao, John T.S. Irvine. Facile synthesis of nanocrystalline CeO_2 coated β-MnO_2 nanorods with enhanced oxygen transfer property, ***to be submitted***.

2. **Xiubing Huang**, Chengsheng Ni, John T.S. Irvine. Oxygen storage capacity and thermal stability of brownmillerite-type $Ca_2Al_{1-x}Ga_xMnO_5$, ***to be submitted***.

3. Jae-ha Myung, Tae Ho Shin, **Xiubing Huang**, Cristian Savaniu, John T.S. Irvine. $La_{1.7}Ca_{0.3}Ni_{0.75}Cu_{0.25}O_{4-\delta}$ layered perovskite as cathode on $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ and $Ce_{0.8}Gd_{0.2}O_2$ electrolyte for intermediate temperature Solid Oxide Fuel Cells, ***Int. J. Appl. Ceram. Tec.***, **2016**, 13, 269-273.

4. Guan Zhang, Chengsheng Ni, **Xiubing Huang**, Aakash Welgamage, Linda A. Lawton, Peter K. J. Robertson and John T. S. Irvine. Simultaneous cellulose conversion and hydrogen production assisted by cellulose decomposition under UV-light photocatalysis, ***Chem. Commun.***, **2016**, 52, 1673-1676.

5. Jae-ha Myung, Tae Ho Shin, **Xiubing Huang**, George Carins, John T.S. Irvine. Enhancement of redox stability and electrical conductivity by doping various metals on Ceria, $Ce_{1-x}M_xO_{2-\delta}$ (M = Fe, Ni, Cu, Co, Mn, Ti, Zr), ***Int. J. Hydrogen Energy***, **2015**, 40, 12003-12008.

6. **Xiubing Huang**, Guixia Zhao, Xiangke Wang. Fabrication of reduced grapheme oxide/metal (Cu, Ni, Co) nanoparticle hybrid composites via a facile thermal reduction method, ***RSC Adv.***, **2015**, 5, 49973-49978.

7. **Xiubing Huang**, Tae Ho Shin, Jun Zhou, John T.S. Irvine. Hierarchically nanoporous $La_{1.7}Ca_{0.3}CuO_{4-\delta}$ and $La_{1.7}Ca_{0.3}Ni_xCu_{1-x}O_{4-\delta}$ ($0.25 \leq x \leq 0.75$) as potential cathode materials for IT-SOFCs, ***J. Mater. Chem. A***, **2015**, 3, 13468-13475.

8. **Xiubing Huang**, Chengsheng Ni, Guixia Zhao, John T.S. Irvine. Oxygen storage capacity and thermal stability of $CuMnO_2$-CeO_2 composite system, ***J. Mater. Chem. A***, **2015**, 3, 12958-12964.

9. Guixia Zhao, **Xiubing Huang**, Federica Fina, John T.S. Irvine. Z-scheme water splitting by C_3N_4-WO_3 composites under visible light: enhanced by reduced graphene oxide, ***Catal. Sci. Technol.***, **2015**, 5, 3416-3422.

10. Guixia Zhao, **Xiubing Huang**, Xiangke Wang, Paul Connor, Jiaxing Li, Shouwei Zhang, John T.S. Irvine. Synthesis and lithium-storage properties of MnO/reduced graphene oxide composites derived from graphene oxide plus the transformation of Mn(VI) to Mn(II) by the reducing power of graphene oxide, ***J. Mater. Chem. A***, **2015**, 3, 297-303.

11. **Xiubing Huang**, Guixia Zhao, Ge Wang, Yinhai Tang, Zhan Shi, Effect of metal species on the

morphology of metal (oxides) within mesochannels of SBA-15 via a double-solvent method, ***Micropor. Mesopor. Mater.***, **2015**, 207, 105-110.

12. Wanchun Guo, Ge Wang, Qian Wang, Wenjun Dong, Mu Yang, **Xiubing Huang**, Jie Yu, Zhan Shi, A hierarchical Fe_3O_4@P4VP@$MoO_2(acac)_2$ nanocomposite: Controlled synthesis and green catalytic application, ***J. Mol. Catal. A-Chem.***, **2013**, 378, 344–349.

13. **Xiubing Huang**, Wanchun Guo, Ge Wang, Mu Yang, Qian Wang, Xinxin Zhang, Yanhui Feng, Zhan Shi, Chunguang Li. Synthesis of Mo-Fe_3O_4@SiO_2@P4VP core-shell-shell structured magnetic microspheres for alkene epoxidation reactions, ***Mater. Chem. Phys.***, **2012**, 135, 985-990.

14. **Xiubing Huang**, Ge Wang, Mu Yang, Wanchun Guo, Hongyi Gao. Synthesis of polyaniline-modified $Fe_3O_4/SiO_2/TiO_2$ composite microspheres and their photocatalytic application, ***Mater. Lett.***, **2011**, 65, 2887-2890.

15. **Xiubing Huang**, Mu Yang, Ge Wang, Xinxin Zhang. Effect of surface properties of SBA-15 on confined Ag nanomaterials via double solvent technique, ***Micropor. Mesopor. Mater.***, **2011**, 144:171-175.

16. **Xiubing Huang**, Wenjun Dong, Ge Wang, Mu Yang, Li Tan, Yanhui Feng, Xinxin Zhang. Synthesis of confined Ag nanowires within mesoporous silica via double solvent technique and their catalytic properties, ***J. Colloid Interf. Sci.***, **2011**, 359, 40-46.

Research summary

Part 1. Research summary of my postdoctoral research work

What I have been working on during my postdoctoral research in Research Center for Materials Science of Nagoya University since July of 2015 is about the preparation and characterization of novel selective oxidation catalysts based on CeO_2-related nanomaterials. I mainly adopted the strategy of doping of transition-metals (e.g., Mn, Cr, Fe, Rh, Pd, Ru) into the lattice of CeO_2 and investigated the effect of doping on the oxygen mobility and oxygen storage capacity, as well as the catalytic activity of selective oxidation. Up to now, I have prepared several kinds of doped or coated CeO_2 and investigated their TPR and TPO properties, as well as catalytic activity.

1). Synthesis of Pt-deposited $Ce_{1-x}Mn_xO_2$ nanocubes and nanorods

Mn-doped CeO_2 nanocrystals (e.g., nanorods and nanocubes) exposed with different lattice planes have been prepared via a hydrothermal method through the control of hydrothermal temperature and concentration of NaOH. With the increase of Mn doping amount in $Ce_{1-x}Mn_xO_2$ ($x = 0, 0.1, 0.2, 0.3$), their oxygen storage capacity increased, however, their reduction temperatures via TPR are still high (> 200 ^{o}C). In addition, $Ce_{1-x}Mn_xO_2$ nanocubes displayed lower reduction temperature than that of $Ce_{1-x}Mn_xO_2$ nanorods. The deposition of Pt nanoparticles on $Ce_{0.7}Mn_{0.3}O_2$ nanorods and nanocubes would lead to a lower reduction temperature but also reduced oxygen storage capacity.

2). Synthesis of $Ce_{1-x}Cr_{0.15}M_xO_2$ (M = Rh, Pd, Ru) nanocrystals

$Ce_{0.85-x}Cr_{0.15}M_xO_2$ (M = Rh, Pd, Ru) nanocrystals have been prepared via a hydrothermal method through the control of composition. The doping of noble metals (e.g., Rh, Pd, Ru) with $x = 0.05$ would favor the oxygen removal at lower temperatures (< 160 ^{o}C), in which Pd-doped samples displayed the lowest temperature (i.e., 60 ^{o}C), much lower than that of $Ce_{0.85}Cr_{0.15}O_2$ (i.e., 360 ^{o}C).

Part 2. Research summary of my PhD course

What I was working on during my PhD courses is about synthesis of oxygen storage materials based on transition-metal oxides and their energy-related applications. The main work is to develop solid state oxygen storage materials (OSMs) using transition metal compounds, which could reversibly intake and release oxygen dependence on oxygen partial pressures and/or temperatures. I investigated several kinds of oxides based on transition metals with various phase structures.

1). Synthesis of transition-metal doped CeO_2 nanocrystals

Transition-metals (e.g., Cr, Mn, Fe, Co, Ni, Cu) doped CeO_2 nanocrystals have improved oxygen storage capacity and excellent reversibility, even though their reduction temperatures are still high.

Especially, Ni- and Cu-doped CeO_2 exhibit excellent performance as anode catalysts for solid oxide fuel cells.

2). Synthesis of CeO_2-modified $CuMnO_2$ as oxygen storage materials

CeO_2 modification with molar ratio of $CeO_2/CuMnO_2$ smaller than 20 mol% would enhance the oxygen storage amount and mobility, as well as reversibility of $CuMnO_2$. However, with the increasing cycles after the 4th time under alternative argon and O_2 between 300 and 900 ^oC, the oxygen storage capacity and reversibility of CeO_2-modified $CuMnO_2$ become worse due to phase separation of CeO_2 and $CuMnO_2$, demonstrating enhanced oxygen mobility by CeO_2 modification.

3). Synthesis of brownmillerite-type oxides as oxygen storage materials

Brownmillerite-type $Ca_2Al_{1-x}Ga_xMnO_5$ oxides could uptake/release remarkable amount of oxygen (e.g., 2.7 wt% for Ca_2AlMnO_5) depending on temperature even under flowing oxygen atmospheres. They can also uptake/release oxygen under alternating oxygen and argon during certain temperature range (i.e., 500 - 700 ^oC).

4). Synthesis of hierarchical mesoporous/macroporous perovskite oxides

A citrate-modified evaporation-induced self-assembly (EISA) method was developed to prepare hierarchically mesoporous/macroporous perovskite oxides with pure phase at low temperatures. Hierarchically nanoporous $La_{1.7}Ca_{0.3}Cu_{1-x}M_xO_4$ (M = Fe, Co, Ni, Cu) layered-perovskite oxides were demonstrated as potential cathode materials for intermediate-temperature solid oxide fuel cells (IT-SOFCs) with high power density (e.g., 1.5 W/cm^2 at 850 ^oC for $La_{1.7}Ca_{0.3}CuO_4$ cathode). The effects of B-site composition and morphology on their electrochemical performance were systemically investigated.

5). Synthesis of nanocrystalline CeO_2 or SnO_2 coated β-MnO_2 nanorods

To further reduce the oxygen release temperature of β-MnO_2 nanorods, other metal oxide (such as CeO_2, SnO_2) nanocrystals were coated onto the surface of β-MnO_2 nanorods, in which CeO_2 modification could reduce the oxygen release temperature under N_2 while SnO_2 can't. These results indicated the positive synergetic effect on the oxygen mobility between CeO_2 and β-MnO_2.

Part 3. Summary

Doping and coating of other elements have been demonstrated to be effective routes to improve the oxygen mobility and removal at low temperatures. However, the synergetic effects among the doping/coating and the supports need more research. Due to the enhanced oxygen mobility, they have great potential applications in energy storage and conversion, as well as catalysis field in selective oxidation of hydrocarbons.

Preparation and Characterization of Novel Selective Oxidation Catalysts based on CeO_2-related Nanomaterials

Recent years, much attention and endeavors have been paid to selective oxidation reactions, due to their crucial importance in activating raw materials to synthesize useful chemical products (such as alcohols, aldehydes, ketones, carboxylic acids and derivatives) for use in the chemical, pharmaceutical, and agricultural business sectors. However, oxidized products of alkanes are more reactive than the alkane reactants thus their selective oxidation is still one of the most challenging reactions. Therefore, further optimization and development of heterogeneous catalysts for selective hydrocarbon oxidation at low temperature with high conversion and selectivity is crucial and imperative, which needs consideration mainly from the point of view of increasing the oxygen vacancies and redox ability, designing special nanocrystal plane exposure and composition to lower the adsorption and activation energy of C-H bond.

For this project, I would like to propose preparation and catalytic application of metal-doped CeO_2 nanocrystals for selective hydrocarbon oxidation, in particular low-temperature alkane oxidation. Transition metals (e.g., Ni, Cr, Mn) and noble metals (e.g., Rh, Pd) will be co-doped into the lattice of CeO_2 nanocrystals, which is supposed to improve the oxygen vacancies and redox ability. In addition, metal nanoclusters (e.g., Pt) will be formed onto the surfaces of these doped CeO_2 nanocrystals as a possible co-catalyst to further enhance the cleavage of C-H bonds in alkanes and improve conversion/selectivity in selective hydrocarbon oxidation at low temperature.

Proposal 1: Cr and noble metal co-doped CeO_2 nanocrystals as novel selective oxidation catalysts.

Synthesis of Cr and noble metal (e.g., Rh, Pd, Ru) co-doped CeO_2 nanocrystals has been carried out by a hydrothermal method. The influence of doping amount (e.g., Cr, Rh, Pd, Ru) has been systematically investigated. The TPR and TPO results show that doping a small amount ($x \leq 0.05$) of noble metals (M = Rh, Pd, or Ru) in $Ce_{0.85-x}Cr_{0.15}M_xO_2$ nanocrystals would greatly decrease the reduction temperature, especially for Rh and Pd-doped samples. The synergetic effects between the doping elements and CeO_2 are being under investigation by various techniques, such as TEM, nano-XAFS, H_2-TPR. Their further catalytic applications in selective oxidation of saturated alkanes (e.g. CH_4, cyclohexane) or aliphatic compounds (e.g., toluene) in gas/liquid phase reaction systems will be investigated.

Proposal 2: Preparation and characterization of metal nanoclusters (e.g., Pt)/metal-doped CeO_2 nanocrystals as selective oxidation catalysts.

Based on my previous research results, the reductant ($NaBH_4$) used in the subsequent deposition of noble metal nanoclusters (e.g., Pt) onto the surface of transition metal doped CeO_2 nanocrystals may also reduce the doped elements, which will affect their properties. Therefore, I will adopt another in-situ method to prepare metal nanoclusters supported onto transition metals (e.g., Cr, Fe, Mn) doped CeO_2 nanocrystals. By controlling the doping element species and concentration, metal nanoclusters (e.g., Pt) will be possibly formed onto the surfaces of as-prepared samples. The structures of bulk, interface, and surface of the prepared samples will be characterized by XRD, XRF, XPS, BET, FT-IR, Raman, TEM, and XAFS techniques. Then, I would like to apply these samples for hydrocarbon selective oxidation, in particular alkane selective oxidation.