

Lifen Wang

Associate Professor

State Key Laboratory for Surface Physics

Institute of Physics

Chinese Academy of Sciences

Email: wanglf@iphy.ac.cn

Phone: +86-18210282128



Academic and Research Experience

- Sep. 2018 - now Associate Professor
State Key Laboratory for Surface Physics,
Institute of Physics, Chinese Academy of Sciences, China
- Sep. 2014 – June 2018 Postdoctoral Appointee,
Nanoscience and Technology Division,
Center for Nanoscale Materials,
Argonne National Laboratory, IL, USA.
- 2009 - 2014 Ph. D. in Condensed Matter Physics with Honors,
Institute of Physics, Chinese Academy of Sciences, China
- 2004 - 2008 B. S. in Applied Physics with Honors,
Qingdao University, Qingdao, Shandong, China

Research Focus

1. Nanocrystal nucleation and aggregation dynamics in graphene liquid cell

Graphene windows were used in liquid cells for *in situ* electron microscopy because the single atom thickness, extraordinary mechanical strength and high conductivity of graphene allows the study of liquid in the confined environment with atomic resolution. Nanocrystal nucleation and growth dynamics were characterized at atomic scale.

2. Phase transition induced by ionic diffusion

Real time *in situ* observation could help to identify the trans state like charge density wave during phase transition. We tracked the lithium ions insertion and diffusion in 2D material MoS₂ and demonstrated the CDW phase of MoS₂ induced by electron injection. When follow oxygen diffusion in bulk CeO₂, distortion of the Ce plane as well as the enhanced diffusion path of oxygen was observed.

3. Dynamic Lithium Storage Mechanism in Electrode Materials

We fabricate open lithium ion battery utilizing an *in situ* Transmission Electron Microscopy (TEM) specimen holder with nanomanipulator to study dynamic (de)-lithiation processes at the level of single nanostructure, interface and grain/domain boundary. Structural evolution and phase transition in individual electrode materials get to be correlated with electrochemical performance down to atomic scale by performing TEM and electrochemical measurements at the same time on the battery.

4. In Situ Microscopy of nanomaterial aggregation and growth at the solid liquid interface

We assemble electrochemical wet cells inside an *in situ* (Scanning) Transmission Electron Microscopy ((S)TEM) holder. *In situ* records of the first few stages of nanoscale clusters aggregation and growth at the liquid and solid interface reveal the basic physics of electrodeposition mechanism.

5. Evolution of morphology, composition and interfaces correlated with electrochemical performance in lithium ion batteries

We assemble lithium ion batteries for *operando* Scanning Electron Microscopy (SEM) observation. Microscale morphology evolution during electrochemical cycling could be clearly related to stress formation inside electrodes and between interfaces.

Skills & Expertise

Assemble of graphene liquid cell

Construction of *in situ* miniaturized open solid lithium cells and electrochemical liquid cell

Analytical (S)TEM characterization (HR-TEM, EELS, SAED, CBED, EDS, HADDF)

TEM Sample Preparation Technique

Fabrication and Measurement of Coin Cell-Type Lithium Ion Battery

Pulsed Laser Deposition (PLD) and CVD film growth

Focused Ion Beam (FIB), Atomic Force Microscopy (AFM), Reactive Ion Etching (RIE)

Publications

1. **Lifen Wang**, Zhi Xu, Wenlong Wang, Xuedong Bai. Atomic mechanism of dynamic electrochemical lithiation processes of MoS₂ nanosheets. *J. Am. Chem. Soc.* 2014, **136**, 6693-6697.
2. **Lifen Wang**, Donghua Liu, Shize Yang, Xuezheng Tian, Wenlong Wang, Enge Wang, Zhi Xu, Xuedong Bai. Exotic reaction front and stage structure in lithiated Si nanowires. *ACS Nano*. 2014, **8**, 8249-8254.
3. **Lifen Wang**, Jian Yan, Zhi Xu, Wenlong Wang, Jianguo Wen, Xuedong Bai. Rate Mechanism of Vanadium oxide coated tin dioxide nanowire electrode for lithium ion battery. *Nano energy* 2017, **42**, 294-299.
4. **Lifen Wang**, Jianguo Wen, Huaping Sheng, Dean J. Miller. Fractal growth of platinum electrodeposits revealed by *in situ* electron microscopy. *Nanoscale* 2016, **8**, 17250-17255.
5. **Lifen Wang**, Xuezheng Tian, Shize Yang, Zhi Xu, Wenlong Wang, Xuedong Bai. Dynamic nanomechanics of zinc oxide nanowires. *Appl. Phys. Lett.* 2012, **100**, 163110.
6. **Lifen Wang**, Zhi Xu, Shize Yang, Xuezheng Tian, Jiake Wei, Wenlong Wang, Xuedong Bai. Real-time *in situ* TEM studying the fading mechanism of tin dioxide nanowire electrodes in lithium ion batteries. *Sci. China Tech. Sci.* 2013, **56**, 2630-2635.
7. Xuezheng Tian, Shize Yang, Min Zeng, **Lifen Wang**, Jiake Wei, Zhi Xu, Wenlong Wang, Xuedong Bai, Bipolar electrochemical mechanism for mass transfer in nanoionic resistive

- memories. *Adv. Mater.* 2014, **26**, 3649-3654.
8. Yunlong Zhao, Jiangang Feng, Xue Liu, Fengchao Wang, **Lifen Wang**, Changwei Shi, Lei Huang, Xiyaun Chen, Lin Xu, Mengyu Yan, Qingjie Zhang, Xuedong Bai, Hengan Wu, Liqiang Mai. Self-adaptive strain-relaxation optimization for high-energy lithium storage material through crumpling of graphene. *Nat. Commun.* 2014, **5**, 4565.
 9. Shize Yang, **Lifen Wang**, Zhi Xu, Xuedong Bai. The Piezotronic Effect of Zinc Oxide Nanowires Studied by In Situ TEM. *Adv. Mater.* 2012, **24**, 4676–4682.
 10. Xuezeng Tian, **Lifen Wang**, Jiake Wei, Shize Yang, Wenlong Wang, Zhi Xu, Xuedong Bai. Filament growth dynamics in solid electrolyte-based resistive memories revealed by in situ TEM. *Nano Research* 2014, **7**, 1065-1072.
 11. Yan Li, Rui Xu, Yang Ren, Jun Lu, Huiming Wu, **Lifen Wang**, Dean J Miller, Yang-Kook Sun, Khalil Amine, Zonghai Chen. Synthesis of full concentration gradient cathode studied by high energy X-ray diffraction. *Nano Energy.* 2016, **19**, 522-531.
 12. Guiliang Xu, Yan Li, Tianyuan Ma, Rang Ren, Hsien Hau Wang, **Lifen Wang**, Jianguo Wen, Dean Miller, Khalil Amine, Zonghai Chen, PEDOT-PSS coated ZnO/C hierarchical porous nanorods as ultralong-life anode materials for lithium ion batteries. *Nano energy.* 2015. 18, 253-264.
 13. Shize Yang, Xuezeng Tian, **Lifen Wang**, Jiake Wei, Kuo Qi, Xiaomin Li, Zhi Xu, Wenlong Wang, Jimin Zhao, Enge Wang. In-situ Optical Transmission Electron Microscope study of exciton phonon replicas in ZnO nanowires by Cathodoluminescence. *Appl. Phys. Lett.* 2014, **7**, 071901.
 14. Jiake Wei, Zhi Xu, Hao Wang, Xuezeng Tian, Shize Yang, **Lifen Wang**, Wenlong Wang, Xuedong Bai. In-situ TEM imaging of the anisotropic etching of graphene by metal nanoparticles. *Nanotechnology* 2014, **25**, 465709.

Academic Honors and Awards

Outstanding graduate of Institute of Physics, Chinese Academy of Sciences 2014

Scholarship of Institute of Physics, Chinese Academy of Science 2013-2014

Scholarship of Institute of Physics, Chinese Academy of Science 2012-2013

Conferences and Academic Experiences

Talk, MRS Fall Meeting, Layered BeO formed in graphene liquid cell. Boston, Massachusetts, Nov. 26 – Dec. 1, 2017

Talk, Microscopy & Microscopy Analysis, Dynamic Nanobubbles in Graphene Liquid Cell under Electron Beam Irradiation. St. Louis, MO, Aug. 6-10, 2017

Talk, APS March Meeting, Hexagonal bubble formation and nucleation in sodium chloride solution. New Orleans, Louisiana, March 13 – 17, 2017

Talk, Microscopy & Microscopy Analysis, Fractal Growth of Platinum Electrodeposits Revealed by in situ Electron Microscopy. Columbus, Ohio, July 24-28, 2016

Talk, Microscopy & Microscopy Analysis, Dynamic rate mechanism of V₂O₅ coated SnO₂ nanowire for lithium ion battery studied by in situ TEM. Portland, Oregon, Aug. 2-7, 2015

Talk, Fall Meeting of the Chinese Physics Society, Xiamen, China, Sept. 19-21, 2013

Talk, Fall Meeting of the Chinese Physics Society, Hangzhou, China, Sept. 19-21, 2011

Poster, Microscopy & Microscopy Analysis 2016, Columbus, Ohio, Jul 24-29, 2016

Poster, China Nano 2013, Beijing, China, Sept. 5-7, 2013

Poster, 2012 Chinese Conference on Microscopy, Chengdu, China, Sept. 10-15, 2012