

Zhaoliang Liao

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Education:

Dept. of Physics and Astronomy, Louisiana State University, Ph.D candidate (expected) Sept. 2012
Advisor: **Ward Plummer, Jiandi Zhang**
Institute of Physics, Chinese Academy of Sciences, Ph.D in Condensed Matter Physics Nov. 2011
Advisor: **Dongmin Chen, Li Lu**
University of Science and Technology of China, BSC with distinction in theoretical physics Jul. 2006

Professional skills:

Experiment technics: Lithography (UV, E-Beam, Ion-Beam), Reactive Ion Etching, Thermal Deposition, Surface Profiler, Laser-MBE, PLD, PPMS, Transmission Electron Microscopy (TEM) & (In-situ TEM), SEM, Furnace, Low Energy Electron Diffraction (LEED), STM and Spectroscopy (STS), XPS.

Computer: Labview, C++, Visual Studio 6.0, MFC, Solidwork, AutoCAD, L-edit, Mathematica, PhotoShop.

Research Experience:

Jan. 2010-present, Dept. of Physics and Astronomy, Louisiana State University

Studied emergent phenomena in nanostructural transition metal oxides

- ★ Successfully grew $(\text{La}_{2/3}\text{Sr}_{1/3}\text{MnO}_3)_{1-x}(\text{V}_2\text{O}_3)_x$ nanocomposite via alternate growth method with PLD and realized a controllable multi-functionality by simply changing the relative growth time ratio.
- ★ Investigated the dimensionality effect on the colossal magnetoresistance material of LSMO. Grew and measured properties of different thickness of LSMO. Fabricated LSMO nanowires with (e-beam, UV, Ion-Beam) lithography and RIE from LSMO thin film and investigated its properties including the $1/f$ noise. Low dimensionality induced suppressed metallicity effect was found.
- ★ Explored and found the recipe to treat the SrTiO_3 (001) substrate to get atomically flat surface.
- ★ Wrote a code to simulate the angle-resolved XPS data to analyze the surface chemical composition.
- ★ Built up a time-resolved temperature dependent physics properties and I-V measurement system and wrote a related software with Labview.
- ★ Designed and built up a UHV & O_2 compatible high temperature substrate heater for thin film growth and wrote a software for heating control.
- ★ Wrote a LEED software with Labview & C to control LEED controller and CCD to automatically acquire LEED image and LEED Image Processing software to analyze background & line profiler of diffraction peak to get surface morphology typically the scale of nanostructure as an example; convert image format; acquire intensity of peaks.
- ★ Built up home-made $1/f$ noise measurement system and wrote related software.
- ★ Built up a home-made STM-tip etching instrument with a instant feedback to control the cutting of etching current to get a commercially comparable sharp tip.

Sep. 2006-Jan. 2010, Institute of Physics, Chinese Academy of Sciences

Explored and studied non-volatile memory devices.

- ★ Designed and realized a new method to measure the resistance random access memory (RRAM) devices inside TEM to microscopically investigate the working mechanism in real time. Found direct evidence for oxygen migration for resistance switching with this method.
- ★ Designed a metal oxide heterostructure based device (Pt/PCMO/ CeO_2 /Pt) and realized better resistance switching performance. Developed a theoretic model to describe the metal oxide heterostructure based RRAM

devices and proposed the complementary metal oxide heterostructure concept.

- ★ Studied mechanism of electric field induced non-volatile resistance switching. Found effect of electrodes and revealed that Gibbs free energy of oxidation of electrodes plays an important role in resistance switching besides the work-function. Found the self-limiting effect at active-metal/PCMO junction and proposed the interface redox model.
- ★ Cooperated with 4DS at Silicon Valley on RRAM devices. Characterized the films provided by 4DS with TEM, SEM, XRD, XPS. Fabricated RRAM devices and tested the performance including retention, endurance, ON/OFF ratio, uniformity.
- ★ Studied opto-electrical properties of ZnO nanotubes. Persistent photoconductivity (PPC) induced by ultraviolet light and erase of PPC caused by infrared were found. Demonstrated a prototype of opto-electrical non-volatile memory based on ZnO nanotube.
- ★ Improved software of a unique home-made STM-like single vertical nanowire measurement system
- ★ Built up a home-made preamplifier and a quick I-V test system and related software interface.
- ★ Built up a low temperature Dewar
- ★ Explored anisotropic wet-etching of Si and built up a SiN_x thin film window on Si frame as TEM specimen supporter. This new kind of TEM specimen support film can be used for many kinds of in-situ TEM experiments.
- ★ Designed in-situ TEM thin film cross-section specimen holder to enable applying electric field inside TEM.
- ★ Wrote a monochromator control software and associated building up an in-situ TEM opto-electrical measurement system
- ★ Wrote a Stock software with Microsoft Foundation Class.
- ★ Won champion of artificial intelligence programming of Five-Chess in a C++ class game.

Awards and Fellowships:

Talented student of IOP	2009
Selected into "Top 100 Program" of CAS	2007
Five-Chess Program Champion	2007
Scholarship for Outstanding Students	2005
Scholarship for Outstanding Students	2004
Kwang-Hua Scholarship	2003

Publications:

1. **Z. L. Liao**, Z. Z. Wang, Y. Meng, Z. Y. Liu, P. Gao, J. L. Gang, H. W. Zhao, X. J. Liang, X. D. Bai, D. M. Chen, *Categorization of resistive switching of metal-Pr_{0.7}Ca_{0.3}MnO₃-metal devices*, Appl. Phys. Lett. **94**, 253503(2009).
2. **Z. L. Liao**, P. Gao, Y. Meng, H. W. Zhao, X. D. Bai, J. D. Zhang, and D. M. Chen, *Electroforming and endurance behavior of Al/Pr_{0.7}Ca_{0.3}MnO₃/Pt devices*, Appl. Phys. Lett. **98**, 203108 (2011).
3. **Z. L. Liao**, P. Gao, Y. Meng, W. Y. Fu, X. D. Bai, H. W. Zhao, D. M. Chen, *Engineering of electrodes to improve resistive switching performance in single crystalline CeO₂ thin film*, Solid State Electron (2012), doi:10.1016/j.sse.2011.10.001.
4. S. L. Li, **Z. L. Liao**, J. Li, J. L. Gang and D. N. Zheng, *Resistive switching properties and low resistance state relaxation in Al/Pr_{0.7}Ca_{0.3}MnO₃/Pt junctions*, J. Phys. D: Appl. Phys. **42**,045411 (2009).
5. Y. Wang, **Z. L. Liao (co-first)**, G. W. She, L. X. Mu, D. M. Chen, and W. S. Shi, *Optical modulation of persistent photoconductivity in ZnO nanowires*, Appl. Phys. Lett. **98**, 203108 (2011).
6. P. Liu, G. W. She, **Z. L. Liao**, Y. Wang, Z. Z. Wang, W. S. Shi, X. H. Zhang, Shuit-Tong Lee, and D. M. Chen, *Observation of persistent photoconductance in single ZnO nanotube*. Appl. Phys. Lett. **94**, 063120 (2009).
7. J. L. Gang, S. L. Li, Y. Meng, **Z. L. Liao**, X. J. Liang, D. M. Chen, *Reproducible low-current resistive switching*

- of metal/ $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ /Pt junctions with a point-contact top electrode, *Acta. Phys. Sin.* **58**, 5730 (2009).
8. Y. Meng, P. J. Zhang, Z. Y. Liu, **Z. L. Liao**, X. Y. Pan, X. J. Liang, H. W. Zhao, D. M. Chen, *Enhanced resistance switching stability of transparent ITO/TiO₂/ITO sandwiches*, *Chin. Phys. B* **19**, 37304 (2010).
 9. P. Gao, Z. Z. Wang, W. Y. Fu, **Z. L. Liao**, K. H. Liu, W. L. Wang, X. D. Bai, E. G. Wang, *In situ imaging of Oxygen vacancy migration for electrically induced resistance change effect in cerium oxides*, *Journal of Micron* **41**, 301(2009).
 10. J. L. Gang, S. L. Li, Y. Meng, **Z. L. Liao**, X. J. Liang, and D. M. Chen, *Clockwise vs. counter-clockwise I-V hysteresis of point-contact metal-tip/ $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ /Pt devices*, *Chin. Phys. Lett.* **27**, 027301(2009).
 11. P. Gao, K. H. Liu, L. Liu, Z. Z. Wang, **Z. L. Liao**, Z. Xu, W. L. Wang, X. D. Bai, E. G. Wang and Y. Q. Li, *Higher-order harmonic resonances and mechanical properties of individual cadmium sulphide nanowires measured by in situ transmission electron microscopy*, *J. Electron Microsc (Tokyo)*. **59**, 285 (2010).
 12. F. Pang, X. J. Liang, **Z. L. Liao**, S. L. Yin, D. M. Chen, *Origin of the metallic to insulating transition of an epitaxial Bi(111) film grown on Si(111)*, *Chin. Phys. B* **19**, 087201 (2010).
 13. **Z. L. Liao**, et al., *Evidence for electric-field-driven migration and diffusion of oxygen vacancies in $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$* , under review.
 14. **Z. L. Liao**, D. M. Chen, *Resistance switching in metal oxide heterostructure*, to be submitted.
 15. **Z. L. Liao**, et al., *Surface structure of SrTiO₃ for Laser-MBE*, in prepare.
 16. **Z. L. Liao**, et al., *Metal-Insulator transition in the nanostructural LSMO-V₂O₃ nanocomposite*, in prepare.

Patents:

1. **Z. L. Liao**, L. Li, D. M. Chen, *Manual precise grinding polisher for preparing TEM sample*, CN201537844.
2. L. Li, **Z. L. Liao**, H. X. yang, J. Q. Li, *Process for manufacturing novel TEM sample supporting film (silicon nitride window)*, CN101794694.
3. P. J. Zhang, H. W. Zhao, Y. Meng, Z. Y. Liu, **Z. L. Liao**, T. Su, X. Y. Pan, X. J. Liang, D. M. Chen, *Memister*, CN101546811
4. Y. Meng, H. W. Zhao, P. J. Zhang, Z. Y. Liu, **Z. L. Liao**, X. Y. Pan, X. J. Liang, D. M. Chen, *Transparent resistance non-volatile random access memory*, CN101478031.

Oral Presentations:

- Talks**, *Metal-to-insulator transition in a columnar nanocomposite oxide*, APS march meeting, Boston, 02/2012
- Talks**, *Direct visualization of electric-field-driven migration and decay of oxygen vacancy-induced stripes in $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$* , APS march meeting, Boston, 02/2012
- Talks**, *The effect of oxygen migration for random resistance access memory in oxide-based devices*, APS march meeting, Dallas, 03/2011.
- Talks**, *Research of optoelectronic properties of ZnO nanotubes*, 2008 Annual Meeting of Chinese Physical of Society

Poster Presentations:

EP2DS-18 conference: *Categorization of resistive switching of Metal- $\text{Pr}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ -Metal devices*, 2009.

References:

- Personal Link:** <http://www.linkedin.com/pub/zhaoliang-liao/33/a35/a29>
- Ward Plummer** <http://www.phys.lsu.edu/plummer/>
- Jiandi Zhang** <http://www.phys.lsu.edu/~jzhang/>
- Dongmin Chen** <http://www.linkedin.com/pub/prof-dongmin-chen/a/778/1ab>
- Li Lu** <http://english.iop.cas.cn/pe/?t=detail&id=4>