High-Pressure, Low-Temperature Research (HTS & Related Materials)

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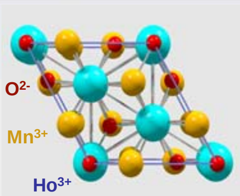
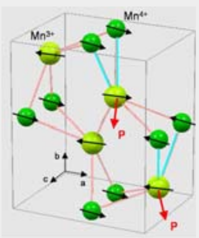
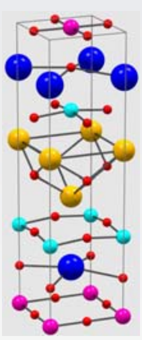


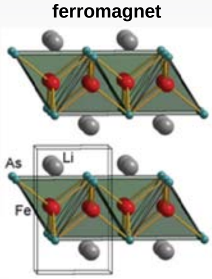
Lattice structure of $HoMnO_3$



Ferroelectricity through magnetic frustration in $HoMn_2O_5$



$RuSr_2Gd_2Cu_2O_{10}$: The superconducting ferromagnet



LiFeAs: A new member of the iron pnictide superconductors

Current Projects/Achievements:

In the TcSUH High-Pressure, Low-Temperature Research Laboratory we search for new and improve existing high temperature superconducting (HTS) and related materials; evaluate reports of new HTSs; understand and improve HTSs through the routes of extreme conditions and chemical manipulation; identify critical processing parameters and develop processes for the efficient fabrication of high quality HTS coated conductors; and determine crucial issues in HTS devices.

MULTIFERROIC MAGNETO-ELECTRIC MATERIALS

Novel Magneto-Electric Memory and Sensors: The program focuses on the growth, fundamental study and applications-related investigation of bulk and thin-film multiferroics. Multiferroic magneto-electric materials exhibit the coexistence and mutual interaction of magnetic and ferroelectric orders. We have detected the strong magnetoelectric effect, discovered several complex magnetic phase diagrams, and identified spin-lattice coupling as a main cause for the coupling in these compounds. The strong coupling between magnetism and ferroelectricity in these materials provides the foundation for new physical phenomena such as magnetic-order-induced ferroelectricity, tuning of electric polarization by magnetic fields, or electric-field-induced magnet-ization. Based on these novel properties new magneto-electric sensors can be developed, and a novel magneto-electric memory can be designed. The underlying mechanism is yet to be unraveled.

E-FIELD DRIVEN RESISTIVE SWITCHING IN INTERFACIAL OXIDE LAYERS

Nano-Scale Memory Devices: We have identified that the reversible field-driven resistive switching is localized in the interfacial thin layers between the electrodes and a large number of bulk oxides. We have also determined that the switching is fast (down to 100 ns or shorter) and the resistance change is large (up to 100x). Preliminary evidence suggests that the switching occurs only within a few hopping steps, i.e. reaching nanometer scale. Such reversible field-driven resistance-switching holds great promise for next-generation nonvolatile nano memory devices. Both the underlying physics and the techniques to produce the necessary microstructures, however, are only poorly known. This will be a challenge to both science and technology.

HIGH TEMPERATURE SUPERCONDUCTOR APPLICATIONS

HTS Sensors and Magnets for Breast Scan: We will focus on the development of functional ultra sensitive sensors and low-cost magnets, *i.e.* including cryogenic system designs, for the recently announced MRI breast scan system which has extremely high resolution and throughput, but is expensive, i.e., at ~ $2000/scan. To reduce the cost, we propose: 1). to use HTS sensors to enhance the sensor resolution and thus to reduce the field required and/or 2). to use MgB_2 magnet to reduce the cryogenic cost and complications of the magnet. The project will include collaboration with colleagues in other TcSUH groups and two industrial companies.

NOVEL HIGH TEMPERATURE SUPERCONDUCTORS

Study of Newly Discovered Superconductors: We focus on the investigation of new iron pnictide HTS with the objective to unravel the intrinsic correlation between magnetic fluctuations and superconductivity and study the physical properties in the quantum critical regime, the existence of which was recently proposed by us. We will seek for chemical modification of known iron pnictides with the goal to increase their superconducting T_c and improve their most relevant superconducting properties.

Search for Possible Room Temperature Superconductors: We will explore several possible approaches that have been conceived and developed by C. W. Chu over the last few years. Some of them were presented at the 2007 Workshop on Room Temperature Superconductivity co-sponsored by USAFOSR, NATO, and TcSUH at Loen, Norway and published recently. The scientific challenges and the technological promises posed by a room temperature superconductor are tremendous.

Unidentified Superconducting Objects: We continue to monitor, confirm, or dismiss the numerous reports of sighting superconductivity at unusually high temperatures and act as the information repository for the HTS field. Due to their uncertain nature and poor reproducibility, they are called the Unidentified Superconducting Objects (USOs). Although USOs are too fleeing to confirm, they are too tantalizing to ignore. It is not impossible to find that some are credible. If even one is found to be real, the possibility of raising the superconducting transition temperature will make the effort of investigation worthwhile.

Personnel

Dr. Yu-Yi Xue: Research Prof. of Physics; Dr. Bernd Lorenz: Research Prof. of Physics; Dr. Victor Diatschenko: Research Asso. Prof. of Physics; Dr. Yanyi Sun: Research Associate 2; Dr. Yaqi Wang: Research Associate 2; Dr. Feng Chen: Research Asst. Prof. of Physics; Dr. Takaki Muramatsu: Post Doctoral Fellow; Dr. Gang Wu: Visiting Researcher; Chris Kinalidis: Research Engineer; Duc Pham: Research Engineer. **Graduate Students:** 6 Ph.D. (Physics)