



Center for Advanced Materials (CAM)

(UK, Centre College, Berea College and Morehead State U)

“Novel Materials and Their Applications in Epitaxial Thin Films and Device Structures: Formation of a Center for Advanced Materials”
NSF Grant #EPS-0814194, 09/01/08–08/31/13

Goal: To create complementary expertise and facilities that foster wide-ranging **materials synthesis and characterization**, advanced applications, and **theoretical insight**.

Participating Faculty: 19 (Physics, Chemistry, Engineering)

Grant Duration: 2008-2013

Budget: \$4.4 M

- o **\$ 2.3 M:** Equipment (~ \$ 0.5 M, one or two major instruments/year)
- o **\$ 1.5 M:** Salaries for two new Faculty for two years, outreach, materials & supplies, seminar, etc.
- o **\$ 600 K:** Centre, Berea and Morehead State research support



Support from University of Kentucky and Private Donor

- Four faculty lines
- Four RAs
- CAM space renovation, ~ \$ 600 K
- Private donation for RAs, summer internships, seminar series, and outreach program: \$100 K/year since 2009
- Faculty startup funds

Motivation and Emphasis

- ❑ It is widely recognized that whoever controls the synthesis and discovery of novel materials controls research and technologies.
- ❑ The traditional U.S. leadership in materials research has eroded in recent years due in part to the lack of scientists who possess skills in both the synthesis and characterization of new materials.
- ❑ **Discovery and Synthesis** of novel electronic materials in **both bulk-single-crystals** and **multilayer films** having unusual electric, magnetic, thermal and optical properties.
- ❑ **Characterization** techniques covering a broad spectrum of experimental probes and in extreme conditions, namely, high pressure, relatively high magnetic field and ultra low temperature.
- ❑ The scope of **CAM** research can be aggressively expanded to explore emerging or unanticipated research topics and interdisciplinary areas.

NOVEL MATERIALS ⇒ NOVEL EFFECTS ⇒ NOVEL THEORIES ⇒ NOVEL DEVICES



2008-2011: Milestones and Major Activities

1. Completion of four faculty hires (2008-2010)
2. Completion of installation of CAM major instruments **(1)** Helium liquefier and recovery system (2008-2010); and **(2)** 14 T Physical Property Measurement System (PPMS) with a dilution refrigerator (September, 2010)
3. To install **(1)** a Bruker D8 Advance X-Ray Diffractometer for powder and thin-film samples, and a temperature range of 90 K-1400K; and **(2)** a Bruker D2 Cryso X-Ray Diffraction System (Laue X-Ray Camera) in June, 2011
4. To purchase an AJA sputtering system in summer, 2011
5. UK supports four CAM RA's/year since 2008
6. Outreach activities, and **CAM Summer Internship Program** for both undergraduate and high school students (Outreach Program Director, Prof. Strachan is to present details)
7. Collaborations between UK and Centre College, and between faculty members in Physics, Chemistry and Engineering (Prof William Crummett at Centre College)
8. Monthly **CAM Seminar** given by distinguished scientists worldwide. (CAM Seminar Coordinator, Prof Kaul)
9. The **3rd Workshop on Novel Electronic Materials** is to be held in Wuhan, China in June 10-15, 2011. (The 1st and 2nd Workshop was held at UK in 2005 and 2008, respectively)



2008-2010: Completion of Four Faculty Searches

- 1. Prof. Douglas Strachan: Experimental Physics of Nanostructures** (2008, PD, U. Pennsylvania)
- 2. Prof. Elizabeth Guiton: Experimental Materials Chemistry, High Resolution Atomic Imaging** (2009, Wigner Fellow, ORNL)
- 3. Prof. Ribhu Kaul: Theoretical Physics of Strongly Correlated Electrons** (2009, PD, Kavli Institute for Theoretical Physics, UCSB)
- 4. Prof. S. S. Ambrose Seo: Experimental Physics of Thin-Film Materials** (2010, PD, ORNL)

2008-2010: Helium Liquefier Installation



Liquefier Cost: \$ 570 K

Installation Cost: \$ 302.2 K [\$150 K (CAM loan) + \$ 77.3 K (CAM) + \$ 74.9 K (LevTech royalties, P&A incentive funds & fees)]

Production: Operates one day/week @ 300 L/week

Recovery Rate: > 95% (Our cost **\$2 - \$3/L**; commercial rate ~ \$10/L)

Technician: Gene Baber (one day/week)

2010: Wide-Temperature, High-Field Lab



**Quantum Design Physical Property
Measurement System:**

Temperature Range: 50 mK – 1200 K

Magnetic Field Range: 0 - 14 T

Instrument Cost: \$570 K

Measurements: AC/DC Magnetic properties, electric resistivity, Hall effect, thermal conductivity, heat capacity, thermoelectric power, etc.

2011: X-Ray Diffraction Systems (to be installed in the week of June 27th, 2011)



1. **Bruker D8 Advance Diffractometer** (for powder and thin-film samples, and a temperature range of 90K - 1400K)
2. **Bruker D2 Cryso (Laue X-ray Camera)**



2008-2010: CAM Central Laboratory

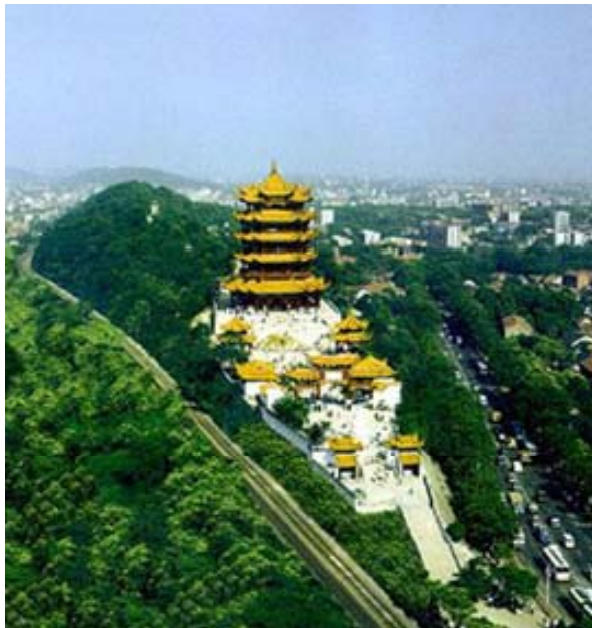


Initial Facilities

- (1) Quantum Design SQUID Magnetometer (donated by Department of Physics and Astronomy)
- (2) Bruker D8 Advance Diffractometer (2011)
- (3) Laue X-ray Camera (2011)
- (4) Pulsed Laser Deposition System (in Prof Seo' lab, 2011)
- (5) AJA Sputtering System (2012)
- (6) Optical Floating Zone Furnace (2012)
- (7) 22T Superconducting Magnet (2013) (???)
- (8) A few more major items to be determined (2012-2013)

Synergistic Activities

- ❑ **CAM International Workshop: 3rd Workshop on Novel Electronic Materials, June, 2011, Wuhan, China**



- ❑ **CAM Seminar:** Monthly seminar given by distinguished scientists
- ❑ Enhance/increase productive collaborations or partnerships with National Labs.



2011-2013: Planned Activities

- Submit a **World Materials Network (WMN)** Proposal to NSF (2011)
- Obtain NSF Summer REU grant
- Establish strong international collaborations
- Enhance productive collaborations or partnerships with National Labs
- CAM Visitor Program:** Invite 2-3 distinguished scientists/year for an extended stay (~ 4 weeks)
- Organize an **International Symposium on Physics Driven by Spin-Orbit Interaction** in May, 2012
- Submit a MIRT or CEMRI proposal by 2013
- Submit a NSF proposal for an **International Materials Institute for Complex Oxides** in 2013