

A TIE Funded Ohio State University Initiative: The Center for Electronic and Magnetic Nanoscale Composite Multifunctional Materials (ENCOMM)

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Executive Summary

ENCOMM is exploiting broad interdisciplinary strength in materials to address central challenges and overcome key problems currently faced in the development of forward looking approaches to information processing, energy conversion and sensing through discovery, understanding and development of complex multicomponent materials and interfaces between them. We are accomplishing this by

- Creating an environment in which inter-disciplinary research groups can form and interact
- Providing the infrastructural foundation for the research

A year of interaction, meetings and presentations has fostered several active collaborative research projects. These in turn are providing a basis for proposals. One important current example is the four Interdisciplinary Research Groups or IRGs that have emerged. Under the auspices of the OSU Institute for Materials Research (IMR), these and other IRGs are currently being shaped into a MRSEC white paper to be submitted to the National Science Foundation on September 5, 2007.

The newly formed ENCOMM Nanosystems Laboratory is up and running. Several high value instruments were selected by ENCOMM members and their importance prioritized. The top priority was given to a sophisticated instrument, a Focused Ion Beam Mill (FIB) purchased using TIE funds that has been purchased and received, and is currently being installed. This is a powerful instrument for nanosystems prototyping, high resolution lithography and characterization that will greatly enhance our ability to establish a unique and visible presence in the scientific areas described in our IRG summaries.

The key implementation issue we face arises because our primary opportunity afforded by TIE funds is the purchase of equipment that will allow us to accomplish the groundbreaking science that underlies our IRG's and hence to enhance the impact and recognition of ENCOMM and the OSU Materials community. We cannot overstate the importance of being allowed to borrow against later years of TIE funds so that we may purchase the equipment as quickly as possible.

ENCOMM's First Year

ENCOMM has been meeting weekly for one year as a group that now comprises 35 faculty members from six departments in the College of Math and Physical Sciences and the College of Engineering (see Appendix for membership; more information on the activities of the Center can be found at <http://www.physics.ohio-state.edu/ENCOMM/index.htm>). Initial presentations (the Appendix also shows the schedule of presentations) acquainted the Center membership with the interests, capabilities and researcher's suggestions for fruitful directions. These interactions fostered interdisciplinary collaborative research groups that have embarked on new research projects and are competing for funding both internal (such as IMR Facilities grants and seed grants) and external. Of particular importance are four Interdisciplinary Research Groups (IRGs) that, working with the IMR, will contribute to an NSF Materials Research Science and Engineering Center. The four topical areas of these IRGs are shown here:

Topic	Leader
Electronic Metamaterials	E. Johnston-Halperin
Expanding the Materials Basis for Magneto-electronics	P.C. Hammel
Complex Oxides: Ferromagnetics, Ferroelectrics, and Multiferroics	L.J. Brillson
Inorganic/Organic Interfaces	M.H. Chisholm

Four focus areas that emerged from ENCOMM's first year. Of these the first three were developed into IRGs currently being shaped into an NSF MRSEC white paper due September 5, 2007 under the auspices of the IMR. A fourth proposed IRG contains many elements of the Organic/Inorganic topical area.

A primary objective of ENCOMM is to win block funding for our research thrusts; a key upcoming opportunity is the highly prestigious and competitive NSF Material Research Science and Engineering Centers or MRSEC. NSF recently announced a request for proposals: white papers are due at NSF by September 5, 2007. A MRSEC is typically composed of three to four IRGs. The work outlined above prepared us well to develop three very strong IRG proposals (the first three

of the four listed above) that are currently being considered as components of the MRSEC white paper. A fourth IRG strongly related to the Organic/Inorganic focus group is also under consideration. The full text of these white papers is available at <http://www.physics.ohio-state.edu/ENCOMM/private/index.htm> (Username: ENCOMMprop, Password: HybridMaterials).

The ENCOMM Nanosystems Laboratory

A key ENCOMM objective is to provide the sophisticated materials fabrication and characterization equipment that is essential to realizing ENCOMM's goal of revolutionary advances forefront areas of materials science. The defining opportunity presented by TIE funds is to acquire critical nanoscience equipment; this will leverage premium space donated by MAPS (~ 2000 ft² of state-of-the-art laboratory space and an additional ~ 2000 ft² of conference, administrative and dedicated lab space) to create a focused state-of-the-art nanoscience facility. This objective will consume the majority the TIE funds awarded.

Equipment Selection

Proposals for equipment were solicited from ENCOMM faculty. These were evaluated and prioritized by the entire membership. We have embarked upon purchasing this equipment in order of priority as funds become available. Top priority was given the Dual Beam Focused Ion Beam Mill (FIB) able to directly form nanoscale systems with a nanoscale milling tool, and to perform sub-nanometer electron microscopy and high resolution electron beam lithography. This instrument has been received by ENCOMM and is currently being installed in the ENCOMM Nanosystems Laboratory (ENSL) in the new Physics Research Building. This is a powerful instrument for nanosystems prototyping, high resolution lithography and characterization that will greatly enhance our ability to establish a unique and visible presence in the scientific areas described in our IRG summaries.

In addition several pieces of equipment have been granted to ENSL by the Department of Physics; these include a SQUID magnetometer, an atomic force microscope, a scanning electron microscope and other lithography and fabrication equipment. This equipment has also been installed in the new ENSL space.

ENSL is being planned and developed by a Facility Manager provided by the Department of Physics. Working with the Institute for Materials Research (IMR) we are identifying and recruiting an IMR Member of Technical Staff to assist this Facility Manager with

training users, supervising usage and maintaining the facility and equipment.

In addition to this process, one application of research equipment funds deserves note. A key commitment to ENCOMM by MAPS and the Department of Physics was to hire a demonstrated driver in the field of nanoscience and nanomaterials fabrication: we were successful in recruiting a young leader in this field. ENCOMM places top priority upon providing him the equipment and tools necessary to enhance his research effort and the consequent ENCOMM access to cutting edge nanomaterials.

Implementation Issues: Timely Purchase of Equipment

Excellent progress is being made. The single most notable impediment to our progress is the inability to use the several pieces of equipment that were highly prioritized by ENCOMM but are not yet available because we are not yet able to purchase them. We cannot overstate the importance of being allowed to borrow against later years of TIE funds so that we may purchase the equipment as quickly as possible. We need these instruments *as soon as possible* in order to bolster the MRSEC proposal and to accomplish the groundbreaking science that will strengthen our reputation and ability to compete for funds.

Appendix

ENCOMM has 35 faculty members from six departments in the College of Math and Physical Sciences and College of Engineering

G. Agarwal	Biomedical Engineering
J.D. Badjic	Chemistry
P.R. Berger	Electrical Computer Engineering and Physics
L.J. Brillson	Electrical Computer Engineering and Physics
M. Chisholm	Chemistry
J.V. Coe	Chemistry
P.K. Dutta	Chemistry
A.J. Epstein	Physics and Chemistry
T. Gramila	Physics
J.A. Gupta	Physics
T.L. Gustafson	Chemistry
P.C. Hammel	Physics and Electrical Computer Engineering
J. Heremans	Mechanical Engineering
C. Jayprakash	Physics
E. Johnston-Halperin	Physics
T. Lemberger	Physics
W. Lu	Electrical Computer Engineering
J.S. Meyer	Physics
S.V. Olesik	Chemistry
N.P. Padture	Materials Science Engineering
J. Parquette	Chemistry
J. Pelz	Physics
M. Poirier	Physics
W. Putikka	Physics
M. Randeria	Physics
S.A. Ringel	Electrical Computer Engineering and Physics
R. Sooryakumar	Physics
D.G. Stroud	Physics
V.V. Subramaniam	Mechanical Engineering
N. Trivedi	Physics
H. Verweij	Materials Science Engineering
J.W. Wilkins	Physics
P. Woodward	Chemistry
Y. Wu	Chemistry

ENCOMM Meeting Schedule

2006

20, 27 January	Rick McCreery	Chemistry	Bistable Molecular junctions as potential low volatility memory
3 February	James Coe	Chemistry	Surface Plasmons and the Extraordinary Infrared Transmission of Metallic Arrays with Subwavelength Holes
10 February	Arthur J. Epstein	Physics	Strong Effects of Weak Magnetic Fields in Organic Semiconductors
24 February	David G. Stroud	Physics	Introduction to Nanoplasmonics
3 March	Jay Gupta	Physics	Frontiers in spectroscopy with the scanning tunneling microscope
31 March	Chris Hammel	Physics ECE	High Resolution Magnetic Resonance Imaging in a Ferromagnet
7 April	Yiying Wu	Chemistry	A general method towards complex metal oxide nanostructures and their photovoltaic applications
14 April	Nandini Trivedi	Physics	Multifunctional Materials and Imaging: Insights from computer simulations
21 April	Jonathan Pelz	Physics	Measurement and modeling of nm-scale electronic properties at buried interfaces
28 April	Fengyuan Yang	Physics	Spin Transport in nanoscale metallic and semiconductor magnetoelectronic devices
5 May	Malcolm Chisholm	Chemistry	Control of Electronic Coupling Between Dinuclear Metal Centers: Molecular Rheostats and Switches
12 May	Jovica Badjic	Chemistry	Measurement and modeling of nm-scale electronic properties at buried interfaces
19 May	Nitin Padture	Matls Sci & Eng	Novel 1-D and 2-D Nanostructures of Functional Oxides
2 June	Leonard Brillson	ECE Physics	Recent Advances in Spectroscopy of Electronic Materials Surfaces and Interfaces
22 September	Organizational Meeting:		Define meeting schedule and format
29 September	Thomas Lemberger	Physics	Growth and Properties of Cuprate Superconducting Films
6 October	Zeke Johnston-Halperin	Physics	Controlling structural, electronic, and magnetic properties at nanometer length scales
13 October	Pat Woodward	Chemistry	Multiferroic Materials: Chemical Design Principles
20 October	Paul R. Berger	ECE & Physics	Organic-based semiconductors and materials for quantum functional circuitry flexible circuitry and foldable photovoltaics
27 October	Julia S. Meyer	Physics	Interaction effects in quasi-1d electron transport
3 November	R. Sooryakumar	Physics	Recent Advances in Magneto-Electronics
17 November	Steven Ringel	ECE & Physics	Quantified Detection of Deep Defect States in Wide Bandgap AlGa _N and GaN with Nanometer Resolution
1 December	Joseph Heremans	Mech Eng	Thermomagnetic Transport in Single-Walled Carbon Nanotubes
8 December	Organizational Meeting		IRG Presentations and Equipment Selection
19 December	Organizational Meeting		Equipment Selection

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5 January	Organizational Meeting: Equipment Selection		
12 January	John W. Wilkins	Physics	Can You Trust Electronic Structure Calculations?
26 January	Mohit Randeria	Physics	Theory of Scanning Tunneling and Photoemission Spectroscopies of Strongly Correlated Materials
2 February	IRG Meetings: IRGs meet individually		
9 February	IRG Presentations: Ten minute overviews		
16 February	IRG Meetings: IRGs meet individually		
23 February	IRG Meetings: IRGs meet individually		
2 March	IRG Meetings: IRGs meet individually		
9 March	No Meeting: APS March Meeting		
16 March	IRG Meetings: IRGs meet individually		
23 March	Spring Break		
30 March	IRG Presentation:		Electronic Metamaterials
6 April	ENCOMM First Anniversary Meeting		
13 April	IRG Presentation		Magnetolectronics
20 April	IRG Presentation		Oxides
27 April	IRG Presentation		Organic/Inorganic
4 May	Organizational Meeting		IRG White paper preparation
11 May	IRG White paper preparation		
18 May	IRG White paper preparation		
25 May	Wu Lu	ECE	Preliminary Results on Biosensing Gas Chemical Sensing Based on III-Nitride Materials
1 June	Terry L. Gustafson	Chemistry	TBA
8 June	Andrew Stollenwerk	SUNY-Albany	Spin Transport and Structural Properties of Transition-Metal/Semiconductor Interfaces

