COVER PAGE FOR POST-KATRINA SUPPORT FUND INITIATIVE
PRIMARILY RESEARCH SUBPROGRAM PROPOSALS
BOARD OF REGENTS SUPPORT FUND, FY 2006-07

032PKSFI-R-07

1. Submission Discipline: ☐ Biological Sciences ☐ Information Technology ■ Materials Science (check only one)	(For BoR Use Only) Application Number:
2. Name(s) of Lead Submitting Institution of Higher Education: (Include Branch/Campus/Other Components)	University of New Orleans, Lakefront, New Orleans, LA
3. Address of Lead Institution of Higher Education: (Include Dept/Unit, Street Address/P.O. Box Number, City, State, Zip Code)	University of New Orleans, Advanced Materials Research Institute, College of Sciences, 2000 Lakeshore Drive, New Orleans, LA 70148
4. Title of Proposed Project:	A Center for Advanced Materials and Nanotechnology in AMRI at the University of New Orleans
5. Proposed Duration: (Circle # of Yrs.) 1 2 3 4 (5)	6. Funds Requested — P-KSFI Year 1: $ 1,600,000; ESIP: $ 800,000; Project Total: $ 8,800,000
7. Name(s) of Partnering Institution(s)	University of New Orleans; Children's Hospital-New Orleans-LSUHSC; Tulane University; Institute for Micromanufacturing-LA Tech University, LSU-CAMD; Communities in Schools

8. Does This Proposal Contain Confidential or Proprietary Information Which Falls Into a Category Described in R.S. 44:4(16)?
☐ YES ■ NO (NOTE: If YES, the proposal MUST be appropriately marked.)

By signing and submitting this proposal, the signators are certifying that: (1) the proposed project has not already been funded/is not currently being funded/has not been promised funding; (2) this proposal has been reviewed and approved by an Institutional Screening Committee; and (3) the institution and the proposed project are in compliance with all applicable Federal and State laws and regulations, including, but not limited to, the required certifications set forth in: (a) Grants for Research and Education in Science and Engineering, NSF Grant Proposals Guide (GPG), NSF 03-2, effective 10/1/02, and (b) 45CFR 620, Subpart F (Requirements for a Drug-Free Workplace).

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(Form 1-PKSFI-PRS, 1-2007)

PROJECT SUMMARY

Name of Lead Institution (Include Branch/Campus): University of New Orleans, Lakefront, New Orleans, LA

Name(s) of Partnering Institution(s) (Include Branch/Campus):
University of New Orleans; Children's Hospital-New Orleans-LSUHSC; Tulane University; Institute for Micromanufacturing-LA Tech University; LSU-CAMD; Communities in Schools

Principal Investigators: Dr. Charles J. O'Connor

Title of Project: A Center for Advanced Materials and Nanotechnology in AMRI at the University of New Orleans

Abstract (DO NOT EXCEED 250 WORDS):

The ultimate goal of this proposal is to enhance the collaborative infrastructure that will allow the Advanced Materials Research Institute (AMRI) at the University of New Orleans to successfully compete for major centers grants (*e.g.*, NSF MRSEC, NSEC, ERC; DOD MURI, DOE, NIH, *etc.*). Since opening in 1996, AMRI has averaged over $3M/yr in grants and contracts. AMRI currently has over $6M in active funding and the funding for P-KSFI will be leveraged by current and subsequent grants. AMRI will recruit two faculty who will be charged with helping to organize the centers initiative; the UNO administration has allocated the new faculty to AMRI as cost-sharing for PKSFI. These positions are focused on projects that overlap with the research proposed here. Substantial startup funds are needed to be competitive when recruiting top notch faculty; the funds from P-KSFI combined with monies provided by UNO will afford a very attractive and competitive package that will increase the likelihood of landing first rate candidates. The premier research centers in the U.S. are defined by strong interdisciplinary research efforts. Towards this goal, this white paper is divided into four sections, three Focused Research Groups and Broader Impacts as follows:

1. *Nanomaterials for Biological Sensing and Imaging: FRG co-leaders – S. Pincus (Children's Hospital), W. Zhou (UNO)*
2. *Nanoscale Mechanical Devices: FRG leader - J. Wiley (UNO)*
3. *Nanomaterials for Energy Conversion and Storage: FRG co-leaders – Y. Lvov (LaTech), K. Stokes (UNO)*
4. *Broader Impacts (Educational and Commercial Outreach): FRG leader - M. Tarr (UNO)*

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4. GOALS AND OBJECTIVES:

The fundamental goal of this P-KSFI proposal is to establish a federally-funded center for advanced materials and nanoscience in Louisiana. We will focus our efforts on being the lead institution in an NSF-MRSEC.

For AMRI to be the lead institution in a major center, it is clear that a competitive and successful proposal must describe a center whose focus is precisely defined. In order to clearly define the focus of our programmatic goal, we have selected three research areas to develop. Using a MRSEC proposal as a guide, this P-KSFI proposal is divided into three Focused Research Groups and a Broader Impacts section.

To reach our goal, the team must build a significant body of collaborative successes in the fields of materials research for bio-sensing and imaging, nanoscale mechanical devices, energy conversion and storage, and outreach. Our primary performance metrics will be success in obtaining competitive federal research cluster funding (jointly with two or more PI's from this team) and production of intellectual property (IP). Secondary metrics will be those activities which increase our profile in the scientific community: publications in high-profile journals and presentations at meetings (particularly invited presentations and lectures). Again, these will be jointly-authored with other team members, outreach participants and industrial partners. The specific technical objectives of the focused research and outreach groups are described at the end of the Narrative section (pp. 18-19). The table below summarizes the objectives of the entire consortium for the five years; the fundamental project goal of developing a major federally funded center at AMRI.

Funding agencies (especially NSF) are directing an increasing component of their research budget towards funding of collaborative research programs for example in the Mathematics and Physical Sciences Directorate at NSF, especially in the Divisions of Materials Research (DMR) and Chemistry. In addition to the major centers grant, each year we will target several collaborative multi-investigator grants.

We expect to have at least 2-4 patent disclosures each year, with at least two patents issued and licensed by year 5. In addition to the two spin-off companies in existence (NanoPrism Technologies, Inc. and NSCR Biotechnologies LLC) we expect these companies to become more established commercial ventures and AMRI will spin-off at least two additional companies in the area of energy conversion and nano-mechanical devices.

Table 1. Goals for this research team for the PKSFI grant period. All outcomes listed will include two or more team members as principal authors.

PERFORMANCE METRIC	Year 1	Year 2	Year 3	Year 4	Year 5
Federal grant proposals (both major center and cluster)	2	4	4	4	4
Publications	5	10	15	29	20
Presentations	8	15	20	20	20
Patent Applications and Disclosures	0	2	3	4	4
Outreach Interns	17	17	17	17	17

5. Narrative and Bibliography

A. Project Rationale and Structure

(1) DESCRIPTION OF RESEARCH GROUP

The Advanced Materials Research Institute (AMRI) consortium includes 22 co-investigators from the following six partner institutions in Louisiana: University of New Orleans (AMRI and Center for Innovation), Children's Hospital, LSU (CAMD and Physics), Louisiana Tech (IfM), Tulane University (Chemical Engineering), and Communities In Schools of New Orleans, Inc.

The proposal is divided into three Focused Research Groups and a Broader Impacts section with 22 participating team leaders (co-P.I.'s) and co-investigators as follows:

1. ***Focused Research Group #1; Nanomaterials for Biosensing and Imaging:*** **S. Pincus** (co-Leader, Children's Hospital, LSUHSC), **W. Zhou** (co-Leader, UNO-AMRI), **C. O'Connor** (UNO-AMRI), **Z. Rosenzweig** (UNO-AMRI), **J. Goettert** (LSU-CAMD), **M. DeCoster** (LaTech-IfM)
2. ***Focused Research Group #2; Nanoscale Mechanical Devices*: J. Wiley** (UNO-AMRI, Leader), **B. Gibb** (AMRI-UNO), **L. Spinu** (AMRI-UNO), **S. Whittenburg** (UNO-AMRI), **V. John** (Tulane–Chemical Engineering), **H. Ashbaugh** (Tulane–Chemical Engineering).
3. ***Focused Research Group #3 - Nanomaterials for Energy Conversion and Storage*; Y. Lvov** (co-Leader, LaTech), **K. Stokes** (co-Leader, UNO-AMRI), **H. Gabrisch** (UNO-AMRI), **L. Malkinski** (UNO-AMRI), **K. Varahramyan** (LaTech-IfM), **D. Young** (LSU-Physics)
4. ***Broader Impacts - Educational Outreach and Commercial Outreach;*** **M. Tarr** (Leader, UNO-AMRI), **P. Hanson** (UNO-AMRI), **R. Bidwell** (Communities In Schools of New Orleans, Inc.), **N. Grace** (Vice Chancellor for Technology and Economic Development, UNO).

(2) CONTEXT FOR PROJECT:

Following the destruction of Hurricane Katrina, AMRI has resumed operations at the University of New Orleans. The devastation to AMRI was profound; many of our staff suffered immense loss and damage and the research infrastructure of the institute has taken many months of hard work to restore. In the days immediately following the hurricane, AMRI was able to form a virtual institute on the internet, coordinate communication between staff and the emerging university administration, and assist our displaced research staff to continue their programs at remote host institutions around the country. As we re-organize AMRI, we are building a better, more successful institute and have reclaimed our position as the region's premier institution in advanced materials and nanoscience.

The Advanced Materials Research Institute is a multidisciplinary research institute founded in 1996. AMRI provides a unique opportunity to develop novel research ideas that ultimately involve the government, private, and academic sectors in the conception and development of research programs. The interactions with corporate laboratories provide a synergistic pathway that promotes technology transfer and private sector involvement in the operation of AMRI.

The focus of this proposal is to enhance the collaborative infrastructure of AMRI to allow the AMRI consortium to successfully compete for major centers grants. AMRI has developed an international reputation for excellence in the 10 years since its inception and has averaged over

$3M per year in external grants and contracts. This project will be managed by the AMRI management team that is experienced in the administration of major grants.

(3) EXISTING SCIENTIFIC EXCELLENCE:
The consortium is lead by a group of outstanding Louisiana researchers, all of whom have significant federal funding and have experience leading productive interdisciplinary research teams. In addition, Profs. **O'Connor**, **Pincus** and **Lvov** are entrepreneurs and have each established spin-off companies using technologies developed in the course of their research.

Since its inception in 1996, AMRI has obtained over $30M in grants and contracts, most of these funds cane from the National Science Foundation, Department of Energy, and agencies of the Department of Defense. The AMRI research laboratories are located in the Science Building at the University of New Orleans, where it occupies more than 8,000 square feet of laboratory and office space. Over its 10 year history, AMRI has received over $30M in outside funding and has amassed an inventory of more than $4.0 million of specialized materials research instrumentation to carry out its research programs. The facilities available to AMRI researchers and collaborators are listed on the AMRI web page (http://amri.uno.edu/). In addition to occupying first rate facilities, AMRI is already well positioned for the transition to a federally funded center.

AMRI is a participant in a research cluster that is now applying for an NSF-ERC. Dr. Stuart Wolf was AMRI's first program director at DARPA. After about 10 years at DARPA, Dr. Wolf joined the Department of Materials Science and Engineering at the University of Virginia. Prof. Wolf is very much aware of our expertise and capabilities and he has asked AMRI to participate in an NSF-ERC Proposal. The name of the proposed center is: "*Spins in Quantum Electronic Systems and Technology (SpinQuEST)*". In addition to the University of Virginia, the partner universities include University of California at Santa Barbara (David Awschalom), Florida State University (S. von Molnar), University of California at Riverside (R. Haddon), Morgan State University (C. Williams/A. Lisfi), and the University of New Orleans (C. **O'Connor**, AMRI).

AMRI-UNO is also the lead institution for the Louisiana collaborative program funded under DARPA's BioMagnetic Interfacing Concepts (BioMagnetICs) initiative. The three partner institutions for that proposal were AMRI at UNO (lead institution), the Neurosciences Center at LSUHSC, and CAMD at LSU. This project was a three year collaborative program with total project funding of $6,115,538 from 2003 – 2006.

(4) MULTI-INSTITUTIONAL FOCUS:

AMRI has a history of multi institutional programs and has established a research consortium which includes academic, government, and industrial participants and their research laboratories. Together with the AMRI Technical Advisory Board (TAB), these institutions include:

Academic Laboratories

- University of New Orleans
- Louisiana State University
- LSU Health Sciences Center
- Tulane University
- Louisiana Tech

Industrial Laboratories

- NanoPrism Technologies, Inc.

- NSCR Biotechnologies LLC
- Parallel Synthesis Technologies (TAB)
- Lockheed Martin, Advanced Technology Center (TAB)
- Intel Corporation (TAB)
- Seagate Recording Media Operations

Government Laboratories

- Argonne National Laboratory (TAB)

B. RESEARCH PLAN

(1) PROPOSED WORK

a. FRG1: Nanomaterials for Biosensing and Imaging

***Participants*:** **S. Pincus** (co-Leader, Children's Hospital, LSUHSC), **W. Zhou** (co-Leader, UNO-AMRI), **C. O'Connor** (UNO-AMRI), **Z. Rosenzweig** (UNO-AMRI), **Jost Goettert** (LSU-CAMD), **M. DeCoster** (LaTech-IfM)

Objectives: The objective of this research group is to develop nanomaterials to be used as biosensors and for clinical imaging. Specifically, we propose to develop highly sensitive nanowire-based biosensors and nanoparticle based real time imaging of biomolecules. The biosensors will be tested by detecting ricin toxin and secreted phospholipase A_2 ($sPLA_2$) enzyme, and through nanoparticle based real time imaging of biomolecules. The project will be led by **Seth Pincus** (LSUHSC, Children's Hospital, New Orleans) and co-led by **Weilie Zhou** (UNO-AMRI). The participants are **S. Pincus** (Biologist, LSUHSC, Children's Hospital, New Orleans), **W. Zhou** (Materials, scientist/physicist UNO-AMRI), **C.J. O'Connor** (Chemist, UNO-AMRI), **M. DeCoster** (Biologist, LaTech-IfM), **Z. Rosenzweig** (Biochemist, UNO-AMRI), and **J. Goettert** (Microfabrication specialist, LSU-CAMD) coupled with the expertise from four institutions and universities for nanomaterials synthesis, nanomaterials and biomaterials assembly, microfluid and sensor prototype fabrication, and biosensor and bioimage testing. Three sub-teams will be formed to accomplish three sub-projects associated with biodetection and clinical imaging.

Nanowire Biosensors

As binding of bio-agents to the surface of the nanowires can be detected at femtomolar (fM) concentration with millisecond response time,[1,2] developing highly sensitive nano-biosensors for biomedical research and pathogen monitoring has great potential for instant application. We will test the biosensors in two experimental systems that are well studied at our institutions and have considerable practical application: the detection of ricin toxin, a major biodefense concern, and secreted phospholipase A_2, an important clinical marker. Nanoscale biosensors can provide highly sensitive measurements, in real time and in extremely small volumes. Thus, they may have real application for in vivo sensing, distant monitoring, and the development of bioassays. Our test system will allow comparison to established bioassays.

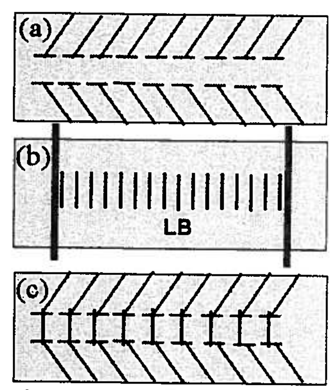


Fig.1 (a) pre-addressed electrode array (b) LB aligned NWs (c) NW FET array.

Ricin toxin, derived from the castor bean, is a major concern as a bioterrorist weapon. It is ubiquitous, reasonably easy to purify, and highly deadly. It is estimated that 1 million metric tons of castor beans are produced commercially each year.[3] In contrast, the lethal dose of ricin toxin for a human, by inhalation or injection, is estimated to be 0.5 mg.[4,5] In this sub-project, we will build multiplexed field effect transistors (FETs) for ricin toxin selective detection. This sub-team will accomplish the following tasks: 1. Nanowire synthesis (**Zhou** and **O'Connor**); 2. Patterning of micro- and nano- multiplexed electrodes (**Goettert** and **Zhou**); 3. Assembly of nanowires (**O'Connor** and **Zhou**); 4. Attachment of antibody and ricin toxin on nano-FETs (**Pincus** and **Zhou**); 5. Transport property measurement of FETs using a microfluid system (**Zhou** and **Goettert**); 6. Construction of a database for selective detection (**Zhou** and **Pincus**). Nanowires (Si and ZnO) will be fabricated through chemical and physical methods at AMRI (**Zhou** and **O'Connor**). In the past, AMRI has successfully fabricated all kinds of nanomaterials, such as one dimensional semiconductor nanowires[6] and magnetic[7] and luminescent[8] nanoparticles. A pre-addressed electrode array will be patterned on a Si/SiO_2 substrate by photolithography and e-beam nanolithography (Fig.1(a)) (**Goettert** and **Zhou**). Langmuir Blodgett techniques will be used to align ultra-thin semiconductor nanowires (Si or ZnO) (**O'Connor** and **Zhou**). By proper surfactant selection and controlled compression speed, evenly spaced aligned nanowires can be achieved (Fig.1(b)).[9] The aligned nanowire array can be transferred to the pre-patterned chip to form a nano-FET array (Fig.1(c)). We will then functionalize nano-FETs with different antibodies (**Pincus** and **Zhou**). A panel of 49 monoclonal antibodies that bind to ricin have been developed by the **Pincus** group.[10] We will first investigate the response of a single transistor to ricin toxin using different antibodies, buffer solutions, concentrations, etc. Then a series of antibodies will be attached to multiplexed nanowire FETs through a microfluid system (**Goettert** and **Zhou**). After collecting a series of data from each FET, a characteristic database for whole transistors will be generated for selective ricin toxin detection (**Pincus** and **Zhou**).

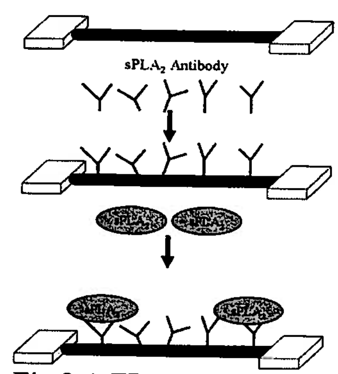


Fig.2 A FET Biosensor for $sPLA_2$ detection.

$sPLA_2$ is an endogenous component of the inflammatory response of mammalian cells, including humans, which has been detected in the clinically relevant conditions of cancer,[11] brain injury and disease,[12, 13] rheumatoid arthritis,[14] sepsis,[15] sickle cell disease, and acute chest syndrome.[16] Thus, the immediate detection of $sPLA_2$ from clinical (including blood) and cell samples is crucial. It is anticipated that detection will be much faster than the traditional methods of ELISA, Western blot, and enzyme assays currently used. Essentially similar tasks will be performed by this sub-team that parallel the ricin toxin detection. The fabrication process is shown in Fig. 2. Nanowires will be synthesized first (**O'Connor** and **Zhou**), which will be integrated into a patterned biochip detection device (**Goettert** and **Zhou**). Linkers and tails for $sPLA_2$ detection will be functionalized on the nanowires by using LBL technology (**DeCoster**). Transport properties will be measured, and a database will be established (**Zhou** and **DeCoster**). An additional goal of this project is to develop a cellular sensor that can detect responses to cell stress such as release of $sPLA_2$ from living cells and/or tissues (**DeCoster** and **Zhou**). Current methods for detecting $sPLA_2$ require more time for preparation and analysis than would nanowire-based biochips. Successful fabrication of these nanowire-based biochips could reduce the detection time to seconds or less for practical clinical application. **DeCoster** *et al.* have recently reported methods and conditions for eliciting $sPLA_2$ release from brain astrocytes after inflammatory stimulus.[17] We will utilize these methods as a starting point for developing a cell-based sensor to detect $sPLA_2$ release from living cells. Commercially available sources exist for both $sPLA_2$ antibodies and proteins (for example, Cayman Chemical), which will be utilized for device fabrication and testing.

Imaging

The development of in vivo imaging technologies is progressing rapidly. Imaging techniques cover a wide range of applications from the use of X-ray microscopy for cardiac imaging [18] to the employment of IR microscopy to study neuronal behavior.[19] In spite of many accomplishments, currently used imaging methods are limited in their spatial and temporal resolution and for the most part do not provide the information required to understand chemical and biological processes at the molecular level. A paradigm shift is needed to overcome the limit of diffraction in chemical and biological imaging techniques. The recent development of bio-nanotechnology[20] provides a unique opportunity to explore the use of nanomaterials as probes in imaging applications with temporal and spatial resolution superior to currently used state of the art imaging methods. The objective of the proposed study is to synthesize and utilize nanomaterials in imaging applications of chemical and biological systems. The hypothesis to be tested is that these nanomaterials could be targeted and placed selectively at sites of interest to provide dynamic information at the nanometer scale. The proposed study will focus on the synthesis of nanoparticles that are 50 times smaller than the limit of diffraction in optical imaging. The tasks will be carried out as follows. **O'Connor** and **Rosenzweig** will design and use nanomaterials as magnetic and luminescent vicinity probes with real time and sub-diffraction limit spatial resolution capabilities in magnetic and optical imaging applications. **DeCoster** will employ magnetic nanoparticles as magnetic resonance imaging (MRI) contrast agents and functionalized luminescent quantum dots to study signaling processes in neuron cells to demonstrate the capabilities of these materials. **Pincus** will derivatize these materials using antibodies to well established tumor antigens and test their ability to localize to tumors implanted into immunodeficient mice, thus testing the ability of these materials to function in vivo.

The proposed group represents a broad variety of established institutions and expertise from a cross-section of this state, with prior and on-going collaboration.[21,22] Collaboration on this project would repair and solidify these ties that were disrupted by Katrina, and would help foster new ideas and approaches that could lead to national and regional scientific impact, funding, and possible commercialization of technology.

It should also be noted that the research activities of **O'Connor** and **Rosenzweig** have already resulted in the formation of two startup companies, **NanoPrism Technologies Inc**. and **NSCR Biotechnologies LLC**. Both companies rely on intellectual property developed by UNO researchers at UNO. The proposed study will increase the property base of these companies and support their growth. It is worth mentioning that while the Biotechnology sector in Louisiana has been an area of targeted growth, there have been very few Biotechnology companies in the city of New Orleans before Katrina. This number decreased even more in the aftermath of Katrina. The proposed study will support the growth of the two Biotechnology companies and provide high paying jobs to scientists in the city of New Orleans.

b. FRG2: **Nanoscale Mechanical Devices**

Participants: **J. Wiley** (UNO-Chem-AMRI), **V. John** (Tulane-Chem. Eng.), **B. Gibb** (UNO-Chem-AMRI), **L. Spinu** (UNO-Physics-AMRI), **S. Whittenburg** (UNO-Chem-AMRI), **H. Ashbaugh** (Tulane-Chem. Eng.)

Objectives: The objectives of this program will be to design and fabricate a series of nanoscale mechanical devices. Combinations of nanocomponents will be assembled to make structures with specific functions. Applications for such systems will be widespread including fluidics, medicine, tools for nanocomponent manipulation, communications, data storage, and sensors. The program will also tackle fundamental issues pertinent to the scaled up production of such nanoscale mechanical devices and the fabrication of motorized components.

Program: To realize the targeted nanoscale mechanical devices, this program will require the coordination of many activities. These include the fabrication of nanocomponents (**Wiley, John**), the assembly of the components (**Wiley, Gibb**), the design and fabrication of platforms via nanolithography for assembly and testing of devices (**Wiley, Whittenburg, Spinu**), testing of the devices (**Spinu**), and the modeling of the devices (**Whittenburg**) and their assembly (**Ashbaugh**). Subsets of these efforts are molecular directed assembly, actuation methodologies, and motorization.

Nanocomponents (**Wiley, John**). Team members have extensive experience in the fabrication of nanocomponents via template methods.[23-31] They will be able to routinely provide various nanoscale wires (simple wires, superlattice, core-shell, porous, etc.), tubes, or spheres. Samples are typically prepared by chemical or electrochemical methods and can be made of metallic, magnetic, and/or polymeric materials. Further efforts will involve the formation of gel nanocomponents that are to be used as actuators (see below).

Nanolithography (**Wiley, Whittenburg, Spinu**). AMRI is well equipped to carry out in-house e-beam nanolithographic preparations and thin film depositions. Platforms, designed by **Spinu, Wiley and Whittenburg**, will be routinely fabricated. Photolithographic preparation of larger features, such as macroscopic interface components, can also be carried out in-house; photolithographic masks can be obtained commercially or prepared through the facilities at CAMD.

Assembly (**Wiley, Gibb, Ashbaugh**). The assembly of nanocomponents will be directed either through physical or chemical methods. Physical methods will utilize nanolithographically patterned substrates where clefts in the substrates will be used to align and contain nanocomponents.[32-34] Insertion into these clefts will be carried out by hydrodynamic and/or magnetic methods or via the nanomanipulator available in AMRI. Chemically-directed assembly methods will also be explored. Sets of specific binding pairs of host-guest molecules[35,36] will be used to direct the assembly of nanocomponents – either for placement of components onto surfaces or for the combining of sets of components. Modeling of assembly processes will be carried out (see below) to help refine this approach.

Actuation (**Wiley, Spinu, John**). The movement of the nanocomponents in these devices will be critical to their success. Here we will utilize electrostatic or magnetic interactions to direct the movement of the components. Interconnects will be positioned adjacent to nanocomponents to direct them up-down, left-right, etc. depending on the device (see example devices below). Further efforts will investigate the use of gel-based actuator systems. Various gels can exhibit significant volume expansions with different stimuli such as solvent uptake, pH change, thermal variation or electrical stimulation.[37] Some response times in terms of volume expansions are slow, while others are in the millisecond range. Further volume changes can also vary greatly with some values exceeding 1000% being reported. While the electromagnetic components will be integrated during the fabrication of the platform, the gel components may be integrated during the nanocomponents fabrication step.

Testing of components (**Spinu**). Once assembled, device testing will be carried out. Visualization of the active components during testing will be highly desirable. Since the components will be in the nanometer-to-micron scale (50 - 1000 nm), simple optical microscopy will not be effective. Therefore we will work to characterize devices in an electron microscope (SEM or FESEM) or with probe microscopy. Due to the interactive nature of each of these techniques, we may not necessarily be able to follow the movement within the device continuously, but instead would monitor the process at each endpoint. In those cases where the devices are switches (see below), we can also measure the output of the device before and after the circuit is complete.

Modeling (**Whittenburg, Ashbaugh**). Modeling of various aspects of these devices will be important to understanding their response and sustainability. Factors such as the electromagnetic field strengths needed to move components, the impact surface roughness on movement from the nanocomponents and the platforms, structural fatigue in repetitive processes, response times, and in the case of gel expansions, variations needed to effect desired movement, will all be studied. Further, directed assembly of nanocomponents will also be an important part of this study; here we will model assembly processes controlled by complementary host-guest (HG) pairs based on organic capsule structures. The effectiveness of sets of HG pairs in directing assembly, the importance of surface coverage and topology on HG-directed nanocomponent interactions, and ease of orientational control will all be considered over multiple length scales.

Devices – Specific examples of the types of devices targeted in this program are shown in Figures 3 and 4. An on/off switch will be prepared (Fig. 3a); these switches can then be used in parallel or series to make nanoscale logic devices (e.g. AND or OR gates), in simple data storage architectures or as part of sensor arrays. The second device (Fig. 3b) will allow control of fluidics in the nanoscale. The valve is 2-way where fluid flow direction (left or right) will be controlled via the positioning of a nanosphere. The third targeted device is a nanopump system (Fig. 3c). It combines some ball valves with a plunger system; as the valves are alternately opened and closed, the plunger is moved in and out to drive the flow of fluid from the lower part of the pump to the upper part. Both the valve and pump assemblies will allow for significant advances in drug delivery, medical implants, separations, chemical synthesis, chemical analysis, etc. Finally, architectures for the propulsion of small mechanical devices will be developed (Fig. 4); these motors will be based on electromagnetic or chemical propulsion and can serve as the foundation for the fabrication of a set of active and potentially mobile nanodevices (see below).

Motors – The switch, valves, and pump will be designed such that they are mostly run in an on/off mode. Alternatively, we wish to design and fabricate devices that can operate in a more continuous fashion. These motorized devices will be used to drive a simple cog assembly. One propulsion technique will be based on an electromagnetic system where the cog will have a magnet piece attached and will be turned by sequentially activating a series of pads. A second propulsion method will be based on the chemical system recently reported by Mallouk and coworkers;[38] they found that a platinum-gold segmented wire was drawn through a peroxide solution. If a similar component can be tethered to the cog (Fig. 4), it too could be driven (motorized) in the presence of a peroxide solution.

Economic Impact – This grant will allow our team to then pursue major grants such as the NSF NIRT or MRSEC center grant. Further, patents will be sought on processes and devices; these will then lead to licensing agreements and/or the development of small businesses putting Louisiana in a leadership role with respect to nanotechnology and nanodevice development.

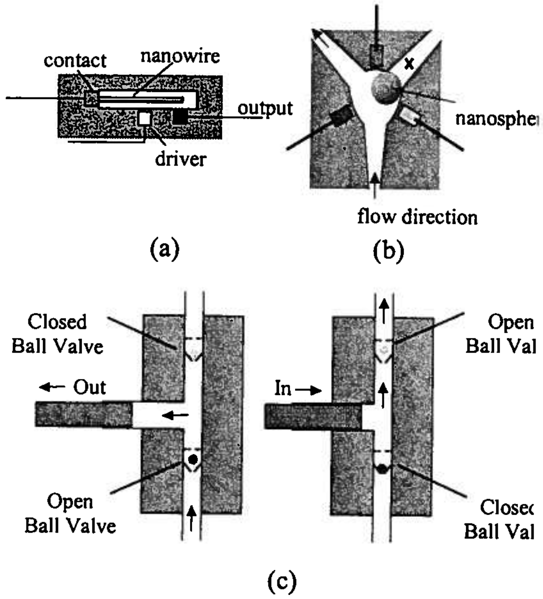
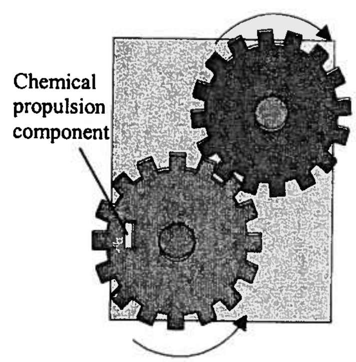


Figure 3. Top views of nanomechanical devices will be prepared that consist of one or more nanocomponents assembled into nanolithographically patterned arrays. The active structures will be driven by either magnetic or chemical means. The devices shown here consist of a (a) simple electric on/off switch, (b) 2-way ball valve where nanosphere controls flow direction (drivers shown as colored pads). (c) A pump system consisting of two one-way valves that will be controlled independently of each other. The red plunger works as the pump, pulling fluid from below (left) with an outward stoke and expelling it above (right) as the plunger moves inward.

Figure 4. Chemically driven mechanical device; the chemical propulsion unit (motor) on top of one cog will be used to drive the second cog – this is important in the fabrication of active nanomechanical devices.



c. *FRG3:* Nanomaterials for Energy Conversion and Storage

***Participants*: Y. Lvov** (co-Leader, LaTech-IfM), **Kevin Stokes** (co-Leader, UNO-AMRI), **Heike Gabrisch** (UNO-AMRI), **Leszek Malkinski** (UNO-AMRI), **Kody Varahramyan** (LaTech-IfM), **David Young** (LSU-Physics)

The world demand for energy is projected to increase to 28 TW (terawatts) by 2050, almost double what it is today.[39] As the finite supply of fossil-fuel is being consumed at an ever increasing rate, the search for alternative energy sources and more efficient energy storage and distribution materials is critical. Engineered nanomaterials are key enablers in the development of next-generation energy conversion and storage technologies.[39] Nanomaterials are attractive since, in nanostructures, it is possible to manipulate and control electron transport, phonon transport and chemical reactions at nanometer-scale interfaces. To accomplish this goal, we have assembled a team which combines expertise in chemical synthesis, thin film deposition, solid-state materials synthesis, and micro- and nano-fabrication. This team will apply the fundamental science of nanometer-scale materials and engineering architectures to four key areas: 1. Thermoelectric materials (**Stokes, Varahramyan** and **Young**), 2. Electrochemical storage materials (**Gabrisch**), 3. Ferroic composites for magnetostrictive and electrostrictive materials (**Malkinski and Varahramyan**) and 4. Nanomaterials for hydrogen storage (**Lvov**).

THERMOELECTRICS

Objective - Our objective is to design and engineer highly efficient thermoelectric materials that can be used in microdevices or to directly replace existing thermoelectric materials. Direct thermal to electrical energy conversion can be accomplished using compact, solid-state thermoelectric devices. The engineering applications of these devices have been limited by the relatively low intrinsic efficiency of the constituent semiconductor materials. This efficiency is directly related to figure of merit, *Z,* for the materials and is given by $Z = S^2\sigma/(\kappa_e + \kappa_p)$ where S is the Seebeck coefficient, σ is the electrical conductivity and κ_e and κ_g, are the electronic and lattice components of the thermal conductivity.[40] High thermoelectric efficiency then requires materials with large Seebeck coefficient and electrical conductivity, but small thermal conductivity. While these properties are strongly coupled in bulk materials, material structures in which at least one dimension is on the nanometer scale dramatically alter the carrier transport properties due the confinement of the carriers inside the material and provide possibilities to increase the figure of merit. [41]

Engineered nanometer-scale materials have been shown to provide an increase in the thermoelectric figure of merit of semiconductor materials.[42] At present, these materials are fabricated using thin-film deposition technology. The challenge is now to use the enhancements provided by nanometer-scale materials on both a larger scale and in a three-dimensional geometry. We believe that to address this challenge, other nanoscale architectures and manufacturing avenues will have to be developed. To this end, we propose to fabricate high-efficiency thermoelectric composites composed of binary assemblies of nanoparticles and conducting polymer/nanoparticle composites. These architectures are designed to take advantage of the intrinsic quantum confinement effects associated with increased Seebeck coefficient as well as increased phonon scattering.

Nanoscale semiconductor structures and/or conducting polymers will be combined to design and fabricate composites. In these nanocomposites, the electron and phonon transport is decoupled, allowing disruption of heat transport by phonons while retaining high electrical conductivity. In addition, quantum confinement of electrons enhances the Seebeck coefficient (thermal-to-electrical energy conversion capability) of the constituent semiconductor. We will also explore binary assemblies of nanoparticles[43] and bulk-like, complex compounds which have intrinsic nanostructure.[44] For proof-of-concept, we will incorporate the materials into MEMS-like device structures to develop small-scale energy conversion modules.[45]

TASKS: Synthesize semiconducting lead telluride and lead sellenide nanoparticles with controlled surface chemistry (**Stokes**); Form the nanoparticle materials into composites (**Stokes**); Measure thermophysical properties of the composites (**Stokes** and **Young**); Synthesize "bulk" materials with intrinsic nanostructure (**Young**); Investigate novel high-temperature oxide materials (**Young**); Incorporate the materials into a prototype microdevice structure demonstrating high efficiency (**Varahramyan**).

ADVANCED BATTERY MATERIALS

Objective - Our objective is to create characterization techniques to study micro-structural details in Li-intercalation compounds on sub-particle size-scale and apply these techniques to the study of new electrode materials.

Rechargeable batteries (e.g. Li-ion) currently suffer from several limitations including the amount of retrievable capacity at a given discharge rate, capacity retention in the charged state, and stability over a high number of charge discharge cycles. While electrochemical characterization of assembled batteries accompanied by x-ray diffraction studies are traditional investigation techniques in battery research, it has become evident that investigations on the sub-particle size scale will advance the understanding of failure in the battery electrode materials. Examples are the role of the interface between heterosite and tryphelite in $LiFePO_4$ or the role and details of cation ordering in layered manganese oxides [46-50]. The proposed research is aimed at understanding the fundamental electrochemical processes in the battery electrodes in order to improve battery performance.

Various intercalation compounds will be synthesized and subjected to charge/discharge cycling and/or chemical delithiation in collaboration with LIFCO, Inc. (see the attached support letter). The micron and nanometer-scale structure of the materials will be characterized with advanced transmission electron microscopy (TEM) techniques (convergent beam electron diffraction) complemented by x-ray diffraction.

TASKS: Choose suitable candidates for the study synthesis methods; develop techniques to assemble and cycle batteries; characterize structural and chemical changes **(Gabrisch)**.

FERROIC COMPOSITES

Objective - The objective is to design ferroic composites consisting of electrostrictive ferroelectrics and magnetostrictive ferromagnetics that both produce small, usable power for micro and nanodevices and provide control of magnetic properties using electric field.

Present magnetoelectronic devices such as magnetoresistive random access memories (MRAMs) and nanomechanical devices use relatively high currents to switch magnetization of memory elements or actuators.[51] High currents result in high energy consumption and heat dissipation which can be significant considering the density of nanoscale magneto-electronic elements (for example, ~Gigabit/in^2 density for information storage). This problem can be solved using electric potential instead of current to switch magnetization of the memory elements, provided a suitable electrical to magnetic conversion material can be created. In addition, micro and nanoscale magnetoelectronics require reliable, sustainable power supplies, particularly for those devices used in remote or in-situ operation. Replacement of traditional power sources (miniature magnetic coils and batteries) by microscopic magnetic-to-electrical power conversion devices would lower the cost, reduce energy consumption and expand the applications of microelectronic devices. Further, the principle of operation (stress induced magnetic anisotropy by piezoelectric component) can be used to tune radio-frequency and microwave responses in the devices for wireless communications. In addition, the magnetoelectric effect can be used to provide galvanic isolation of electric circuits in a similar manner as optoelectronic isolators.

Piezoelectric materials exhibit mutual coupling between their electric and elastic properties and a similar relation exists between magnetic and elastic properties in piezomagnetic materials. Materials which consist of combined piezoelectric and piezomagnetic materials make it possible to convert electric into magnetic energy (or vice versa) through the stresses produced in both materials by the electric or magnetic fields. The application of electric field (or potential) will result in the change of the magnetization of the composite, and application of magnetic field will change the electric properties of the material (magnetoelectric effect). Two different approaches will be used to fabricate granular and multilayered ferroic composites. 1. Thin film materials which consist of alternating layers of magnetostrictive and piezoelectric materials and 2. Composites made from nanoscale piezoelectric and giant magnetostrictive materials.

TASKS: Produce multilayer piezoelectric-magnetorestrictive films using both magnetron sputtering and pulsed laser deposition (**Malkinski**); Create nanocomposites from piezoelectric-magnetorestrictive nanoparticles (chemically or mechanically derived) (**Malkinski**); Systematically investigate the magnetic-electrical coupling in the films and composites as a function of nanosctrure and processing parameters (**Malkinski**); Develop a prototype device structure demonstrating electronic control of magnetic fields and/or conversion of magnetic to electric power. (**Varahramyan**)

NANOMATERIALS FOR HYDROGEN STORAGE

Objective - We aim to develop "smart" nanofilms for the protection of metal hydrides against air and moisture, while permitting release of hydrogen gas through these semi-permeable protective nanofilms. Future generations of these films will have catalytic metal nanoparticles (like TiO_2)-known to enhance the dehydrogenation reaction-embedded within for the purpose of controlled release of catalyst to the hydride particle surface.

The increased need for energy requires that viable alternatives to fossil fuels be explored. Hydrogen may provide an alternative but will require a significant research effort in production, storage and distribution if hydrogen is to become economically competitive with fossil fuels.[52] This research impacts on the hydrogen energy economy through the nanoparticles and molecular assembly procedures to create next-generation hydrogen storage materials.

Metal hydrides are compounds comprised of metals which crystallize with anionic hydrogen in their lattice. There are a vast number of metal hydrides that can be synthesized, but the prevalent scope of interest is in the lighter metal hydrides. Of these light metal hydrides - sodium aluminum hydride, lithium aluminum hydride, lithium hydride, and sodium hydride have high gravimetric storage capacity for hydrogen, but are also reactive in air and moisture-rich environments.

Our nanofilms for encapsulating metal hydrides are formed using layer-by-layer electrostatic self-assembly. Layer-by-layer (LbL) thin films are comprised of polyelectrolyte layers each on the order of 2 nm thickness. The LbL self-assembly technique can be used to deposit conformal, multilayer nanofilms onto planar surfaces and colloidal particles. The working medium for LbL self-assembly is always a polar solvent and has, typically, been water. However, water as a solvent cannot be used to coat the water sensitive metal hydrides. For metal hydrides, pure formamide will be used as a solvent for the LbL self-assembly of nanofilms by alternate adsorption of montmorillonite clay and polycations. In preliminary studies, we have already produced protective nanocoating for $NaAlH_4$ microparticle material.

TASKS: Create protocols for the synthesis of semi-permeable nanofilm coatings for a variety of metal hydrides; Systematically investigate the hydrogen storage/release capability of these nanostructures (**Lvov**).

d. Broader Impacts

Matthew A. Tarr (Educational Outreach Leader, UNO-AMRI), **Paul Hanson** (UNO-AMRI), **Rebecca Bidwell** (Communities In Schools of New Orleans, Inc.), Collaborating High Schools in New Orleans, **Norma Grace** (Commercial Outreach Leader, Vice Chancellor for Technology and Economic Development, UNO, Coordinator – Center for Innovation)

Educational Outreach Group

Objectives and Background

Objectives of this component are: 1) To provide summer research opportunities in nanoscale science for secondary educators and high school students; 2) To develop academic-year programs to expose students and teachers to nanoscale science and technology; and 3) To provide undergraduate and graduate training in materials science and nanoscale science. Based on programs in this project, we expect to receive sustained funding through the National Science Foundation GK-12 program as well as through center grants such as the NSF MRSEC program.

The United States is facing a critical shortage of qualified workers in science and technology, while demand for skilled workers in nanotechnology is growing rapidly. Furthermore, basic science skills among US students are very weak.[53] Effective development of technology based business in Louisiana requires an investment in human resource development. We include an extensive education outreach program to stimulate science education as well as to attract young students into careers in science and technology. We have a strong history of effective training of high school students and teachers, including conference presentations and research publications[54-58] with high school co-authors. We also have a strong history of providing research opportunities for undergraduate students, and our NSF supported Research Experiences for Undergraduates (REU) program has focused on providing opportunities for students from Historically Black Colleges and Universities (HBCUs). REU participants have been co-authors on numerous presentations at local, regional, or national meetings.[59-77] Program participants are also co-authors on several published, submitted, or in preparation journal articles.[58,59,78-87]

Outreach Plan

The education outreach program will include several components: 1) a summer research and training program for secondary teachers, high school students, and undergraduate students from HBCUs; 2) an intensive pre-matriculation training program for incoming UNO freshman chemistry and physics majors; 3) implementation of available nanoscale science modules at participating secondary schools in New Orleans, including teacher training; 4) a comprehensive pre-college mentoring and training program for high school students in New Orleans; and 5) training of graduate students in materials and nanoscale science.

Summer Research Training. Each summer we will provide research experiences for high school students (12/year), secondary educators (2/year), and undergraduate students from collaborating HBCUs (3/year). These interns will be joined by 4-6 additional teachers and 9-12 additional undergraduates supported through separate programs. High school interns will participate for 7 weeks of research and undergraduates for 9 weeks. Each intern will be assigned to an AMRI research group and a semi-independent research project. Interns will work alongside graduate students and post doctoral fellows. Interns will gain a first hand understanding of cutting edge research and facilities, gain substantial self confidence, and gain access to future opportunities through their research experience and contact with faculty mentors. Secondary educators will gain insight and perspective that are uncommon among teachers; their personal and professional growth will be passed on to the hundreds of students they teach each year. During the summer, weekly meetings will familiarize interns with materials science and nanoscale science and provide training on specific skills (such as using the scientific literature). Interns will also interact with professors during informal sessions designed to build relationships among participants and faculty members. Each intern will prepare and present an end of summer poster reporting the results of their summer research projects.

Pre-Matriculation Training Program. Major barriers for entering freshman students include poor reading skills, writing skills, math skills, and time management/study skills. To overcome these barriers, we will provide an intensive immersion program for entering UNO chemistry and physics majors, including several of our high school research interns. These students will participate in a five week chemistry and physics immersion program designed to improve their chances of success in college. The program will address important weaknesses among entering students through structured programs in an active learning environment. Math and writing skills will be presented in context of nanoscale science and materials science. Important chemistry and physics concepts will also be introduced. Strong emphasis will be placed on developing critical thinking skills and good study skills.

Implementation of Available Nanoscale Science Modules. Summer teacher participants will also attend a graduate level course. This class will provide guidance on how to incorporate scientific inquiry and research concepts into secondary classrooms. These teachers will be expected to incorporate into their classes at least one new teaching module focusing on nanoscale science or materials science.[88-94] Support for such activities will be provided by graduate students and professors during the academic year. This support will include classroom visits as well as periodic workshops. Communities In Schools will involve other teachers through already established contacts and will provide assistance with correlation to grade level expectations established by the state Board of Elementary and Secondary Education.

Comprehensive Pre-College Mentoring and Supportive Guidance Program. High school students who complete the summer research program will be provided ongoing pre-college mentoring and supportive guidance by the staff of Communities In Schools. Regular mentoring will be conducted with individuals and small groups of students attending the same school in order to provide follow-up and guidance related to study skills, college investigation, the college admissions process, and financial aid. Each student in grades 9-11 will participate in 3-4 mentoring sessions per month. Graduating seniors will be offered additional mentoring sessions, as well as family information sessions. Communities In Schools will also complete an individual and family needs assessment for each student so that appropriate referrals can be made to overcome barriers to college admissions and success related to health/human services, educational enhancement, enrichment, and other support services.

Training of Graduate Students in Materials Science and Nanoscale Science. Focused Research Groups 1-3 will each involve graduate students in materials science and nanoscale science research. These graduate students will serve as a base of highly skilled scientists who will be ready to enter the workforce in roles that require advanced training. In addition, each of these graduate students will be integrally involved in our outreach programs by mentoring summer research interns and by working with teachers and students during the academic year.

Partnership with Communities in Schools

We will team with Communities In Schools (CIS) of New Orleans, Inc., a local non-profit affiliated with the Communities In Schools national network. The CIS network specializes in providing resources to help at-risk students across the country learn, stay in school, and prepare for life. This national network is recognized as a leader in dropout prevention. CIS will serve two roles by: 1) coordinating interactions between UNO and several high schools in New Orleans and 2) providing mentoring and supportive guidance for high school students who are potential undergraduate students in science, technology, engineering, and math (STEM) fields.

Coordinating Interactions Between UNO and High Schools. Most high schools in New Orleans lack the appropriate resources to encourage students to pursue careers in STEM fields.

The University of New Orleans is able to provide important assistance in this regard. However, high school teachers and administrators are currently overwhelmed and lack the ability to coordinate such interactions. At the same time, UNO personnel lack the necessary familiarity with the needs of high school students, but are able to provide a number of important resources (access to research opportunities, formal and informal training for teachers, mentoring of students and teachers). Communities In Schools has a substantial history of working with New Orleans high schools and can readily coordinate UNO resources with high school needs. Specific tasks will include: identifying students and teachers for participation in summer programs at UNO, coordinating UNO professors and graduate students to provide classroom assistance (mentoring teachers) and student mentoring (e.g. science fair projects), and coordinating UNO run workshops for teacher training in nanoscale science.

<u>Providing Supportive Guidance for Students</u>. Many high school students in New Orleans do not have the necessary skills to successfully apply to and attend college. For example, students are often unaware of the expected length or content of a college application essay or deadlines for application. Without these basic skills, many otherwise qualified students are at a severe disadvantage and are not likely to succeed in college. Furthermore, most students are unaware of career opportunities in STEM fields. Communities In Schools will provide mentoring and supportive guidance for high school students at six targeted high schools (Edna Karr Secondary School, Capdau Early College High School, New Orleans Math and Science High School, McDonough 35 High School, McMain Secondary School, Warren Easton High School). These schools were chosen because they have a large population of students with reasonable academic skills but a lack of other basic skills needed for college entry. In addition, these schools are currently involved with other CIS programs. The Capdau Early College High School is a charter school that is administered by UNO.

In this project CIS will 1) Provide UNO faculty, staff, and students inroads into Orleans Parish high schools; 2) Schedule and coordinate information session/recruitment events at each of the identified schools; 3) Provide ongoing college/career mentoring for students after their summer research experience; 4) Work with the Office of Financial Aid at UNO to assist students; 5) Provide referrals to health/human services, educational enhancement, enrichment, and other programs; and 6) Coach UNO personnel for outreach exercises at local schools.

The roles of each member of this FRG are: **Tarr** (team leader) will coordinate student/teacher research opportunities, develop/implement curriculum materials and teacher training; **Hanson** will run the 5-week pre-matriculation training program and will assist with academic year workshops for teachers as well as on-site school visits by UNO personnel; **Bidwell** will coordinate all Communities In Schools participation.

Economic Impact

Short term impacts will result from strengthening schools in Katrina impacted neighborhoods. Providing strong primary and secondary academic options will facilitate repopulation of these impacted neighborhoods, stimulating economic redevelopment. Long term economic growth will be developed by building strong links between K-12 educational institutions and nanoscale research teams. A culture of nanoscale literate students will result. These students will fill future jobs in nanotechnology businesses. The availability of trained workers and the academic/research culture will encourage nanotechnology companies to locate in the region.

Commercial Outreach Group

The National Science Foundation awarded a Center for Innovation (CFI) grant to the University of New Orleans in September, 2005. The mission of the CFI is to 1) develop and manage a process to facilitate the transformation of innovation into viable businesses for the creation of wealth for the region, and 2) develop a core of entrepreneurs to sustain the regional economy. In pursuit of its mission the Center will achieve the following objectives:

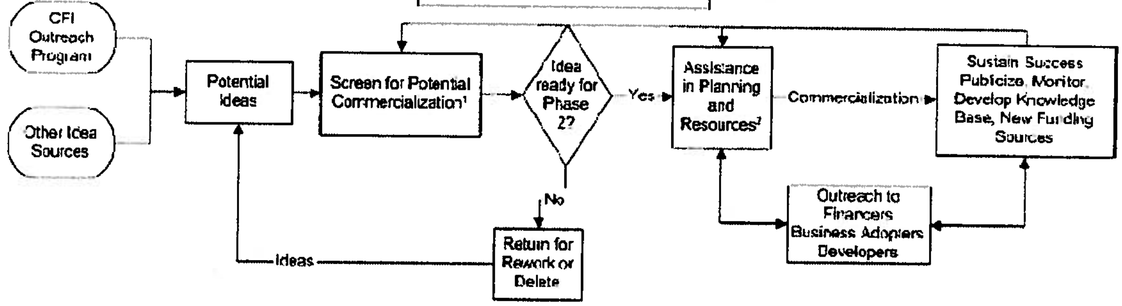
- emphasize industry-based and university-based translational research in the region and the Gulf Coast as a source for potential business concepts;
- focus primarily on developing products and services that include applied materials, nanotechnology, marine technology, and software and information technology; and,
- target projects with the potential to generate a regional impact of $5M within 5 years.

To achieve this mission, CFI will identify innovative technologies using its "Community of Practice" partners:

CFI will work with the inventor through the intellectual property protection process and analyze potential for commercialization. It will use its industry advisory board to assist with screening of commercially viable outcomes. It will then help create the business plan, provide access to capital and assist in the growth of a business or license agreement, whichever best fits and promotes the outcomes for the inventor, institution and organizations.

One of the goals of sustainability is to develop a template for discovering potential ideas from research centers and to transform them into viable products and processes in industry and government organizations. The CFI team has developed a process that will be the initial step in developing a template. The process flowchart is depicted below.

Figure 1
CFI Process Flowchart



1. Screen for Potential Commercialization
Receive, Route, Integrate, Facilitate

2 Assistance in Planning and Resources
Business Planning - Marketing Research
Legal
Funding Sources - Startup Funding
Assistance from State and Local Government

The best indicator of success will be the creation of jobs and new start-up companies. However other important indicators are patents granted, licenses granted, royalties received, start-up loans and investments, and increase in average incomes.

The University of New Orleans Center for Innovation will work with the Center for Advanced Materials to identify potential commercial applications for business growth and development. CFI is currently working with NanoPrism Technologies, Inc., and AMRI spin off established in 2005. **Norma Grace** and the CFI team will engage a specialist in technology development and commercialization to concentrate specifically on the innovative technology coming out of the research of this grant. It would also support intellectual property protection -- attorneys and market research -- appropriate to the inventions.

(2) PROJECT IMPACT

The President's nearly $1 billion budget proposal for nanotechnology R&D in 2005, a doubling over levels in 2001, reflects how fast nanotechnology is growing (http://www.nano.gov/). Since last year, more companies associated with nanotechnology products have been established, such as First Nano, Inc, NanoSys, Inc., Zevex, Inc, Quantum Dot Corp., The Nanotech Company, LLC, NanoPrism Technologies, Inc, *etc*. This trend indicates the growing market for nanotechnology products in the next ten years. Our proposed project targets areas of nanotechnology in which individual Louisiana researchers are already making significant contributions. Collectively, the group of researchers in this proposal will leverage their individual research programs and strengths of their respective institutions to create a state-wide consortium for nanomaterials research and technology development. This consortium will impact the local economy architecture, providing a high technology platform for start-up companies and/or stimulating investments of larger corporations. Specific impacts in four key areas of nanotechnology research and education are listed below.

Biotechnology - The project will impact the biotechnology sector in Louisiana, which has been an area of targeted growth, especially after Katrina. It will spur the application of nanomaterials in clinical procedures. It will bring a revolution of biosensors for detecting bio-agents at shorter times and higher sensitivities. And it will open a new regime for real time imaging of biomolecules in vivo. Fast detection nanosensors for ricin toxin and $sPLA_2$ could provide commercially important alternatives to traditional detection methods. Development of a functional nanowire based biodetection sensor will have direct commercial value for diagnostic purposes and bio-defense applications. Magnetic and luminescent nanoparticles integrated with chemical and biological systems will help to connect the application of nanoscale materials to clinical applications.

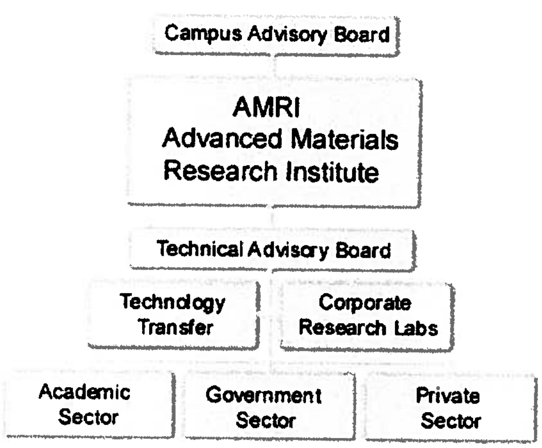
Nanodevices - Advances in the area of nanoscale mechanical device fabrication will also greatly impact nanotechnology. Various device constructs will be useful in electronic, fluidics, medicine, etc. Our team is uniquely positioned to become a leader in this area. Industry will be greatly interested commercializing our technology, routinely licensing the patents generated on our products. This will positively impact our state's economy as well as raise revenue for the associated universities. Also, extended success in this area will likely lead to spin off companies in Louisiana, further impacting the state's economy.

Energy - Louisiana is a national leader in the production of fossil fuels and this industry drives much of our economy. However, to build our economy, we require research programs which investigate affordable, renewable energy conversion technologies and technologies which make more efficient use of available energy. This proposed research is focused on developing the materials which will enable these next-generation technologies. Expected outcomes will be high efficiency thermoelectric materials which would produce electrical energy using the waste heat from a power plant or an automobile engine. Practical, low cost, low power thermoelectric generators which use temperature gradients from the environment will be possible for powering remote sensors or in military applications. Battery research would impact both low power (consumer and military portable electronics and medical devices) and high power applications (back-up power supplies, and automobiles, for example). High efficiency, high power density batteries are required to support renewable energy technologies like solar and wind power conversion by storing energy for use during those times when wind or solar energy is not available. Micropower sources based on novel electro- or magneto-strictive nanostructures could be used in conjunction with microelectromechanical (MEMS) devices to provide power for microelectronic circuits. Finally, novel materials for hydrogen storage will developed enabling economically-feassible hydrogen distribution and storage for pollution-free energy production, safe on-board vehicle storage and use in proton exchange membrane fuel cells, and micro/nano scale fuel cells having energy density exceeding present-day rechargeable batteries.

Science and Technology Workforce - Not just within Louisiana but throughout the United States, there is a critical shortage of workers in emerging high tech fields such as nanoscale science. In order to reverse this trend, it is essential that institutions of higher education interact extensively with primary and secondary education programs in order to attract more students into science and technology fields. Over the past five years, our efforts with high school students, secondary educators, and undergraduates have been extremely successful. We have multiple peer reviewed publications with these participants. Furthermore, we have shown many students how they can succeed in science and technology fields. The current project builds upon and strengthens our previous efforts at levels from secondary education through graduate school. Furthermore, the components of this project will serve as models that can be readily copied by other institutions. Successful implementation of this project will make substantial progress toward the goal of building Louisiana into a state that can educate, employ, and retain highly skilled workers for new and growing economic sectors such as nanotechnology and materials science.

(3) MANAGEMENT PLAN

This project will be managed by the Advanced Materials Research Institute (AMRI) at the University of New Orleans. AMRI was formed to meet the research needs of the University of New Orleans in the area of materials science. An organizational diagram of the components of AMRI is shown below.



The administration of AMRI is structured to involve two advisory boards, the Campus Advisory Board (CAB) and the Technical Advisory Board (TAB). The Director of AMRI reports to the Dean of the College of Sciences (Dr. Joe King) who consults the CAB on matters pertaining to the administration of AMRI (*e.g.*, appointments to the senior staff of AMRI, ratification of nominations for membership on the Technical Advisory Board, *etc.*). Although AMRI has a multi-disciplinary research mission, it is sponsored jointly by the Departments of Chemistry and Physics in the College of Sciences and the College of Engineering at the University of New Orleans and the composition of the Campus Advisory Board reflects this authority. The CAB consists of the following members:

- Dr. Joe M. King, Dean of the College of Sciences and Chairman of the CAB
- Dr. Charles J. O'Connor, Director of AMRI
- Dr. Robert C. Cashner, Vice Chancellor for Research
- Dr. Russ Trahan, Dean, College of Engineering
- Dr. Edwin D. Stevens, Chairman, Department of Chemistry
- Dr. Greg Seab, Chairman, Department of Physics

Industrial and government involvement is crucial to the development of AMRI. A Technical Advisory Board (TAB) oversees the operation of AMRI. The duties of the TAB are to provide expertise and insight as AMRI projects are initially developed and to ensure the value and utility of the research to both the private sector and government agencies. The TAB oversees the development of research initiatives at AMRI, directs the addition and distribution of personnel, conducts a yearly review of the operation and performance of the Institute, and makes recommendations on reallocation of AMRI resources. The TAB consists of the following members:

- Dr. Robert Haushalter, Parallel Synthesis Technologies
- Dr. Gary Bush, Lockheed Martin, Advanced Technology Center
- Dr. John T. Vaughey, Argonne National Laboratory
- Dr. Youren Xu, Intel Corporation, Components Manufacturing Quality & Reliability
- Dr. Dieter Weller, Seagate Recording Media Operations

The overall project management will be melded into AMRI's existing management and review structure as follows. Each year, all P-KSFI teams will hold a comprehensive annual review of its funded programs in conjunction with the Annual AMRI Mardi Gras Review and Symposium. Invited to participate in this review are the members of the TAB and review teams from the funding agencies. In addition to this meeting, there are one day AMRI review meetings for the other three quarters in the year where the teams and investigators will present their research and discuss strategies.

Each Focused Research Group team will hold meetings once a month and all researchers in the consortium are encouraged to attend these meetings even when other FRG's are being presented. This will promote cross-fertilization of ideas and help to further expand the pool of expertise available within these groups. The basic management tasks at this level (FRG) is to facilitate communication, minimize the administrative burden on the faculty and to mentor the junior faculty in writing large, multi-PI grant proposals and effectively handling intellectual property (IP) issues. This will be accomplished using video conferencing facilities and coordinating the quarterly meetings with the lead PI. The AMRI multi-investigator meetings are currently held on each Thursday afternoon with a different multi-investigator group each week.

The research groups of all co-investigators will also hold their group meetings, usually once a week.

(4) PERFORMANCE MEASURES AND OBJECTIVES

The fundamental goal of this P-KSFI proposal is to establish a federally-funded center for advanced materials and nanoscience in Louisiana. To reach that goal, the team must build a significant body of collaborative successes in the fields of materials research for bio-sensing and imaging, nanoscale mechanical devices, energy conversion and storage, and outreach. Our primary milestones and objectives for the AMRI consortium are listed in section *4. Goals and Objectives* (p. iv). In this section we will concentrate on technical milestones and deliverables for the four sections of the proposal.

FRG#1: Technical Milestones:

- Assemble and pattern bio-nanosensor prototypes
- Fabricate biosensors for ricin toxin and $sPLA_2$ detection
- Attach the magnetic nanoparticles and photoluminous nanoparticles on biomolecules and mice for signaling processes and bioimaging in vivo.

FRG#2: Technical Milestones

- Develop schemes based on specific binding pairs of host-guest molecules to direct the assembly of nanocomponents
- Use gel-nanocomponent systems to create new actuators
- Create devices where the mechanical properties are used to control a switch or a valve can be used in switch and valve to control

FRG#3: Technical Milestones

- Create nanocomposite demonstrating enhanced thermal and electrical transport properties.
- Create nanocomposite material which allows electrical control of magnetization.
- Develop prototype, microscale energy conversion devices using novel nanocomposites.

Broader impacts:

Educational Outreach Milestones

- Secondary teachers in this project (funded by this and other programs) will impact at least 600 secondary students per year; grow to at least 3000 per year by project end.
- Obtain NSF funding through the GK-12 mechanism.

Commercial Outreach Milestones

- Finalize the business plan for NanoPrism Technologies, Inc. and establish it as a viable company in the UNO Research and Technology Park small business incubator.
- Find customers and secure licensing agreements for patents that arise from this project.

(5) SUSTAINABILITY

Our P-KSFI program will be sustained by industrial and federal funding. AMRI has already achieved the funding momentum necessary to sustain its research programs. We are now focused on reaching the level of a federally funded major research center. The main agencies that fund such fundamental materials-related research are the National Science Foundation (NSF), the Department of Defense (DOD), the Department of Energy (DOE), and the National Institutes of Health (NIH). Within each of these agencies, there are several interdisciplinary programs we will take advantage of. The AMRI cluster of co-investigators will lead to strong teams for applying for multi-PI (2-5 members) grants from the funding agencies. Recently, both the Division of Chemistry and Division of Materials Research have promoted such efforts. For example, we will apply to the Nanoscale Interdisciplinary Research Team (NIRT) program at NSF. In fact J. Wiley (AMRI) already heads an existing NIRT program at AMRI and proposals will be submitted by the Energy and Biomaterials groups. By the end of year two (summer 2009) we will submit at least one NIRT using researchers from this consortium as the core. Also, we will target the Grant Opportunities for Academic Liaison with Industry (GOALI) program which is a joint industry/university program sponsored by the NSF. We will continue to work with small businesses to obtain SBIR/STTR funding in the near term in order to build a platform with which to apply for larger federal grants, in partnership with industry.

C. Leveraging of Resources:

As part of its cost sharing for this proposal, the University of New Orleans has agreed to the addition of two faculty positions to AMRI to strengthen its P-KSFI proposal. The UNO administration has also agreed to provide $125K for start-up for each position. This $125K will be matched by AMRI's existing grants and contracts for a total start-up package of $250K for each position. The new faculty will join the P-KSFI projects as well as AMRI's other programs. An additional leveraging of this proposal by AMRI is a promise to cover tuition expenses of all graduate students that are funded by this proposal through a rebudgeting of its existing grants and contracts,

Part of AMRI's success has been its educational outreach program. This program leverages the P-KSFI educational outreach component. Each summer, AMRI brings 20-25 high school teachers and students and undergraduates to its outreach programs supported by the Board of Regents and NSF (REU). A majority of AMRI's outreach participants come from under-represented minorities. With the addition of the P-KSFI educational outreach component, we plan to expand this program to a year round effort that includes UNO directed charter schools in the revamped post-Katrina New Orleans public school system.

AMRI is also active in commercial outreach. To maintain commercial viability of its research programs, AMRI has recruited 4 researchers from corporate research labs for membership on its Technical Advisory Board. Also two start-up companies, NanoPrism Technologies, Inc and NSCR Biotechnologies LLC., have grown from research that has been conducted at AMRI with assistance from UNO's Center for Innovation. NanoPrism Technologies focuses on the synthesis of functionalized nanoparticles for various applications. NSCR Biotechnologies develops clinical assays based on the use of bio-functionalized luminescent nanoparticles. The development of these companies will be assisted by this project. NanoPrism Technologies will provide nanoparticles for biomedical research. Advances in luminescent nanomaterials used in studies proposed here will be further developed and commercialized by NSCR Biotechnologies, LLC. The commercial outreach component will be leveraged by the NSF funding for the Center for Innovation.

The ultimate goal of this program is to successfully compete for a federally funded major centers grant. Furthermore, NSF is directing an increasing component of its research effort towards funding of collaborative research programs in the Mathematics and Physical Sciences Directorate, especially in the Divisions of Materials Research (DMR) and Chemistry. AMRI's successes in these programs will be further leveraged by the program proposed here.

AMRI will be starting two projects with DARPA this summer with a total of $4.5M in new funding; the two projects are on Nano-Sensors and Quantum Computing. The Nano-Sensors project has a direct positive overlap with the research in FRG1 and will significantly impact and leverage the progress of this project. In addition, other AMRI grants will bring consultants and seminar speakers to the consortium. There is a minimum of management expense in the budget because the existing AMRI management team is experience in administering large collaborative programs and will oversee the day to day execution of this proposal.