ONR/ONAMI Program on Nanometrology, Nanoelectronics and Nanobiotechnology

Call for White Papers

2009 Projects

November 21, 2008

Objective

The objective of this solicitation is to identify projects that can be funded under the ONAMI FY2009 Nanometrology, Nanoelectronics and Nanobiotechnology congressional interest initiative. These projects should address the goals of the initiative and relate to the research needs of ONR (the sponsor of this initiative) and lead to significant external funding in the future.

Background

In FY2006 the Oregon Nanoscience and Microtechnologies Institute (ONAMI) was awarded $2.5M to establish the Nanometrology and Nanoelectronics Initiative, now the Nanometrology, Nanoelectronics and Nanobiotechnology Initiative (N^3I). The technical sponsor for this project is the Office of Naval Research. Working with ONR, ONAMI selected 21 proposals for the FY2006 research effort. An additional $2.5M was allocated within ONR for FY2007 and 22 additional proposals were selected for funding. In FY2008, An additional $2M was awarded and 12 projects were selected. A summary of Program activities to date are given in the Appendix. A further $4M has been allocated for 2009 and this Call for White Papers describes the guidelines for submitting proposals for the anticipated continuation of the Initiative through the third round of funding for FY09.

Our approach for allocating these funds involves the solicitation of 3-5-page White Papers that will be evaluated and selected for funding. Research can be either 6.1 (basic research) or 6.2 (proof-of-principle testing) but must have high potential for follow-on external funding and contribute to the science of nanometrology, nanoelectronics, and nanobiotechnology. In addition, for this round of funding, proposals in the nanobiosciences at the intersection of physical and chemical sciences with the biomedical sciences at the cellular level and below are solicited. Nanobiotechnology is an emerging research area where the application of nanometrology methods and nanoelectronic materials and devices are expected to have a major impact on biomedical and biological applications at the cellular and molecular levels.

The intent of the N^3I for 2009 is to support projects in the three thrusts that have specific applications in mind and that may even have the possibility for commercial applications in the foreseeable future.

Our objective is to have collaborative research teams in projects selected for this solicitation apply for other funding, including SBIR and STTR sources, to maximize the total amount of external funding coming to ONAMI. Therefore we are seeking multi-disciplinary and multi-institutional "seed" projects where the research funded under this solicitation will allow research teams to complete a key experiment proof-of-principle test or acquire key data that will let the team(s) prepare winning proposals to funding agencies such as NSF, NIH, NASA, AFOSR, ARO, or ONR. If any additional earmark funds are approved for future years, it is expected that other new seed grants will be funded in the spirit of encouraging the current seed activities to grow by accessing other, larger funding sources.

The goals of the ONAMI N^3I are:

1) Develop methods for the imaging (nanoscopy) and measurement (spectroscopy) of materials, biomaterials, structures, interfaces, and devices at the nanoscale, particularly for chemical imaging using multimodal and correlated approaches.
2) Fabricate, characterize, model, and measure the performance of novel nanoscale devices including electronic (charge and spin) or photonic (near-field and plasmonic) state variables and including nanodevices that can perform logic functions as opposed to binary switching alone
3) Apply nanometrology, nanoelectronics and nanobiotechnology capabilities to important problems in the biological and biomedical sciences such as cellular and molecular imaging and measurement, cell membrane studies, interface biochemistry, nanobiosensing, and molecular studies of proteins and DNA using advanced microscopy, nanoscale probe methods, and applications of nanoparticles such as drug delivery and imaging of targeted diseases states.

Collaboration is expected to be across research institutions, nationally and internationally as well as with other ONAMI partners. In addition, there are four specific areas of collaboration that have been developed over the last year and that are encouraged for this round of funding:

1) Joint projects with the Western Institute for Nanoelectronics where alternate state variable devices and materials in spintronics and plasmonics are being explored. The Nanoelectronics Research Institute (NRI) of the Semiconductor Research Corporation (SRC) is the funding source for many nanoelectronics research projects of wider scope and should be a resource considered in proposals to ONAMI.
2) Joint projects on cellular imaging, nanobiosensing, inorganic-organic-biochemical interface properties, cell membrane property measurement, and molecular studies of proteins and DNA.
3) Joint projects with PNNL on nanoscale sensors and chemical imaging at the nanoscale.
4) Joint projects in nanometrology that include NIST and/or FEI Company

For 2009 proposals, we will accept capital equipment requests of up to $250K per proposal. Any equipment purchased using ONAMI funds must be installed in Oregon universities. These equipment requests must be a part of a research proposal and must be accompanied by a preliminary level of detail such as supplier quotations, comparisons to similar equipment, a description of the alternatives, an estimate of the facilitation costs and the availability of lab space. If the proposal is selected, the actual costs must be accommodated within the proposal total cost if the original estimates are changed. Additional ONAMI matching funding is not available for proposals in this initiative although the N^3I funds may be used to leverage funds from other sources such as Foundations or NSF.

Proposals including PNNL for this round of funding should include Principal Investigators from any one of the four participating universities, the University of Oregon, Oregon State University, Portland State University and Oregon Health and Science University. All proposers should be ONAMI members.

New proposals are being solicited to widen the research agenda and open new collaborative research opportunities, especially across disciplinary lines.

Proposal subjects that have been picked up by the new ONAMI Army Center on Nanoarchitectures for Enhanced Performance will not be considered for support under the Nanometrology and Nanoelectronics Initiative. Proposals on Nanomaterials and Nanostructures should be sent to the Army Center for consideration.

The current ONR Nanoelectronics Research Program includes:

- electronic, optical and magnetic properties of semiconductor and magnetic structures with nanometer scale dimensions
- layered materials of semiconductors and magnetic metals
- nanolithographic methods used to fabricate device structures dominated by quantum or spin phenomena
- devices of interest include quantum wells, quantum dots, single electron transistors, spin transistors, magneto-resistance devices, and ultrashort channel FETs.
- novel circuit architectures based on quantum effect devices are investigated.

White Paper Format

White Papers should be submitted electronically as a Word document to John Carruthers (carruthe@pdx.edu) by Friday, March 13, 2008.

- Project description: 3-5 pages
- Biographical sketches of PI and co-PI's: 2 pages each, NSF format preferred (http://www.nsf.gov/pubs/gpg/nsf04_23/2.jsp#IIC2f) including a record of any publications relevant to the proposal
- Budget: one page with cost information (see details below)
- Details on any capital equipment estimates
- List of current and pending proposals

- The project description should consider the following factors:
    - Overview, objectives, and work plan
        - Relation to ONAMI nanometrology and nanoelectronics thrust
        - Current knowledge
        - Gap in the knowledge base and why this is important
        - Overall objective for this project to fill the gap above
        - Specific problem statement
        - Description of proposed work and rationale that this approach will work
        - Relationships with other partners such as WIN, OHSU, and PNNL
        - What are other competing approaches and why the proposed approach is different, better, and more innovative
        - Expected outcomes in a Statement of Work with clear deliverables and timelines
    - A "Vision Statement" describing how the proposed project is related to the PI's long-term goals and how it will lead to future collaborations with other relevant research groups and attract additional competitive funding from NSF, DoD, NIH, or other agencies
    - Faculty and other government lab or industry involved as collaborators in the current proposal
    - Broader impact
        - Relevance to ONAMI goals (grow the Nanometrology and Nanoelectronics research budget), increase the education base and number of trained people, contribute to Oregon's economic base by transfer of the learning to industry or commercialization of the concepts)
        - Relevance to ONR goals to study nanoscale charge and spin based as well as photon-based quantum device structures, especially integrating these separate approaches
        - Relevance to current collaborative partner goals
        - Dissemination of results through publications and presentations

Reporting

All funded Principal Investigators will be expected to provide short (1-2 pages) quarterly progress reports which will be included in our quarterly reports to ONR. A final project report at the end of 12 months will document the approach, results, and progress towards the larger grant application.

Cost Information

A separate cost page should include the following information:

Faculty time (faculty months)
Total Faculty Direct Labor cost
Faculty OPE (fringe benefits)

Technician time (man months)
Total Technician Direct Labor cost
Technician OPE (fringe benefits)

Graduate Student time (fraction of FTE)
Total Graduate Student direct labor cost
Graduate student summer direct labor
Graduate student OPE (fringe benefits)
Graduate student tuition

Materials and supplies

Equipment (equipment < $5 K)

Capital equipment (up to $250K)

Subcontracts

Travel

Publishing expenses

Indirect Cost

Total Project Cost

Funding and Time Constraints

The total available funds are expected to be about $3.8M and the number of funded studies is expected to be 10-12. The time period will be approximately October, 2009 to September, 2010. It is not expected that funds will be available for continuing any project beyond one year. Major equipment requests (up to $250K) will be considered in this round.

Review Process

The review panel will consist of

1) The ONAMI Nanometrology, Nanoelectronics, and Nanobiotechnology leadership team with representatives from each of the Oregon universities. Leadership Team members who also submit proposals will select alternates from their university for the review of all proposals.

2) The results of the Review Panel will be examined by the Leadership Team for adherence to the guidelines of the Program and this Solicitation
3) External reviewers from NRI. WIN, and PNNL will be used as needed for proposals that include collaborators from their institutions.

Administration

Funds will be administered by PSU. John Carruthers and his Team will be the technical program managers and Alan Kolibaba, PSU Assistant Vice Provost for Research Services, will oversee the contract implementation. The Nanometrology and Nanoelectronics Leadership Team will approve any changes or address any issues.

The ONAMI Nanometrology and Nanoelectronics Team includes John Carruthers (PSU), David McIntyre (OSU), Heiner Linke/Richard Taylor (UO), and Tania Vu, OHSU.

Key Dates

The White Papers should be submitted in Word format to John Carruthers (carruthe@pdx.edu) by March 13, 2009 by 5pm. Reviews will be completed by the Review Panel and results will be announced by April 28, 2009. John Carruthers will roll the selected proposals into one proposal to ONR by July 15, 2009.

Appendix

Additional Information on the ONAMI Nanometrology and Nanoelectronics Program

Number of Projects Breakdown by Topic and Year

	2006	2007	2008	Total
Nanoelectronics	**8**	**8**	**4**	**20**
Nanometrology	**9**	**3**	**2**	**14**
Nanobiotechnology	**2**	**9**	**5**	**16**
Nanomaterials	**2**	**2**	**1**	**5**
Total	**21**	**22**	**12**	**55**
Budget Total	**$2.3M**	**$2.3M**	**$1.8M**	

Summary of Significant Research Rationale

Nanoelectronics (Projects collaborative with the Western Institute of Nanoelectronics)

Nanoelectronics projects are tied to the research opportunities defined in the International Technology Roadmap for Semiconductors (ISTR) and the challenges presented by continued feature-size scaling of MOS transistors. Charge-based device behavior at the quantum level is being covered by the work of Taylor and Linke at the University of Oregon and includes the transport of charge by electron wave functions and the effects of quantized heat transport on improving the thermoelectric efficiency of semiconductor nanowires. Spin-based devices are covered by the magnetoresistance device work of Jander at OSU and the new nanoscale domain imaging work of Sanchez at PSU. Other types of devices based on ion transport are being studied by Lonergan at UO. Organic semiconductors that can be fabricated by low-temperature processing are being studied by Ostroverkhova at OSU. The problem of high contact resistance of metals to carbon nanotubes as a modulator of charge transport is being studied by Jiao and Solanki, both at PSU.

Advanced device concepts such as Terahertz switching speeds in CNT transistors are being studied by Minot and Lee at OSU and piezoelectric energy harvesting devices by Conley at OSU. The deposition processes for the new zero-band-gap semiconductor, graphene are being studied in two projects, atomic layer deposition by Solanki at PSU and solution-based deposition by Yan at PSU. Graphene promises ballistic electron transport in the sub-10nm feature size and thus is a possible FET channel replacement candidate. However no suitable fabrication techniques exist for manufacturing yet.

Nanophotonics materials and structures that will be useful in manipulating photons for information processing are being studied by Podolskiy at OSU and Deutsch at UO. Of particular interest is the understanding of negative refraction, the possibility of providing gain in plasmonic structures, and the nature of nanoscale electro-optic effects of plasmons so that logic circuits can be constructed.

Nanometrology (Projects collaborative with PNNL and NIST)

In nanometrology, projects are dedicated to developing new ways of imaging and measuring at the nanoscale so that future research will not need to "work in the dark". By analogy, electron microscopy opened up the microscale world of technology. Indeed electron microscopy will continue its role into the nanoscale world because of the very short electron wavelengths. However other probes are also needed such as proximal probes (such as atomic force microscopy and its derivative methods), near-field optical probes, and ion probes. The overall goal established jointly with PNNL is to enable nanoscale chemical imaging at both surfaces and interfaces. This goal is critical to the nanoscale since all physical and chemical phenomena at the nanoscale occur at surfaces and interfaces.

In electron probes, Moeck at PSU is working on nanocrystallography where the structures of nanoscale objects can be determined by capturing more of the diffracted beams and by the major reductions in electron optics aberrations now available in modern transmission electron microscopes. Moeck has also established a world-wide database of such structures that is now available for researchers on the Web. In another project, Koenenkamp at PSU is building a photoemission microscope with nanometer resolution by using innovative electron optical focusing of the emitted electrons. This capability will allow chemical bonding changes at interfaces to be studied.

For optical probes, Sanchez at PSU is developing a near-field optical microscope that is coupled to an ion sputter source so that chemical profiling normal to the surface or interface can be performed at the lateral nanoscale dimensions for the first time. LaRosa at PSU is developing nanoscale optical near-field microscopy that combines far-field and near field imaging so that finding nanoscale objects will be easier. LaRosa is also working on the nanoscale imaging of electron and plasmon transport in semiconductors in metals respectively. Gregory at UO is studying the use of optical vortices to improve the imaging of near-field scanning optical microscopes. In the area of optical tweezing, McIntyre at OSU is exploring the capture of single molecules for spectroscopic studies. Photosensitive nanoprobes are being explored by Shvarev at OSU to measure the acid/base titration at the nanoscale.

Spectroscopic studies include THz spectroscopy of myglobin moelecules by Lee at OSU and the combined use of ellipsometry and atomic force microscopy by Freeouf at PSU to measure specific dielectric properties at the nanoscale.

For proximal probes, Sanchez at PSU is developing a novel nanoscale pipette for membrane studies in partnership with OHSU where the introduction of gentimicin into cells is of interest. LaRosa at PSU is developing a novel combination of shear force and atomic force probe to study the effects of surface films on AFM measurements. Such probes will also be useful for intracellular imaging of nanoparticles.

<u>Nanobiotechnology</u> (Collaborative with PNNL and OHSU)

Nanobiotechnology projects respond to the increasing interest in molecular-based and personal medicine as well as emerging clinical interest in nanobiosensors for point-of-care treatment. The intersection of the nanosciences and the biosciences will provide new and better tools for the complex world of biomedicine at the molecular and cellular levels. The main categories of current projects are: nanobiosensors, cellular and membrane imaging and measurement, molecular studies.

Nanobiosensor projects include electrical and optical detection schemes that take advantage of our nanoelectronics knowledge. The detection methods involve mostly antibody-antigen binding and monitoring the binding reaction through magnetic resonance of nanobeads (Dhagat, OSU), electrode impedance changes (Prasad, PSU, Solanki, PSU, Jiao, PSU), nanoparticle detection (Reed, PSU and Atre, OSU), chemFET sensing using CNT's (Minot, OSU), force detection using AFM's (Sanchez, PSU), fluorescence (Strongin, PSU), and photoluminescence (Rorrer, OSU).

Cellular and molecular imaging and measurement projects include synthetic membrane nanocapsules for protein preservation (Parthasarathy, UO), biomembrane microrheology (Parthasarathy, UO), and protein-membrane interactions using force measurements (Sanchez, PSU).

Molecular studies include electron detection of single molecule dynamics using CNT's (Minot, OSU), and optical tweezer isolation of molecules for spectroscopic studies (McIntyre, OSU).

<u>Nanomaterials</u>

The synthesis of ultra-thin, defect-free films with thicknesses in the range 1-10nm and controlled lateral nanostructures is a critical element of nanoelectronics so that controlled properties can be fabricated that are stable and repeatable. Current nanomaterials projects include nanolaminated materials structures fabricated from low-temperature solutions (Tate, OSU, Johnson, UO), and graphene monatomic layers (Yan, PSU). In addition, a method for studying the growth dynamics of nucleated semiconductor nanowires by TEM is being developed on specially designed TEM grids (Hutchison, UO). These studies explore the possibilities of using simpler fabrication techniques that are relevant to nanoscale geometries.

Listing of Projects

1. **Nanoelectronics (and Nanophotonics)**

2006 Projects

Understanding the bulk optical properties of materials through nanoscale design
M. Deutsch, U. Oregon and V. Podolskiy, OSU

Active plasmonic materials
M. Deutsch, U. Oregon and V. Podolskiy, OSU

Nanoionics/electronics of mixed ionic/electronic conductors
M. Lonergan, U. Oregon

Charge carrier dynamics in organic semiconductors
O. Ostroverkhova, OSU

Heterostructure nanowire thermal conductance
H. Linke, U. Oregon, A. Persson, U. Oregon, R. Taylor, U. Oregon

Carbon Nanotube contact investigation
J. Jiao, PSU, R. Solanki, PSU

Electron wave probes
R. Taylor, U. Oregon, H. Linke, U. Oregon

Logic magneto resistance devices
Jander, OSU, P. Dhagat, OSU, R. Solanki, PSU

2007 Projects

UV crosslinked polymer nanoscale films as gate dielectrics for solution-processable organic field-effect transistors
M. Yan, PSU, R. Solanki, PSU

Atomic layer epitaxy of graphene: nanoelectronics beyond silicon
R. Solanki, PSU

Low-loss macroscopic negative index materials in the visible: subdiffraction light manipulation and dispersion management
V. Podolskiy, OSU, X. Zhang, UC Berkeley

Identification, imaging, and manipulation of charged states in organic semiconductors: from macroscopic to microscopic optoelectronic devices

O. Ostroverkhova, OSU, G. Schneider, OSU, E. Minot, OSU, D. McIntyre, OSU

A quantum standard for the Seebeck coefficient
H. Linke, U. Oregon, R. Taylor, U. Oregon

Electro-optic devices based on carbon nanotubes with Terahertz switching capability
Y-S. Lee, OSU, E. Minot, OSU

Novel functions in nanowire devices
R. Koenenkamp, PSU, R. Word, PSU, B. Seipel, PSU

Electro-plasmonics: merging nanoplasmonics with electro-optics
V. Podolskiy, OSU, M. Deutsch, U. Oregon

2008 Projects

Ultrahigh spatial resolution Kerr-rotation imaging at the nanoscale using tip-enhanced near-field microscopy
E. Sanchez, PSU (with UCLA/WIN funding)

Metrology of low-disorder semiconductor quantum heterostructures
R. Taylor, U. Oregon (with U. New South Wales)

Developing a UHV probe station for exploration of surface chemistry impact on nanoelectronics
J. Jiao, PSU

Energy harvesting using piezoelectric nanowires
J. Conley, OSU, D. Cann, OSU, B. Gibbons, OSU, J. Holberry, PNNL, C. Huang, PNNL

2. Nanometrology

2006 Projects

SIMS Nanotomography
E. Sanchez, PSU, J. Simonsen, OSU, A. Benight, PSU, S. Atre, OSU

Nanostructure identification
P. Moeck, PSU, B. Seipel, PSU, B. York, PSU, W. Garrick, PSU

THz spectroscopy of myoglobin
W. Kong, OSU, Y-S. Lee, OSU, P-S. Ho, OSU

Optical tweezing field enhancement and single molecule spectroscopy
D. McIntyre, OSU and O. Ostroverkhova, OSU

Near-field imaging of carriers and plasmons
LaRosa, PSU, S. Prasad, PSU

Improving the resolution of apertureless scanning near-field microscopes with a vortex nulling technique
S. Gregory, U. Oregon

Shear-force AFM
LaRosa, PSU, J. Freeouf, PSU, R. Solanki, PSU, M. Yan, PSU

Dual mode ellipsometry /AFM imaging
J. Freeouf, PSU, A. LaRosa, PSU, M. Yan, PSU

Photoemission at high resolution
R. Koenenkamp, PSU

2007 projects

Image-based nanocrystallography
P. Moeck, PSU, S. Cady, PSU, K. Stedman, PSU, C. Li, PSU, B. York, PSU, W. Garrick, PSU, D. Johnson, U. Oregon

Metrology of non-equilibrium quantum transport in the high-bias regime
H. Linke, U. Oregon, R. Taylor, U. Oregon

Beyond sensing under equilibrium: photoresponsive nanoprobes for rapid localized acid-base titration
Shvarev, OSU, O. Ostroverkhova, OSU

2008 Projects

Structural fingerprinting and electron crystallography of nanocrystals from HRTEM images and precession electron diffraction data
P. Moeck, PSU

Breaking the diffraction barrier by selective control of near-field and far-field optical modes
A. LaRosa, PSU, T. Vu, OHSU, S. Reed, PSU, P. Moeck, PSU

3. Nanobiotechnology

2006 Projects

Ferromagnetic resonance biochip
P. Dhagat, OSU, S. Prasad, PSU

Nanomonitors for clinical diagnostics
S. Prasad, PSU

2007 Projects

Nanomonitors: electrical protein sensors for clinical diagnostics
S. Prasad, PSU, T. Barrett, OHSU/VA Hospital

Investigation of nanoelectrode biosensors for enhanced sensitivity
R. Solanki, PSU, A. Vandenbark, OHSU/VA Hospital

Optically controlled DNA sequencing through nanoscale funnels
D. McIntyre, OSU, S. Prasad, PSU

Biomembrane microrheology using nanocrystal probes
R. Parthasarathy, U. Oregon

A molecular approach to monitoring cardiovascular disease
S. Reed, PSU

Design of nanoscale electronics for protein sensing
E. Minot, OSU, E. Barbar, OSU, J. Jiao, PSU

Towards the development of an enzyme functionalized biosensor for detection of gentimicin on the nanometer scale
E. Sanchez, PSU, P. Steyger, OHSU, A. Kachelmeier, OHSU, P. Smith, Woods Hole Marine Biology Lab

High-sensitivity protein detection using nanoparticle-based arrays
S. Atre, OSU, S. Prasad, PSU, B. Tarasevich, PNNL, S. Varnum, PNNL, S. Seurnyck-Servoss, PNNL

A novel approach for the fabrication of CdS nanowire network-based nanosensors
J. Jiao, PSU

2008 Projects

Dehydration-resistant nanocapsules for protein and biomembrane preservation
R. Parthasarathy, U. Oregon, J. Abramson, PSU

Next generation multicolor, multimodal, fluorescent nanoprobes
R. Strongin, PSU

Electron detection of single molecule dynamics
E. Minot, OSU, D. Roundy, OSU, L. Fifield, PNNL, M. Chapman, OHSU

Development of nanopatterned antibody-functionalized surfaces for the selective detection of bioactive molecules through enhanced photoluminescence
G. Rorrer, OSU, M. Jones, PNNL

Biochemical sensors and integrated measurement platform controlled by optical tweezers and microfluidics
D. McIntyre, OSU, O. Ostroverkhova, OSU, S. Prasad, PSU, S. Reed, PSU

4. <u>Nanomaterials</u>

2006 Projects

Nanolaminated materials structures
D. Johnson, U. Oregon, D. Keszler, OSU, P. Moeck, PSU, B. Seipel, PSU

Solution based printing of nanoscale films
J. Tate, OSU, D. McIntyre, OSU, D. Keszler, OSU

2007 Projects

Micro- and nanoscale building blocks for optoelectronics: solution-based fabrication of high-performance nanophotonic and nanoelectronic devices
J. Tate, OSU, D. McIntyre, OSU, D. Keszler, OSU

Grid-based materials development platform: integrating production and analysis of ZnO nanowires grown from self-assembled nanoparticle arrays
J. Hutchison, U. Oregon, J. Miller, Dune Sciences, LLC

2008 Projects

Low-temperature, solution-based graphene synthesis, characterization, and device fabrication
M. Yan, PSU, R. Solanki, PSU