From Technology Push to Market Pull: Commercializing Nanoscience Research via Startups and Spinouts

Nanomanufacturing Summit
September 4-6, 2012
Boston, MA

Robert D. “Skip” Rung
President and Executive Director
Agenda

- ONAMI Investment Thesis and Results
- Research Focus – Green Nanoscience for High Performance Materials and Thin Films
- Results Focus: Innovation, Commercialization, ROI, Jobs
  - Entrepreneur-scientist partnerships
  - Shared facility access for startup companies
  - Commercialization Gap Fund
- Selected Company/Technology Profiles
Pacific Northwest Micro and Nano Industry Assets

9 posters (3 CA, 2 MA, 2 TX, 1 AZ, 1 PNW) available at www.siliconmaps.com
Manufacturing industry employment, annual pay, and job growth 2004-2009

NOTE:
Size of bubbles represents 2009 industry employment.

SOURCE: Oregon Employment Department

ONAMI
OREGON NANO SCIENCE AND MICROTECHNOLOGIES INSTITUTE
Identified Research Strengths

- **Microtechnology-based Energy and Chemical Systems**
- **Green Nanomaterials and Nanomanufacturing**
- **Nanolaminates and Transparent Electronics**
- **Nanoscale Metrology and Nanoelectronics**
Mission: Create Jobs and Attract Investment by Accelerating Materials & Device Research and Commercialization in Oregon

Grow research and talent development at Oregon universities

**Metric: Federal and private awards and contracts**

Support Oregon industry and start-ups with accessible shared high-tech facilities and tools

**Metric: # of external clients, service revenue**

Attract capital to Oregon start-ups via a professionally managed commercialization gap fund

**Metric: #FTE employed, leveraged capital investment and grant $$**
Coupling Applications and Implications: An integrative and prioritizing approach

New Engineered Nanomaterials

Pioneering Nanotech Applications

Nano EHS Implications

Greener Nano

Nano EHS Implications

SNNI = Nine interdisciplinary teams at four institutions
80 researchers
chemistry, materials, toxicology, engineering

adapted from Hutchison, J.E. ACS Nano 2008, 2, 395-402
Center for Sustainable Materials Chemistry

Conduct curiosity-driven and use-inspired research to enhance the green chemistry toolbox with new methods and new techniques that will advance the scientific enterprise and transform the next generation of products.
Industrial and National Lab Partners
Research Focus

• Clusters
  • First technique for synthesizing chemically labile metal clusters
  • New inorganic clusters without bulky ligands

• Films
  • High-quality inorganic films from water
  • Living films
  • High-fidelity sub-10-nm patterning
  • Tunability and high performance

• Ferecrystals - a new class of solid
  • Designed structures at the atomic scale
  • Abrupt structural interfaces
  • Unique and tunable properties
Research Examples

flat $\text{Al}_{13}$

The highest quality obtained by directed assembly
Innovation

• Workshops – NCIIA Lens of the Market 1-day w/ breakout
  • Follow-up with Innovation Lab – 2-day intensive workshop aimed at selecting options for potential market innovations

• Webinars – 3 per year (coordinated by NCIIA)
  • First webinar - Intellectual Property and Tech, 2/2012
  • Webinars are recorded and posted on the web: http://www.venturewell.org/csmc-webinars/

• Commercialization
Innovation

Phase-I
Series A
April 2011

Phase-II
Seed Funding
Dec 2011
The US’ Challenge: Commercialization and Opportunity Retention

"U.S crosses into ‘Ivory Tower’ territory"

- Lux Research
Organizational roles/needs in technology commercialization:

**Research Institutions:** scientific discovery, fundamental invention, talent development, shared user facilities. **Need:** public and philanthropic funding, enabling regulatory/legal environment

**Startup companies:** pioneering technology and market development of small - but disruptive – first opportunities. **Need:** equity/royalty licenses, large company customers/partners, high-risk (early stage) capital, minimal regulatory/legal burdens

**Large companies:** Manufacturing scale-up and global business development. **Need:** large & profitable “mainstream” markets, low-risk technology options
Federal/state partnerships in “gap” (aka “valley of death”) funding for new ventures commercializing NNI technology could accelerate commercialization by 2-4 years and also ensure proper focus on economic returns and job creation.
Review: ONAMI’s Role in Technology Commercialization

Focus on interfaces and operations
Two Paths Into the ONAMI Fund

Company/entrepreneur will commercialize university IP, obtains exclusive license option and engages research team/facilities

Company brings own IP, will utilize shared facilities and/or research team
ONAMI Entrepreneurs In Residence

Team, Network, Market and Sales assistance from veteran CEOs

Augie Sick asick@onami.us
- Chemistry, nanomaterials, life science tools

Michael Tippie mtippie@onami.us
- Biomedical, pharma, nanomedicine

John Brewer jbrewer@onami.us
- Semiconductors, electronics, optics
Gap Company Funding History

20x Leverage on Disbursed Funds

External Funding, $M
Gap Funds Committed, $M

Diagnostic Composition:
- 9% Grants
- 90% Commercial
Water
Crystal Clear Technologies
MTek Energy Solutions
Puralytics
ZAPS Technologies

Bio and Health Care
Cascade Prodrug
DesignMedix
Floragenex
Flash Sensor
Home Dialysis Plus
Northwest Medical Isotopes
NemaMetrix
PDX Pharma

Advanced Materials
Amorphyx
CNXLs
CSD Nano
Dune Sciences
Inpria
Microflow CVO
OnTo Technology
Pacific Light Technologies
QE Chemical
Voxtel Nano

Energy
Applied Exergy
Energy Storage Systems
Mtek
NWUAV
Perpetua Power
Trillium FiberFuels

$112M leverage to date, more pending
# A Green Nano Startup Portfolio

<table>
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<tr>
<th></th>
<th>Green Nano-Material</th>
<th>Green Nano-Manufacture</th>
<th>Green Nano Application</th>
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<td>Safer Design</td>
<td>OnTo Technology</td>
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<td>Reduce e-impact</td>
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<td>Waste Reduction</td>
<td>Crystal Clear</td>
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<td>Safety Process</td>
<td>VoxelTechNano</td>
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<td>Materials Efficiency</td>
<td>CSD Nano Inc</td>
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<td>Energy/H2O Efficiency</td>
<td>Amorphyx A</td>
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[Image of logos and company names]
ONAMI Gap Fund Portfolio Highlights

- Inpria
- Amorphyx
- Pacific Light Technologies
- ZAPS Technologies
- Perpetua Power Source Technologies
- Puralytics
- CSD Nano
- Voxtel Nano
- Microflow
- Dune Sciences
The World Needs Solid State Lighting

Worldwide Electricity Consumption

Lighting: 27%
4.7B KWh in 2009

Other: 73%

Solid State Lighting Will:

• Save a cumulative 5T kWh of electricity WW in the next decade,
• Remove the need for 500 power plants from the grid
• Reduce cumulative tons of CO2 emissions by 8B tons (equal to the emissions from all of the passenger cars in the world)

Source: Canaccord Genuity
SSL Bulbs Today Reduce Electricity Usage by:
- 80% vs. Filament Bulbs (But initial price is 2-3x too high)
- 10-20% vs. Florescent (Not sufficient)

PLT’s High Efficiency QD Down Converters Will:
- Reduce Cost by Reducing Number of LEDs (20-50%)
- Reduce SSL “Florescent” Electricity Usage by another 20-50%
- Improve Stability of Color (no objectionable CFL color “shifts”)
• Start-up specialty chemical building blocks business – Azaborines as phenyl alternative

• U. of Oregon inventor and CSO Liu is co-founder. CEO Upson is co-founder; was VP of catalog chemicals business

• NIH grant ($254K) to show if Azaborine in place of phenyl in Acetaminophen can reduce/eliminate liver toxicity

• ONAMI ($74.5K) grant to scale-up and cost-engineer

• Early interest from AstraZeneca, GlaxoSmithKline, and academics

• Contact: Donald A. Upson, 541-913-3921
Business Opportunity: Azaborine Building Blocks as Tools to understand Structure-Activity, and Likely to be Active

99% of Drugs Contain Phenyl – “Privileged” Building Block

Current Discovery is limited by current building blocks

Azaborines similar to phenyl, likely to produce active analogs, with novel properties. This is the VALUE to Customers.

“….I routinely looked for novel building blocks, regardless of the cost, to add to the diversity or expand the Structure-Activity Relationships...”

Dr. Joseph Salvino, Med Chem Professor, Drexel Medical, July 11, 2012
QE Chemicals, Inc.

- **Financial Projection**
  - 2018, Revenues projected at ~$30M+
    - Building Blocks => $18-36M, **Plus**
    - Custom Synthesis, Libraries, Co-Marketing => $5-10M
  - Licensing => **Potential for big payoff** (e.g., acetaminophen)

- **Milestones**
  - June 2012: Began lab work on grant objectives
  - 4Q12: Sign licensing agreement with U. of Oregon
  - 2013: Gain follow-on grant funding from NIH and ONAMI
  - April, 2013: First sales
  - 1Q14: Pass $1M in cumulative sales of building blocks
One machine provides a wealth of accurate, reliable real time information relevant for process optimization. Understanding nitrogen input can help systems predict and manage sludge microbe behavior, while observing efficiency in real time through oxygen demand and solids removal provides a basis for efficiency measurement and improvement.
**LiquID™ features**

**Tri-Optical:**
The LiquID™ made by ZAPS Technologies, Inc. is the only early warning system that can apply a variety of analytical techniques; absorption, fluorescence and reflectance measurements, with the same machine. The LiquID™ uses novel flow-cell and optical arrangements to manage the light more efficiently than any other optical detection system. This patented innovation together with its unique analytical capabilities makes the LiquID™ a powerful event detection system.

**Multi-Parameter:**
LiquID™ optically monitors diverse processes from drinking water to waste and industrial fluids. ZAPS Technologies' patented Multi-Parameter Technology™ allows for real-time measurement of numerous fluid quality indicators in a single station.

**Real-Time Detection, Analysis and Control:**
The LiquID™ system is accessible via a web-based user interface allowing for a comprehensive view of the entire region. A layered Observation system such as Regional, System, Site, Machine, Parameter, diagnostic, calibration and even control activities can be observed and acted upon from anywhere in the world.
Award-Winning Power Pucks®

Life-long, renewable battery for powering Wireless Sensor Networks

- Renewable energy from waste heat
- Eliminates batteries
- Like a battery – constant voltage
- Easy installation
Renewable energy solutions for wireless sensors.

Contact Information

Perpetua Power Source Technologies, Inc.
Nicholas Fowler, Chairman & CEO

4314 SW Research Way
Corvallis, OR 97333 USA

Telephone: 541.223.3112
Fax: 253.399.0373
Email: nff@perpetuapower.com

Web site: www.perpetuapower.com

Perpetua Power Puck®
LEDs excite a nanotechnology coated mesh which destroys germs and chemicals.

4 Patent Apps Filed, 3 Grants, Field tests successful
Puralytics Solution

- Novel LED-activated nanotechnology coated mesh for water purification
  - **Green:**
    - Water and electricity reduced
    - Contaminants destroyed
  - **Lean:**
    - Operating Expenses reduced 80%
    - 18 Month Payback
  - **Mean:**
    - Eliminates contaminants competitive systems can’t

**Shield 500** – world’s first solid state water purification system
VoxtelNano

- Located in Eugene, OR
- Wholly-owned subsidiary of Voxtel Inc. (Beaverton, OR)
- Nanocrystals and Nanocrystal Device Development
  Wet Laboratories & Nanocrystal Flow Reactors
- Located at CAMCOR Analytical Facilities
  - Nanofabrication Facility
    - FEI Helios dual-beam focused ion beam (DB-FIB)
    - photolithography
    - e-beam lithography
  - Bio-Optics Facility
    - Bio-Rad confocal microscope
  - Microanalytical Facility
    - FEI Quanta scanning electron microscope (SEM)
  - Surface Analytical Facility
    - ION-TOF time-of-flight secondary ion mass spectrometer (SIMS)
  - X-Ray Diffraction Lab
    - Bruker D8 Discover thin film X-ray diffractometer
  - High-Resolution Lab
    - FEI Titan transmission electron microscope (TEM), 0.5 Å
- 7 employees, 4 PhD
  - Core team from Hewlett Packard (Corvallis, Oregon)
Product Technology Focus

- Continuous Flow Nanocrystal Reactor Platform ($20/gram; kg/hour)
- Hybrid Nanocrystal-Organic Deposition Systems
- Printed 3D Gradient Index Optics and Nanocrystal Optical Films
- Thermoelectric Materials
- Printed Detectors

We develop functional hybrid organic-inorganic materials and the methods to synthesize and deposit them.
High Temp High ZT Thermoelectric Materials

- Good TE materials have a ZT value ~1.
- Thermoelectrics with ZT > 1 have low lattice thermal conductivity and high electrical conductivity.
- Voxtel uses multiphase composites on the nanometer scale, delivering high electrical and low thermal conductivity.
Products & Services

Photodetectors and Detector Arrays
- InGaAs (InAlAs/InP) PIN and APDs
- Silicon

Photoreceivers and Rangefinders
- InGaAs PIN and APDs
- Integrated uLRF Receivers
- uLRF ROICs

Readout Integrated Circuits (ROICs) & Focal Plane Arrays
- Radiation Hard Silicon Imagers
- Wavefront Sensors
- Active/Passive Imagers
- LIDAR/LADAR sensors

Photon Counting Detectors and Instruments
- InGaAs linear mode and Geiger mode (GM) APD
- Silicon GmAPD and SiPM
- Time-of-flight (TOF) ROICs and electronics
- Photon Counting and TOF ROICs

www.voxtel-inc.com
Microwave Flow Cell Reactor for High Precision Nanoparticle Synthesis

- Green Aspects
  - Reduced Waste
  - Increased Yield
  - Elimination of Heavy Metals (Pb, Hg, Cd)

- Business Aspects
  - Reduced Cost
  - Increased Process Control
    (Particles of known size, shape and chemistry)

- Green Performance and Business Success are compatible.

Zoned / Modular Reactor enabling:
- Process Control / Monitoring at each zone
- New chemistries not available to batch processes
- Increased scientific understanding of each step in nanoparticle synthesis (nucleation, growth, ligand exchange)
• Better Mixing
• Lower Cost
• Customizable
• Scalable

Microflow CVO M11-5

Microflow CVO
Comparison of M11-5 to IMM SIMM-V2

Absorbance at 353nm

Pressure drop, psi

Throughput, ml/min

M11-5 Absorbance
SIMM-V2 Absorbance
M11-5 Pressure
SIMM-V2 Pressure
On-going efforts to streamline analysis

Avoiding artifacts and streamlining sample preparation – custom TEM grids

Speeding the analysis of large numbers of particles\(^1\)

New tools (SAXS) and new analysis methods (image processing)

**Dune Sciences**

**Nanoparticle Capture for Visualization and Surface Functionalization**

**LinkedON™ Technology**
- Permanent bonding of nanoparticles to surfaces.
- Reduces environmental impact and footprint.

**Nanoparticle Adhesion**

**Durable anti-microbial coatings.**

**Smart Grids™**
- New standards for nanoparticle metrology.
- Better understanding of nanomaterial risks.
- Enhanced imaging of biomolecules for research and diagnostics.
Acknowledgements

- Air Force Research Laboratory
- Army Research Laboratory
- Naval Research Laboratory
- National Science Foundation
- Jim Hutchison - University of Oregon
- Doug Keszler - Oregon State University
- Bettye Maddux, SNNI and CSMC
- Dave Johnson - University of Oregon
- Andrew Grenville – Inpria
- John Brewer, Amorphyx
- John Miller - Dune Sciences
- Mark Owen - Puralytics
- Chih-hung Chang - CSD Nano
- George Williams - Voxtel
- Ron Nelson - Pacific Light Technologies
- Matt Johnen – ZAPS Technologies
- Nick Fowler – Perpetua Power Source Technologies
- Todd Miller - Microflow
Backup slides
## Principles for greener nanoscience

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<tr>
<th>Green Chemistry Principles</th>
<th>Designing Greener Nanomaterial and Nanomaterial Production Methods</th>
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<tr>
<td>P1. Prevent waste</td>
<td>Design of safer nanomaterials (P4, P12)</td>
</tr>
<tr>
<td>P2. Atom economy</td>
<td>Design for reduced environmental impact (P7, P10)</td>
</tr>
<tr>
<td>P3. Less hazardous chemical synthesis</td>
<td>Design for waste reduction (P1, P5, P8)</td>
</tr>
<tr>
<td>P4. Designing safer chemicals</td>
<td>Design for process safety (P3, P5, P7, P12)</td>
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<tr>
<td>P5. Safer solvents/reaction media</td>
<td>Design for materials efficiency (P2, P5, P9, P11)</td>
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<tr>
<td>P6. Design for energy efficiency</td>
<td>Design for energy efficiency (P6, P9, P11)</td>
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<td>P7. Renewable feedstocks</td>
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<td>P8. Reduce derivatives</td>
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<td>P9. Catalysis</td>
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<td>P10. Design for degradation/Design for end of life</td>
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<tr>
<td>P11. Real-time monitoring and process control</td>
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<tr>
<td>P12. Inherently safer chemistry</td>
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Green chemistry: a proactive approach to safer design, production and application of nanomaterials

Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products

- Greener solution must meet or exceed functional needs
- Risk = \( f \) (Hazard, Exposure)

Design for reduced hazard and exposure at the molecular level – inherent safety

More efficient and safer processes

*Early feedback and intervention – get the technology right the first time*
**The ONAMI Gap Fund Portfolio, August 2012**


<table>
<thead>
<tr>
<th>Thrust Area and Project Host Campus</th>
<th>MECS (microtech-based energy and chemical systems)</th>
<th>Green Nano (materials and processes)</th>
<th>Solid State (batteries, printed electronics, green electronic materials)</th>
<th>Nanoscale Metrology</th>
<th>Nano Bio-Tech</th>
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<tbody>
<tr>
<td>OSU</td>
<td>Home Dialysis Plus ABP</td>
<td>Inpria, Nanobits, CNXL, Voxtel Nano, CSD Nano, Microflow CVO, Amorphyx</td>
<td>Peregrine/Promat OnTo Technology, Inspired Light e1NA</td>
<td>ZAPS Technologies</td>
<td>Northwest Medical Isotopes</td>
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<tr>
<td>PSU/OHSU</td>
<td>Puralytics</td>
<td>Pacific Light Tech., Energy Storage Systems</td>
<td>Flash Sensor</td>
<td>DesignMedix, PDX Pharma</td>
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<tr>
<td>UO</td>
<td>Crystal Clear Technologies, Dune Sciences</td>
<td>Perpetua Power Voxtel Optics</td>
<td>NemaMetrics</td>
<td>Floragenex, QE Chemical, Cascade Prodrug</td>
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</table>

$112M leverage to date, more pending
* Moth-eye structure (<100nm) with polymer hard coat

* Average 5.85% increase across 400nm-750nm
  (3rd party measured, 12 Eagle 2000 solar cover glass)

* Excellent broadband and angle of incidence performance without extra film layers

Percent Transmission (%T)

100% is PV cell with no glass cover, ATSM 1.5 curve normalized

ARC* Moth-eye Structure

ARC glass

Bare glass

Solar Spectrum

Solar Cells

Glass

1%

3%

1%

3%

100% is PV cell with no glass cover, ATSM 1.5 curve normalized
ARC* Moth-eye Structure

Moth-eye Structure

Synthesis + Deposition

SiO₂ Stochastic Tapered Structure

* Anti-Reflective Coating
Company Introduction
Vacuum quality metal oxide thin films from solution

Platform accesses large range of metal oxides
High Density Al based Oxide

Key attributes
- Fully dense films, atomically smooth surfaces without cracking
- Directly imageable
- Widely tunable optical properties
- Film thickness ~1 - 100nm per coat
- Planarizes over nanoscale, conformal at micron scale
- Deposition by spin coating; path to large area coating
- Anneal at moderate temperatures (200C – 450C)
Digital Control of Index of Refraction via Sequential Solution Processing

Individual layers added one by one with control of composition

$\text{Al}_4\text{O}_3(\text{PO}_4)_2$  \hspace{2cm} $\text{HfO}_2$

$\text{Al}_4\text{O}_3(\text{PO}_4)_2$
Inorganic Optical Coatings by Solution

HRI: $n = 2.26$ (@ 500nm)
LRI: $n = 1.50$ (@ 500nm)

Note: maximum processing temperature was 300C; multilayer film stack deposited entirely by solution process (spin coating)
Applications

Display Backplane TFT Materials

Thin Film PV

Lithography Materials

Window Coatings

Printed Electronics & Lighting
Resist for Semiconductor Lithography

15 nm Etched Si Fins

1.6 nm Linewidth Roughness

Key Attributes
- High resolution
- High etch selectivity
- High EUV absorbance
- Low LWR
Amorphyx Overview

• Breakthroughs in manufacture and use of amorphous metals
• Revolutionize manufacturing of flat-panel display backplanes while enabling the future of flexible displays

Replaces complex Thin Film Transistor with simpler Amorphous Metal Electrode Thin Film Diode

Roughly 3x capacity increase in TFT Array manufacturing facilities using existing tooling

• License AMTFD Process into FPDs
• Develop Reference Plant for Flexible

Convert $Bs in annual FPD industry losses into profits by redefining backplane manufacturing throughput

Generation 8 glass panel patterned with six backplanes for 52” Samsung televisions. Previous generation glass panels are seen to lower left.
AMTF Metal-Insulator-Metal Diodes

An ultra-smooth surface eliminates localized “eddy currents” that modulate MIM diode “on resistance” at a given forward-bias voltage.

Flat Panel Display Benefits
- improved gray-level performance
- improved brightness uniformity
- increased backplane glass yields
- lower power consumption

Development Status
- AMTFDs operating 1nA-10µA produced on 1” glass substrates using ALD
- Validated ability to engineer I-V characteristics with insulator thickness, electrode materials
- Initiated development of CVD process

Amorphous metal thin films: Device control through material properties
An NSF Center for Chemical Innovation
New Materials - Unprecedented Performance

Doug Keszler
Oregon State University

Dave Johnson
University of Oregon

$21.5M Awarded from NSF Oct. 2011!!
Conduct curiosity-driven and use-inspired research to enhance the green chemistry toolbox with new methods and new techniques that will advance the scientific enterprise and transform the next generation of products.

Prepare students to implement sustainable chemistry
University Partners
Project-oriented Research Thrusts

Clusters
Darren Johnson (UO)
Bill Casey (UCD)
Jim Hutchison (UO)
Mark Asta (UCB)
Paul Cheong (OSU)
Scott McIndoe (U. Victoria, Canada)

Solution Films & Patterns
Doug Keszler (OSU)
Cathy Page (UO)
Rick Garfunkel (Rutgers)
Greg Herman (OSU)
Deidre Olynick (LBL)

Ferecrystals
Dave Johnson (UO)
Janet Tate (OSU)
Ian Anderson (NIST)
Paul Zschak (Argonne Nat’l Lab)

Cross-cutting research
Sophia Hayes (WUSTL)
Shannon Boettcher (UO)
Mark Lonergan (UO)
George Nazin (UO)

John Wager (OSU)
John Conley (OSU)
Thomas Proffen (Los Alamos Nat’l Lab)
Mas Subramanian (OSU)
Nanoscience facilities and equipment can best benefit technology development when they are conveniently located and easy to use by businesses. **Such access is especially important to the small and medium enterprises (SMEs) that are critical for early stage commercialization.** State and regional economic development field staff can serve as “high tech extension” agents.

**The “High Tech Extension” Concept**
ONAMI Shared User Facilities

Center for Materials Characterization (CAMCOR)

CAMCOR is a full-service, comprehensive materials characterization center at the University of Oregon (UO) open to outside clients. Benefit from capabilities, access to analytical experts, priority for time critical data, and remote access from your office. Equipment includes: Transmission electron microscope (TEM), Field emission Scanning electron microscope (SEM), SEM/FIB nanofabrication, Electron Microprobe Analysis (EPMA), X-ray photoelectron spectrometer (XPS), Time-of-Flight Secondary Ion Mass Spectrometer (ToF-SIMS), Single crystal and powder diffractometers, and more.

Center for Electron Microscopy and Nanofabrication (CEMN)

The CEMN at Portland State University (PSU) provides researchers and industry with state-of-the-art facilities for characterization and fabrication of nanoscale materials and devices. Equipment includes: Transmission electron microscope (TEM), Field emission Scanning electron microscope (SEM), SEM/FIB nanofabrication, thin film deposition and sample preparation.

Microproducts Breakthrough institute (MBI)

The MBI is a microsystems fabrication facility located on the Hewlett Packard (HP) campus in Corvallis. Through miniaturization, microtechnology has the potential to revolutionize many products. The MBI uses microfabrication methods to support researchers and industry to invent and prototype products for energy, environmental, medical and defense applications. Applications include, blood processing, fuel injection, DNA sample preparation, nanomaterial deposition, and microchannel heat exchangers.

CAMCOR is located in the Lorry Lokey Science Complex, University of Oregon

View inside the CAMCOR Surface analytical laboratory and the X-ray photoelectron spectrometer (XPS)

CEMN is located in the heart of Portland

Transmission electron micrograph of virus particles.

The MBI is managed by Oregon State University and located on the HP Corvallis campus.

ESI laser machining tool at the MBI facility.