OREGON NANOSCIENCE AND MICROTECHNOLOGIES INSTITUTE

From Blue Sky to Green Dollars – Why Safer Nano is a Win-Win

Robert D. “Skip” Rung
President and Executive Director

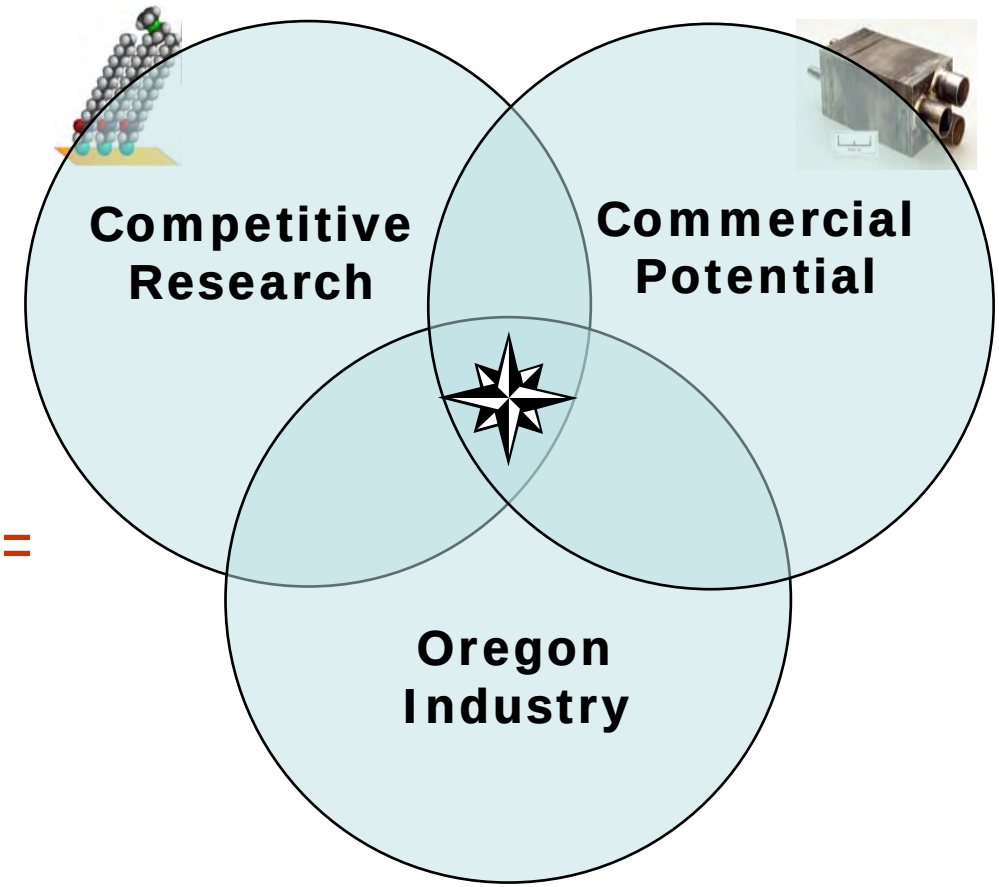
ONAMI

Topics

- ONAMI and green nano
- Nano and EHS – what's really new?
- Opportunity and risk – what's at stake?
- What to do – and who entrusted to do it?
- Analogy – high tech/manufacturing "concurrent development"
- Conclusion: Nanotech R&D and EHS must be a concurrent, collaborative effort from Day 1

Signature Research Center Investment Criteria

OCKED's 2002 study pointed to: "multiscale materials and devices" = Nanoscience & Microtechnologies



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Why Small Tech for Oregon?

- Global reality: lead at innovation… *or else*
- Situation: where our high-wage jobs are
- Signature Research Strategy

  Industry cluster strength

  + Emerging markets

  + Competitive research

  = Future Prosperity Source

- Implementation Framework:

  Collaborative Research Engine

  NanoNet – researchers & user facilities

  Gap and Early Stage Equity Funding

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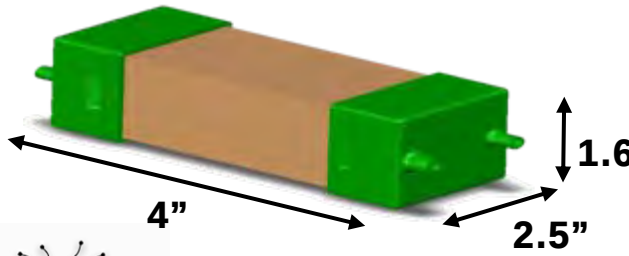
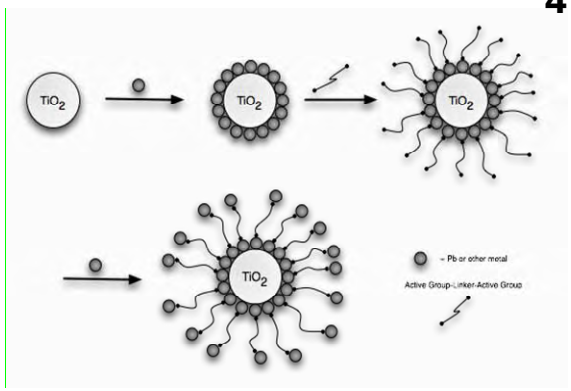
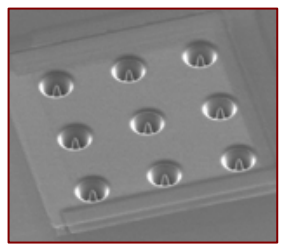
ONAMI Research Thrusts

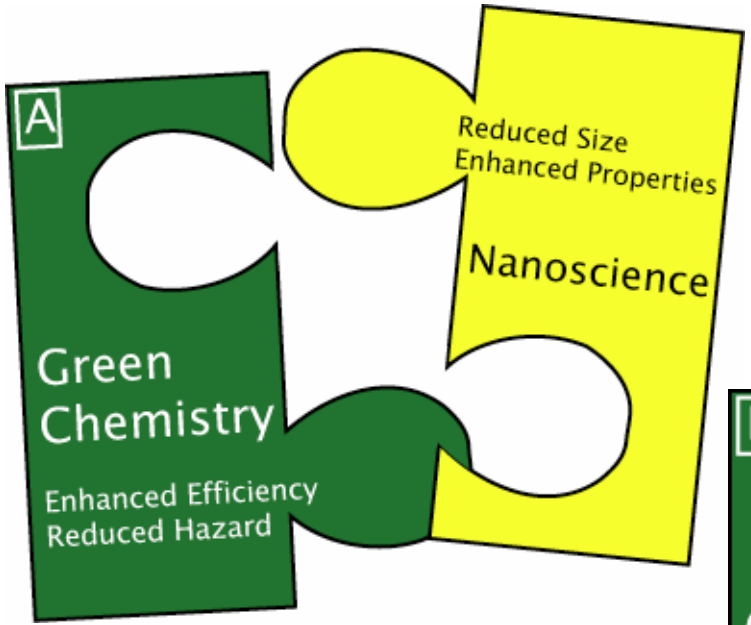
- Research leads: OSU, PNNL, PSU, UO
- Four collaborative thrusts, ~$25M/year
  - *Microtechnology-based Energy and Chemical Systems*
  - ***Green Nanomaterials and Nanomanufacturing***
  - *Nanolaminates and Transparent Electronics*
  - *Nanoscale Metrology and Nanoelectronics*

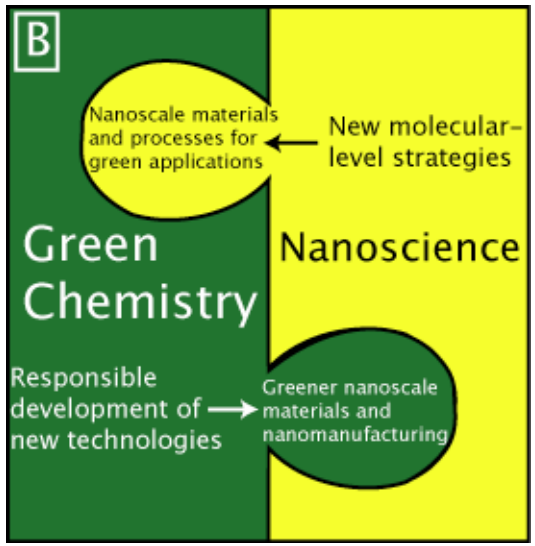


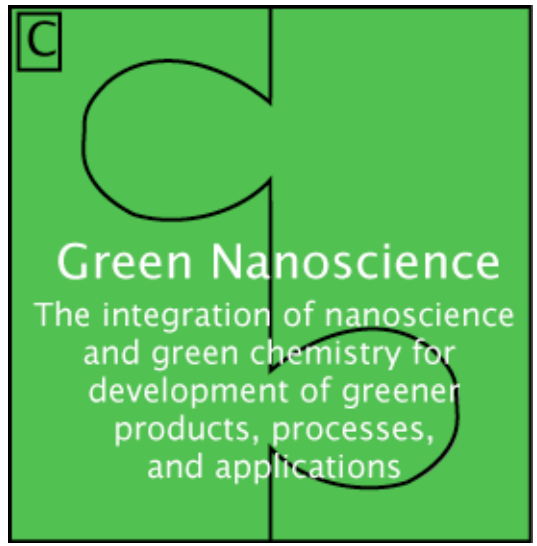




Merging green chemistry and nanoscience







McKenzie, L.C; Hutchison, J.E. "Green nanoscience: An integrated approach to greener products, processes, and applications," *Chemistry Today*, In press.

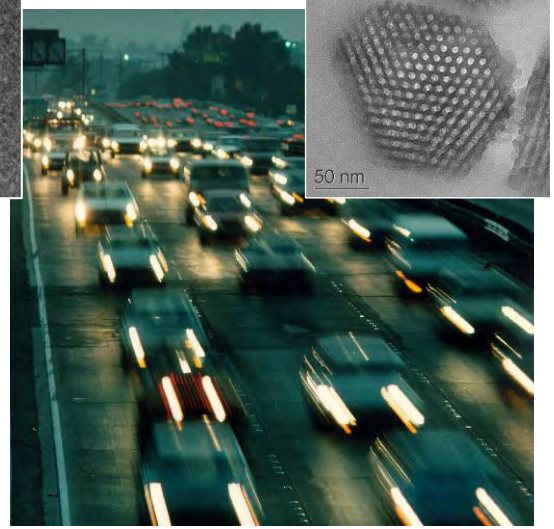
Jim Hutchison, UO

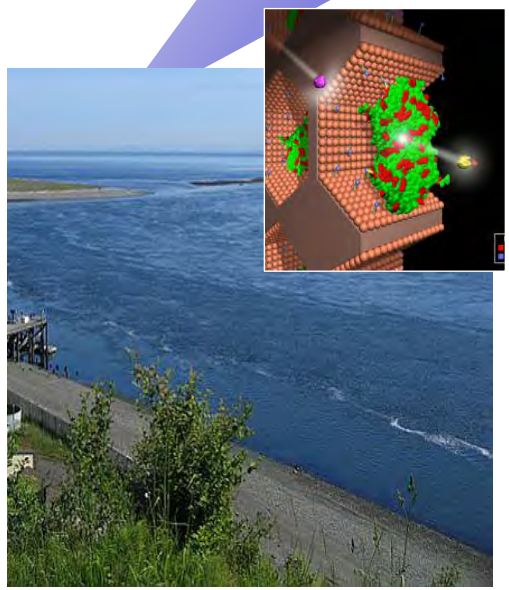
Nanoscience can offer solutions to environmental problems

Homeland Security
Signature Detection

Energy
Hydrogen Storage

Cleanup
Enzyme Immobilization



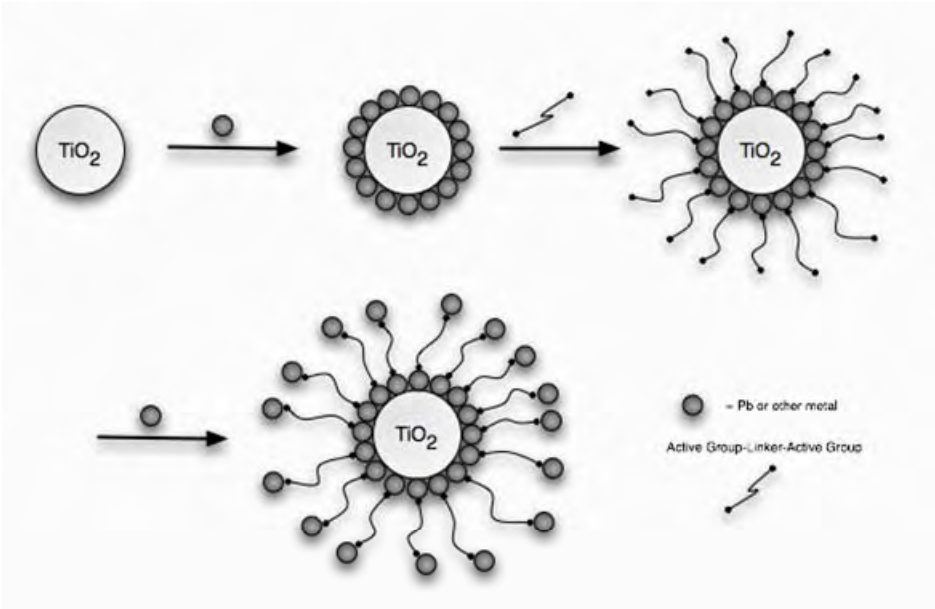


Slide courtesy of PNNL

Nanocoated Minerals for Toxic Metal Remediation

- ***Transferring basic science discoveries in arsenic and lead coordination chemistry to the preparation of materials for water remediation.***
  - ***A collaboration that has resulted in joint intellectual property between Crystal Clear Technologies, Inc. (Dr. Jim Harris, Lisa Farmen) and the University of Oregon (Prof. Darren Johnson, Melanie Pitt).***

- TiO_2 granules are marketed for use in heavy metal adsorption.
- Addition of a bifunctional nanocoating (ligand) layer to Pb-coated TiO_2 exposes a fresh metal binding surface which increases the capacity of the material for toxic metal adsorption.
  - Harris, Johnson, Pitt, U.S. Patent Pending (filed Feb. 2006).



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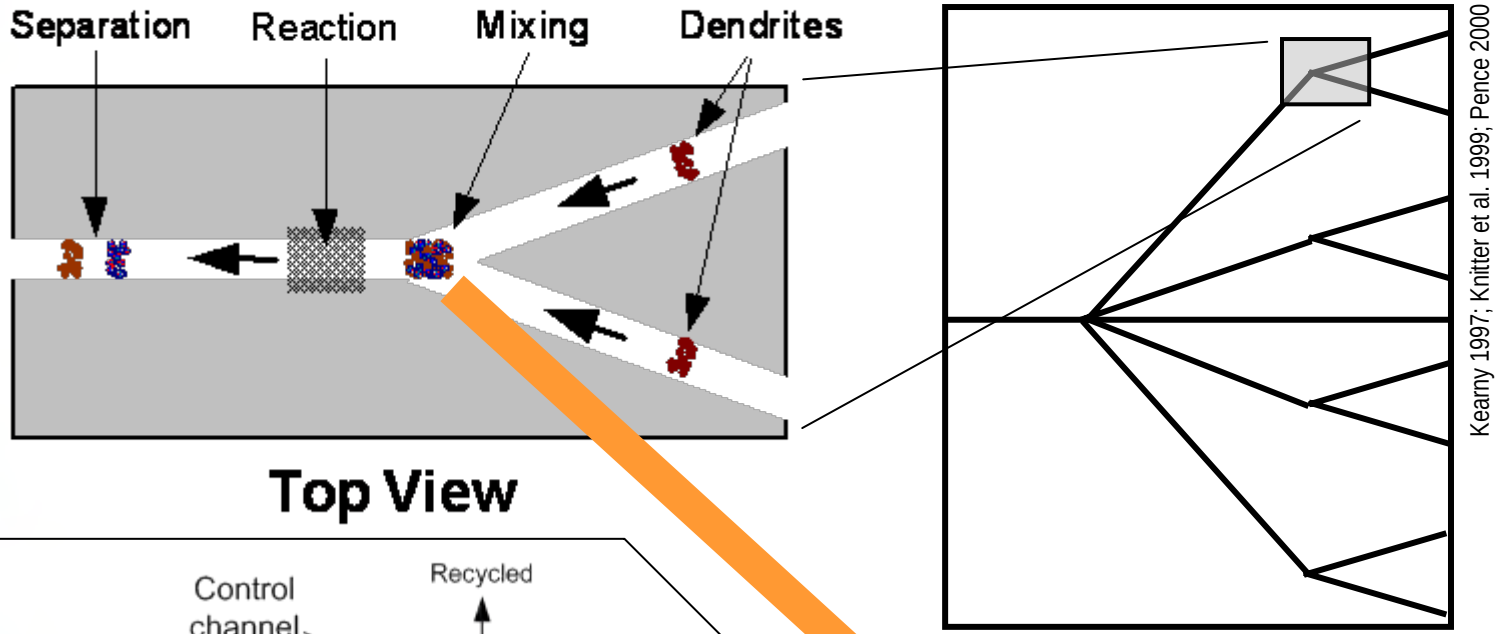
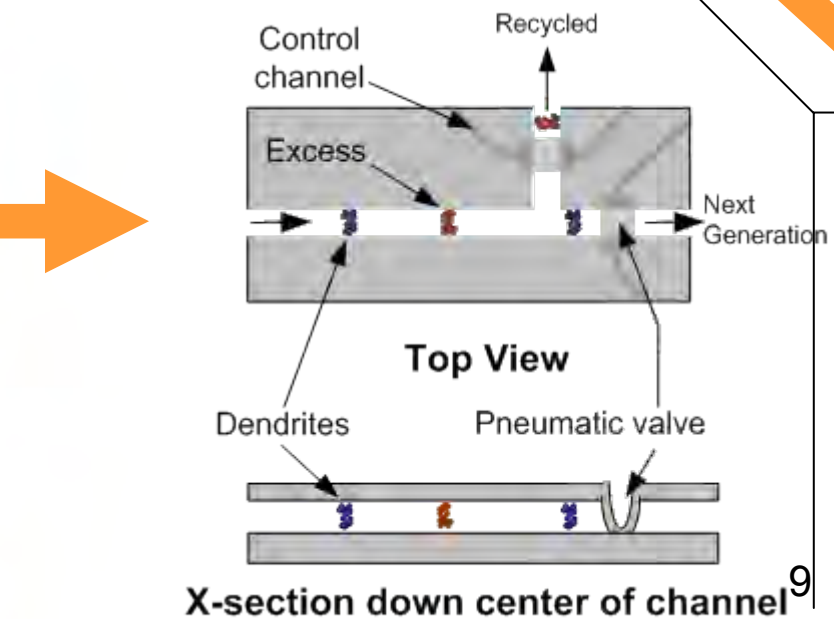
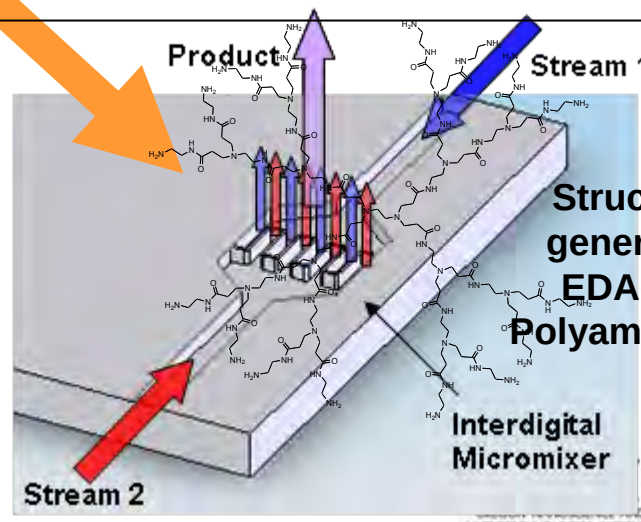
CRYSTAL CLEAR TECHNOLOGIES, INC.

The "nanofactory" microsystem

Production of Nano Building Blocks







Structure of generation-2 EDA-cored Polyamidoamine

Nanotechnology and EHS – What's Really New (since 1980s)?

- Expanding research investment and capability to image, measure and manipulate at the nanometer scale
- *Intentionally engineered* nanomaterials for industrial and consumer products – small, but growing shipment volumes
- Investment appetite/trend for "clean tech" as source of solutions and wealth creation
- Belief by some in possibility of "autonomous replicating assemblers" and associated risks

Opportunity and Risk – What's at Stake?

+ Societal benefits: energy, environment, medicine, communications
+ U.S. leadership in the applied sciences, entrepreneurial achievement
+ Innovation-derived wage differentials, affluence and societal wealth
– Workplace safety - new hazardous materials handling challenges
– Consumer product safety
– Environmental quality – fate and transport

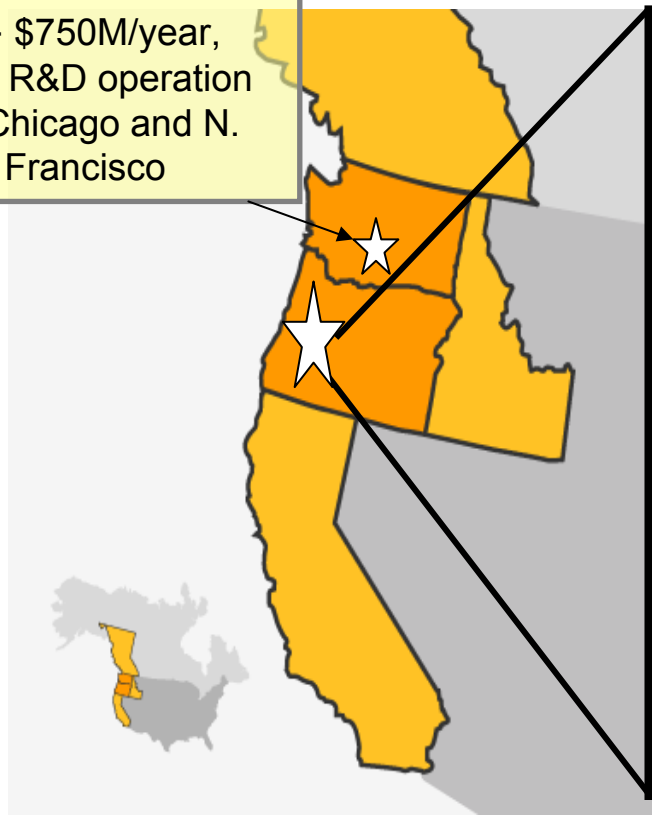
Oregon Traded Sectors (2005)

Industry	# OR Jobs	Annual Pay per Worker	Location Quotient	Δ% Job Growth vs. US ('04-'05)
Electronics	43,357	$78,613	1.98	2.0%
Forest Products	47,140	$42,154	3.37	0.7%
Metals	24,313	$45,361	0.98	3.6%
Apparel/Sports	9,780	$83,587	1.49	7.5%
Food Processing	24,195	$30,691	1.15	-0.8%
Trans. Equipment	17,983	$39,115	0.81	7.3%
Machinery	11,662	$51,041	0.80	-1.7%
SW Publishing	7,276	$84,126	2.44	9.3%

Source: Oregon Business Plan 2007 Competitive Index

Oregon: The Surprise World Leader in Industrial "Small Tech" R&D Assets

PNNL- $750M/year, largest R&D operation W. of Chicago and N. of San Francisco



INTEL: #1 Nanotech application and R&D
- 16,700 Employees In Oregon
- HQ Semiconductor Process Engr. ($11B capex, 90/65/45 nm R&D and lead production)

HP: #1 MEMs application and R&D
- HP Ink Jet HQ (MEMs & nanometer technology)
- Largest HP technology site – 3000 people.
- 25% of all HP patents here, #1 nano patent portfolio

FEI: World leader in tools for nanotechnology;

INVITROGEN: World Leader in Quantum Dots

TriQuint: World leader in GaAs ICs

ESI: World leader in laser micromachining

Tektronix, Xerox, ON Semi/Nantero, Applied Materials, Novellus, TSMC, Hynix, Microchip, IDT, Siltronic, SEH, Planar, Sharp…

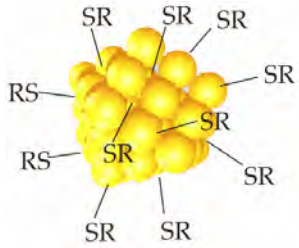
"You already have what everyone else wants"

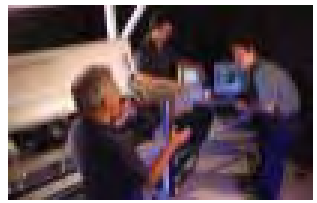
Dr. John Marburger, Presidential Science Advisor

Oregon Micro/Nano Startups

CleanTech and green nano major themes

- **Nanotools, nanophotonics**
  Ascend Instruments, Deep Photonics
  LightSmyth, AISthesis, **Dune Sciences**
  NanoBits, OMG
- **Nanomaterials, nanobio**
  Acrymed, Nuvometrix, Voxtel
  Crystal Clear Technologies,
  Quantum Dot & Biocrystal (Invitrogen),
  Brilliant Tech, **Dune Sciences, Trillium**
- **MEMS / microtechnology**
  ClearEdge Power, Home Dialysis Plus,
  Octavian Scientific, Hydration Technologies
  Imtech, **Perpetua,** Phoseon, PicoJet,
  Rogue Valley Micro, WiSPI, DTLTech
  ABP / ABD





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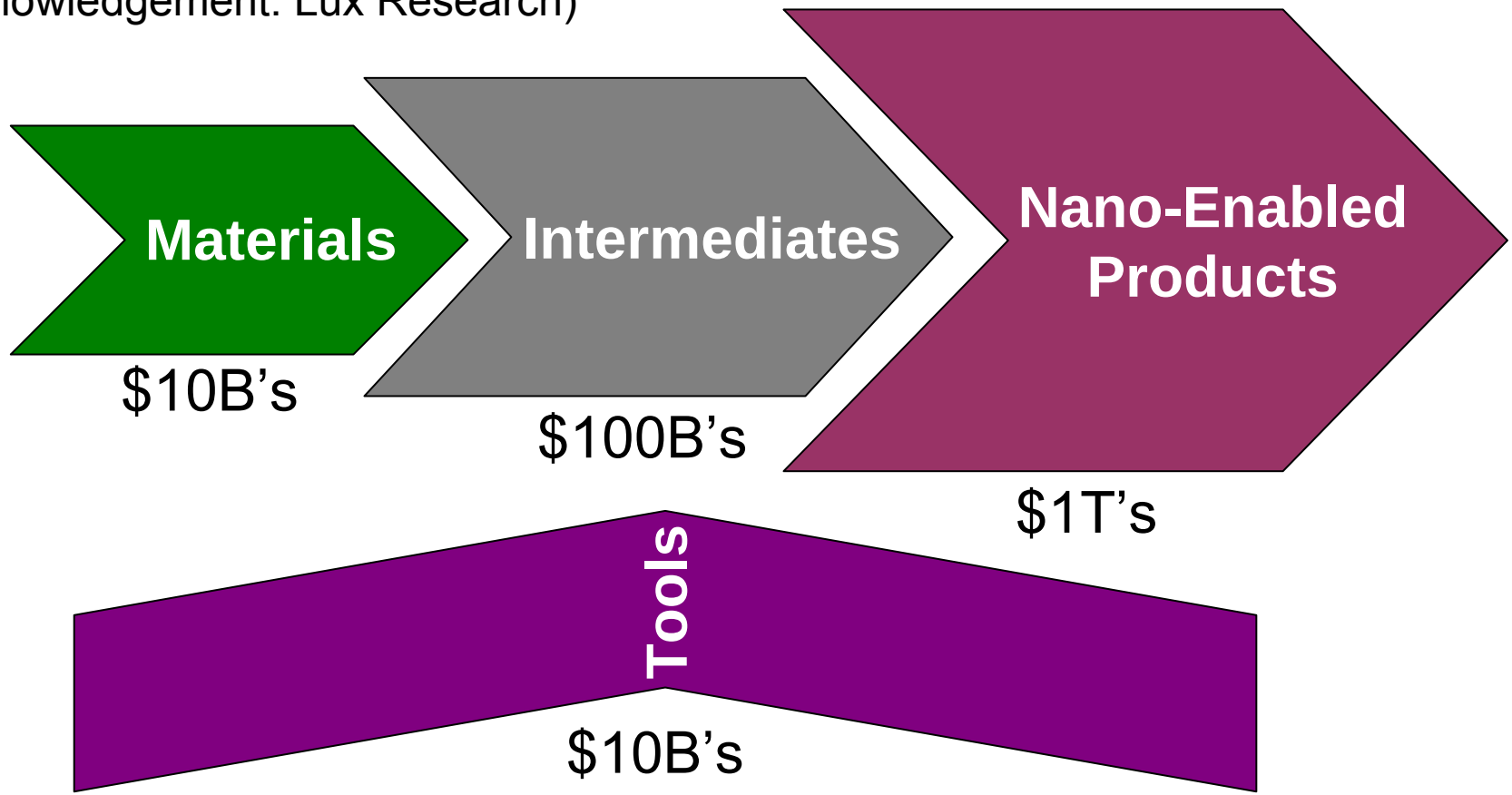
Pacific Northwest Venture Capital Symposium:
Opportunities Beyond Silicon Valley

What's "Real" In Nanotech?

Monday, Sept. 12, 3:45-4:45 PM

Framing the "Nanotechnology Business"

(acknowledgement: Lux Research)



Preliminary Conclusions

- Benefits are significant, and worth some risk (e.g. household electricity)
- Attention to potential risks is warranted
- Draconian regulation is premature (lack of information, low volumes, etc..)

What to Do, and Who Should be Entrusted?

- There's plenty of non-altruistic motivation (e.g. publicity of adverse events, high cost of quality/safety/liability problems) for researchers and developers/investors to get things right – "de-risking" is key
- Connected public investment in both performance and safety research - e.g. the SNNI approach
- Neither advance inhibition nor after-the-fact response will produce optimum results

Concurrent Design – How High Tech Process/Product Development is Done

- Old way – "silo" organizations and "over the wall" handoffs from R to D to P
- 1970s – We *can* be beaten – by hungry competitors - using our own ideas (total quality, lean manufacturing)
- Principles of optimized development:
  - Early Manufacturing Involvement → sophisticated "product life cycle" processes
  - Cross-functional teams, personnel transfer
  - "That's  my job"
- Post-production/field problems are ruinous!

High Volume / High-Tech Process & Product Development Context

R&D Phases	Objective/ Purpose	Nature of Activity	Metrology Needs
Applied Research	Strategic choices	**BOLD** experimentation	Performance, EHS
Product Development	Set recipes and specs	Thorough Characterization	Everything!
Early/Pilot Production	Climb ramp, improve cost & quality	Problem solving, early SPC	Overkill in-process, FA
Mature Production	**Reap ROI** Efficiency: cycle time, cost, defect rate	Replication, SPC	As little as possible – sampling, FA

Final Conclusions

- It is our national heritage and character to lead in the discovery and creative commercialization of science. To fail at this going forward will bring very unpleasant changes and losses, but success in a competitive world is no longer a given
- There is every reason to believe that a proactive, combined performance/safety "correct by design" approach to nanotechnology will deliver the best social, financial and public safety results
- Green Nanotechnology approach is both timely and essential for success

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Questions?

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