

# OREGON NANOSCIENCE AND MICROTECHNOLOGIES INSTITUTE

**Panel:**

## **High Performance Nanomaterials for Electronic and Industrial Applications**

**Nanomanufacturing Summit 2011**

*September 26, 2011*



**ONAMI**

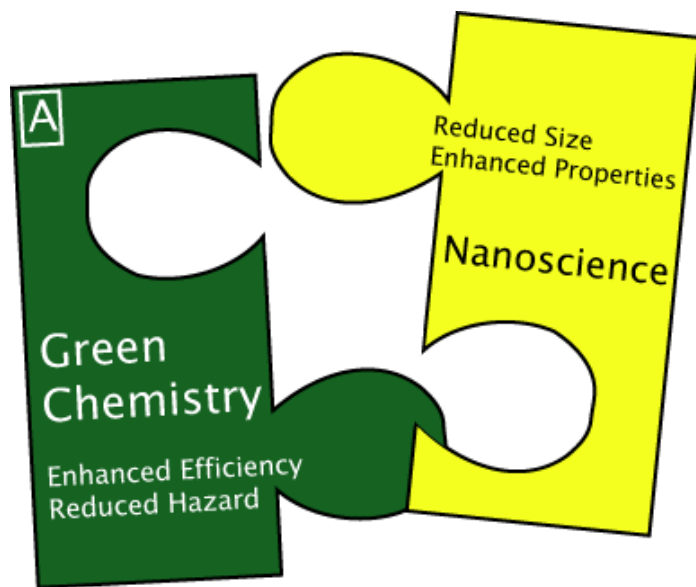
# What We Mean by “Green” Nanomaterials”

- Earth abundant and non-toxic materials,
- Reduced material waste
- Reduced energy and water use
- Lower cost
- *Better* performance (required by customers)



# Applying green chemistry to nanomaterials and nanomanufacturing

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**Higher performance**  
**Cheaper**  
**More convenient**  
**Greener**

McKenzie and Hutchison “Green nanoscience,” *Chemistry Today*, **2004**, 30.  
Dahl, Maddux and Hutchison “Toward Greener Nanosynthesis,”  
*Chem. Rev.* **2007**, 107, 2228.

# Principles for greener nanoscience











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

McKenzie and Hutchison "Green nanoscience," *Chemistry Today*, **2004**, 30.  
Dahl, J.A.; Maddux, B. L. S.; Hutchison, J. E. *Chem. Rev.* **2007**, 107, 2228

# Example Applications

- **Semiconductor (Si and compound) films**
- **Display backplane and PV process films**
- **High-performance nanolithography and EUV resists**
- **Anti-reflective, thermal insulation and other functional coatings**

# A Green Nano Startup Portfolio

	Green Nano-Material	Green Nano-Manufacture	Green Nano Application
Safer Design			
Reduce e-impact			
Waste Reduction			
Process Safety			
Materials Efficiency			
Energy/H2O Efficiency			

# The Panelists:

**Doug Keszler**, Founder/CSO of Inpria Corp., Distinguished Professor of Chemistry; Oregon State University; Director, Center for Sustainable Materials Chemistry (NSF CCI)

**David C. Johnson**, Rosaria Haugland Foundation Chair in Pure & Applied Chemistry, University of Oregon; Co-Director, Center for Sustainable Materials Chemistry

**Judy Giordan**, Partner, ecosVC; CSMC Innovation Program

**Skip Rung**, President & Executive Director, ONAMI (Moderator)