Nanotechnology Impact
Driving the Materials Revolution

OECD / NNI Symposium
27 March 2012

Travis Earles
Advanced Materials & Nanotechnology Initiatives
Nanotechnology Innovation

- Control/manipulation/engineering
- Scale (~1-100 nanometers)
- Novel resultant properties
- Breadth and speed of impact
  - Materials
  - Energy
  - Health and medicine
  - Electronics
  - many more...
  - Agriculture
  - Construction
  - Transportation
  - Consumer products

- Specific, intentional focus in the U.S. since 2001

NATIONAL NANOTECHNOLOGY INITIATIVE
www.nano.gov
Nanotechnology at Lockheed Martin

Aeronautics
- Materials
- Sensors

Information Systems & Global Solutions
- Control Algorithms
  - Biomedical

Electronics Systems
- Materials
- Sensors
- Electronics

Space Systems
- Materials
- Sensors
- Power

Novel computing
Focus Areas and Approaches

• **Materials and Structures**
  - Revolutionary composites and polymers
  - Affordable and sustainable manufacturing
  - Broader supplier base

• **Energy Conversion and Storage**
  - Solar coatings, flexible photovoltaics
  - Advanced batteries and supercapacitors

• **Sensors and Electronics**
  - Broad-band infrared
  - Chem/bio sensors
  - Flexible electronics

• **Modeling and Simulation**
  - Reduce cost, accelerate development
  - Understand results, provide direction
  - Create design tools

• **Harness The Power of Nature**
  - Biomimetics
  - Novel computational approaches and architectures
  - Adaptation and stealth
R&D Coordination and Support

- Materials & Structures
- Sensors & Electronics
- Modeling & Simulation
- Energy
 Structures

- Need: Light weight material that leverages low cost manufacturing processes to bring producible and affordable solutions for complex designs.
- Solution: Best-in-class ultra light weight and affordable structural thermoplastic enhanced with nanoparticles improves
  - mechanical properties
  - thermal stability
  - electrical conductivity
  - processability
Multifunctional Materials

- Carbon nanostructures (CNS) are grown directly (infused) on surfaces in a continuous, in-line, production scalable process for glass, carbon, ceramic, metals.

© 2010 - 2011 Applied NanoStructured Solutions, LLC. All Rights Reserved.
Energy Storage and Efficiency

- Solid-state lithium-ion batteries (high capacity, long life)

- Safety is the #1 issue of liquid-containing lithium-ion batteries. Thermal runaway and solvent leakage limit the potential of lithium technology.

- Rapid self discharge of liquid-containing batteries results in dead batteries within months.

- Solid-state batteries are inherently safer by using nonflammable materials.

- Solid construction reduces self-discharge and is more robust and impact safe.

- Manufacturing processes of all-solid-state batteries are scalable and low cost.

A Safer Battery Is Needed

<table>
<thead>
<tr>
<th>Solvent Leakage</th>
<th>Flammability</th>
<th>Rapid Self Discharge</th>
<th>6 months of storage</th>
<th>12 months of storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>15%</td>
<td>6 months</td>
<td>12 months</td>
<td></td>
</tr>
</tbody>
</table>

Solid Batteries Are More Robust and Impact Safe
Electronics and Sensors

Memory – non-volatile / L2 cache (rad-hard)

Photon sensors (platform flexibility)

FPGAs (reprogrammability)

Complimentary logic (rad-hard, low power)

Environmental sensors

Cabling

Power distribution

Thermal management (efficiency)
Why we do what we do

- Global security
- Geopolitical stability
- Economic prosperity

How

PARTNERSHIP

Discovery > Development > Deployment

INNOVATION