Nanomanufacturing: Realizing the Promise of Nanotechnology for Energy Security

ORNL works to bridge the gap between nanoscale science and the commercialization of innovative products. Examples of energy R&D activities include:

C³'s MIST Nanocoatings Launches Startup Company

C³'s MIST (Metal Infusion Surface Treatment) technology is a low-temperature coating process that infuses a new alloy several hundred nanometers (nm) deep into the surface of a metal to create enhanced durability and extend the service life of equipment. C³ worked with ORNL to use unique processing methodologies and characterization tools, such as X-ray diffraction (XRD) and scanning auger microanalysis (SAM), to understand how the process works and to develop it for industrial applications. By working with ORNL, C³ has moved from a start-up company to an industry leader, with two dedicated plants serving 35 aluminum die-casting companies and a $1M payroll and hundreds of millions of dollars in expected sales.

Rapid Infrared Heating

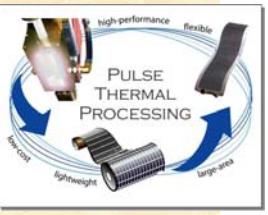
ORNL's revolutionary rapid infrared heating process controls grain refinement at the nanoscale to produce high-performance forgings with superior tensile and fatigue properties. It also decreases energy consumption by a factor of three and reduces heating times by an order of magnitude, while improving yield. In one application, nano-strengthened aluminum has replaced titanium, thus dramatically reducing material costs. ORNL is working with the Forging Industry Association to commercialize this R&D 100 award winning technology. For example, Queen City Forging is using the technology to produce a 1000 components per day, a 4x improvement in production rate. Rapid infrared heating equipment is available commercially through Infrared Heating Technologies, LLC.

Ultra-Hard Nanocomposite Coatings for Tunnel Boring

ORNL has developed scaled melting, powder fabrication, and laser processing techniques that fuse and devitrify Fe-based amorphous powders into ultra-hard nano-composite coatings which are 1.3 to 7 times harder than conventional tool steels. An ORNL-led team developed process techniques to laser fuse the amorphous powders to state-of-the-art disc cutters used in tunnel-boring applications. The nanocomposite coatings were the first coatings of any kind to survive rigorous testing in hard rock simulations and recently, six full-scale coated disc cutters were tested at a project site in Atlanta, Georgia. ORNL is working with Herrneknecht USA and other companies in applying and licensing this technology.

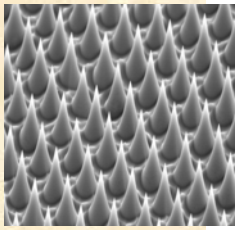
Novel Carbon Materials for Electrical Energy Storage

ORNL has developed a capability to synthesize novel carbon materials with tailored energy-storage performance to serve as electrodes in electrochemical capacitors (supercapacitors). Carbon materials with controllable, nanoscale pore size can now be produced by self-assembly using conventional manufacturing processes. The new materials have competitive energy and power densities relative to commercial activated carbon materials. ORNL is working with industrial collaborators to develop materials and devices that are expected to impact electrical grid, distributed energy, and transportation applications.



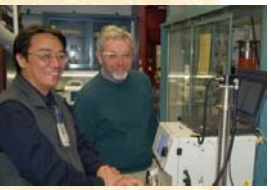
Pulse Thermal Processing (PTP) of Microelectronics

ORNL has developed a unique high-density plasma arc-based pulse thermal processing technology for rapid thermal annealing of thin-film light-emitting diodes and thin-film and nano-particle photovoltaic (PV) materials. This process has the potential to significantly increase PV collection efficiency and LED electrical properties while increasing production rates and decreasing production costs. The unique characteristics of this technology (high heating rates, short processing time and large processing area) will enable high-performance microelectronics that are lightweight, flexible, and low cost. ORNL is working with a multitude of companies that are on the leading edge of their respective technologies to make an impact on energy efficient microelectronics such as PV, LED, thin-film transistors (TFT), and thin-film batteries.



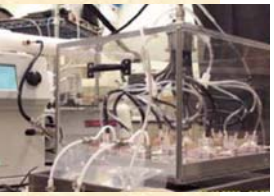
Superhydrophobic Materials

ORNL has developed the capability to produce macroscopic objects having nanoscale features that impart superhydrophobicity. There are a number of everyday and advanced uses for these ultra-waterproof materials, including energy-efficient applications for drag reduction and enhanced heat transfer, novel sensors, and biomedical applications. Several patents have been filed, and ORNL is actively pursuing commercialization with multiple companies.



Nanocharacterization Tools

ORNL has developed a technology that uses a commercial differential mobility analyzer to sample and characterize in real time the nanoparticles produced in gas-phase processes. Demonstrations have been performed on processes for production of metal-oxide particles and carbon nanomaterials. This innovation impacts process improvement and responsible nanomanufacturing by allowing scientific instruments to work in an industrial setting to measure nanoparticles both in process and in the workplace environment. The system was recently tested at a plasma arc reactor at Luna nanoWorks.



Responsible Nanomanufacturing

ORNL is active in developing knowledge and capabilities on health and environmental impacts of nanomaterials. The ability to deliver well-characterized nanoparticles in singlets and controlled aggregate states has been developed to facilitate ongoing research in biological impacts of nanoparticles. Unique exposure techniques combined with nose-only inhalation exposure are being applied to investigate biological responses at cellular and physiologic levels.

Seamless transition:

Scientific discovery to **technology innovation** to **energy applications**

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