Breaking the fire cycle

A soldier's clothing can provide a last line of defense against fire and heat, but measures to increase the flame resistance (FR) of clothing often weigh them down with coatings or simply retard flame without insulating against heat. **ResQ FR Fabrics** from **Milliken & Co.**, Spartanburg, S.C., reduce body burn by as much as 50% through a mechanism that breaks the "Fire Cycle"—fuel, oxygen, and heat. If any one of these components is removed from the fire system, the chain reaction stops and the fire goes out.

ResQ works by combining charring and the use of inherently FR fibers. The cotton component of the fabric is treated with a proprietary phosphorous-based FR that promotes charring. When the cotton chars, the outside of the cotton is converted to a heat-stable char that insulates the cotton from external heat and prevents the cotton surface from producing more fuel. Use of approximately 30% meta-aramid, a temperature-stable fiber that resists breakdown, denies fire a fuel source. ResQ's twill and yarn construction traps air in the fabric, which increases the insulation value of the fabric.

▶ **Milliken & Co.**, www.milliken.com

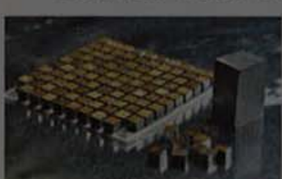
Nanoscale-engineered cermets

Thermal sprayed coating techniques involve melting or heating materials and spraying them onto a surface. The coating precursor, or feedstock, is heated or melted by electrical (plasma or arc) or chemical (combustion flame) sources, accelerated to the substrate direction, and finally flattened onto the substrate forming a coating with a fine microstructure. These coatings are effective in increasing component life and value and decreasing machinery downtime.

MesoCoat Inc. and **Powdermet Inc.**, both of Euclid, Ohio, have improved on this technology by engineering their **PComP Nanocomposite Cermet Coatings** down to the nanoscale to form a hierarchical structure. Formed from particulate composite powders (PComP) containing both ceramics and metals (cermet), the coatings are up to 70% lighter than commercially available tungsten carbide coatings, and up to 40% lighter than electrolytic hard chrome coatings (EHC), due to the use of light and low-cost hard particle-based reinforcements. Like other cermet coatings, PComP can be applied quickly, and can be machined to tight tolerances. Applied thermally, PComP is available in a number of formulations, ranging from high-toughness tungsten-carbide-cobalt to low-density corrosion-resistant silicon-nitride-based coatings.

▶ **MesoCoat Inc.**, www.mesocoat.com

Lower-cost thermoelectrics



Thermolectric modules (TEM) are able to convert heat into electricity, or vice versa, and have been successfully used in machinery ranging from refrigerators to spacecraft. The performance has been useful, but TEMs have been, in general, too costly for widespread use.

With its new **TEMM Thermoelectric material and module technology**, the **Industrial Technology Research Institute**, Chutung, Taiwan, has designed a thermoelectric solution with a high conversion efficiency and a low price per watt. A typical TEM relies on the ability of its constructed material to achieve a high ZT, or figure of merit for energy conversion. For its TEMM product, the ITRI project team designed a theoretical composite material made from micrometer- and nanometer-grade grains. Melt spinning was applied to actual production of the material. When high thermal stress threatened structural stability for prolonged operation, the team designed a gradient architecture for the module bulk body. A specially designed bonding structure, built with a solid-liquid diffusion bonding technique, successfully handles changing thermal stress across junctions. This inter-metallic compound provides a higher melting point, which improves thermal resilience and conversion efficiency of the module.

▶ **Industrial Technology Research Institute**, www.itri.org.tw

Graphene enhances lithium-ion batteries

Traditional rechargeable, lithium-ion cells are comprised of two electrodes soaked in a nonaqueous electrolyte and isolated from one another by an electrically insulating separator. This allows ions to flow between the two electrode compartments, but prevents shorting of the cell. To achieve higher energy density, the concentration of lithium-active species stored in the battery electrodes—which determines the battery's capacity—needs to increase significantly.

Graphene, the strongest and most conductive material known to science, has recently been tapped to provide this capability. Using a method for manufacturing functionalized graphene at a commercial scale—patented by Aksay Labs at **Princeton University**, Princeton, N.J.—**Vorbeck Materials**, Jessup, Md., was founded in 2006 to develop graphene-based products. Led by researchers at **Pacific Northwest National Laboratory**, Richland, Wash., the collaborators have recently completed development of **Graphene Nanostructures for Lithium Batteries**.

Simple solution methods have been designed to prepare atomic-scale, 2D honeycomb lattices of high-capacity electrode materials and graphene. These ultrafine composites can further assemble into much larger particles that retain the intimate mixing. These larger particles/powders are in the size range currently used in commercial battery manufacturing equipment, thus facilitating rapid adoption. When used as electrodes in lithium-ion cells, these nanometer-scale composites show increased battery capacity, improved charge-discharge rates, shorter recharge time, and longer cycle life.

▶ **Pacific Northwest National Laboratory**, www.pnl.gov