

New uses for Nano-crystalline Nickel

Ultra-fine grain size key to new applications for nickel in the defense industry and in consumer sporting goods.

Thanks to ongoing developments in nano-technology research, nickel may one day compete with other materials in lightweight applications such as aerospace components, sporting goods and armour systems for defense.

A Canadian nano-technology company, Integran Technologies, has developed a relatively low-cost electro-forming process that can manufacture a variety of nano-crystalline forms, such as plates and strips, with a higher strength-to-weight ratio than some of the strongest lightweight alloys made of titanium and aluminum.

For example, the company's nickel-iron (50% nickel) armour plating is 2.5 times tougher than the required specifications for U.S. military vehicles, whereas its body armour is seven times stronger than that currently worn by soldiers and police. This increase in strength is accompanied by a decrease in weight.

Integran has partnered with the U.S. Department of Defense to design new products based on these properties.

On the consumer front, potential applications include lightweight helmets that use nano-metal foam technology, lightweight coatings to add stiffness to tennis rackets and golf clubs, and corrosion-resistant, durable edges for skates, skis and snowboards.

The key to the technology is a single-step process that produces nano-materials with a grain size a thousand times smaller than conventional alloys without sacrificing ductility. The tiny grain size makes the metal stronger and more resistant to wear.

Although first tested in the lab in the early 1980s, it was another decade before the technology found commercial applications.

The breakthrough occurred in the 1990s, when Ontario Hydro, a government-owned power company in Canada, was seeking an *in-situ* repair technology for the degraded tubes in its nuclear steam generator. Although nickel seemed like the ideal choice, because of its resistance to corrosion and stress corrosion cracking in nuclear reactors, its use was limited by poor mechanical strength.



POTENTIAL FUTURE USES of nano-crystalline nickel include corrosion-resistant, durable edges for sporting goods such as skates, skis and snowboards.

Nano-crystalline nickel saved the day, as it is four times stronger than conventional nickel while retaining all of the metal's other attributes. The resulting nano-crystalline "electro-sleeves" were fitted over the original tubes to provide resistance to pitting, denting, cracking and other forms of degradation. They remain intact today.

More recently, Integran has been working on bringing other applications to market. The versatility of the company's process allows for a wide range of product forms including powders, foams and complex net-shape components.

"The electro-sleeve process remains one of the first-ever large-scale applications for nano-structured materials," says Gino Palumbo, Integran's president and CEO. "But we're still only scratching the surface in terms of applications for nano-nickel products. Our main limitation in promoting our technology in the nickel community has been in identifying the areas where our materials can best be of benefit."

Recent breakthroughs in nano-crystalline nickel have included its use in a nickel-iron coating with superior magnetic properties and as an environmentally benign substitute for nickel-beryllium alloys with better strength, resilience and electrical conductivity. Equally valuable are nano-structured analogs of nickel-iron alloys with low thermal expansion coefficient, such as those used in the shadow masks of televisions and computer monitors.

Palumbo also sees a future for nano-crystalline nickel-iron alloys in the manufacture of micro-electro-mechanical devices by electro-deposition. The current electro-deposits fall short on reliability because of their unpredictable properties. Electro-deposited bulk nano-structures promise to overcome this challenge by providing a uniform fine-grain structure throughout the device.



A RELATIVELY LOW-COST electroforming process has been developed to manufacture nano-crystalline nickel plates and strips.

MORE INFO: www.nickelmagazine.org/0704/7.htm