Scientists discover networks of metal nanoparticles are culprits in alloy corrosion

August 4 2008

Oxide scales are supposed to protect alloys from extensive corrosion, but scientists at U.S. Department of Energy's Argonne National Laboratory have discovered metal nanoparticle chinks in this armor.

Oxide scales develop on the outer surface of alloys at high temperatures creating a protective barrier that keeps destructive carbon-bearing molecules from slipping into the alloy. The diffusion of carbon into oxide scales should be negligible, but studies have shown that carbon can sneak through the oxide line of defense leading to brittleness and corrosion.

"The United States loses four percent of the gross national product due to alloy corrosion," Argonne Distinguished Fellow Ken Natesan said. "A network of continuous metal nanoparticles allow the carbon to dissolve and diffuse through the protective oxide scales without the need of a crack or a pore."

It was commonly believed that carbon-containing molecules escaped into cracks or pores in the oxide scales, but using three separate techniques -- nanobeam x-ray analysis at the Advanced Photon Source, magnetic force microscopy at the Center for Nanoscale Materials and scanning electron microscopy at the Electron Microscopy Center -- Natesan, along with Argonne scientists Zuotao Zeng, Seth Darling and Zhonghou Cai, discovered networks of iron and nickel nanoparticles embedded within the oxide scales.

Carbon can easily diffuse through the metals and create a path for carbon atom transport which does not involve defects in the scale.

"By examining the oxide scale, we find the metal nanoparticles," Zeng said. "If they are eliminated we can create a more corrosion-resistant and longer lasting alloy."

Based on the study, ANL has developed laboratory size batches of materials that exhibit as much as ten times longer life than commercial alloys with similar chromium contents, Natesan said. At present, 50-lb batches of the alloys have been cast successfully by an alloy manufacturer and will be commercialized in due course. The ANL-developed alloys are of considerable interest to the chemical, petrochemical, and refining industry.

The findings might also have broad influence on not only metal dusting and carburization, but also in other research areas such as alloy development and surface coatings for high-temperature fuel cell applications.

A paper based on this work has been published recently in *Nature Materials*.

Source: Argonne National Laboratory

Citation: Scientists discover networks of metal nanoparticles are culprits in alloy corrosion (2008, August 4) retrieved 24 April 2024 from https://phys.org/news/2008-08-scientists-networks-metal-nanoparticles-culprits.html