match to the NTSC-recommended blue. In the mean time, the researchers believe that they have found a material with a blue emission already suited for many other video display applications.

PAMELA JOHNSON

### Dislocations in Copper Observed to Form Preferentially at Twin Grain Boundaries

A team of scientists from the University of Idaho, Washington State University, and the Idaho National Engineering and Environmental Laboratory (INEEL) has discovered that dislocations in metals tend to form at twin grain boundaries. The research team further reported that while grain size determines at what stress level a material begins to deform, it has little effect on the ultimate strength a material can attain through deformation processing.

As published in the June issue of *Acta Materialia*, the researchers created copper samples with a range of crystal sizes by first straining the samples to create a high density of imperfections, and then heat-treating the metal at different furnace temperatures. Different grain sizes developed during recrystallization, depending on both the temperature and the number of imperfections in the original material. The team then tensile tested the material—stretching it at room temperature and monitoring the load generated by the applied strain. Using high-magnification microscopy, they periodically analyzed the deformed microstructure of each sample for clues to the formation of dislocations, dislocation density, and dislocation behavior.

"This is a basic mechanism of dislocation behavior not previously reported," said John Flinn, adjunct professor with the University of Idaho and retired INEEL researcher.

This observation is a departure from conventionally accepted materials-science theory stating that dislocations can form within the crystal grain itself or at any grain boundary—not just primarily at twin grain boundaries. This is the crux of understanding the role grain size plays in material strength, the researchers said.

By observing when and where dislocations develop, the research team documented that grain size plays a role only when plastic deformation begins. Materials with very small grain size can remain elastic longer than materials with larger grain size, and it takes more strain and higher stress to cause dislocations to develop. However, after dislocations have developed, grain size makes little difference. The increasing resistance to further deformation (strengthening) as a function of strain once plastic deformation was initiated was the same for materials of all grain sizes. The team analyzed samples with grain sizes ranging from 3 μm to 60 μm and found that strain-hardening from plastic deformation was completely independent of grain size.

"Once you exceed the elastic limit of a material, the deformation behavior of the metal and improvements in mechanical strength from hardening is controlled by the interaction of one dislocation with another and not through interactions with grain boundaries," said INEEL scientist Tom Lillo.

For this research, the team initially strained the copper samples to induce a very high density and uniform distribution of imperfections before heat treatment. The combination of a high number of imperfections and low heat treatment temperatures enabled the researchers to create a range of grain sizes for experimentation. Using the technique called equal channel angular extrusion (ECAE), metal was extruded through a die with an internal 90° corner, rotated, and re-extruded. ECAE was much more effective in creating a high density of twin grain boundaries during heat treatment and subsequent recrystallization than the traditional cold-rolling. With ECAE, the research team achieved a density of almost 50% twin grain boundaries.

Flinn said, "The challenge now will be learning how to use this knowledge to design new high-strength, light-weight alloys." Such knowledge, Flinn said, will also help researchers to develop techniques for fabricating metals into various geometric forms for industrial utilization.

### Silicone Polymer Scaffolds Facilitate the Growth of Lifelike Cardiac Tissue

Researchers at the University of Illinois at Chicago (UIC) and Loyola University Medical Center have grown lifelike cardiac tissue for possible use in the scaffolding and repair of damaged heart cells. The researchers first built scaffolds made from silicone polymers, which enabled them to study the grooves, pegs, and bumps of heart tissue. They were also able to mechanically manipulate the surface of the scaffolds to mimic the pumping of heart cells.

In the final phase of the project, the researchers attached heart cells firmly to the silicone surfaces of the scaffolds so that the mechanical activity could be mimicked in the laboratory. Luke Hanley, associate professor of chemistry and bioengineering at UIC, applied a rf discharge plasma to form hydroxy groups on the surface, followed by wet chemical reactions with amine-terminated silanes and maleimide cross-linkers to link polypeptides to the silicone surfaces, fusing the cells to facilitate growth into healthy tissue.

Brenda Russell, professor of physiology and biophysics at the UIC College of Medicine, said, "The cells... migrated, found a micro projection, or a peg, and attached to it. More than 90% of the cells attached to a peg and stayed attached when mechanically pulsed." She explained that this is mainly due to the vertical topography, not the material itself. However, Russell said that the polypeptides are also enhancing the cell binding to the surface, presumably by activation of integrin-based cell adhesion mechanisms.

### Silane Shown to Adhere to Phosphate Glass Surface

Sodium aluminophosphate glasses, doped with rare-earth elements such as erbium and ytterbium, are used in optical and photonic systems as laser sources and as waveguide amplifiers. In order to combine glass with another material to create a composite, an intermediary polymer coupling agent can be used, typically the silane aminopropyltrethoxysilane (APS). At the 19th International Congress on Glass, Amy Barnes, a graduate student at The Pennsylvania State University, reported, "We have shown that we can get silane to adhere to phosphate glass surfaces. The coating can protect the surface, minimizing corrosion, or can be a mediator between the glass and a polymer." The conference was sponsored by the Society for Glass Technology in Edinburgh, Scotland, in the beginning of July.

The researchers at Penn State studied the phosphate glass without the rare-earth elements to see how the silane adhered to the surface of the phosphate glass. The glass was dipped in APS and rinsed to remove loosely bound molecules. The researchers found that the silane forms a single or multiple molecular layers on the glass surface. The acidity of the silane solution affects the coverage of the surface differently than on traditional silicate glasses. The researchers said that the stability of the bond that forms may be different if the surface corrodes during coating.

For silicates, the maximum amount of adsorbed silane is reported to occur when the solution pH is near the natural pH of the molecule (pH of 10.5). In contrast, the maximum amount of adsorbed silane on the multicomponent phosphate glass occurred at a solution pH ~7 and decreased with both increasing and decreas-