Researchers find ordered atoms in glass materials

October 2 2012

Matthew Kramer, scientist at the US Department of Energy's Ames Laboratory, examines data produced by transmission electron microscopy. Kramer and his team have been able to show the underlying order in metallic glasses. Credit: Ames Lab

(Phys.org)—Scientists at Ames Laboratory have discovered the underlying order in metallic glasses, which may hold the key to the ability to create new high-tech alloys with specific properties.

Glass materials may have a far less randomly arranged structure than formerly thought.

Over the years, the ideas of how metallic glasses form have been evolving, from just a random packing, to very small ordered clusters, to realizing that longer range chemical and topological order exists.

But by studying the structure of a metallic glass alloy formed at varying cooling rates, Matthew Kramer and his team of fellow scientists at the Ames Laboratory have been able to show there is some organization to these structures. These findings were recently published in *Scientific Reports*, and in a second paper in Physical Review Letters with Paul Voyles' team from University of Madison, Wisc.

"This has been one of those burning questions in material science for a while, how to describe these disordered systems. Our studies are showing this underlying structure. It's diffuse, but it's there. It's been suspected for a long time and even the general structures have been postulated, but to what degree and how to quantify them, that has been the trick," Kramer said.

Kramer's team of scientists used melt spinning to form the alloy samples, a technique that supercools liquids by ejecting it in a stream onto a rapidly spinning copper wheel. These high cooling rates allows the liquid to form a non-crystalline alloy, or metallic glass.

"It's not only the chemistry of that metal that's important. In many cases, how you get it to the solid state, how it solidifies is also a critical factor," said Kramer.

Data was gathered using a high energy X-ray beam at the Advanced Photon Source at Argonne National Laboratory, atom probe chemical analysis, and computational modeling.

The researchers found there are local configurations of the atoms that tend toward a more ordered structure compared to looking at the whole structure. Kramer compared it to design elements in a complex wallpaper style.

"You'll see a little individual design in that wallpaper, and it has a bit of intricacy. That smaller, complex design, you'll see it repeated throughout the wallpaper. In crystallography we call that a motif. A crystalline solid has those motifs in a very ordered array. In the liquid structure, these motifs are still present, but are shuffled around a bit. They're not marching in rows anymore."

Kramer said in liquids these motifs, while not well organized in repeating patterns like crystalline structures, do tend to fall into discrete distances from each other within a certain range.

Not only that, they begin to organize themselves into interconnected networks, similar to the polymeric chains seen in silicate glass and polymers.

"It's these interconnected networks and the degree to which they develop, which probably controls the ability to go from a liquid state to a glassy state with a metal," said Kramer.

Understanding exactly how these metallic glasses form is the key to being able to manipulate their structure for development of new alloys.

"Developing new materials has largely been an Edisonian process. People guess at some interesting alloy compositions, they do some sort of casting, and they look and see what they get. We're trying to get at the challenge in looking for new materials in a different way," Kramer explained. "What might the arrangement of atoms need to be in order to provide the properties we want? Can you actually in fact create these novel structures? By understanding these fundamental building blocks and arranging them in new ways, can we create materials with new or different properties? These are the questions we want to answer."

Provided by DOE/Ames Laboratory

Citation: Researchers find ordered atoms in glass materials (2012, October 2) retrieved 9 April 2024 from https://phys.org/news/2012-10-atoms-glass-materials.html