New experiment opens window on glasses

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Metallic glass - shiny, easy to mould and with a high strength-to-weight ratio.

(Phys.org) —For the first time, scientists have mapped the structure of a metallic glass on the atomic scale, bringing them closer to understanding where the liquid ends and the solid begins in glassy materials.

A study led by Monash University researchers and published in *Physical Review Letters* has used a newly developed technique on one of the world's highest-resolution electron microscopes to understand the structure of a zirconium (Zr)-based metallic glass. The findings could help explain the mystery of why glasses, or disordered solids form.

At the liquid-glass transition, the melt doesn't become solid at a distinct point, but becomes gradually more viscous until it is rigid. When crystalline solids - such as graphite, salt and diamonds - form they become abruptly rigid as the atoms form a regular, periodic arrangement. Glass never develops into an ordered atomic arrangement,but seems to retain the disordered structure of the liquid, despite its solidity.

This disordered structure gives glasses unique properties. Metallic glasses have a higher strength-to-weight ratio than aluminium and titanium alloys and are extremely promising structural materials with unique applications as biomaterials and microelectromechanical systems.

Led by Dr Amelia Liu from Monash University's School of Physics and the Monash Centre for Electron Microscopy, the researchers found that the structure of this Zr-based glass was not random, but composed in large part by efficiently arranged 13-atom icosohedral clusters.

Icosahedra have 20 faces, 12 vertices and 12 axes of five-fold symmetry, which means they cannot be packed into an ordered three dimensional, crystalline structure.

"It has long been theorised that icosahedra were a key atomic motif in the structure of metallic glasses and could, in fact, underlie glass formation. We have provided the first experimental confirmation of this," Dr Liu said.

"Our findings also point the way towards understanding the glass transition from liquid to solid – a grand challenge in modern condensed matter physics."

The researchers - from Monash, the University of Melbourne, the Australian Synchrotron, Ames Laboratory and Iowa State University in the US – developed a new electron scattering technique. By analysing the diffraction patterns from nano-scale volumes in the glass, they were able to identify symmetries in individual atomic clusters in the Zr-glass. Previous techniques had not provided sufficient detail to do this.

Dr Liu said that the new technique can now be used to understand the structure of other glasses and help progress the study of disordered materials.

Provided by Monash University

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