Shape-Shifters at Cal Tech Work at Perfecting Metallic Glass

alchemy n. *A process by which paradoxical results are achieved or incompatible elements combined with no obvious rational explanation; a power or process of transforming something common into something special.*
—Webster's New World Dictionary

There are no alchemists at the California Institute of Technology, but a team of research scientists at the Pasadena-based institution is doing some pretty remarkable things "transforming something common into something special."

Cal Tech researchers have developed a proprietary process—rapid discharge forming—by which metal alloys are fashioned into solid—very solid—shapes—but with the same ease and net-shape accuracy as injection-plastic molding—and—with the value-added feature of much greater strength. Or, "stronger than titanium," as one published claim has it. The material is known as "glassimetal"—a metallic glass actually invented more than a half-century ago at Cal Tech.

"Metallic glasses are materials with striking properties," says Dr. A. Lindsay Greer, a professor of materials science at the University of Cambridge in the May 13 issue of *Science*. "They are quite hard, but also rather formable like plastics—an attractive combination."

The Cal Tech team is headed up by research scientists Dr. William L. Johnson and Marios D. Demetriou, and they have launched a company—Glassimetal Technology—along with an engineering and prototype demonstration center in Pasadena.

Make no mistake—this process is still in development and, short term, its use in real-world applications will be necessarily limited. Cost, more than anything, will initially restrict widespread application use. But think of the possibilities—some niche applications already exist for metallic glass for small structural components for aircraft, or casings for such things as laptops, watches, etc.

The team's paper, "Beating Crystallization in Glass-Forming Metals by Millisecond Heating and Processing," explains the proprietary process by which they were able to surmount the intense heat/rapid speed requirement that had long been a detriment to advancing application use of metallic glass.

(courtesy Glassimetal Technology).

In a June 4 *New York Times* article by Anne Eisenberg, Johnson declares:

"We've taken the economics of plastic manufacturing and applied it to a metal with superior engineering properties. We end up with inexpensive, high-performance, precision net-shape parts made in the same way plastic parts are made—but made of a metal that's 20 times stronger and stiffer than plastic."

But Greer nevertheless cautions in the same article that metallic glasses like the zirconium-based mix used by Johnson might be less than is practically cost-effective.

"Because the alloys are expensive, these materials will probably be used mainly in niche applications where the benefits of the properties give you sufficiently better performance to justify the expense," Greer says, adding that the patented manufacturing method Johnson has developed might one day soon be affordable enough to offset the expense of raw materials.

He also expresses wonder at Johnson and his team's ability to "demonstrate extremely uniform temperatures throughout the material" in a controllable process that could ultimately have a significant impact on materials processing and manufacturing in general.

The "eureka!" in Johnson's method is that his process overcomes the long-existing drawback of metallic glasses—rapid crystallization when heated and the equally rapid, subsequent loss of the microstructure that provides their strength. According to the *Times* article, Johnson's entire process of shaping and cooling "takes only hundredths of a second—so fast that the material turns viscous and can be molded without crystallization."

As things stand, and has already been stipulated, applications for metallic glass over plastic and or powdered metal, for example, are necessarily limited due to cost. But consider: the number of people who could afford the first Winchester rifles, automobiles, personal computers, flat screen televisions, CD players, etc., etc., was by in large limited to the relatively wealthy. But American knowhow—in the form of industrial automation, for instance—soon made those products affordable for most everyone.

And if the same holds true for metallic glass, its use in common applications—gears, bearings and actuators—to name a few, could be a real game changer. It will all boil down to the "value added" paradigm. That is, at some point the "value" benefit will have to equal or surpass the "added" component of the equation.

If past American wizardry is prologue, don't bet against it. For more information: *wlj@caltech.edu.*