Making microscopic machines using metallic glass

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Researchers in Ireland have developed a new technology using materials called bulk metallic glasses to produce high-precision molds for making tiny plastic components. The components, with detailed microscopically patterned surfaces could be used in the next generation of computer memory devices and microscale testing kits and chemical reactors.

In their article published in the latest edition of the open access journal *Materials Today*, Michael Gilchrist, David Browne and colleagues at University College Dublin explain how bulk metallic glasses (BMGs) were discovered about thirty years ago. These materials are a type of metal alloy, but instead of having a regular, crystalline structure like an everyday metal such as iron or an alloy like bronze, the material's atoms are arranged haphazardly. This disordered, or amorphous atomic structure is similar to the amorphous structure of the silicon and oxygen atoms in the glass we use for windows and drinking vessels.

The haphazard arrangement of atoms in BMGs means that they have some very different mechanical properties from conventional metals. They can be heated and molded like plastics and they can be machined with microscopic precision below the grain size of conventional metals. BMGs also retain the strength and durability of normal metals.

Gilchrist and his colleagues have now exploited the haphazard nature of the atoms in BMGs to allow them to machine microscopic features on to the surface of a BMG. This is not possible with conventional metals such as tool steel used in molds which cannot typically be machined with better than 10 micrometer precision because of its crystalline grain structure. They have then used the resulting strong and durable metallic devices to carry out injection molding of plastic components with microscopic surface patterns using a straightforward tool production route.

"Our technology is a new process for mass producing high-value polymer components, on the micrometer and nanometer-scale," explains Gilchrist. "This is a process by which high-volume quantities of plastic components can be mass produced with one hundred times more precision, for costs that are at least ten times cheaper than currently possible."

The research team explains that with BMG injection molding equipment it is now possible to create millimeter-sized polymer components that have surface features of a similar size to mammalian cells at 10 micrometers or even the smallest viruses at less than 100 nanometers. The new manufacturing process could thus allow 'lab-on-a-chip' devices to be constructed that could handle and test samples containing single cells and viruses or large biomolecules including DNA and proteins.

"These precision plastic parts are the high value components of microfluidic devices, lab-on-chip diagnostic devices, micro implantable components and MEMS sensors," Gilchrist adds.

Once the technology is extended to the tens of nanometers length scale, the team suggests that it could be used to make high-volume, low-cost, information storage systems. The team is currently optimizing their technology with this goal in mind.

The research team concludes, "The worldwide trend of miniaturization means that these devices and components are getting progressively smaller and smaller; the problem faced by today's technologies is that they will soon be unable to manufacture at these smaller dimensions at competitive prices. If you just consider the microfluidic devices market without the biological content: this is forecast to reach $5 billion by 2016."

More information: This article is "Towards nano injection molding" by Nan Zhang, Cormac J. Byrne, David J. Browne, and Michael D. Gilchrist. It appears in *Materials Today*, Volume 15, Issue 5, Page 216 (2012)

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