Fabrication of miniature parts and molds from bulk metallic glass

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**Description:**
Advances in the precision net-shaping, micromolding, and fabrication of high-aspect-ratio metal structures have greatly expanded the range of applications for micro-electromechanical and nanoelectromechanical systems (MEMS and NEMS). Bulk metallic glasses (BMGs) have unique properties that make them ideal for micro- and nano-structure applications. However, they have been limited by the types of master molds available. Yale University researchers and their collaborators at the University of California have developed a system to fabricate precise molds and microparts from bulk metallic glasses (BMGs) using low cost carbon molds (BMG*CMEMS). Unlike silicon or polymer molds, these carbon molds are stable at the high temperatures which required for the thermoplastic forming (TPF) of BMGs.

**Field of Application:** Applications include the use of BMG parts and molds in MEMS, NEMS, precision tools, watch movement components, surface patterning, nanoimprinting, and data storage. Additionally, many BMGs are biocompatible, so this technology can be used in biomedical implants.

**Advantages:** The unique properties of BMGs confer a number of advantages. They exhibit high strength, large elastic strain limit, and high corrosion resistance owing to their amorphous nature. They are isotropic, homogenous, and free from any crystalline defects down to atomic scales. Surface roughness is not dependent on mold finish, since it can be reduced by heating. Thus, BMG parts and molds produced by TPF are much superior in mechanical, chemical, and surface properties compared to metallic parts produced by LIGA (Lithography, Electroplating and Molding), an existing fabrication technology for producing high-aspect-ratio microstructures. In addition, the process described here using carbon molds contains important advantages over LIGA in terms of cost, complexity, and versatility. The electroplating step in LIGA is complex and limits material selection. Additional drawbacks of LIGA which are not a factor with BMG*CMEMS are limited geometric complexity, inconsistent pattern transfer, and residual stresses.

**Stage of Development:** Low cost carbon templates have been developed that are stable at high temperatures and have sufficient mechanical strength. These have been used as master molds to produce high quality BMG parts. The BMG parts can be as a final product or as a further mold for other materials.

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**Publications:**

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