Method for Imprinting and Erasing Amorphous Metal Alloys

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Description:

Imprint lithography, based on the mechanical embossing of a polymer, can achieve pattern resolutions beyond the limitations set by the light diffractions or beam scattering in other techniques. Conventional imprint lithography is limited by mold materials. Silicon molds are brittle and fail after roughly 100 uses. Metal molds are hindered by their grain structure, which places a lower limit of approximately 10 micrometers on feature size. Bulk metallic glasses (BMG) are robust, noncrystalline materials that can be patterned as finely as silicon and are strong enough to withstand millions of imprints. Yale researchers have developed novel nanomolding processes with BMG, employing the materials in both lithographic imprinting and direct molding for simple, high throughput replication of nanopatterns in polymers and other BMG.
Advantages: The unique properties of BMG confer a number of advantages. They have high strength, hardness, and corrosion resistance, making them an ideal material for imprint lithography. The amorphous structure theoretically allows for patterning of details the size of a single atom. The thermal conductivity of BMGs (7 W/m K) is significantly larger than that of polymers (0.2 W/m K), greatly reducing thermal cycle time in parallel imprinting processes. The wide range of BMG softening temperatures (128°C - 637°C) makes it possible to replicate molds with different alloys, effectively extending the lifetime of the original. Finally, the low viscosity in the supercooled liquid region enables the erasing of features using just surface tension, a significant development for re-writable data storage and mold repair.

Value Proposition: In one embodiment, this technology will lead to distinct advancements in high density data (HDD) storage. The grid size reduction from CD media (0.83µm) to DVD media (0.4µm) allows 7-fold increase in data storage capacity. BMG disks have potential to scale down the grid size to below 50nm, yielding 300GB capacity disk media (64x larger than DVD). For HDD storage, including rewriteable data storage and non-volatile memory.

Other Fields of Application:
- Large Area Low Cost Nano- Patterning.
- High aspect ratio pattern generation, such as production of lithography molds for LIGA x-ray lithography and hard-drive head fabrication.
- Microimprint and nanoimprint lithography for displays.
- Integrated anti-counterfeiting; Holograms; Structural color.
- High aspect ratio nano-molds for molds.
- Metallic microfluidic devices.
- Biocompatible medical implants with patterned surfaces for controlled cellular responses.

Stage of Development: The following have been demonstrated with BMG: replication of complex 3D structures; production of features as small as 13 nm; flawless release from patterned substrates; high thermal stability; fast time response; and robustness against tear and wear.

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Publications:

Licensing Contact: Richard Andersson
richard.andersson@yale.edu