Flexible Nanoimprint Template from Amorphous Metals

Xinglong Huang, Xin Zhuang, Ye Tian, Youwei Jiang, Bingqing Luo and Xing Cheng
Department of Materials Science and Engineering, Southern University of Science and Technology, Shenzhen, Guangdong, China 518055
chengx@sustc.edu.cn

Nanoimpirnt lithography (NIL) has emerged as one of the most promising next-generation lithography techniques with ultra-high resolution and high throughput [1]. Amorphous metals show promising potentials in NIL template fabrication due to their excellent mechanical properties, such as high strength and hardness, high wear and corrosion resistance, very low surface roughness and so on. Although bulk metallic glasses were studied in nanomoulding due to their excellent formability above glass transition temperature [2], there exists few report on flexible nanoimprint templates based on amorphous metals.

In this work we successfully fabricated flexible nanoimprint template using Zr-based amorphous metals. The detailed fabrication process is shown in Fig. 1. Firstly, one micron thick amorphous metal film was sputtered onto a patterned polycarbonate (PC) sheet with $Zr_{55}Cu_{30}Ni_{5}Al_{10}$ target [3]. The PC sheet was patterned by thermal nanoimprint with a silicon template fabricated by conventional microelectronic processing approaches. Then a layer of 100 nm Ni film was sputtered on top of the amorphous metal layer, and it was used as the seed layer for nickel eletroplating. Finally, the flexible nanoimprint template, consisting of the nickel and amorphous metal stack, was successfully released after the PC sheet was peeled off (Fig. 2). We demonstrated the nanoimprinting of another PC thin film using the amorphous metal template (Fig. 3). The XRD spectrum of the amorphous metal film indicates there is no crystalline phase (Fig. 4a) in the thin film, and the atomic-force microscope image of the template surface shows that the surface roughness is very low (R_a=0.386nm) (Fig. 4).

Since the surface roughness of the amorphous metal film is significantly lower than that of an electroplated nickel film, which is typically in the range of a few nanometers, flexible nanoimprint templates from amorphous metals have the potential in achieving roll-to-roll nanoimprint with sub-20 nm resolution. With their better mechanical strength and chemical resistance, flexible templates from amorphous metals may play an important role in commercial applications of nanoimprint technology.

References:

[1] Chou S Y, Krauss P R, Zhang W, Guo L, and Zhuang L, Sub-10 nm imprint lithography and applications. Journal of Vacuum Science and Technology B: Microelectronics and Nanometer Structures, 1997. 15(6): p. 2897-2904.
[2] Kumar, G., et al. (2009). "Nanomoulding with amorphous metals." Nature 457(7231): 868-872.
[3] Liu, Y. H., et al. (2012). "Deposition of multicomponent metallic glass films by single-target magnetron sputtering." Intermetallics 21(1): 105-114.

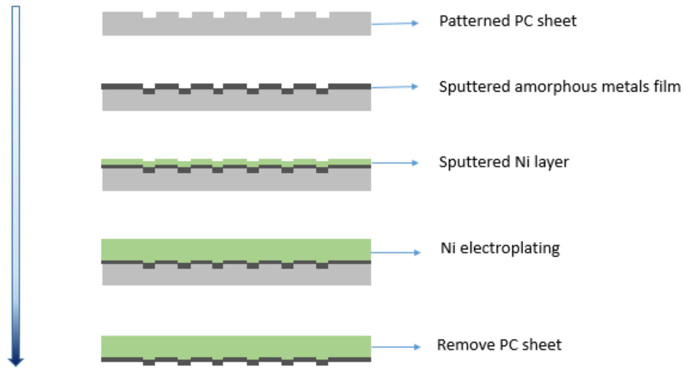

Figure 1. The schematic of the fabrication process for flexible nanoimprint template based on amorphous metals.

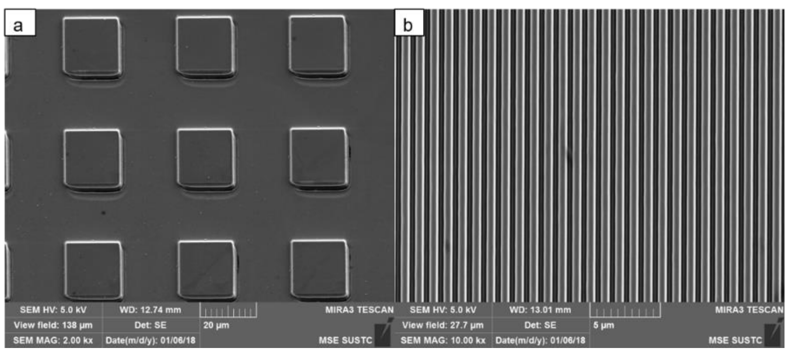

Figure 2. The SEM images of the amorphous metal templates: (a) 20μm square pillars. (b) 600nm gratings.

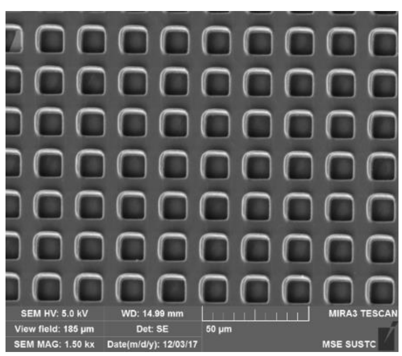

Figure 3. The SEM image of a PC sheet imprinted by the amorphous metals template.

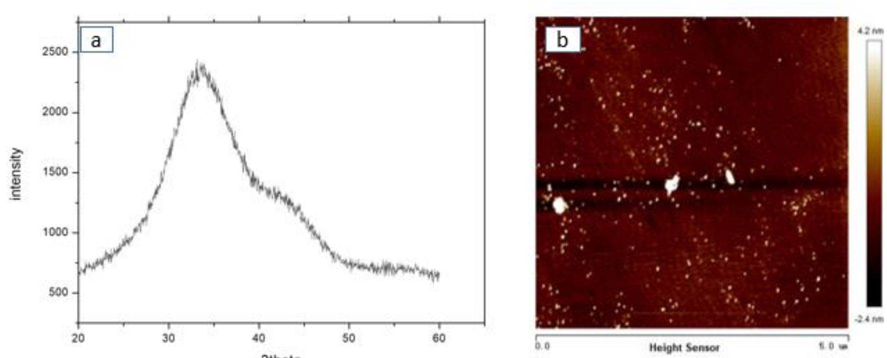

Figure 4. (a) The XRD pattern and (b) the AFM image of the amorphous metals template.