Nano scale three-dimensional metal pattern transfer by nanoimprint lithography using metal oxide as a release layer

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In the next generation, a strong need exists for flexible and transparent electronic devices because they are used in the fabrication of wearable devices and bendable thin-film displays. Therefore, fine metal patterning technique on the flexible substrate (especially on the plastic substrate) is critically required and have recently become intensive subjects of research. Nanotransfer printing is well known technique for fabricating the metal pattern directly [1]. However, the obtained patterns using this process are the plane patterns. On the other hand, recently, nano scale three-dimensional (3D) metal patterns such as plasmonic devices and patterned media are strongly required. In order to fabricate these devises easily, we have developed the 3D nanoimprint lithography technique using spin on glass (SOG) mold with metal oxide release layer. The process is shown in figure 1. The control-of-acceleration-voltage electron-beam lithography (CAV-EBL) was employed to obtain the three-dimensional SOG pattern [2]. A Cr layer having a thickness of around 10–20 nm was deposited on a fabricated mold by using a resistively heated vacuum evaporation system (VPC-260F, ULVAC KIKO Inc.). After coating the mold with Cr, we ventilated the vacuum evaporation system. Thus, the surface of Cr layer was oxidized to Cr_2O_3. Then, gold was deposited on the Cr layer at around 320 nm. Next, the hot plate was heated up to 80 °C, and the polyethylene terephthalate (PET) substrate was placed on the hard mold for 30 min. After that, the PET substrate was removed, and the gold pattern was transferred onto the PET substrate. As a result, the fine three-dimensional gold patterns were obtained on the PET substrate (figure 2).

Next, the performance of Cr_2O_3 release layer was examined. The left image of figure 3 shows the moth-eye structure on glassy carbon (GC), which was used as a high aspect ratio mold [3]. The right image of figure 3 shows the surface of GC after nanoimprint with Cr_2O_3 release layer. It is difficult to duplicate this kind high aspect ratio structure with PDMS. However, with Cr release layer, the high aspect ratio gold pattern on the PET substrate was obtained (figure 4). The diameter, the pitch and the height were approximately 40 nm, 60nm, over 1 μm, respectively. This technique is also very useful to fabricate nano-electrode and nano-scale metal wiring on the flexible plastic substrate because the SOG resist has high resolution with EB lithography and suitable for nanoimprint process [4].

[1] Y. L. Loo *et al.*, *Appl. Phys. Lett.* **81** (2002) 562.
[2] N. Unno *et al.*, *J. Vac. Sci. Technol. B* **25** (2007) 2361.
[3] J. Taniguchi *et al.*, *J. Nanosci. nanotechnol.* **9** (2009) 445.
[4] N. Unno *et al.*, *J. Vac. Sci. Technol. B* **26** (2008) 2390.

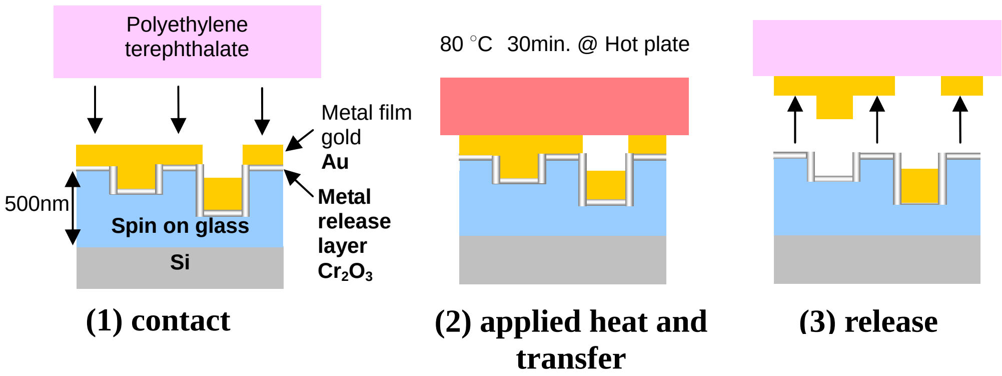

Figure 1 Process schematic of three-dimensional metal nanoimprint technique.

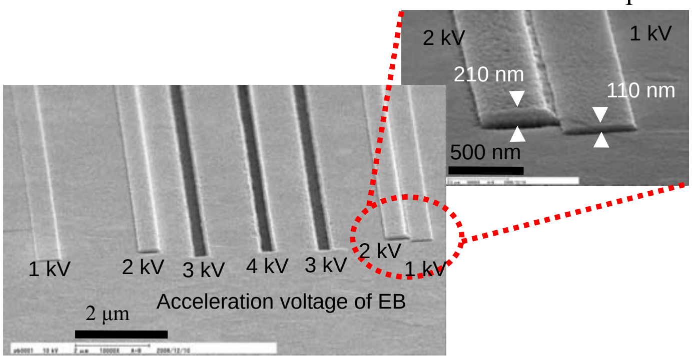

Figure 2 The SEM image of the gold pattern on PET by tilting the specimen to 75°.

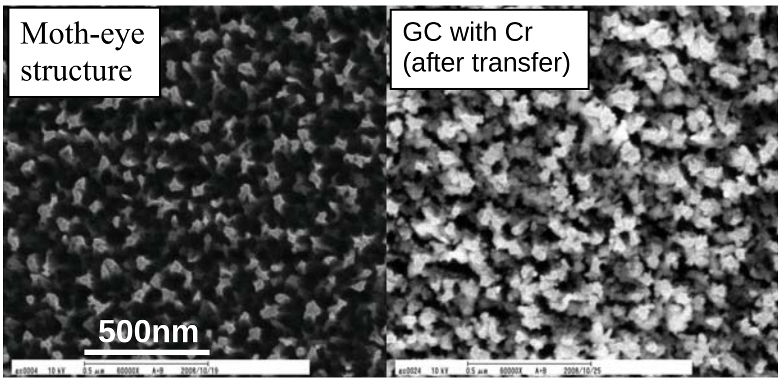

Figure 3 The SEM image of GC substrate before and after nanoimprint.

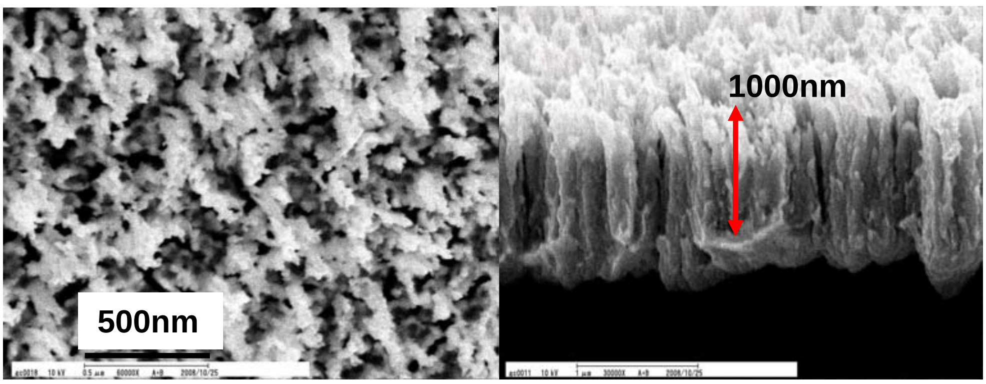

Figure 4 The SEM image of the high aspect ratio gold pattern on PET substrate.