Thermal Nanoimprint of Soda-Lime Glass Using Induction Heating and Sapphire Molds

Jingxuan Cai[1], Xu Guo[2], Haixiong Ge[2], and Wen-Di Li[1]

[1]*Department of Mechanical Engineering, Univ. of Hong Kong, Hong Kong*

[2]*Department of Materials Science and Engineering, Nanjing University, Nanjing, China*

liwd@hku.hk

Glass is a widely used fundamental material for various optical, bio and chemical applications due to its excellent properties such as high chemical and heat resistance, good electrical isolation, high optical transmission at wide range and biocompatibility[1]. While most of these applications require patterning of glass surface at the micro- or nanoscale, micro/nanofabrication on glass is not easy. Currently, micro/nanoscale surface modification of glass is chiefly performed by photolithography or mechanical machining, both are complicated and expensive processes. The nanoimprint lithography (NIL) is a prime candidate for nanopatterning of glass surface because its capability of simple and low-cost fabrication with a resolution down to a few nanometers[2]. However, nanoimprinting on glass surface demands high strength and durability of the mold because the glass transition temperature (Tg) of typical soda-lime glass is over 600 ℃. In this research, a soda-lime glass nanoimprinting method using sapphire molds is demonstrated and a 650 nm period hexagonal hole array is fabricated on the soda-lime glass substrate. Moreover, application of the imprinted glass substrate as a SERS substrate is demonstrated.

Figure 1a and 1b demonstrate the process of thermal NIL on glass surface. A soda-lime glass substrate with Tg ~ 570 ℃ covered by a sapphire mold patterned with a 650 nm period hexagonal pillar array is placed between two sapphire plates in a home-made 2Cr13 stainless steel container. After 3 minutes heating, ~700 ℃ is produced by a 650W inductive heater within the stainless steel container. Imprinting pressure is applied and the inductive heater is powered off after 30 seconds. The imprinting pressure is released after another 30 seconds when the system temperature is lower than Tg. Figure 1c shows the SEM photograph of the hexagonal hole array formed in the soda-lime substrate. Figure 1d shows the depth of holes increasing with imprinting pressure applied. Figure 2 shows the Raman spectra of 10^{-4} M R6G on an imprinted glass substrate with 87-nm-depth hole array coated with 70-nm-thickness gold layer by thermal evaporation. The typical Raman spectra of R6G was presented with dominant peaks labeled.

Our method demonstrates the possibility of simple and low-cost nanofabrication of glass surface. New device applications may be developed from this fabrication method.

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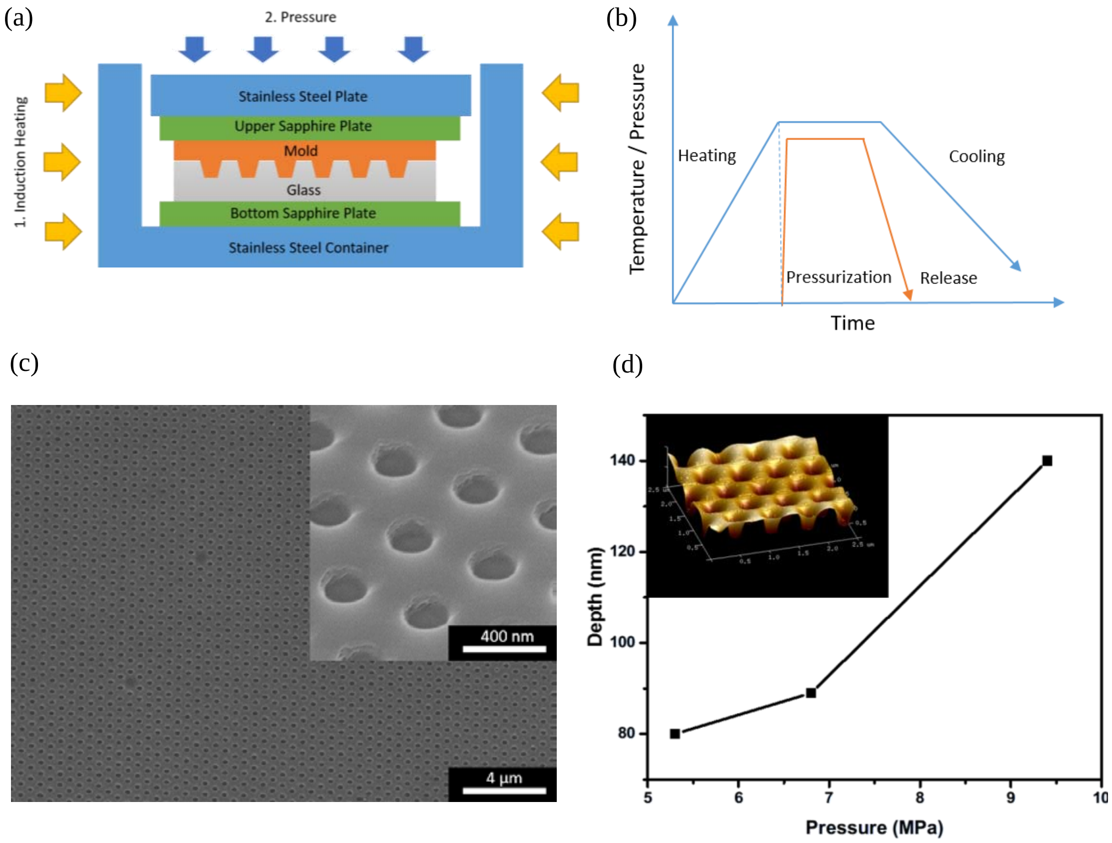

Fig. 1 (a) Schematic and (b) sequence of the imprinting process. (c) SEM photograph of 650 nm period hexagonal hole array fabricated in a glass substrate by thermal nanoimprint lithography. (d) AFM photograph of 140-nm-depth imprinted hexagonal hole array and plot showing the depth of holes increasing with imprinting pressure.

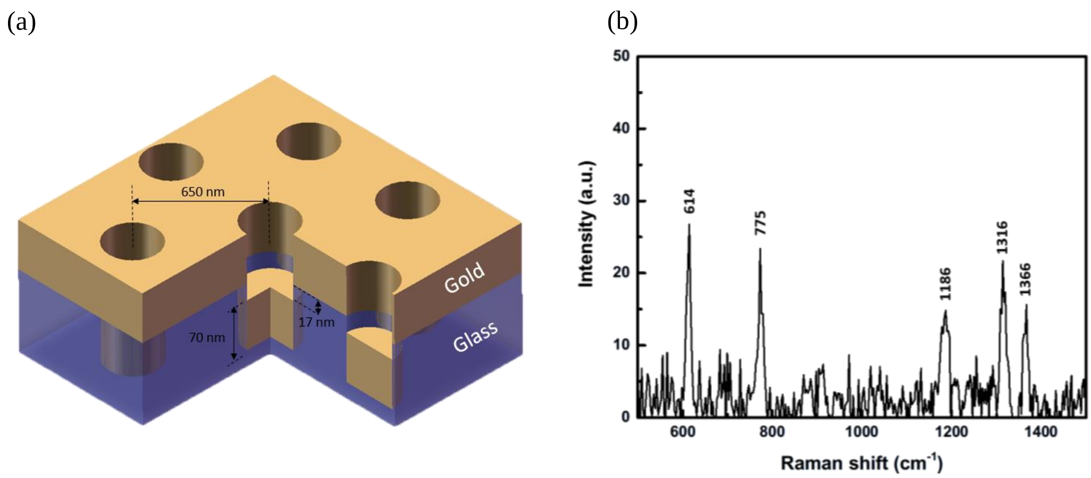

Fig. 2 (a) Schematic of the fabricated SERS substrate. A Soda-lime glass substrate imprinted with a 87-nm-depth hole array is coated by a 70-nm-thickness gold layer by thermal evaporation. (b) Raman spectra of 10^{-4} M R6G on the SERS substrate with dominant peaks labeled.