Thermal Imprinting on Quartz Fiber using Glass-Like Carbon Mold

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We prepared a polished glass-like carbon (GC) disk by polishing and fabricated a GC mold for quartz imprinting by applying MEMS fabrication technologies. Various patterns on a GC mold were imprinted onto one side of a 200 μm square cross-sectional shaped quartz fiber.

Figure 1 shows a process flow of a GC mold. The average surface roughness and the thickness of the polished GC disk were 5 nm (or less) and 2 mm ± 0.5 μm, respectively. A 900-nm-thick Au film was sputter deposited on the GC disk. A 4-μm-thick film of AZ 5200NJ photoresist was spin-coated on the Au layer and then UV light was irradiated through a reticle using a stepper 1500 MVS R-PC system. The Au layer was etched by Ar in an inductively coupled plasma (ICP) system Multiplex ASE. The patterned Au layer was then used as mask for selective etching of GC by O_2+SF_6 plasma using a Model RIE-10NRS system. In this process, by controlling the etching time, the depths of mold pattern were made to be 2.4, 3.5, 7.5, and 14.7 μm. The leftover Au layer covering the un-etched GC was then chemically removed, and a GC mold was thus completed.

Figure 2 shows a photograph of the bottom loading stage of a thermal nanoimprint system ASHE0201. Two quartz fibers lied on a 20-mm-square GC mold placed on five GC plates; the step was followed by placing a GC plate on top of the quartz fibers. Thermal imprinting was then executed in vacuum. In this operation the GC mold was heated up to 1350 °C, and an upper loading stage was pressed for two minutes by a contact force of 300 N. Subsequently, the GC mold and quartz fibers were left to cool down to the room temperature.

Figures 3(a) and 3(b) show SEM images of convex line/space and square-dot patterns in the GC mold pattern with depth of 14.7 μm. Figures 3(c) and 3(e) show optical micrographs of line/space, square-dot and circle-dot patterns imprinted on the quartz fiber. Each imprinted pattern was clearly observable, and the width of the quartz fiber was increased to 278 μm after thermal-imprinting.

Figure 4 shows the relationship between line width and height after imprinting under the same conditions with four GC molds. It shows that the height of imprinted pattern increased as the line width increased. It also shows that in case of large line-widths the height of the pattern very closely matched the corresponding size of the patterns on the mold.

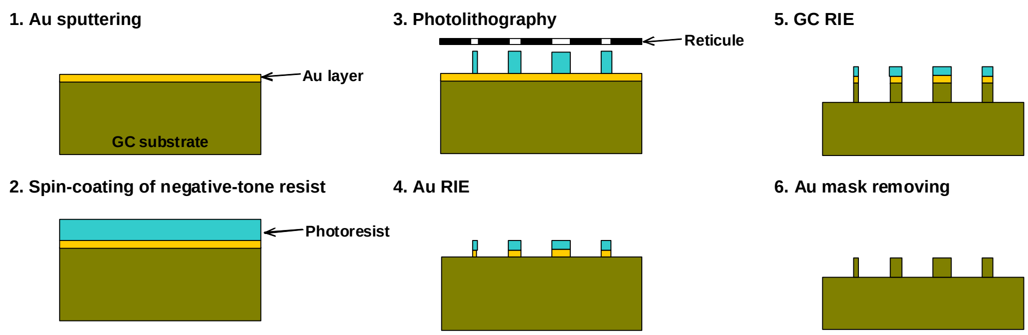

Fig. 1: Process flow in fabrication of a GC mold for quartz imprinting.

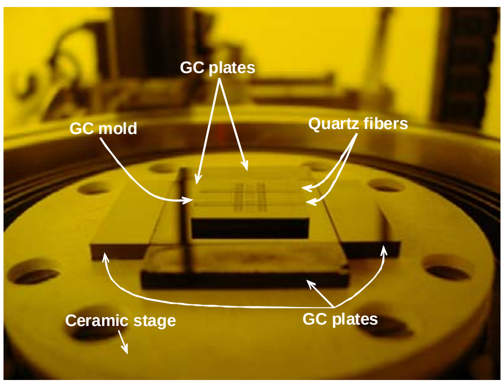

Fig. 2: Photograph of experimental arrangement on the bottom loading stage for high-temperature thermal nanoimprint system ASHE0201.

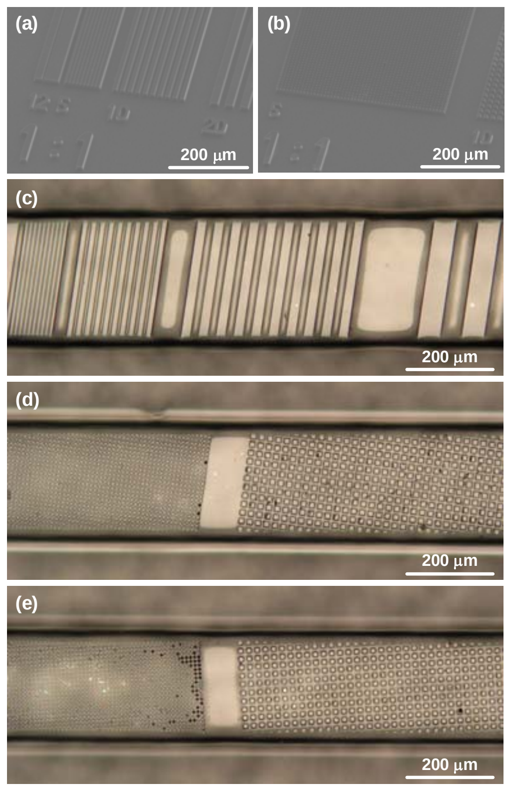

Fig. 3: SEM images of mold patterns in a GC mold: (a) line / space patterns and (b) square-dot patterns. Optical micrographs of imprinted patterns on a quartz fiber: (c) line / space patterns, and (d) square-dot patterns, and (e) circle-dot patterns when the heating temperature and the contact time were 1350 °C and 2 min, respectively.

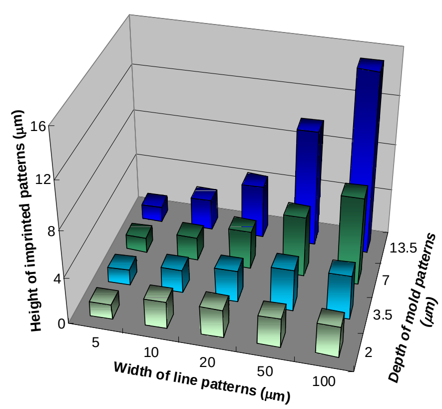

Fig. 4: Height of the imprinted patter as function of width of line patterns for different mold-pattern depths.