Room-Temperature Nanoimprinting Using Ladder Hydrogen Silsesquioxane(HSQ)

K. Nakamatsu[1, 2], K. Ishikawa[3], N. Taneichi[3] and S Matsui[1]

[1] *University of Hyogo, Graduate School of Science, LASTI,*
3-1-2, Koto, Kamigori, Ako, Hyogo 678-1205, Japan
[2] *JSPS, Research Fellow of the Japan Society for the Promotion of Science, Sumitomo-Ichiban Bldg., 6 Ichibancho, Chiyoda-ku, Tokyo 102-8472, Japan*
[3] *Tokyo Ohka Kogyo Co., Ltd, 150, Nakamaruko, Nakahara-ku, Kawasaki, Kanagawa 211-0012, Japan*

E-mail: kenichir@lasti.u-hyogo.ac.jp

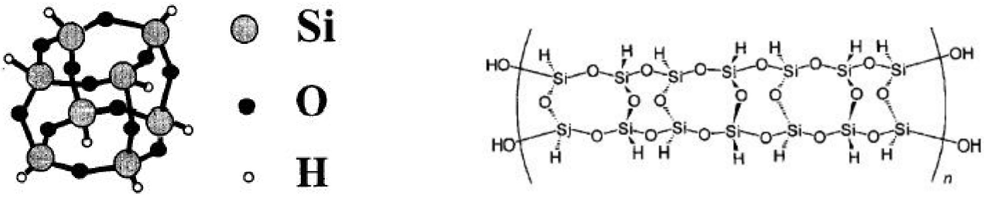
Nanoimprint lithography (NIL) is attracting considerable attention from many industries, and supported as the prime candidate for next generation lithography. There are many polymers that can be used as the replication materials in imprinting. In particular, hydrogen silsesquioxane (HSQ) is very useful owing its unique property to enable imprinting at room-temperature, meaning that NIL using HSQ as the replication material completely eliminates resist-thermal cycle and UV exposure. Therefore, HSQ allows a precise nanopattern replication with a simple and low cost process in imprinting. HSQ also has many efficient properties such as low dielectric constants below 3.0.

There are two different schemes on the HSQ polymer structure, as shown in Fig. 1. One HSQ-caged structure (Fig. 1(a)) and the other HSQ ladder structure (Fig. 1(b)). In previous experiments on the HSQ pattern replication, we used HSQ contained both caged- and ladder structure (FOX-16, Dow Corning Co.) as the replication material. In this report, we newly propose HSQ with ladder structure (OCD T-12, Tokyo Ohka Kogyo Co. Ltd) as the replication material, and compare the two types of HSQ.

Figure 2 shows baking temperature dependence of imprinted pattern profiles of the two kinds of HSQ. Both HSQ resins formed by spin-coating were successfully imprinted at RT with 50 MPa pressure, as shown in Figs. 1(a) and 1(e). However, as Fig. 2(b) shows, patterns imprinted using the caged-HSQ as the replication material completely disappeared when baked at 300°C. This was attributed to a network structure formation by opening the HSQ-caged structure during the baking. While the pattern collapse was prevented by O_2 plasma preirradiation before baking, we found a severe problem that some cracks were formed into the caged-HSQ imprinted patterns with O_2 plasma irradiation beforehand after baked at 800°C, as shown in Fig 3. On the other hand, the ladder HSQ showed a contrasting result that the patterns without any treatment remained almost the same as the profile without baking, even at a high baking temperature of 1000°C, as shown in Fig. 2(h). This is an excellent characteristic of the ladder HSQ imprinted patterns in high-temperature annealing.

Figure 4 shows a ladder HSQ pattern imprinted with 1 MPa by liquid-phase HSQ method that we previously developed. In this case, the imprint temperature was RT.

These results indicate that the ladder HSQ is more suited as the replication material than the caged HSQ currently used.



(a) (b)

Figure 1. Two different schemes of HSQ. (a) Caged structure and (b) ladder structure

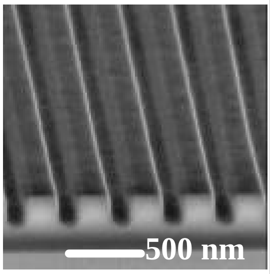
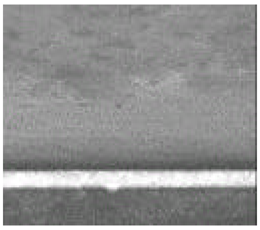
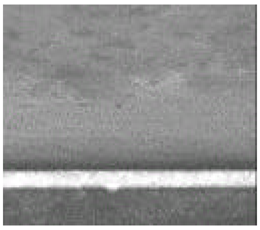
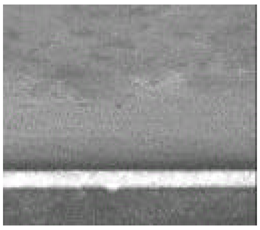
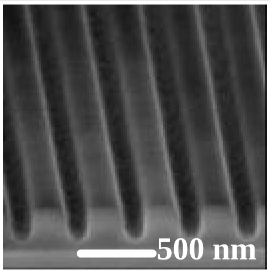
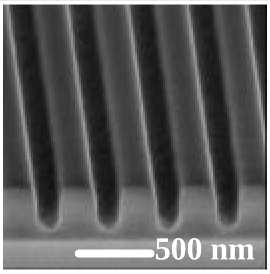
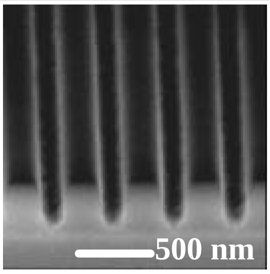
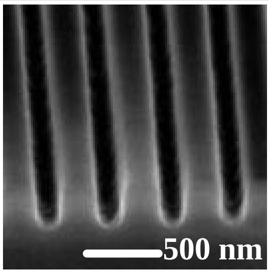
Baking temperature	No baking	300°C	800°C	1000°C
Imprinted pattern of caged HSQ	 (a)	 (b)	 (c)	 (d)
Imprinted pattern of ladder HSQ	 (e)	 (f)	 (g)	 (h)

Figure 2. Baking temperature dependence of imprinted pattern profiles of the two kinds of HSQ.

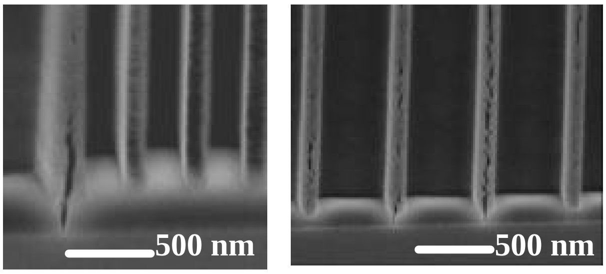


Figure 3. Caged HSQ imprinted patterns with O_2 plasma after 800°C baking. While the rectangular shapes remained, some cracks formed into the patterns.

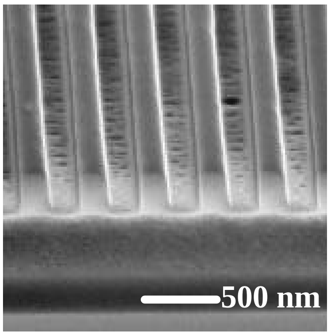


Figure 4. HSQ pattern imprinted by liquid-phase HSQ method