Residual layer uniformity using complementary patterns to compensate pattern density variation in UV nanoimprint lithography

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It is well-known that one of challenges of using nanoimprint lithography is to print fields with non-uniform pattern density at adequate throughput. UV nanoimprint lithography usually leaves a thin residual layer which has to be removed through a reactive ion etch (RIE) process. A lateral erosion of resist pattern during RIE process is unavoidable. This erosion is exacerbated when non-uniform residual layers are formed in the nanoimprint process of varied pattern densities. [1] Therefore forming a uniform residual layer in the nanoimprint of non-uniform pattern density is of great importance and has a practical meaning.

To address this issue, a capacity-equalized mold [2] was studied in which deeper complementary cavities are added into the original trench pattern areas to make a uniform pattern capacity through the mold of variant pattern densities without altering the original pattern layout. We investigated the effects of complementary patterns to compensate pattern density variation on residual layer uniformity in UV nanoimprint lithography. Figure 1 is the laser scanning confocal microscopy image of the mold with the complementary deeper patterns to adjust the capacity of original trench patterns. The width of the complementary pattern is varied according to the line/space ratios while its depth is fixed (90nm in this paper). With the aid of the complementary deeper patterns, uniform capacity was achieved through the mold with varied pattern densities (Line/Space = 3:1, 1:1, 1:2 and 1:3). Figure 2 shows the comparison using the mold with complementary patterns and the conventional mold across the lines with varied pattern densities. It is found that the residual layer thickness became dramatically uniform through the whole field with different line/space ratios.

We also carefully investigated the effects of complementary patterns on the residual layer thickness along a line parallel to complementary patterns as shown in Figure 3. We found that the residual layer thickness at the locations far from complementary patterns was uniform as expected. And more importantly, the residual layer thickness at the locations just next to the complementary patterns was almost equal to those at the locations far from the complementary patterns. This confirms that complementary deeper patterns have no local effects on the residual layer thickness and result in a uniform residual layer throughout the whole field. We believe that using a mold with complementary patterns to compensate pattern density variation is a very economic way for nanoimprinting non-uniform pattern density.

References

[1] N. Chaix, et al, J. Vac. Sci. Technol. 25 (2007) 2346.

[2] H. Hiroshima, Jpn. J. Appl. Phys. 47 (2008) 5151.

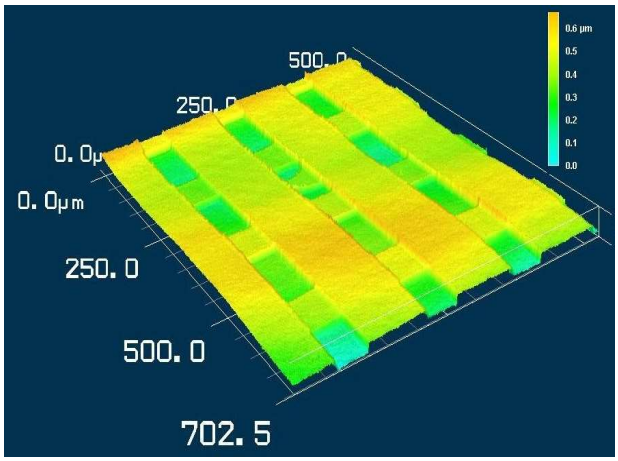
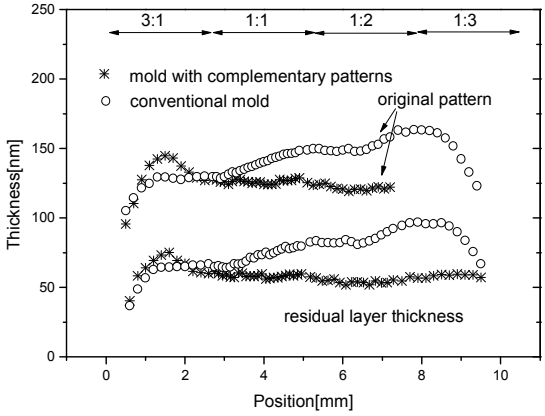
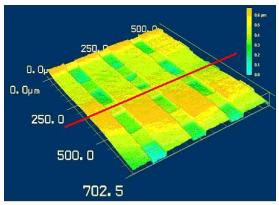


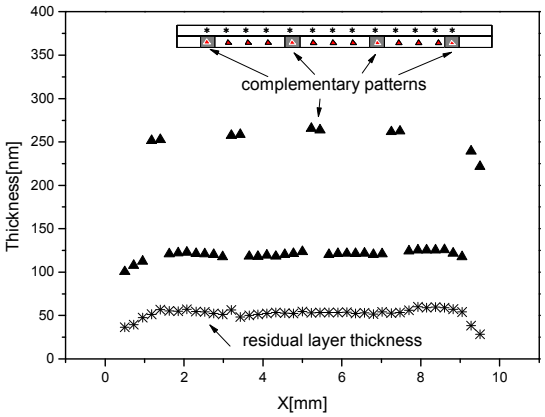
Figure 1. Laser confocal scanning microscopy image of the mold with complementary deeper patterns fabricated in the original UV quartz mold to adjust the capacity of original trench patterns. Deep green areas are the complementary deeper patterns.

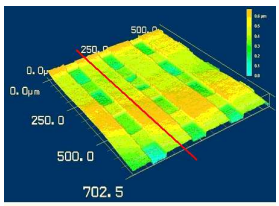




Measurement direction

Figure 2. Residual layer thickness and pattern layer thickness of samples using the mold with complementary patterns and conventional mold. A uniform residual layer is obtained due to the uniform pattern capacity achieved with the aid of complementary patterns.





Measurement direction

Figure 3. Effects of complementary patterns on the residual layer thickness along a line parallel to the complementary patterns. Residual layer thickness (star points) keeps uniform although complementary patterns are much thicker than the original trench pattern (triangle points).