Effects of Fluorosurfactants on Antisticking Layer Resistance in Repeated UV Nanoimprint

S. Iyoshi, M. Okada, Y. Haruyama, S. Matsui
Laboratory of Advanced Science and Technology for Industry, University of Hyogo, Koto, Kamigori, Ako, Hyogo, 678-1205, Japan
s-iyoshi@lasti.u-hyogo.ac.jp

K. Kobayashi, S. Kaneko, M. Nakagawa
Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Katahira, Aoba, Sendai 980-8577, Japan

H. Hiroshima
National Institute of Advanced Industrial Science and Technology (AIST), AIST East Namiki, Tsukuba, Ibaraki 305-8564, Japan

Nanoimprint lithography includes a contact process where fine features in a mold are directly transferred onto a resist layer coated on a substrate. Although the mold surface can be covered with an antisticking layer to ease demolding impact, the problem of its durability against thousands of repeated UV nanoimprints still remains unsolved. This study was focused on an additive that would expectedly have the effect for enhancing antisticking layer resistance against repeated UV nanoimprint operations. With the test machine capable of the automatic UV nanoimprint operation, step and repeat UV nanoimprints were conducted with 6 x 6 mm quarts mold in 6.5mm pitch on a 6 inch wafer. Demolding forces in each imprint step were recorded. Water contact angles of the mold surface were determined on eight spots, as depicted in Fig. 1, in every 225 steps of imprint to track the extent of antisticking layer degradation. The mold was treated with tridecafluoro-1,1,2,2-tetra-hydrooctyl)trimethoxysilane (GELEST). C-TGC-02 (TOYOGOSEI) was used as UV curable resist. PFP (pentafluoropropane) gas was flowed over the imprinting stage, as PFP is known to have the reducing effect of the demolding forces[1]. 1 parts of fluorosurfactant F-444 (DIC) was added to 100 parts of the resist. F-444 was confirmed to be compatible with the resist C-TGC-02.

With surfactant-added resist, the demolding forces were found to stay in no larger than 0.2N in the imprint in PFP except some imprint steps, as is shown in Fig. 2. As Fig. 3 shows, the surfactant-added resist was found to be more resistant than the resist without additive in terms of the water contact angles. Observing the trend of the water contact angle on each measurement spot in the mold, as shown in Fig.4, the water contact angle on particular spot (b) started to drop abruptly at around 3000 steps, and a point-like defect was observed at the equivalent spot (b) as shown in the third defect image from the right in Fig. 4. This defect was found to be generated by a tiny scar in the mold, which has been evidently gotten during the experiment, though when and how are still unspecified. It probably occurred with a hard particle being pinched by the mold and the substrate. The

defect developed beyond 3850 steps to a significant size as shown in the second and third defect images from the right in Fig.4, and at the same time the contact angles at the perimeter spots “a”, “c”, and “d” were driven to accelerated drops, while other spots “e”, “f”, “g”, and “h” remain almost intact. This fact provides the suggestion that without the trouble of mold damage, the whole antisticking layer resistance could have been much longer. From the deteriorating trend of spots “e”, “f”, “g”, and “h”, the projected antisticking layer resistance might be roughly 17000 steps. This supposition is planned to be validated.

---

[1] H. Hiroshima: J. Vac. Sci. Technol. B **27** 2862 (2009)

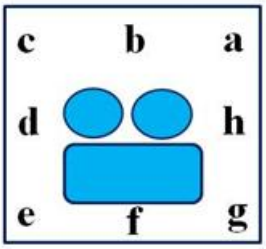

Fig. 1 Measured spots of water contact angles in the mold

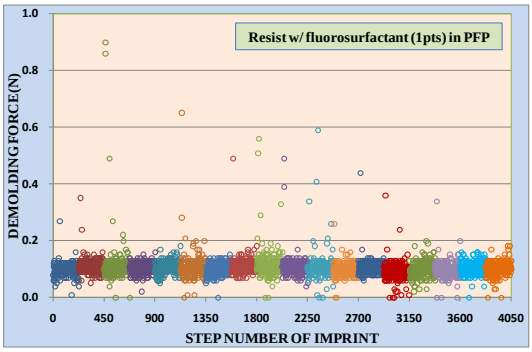

Fig. 2 Demolding forces plotted against step number of imprint in PFP

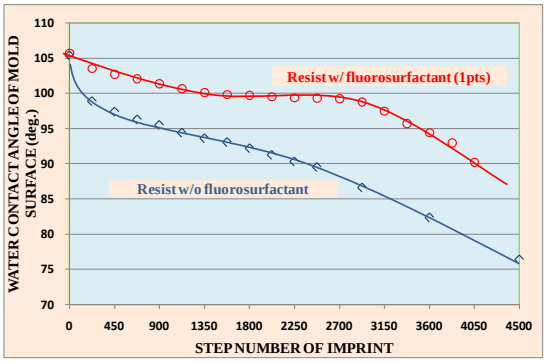

Fig. 3 Average water contact angles plotted against imprint step number in PFP:
○ Resist / fluorosurfactant ◇ Resist without an additive

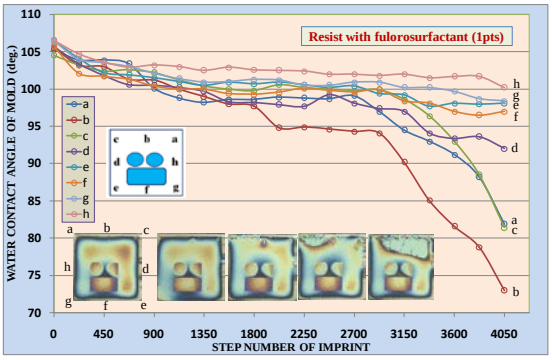

Fig. 4 Water contact angle by each measurement spot of resist / fluorosurfactant plotted against imprint step number in PFP