Effect evaluation of pentafluoropropane gas for UV nanoimprint resin by using contact angle meter

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UV-nanoimprinting under pentafluoropropane (PFP) gas is useful technique to eliminate the bubble defects (Hiroshima method).[1)] Furthermore, the resin filling speed in this method is drastically faster than that under air.[2)] In this study, we evaluated the effect of PFP gas for UV-nanoimprint resin by using contact angle meter.

We first measured the contact angles of UV-nanoimprint resins on the SiO_2/Si substrate coated with an antisticking layer under air and PFP gas ambient. HD-1100TH (Daikin Industries) was used as the release agent. We used NICT103 (cationic UV curable resin; Daicel Chemical Industries) and C-TGC-02 (radical UV curable resin; ToyoGosei Co.) as the UV-nanoimprint resins. As shown in figures 1(a) and 1(b), although the contact angles of NICT103 and C-TGC-02 under air were 55 ° and 73°, those under PFP gas ambient were 43° and 52°. The contact angles under PFP gas ambient were lower than those under air.

We next measured the sliding angle (α), advance angle (θa), receding angle (θr), and sliding speed of NICT103 and C-TGC-02 on the Si substrate coated with an antisticking layer by sliding angle measurement under air and PFP gas ambient. Figure 2 shows the schematic of sliding angle measurement. The sliding angles under air and PFP gas ambient were about 1°. Table I shows the advance and receding angles, and sliding speeds of NICT103 and C-TGC-02 under air and PFP gas ambient. The advance and receding angles of NICT103 and C-TGC-02 under PFP gas ambient were lower than those under air. In addition, the sliding speeds under PFP gas ambient were faster than those under air. These results indicate that the dynamic wettability of the UV-nanoimprint resins for the antisticking layer was improved by using PFP gas.

Subsequently, we examined whether PFP gas dissolved in the resin by Fourier transform infrared spectrometer (FT-IR). We used NICT103 and C-TGC-02. The NICT103 and C-TGC-02 were spin-coated on the Si substrates and then cured by UV irradiation. Figures 3(a) and 3(b) show the FT-IR spectra of NICT103 and C-TGC-02 cured by UV irradiation under air and PFP gas ambient, respectively. The peak around 1150 cm^{-1} was not observed in the spectra of NICT103 cured under air. However, in the case of NICT103 cured under PFP gas ambient, the peak was observed. We assumed from this result that the PFP gas was dissolved in the NICT103 because the peak around 1150 cm^{-1} is due to the C-F bond. On the other hand, in the case of C-TGC-02 cured under air, the peak around 1150 cm^{-1} was also observed because this peak is due to the ester bond and the contained monomer has this bond. The peak around 1150 cm^{-1} of C-TGC-02 cured under PFP gas ambient became higher compared to that under air. This means that the PFP gas was also dissolved in C-TGC-02. This result indicates that the decrease of contact angle and the increase of dynamic wettability under PFP ambient were due to the dissolution of PFP gas into the resin.

1) H. Hiroshima and M. Komuro, Jpn. J. Appl. Phys. **46**, (2007) 6391.
2) H. Hiroshima, J. Vac. Sci. Technol. B. **25**, (2007) 2333.

Table I Advance and receding angles, and sliding speeds of (a) NICT103 and (b) C-TGC-02 on Si substrate coated with antisticking layer under air and PFP gas ambient.

	Air	PFP gas
Advance angle (°)	52	41
Receding angle (°)	46	36
Sliding speed (μm/s)	15	45

(a)

	Air	PFP gas
Advance angle (°)	70	49
Receding angle (°)	67	48
Sliding speed (μm/s)	8	11

(b)

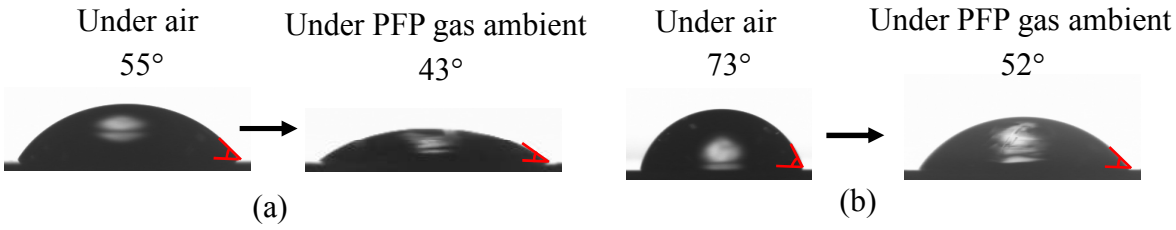

Fig. 1 Contact angles of (a) NICT103 (cationic UV curable resin) and (b) C-TGC02 (radical UV curable resin) on SiO_2/Si substrate coated antisticking layer under air and PFP gas ambient.

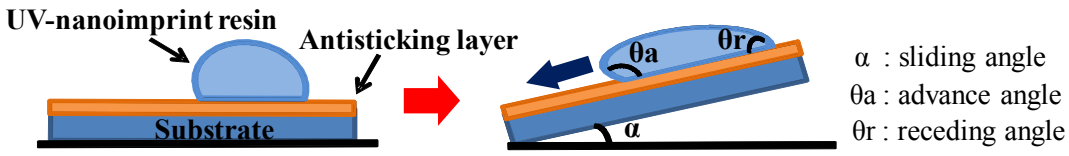

Fig. 2 Schematic of sliding angle measurement.

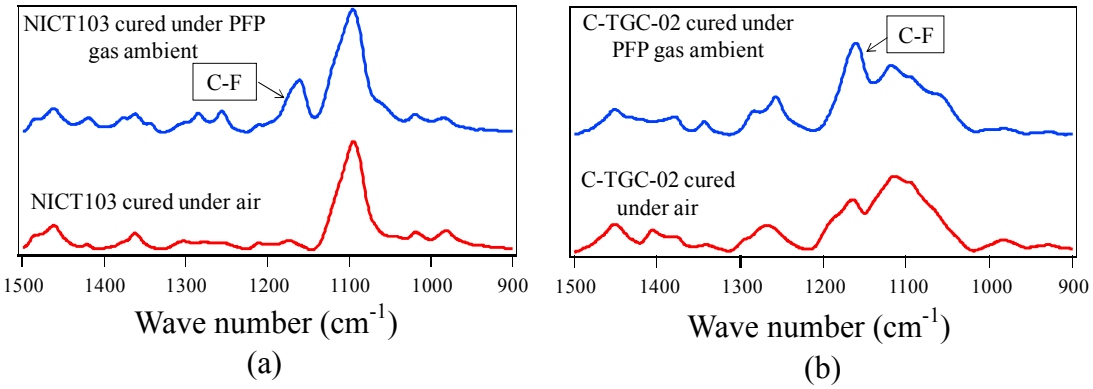

Fig. 3 FT-IR spectra of (a) NICT103 and (b) C-TGC-02 cured by UV irradiation under air and PFP gas ambient.