Diffusers with both surface-relief and particle-diffusing functions fabricated using hybrid extrusion roller embossing

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Abstract

Generally, the diffusers can be classified into two types: the particle-diffusing type or the surface-relief type. Many ways to fabricate these two types diffusers have been reported. However, most of them involve replicated process and require expensive facilities. In this study, an innovative extrusion roller embossing process for directly fabricating plastic diffusers integrating surface-relief and particle-diffusing functions has been proposed. This new process is composed of the film extrusion and the roller embossing processes. As shown in Fig. 1, during the extrusion roller embossing operation, the extruded PC/beads composite film is immediately pressed against the surface of roller mold. Plastic diffusers with surface reliefs and diffusion beads can be successfully fabricated.

Fig. 2 shows the SEM image of a randomly selected area of fabricated diffuser. The average height of fabricated microstructures is 45.69μm with a standard deviation of 0.84μm (1.84%), while the average width is 398.06μm with a standard deviation of 17.05μm (4.28%). The small standard deviations of height and width reveal high uniformity of roller embossed microstructures. The total transmittance(T_t), diffuse transmittance(T_d), and haze of the diffusers can be measured with an automatic haze meter. The T_t, T_d, and haze of the fabricated PC composite diffuser with microstructures are 98%, 87.7%, and 89.5%, showing the good diffusing performance. Table 1 compares the optical properties of various films as a diffuser. The overall performance of the film with surface microstructures and diffusion beads is the best among all. Fig. 3 shows the images of diffusing capacity observed through a flat PC/bead composite film, and a PC/bead composite film with microstructures. Results show that the PC/bead film with microstructures displays the best diffusing efficiency.

Results demonstrate that the fabricated diffusers can scatter the light uniformly and diffuse the light effectively. This novel process shows the great potential for continuous fabrication of high-performance plastic diffusers integrating surface-relief and particle-diffusing functions with low cost and high throughput.

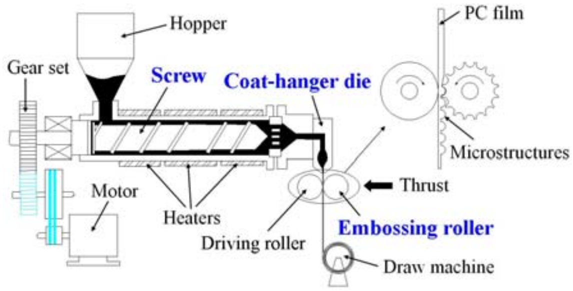
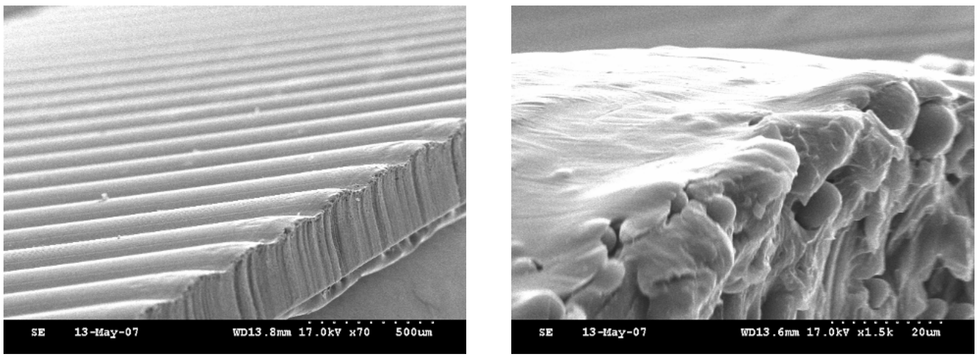


Fig. 1. Schematic showing the hybrid extrusion roller embossing process.

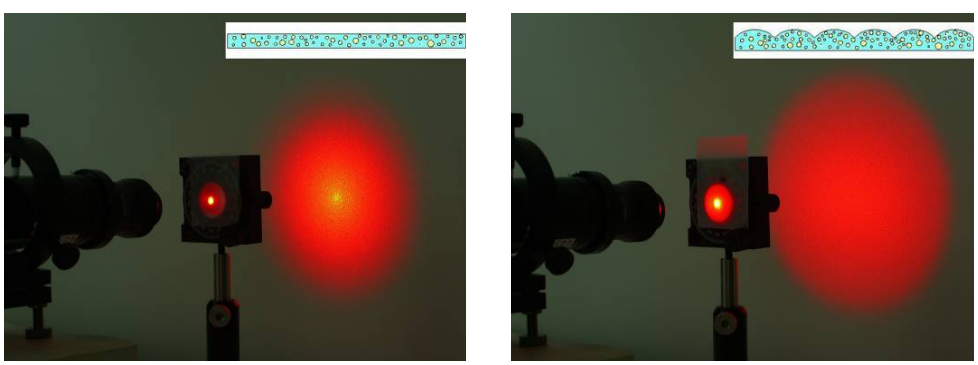


(a) (b)

Fig. 2. (a) SEM images of the microstructures on the fabricated PC composite diffusers. (b)The magnified SEM image of the fabricated diffuser shows the diffusing beads inside the film.

Table 1. Measured optical properties of various films as diffusers.

	T_t (%)	T_d (%)	Haze (%)
Flat pure PC film	87.2	3.8	4.4
Flat PC/bead composite film (without microstructures)	88.2	78.5	89
Pure PC film with surface microstructures	99.3	73.9	74.4
PC/bead composite film with surface microstructures	98	87.7	89.5



(a) (b)

Fig. 3. The images of a laser light source observed behind through (a) a flat PC/bead composite film, and (b) a PC/bead composite film with surface microstructures. The PC/bead film with microstructures displays the best diffusing efficiency.