» New Products

The Development on a Micro Cellular Light Reflector From the Indirect Lighting to the Communication Device

1. INTRODUCTION

Along with the growing awareness in environmental consciousness, the usage of Light Emitting Diodes (LEDs) is progressing in general lightings of dwelling houses, offices or stores. With the advantages of the LED light source like the cost-cutting, the improvement of the light emission efficiency and the flexibility of the lighting design by downsizing, the usage of the LEDs for a room lamp or an ambient lighting in the automobile is expanded, therefore, it is staging an indoor space and improves commodity value. In this article, we introduce the superior characteristics, such as the light reflection property and the thermoformability, and its application to room lamps as a LED lighting of our microcellular foam sheets, MCPET and MCPOLYCA. We also propose a development to the communication device through light and sound, which will contribute to the autonomous driving in the future.

2. THE CHARACTERISTICS OF THE MICROCELLULAR FOAM LIGHT REFLECTOR

2.1 The Light Reflection Property

MCPET and MCPOLYCA (MC light reflectors, below) are foam sheets, known as microcellular plastics, which consist of closed cells in an ultrafine microcellular structure with a cell size of 0.1 to 10 μm and a cell density of 10^9 – 10^{15} pc/cm^3. These light reflectors reflect the light at the cell interface of the microcellular structure and have a high reflectivity, especially for the high diffuse reflectivity. A spectral reflectivity of MCPET is shown in Figure 1. It has a high total reflectivity over 98% (approximately 99% in 550 nm, relative value to the barium sulfate white plate), and its reflectivity has no wavelength dependency in the visible light region, therefore, it is a superior light reflector in reflecting the light from the light source entirely.

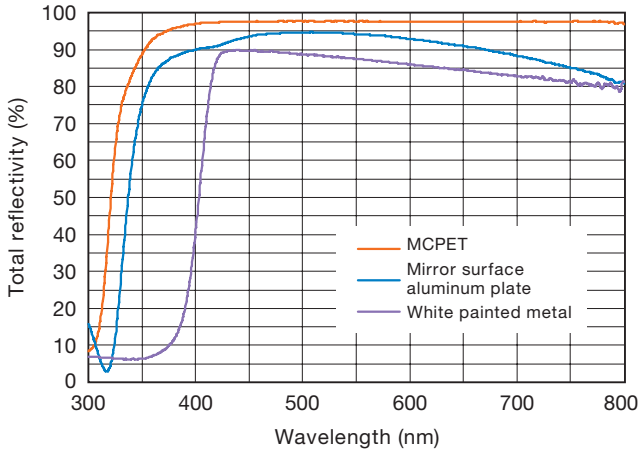


Figure 1 The light spectral reflectivity of MCPET.

2.2 The Thermoformability

The MC light reflector can be formed into various shapes by vacuum forming or matched mold forming, therefore, the reflector shapes can have relatively flexible design according to structures or to designs of the lighting (Figure 2).

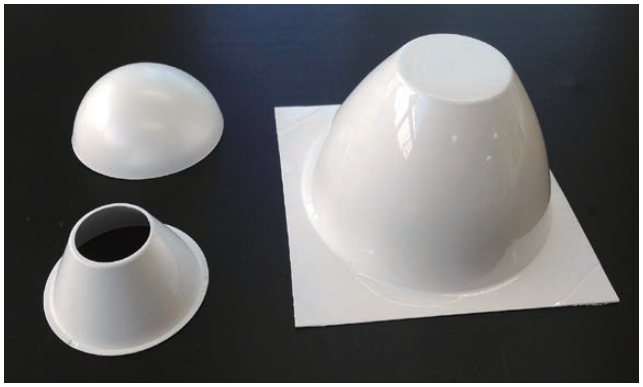


Figure 2 The thermoformed products by matched molds.

2.3 The Lineup of the MC Light Reflector

The lineup of the MC light reflector is shown in Table 1. MCPET and MCPOLYCA are the foam made from the polyethylene terephthalate resin and the polycarbonate resin respectively. The MCPET's feature is a reflection property and the MCPOLYCA's feature is a vacuum forming in addition to the reflection property.

Table 1 The lineup of MC light reflector.

Item		MCPET series			MCPOLYCA
Base Polymer		Polyethylene terephthalate			Polycarbonate
Grade		RB	M2	M4	YN
Thickness (mm)		0.94	1.0/0.5	1.0/0.5	0.99
Features		Standard grade	High diffusion / High reflectivity	High diffusion / High reflectivity	Vacuum formability
Resistance to ultraviolet radiation		Good	Good - excellent	Not good	Good
Flame retardancy (UL-94HBF)		Complying	Complying	Complying	Complying
Light reflection property	Total light reflectivity*1 (%)	100.1	100.1	101.1	100.2
	Diffuse reflectivity*1 (%)	98.8	99.9	100.8	98.3
Thermoformability	Vacuum forming	Good	Good	Good	Excellent
	Matched mold forming	Excellent	Excellent	Excellent	Excellent

Note 1: The reflectivity is a relative value in 550 nm to the barium sulfate white plate. The data are measured values and not guaranteed values.

3. THE APPLICATION TO A LED LIGHTING DEVICE

3.1 The Indirect Lighting Structure

Since the MC light reflectors are superior in the diffuse reflectivity, with using an indirect lighting structure (Figure 3), it can suppress the glaring (uncomfortable brightness) which happens often in a point light source of LED lighting with the strong directivity, and make the output light softer (Figure 4). It is possible to provide a lighting device which has a stereoscopic effect on its light reflector by drawing striation patterns on the surface of the light reflector in order to add a slight change the luminance distribution of the light reflector (Figure 5).

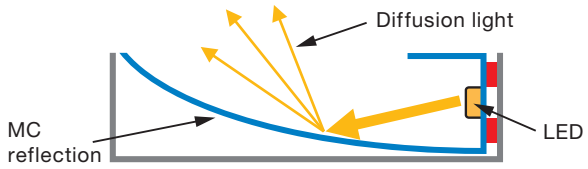


Figure 3 The cross-sectional structure of an indirect lighting and an image of the reflection.

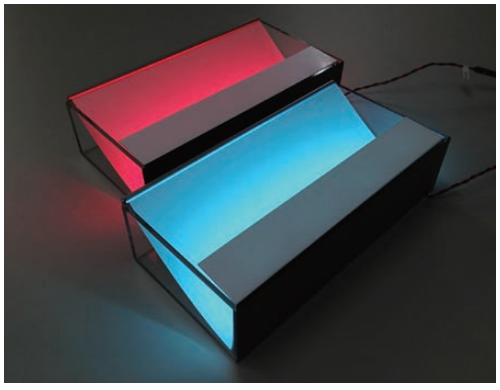


Figure 4 A LED indirect lighting using a MC light reflector.

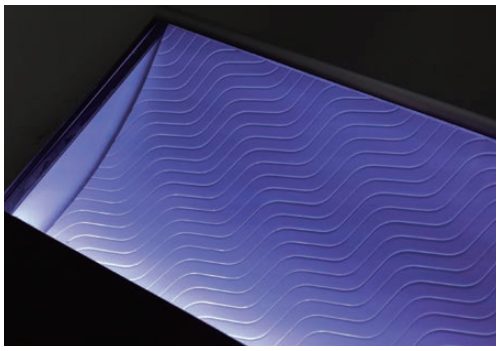
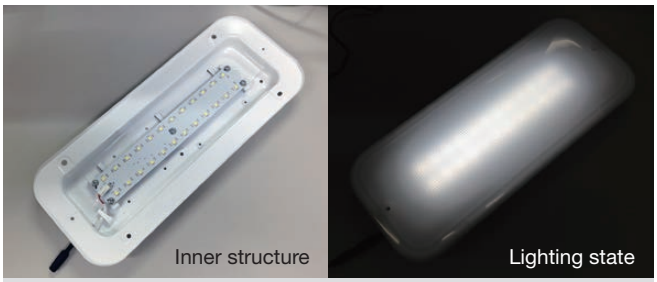


Figure 5 A lighting drawn striation patterns on the surface of the light reflector.

Figure 6 shows the examples of the study for a room lamp where several LED light sources are placed. The conventional lamp has a luminance irregularity and a glare because a substrate which has some LED light sources mounted is placed on the bottom of the lamp housing. However, the glare is resolved and the luminance irregularity is improved by using MCPET for inner surface of the lamp's housing and having an indirect lighting structure with LED light sources placed on an internal peripheral side face, therefore, a surface emitted room lamp can be obtained.



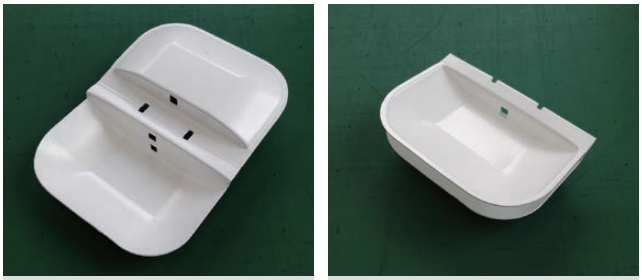
A Lamp with LED mounted substrate on the bottom

A Lamp with MCPET housing and LEDs placed on an internal peripheral side face

Figure 6 A LED indirect lighting using a MC light reflector.

3.2 The Double Layered Lighting Structure Device With the Advantage of a Thermoformability

We will show the examples of the study for the room lamps which take advantage of the thermoformability of the MC light reflector. The MC light reflector is formed as a formed body which has two domical shapes shown in Figure 7(a) and it is folded in half to make two reflection spaces inside and outside (Figure 7(b)). The outside reflection space is a practical white lighting from the white LED light sources. Blue LED light sources are placed in the inside reflection space, therefore, the light from the LED light source repeats inter-diffuse reflection in the space between two reflectors, and an outer circumference of the lamp becomes a linear blue ambient lamp (Figure 8). That is, two modes lightings having the functions of a lamp and an illumination lamp can be easily incorporated with one reflector (Figure 9). The color selection of the illumination lamp can be expanded by using different color variations of LED light sources, red or green and other colors, not limited to blue. In addition, a lightweight lamp becomes available while having the reflector as a part of the housing.



(a) MCPET formed body

(b) MCPET formed body folded in half

Figure 7 The thermoformed MCPET.

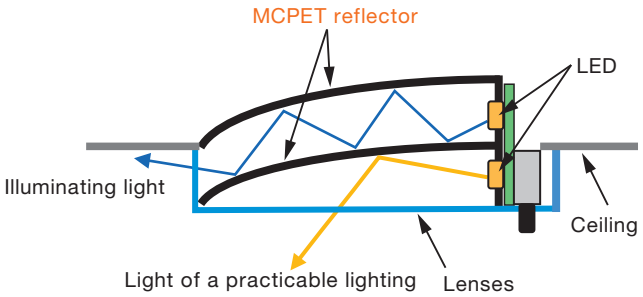
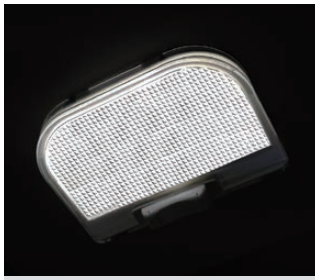


Figure 8 The cross-sectional view of a lighting device.



Room lamp mode

Illumination mode

Figure 9 The two modes lightings using the thermoformed MCPET.

4. THE ADVANTAGES OF AN MC REFLECTOR APPLICATION

Following are the advantages of applying an MC reflector which has the superior reflection characteristics of the room lamp for the automobile as mentioned above.

- The luminance increases (1.3 – 2 times).
- Based on the increase of the luminance, the number of LED light source can be reduced and the energy saving performance is improved.
- The luminance distribution is planarized and the glare is reduced by the difusion reflection or the multi difusion reflection.
- The various optical designs are available with a high reflectivity and a superior thermoformability.
- The lighting quality of the indoor space of the automobile by glow of indirect lighting improves.
- The weight is lighter (Approx. 30 - 50% reduction of the weight is available by using a MC reflector as a part of the lamp housing).

5. MCPET APPLICATION TO A VIBRATION PLATE

The MCPET and MCPOLYCA are superior materials not only for a light reflection property but also for an acoustic property because of its lightweight, its high relative strength and its high relative elasticity. Using this feature, the MC light reflectors are commercialized as a vibration plate for speakers, earphones or headphones (Figure 10).

Figure 10 The audio products where MCPET adopted as a vibration plate.

6. THE NOVEL DEVELOPMENT AS A COMMUNICATION DEVICE WITH LIGHT AND SOUND

To match up with the progress in automatic driving cars which have an accelerating development in the practical use, the importance of a communication between cars and people (a driver, other drivers, pedestrians and others) is increasing. MCPET and MCPOLYCA are the materials which act as a vibration plate in addition to the feature of the light reflector, therefore, using these features, it can be considered that new device made in one material, which can establish a communication with people will be available.

One example of the room lamp which has a communication by light and sound is shown in Figure 11. When the light from the LED light source placed on the back center of the room lamp is diffusely reflected at the MCPET reflector, it becomes the uniformly surface-emitting room lamp on the outer circumference. In an emergency, with a color variation of the light from the LED light source, MCPET reflector is vibrated to make it as a speaker by a piezoelectric device on the back center of the MCPET reflector, therefore, the emergency information can be noticed by the occupants from light and sound.

In addition to the above, with the addition of an AI speaker function in a lighting device, the lighting device becomes intelligent and is expected to have wide application.

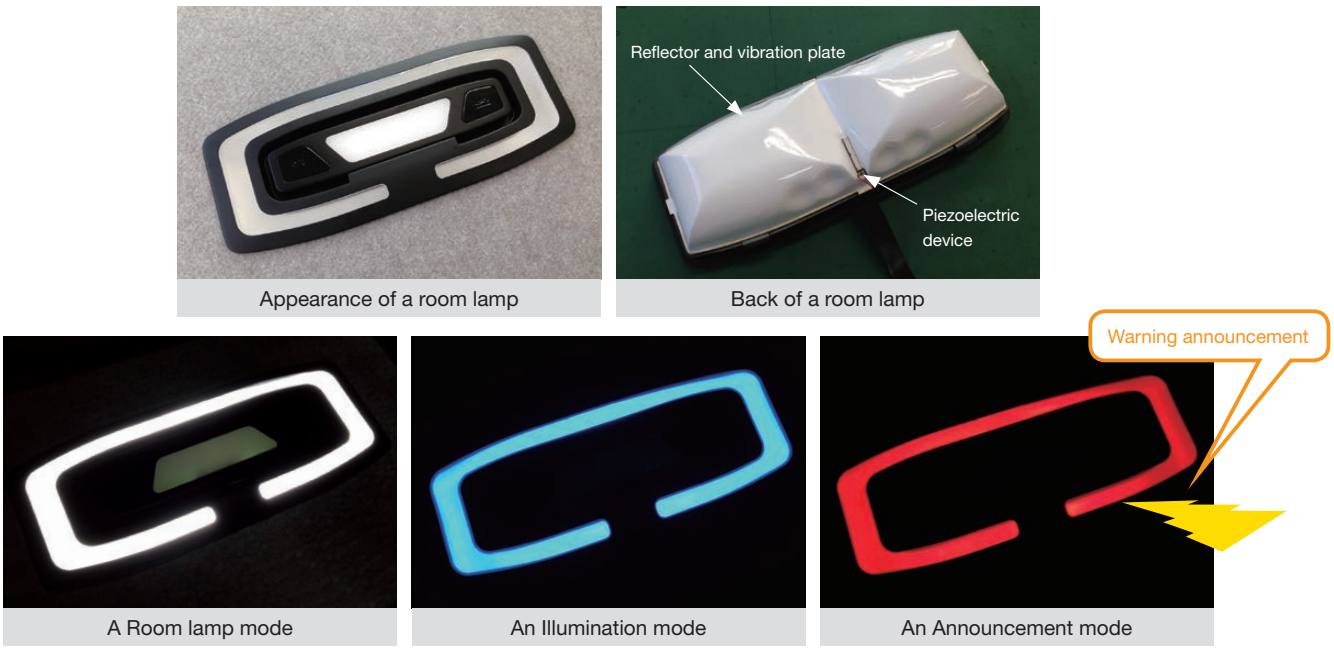


Figure 11 An example of the room lamp as a communication device.

7. CONCLUSION

MCPET and MCPOLYCA are the unique materials which have a superior light reflection property, an acoustic property and a forming processability due to a cell structure of microcellular foam, and also have a light weight and a high stiffness. As high-performance materials which can accommodate to the acceleration of an electrically drive and an automatic drive in the future, they are expected to have wide applications and developments of such as light weight and indirect lighting devices and intelligent communication device.

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