Enabling Materials with Various Optical Performance

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ABSTRACT

Optical performance is one of the key factors to enhance device performance. The main purpose of enabling materials with various optical performance is refractive index, transmittance, and reflectance controlling.

1 Introduction

Next generation display technology that requires to optical control needs various materials to optimize the design as long as the demands of advanced display devices continue. It also helps to enhance device efficiency and reduce environmental impact. This research will be introduced the enablers that focused on optical properties.

2 Refractive Index Photo-Patternable

2.1 Refractive Index Controlling

The material combination of different refractive index materials provides high light extraction efficiency to enhance OLED performance. It is also possible to enhance the view angle and refine the image. Previously, the organic-inorganic hybrid materials based on silsesquioxane polymer containing metal oxide particles were developed [1]. This paper presented the new synthesis method, and optical and physical properties for new materials.

2.2 Sample Preparation

Organic-inorganic hybrid formulation was developed which has radical polymerization system.

Table 1. The composition was prepared with using the following materials.

Sample A, B, C for Refractive Index
Acrylic polymer
Monomer
Photo initiator
Inorganic material
Solvent

Uniform coatings were obtained by spin coating of composition in the thickness range indicated in the spin curves using the compositions from Table 1. The coated samples were heated on a hot plate at 100°C for 90sec. Then the samples were exposure to light by ghi-line exposure tool at 100mJ/cm^2 with using any pattern photo mask. The samples were developed by 0.1%KOHaq. The temperature of the developer was 25 °C. The developed samples were rinsed with D.I. water and then dried. Cured of the developed sample at 230 °C for 30min. For RI, haze, and transmittance measurement of samples, samples were fabricated by using the compositions from Table 1.

2.3 Measurement

Optical performances such as refractive index, haze, and transmittance were measured at ellipsometer, spectrophotometric colorimeter, respectively. Pattern profile of the samples were checked by optical microscope, and SEM. The sample on CPI film was bended without any metal rod used. Surface condition was checked by optical microscope.

2.4 Results

This coating refractive index materials provide the wide range of performance to fulfil the device characteristics.

Table 2. Haze of different refractive index materials

	RI at 550nm	HAZE
Sample A	1.76	0.24
Sample B	1.91	0.53
Sample C	2.06	0.52

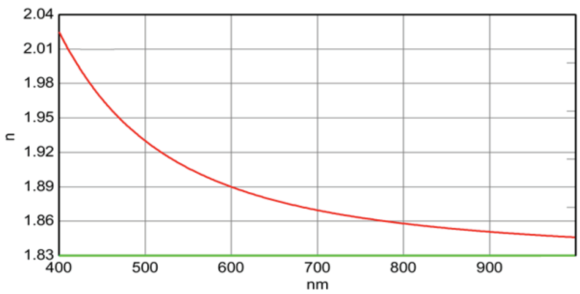

Fig.1 n value of Sample B

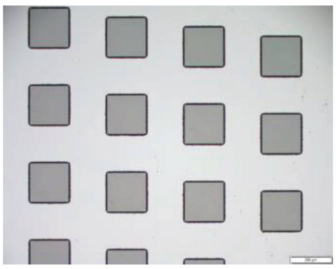

Fig.2 Optical microscope observation of sample B (X 10, 200μm Dot, F.T.=2.2μm)

Haze of different refractive index materials at 550nm was shown in Table 2. The wide range of refractive index materials were designed with minimum haze property. n value of sample B and optical microscope observation were shown in Fig.1, Fig.2. In addition, low-concentration inorganic development is possible.

Optical microscope observation after bending test without any metal rod used in Fig.3. Our material has not seen any crack when bended it itself.

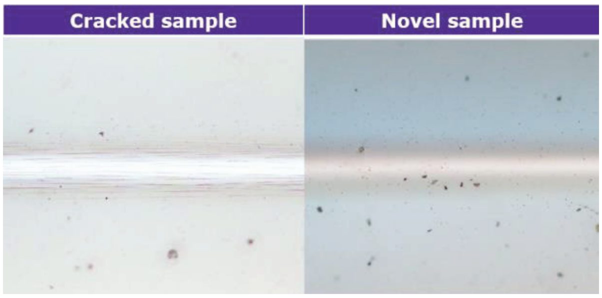

Fig.3 Optical microscope observation of sample C after bending test w/o any rod used (X5, Radius=0mm)

3 Transparence Photo-Patternable

3.1 Transmittance Controlling

The light emitting diodes are mounted at high density and it generates the specific wavelength light. It is necessary to have transparent, insulation, high definition, and high reliability without any color change photosensitive material to maintain high brightness. Recently, highly reliable photo patternable interlayers in TFT and touch sensor layers based on inorganic-organic hybrid polymers have studied [2]. This paper focused on thick film materials.

3.2 Sample Preparation

Uniform coatings were obtained by spin coating of negative tone photosensitive in the thickness range indicated in the spin curves using the compositions from Table 3. The spin coated samples were heated on a hot plate at 100°C for 90sec.

Table 3. The composition was prepared with using the following materials.

Sample D for Transparence Bank	Sample E for Transparence Bank
Siloxane polymer	Acrylic polymer
Monomer	Monomer
Photo initiator	Photo initiator
Solvent	Solvent

Then the samples were exposure to light by ghi-line exposure tool at 190mJ/cm^2 with using any pattern photo mask. The samples were developed by 2.38% TMAHaq. The temperature of the developer was 25 °C. The developed samples were rinsed with D.I. water and then dried. Cured of the developed sample at 230 °C for 30min. For transmittance, color measurement of samples, samples were fabricated by using the compositions from Table 3.

3.3 Measurement

Optical performances such as color, and transmittance were measured at spectrophotometric colorimeter. Pattern profile of the samples were checked by optical microscope, and SEM. Sunlight irradiation evaluation of the samples were performed by Q-SUN XE-1 XENON TEST CHAMBER at 75W/m2 for one week at 25 °C. Optical properties were confirmed before and after the evaluation.

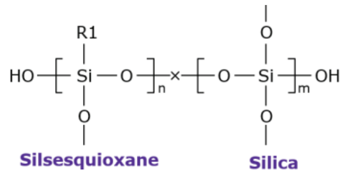

Fig.4 The structure of siloxane material

3.4 Results

Transparent bank was consisted of siloxane polymer (Fig.4). In-house alkaline soluble polymer with Si-O bond has excellent transmittance and reliability. Negative tone formulation was available for high reliable thick film bank.

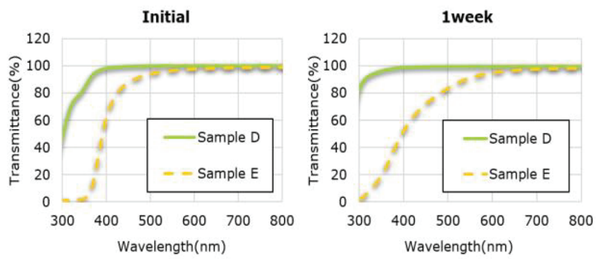

Fig.5 The transmission spectrum of sample D and sample E before and after sunlight irradiation for one week

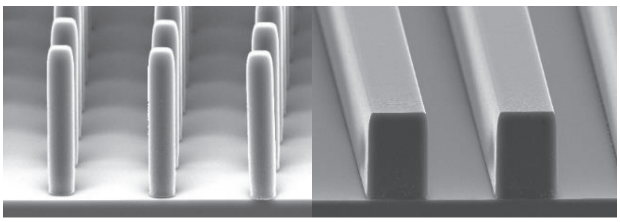

Fig.6 Cross-section SEM images of sample D (Left : X 2,000, 5μm Dot, F.T.=27μm, Right : X 1,300, 20μm L&S, F.T.=27μm,)

As shown in Fig.5, 20μm film thickness photo-patternable sample D showed more than 99% transmittance at 400nm. It is also possible to provide fine pattern resolution with high aspect ratio. Pattern profiles of sample D were shown in Fig.6. Excellent reliability of sample D to prevent any yellowish color change was confirmed when performed sunlight irradiation test for one week. However, sample E as an acrylic sample, a significant color change occurred was shown in Fig.7 and Fig.8.

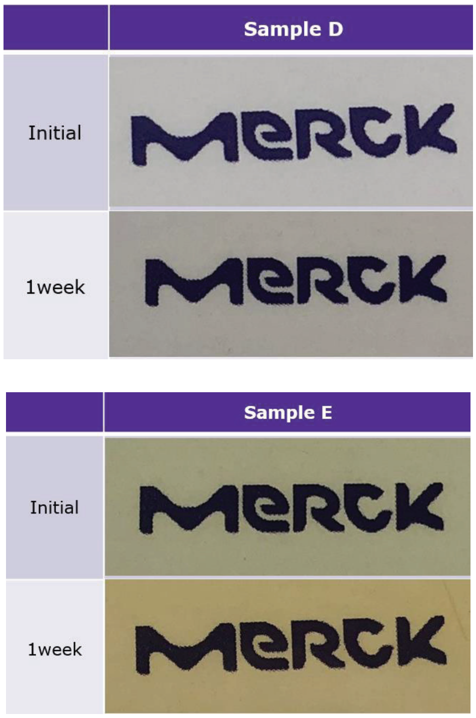

Fig.7 Effect of sunlight irradiation on the color of each thick film material

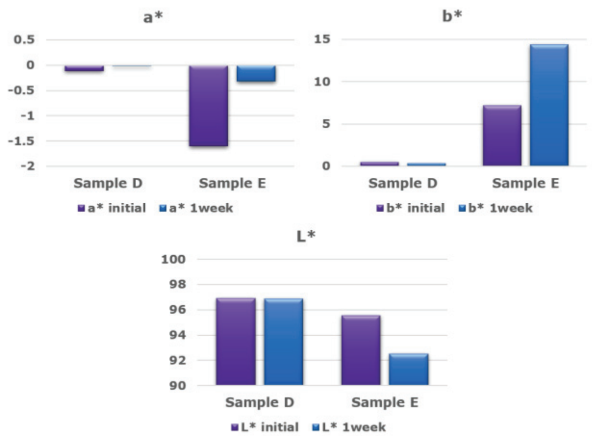

Fig.8 The color change of sunlight irradiation on the thick film material deference for one week

4 Photon Recycling Photo-Patternable

4.1 Photon Recycling Controlling

Photon recycling plays important role in the study of materials for optoelectronic devices. Because photon recycling material for assisting light extraction source is needed to enhance the device performance, which is brightness increase of the display. The study of certain optical density material to prevent color mixing between RGB pixels while maintaining the function of photonic technology was actively carried out. It is needed when pixel size getting smaller for next generation display. As shown in Fig.9, there are white colored, gray colored, black colored bank as positive impact on photon recycling while preventing color mixing. Burschka et.al. mentioned regarding the development of black bank for the next generation QD-OLED [3].

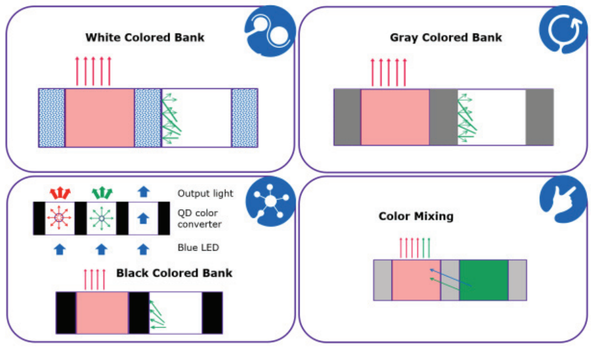

Fig.9 White colored, Gray colored, Black colored bank as positive impact on photon recycling while preventing color mixing

4.2 Sample Preparation

Uniform coatings were obtained by spin coating of the solution in the thickness range indicated in the spin curves using the compositions from Table 4. The spin coated sample were heated on a hot plate at 100°C for 90sec.

Table 4. The composition was prepared with using the following materials.

Sample F for White Colored Bank	Sample G for Gray Colored Bank
Acrylic polymer	Acrylic polymer
Monomer	Monomer
Photo initiator	Photo initiator
Colorant (White)	Colorant (White, Black)
Solvent	Solvent

The coated sample was exposure to light by ghi-line exposure tool at 120mJ/cm^2 without using any pattern photo mask. The samples were developed by 0.03%KOHaq. The temperature of the developer was 25 °C. The developed sample were rinsed with D.I. water and then dried. Cured of the developed sample at 230 °C for 30min. For optical density (O.D.) and reflectance measurement of samples, samples were fabricated by using the compositions from Table 4. The average film thickness of cured samples was 15μm.

4.3 Measurement

The transmission spectrum of the obtained samples was measured by spectrophotometric colorimeter. O.D. values of the sample at 460, 540, 630nm were separately calculated. The reflection spectrum of the obtained sample was measured by spectrophotometric colorimeter.

4.4 Results

A photon recycling bank maximizes diffuse reflection with specific O.D. control utilizing by the conventional photolithography process. Sample F as white colored bank reached more than 80% reflectance with O.D.1, and sample G that was gray colored bank reached more than 50% reflectance with O.D.2 to prevent any color mixing was shown in Fig.10.

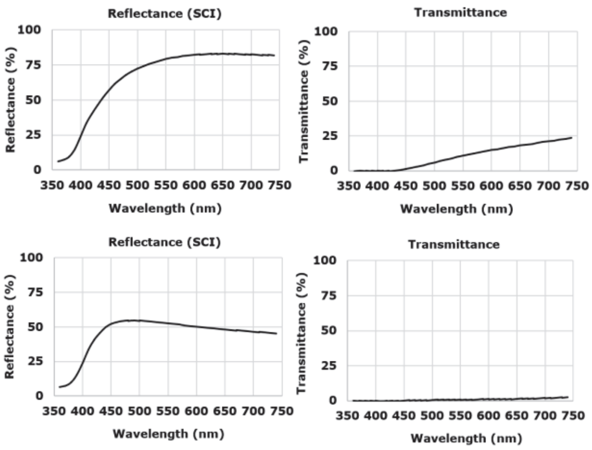

Fig.10 Optical properties (Upper : Sample F, Lower : Sample G)

5 Conclusions

We achieved to establish high performance optical materials. Photo-patternable high refractive index materials can be used for flexible and foldable displays. It was found that these materials indicated low haze property regardless high refractive index difference. High transparent siloxane material has excellent reliability without any yellowish color change when performed sunlight irradiation test. It is photo-patternable transparent bank with high definition. Our photon recycling bank can be controlled reflectance and O.D. when we design the formulation according to the purpose of display devices. These novel materials with high optical performance will be an enabler of future displays.

References

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