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We have investigated selective photoluminescence dye patterning using light stamping lithography (LSL) technique. Polydimethylsiloxane (PDMS) stamp was used for the substrate mold in LSL. In order to determine the formation of patterned PDMS molds, photoluminescence dye was prepared with diaminomaleonitrile moiety and selectively deposited on the patterned PDMS molds. UV-vis absorption and photoluminescence (PL) spectra of the dye were determined at 535 nm and 580 nm, respectively. The corresponding selective dye layer deposition was formed by hydrophobic interactions between PDMS and dye molecules.

Keywords: light stamping lithography (LSL); patterning; photoluminescence

INTRODUCTION

To make designed pattern is very attractive research subject onto the current science and engineering fields. Especially, light stamping lithography (LSL) technique is considered as an important and easy way to generate aimed patterns using elastomeric stamp and offers cost-effective preparation steps. LSL also provides various types patterns with diverse

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sizes and features in shape. It is well known that a patterned PDMS in LSL method is physically attached and transferred onto the substrate using UV-induced adhesion reaction. This LSL technique is regarded as very simple and convenient means to make desired pattern shapes.

Photoluminescence is defined as the emission of light which is caused by the irradiation of a substance with light energy absorption. These photoluminescence materials have been greatly attracted for the potential application areas such as information displays, biomolecule detections, environmental metal-ion recognitions and so on. Thus, the luminescence dyes can be utilized for their fluorescent characteristics in various luminescent sensing or indicating purposes [1–6].

In this context, we report the interesting approaches on the preparation of PDMS molds and consecutive luminescence dye pattering on the patterned PDMS. In this study, the red light emitting dye compound based on diaminomaleonitrile moiety was synthesized [1, 8–10] and selective dye patterning mold was prepared with light stamping lithography (LSL) method [7].

EXPERIMENTAL

Synthesis of *N,N′*-bis[4-(*N,N*-dimethylamino)-benzylidine]diaminomaleonitrile [8]

A solution of diaminomaleonitrile (0.2 g, 1.8 mmol) and 4-(dimethylamino)benzaldehyde (0.5 g, 3.6 mmol) in 20 ml of benzene and 2 ml of piperidine was stirred and heated at 75°C for 5 hr. Water was removed using Dean-Stark trap. After reaction, the mixture was cooled down to room temperature. The mixture was then filtered, washed and recrystallized with chloroform. Yield: 14%, Anal. Calcd. for $C_{22}H_{22}N_6$: C, 71.33; H, 5.99; N, 22.69; Found C, 69.80; H, 5.66; N, 23.66.

The dye structure of *N,N′*-bis[4-(*N,N*-dimethylamino)-benzylidine]-diaminomaleonitrile is shown in Fig. 1.

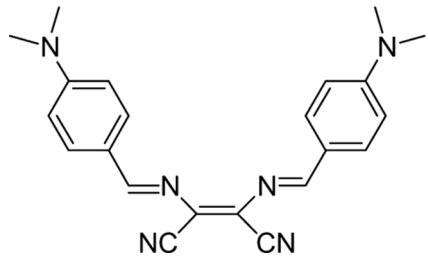


FIGURE 1 Dye structure of *N,N′*-bis[4-(N,N-dimethylamino)-benzylidine]-diaminomaleonitrile.

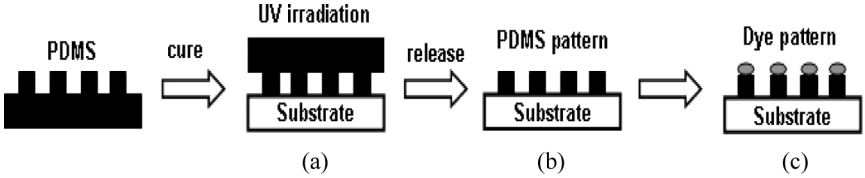


FIGURE 2 Scheme of photoluminescence dye patterning by LSL method.

Preparation of Selective Photoluminescence Dye Patterning

The selective photoluminescence dye patterning was fabricated with light stamping lithography (LSL) skills. Generally, LSL methods include three steps. At first, the surface of the glass slide (76×26 mm) was sequentially ultra-sonicated in acetone and ethanol, followed by sonication in distilled water for 5 min, respectively. After this step, the substrate was pretreated by piranha for 10 min. The piranha is a mixture solution using H_2SO_4 and H_2O_2 (7:3). Pretreatment of the piranha provides the generation of functional group ($-$OH) on the substrate surface. The patterned PDMS stamp was then fabricated on the glass slide surface. In this process, to form chemical bonds between glass slide surface and PDMS stamp, the sample was subjected to UV irradiation using *UVitec CL-E 508G* (250 nm) for 5 min. Secondly, PDMS stamp is physically peeled off from the glass slide. Finally, the synthesized photoluminescence dye was deposited by hydrophobic interaction on the remained PDMS patterned molds of the substrate surface. The patterned photoluminescence dyes on the substrate were washed off using water to remove excess dyes and dried with nitrogen condition. The preparation scheme of photoluminescence dye patterning is shown in Fig. 2.

RESULTS AND DISCUSSION

Absorption and Photoluminescence Spectra of *N,N′*-bis-[4-(*N,N*-dimethylamino)-benzylidine]diaminomaleonitrile

The UV-vis absorption and photoluminescence spectra of the *N,N′*-bis-[4-(*N,N*-dimethylamino)-benzenylidine]diaminomaleonitrile were shown in Fig. 3. Absorption peak of the dye was observed at 535 nm and photoluminescence emission was determined at 580 nm. In comparison with the absorption spectrum, the photoluminescence spectrum showed red shift behavior.

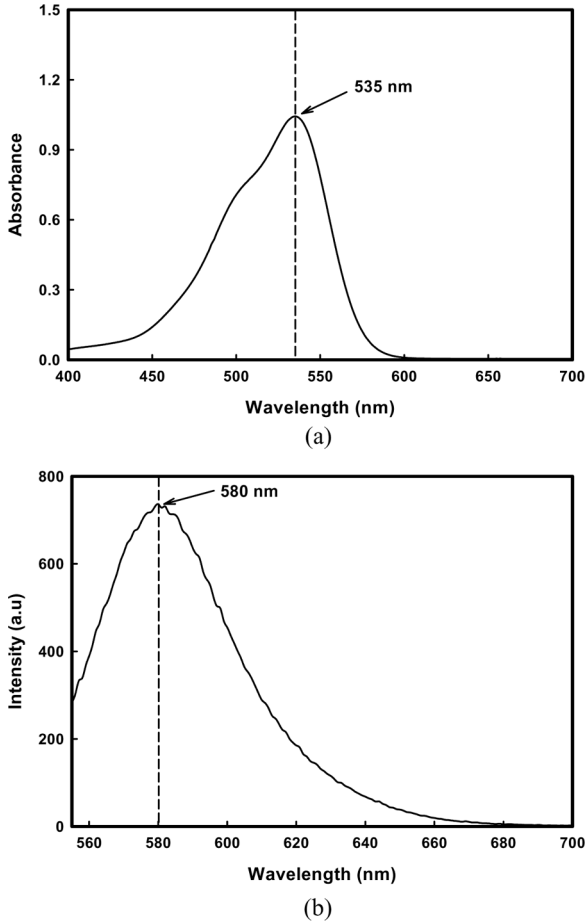
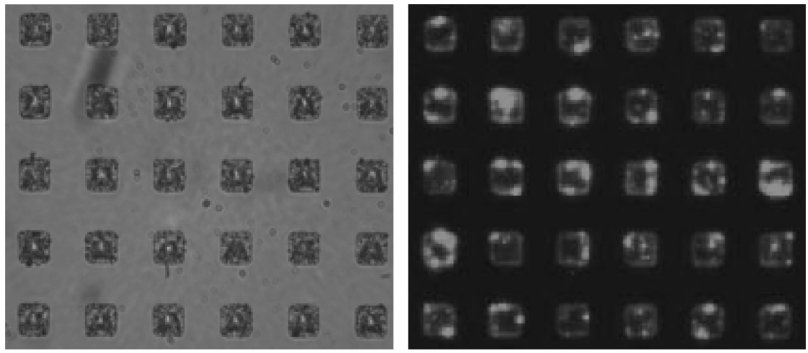


FIGURE 3 UV-vis absorption spectrum (a) and photoluminescence spectrum (b) in chloroform.

Selective Photoluminescence Dye Patterning

The patterning images with the prepared photoluminescence dye are shown in Fig. 4. As described earlier, the PDMS stamp was fabricated on the glass slide surface. This PDMS stamp was attached on glass slide surface by UV irradiation at this step. The PDMS stamp was then peeled off carefully from the substrate surface. The designed PDMS pattern was then completed. Finally, the luminescence dye was deposited by hydrophobic interaction on the patterned substrate



(a) (b)

FIGURE 4 Optical microscope images of PDMS pattern (a) and photoluminescence dye deposition (b).

surface. And the pattern was then washed by distilled water. The dye pattern was clearly determined and observed.

In Figure 4, images of the PDMS pattern and photoluminescence dye deposition on PDMS molds are shown. This dye deposition of the patterned PDMS surface on the plane array of squares (50 μm) was fabricated using 0.001 g/ml photoluminescence dye in chloroform. This patterned photoluminescence dye emits red color light under UV irradiation. From Figure 4 (b), it is proposed that this red light emitting result could confirm the selective dye deposition on the patterned molds by hydrophobic interaction between PDMS and dye.

CONCLUSIONS

In this paper, we have studied photoluminescence dye patterning with PDMS using light stamping lithography method. In order to use luminescence patterning property, the light emitting dye material was synthesized from diaminomaleonitrile derivative. The corresponding photoluminescence property was investigated. The absorption and emission peak of *N,N′*-bis[4-(N,N-dimethylamino)-benzenylidine]diaminomaleonitrile was determined at 535 nm and 580 nm, respectively. The selective photoluminescence dye patterning was determined by optical microscope images. The finding red light emitting result could confirm the selective dye deposition on the patterned stamp by hydrophobic interaction between PDMS and dye.

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