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Langumuir-Blodgett Films for White Light Emission EL Device

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Langumuir-Blodgett (LB) films for white light emitting layer was deposited from mixtures containing as much as 0, 10, 20 and 30 mol% of arachidic acid (AA). In the surface morphology of LB monolayers observed by AFM (atomic force microscope), phase separation, which attributed to a phase-separated polymer and organic molecule, was observed. In the voltage-current characteristics of EL device, which use mixed monolayer of 13 layers deposited by LB method as an emitting layer, current density was much smaller than that of the spin-coated devices. It may due to the large contact resistance existed at the interface of LB layer/organic layer inhibit carrier injection to the emitting layer.

Keywords: Langumuir-Blodgett method; electroluminescence; atomic force microscopy; white light emission

INTRODUCTION

Organic white electroluminescent devices have attracted much attention due to their possible application as light source and backlight for liquid crystal display. So far, various device configuration such as multilayer structure, polymer blends and polymer doped with three primary color dyes and microcavity structure are used to produce white light[1,2]. Recently, we have

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reported that white light emission is achieved by exciplex formation in spin-coated emitting layer[3]. The LB deposition technique is known as the most promising techniques, which allows the oriented layer of molecularly controlled architectures. To date, several groups have been reported physical, electrical and optical properties of various LB ultrathin films[4].
In this paper, we fabricated LB films for white light EL device changed with a ratio of arachidic acid (AA) in order to obtain a controlled multilayer and surface morphology was investigated by AFM.

EXPERIMENTAL

Monolayers of mixtures of poly(N-vinylcarbazole) (PVK) doped with 30 wt% of 2,5-bis(5-tert-bytyl-2-benzoxazolyl)thiophene (BBOT), 2.17 mol% of N,N'-diphenyl-N,N'-bis(3-metylphenyl)-1, 1'-biphenyl-4,4'-diamine (TPD) and 0.039 mol% of poly(3-hexylthiophene) (P3HT) and various amount of AA were spread from chloroform solutions on to a water subphase. Multilayer films containing 30mol% of AA were built up by the typical vertical lifting method at 20 ^{o}C and 26 mN/m. AFM images was performed in air with multimode atomic force microscope (digital instruments). Images were acquired in tapping mode and typical scan range was 5 μm. Organic EL device fabricated having a structure of ITO/CuPc/MEL/BBOT/LiF/Al with deposited LB films of 13 layer and voltage-current-luminance characteristics of device measured with a diode array system.

RESULT AND DISCUSSION

Figure 1 shows surface pressure-area isotherms of mixtures containing as

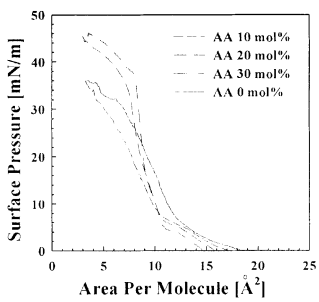

FIGURE 1 Surface pressure-area isotherms of mixed monolayers as a function of mixing ratio of AA.

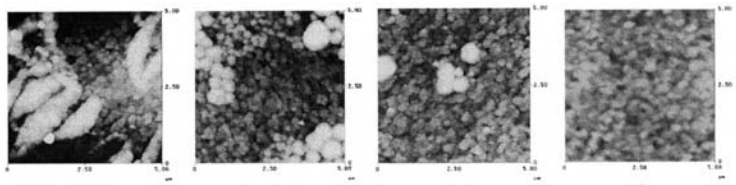

FIGURE 2 AFM images of mixed monolayers as a function of mixing ratio of AA (a) AA 0, (b) AA 10, (c) AA 20 and (d) AA 30 mol%.

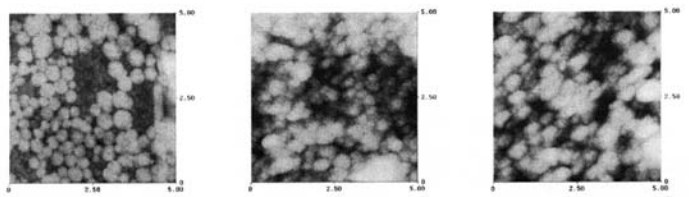

FIGURE 3 AFM images of multilayers mixed with 30mol% of AA (a) 3, (b) 7 and (c) 11 layer.

much as 0, 10, 20 and 30 mol% of AA. As can be seen, mixtures containing as much as 30 mol% of AA form stable condensed monolayer while the monolayer without AA is in the expanded state because PVK take on a 3D collapsed[5]. Also, it is found that a phase transition occurs in these isotherms at about 5 mN/m. All of mixed monolayers with different molar ratios could be readily transferred onto ITO (indium-tin-oxide) substrate at 16, 17, 24 and 26 mN/m, respectively.

Surface morphology of mixed monolayers showed in Figure 2. The brighter intensity of the light visualized at some places in AFM images is related to the phase separation, which attributed to a phase-separated polymer and organic molecule. The monolayer containing 30 mol% of AA, however, showed a roughness value of 28 Å and became homogeneous decreasing with the phase separation.

Figure 3 shows AFM images of 3, 7 and 11 monolayers deposited from mixture containing 30 mol% of AA. The phase separation appears again and the grain size increased with increasing number of monolayer. The roughness value was 116, 83, 90 Å, respectively. These results indicate that the LB multilayer need buffer layer, which conserve the stability of the monolayer.

We fabricated organic EL device of ITO/CuPc/MEL/BBOT/LiF/Al using mixed monolayer of 13 layers deposited by LB method as an emitting layer. Figure 4(a) and (b) shows the voltage-current-luminance characteristics and EL spectrum of EL device. In the voltage-current characteristics of EL device,

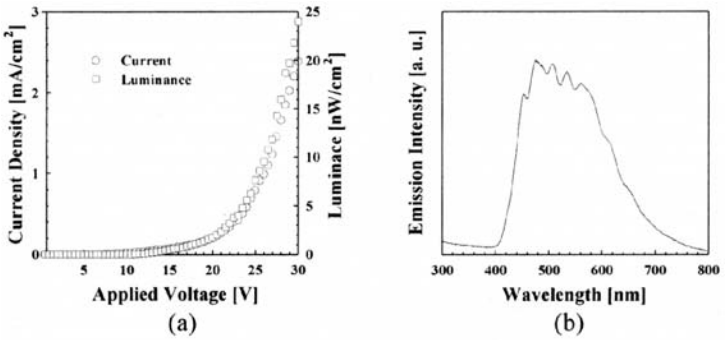

FIGURE 4 Voltage-current-luminance characteristics (a) and EL spectrum of EL device (b).

current density was much smaller than that of the spin-coated devices. It may due to the large contact resistance existed at the interface of LB layer/organic layer inhibit carrier injection to the emitting layer. EL spectrum shows the emission peak at 450 and 470nm from BBOT, 505 and 555nm originated from exciplex, and 650nm from P3HT. Also, it can be seen the device emit white light with CIE coordinate x=0.306, y=0.353.

CONCLUSION

Organic EL device with white light emission was obtained from a mixed emitting layer deposited by LB method. The surface morphology of monolayer containing 30 mol% of AA became homogeneous decreasing with the phase separation whereas the multilayer increase the roughness value. For the stable multilayer, the mixed LB monolayers need buffer layer, which conserve the stability of the monolayer.

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