Influence of Co-solvent Solutions on Ink Filling and Fabrication of High-resolution OLED via Sublimation Transfer Process

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ABSTRACT

We studied the effect of the co-solvent solutions on the ink filling onto the donor substrate and sublimation transfer process. The co-solvented ink properties are closely related to the ink filling. The co-solvented ink prepared with chlorobenzene, ortho-dichlorobenzene, and chloroform mixture. The ink filling and sublimation transfer process with co-solvented ink has successfully optimized.

1 INTRODUCTION

Recently, ultra-high resolution display technology demands are rapidly increases. However, conventional color pattering technologies such as fine metal mask (FMM) and inkjet printing, which are very difficult to fabricate high resolution pixels [1]. We reported high resolution patterning technology of OLED via capillary-induced ink and sublimation transferred process using intense pulse light (IPL) [2, 3]. The relation between various solvents mixture and ink drops into well structure are researched [4]. In order to achieve fine optimization for the ink filling and sublimation transfer process for fabricate high resolution OLED, various co-solvented inks are attempted. First, the co-solvented inks are prepared and bank and microchannel on the donor substrate turns to hydrophobic and hydrophilic by selective surface treatment before ink filling. To fill the ink, spin-coated the co-solvented ink onto the donor substrate and the filled inks were annealed for solidification and rid of residual solvent. Finally, solidified ink deposited on target substrate via sublimation transfer process with IPL. In this work, we studied influence of co-solvent solutions on ink filling into donor substrate and sublimation transfer process to improving ink filling condition and optimization for emitting layer (EML).

2 EXPERIMENT

2.1 Produce Co-Solvent Inks

Solutions for the co-solvented inks prepared by mixture of different solvents: chlorobenzene (CB), ortho-dichlorobenzene (oDCB), and chloroform (CF). These solvents were mixed five types as following volume ratio: CB only, 1:2 ratio of CB: oDCB, 2:1 ratio of CB: oDCB, 1:2 ratio of CB: CF, and 2:1 ratio of CB: CF. The red ink for emission layer has Bis(2-methyldibenzo[f,h]quinoxaline) (acetylacetonate) iridium(III) [$Ir(MDQ)_2acac$] served as a dopant, and 4,4′-Bis(N-carbazolyl)-1,1′-biphenyl [CBP] served as a host. CBP: $Ir(MDQ)_2acac$ (10wt%) were dissolved in co-solvented solutions with concentration of 7.5ml/mg, respectively.

2.2 Sublimation transfer process

The co-solvent inks are spin coating onto donor substrate for the sublimation transfer process. The donor substrate have banks and micro channels on light to heat conversion (LTHC) layer. The structure of light to heat conversion layer consist of metal layer and silicon oxide layer were laminated. These structure makes the energy of intense pulse light converses to heat and this process makes the ink sublimation transferred. The banks and microchannels of the donor substrate turn to hydrophobic and hydrophilic by selective surface treatment. The ink filling onto selective surface treated donor substrate by spin-coating process. Ink-filled donor substrate was annealed for rid of residual solvent and solidification. The deposited ink into the microchannel are sublimation transfer to the target substrate by IPL in vacuum chamber at pressure level of 4.0 x 10^{-7} torr. The transferred patterns were measured using Atomic Force Microscope (AFM) and Optical Microscope (OM).

2.3 Device Fabrication

In this study, bottom emission structured OLEDs were fabricated using thermal evaporation except for emission layer. For the fabrication of OLED, NPB as the HIL was evaporated onto the ITO-patterned substrate and TCTA as the HTL/EBL was evaporated on top of the NPB layer using vacuum thermal evaporation. For the emission layer deposition, the sublimation transfer process was applied. Subsequently, TPBi as the ETL/HBL was evaporated on top of the red deposited pattern of emission layer. A lithium fluoride and aluminum as a cathode were deposited on top of ETL using vacuum thermal evaporation process. The thickness of each layer of OLED were NPB (35nm) / TCTA (15nm) / EML (depends on ink) / TPBi (25nm) / LiF (1nm) / Al (100nm).

3 RESULTS

The influence of co-solvent solutions on ink filling and sublimation transfer process was investigated. Co-solvented ink properties such as boiling point, vapor pressure has changed with mixture ratio of solvents, which can influence the ink filling condition. And ink filling condition in micro channel influence on shape, roughness, thickness of sublimation transferred EML pattern. Fig. 1 shows that the relation between co-solvent solutions properties and ink filling. As shown in Fig. 1 according to the properties such as vapor pressure, the induced thickness of filled ink are influenced. Capillary-induced ink with lower vapor pressure had filled as thinner than the others. Thicknesses of sublimation transferred pattern with each co-solvented ink were shown in Table.1. Also, Fig.2 shows the measured thickness and characteristic comparison of co-solvented inks. As shown in Fig.2, the vapor pressure, boiling point, and viscosity trends are closely related to thickness of transferred pattern. Co-solvented ink properties are influence to filling condition of capillary-induced ink onto the donor substrate.

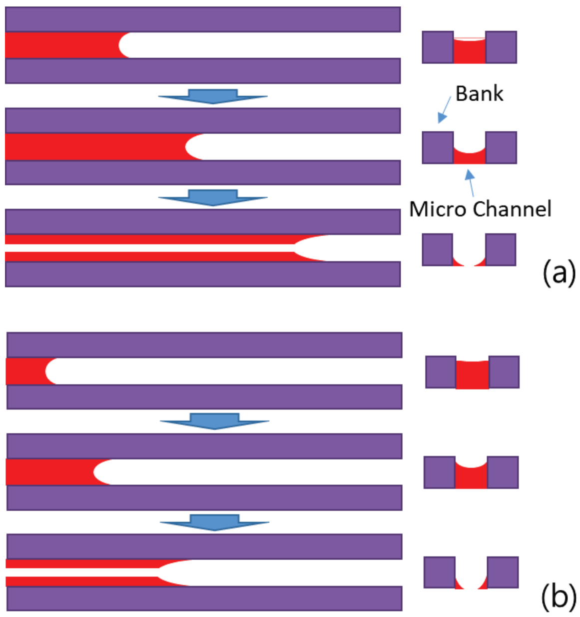

Fig. 1 Schematic diagram of ink filling with (a) low vapor pressure and (b) high vapor pressure inks

Co-solvent Ink	Thickness (nm)
Chlorobenzene	120.065
Chlorobenzene 1 : 2 o-Dichlorobenzene	84.310
Chlorobenzene 2 : 1 o-Dichlorobenzene	88.351
Chlorobenzene 1 : 2 Chloroform	390.613
Chlorobenzene 2 : 1 Chloroform	140.329

Table. 1 Thickness of sublimation transferred pattern with Co-solvented inks

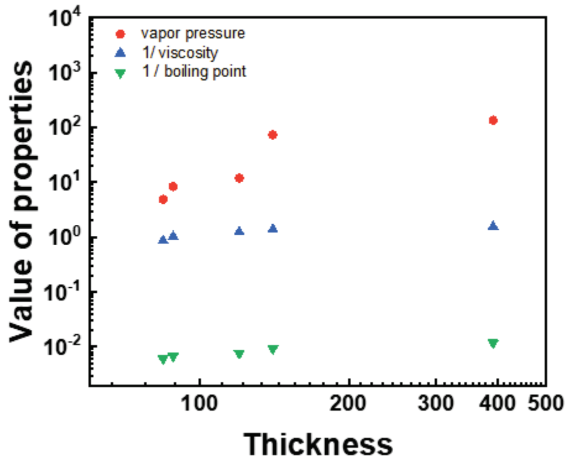

Fig. 2 Characteristic comparison of sublimation transferred pattern

As a result, red co-solvented ink with 2:1 ratio of CB: oDCB is optimized on sublimation transfer process. We fabricated OLEDs device with 2:1 ratio of CB: oDCB co-solvented ink. Fig.3 shows the optical microscope image of fabricated OLEDs with sublimation transferred EML. The electroluminescence spectrum having main peak at 605nm shows fabricated OLED successfully works.

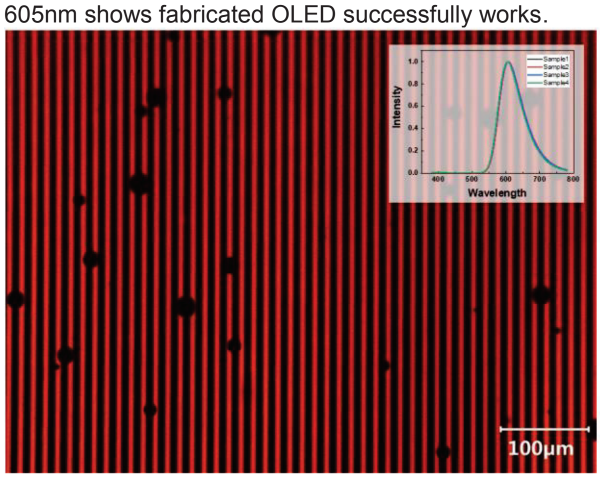

Fig. 3 Optical microscope image of fabricated OLEDs with sublimation transferred EML. Inset shows the normalized EL spectra of OLEDs

4 CONCLUSIONS

To improve the ink filling and transfer process of high-resolution sublimation transferred EML, we studied the influence of co-solvent solutions. Co-solvented ink properties are influence to filling condition of capillary-induced ink onto the donor substrate. And sublimation transferred pattern has different shape, roughness, thickness according to the properties of co-solvented inks. Characteristics of sublimation transferred EML pattern are closely related to properties of co-solvented inks. We fabricated OLEDs device with the sublimation transfer processed EML with 2:1 ratio of CB: oDCB co-solvented ink which have main peak at 605nm. As a result of this study, co-solvent solution for ink filling and sublimation transfer process are successfully optimized.

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