Fivefold Enhancement in the Stability of Organic Light Emitting Diodes with the Addition of a ZAO-based Non-evaporable Getters Pumps

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The intrinsic degradation of organic light emitting diodes (OLEDs) can be attributed to the striking of residual gasses to substrates during the fabrication process [1]. To further evacuation the residual gasses in an evaporation chamber, non-evaporable getters (NEG) pumps were added along with a turbo molecular pump (TMP). In this study, we demonstrate a fivefold enhancement in the initial device lifetime of the devices fabricated with a combination of TMP and NEG pumps for the first time.

NEG pumps based on the new ZAO® getter alloy (Ti-Zr-V-Al) (SAES Getters, CapaciTorrUHV1400 and CapaciTorrUHV600) were installed right next to a substrate holder in the evaporation chamber evacuated with a TMP. A OLED was fabricated on an ITO substrate, on which the multi-layers consist of a molybdenum trioxide layer (MoO_3) (0.75 nm), a 90 nm-thick *N, N'*-di-[(1-naphthaleyl)-*N, N'*-diphenyl]-1,1'-biphenyl-4,4'-diamine (α-NPD) and a 70 nm-thick tris (8-hydroxyquinolinolato) aluminum (III) (Alq_3), lithium fluoride (LiF) (1 nm) and an aluminum layer (Al) (100 nm).To evaluate the operational stability, the luminance/initial luminance-time characteristics of OLEDs were measured at a constant dc current density of 50 mA/cm^2.

With adding NEG pumps, the chamber contains fewer amounts of residual gasses. (Fig. 1) For example, during a deposition of organic layers, each residual gas pressure in the chamber evacuated with only TMP is higher than that in the system evacuated by TMP and NEG pumps: 26 times for H_2O^+ (m/z=18), 14 times for N_2^+ or CO^+ (m/z=28) and 11 times for CO_2^+ (m/z=44). Figure 2 shows luminance/initial luminance-time characteristics of the OLEDs. Although the increase in operation voltage was the same in all devices, time to reach to 90% of an initial luminance (LT_{90}=123 hours) was five times longer in the device fabricated with TMP and NEG pumps than that (LT_{90}=25 hours) of the devices fabricated using TMP alone. This clearly suggests that the increase in the voltage is not responsible for the considerable difference in the initial device degradation. The initial degradation might be governed by formation of fluorescence quenchers or non-emissive centers by the reaction between residual water and organic molecules (α-NPD and/or Alq_3) [2]. For the long term stability of the devices (time to reach to 50% of an initial luminance, LT_{50}), the devices fabricated with TMP and NEG pumps (LT_{50}=1978 h) were 1.6 times longer than that (LT_{50}=1200 h) of the devices fabricated with TMP alone. That is, the effect of residual gasses on the stability of devices is significant at the initial degradation. In particular, we observe almost no change in operation voltage in the devices fabricated with TMP and NEG pumps after the 500 h operation. This suggests that the long term degradation of the α-NPD/Alq_3 OLED may not be related to the voltage increase due to charge traps. More detail on device fabrication and analysis will be presented at the presentation.

[1] T. Ikeda et al., Chem. Phys. Lett. **426**, 111 (2006). [2] H. Murata et al., SID symposium Digest, **45**, 32 (2014).
Key words: stability, residual gasses, non-evaporable getters pumps.

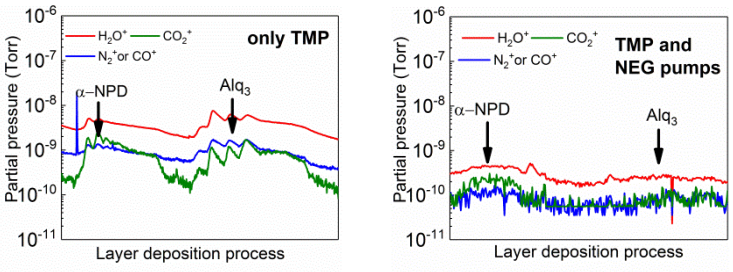

Fig. 1. Residual gas components at organic layers deposition (left) under only TMP, and (right) under TMP and NEG pumps.

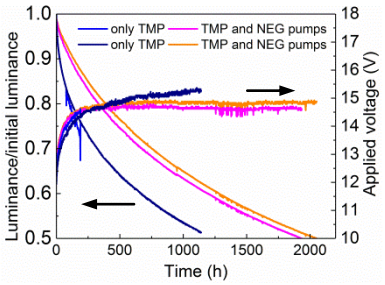

Fig. 2. Luminance/initial luminance-time characteristics of OLEDs fabricated under only TMP, and under TMP and NEG. pumps.