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An Approach to Degradation Mechanisms using Numerical Model Fitting in Thermally Activated Delayed Fluorescence (TADF) Organic Light Emitting Diodes (OLEDs)

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We approach degradation mechanisms in green thermally activated delayed fluorescence (TADF) organic light emitting diodes (OLEDs) by a numerical model fitting method included a Schottky numerical model to evaluate barrier height of carrier injection at interfaces. Using temperature dependent current-voltage (I-V) behavior of hole only (HOD) device ; glass / ITO (100nm) / HAT-CN (10) / Tris-PCz (70nm) / Al (100nm) , electron only device (EOD) ; glass / ITO (100nm) / Bpy-TP2 (40nm) /LiF (0.8nm) / Al (100nm) and our model, we have obtained values for the Richardson factor, and the barrier height. From the temperature dependent I-V characteristics of the HOD and our model fitting, we have estimated PhiB(H)=0.370 [eV], A*(H)=1.0×10-2 [A/cm2/K2] and threshold voltage VTH(H)=1.5 [V] for the injection of hole carriers. Notably, the A* value of the ITO/HAT-CN/Tris-PCz interface is much smaller than that of a metal/Si interface 20). This suggests that A*is strongly dependent on the combination of ma-terials and its interface condition.*
Likewise, we also obtained the device parameters for the electron injection interface from the temperature dependent I-V characteristics of the EOD. From the measurement data and our model fitting, we have estimated PhiB(E)=0.285 [eV], A(E)= 1.0×10-3 [A/cm2/K2] and VTH(E)=2.2 [V].
Therefore, we tried stress tests using 1 hour 500mA/cm2 current stress for HOD and EOD. The param-eter determined for the HOD show no significant change. In contrast to this the EOD parameters show significant change after current stressing; PhiB(E)=0.285 -> 0.345 [eV], A*(E)= 1.0×10-3 -> 1.0×10-2 [A/cm2/K2] and VTH(E)=2.2 -> 2.5 [V]. It is apparent that the interface of electron injection side has undergone significant degradation during the current stressing as revealed by the change in the device parameters.

Hence, we have obtained the delayed response of luminescence under pulsed operation of delta-doped green TADF OLEDs ; glass / ITO (100nm) / HAT-CN (10) / Tris-PCz (30nm) / mCP:4CZIPN (15%,30nm) / T2T (10nm) / Bpy-TP2 (40nm) / LiF (0.8nm) / Al (100nm) after current stress.
In order to approach degradation mechanisms, we fabricated a half doped structure in the emission layer. The results of pulsed operation indicate the quick response of luminescence has been generated in a very thin region con-tacted to the electron injection side in the emission layer.

On the other hand, STEM cross sectional images of the TADF green OLEDs show a different contrast at interface region of Bpy-TP2 as electron injection layer between before and after the current stress. The results are consistent with changes of parameters in the EOD after current stress.

From our experimental and model fitting results, we describe a degradation model dominated at electron injection interface in TADF green OLEDs.

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