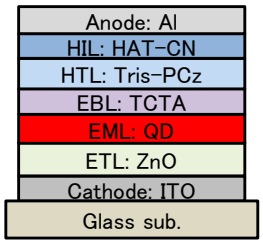
Degradation analysis of QLED devices

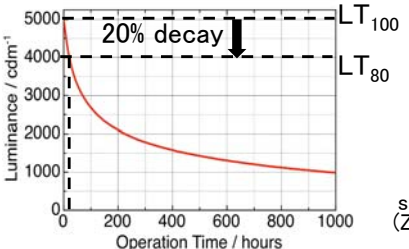
QD-LED (QLED) devices have emissive layer of quantum dots (QDs), and are one of the most promising next-generation electroluminescent devices. We analyzed fresh and degraded QLED devices and attempted to reveal the cause of the luminance decay for the degraded device.

1. QLED device sample

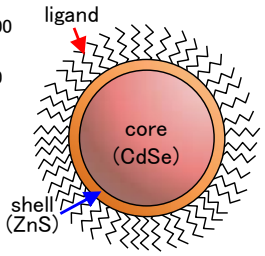
Samples: fresh (LT_{100}) and degraded (LT_{80}) QLED devices　* QLED devices were provided by i³-opera.



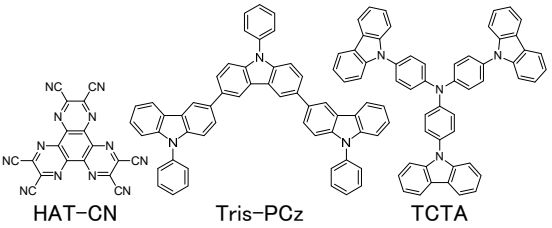
QLED stack



Degradation curve (EL)

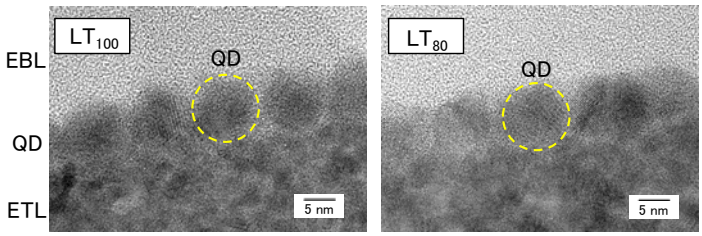


QD structure



Structures of organic materials

2. Cross-sectional TEM

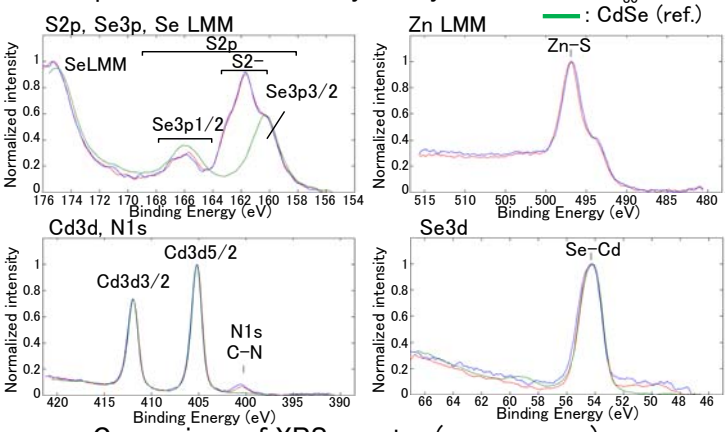


Comparison of TEM images around QDs

✓ No change of QD shape and size
✓ No aggregation of QDs

3. Chemical states of QDs by XPS

Upper layers (anode-EBL) were removed and exposed QDs were analyzed by XPS.



Comparison of XPS spectra (narrow scan)

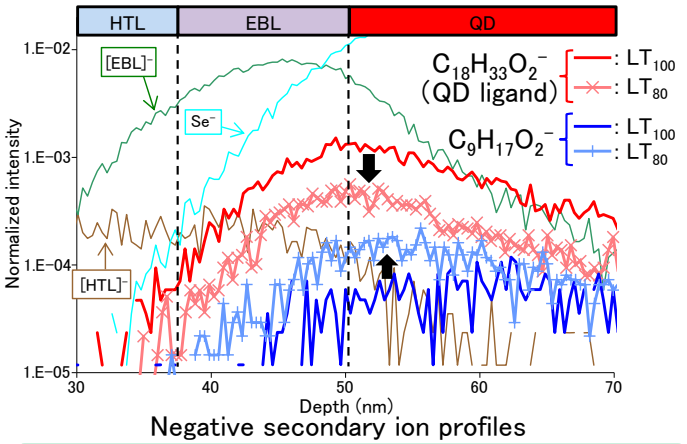
Elemental composition ratio

	S/Cd	Zn/Cd	Se/Cd
LT_{100}	0.87	1.37	0.79
LT_{80}	0.97	1.35	0.86

✓ No significant change of chemical states of the elements in QD core and shell

4. Depth profiles of organics by GCIB-TOF-SIMS

The anodes were pealed off and residual stacks were analyzed by GCIB-TOF-SIMS.



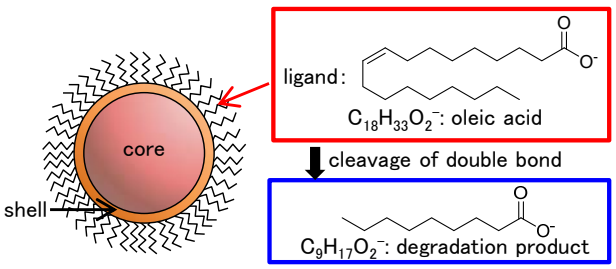
Negative secondary ion profiles

✓ Decrease of QD ligand
✓ Increase of degradation product ($C_9H_{17}O_2^-$)

5. Summary

Decomposition of QD ligand shown below possibly changes the carrier balance and coordination state of QD.

Replacement to more stable ligand would contribute to improve the device lifetime.



Estimated degradation scheme

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