TEM-EDX spectrometry of defective organic electroluminescence devices

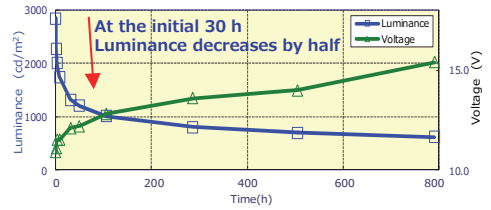
The cause of the defect can be investigated by TEM-EDX analysis for the micro defective parts of organic with spectroscopic imaging-EL method.

The schematic of OLED

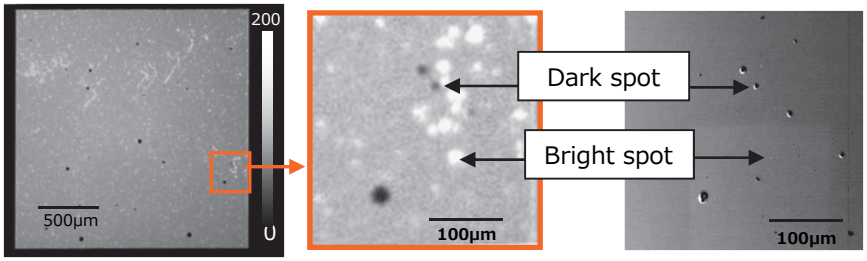
Cathode	Al
EIL	LiF
EML/ETL	Alq3(60nm)
HTL	alpha-NPD(40nm)
HIL	2-TNATA(30nm)
Anode	ITO

Imaging-EL
↓
Initial degradation
(13V, 0.5h)
↓
SEM, TEM

Constant current driving of an OLED(2.5mA)



SEM observation of the surface of defective portions identification by low-voltage imaging-EL



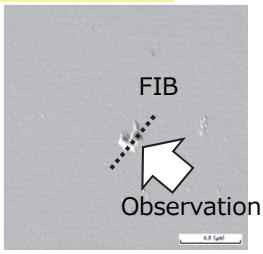
Low-voltage imaging-EL image (Before Driving)
(Left/Right reversed)

SEM image of surface

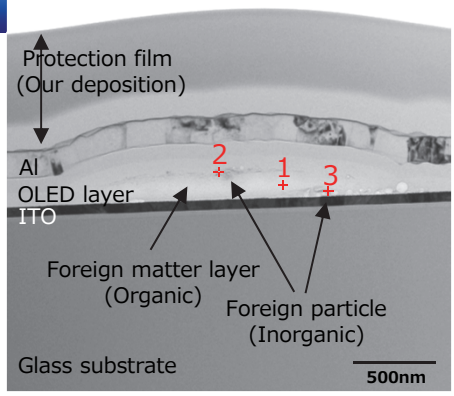
- Low-voltage imaging-EL shows bright spots, dark spots.
- In the surface SEM image, a defect was observed in the same place.
- The defects indicated in the arrows were used for TEM analysis.

Shapes, compositional analyses of defective sections by TEM-EDX

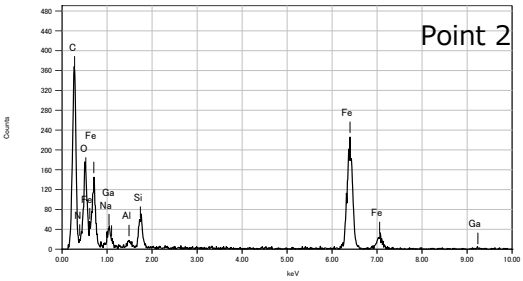
Bright spot



SEM image of surface



FIB-TEM image

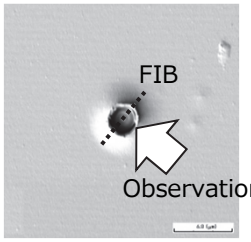


	C	N	O	Fe	In	Si	Na
Point 1	96.9	1.6	1.6	–	–	–	–
Point 2	61.9	2.6	12.5	18.9	–	2.4	1.4
Point 3	78.8	1.5	12.2	–	1.3	1.6	3.8

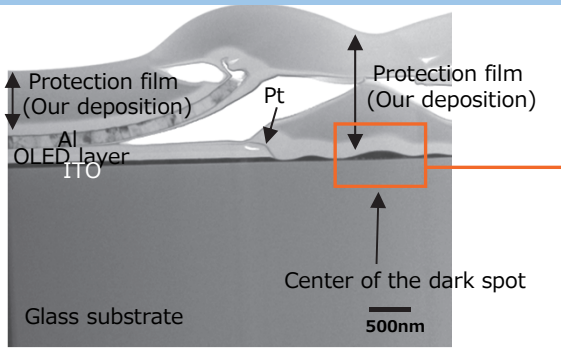
TEM-EDX results

- In the bright spot, a foreign substance which has convex shape is observed under the OLED layer.
- From the EDX results, the foreign matter is found to be hydrocarbon organic matter (point1), which contain impurity elements such as Fe or In (point2, 3 of above image/table).

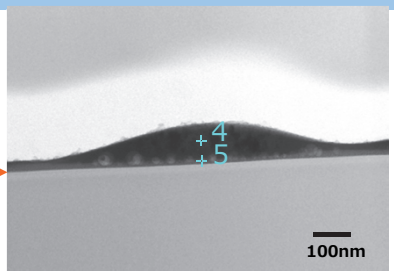
Dark spot



SEM image of surface



FIB-TEM image



	In	O	Sn	Si	Na
Point 4	53.9	36.9	8.3		0.9
Point 5	38.0	26.2	5.7	19.4	10.8

TEM-EDX results

- The dark spot has a crater shape, and the Al electrode is swung up.
- In the center, there is no EL layer, and ITO is exposed. Unevenness in the thickness of ITO is observed.
- Among the central ITO, Na and Si were detected on the glass interface side (point5).