UBI RESEARCH

2020 OLED Emitting Material Report

Contents

4. Emitting Material Industry Issues

4.2 Improvement of Color Gamut of Large Area OLED

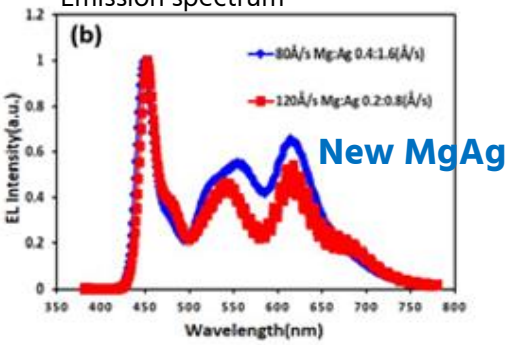
- **BOE's top emission white OLED**
  - The top emission structure is advantageous for high resolution because it can secure a larger aperture ratio than the bottom emission structure. In order to develop a top emission structure, a cathode must be made transparent, but ITO, which is formed by a sputtering process, cannot be used because it damages the organic layer.
  - MgAg used in OLED for mobile devices is an alternative to ITO, but because MgAg is a semi-transparent material, a color viewing angle is generated due to a microcavity. In order to suppress this, if the thickness of MgAg is reduced, the transmittance increases but the resistance value increases.
  - BOE announced in SID 2018 that it is possible to improve the transmittance and obtain a low resistance value by changing the composition ratio and the deposition rate of MgAg. It was mentioned that when the composition ratio of Mg and Ag is 1: 4 and the deposition rate of Mg and Ag is 0.4Å/s and 1.6Å/s, respectively, the surface roughness is small and the specific resistance is lowest. Under this condition, the emission spectrum, current efficiency, and color viewing angle characteristics of the OLED produced by forming MgAg at 80Å and the OLED using MgAg having a thickness of 120Å in the conventional method were compared.

BOE MgAg composition ratio and performance

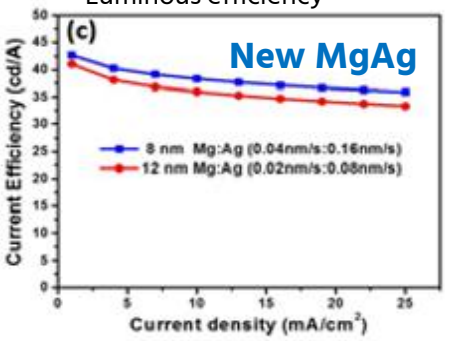
	Mg:Ag 0.1:0.4 120Å Glass base	Mg:Ag 0.1:0.4 120Å Glass base	Mg:Ag 0.1:0.4 120Å Glass base
Rq [nm]	2.56	1.53	1.04
Rs [Ω/sq]	15.256	11.861	9.161

Source: Zhiqiang Jiao et. al. SID 2018 Digest 61-2 p.808

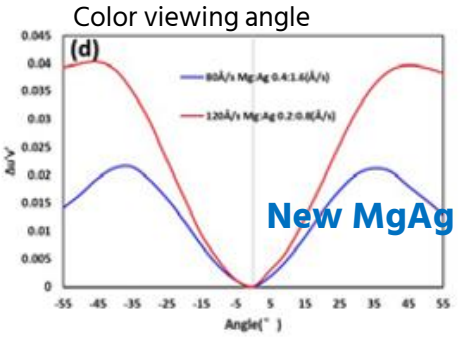
Emission spectrum



Luminous efficiency



Color viewing angle

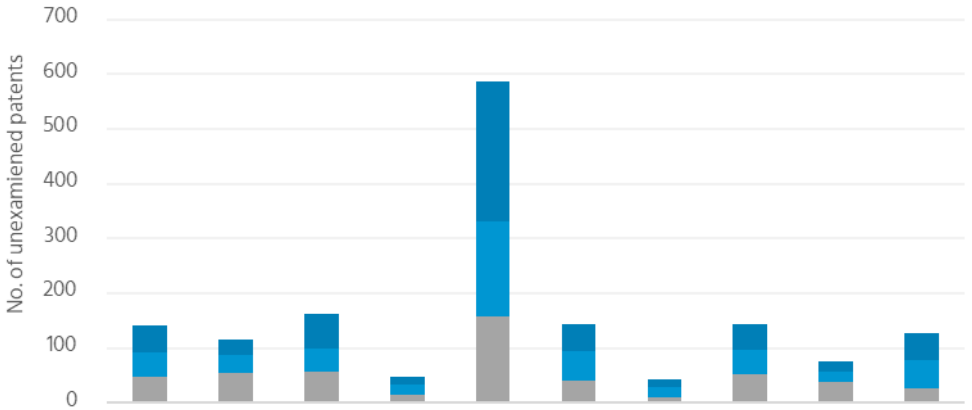


6. Business Trend by Emitting Material Company

6.2 Patent Trend

- In the past three years, LG Chem was the company that published and registered the most patents related to emitting materials.
- LG Chem recorded the largest number of patents with 587, followed by Duksan Neolux with 163 and Samsung SDI with 145. LG Chem registered the most patents with 325, followed by Merck with 93, SFC with 86, and Duksan Neolux with 78.
- Four companies including Duksan Neolux, LG Chem, Samsung SDI, and UDC have been steadily increasing in registered patents over the past three years.

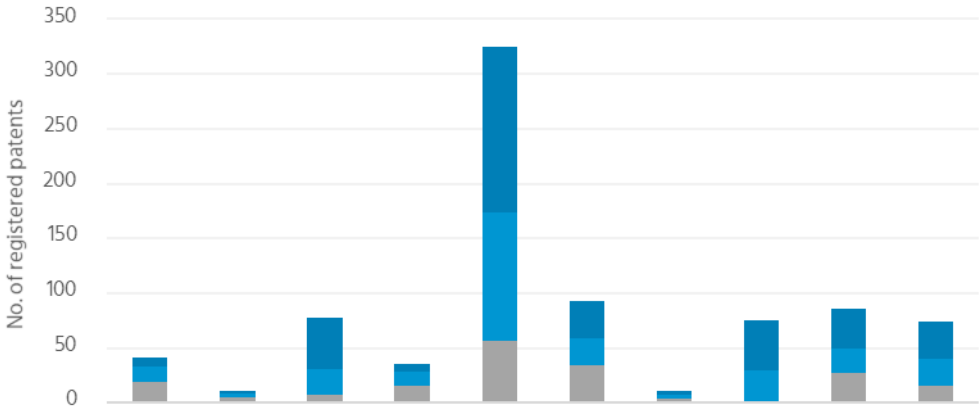
Number of open patents in Korea by company by year



	Doosan Solus	Dow Chem.	Duksan Neolux	Idemitsu Kosan	LG Chem.	Merck	Novaled	Samsung SDI	SFC	UDC
2019	48	28	64	16	256	48	15	49	18	49
2018	44	33	41	17	174	53	18	43	19	51
2017	49	54	58	16	157	42	11	53	39	28

Source: Kipris, UBI Research DB

Number of Korean registered patents by company by year

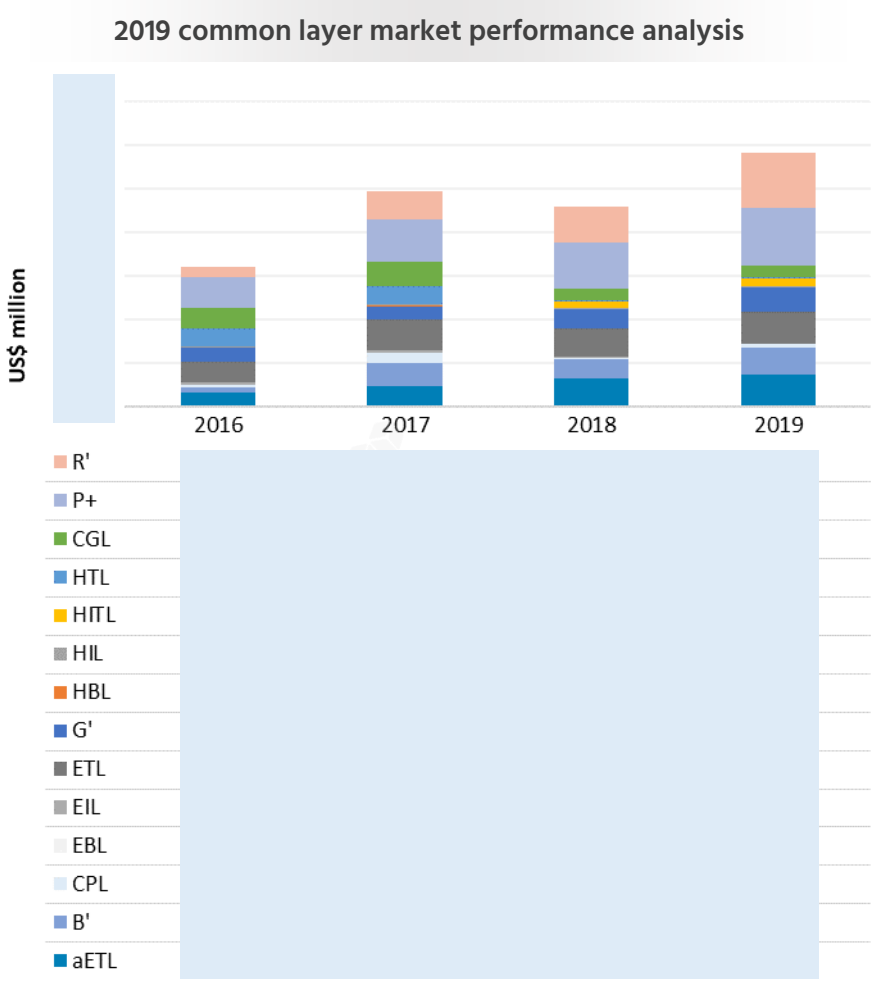


	Doosan Solus	Dow Chem.	Duksan Neolux	Idemitsu Kosan	LG Chem.	Merck	Novaled	Samsung SDI	SFC	UDC
2019	8	3	47	7	151	34	4	46	36	34
2018	14	3	24	13	118	25	3	29	23	24
2017	19	5	7	15	56	34	4	0	27	16

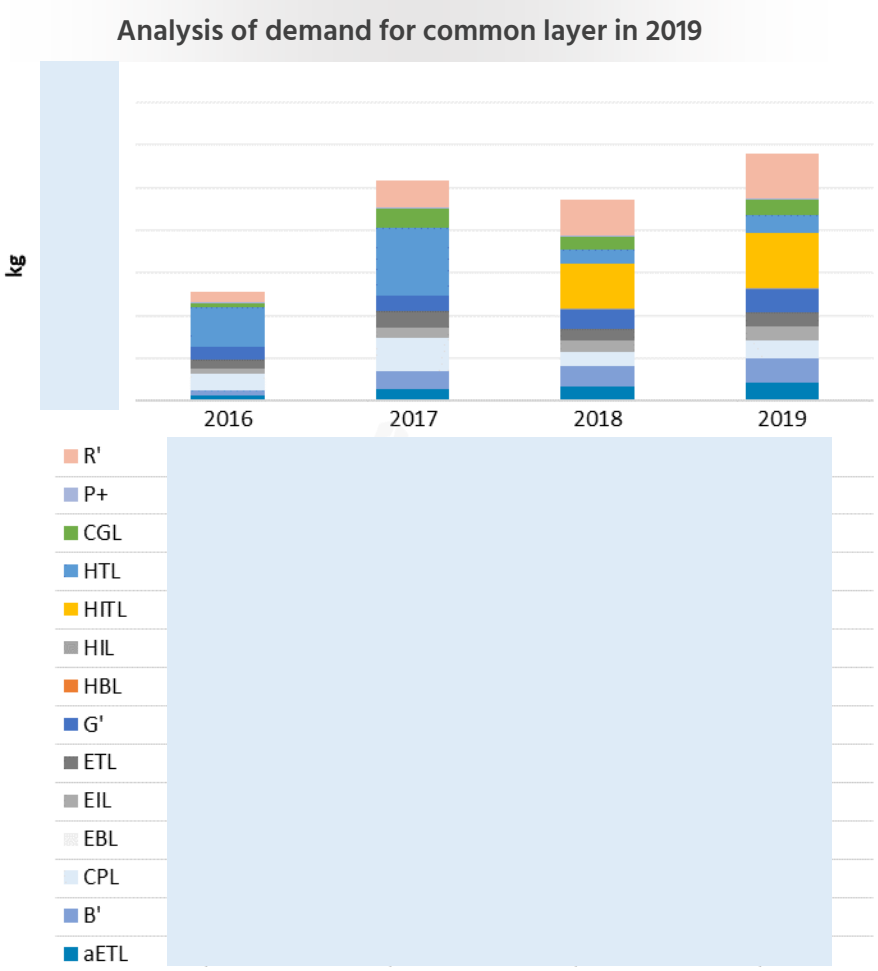
Source: Kipris, UBI Research DB

8.2 Common Layer and Emitting Layer

- **Common Layer**



Source: UBI Research DB

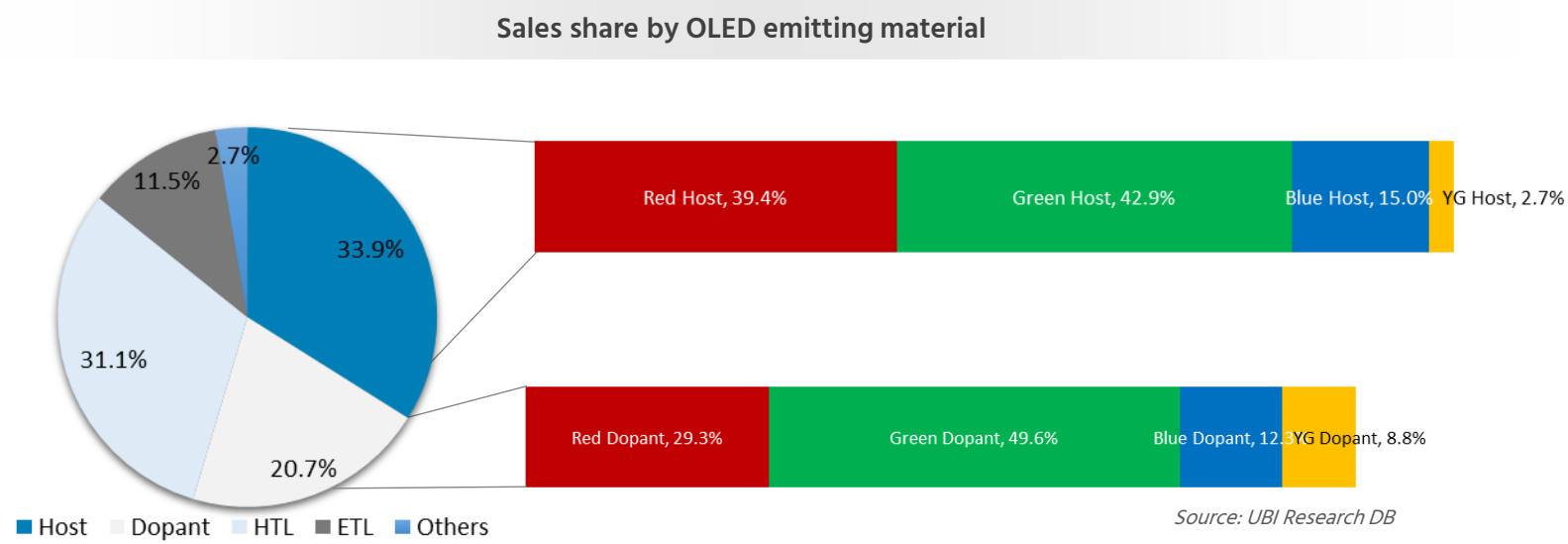


Source: UBI Research DB

9. OLED Emitting Material Market Share Analysis

9.1 Analysis of OLED Emitting Material Sales Share in 2019

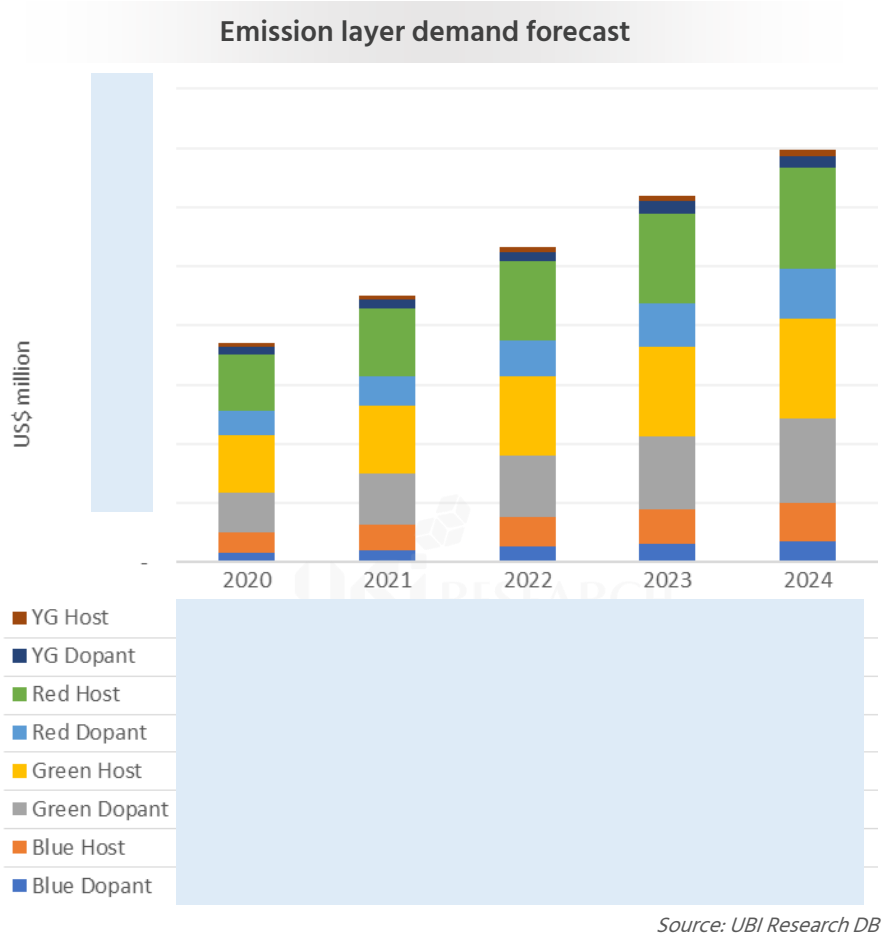
- The share of OLED emitting material sales in 2019 was analyzed by dividing into host, dopant, HTL, ETL, and others.
- HTL contains HIL, HTL, HITL, HTL prime (red, green, blue), p dopant, ETL contains EIL and ETL, aETL (advanced ETL), and other materials include CGL and CPL.
- Host material sales share was the highest at 33.9% of total sales, followed by HTL materials at 31.1%.
- Both the host and dopant materials showed a high sales share in the order of green, red, blue, and yellow-green.



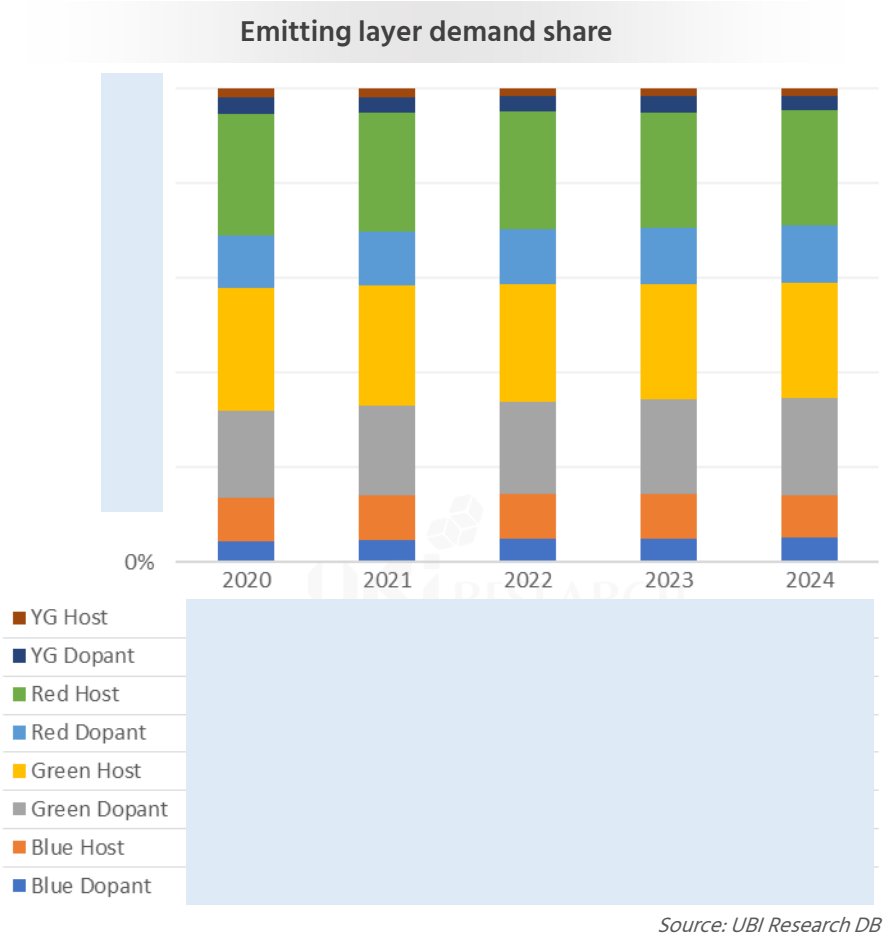
10. OLED Emitting Material Demand Forecast

10.3 Forecast of Demand for Common and Emitting Layers

- **Emitting Layers**



Source: UBI Research DB

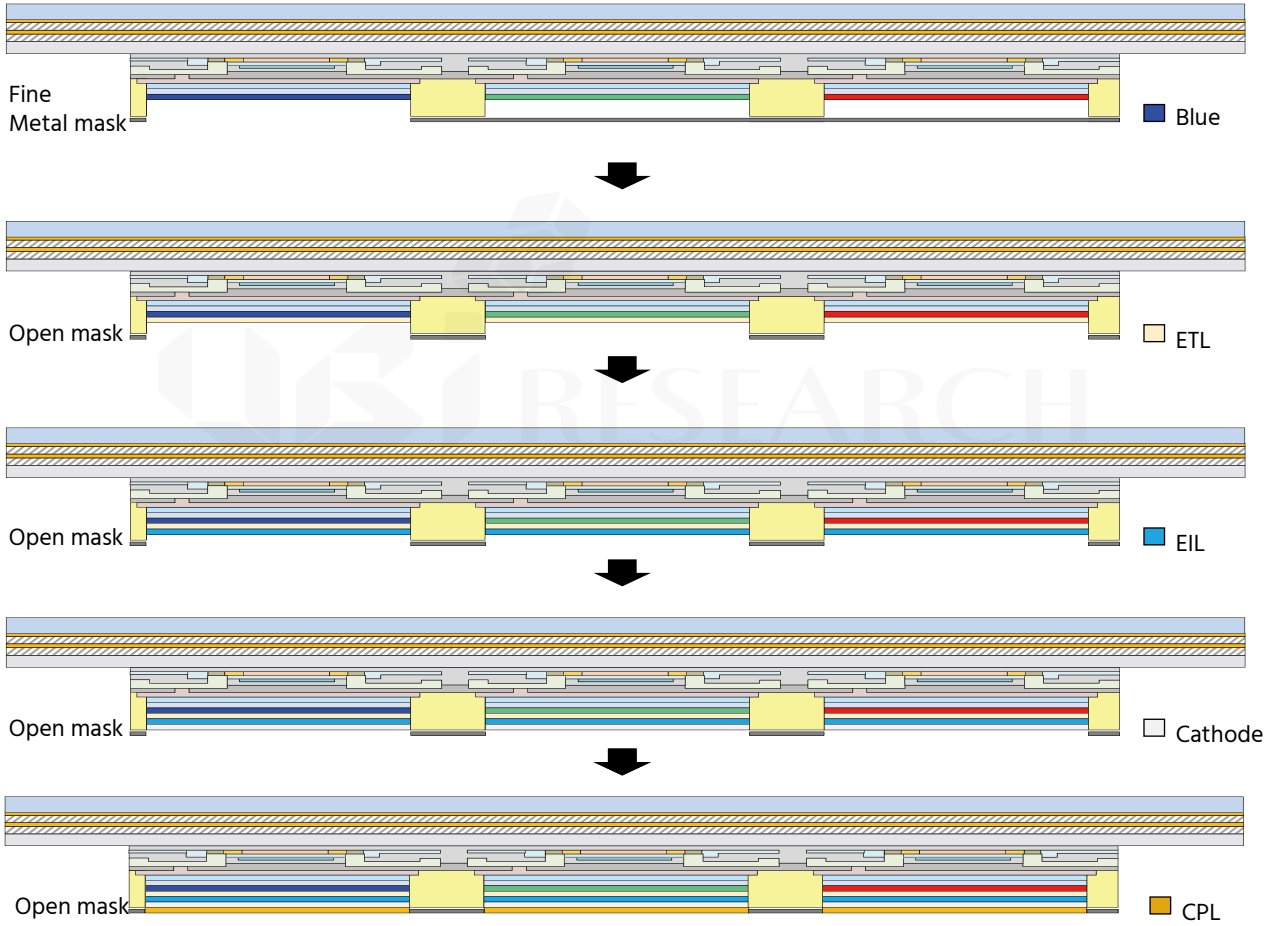


Source: UBI Research DB

12.1 OLED Pixel Process for Mobile Devices

Main OLED pixel process

Pixel forming process and equipment of OLED for mobile devices



Process	Equipment
Blue OLED deposition	Evaporator (FMM)
ETL deposition	Evaporator (open mask)
EIL deposition	Evaporator (open mask)
Cathode deposition	Evaporator (open mask)
CPL deposition	Evaporator (open mask)

Source: UBI Research DB