



OLED Manufacturing: Progress in 2014

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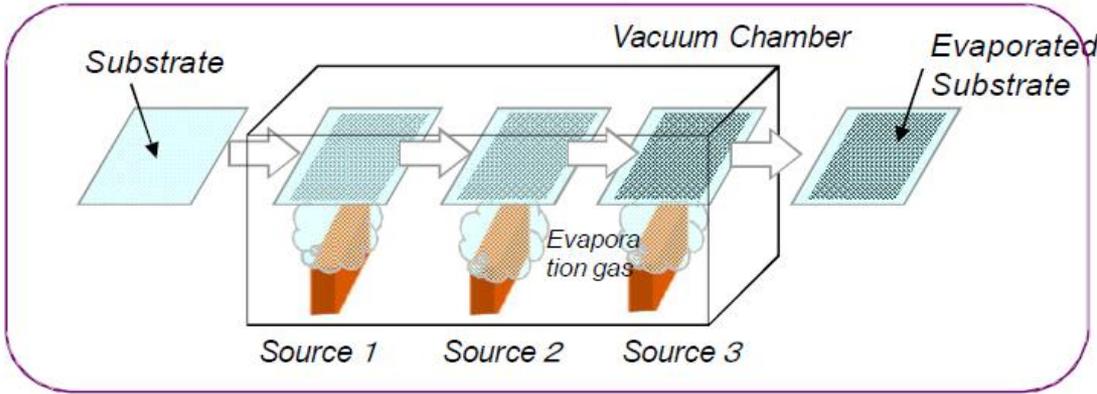
DOE Workshop, San Francisco
January 28, 2015

Phosphorescent Materials: Price and Cost

	Units	2011	2012	2013	2014H1
Material sales	\$M	37	44	96	71
Cost of material sales	\$M	3.7	4.5	29	22
Commercial material sales	\$M	25	27	88	66
Cost of commercial material sales	\$M	3.7	4.3	29	22
Fraction of commercial material sales	%	15%	16%	32%	33%
Royalty and license fees	\$M	15	32	47	30
R&D	\$M	24	30	34	21
Total revenues of UDC	\$M	61	83	146	102
AMOLED display revenues	\$M	3,500	6,700	10,000	6,000
UDC share of industry revenues	%	1.7	1.2	1.5	1.7
AMOLED Display area	M m ²	0.46	0.84	1.4	0.84
Industry revenues per unit area	\$/m ²	7,700	8,000	7,100	7,200
UDC revenues per unit area	\$/m ²	130	100	100	120

VTE by Panasonic

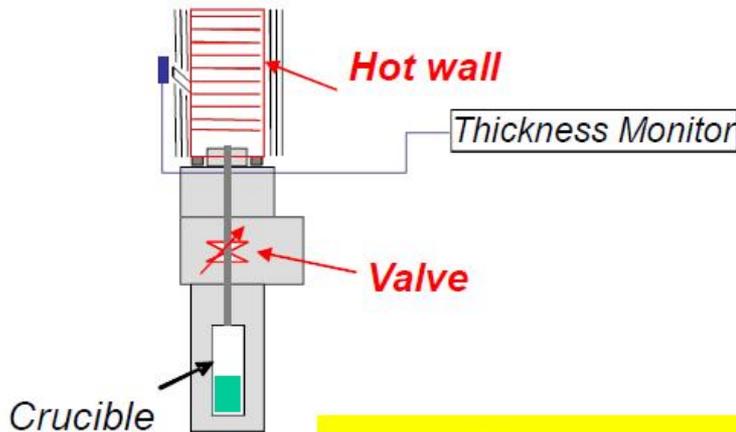
Schematic of In-Line evaporation Process



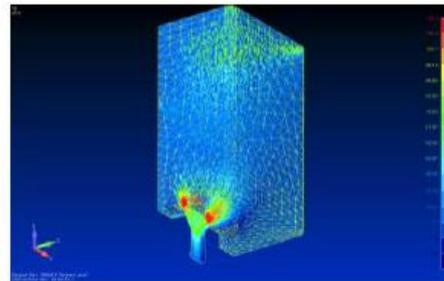
Prototype of In-Line Evaporation Process



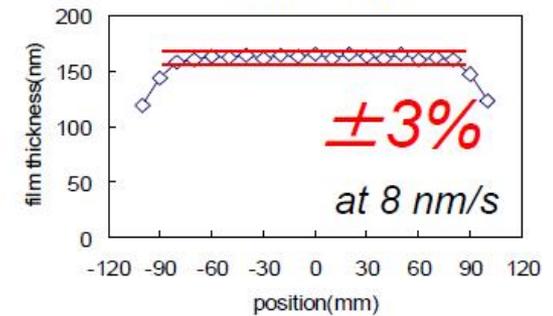
Schematic of Hot Wall Source



CAE Simulation



Distribution

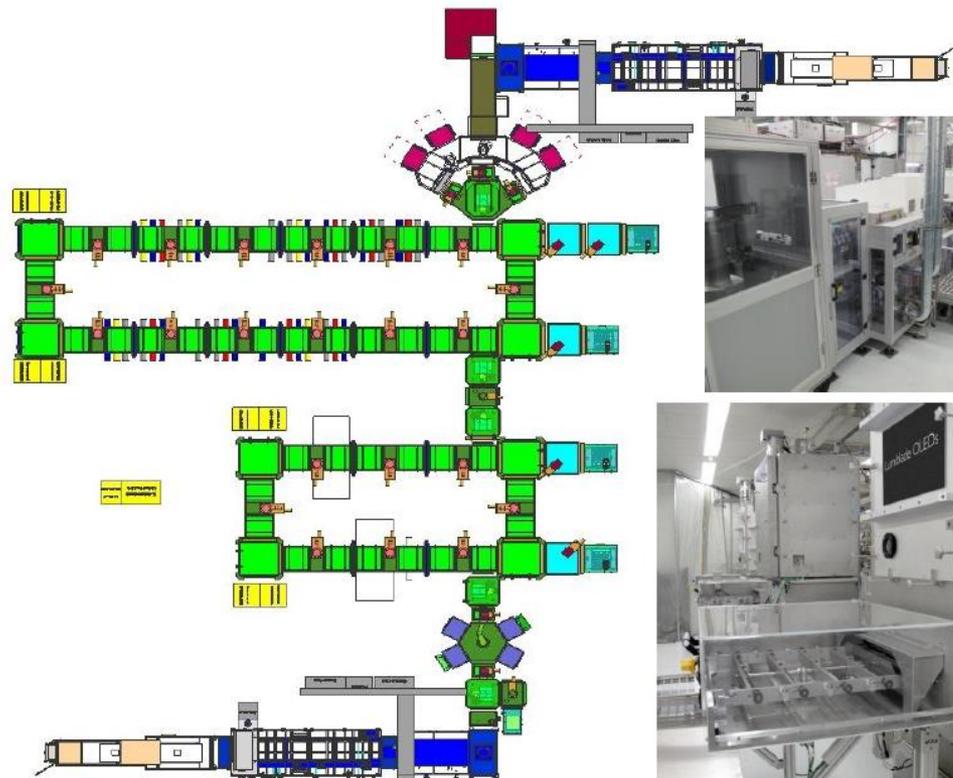


Over 70 % Material Usage and High Speed Evaporation Process

Philips New Line

4 stage quasi-linear line for 400x500mm substrates

- Substrate preparation
- Organic deposition loop
 - ~22 chambers
 - >40 sources (2 crucibles each)
 - Frame return
- Metal deposition loop
 - ~ 10 chambers
 - Frame return
- Finishing
 - Thin-film encapsulation
 - Singulation
 - Testing



Aachen

PHILIPS

The line can be run with only 3 operators

Performance of Philips New Line

- 6 stack structures manufactured with 70% yield
- 3 minute TAKT giving annual capacity of 30,000 m²
(goal is 30 sec TAKT and 180,000 m²/year)

70% yield and 80% substrate us gives 17,000m²/year

- 50% material utilization
- ±1% uniformity for organics from linear source
- ±5% uniformity for metals (Al, LiF, Ag, MoOx)
- Good color control without binning

Current Global Capacity

- Assume the equivalent of 6 Gen 2 lines
 - LG Chem
 - Philips
 - Osram
 - First O-Lite
 - Konica Minolta
 - Blackbody/OLEDWorks/Pioneer/Lumiotec....
- 3 minute TAKT
- 70% yield and 80% substrate use
- Total output could be $\sim 100,000\text{m}^2$ or 10M 4" panels
- IHS estimate of 2014 production is 100K panels
IDTechEx estimate of 2014 production is 1M panels

Depreciation Costs

- Gen 2.5 line (400x500m)
- Capital cost \$75M
- Annual input: \$30K m²
- Good panels: \$17K m²

- Depreciation: \$15M per year
\$900/m² of good panel area

Running Costs: Goal for 2015

- Goal: \$1000/m² yielded
\$550/m² unyielded
- Labor: \$2M (20 staff at \$100K) or \$120/m²
- Facilities: \$1M or \$60/m²
- Materials: \$\$370/m²
 - Organics: \$200/m²
 - Substrate: \$40/m²
 - Light extraction: \$40/m²
 - Electrodes: \$40/m²
 - Encapsulation: \$40/m²
 - Miscellaneous: \$10/m²

Total: \$550/m²