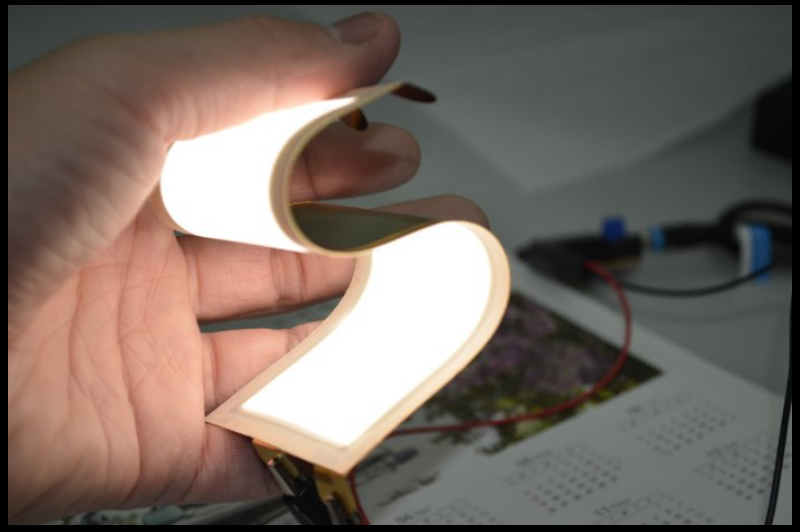
Vectoring From OLED Displays to OLED Lighting

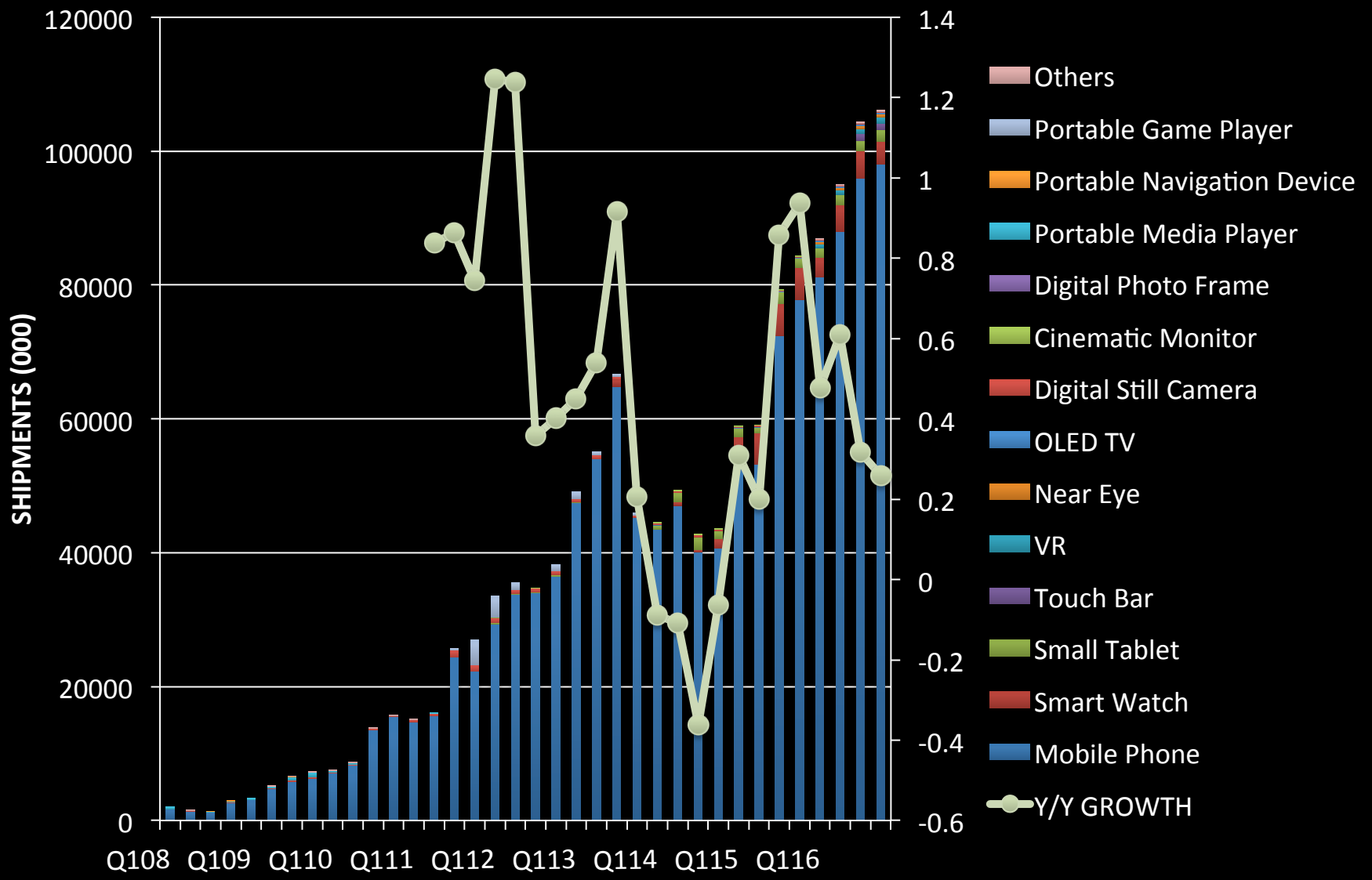


Barry Young, CEO
OLED Association

Deconstructing OLED Display Costs

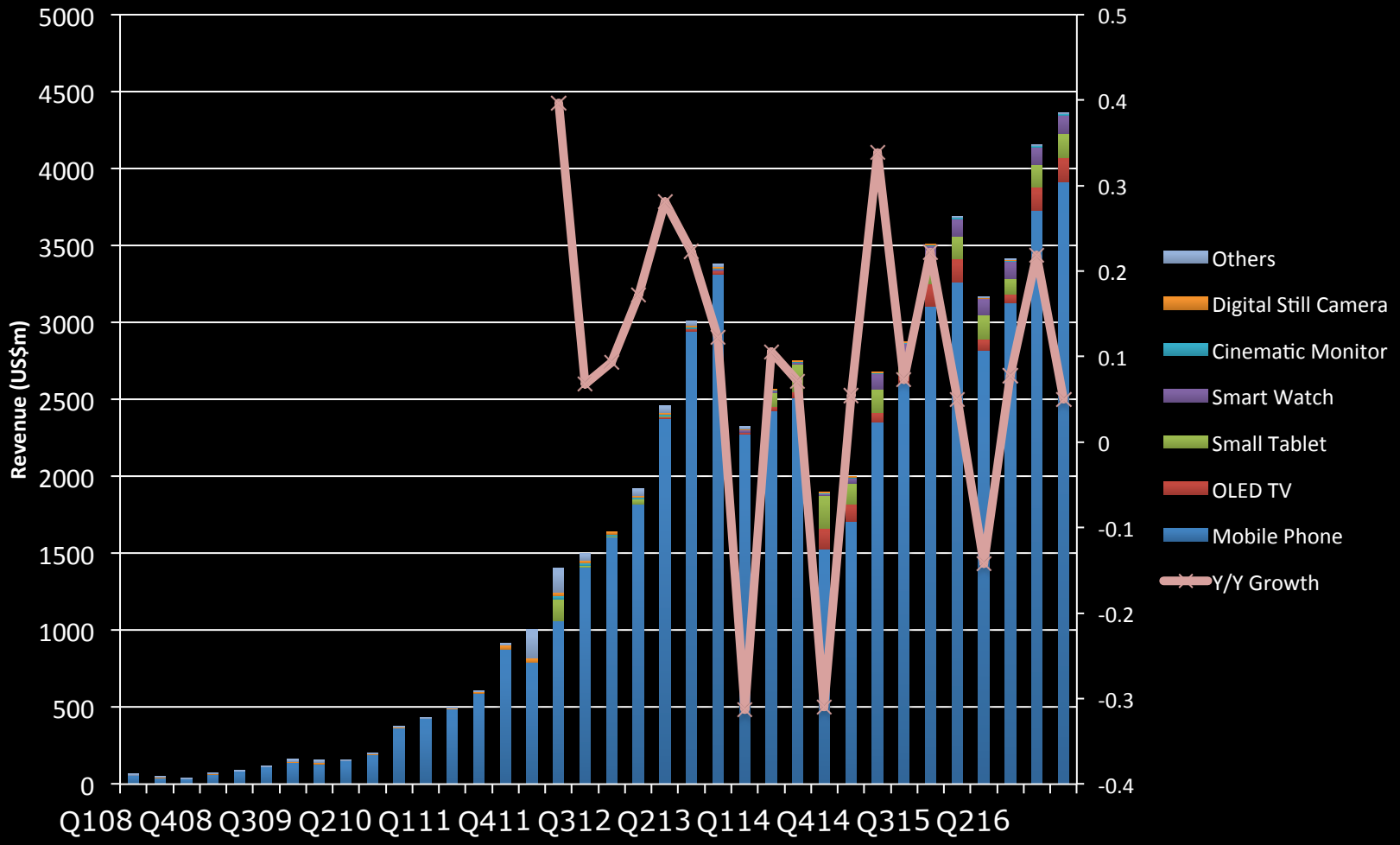
- Small/Medium (S/M) OLED Display Shipment History
- OLED Process Flow
- S/M OLED Display Cost Structure
- Vectoring to Lighting
- Extending the Timeframe
- Comparison w/DOE Forecasts

OLED Panel Shipments (000)



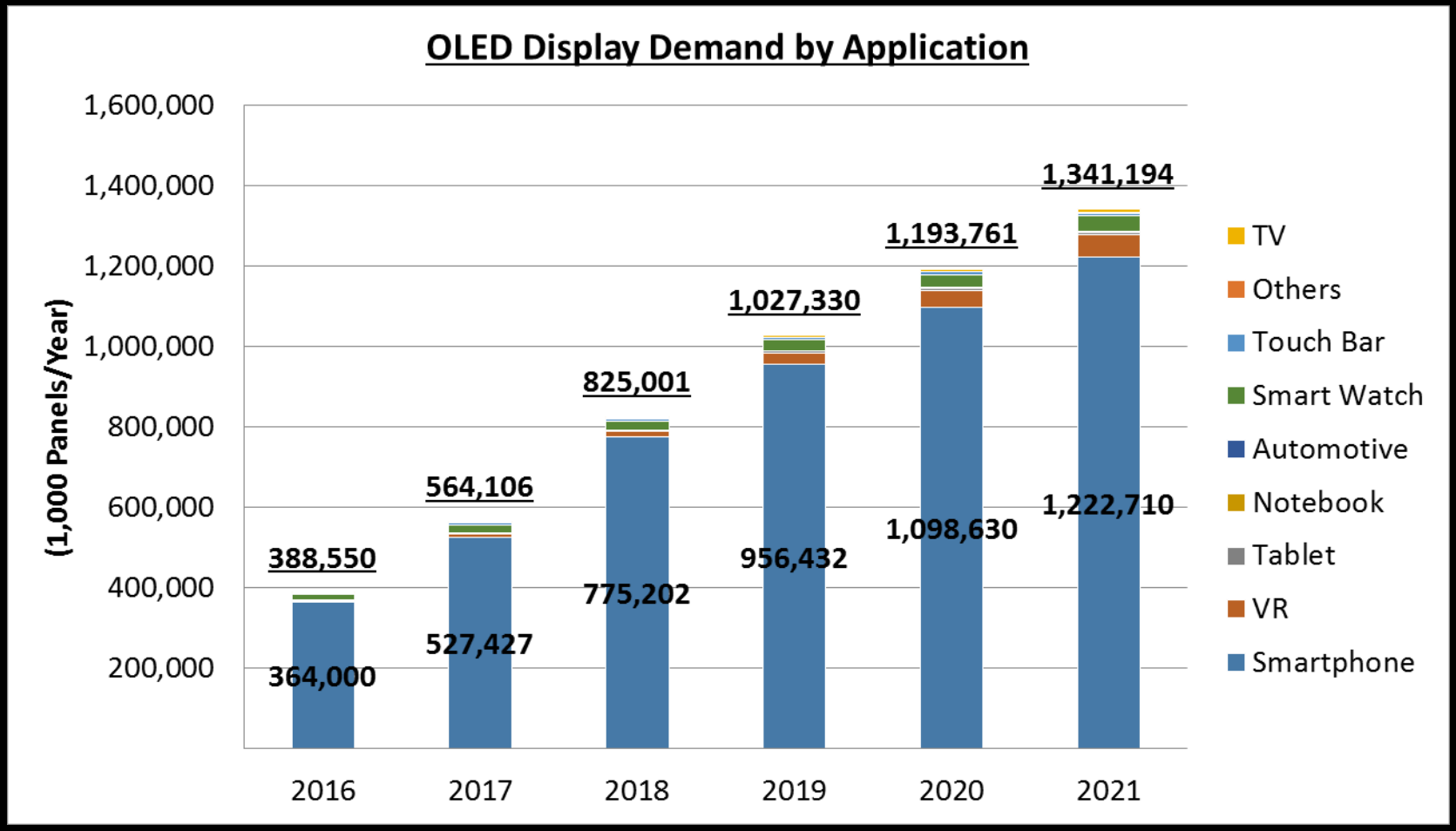
Source: OLED-A

OLED Revenue (US$)



Source: OLED-A

Future OLED Panel Demand



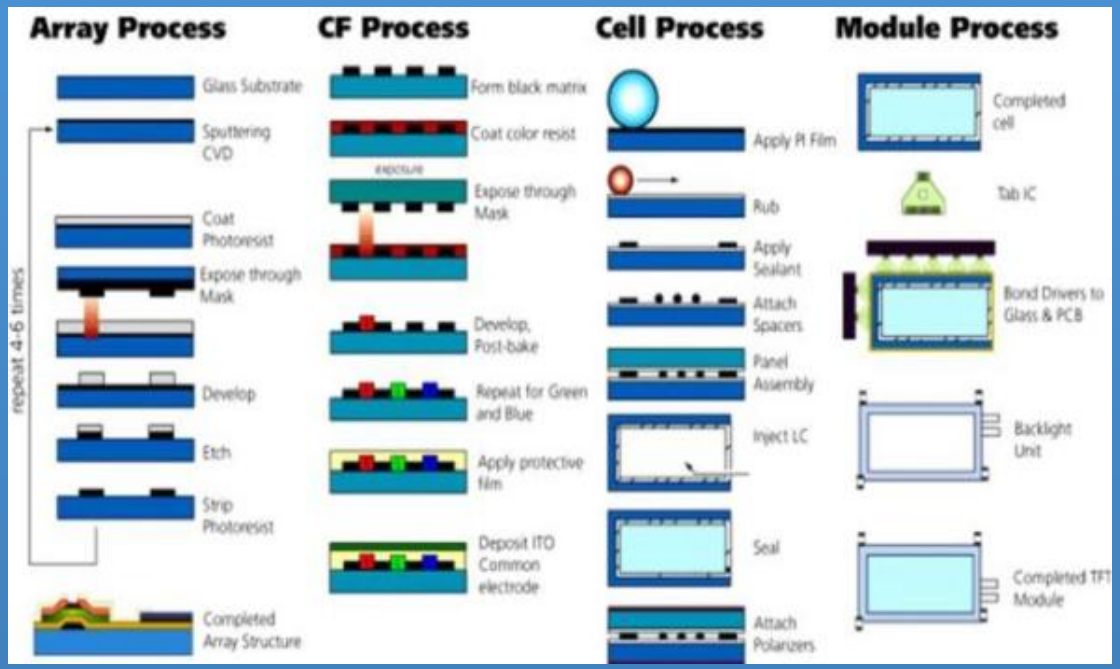
Source: DSSC

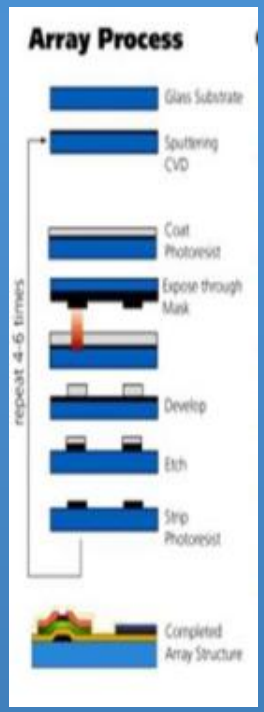
Market Rational

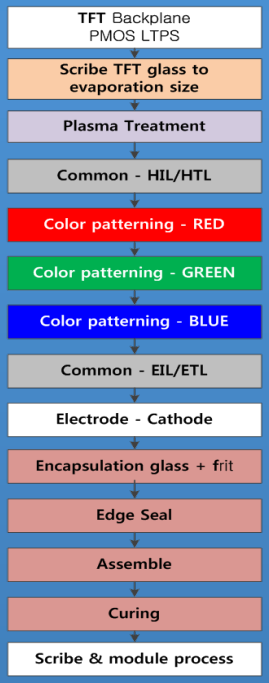
Application	2016	Marketshare	Rationale	2017
Value Shartphone	100m	15%	Form Factor, CR, Black Levels	20%
Premium Smartphone	150m	27%	Form Factor, CR, Black Levels, Luminance	10%
Flexible Smartphone	150m	100%	Monopoly	50%
Premium TVs (>$2000)	0.7m	47%	Viewing Angle, CR, Response Time, Black Levels	50%
VR	4m	80%	Pixel Density, Response Time	25%
Wearable	25m	25%	Power Consumption, Form Factor	Flat

Source: OLED-A

LCD Vs. OLED Process Flow

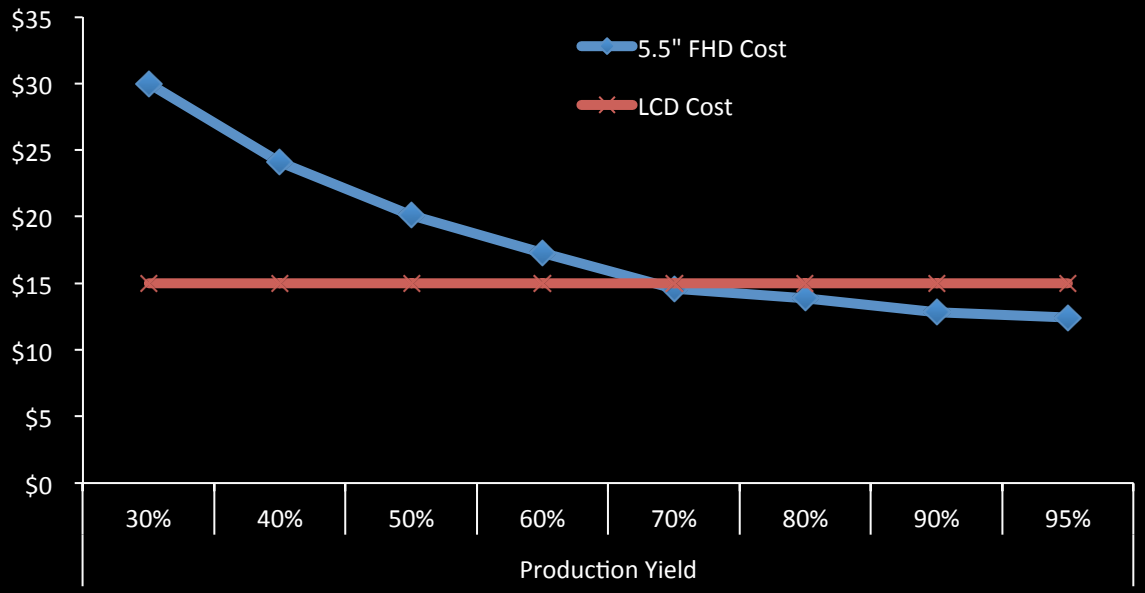






Source: IHS

LCD vs. OLED S/M Cost Comparison



	Gen 6	Gen 5.5	Gen 6	Gen 6
Yielded	**LCD LTPS**	**OLED**	**OLED**	**Flex OLED**
Array Material Cost	0.38	0.47	0.4	1.42
OLED/Cell Material Cost	0.71	3.15	2.69	3.46
Encapsulation Material	_	0.3	0.23	0.03
Module Component Cost	9.74	6.35	6.31	10.57
Indirect Expense	1.08	1.03	0.96	1.55
Personnel Cost	1.29	2.03	1.42	1.63
Depreciation	2.57	5.75	3.87	5.64
S,G,&A	1.82	3.5	3.5	4.55
Total	**17.59**	**22.58**	**19.38**	**28.85**
Yield	**82.3%**	**77.4%**	**73.70%**	**57.3%**
Module Yield	**99%**	**99%**	**99%**	**99%**

Source: IHS

Projecting Cost of Lighting Panels

1. Convert from Yielded to Unyielded
2. Convert from Display to Lighting
3. Project Light Production 2, 4, 9 years
4. Convert to Yielded Costs
5. Compare with DOE Roadmap
6. Run Sensitivity Analysis

Deconstructing Costs Forward

Unyielded

	Gen 6 LCD LTPS	Gen 5.5 OLED	Gen 6 OLED	Gen 6 Flex OLED
Array Material Cost	**0.31**	**0.36**	**0.29**	**0.81**
OLED/Cell Material Cost	0.58	2.44	1.98	1.98
Encapsulation Material	–	0.23	0.17	0.02
Module Component Cost	8.02	4.91	4.65	6.06
Indirect Expense	1.07	1.02	0.95	1.53
Personnel Cost	1.06	1.57	1.05	0.93
Depreciation	2.12	4.45	2.85	3.23
S,G,&A	1.50	2.71	2.58	2.61
Total	14.66	17.70	14.53	17.18

Unyielded – Projecting 2 years forward

Unyielded	Gen 6 LCD LTPS	Gen 5.5 OLED	Gen 6 OLED	Gen 6 Flex OLED
Std. Cost Reduction	**85%**	**72%**	**72%**	**72%**
Array Material Cost	0.26	0.26	0.21	0.59
OLED/Cell Material Cost	0.49	1.76	1.43	1.43
Encapsulation Material	–	0.17	0.12	0.01
Module Component Cost	6.78	3.55	3.36	4.38
Indirect Expense	0.90	0.74	0.69	1.11
Personnel Cost	1.29	1.91	1.27	1.14
Depreciation	1.79	3.22	2.06	2.33
S,G,&A	1.27	1.96	1.86	1.88
Total	13.64	14.28	11.73	13.59

Source: IHS, OLED-A

Display to Lighting Cost Vectors

	Display	Lighting	Change	Explanation
Array Material Cost	0.15	0.09	50%	No array matertial, Less Expensive Glass
OLED/Cell Material Cost	1.03	0.83	70%	Simpler Stack
Encapsulation Material	0.09	0.06	60%	Glass to Glass
Module Component Cost	2.43	0.70	25%	Simpler Driver
Indirect Expense	0.50	0.29	50%	Eliminate Array Component
Personnel Cost	0.92	0.53	50%	Eliminate Array Personnel
Depreciation	1.49	0.34	20%	US$b vs. 300m
S,G,&A	1.32	0.57	20% of Cost	
Total	7.93	3.40		

Displays to Lighting Costs

Unyielded	Display	Lighting	
Std. Cost Reduction	72%	72%	
Array Material Cost	0.15	0.08	50%
OLED/Cell Material Cost	1.03	0.72	70%
Encapsulation Material	0.09	0.05	60%
Module Component Cost	2.43	0.61	25%
Indirect Expense	0.50	0.25	50%
Personnel Cost	0.92	0.46	50%
Depreciation	1.49	0.30	20%
S,G,&A	1.32	0.49	20% of Cost
Total	7.93	2.96	

Lighting Yielded		90%	
	UnYielded	Yielded	
Array Material Cost	0.08	0.09	
OLED/Cell Material Cost	0.72	0.80	
Encapsulation Material	0.05	0.06	
Module Component Cost	0.61	0.61	99%
Indirect Expense	0.25	0.28	
Personnel Cost	0.46	0.51	
Depreciation	0.30	0.33	
S,G,&A	0.49	0.54	20% of Cost
Total	2.96	3.22	

Source: IHS, OLED-A

Future OLED Cost Performance

	cd / m2	3000	4000	5000
	cd for 5.5"	25.0	33.4	41.7
	Lumens for 5.5"	78.6	104.8	131.0
2018	**$/klm**	**40.9**	**30.7**	**24.5**
2020	**$/klm**	**22.9**	**17.2**	**13.8**
2025	**$/klm**	**5.9**	**4.4**	**3.5**

	$/m2				
YEAR	2015	2016	2018	2020	2025
DOE	3350	1850	550	200	100
Calculation			**386**	**216**	**56**

Source: IHS, OLED-A

Sensitivity Analysis

$/m2					
Year			2018	2020	2025
DOE	3350	1850	550	200	100
Base Case			386	216	56

Source: IHS, OLED-A

Other Cost Reduction Opportunities

- Reducing the Dopant Component
- Lower Cost of the Emitter
- Recovering Material Lost on Masks
- Reducing the Thickness of the Layers
- Decreasing the TACT

Questions

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