

# OLED Display and OLED Lighting Technology and Market Forecast

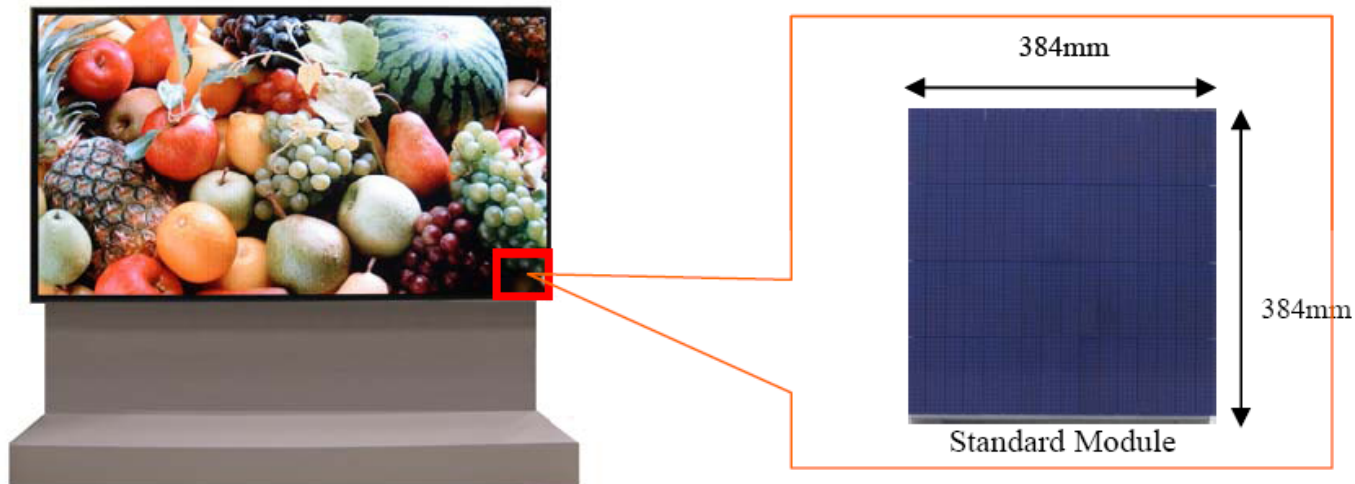


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Director, Display Technologies  
DisplaySearch

- **OLED Display**
  - New OLED Display Products
  - Technology Challenges and New Progress
  - OLED Suppliers and New Fab Activities
  - Past 11 Years
  - Future 7 Years
- **OLED Lighting**
  - Market Drivers
  - OLED Lighting Challenges
  - OLED Lighting Market Forecast
- **Summary and Strategies**

# The World's First >100" OLED Display is Passive Matrix

- Mitsubishi Electric unveiled the world's first prototype model of a 155" large-scale OLED display (called Diamond Vision) at CEATEC JAPAN 2009.
- In September 2010, Mitsubishi Electric announced it will commercialize its Diamond Vision OLED, the world's first >100" OLED display system.
- PMOLED revenues peaked in 2005, and have been falling since. The tile method might be the new way to boost PMOLED display sales in the future.



\*Frame and stand are optional.

# New AMOLED Products in the Market - Small Size

- AMOLED is growing in size, but most products are still under 4".

## Mobile phone



Nokia



LG



Samsung >20 models

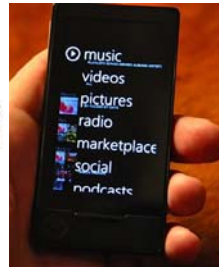


Sony Ericsson

## PMP



Sony



Microsoft



Samsung



iRiver



iRiver

## DSC



Samsung



Nikon

# New AMOLED Products in the Market - Medium/Large Size

- AMOLED medium and large applications include DPF, TV, and public signage.

## Medium size



Kodak



QOO (demo, not product)

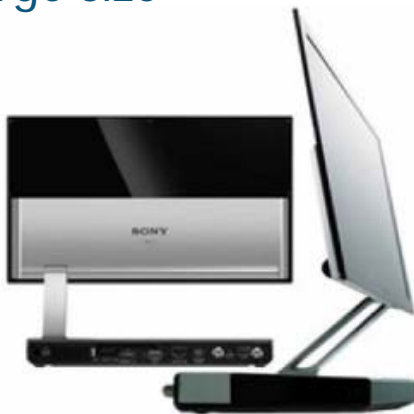


JR



Sony

## Large size



Sony 11"



LG Display 15"



TVLogic 15"

# iPhone 4 vs. Samsung Galaxy S

- iPhone 4 set the bar higher for displays: LCD, 3.5", 960×720, 326 dpi, projected capacitive touch.
- Samsung Galaxy S: AMOLED, 4" (3.97"), 800×480, 235 dpi, on-cell projected capacitive touch.
- Common factors for successful mobile phones: good displays and good touch screens are a must.



Samsung Galaxy S



Apple iPhone 4

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# AM OLED vs. AM LCD

	AM OLED	AM LCD
Thickness/Weight	Thinner, best is 0.05 mm; lighter	Thicker, best is 0.8 mm; heavier
Diagonal Size	Limited to small and medium sizes; largest demo is around 40"	Can be manufactured larger; largest demo is ~100"
Viewing Angle	Up to 180 degrees	Narrower, depends on liquid crystal type
Color Gamut	>100% NTSC (top emission), around 70% NTSC (bottom); high at all gray levels	Around 70%, up to 100% NTSC (LED backlight and new color filter); falls at low gray levels
Color Reproduction	Better; gamut independent of view angle	Good; gamut changes with viewing angle
Resolution	Lower; 308 dpi (SM), 202 dpi (polymer)	Higher; best is 498 dpi
Response Time	Faster, nanoseconds. No motion blur, good for 3D.	Slower, milliseconds
Contrast Ratio	Higher	Lower
Sunlight Readability	Better than transmissive LCD, worse than transfective LCD.	OK if transfective
Operating Temperature	Range is larger, can operate at low temps like -40°C.	Range is smaller, lowest temp is -10°C.
Power Consumption	Lower at typical video content, when around 30% of pixels are on.	Higher at typical video content
Lifetime	Shorter, 5K to 30K hour, but improving.	Much longer, above 50K hour
Manufacturing Investment	Lower, but lack of standards keeps the investment only slightly lower.	Higher
Production Cost	Expensive; low yield and complex structure, potential to be low cost.	Cheaper than AMOLED

Samsung Galaxy S



Apple iPhone 4



# Obstacles and Solutions for OLED TV

Obstacles	Potential Solutions
Scale to larger size back plane	a-Si TFT, oxide TFT, etc
Color patterning	Nozzle printing, LITI, white with color filter, blue with color change methods
Lifetime	Material improvement, hermetic sealing. Red and green is more than good enough. Blue still needs some work.
Cost	Improve yield of TFT backplane, material utilization rate, TAC time
Competing with LCD	Flexible/curve form factor, transparent TV?



Sony



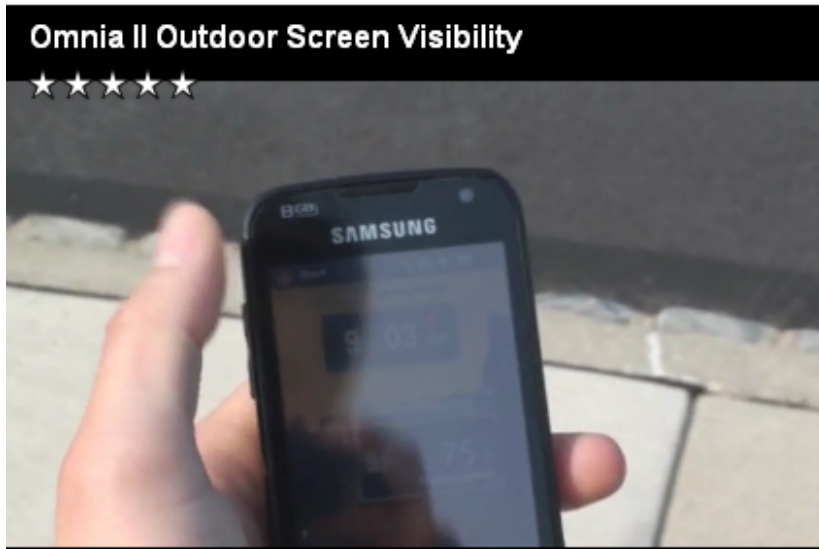
SMD



LGD

# Sunlight Readability of AMOLED vs. LCD (1/2)

- Compared to liquid crystal displays (LCDs), AMOLED displays have many advantages. However, AMOLED also has several challenges.
- Sunlight readability is one of the challenges.
- AMOLED Samsung Omnia (left) under sunlight; (right) indoors.



Source: YouTube

# Sunlight Readability of AMOLED vs. LCD (2/2)

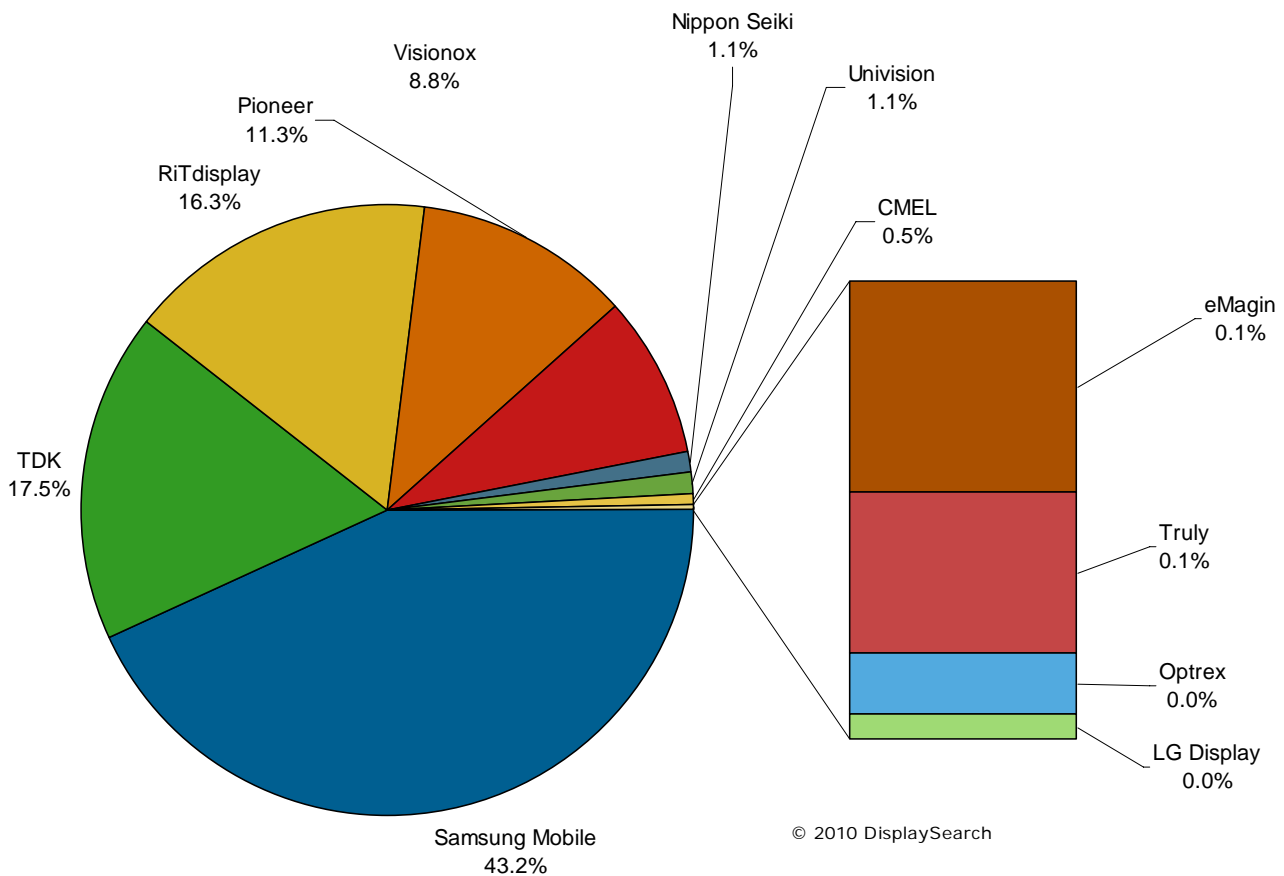
- If there is cover glass or a touch screen on top of the display, more light will be reflected light from the interface.
- There is a trick that LCD can use, but OLED has not figured out a good solution for sunlight readability yet. Transflective LCD has reasonable sunlight readability.
- Suggest that OLED form an alliance with e-paper display. E-paper displays have the best sunlight readability. See the DisplaySearch [E-Paper Displays Report](#) for more detailed information and market forecasts for e-paper displays.



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# OLED Displays Shipment Share

- Samsung Mobile remained at the top with 43% shipment share in Q1'10. TDK, with 18% share, overtook RiTdisplay for second place.
- RiTdisplay slid down to third place with 16%. Pioneer ranked fourth with a 11% share.
- Visionox, in fifth place, had 9% and is steadily gaining share.

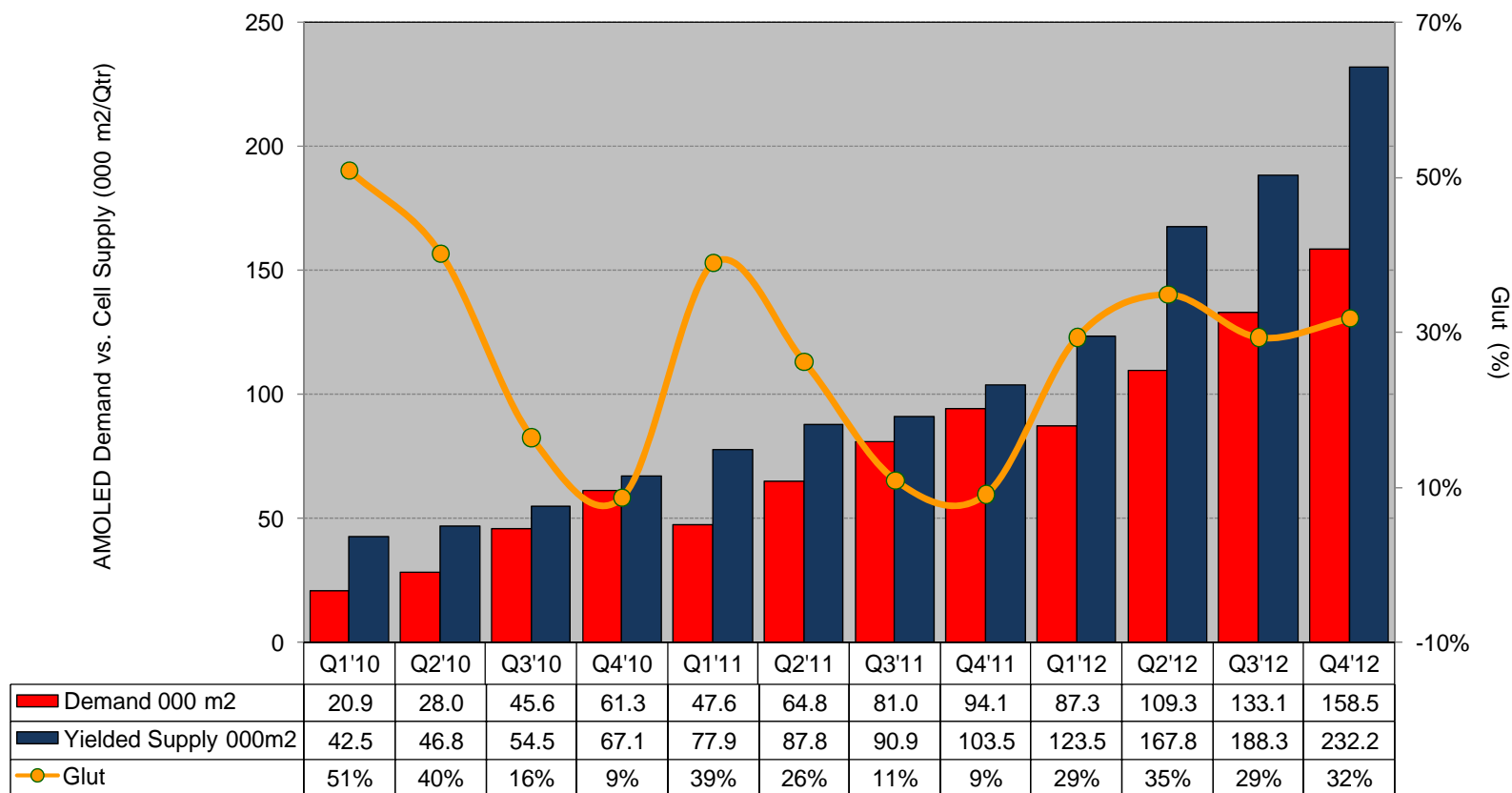


© 2010 DisplaySearch

Source: Q2'10 [Quarterly OLED Shipment and Forecast Report](#)

# AMOLED Supply and Demand

- AMOLED supply/demand balance will continue to be relatively tight until 2011, led by the strong demand for smart phones. This even allows for planned capacity expansions.
- Sufficient supply capacity will be available once Samsung Mobile's Gen 5.5 fab ramps up.



Source: Q2'10 [Quarterly OLED Shipment and Forecast Report](#)

# AMOLED Fab Activity

- Samsung Mobile Display's Gen 5.5 AMOLED fab investment is confirmed. Gen 8 is in the horizon.
- Over 10 new AMOLED fabs will be installed or updated in the next two years.

Country	Manufacturer	Install	Probability	Q1'10	Q2'10	Q3'10	Q4'10	Q1'11	Q2'11	Q3'11	Q4'11	Q1'12	Q2'12	Q3'12	Q4'12	Q1'13
China	Visionox	Dec-09	100%	█	█											
China	CCO	Jan-10	100%	█	█											
China	CCO	Jan-10	100%	█	█											
Korea	SMD	Jan-10	100%	█	█											
Taiwan	AUO	Mar-10	100%	█	█	█										
China	IRICO	Mar-10	100%	█	█	█										
China	IRICO	Mar-10	100%	█	█	█										
Korea	SMD	Jan-11	76%			█	█	█	█							
China	Tianma	May-11	70%				█	█	█	█	█					
Taiwan	Chimei Innolux	Jun-11	44%					█	█	█	█	█				
Korea	LG Display	Jun-11	55%					█	█	█	█	█	█			
Japan	Ortus	Jul-11	44%						█	█	█	█	█			
Japan	Hitachi	Nov-11	30%							█	█	█	█	█		
Korea	SMD	Dec-11	59%							█	█	█	█	█	█	
Japan	Panasonic	Feb-12	30%								█	█	█	█	█	
Korea	LG Display	Mar-12	40%								█	█	█	█	█	
China	BOE	Apr-12	30%									█	█	█	█	
Japan	Ortus	May-12	40%									█	█	█	█	
China	Tianma	Jun-12	30%									█	█	█	█	
Korea	SMD	Sep-12	45%										█	█	█	█
Taiwan	Chimei Innolux	Oct-12	30%										█	█	█	█
Japan	Panasonic	Dec-12	30%											█	█	█

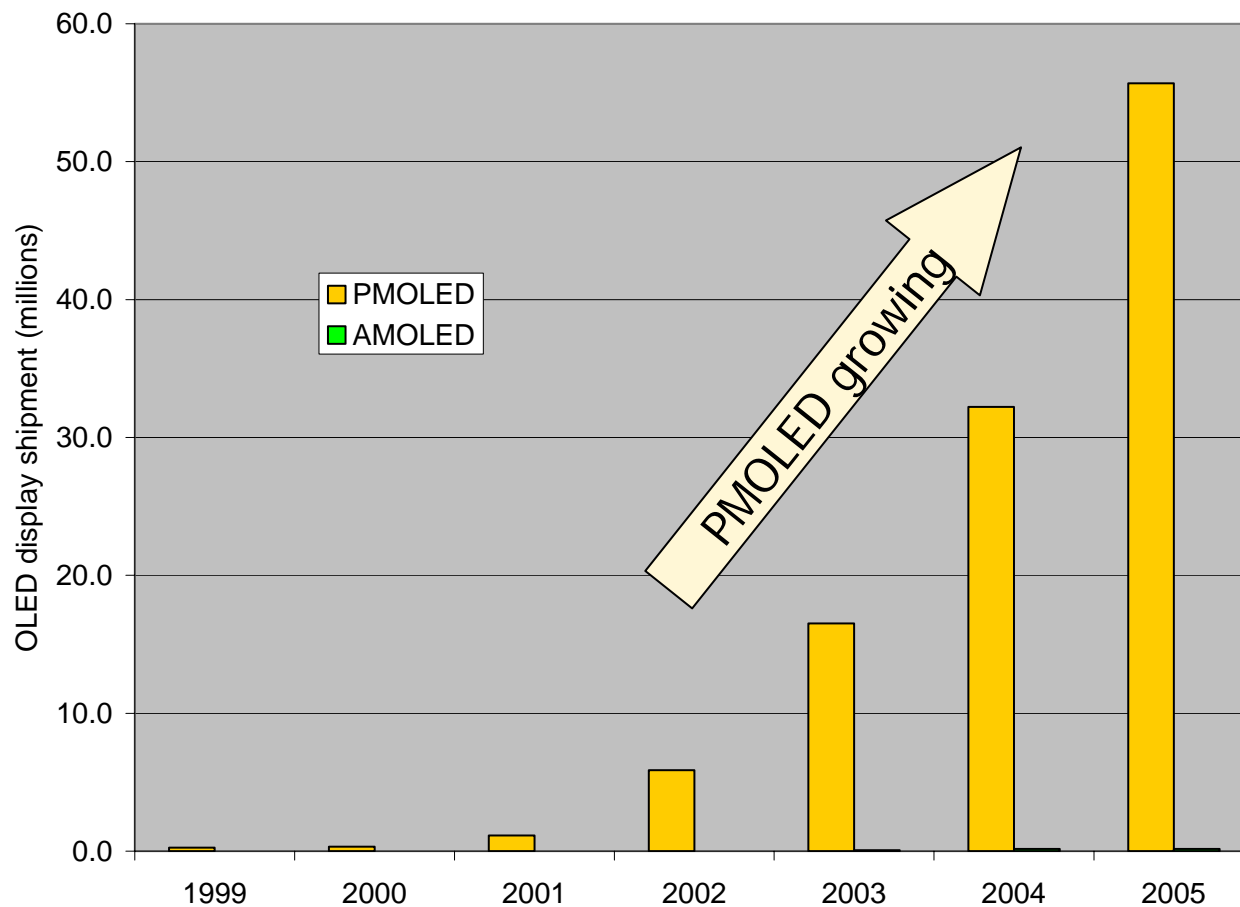
█ Order Equipment     
 █ Equipment Install     
 █ Mass Production

Source: Q2'10 [Quarterly OLED Shipment and Forecast Report](#)

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# Past 11 Years

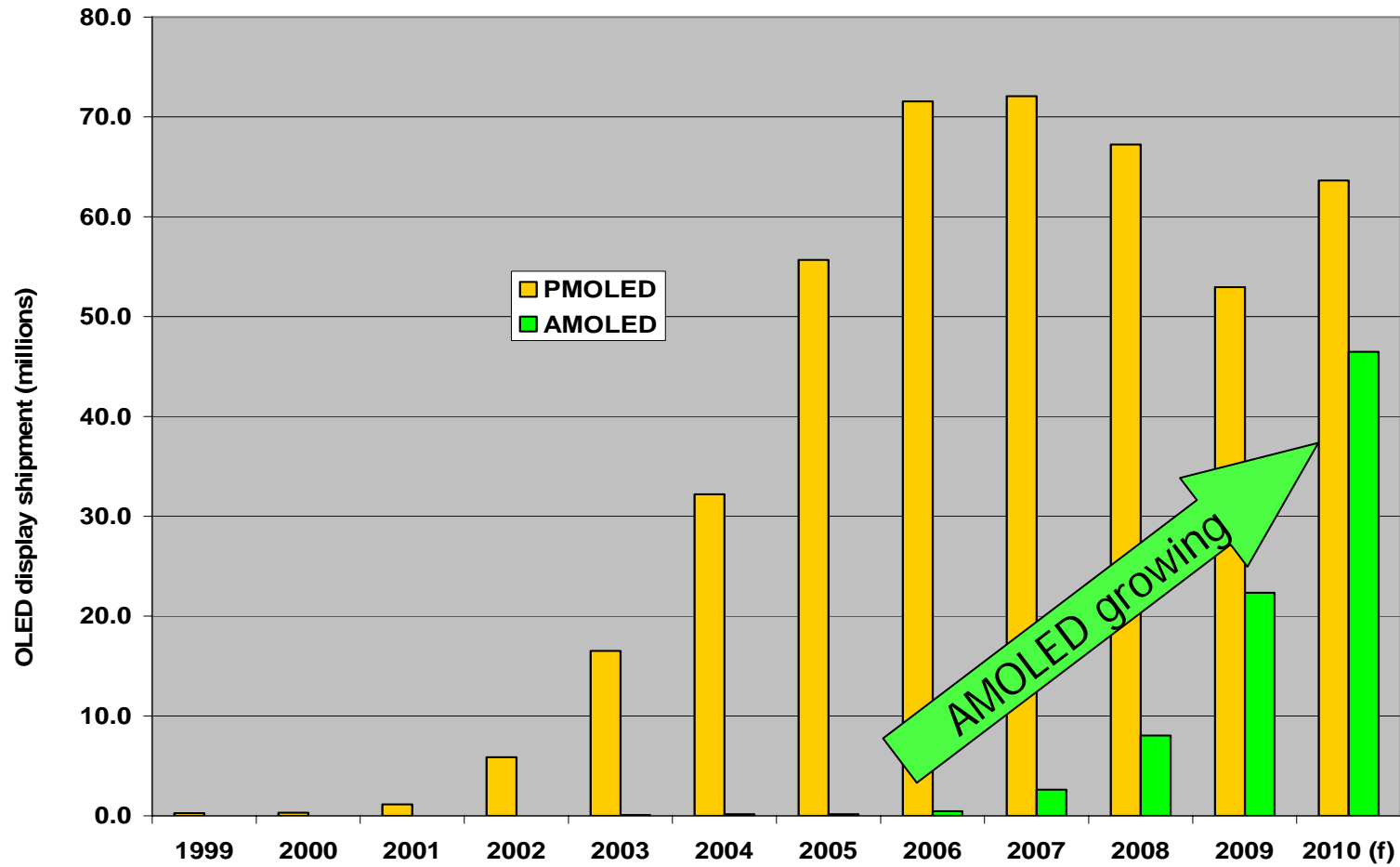
- PMOLED started shipping in 1999.
- AMOLED started shipping at the end of 2002.



Source: DisplaySearch [Quarterly OLED Shipment and Forecast Report](#)

# Past 11 years

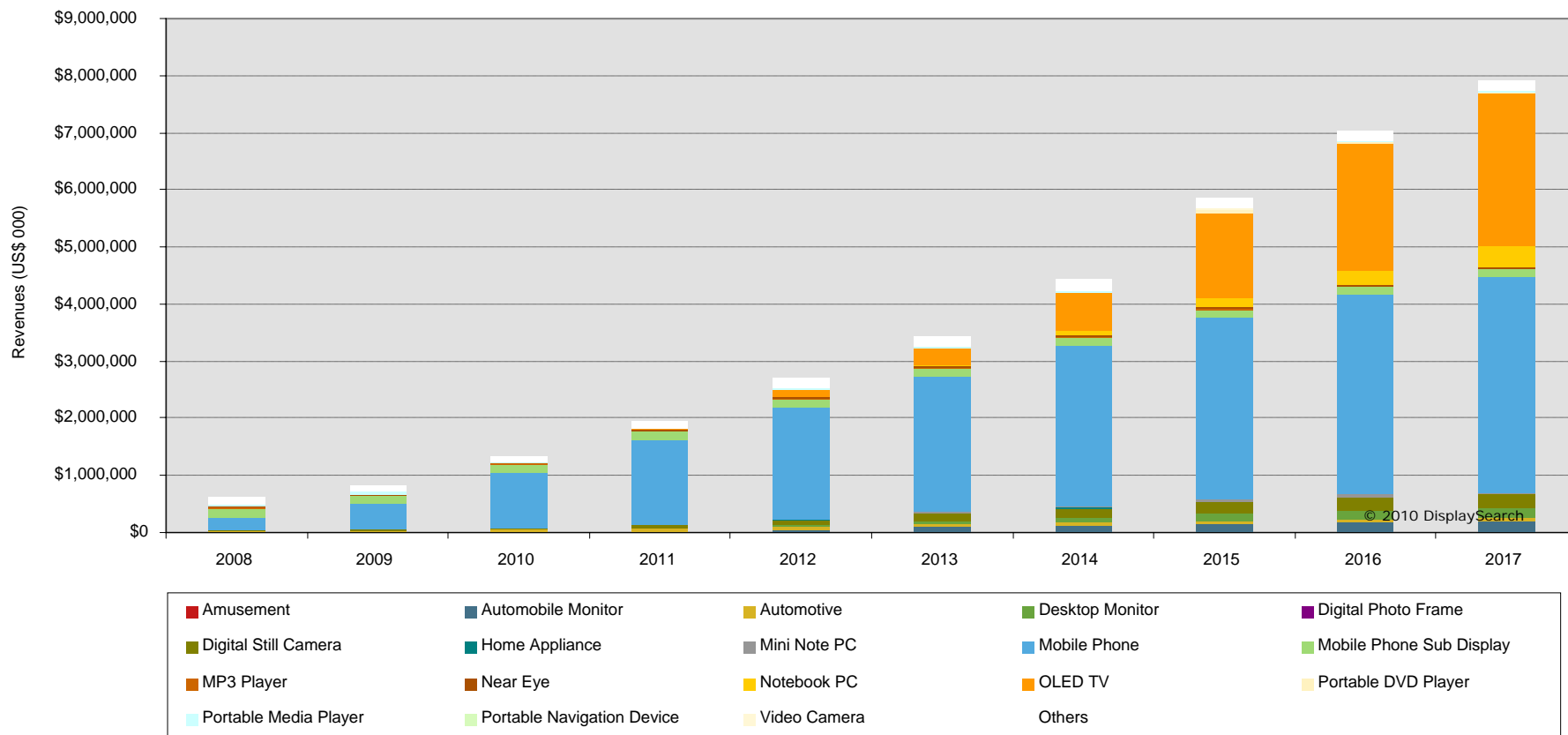
- AMOLED has seen a lot of growth since 2005.



Source: DisplaySearch [Quarterly OLED Shipment and Forecast Report](#)

# Long-Term Annual Revenue Forecast

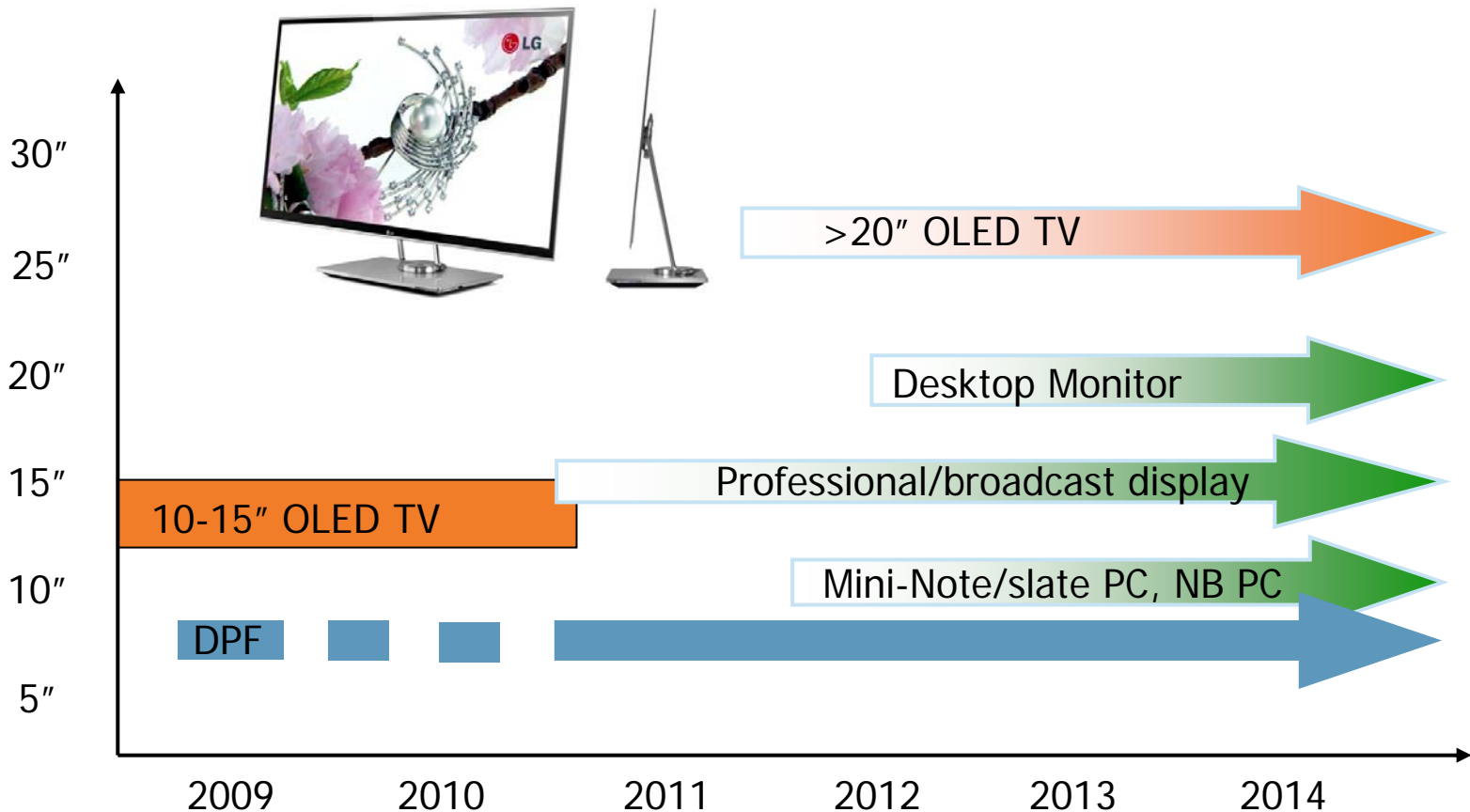
- OLED revenues will grow to about \$8B in 2017, up from \$0.8B in 2009, with 33% CAGR.
- Mobile phone main displays had strong growth recently, and will continue to lead revenues to around \$4B in 2017. TV will become the second largest revenue-producing application, at around \$3 billion in 2017.



Source: DisplaySearch Q2'10 *Quarterly OLED Shipment and Forecast Report*

# AMOLED Entrance into Medium/Large Applications

- Currently most AMOLED shipments are below 5". A small amount is shipped for Digital Photo Frames (7.6") and OLED TV (11" since 2007, and 15" since Q4'09).
- With technological improvements, we forecast that AMOLED will enter more medium/large applications. Professional broadcast displays adopted AMOLED in 2010. Notebook PCs and mini-notebook/slate PCs will be an attractive market to enter in 2011. >20" OLED TVs will enter the market in 2011.



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# Market Drivers for OLED Lighting

- High efficiency for energy savings
- Thin, light weight
- Area/surface lighting: flexible or rigid form factors
- Long life with less frequent replacement
- Tunable color for decorative use and color matching
- Fast switch on; no noise
- Wide operation temperatures for use in extreme environments
- Low drive voltage for better power, smaller power supply
- Environmentally friendly: No toxic material, spectrum similar to sun
- Can be transparent like a window, or reflective like a mirror



Source: OSRAM



Source: GE



Source: Konica Minolta

# OLED Display and Lighting Differences

- OLED displays and OLED lighting have much in common.
- They also differ in the following ways:

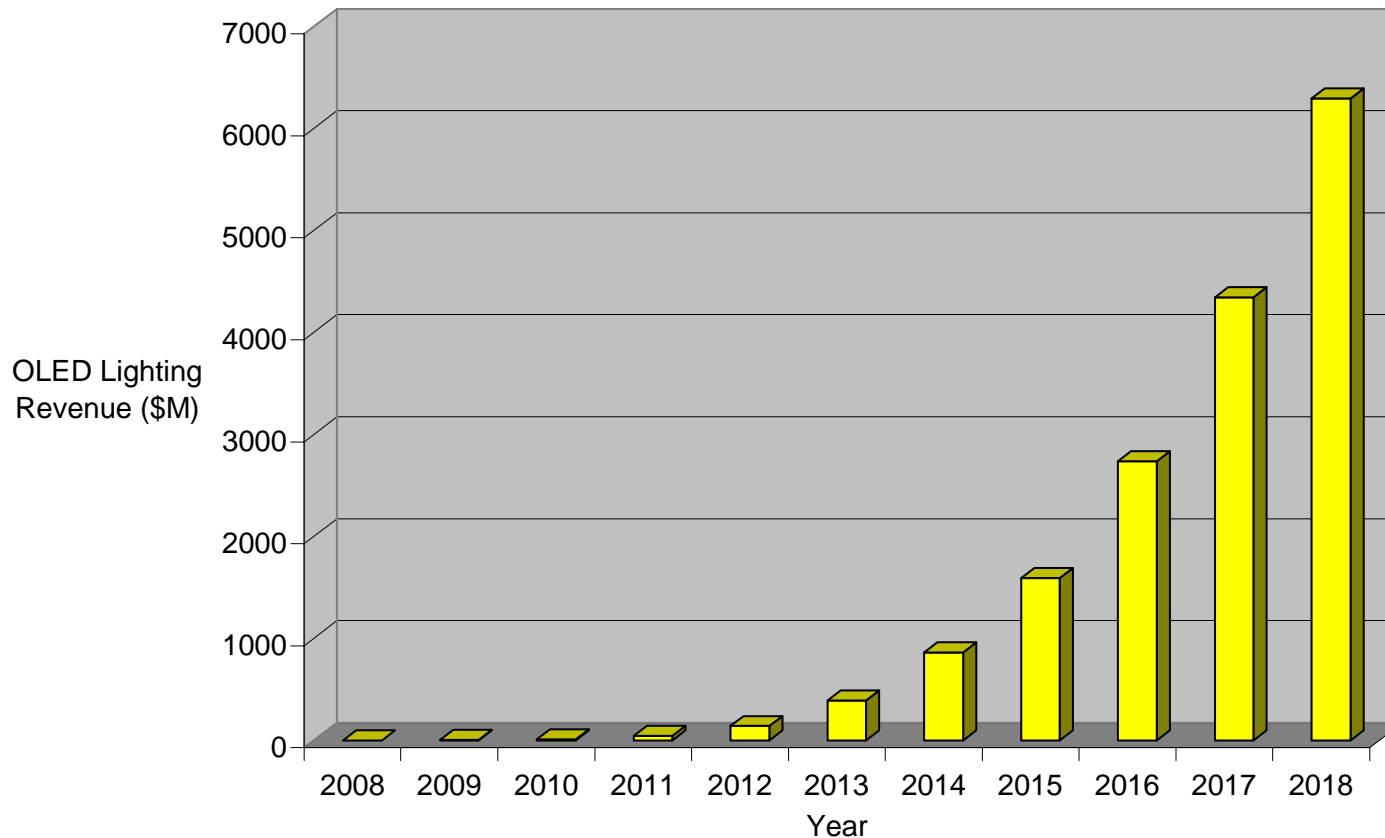
Feature/Specification	Display	Lighting
Luminance (cd/m <sup>2</sup> )	150-1000	500-7000
Color Criteria	Full color	balanced white, or RGB for decorative lighting
Color Specification	>100% of NTSC	CRI >80
Typical Panel diagonal (cm)	2-100	5-200
Pixels	yes	no pixel, but small tiles
Lifetime (K hours)	T50 is about 5-60	T70 need 10-100
Efficacy (lm/W)	10-100	10-150
Backplane	active matrix or passive matrix or segment	simple
Process	typically batch	roll-to-roll, or batch
Cost (US\$/m <sup>2</sup> )	~1000 to 2000	target 30 to 100
Issues	backplane scale to large size, backplane cost, resolution/fine patterning	uniformity and large area, high CRI, material cost, high luminance, infrastructure

Source: *OLED Lighting in 2009 and Beyond: The Bright Future*



# OLED Lighting Market Forecast

- The OLED lighting market will start to pick up around 2011.
- Some PMOLED display fabs will be converted to manufacture OLED lighting.
- The OLED lighting market will reach \$1.5B by 2015, and \$6.3B by 2018.



Source: [\*OLED Lighting in 2009 and Beyond: The Bright Future\*](#)

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# Summary and Business Recommendations

- OLED display revenues will exceed \$8B in 2017, up from \$0.8B in 2009.
  - AMOLED revenues passed PMOLED in Q1'09. AMOLED shipments will pass PMOLED in 2011.
  - Oxide TFT and a-Si TFT backplane breakthroughs, color patterning are needed for AMOLED to move to larger sizes.

- AMOLED fab capacity is currently limited in meeting demand. Over 10 new AMOLED fabs are expected in the next two years.

- PMOLED revenues peaked in 2005, and have been falling since.
  - OLED lighting should be seriously considered.
- OLED displays need a niche application where it is difficult for LCD to compete.
  - Flexible displays, transparent displays, and lighting could be possibilities.

- OLED lighting will pick up in 2011, and reach \$6.3B by 2018.

- OLED lighting should be diversified for different applications.
- OLED lighting costs need to be reduced, and efficiency should be improved for mass adoption.
- OLED can be combined with other hot technologies, like touch screens, e-paper displays, and 3D.

**Want More information?** Contact us.

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