

Will MO Compound the Problem?



Thoughts on technology transition for
Metal Oxide TFT Devices and Technology
at SEMICON/West 2012—

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Displays depend on frontplanes and backplanes that influence market economics

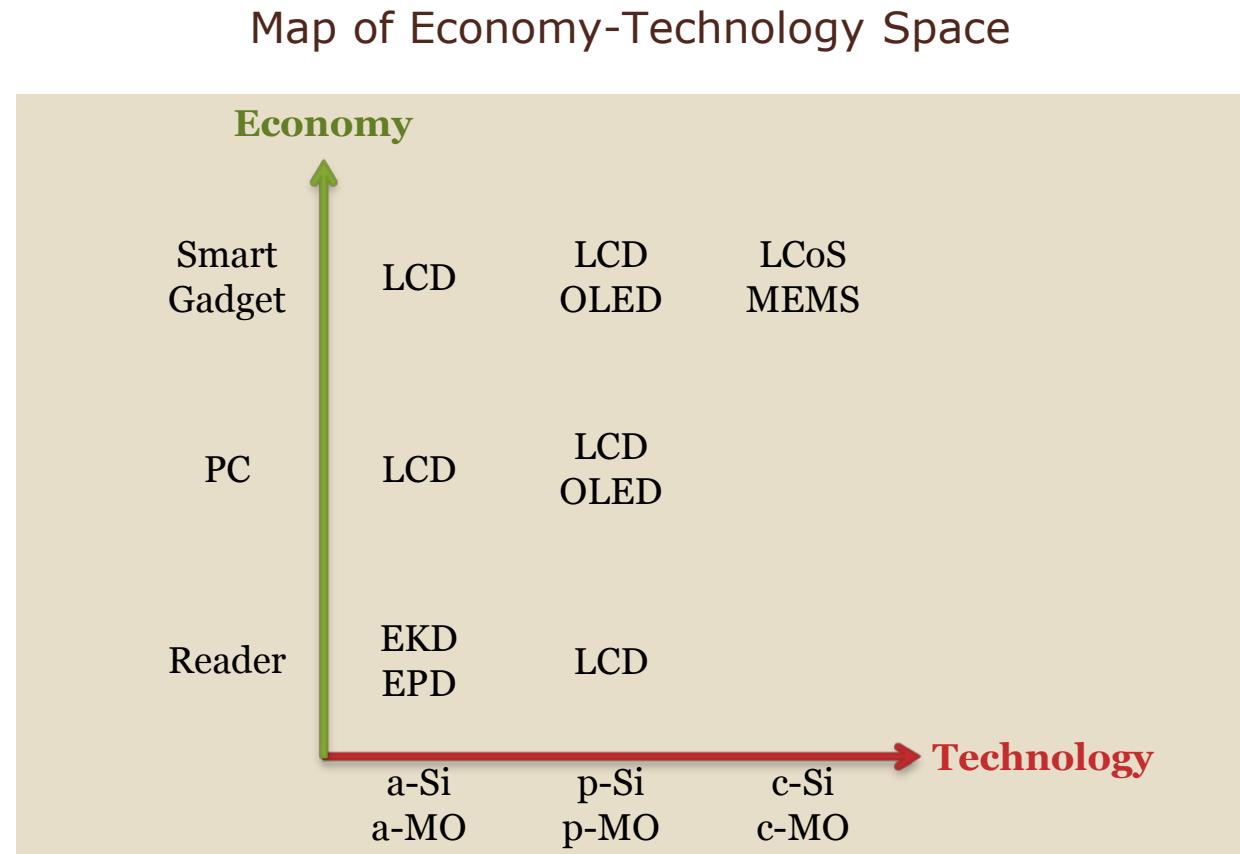
I have attended a similar number of SEMICON/West and SID conferences.

Economy and Technology play important roles in the development of IC and FPD.

The selection of frontplane and backplane are somewhat independent... and IGZO (metal-oxide, TAOS, a-OS) may increase the options.

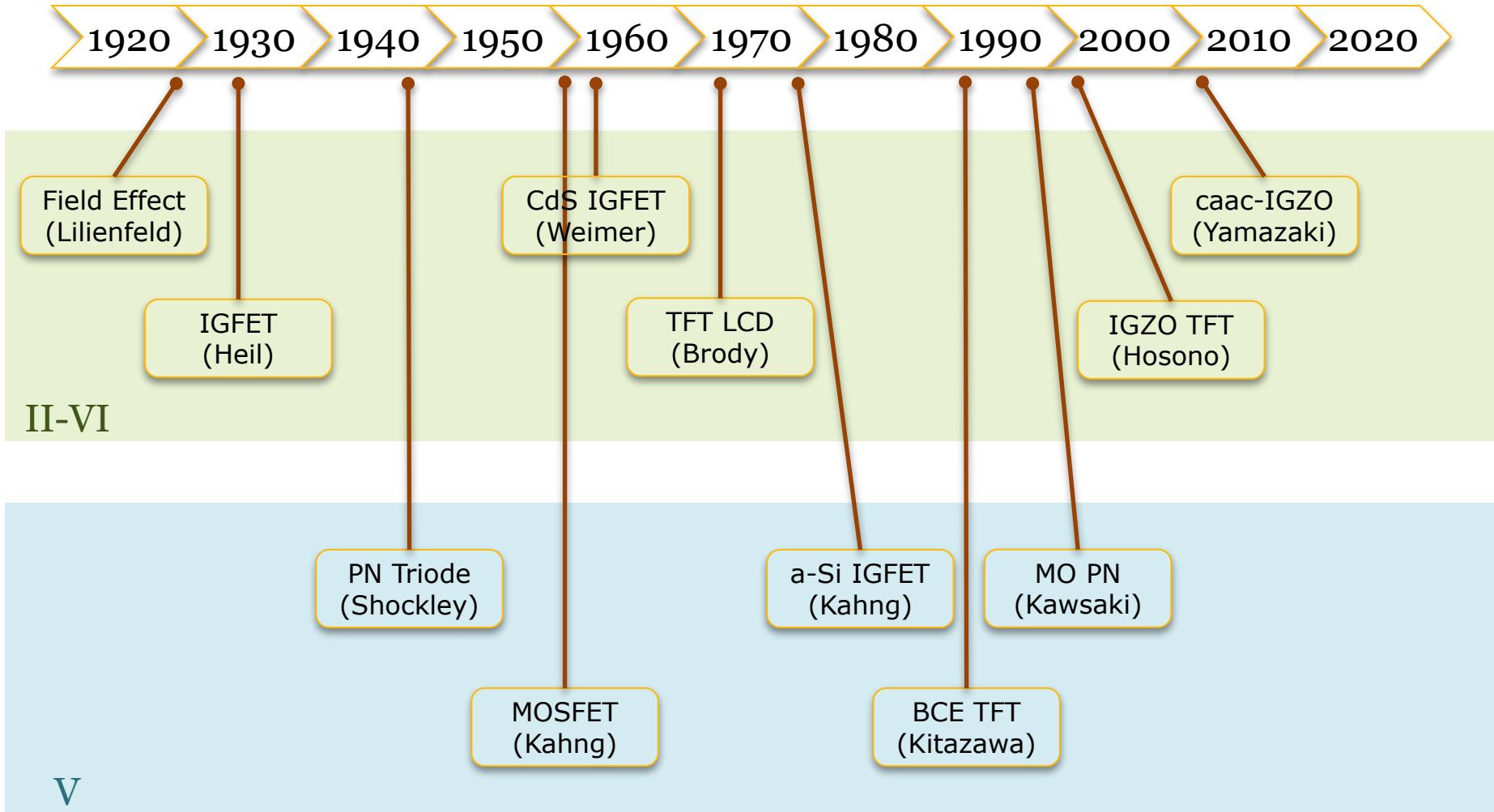
If MO TFT backplanes can drive most frontplanes, then consumers may win and producers may lose...

unless capacity and capability become differentiated.



Source: BizWitz, conceptual

II-VI compound semiconductors pre-date the Group V devices... 80 years of development



Much of what has happened was predicted

- “The Thin Film Transistor—A Late Flowering Bloom”
 - T. Peter Brody, IEEE Transactions on Electron Devices, Nov '84
 - He illuminated the past and cast light on the future
 - Advantages of II-VI TFT devices
 - Challenges of device interfaces and contaminates
 - Hegemony of LCD and potential for 400 ppi resolution
 - Small window of opportunity for non-TFT display backplanes
- “LTPS may be the GaAs of FPD” (me, 1999)
 - It enables high-performance displays, at a cost
 - It remains less than 5% of capacity despite AMOLED
 - It has potential new life if CW or other processes evolve
 - It may seldom be preferred over compound semi, e.g. IGZO

Conference topics indicate we are moving beyond devices to circuits and products

- Concentration of SID papers shifting from materials and deposition to circuit compensation and integration
 - Compensating for threshold shift in a-MO
 - Designing around depletion-mode complications in a-MO
- Publication of US patent application 13/308601 by SEL and presentation of CAAC IGZO processes at SID in June
 - Sputter conditions
 - Crystallization - RTA
 - Insulator composition
- Introduction of IGZO-TFT for high-ppi LCD by Sharp

Breakthroughs are still occurring: caac-IGZO could extend LCD's reach

- SEL's c-axis aligned crystalline IGZO invention might enable good-enough TFT at a-Si budgets
 - Channel deposition at 250° to 300° with RTA
 - Less Hydrogen desorption, fewer Oxygen defects
 - Enhancement-mode devices with stable thresholds
 - Low carrier density >> low leakage >> low frequency!
- Forget OLED for a moment...
- What about 400 ppi, speed-stepped, transreflective-FFS LCD?
 - Power saving e-Readers with HD video capability
 - Sunlight-readable displays with hi-res, full-color video
 - Invasion of application markets coveted by EKD, EPD and MEMS
- Now add OLED to that list...

Better, lower cost TFT might excite more competition in an unprofitable industry

Demand has been elastic for leading AMLCD makers.

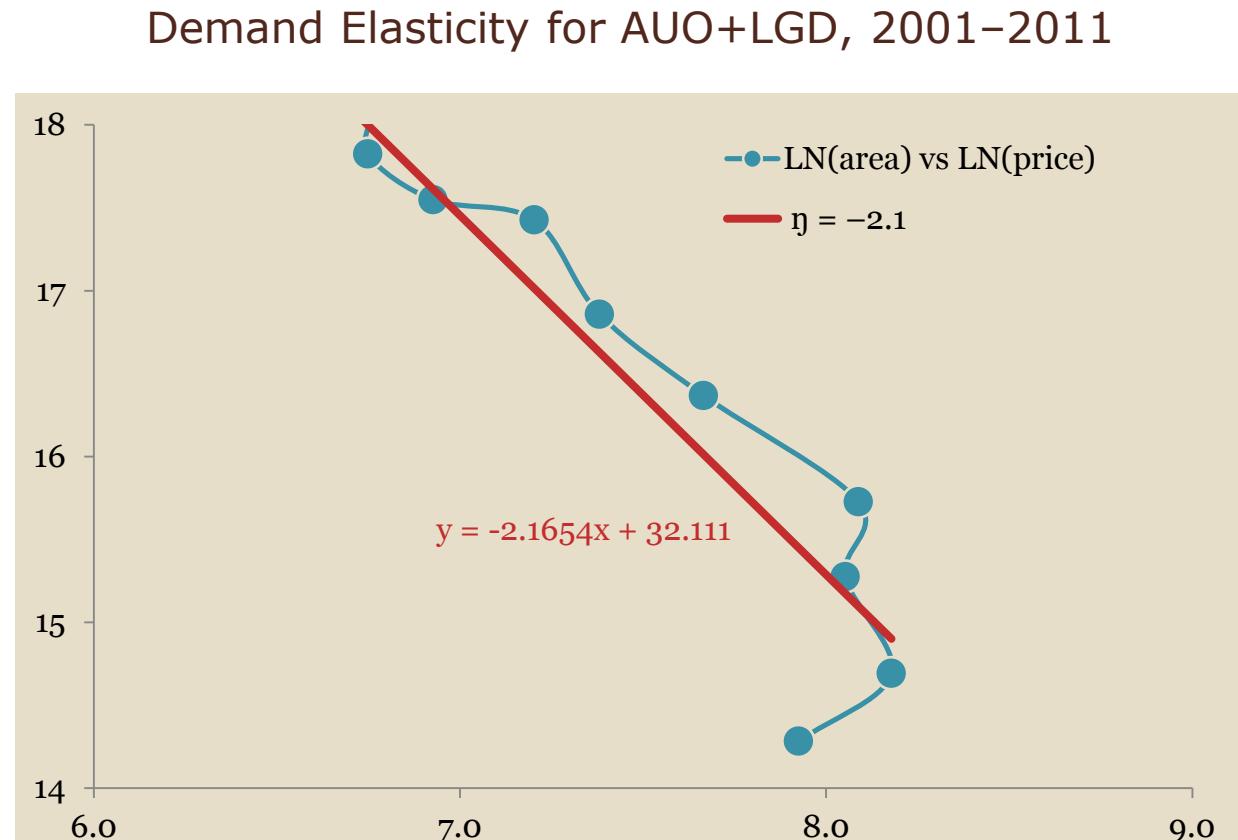
At $\eta = -1$, decreases in price stimulate demand so that sales revenue remains level.

At $\eta = -2.1$, decreasing price by 10% per square meter increases sales by 12%.

From this perspective, cutting prices looks like a good thing.

Producers with a cultural bias towards increasing exports have reasons to drive more display area into the market.

Stakeholders such as their employees and suppliers benefit from increased output.



Demand elasticity relative to price is the slope of Log Q versus Log P

Source: AUO and LGD disclosures of Area sold (m^2) and Sales (USD)

And rivalry is starting to increase as new entrants add capacity and old ones restructure

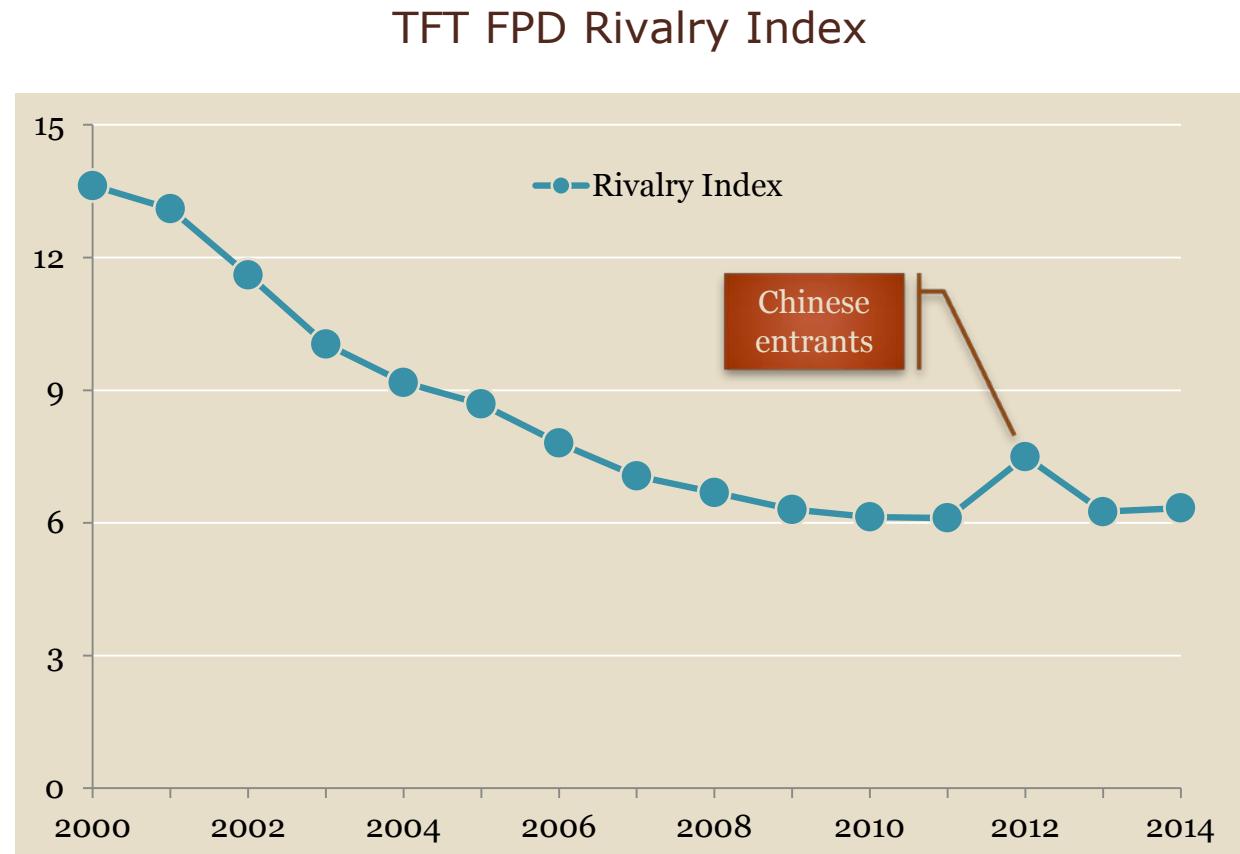
TFT display makers had some reason to hope consolidation would improve stability last decade.

Rivalry bottomed-out in 2010 however. Since then, Chinese entrants, Korean spin-outs and other moves have raised the rivalry index.

Such data suggests that the industry's dynamics may not change much for awhile.

What would producers do with LCD technology that could serve more markets?

Pile on, of course...



Rivalry based on the normalized, inverse Herfindahl index of capacity

Source: DisplaySearch, Bizwitz analysis

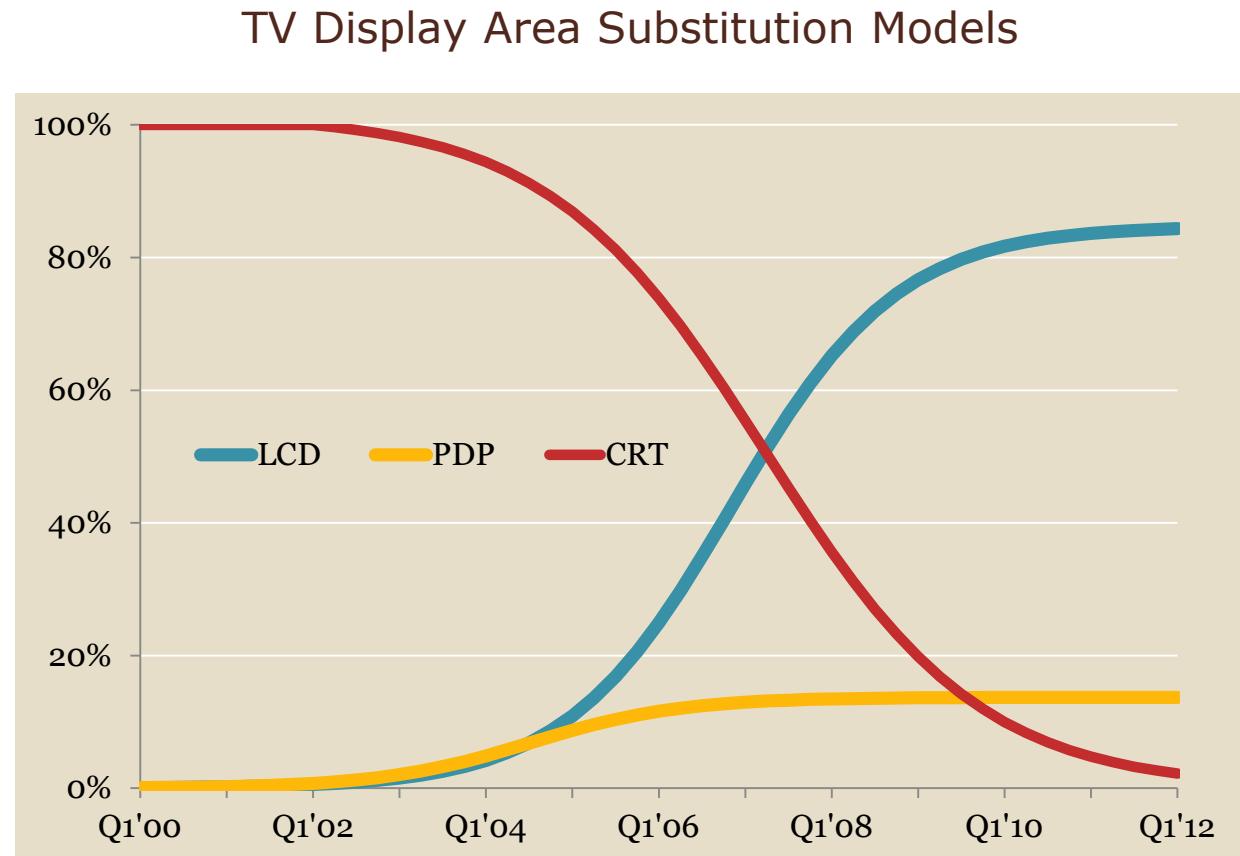
Technology substitutions can happen fast... early movers have an advantage

Looking at models of tech substitution in the TV market, we see classic, S-curves.

TFT LCD display area shot-up from 20% to 80% share of total TV display area in four years, 16 quarters.

It spent the prior ten years (from early notebook days) getting ready.

Given how fast the change happens, can you blame LCD makers for piling on?



Source: DisplaySearch, BizWitz estimates for Pearl-Reed trends

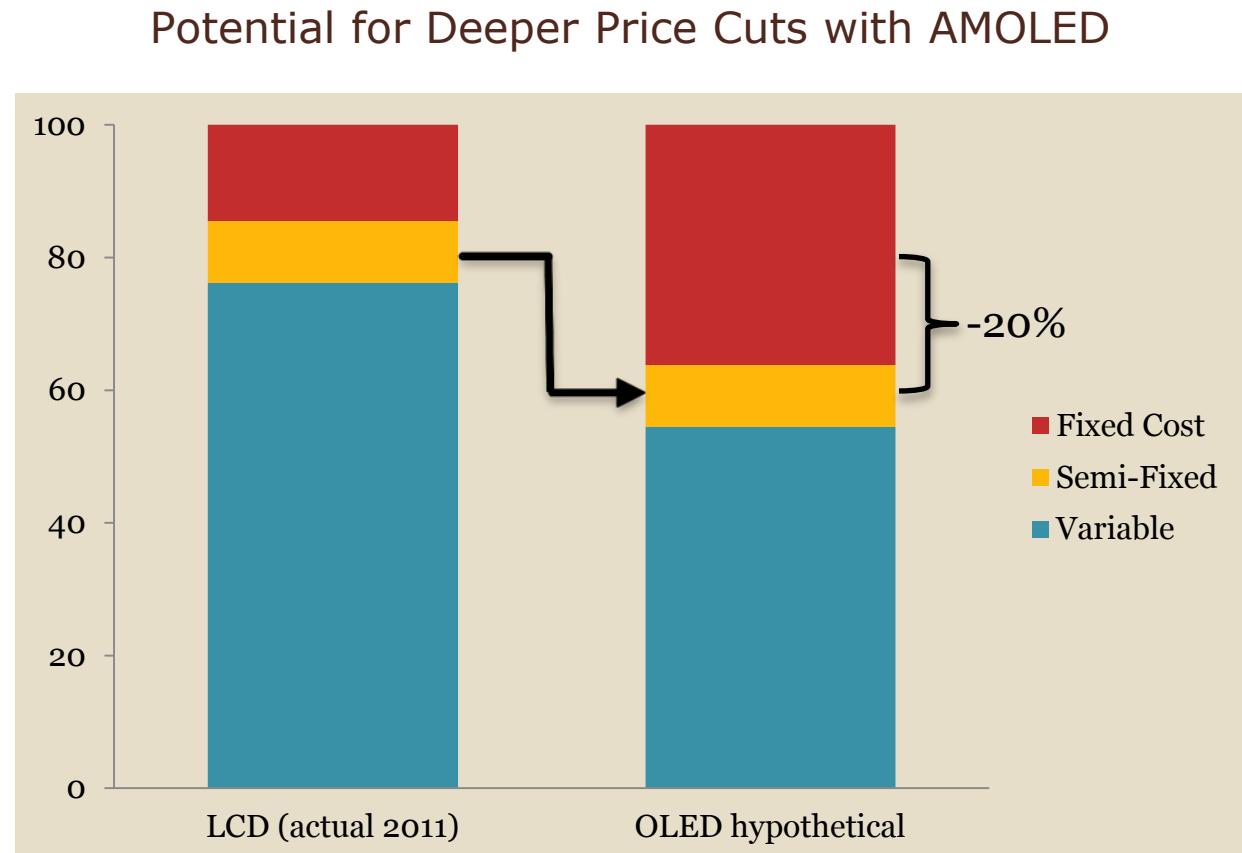
And what if AMOLED saves material cost... will display makers trade that away for share?

This chart from SID 2012 still serves to show the potential for cutting product margins if MO-OLED makes fixed costs a larger portion of total cost.

If OLED means 2.5X fixed-cost share compared to LCD, then price cuts could be 20% deeper in the future.

Given that FPD makers are already under water, this could sink all but one or two... think DRAM.

It is time for the FPD industry to think different.



Cost of product at 100 nominal units and potential depth of price cuts wherein semi-variable costs include R&D plus G&A expenses

Source: LGD disclosures and BizWitz conjecture

Advent of backplane technology with the cost of a-Si and with performance approaching p-Si...

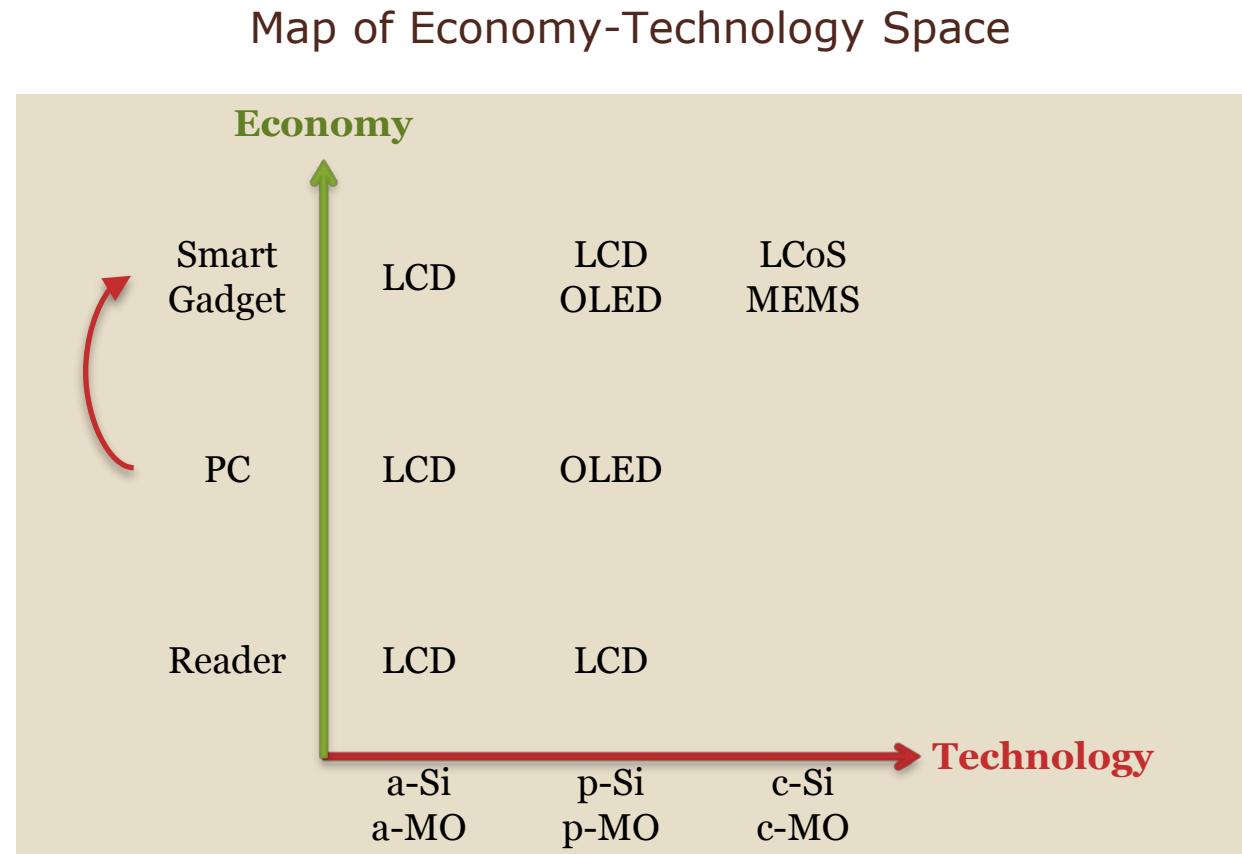
...could increase rivalry in the FPD market and motivate producers to cut prices to variable costs.

Variable costs for OLED may become less than for LCD.

LCD frontplanes could serve most display markets in the future. Scale economies could raise insurmountable entry barriers for alternatives.

Does this imply LCD will dominate until the “Princess Leia” holographic display emerges?

Not necessarily. Producers can choose to serve different markets...



Source: BizWitz, conceptual

FPD is a difficult business... BizWitz analysts are here to help



Growth	Performance	CapEx	Sourcing
<ul style="list-style-type: none">▪ Market entry▪ Business structure▪ Phase gates, R&D	<ul style="list-style-type: none">▪ Price position▪ Cost reduction▪ Portfolio balance	<ul style="list-style-type: none">▪ Factory plans▪ Tool selections▪ Plant conversions	<ul style="list-style-type: none">▪ Make/buy▪ Value chains▪ Supplier selection
Technologies	Alliances	Plans	Materials
<ul style="list-style-type: none">▪ Market sensing▪ Market & IP value▪ Consortia synergy	<ul style="list-style-type: none">▪ M&A candidates▪ Partnerships, JVs▪ Integration plans	<ul style="list-style-type: none">▪ Strategic audits▪ Investor insights▪ Business valuation	<ul style="list-style-type: none">▪ Pricing policies▪ Market strategies▪ Licenses, royalties