
Introducing new materials into the display industry

July 2016

Context

- Hendy Consulting is a strategy provider to the display market and has been advising players for nearly 20 years
- Our staple work is for electronic materials companies seeking to introduce new materials into the display industry
- This presentation seeks to distil some of our case examples into 12 main ideas that players seeking to offer novel electronic materials can use
- The reality of the situation of course is more complicated than a few rules, so we also present our methodology for looking at the opportunity for a new electronic material, in case this helps others structure the analysis
- The areas of current high interest of course will be related to the hot topics of the summer of 2016: the other areas should have shelf life beyond that
- As always with our executive briefings: we appreciate your detailed critique from you, the reader!

12 Key points in the adoption of novel materials into displays

1 Where are the opportunities?

2 Understand the segment implications and competitive approaches

3 The link to the tool matters

4 Incumbents have greater chances
Familiar materials have greater chances

5 Typical adoption process

6 Persistence is needed in Asia
Customers have siloed organisations

7 Understanding process implications important

8 Drivers of value in use

9 Customer strategies matter

10 Understand value chain pressures

11 It's about the stack

12 Selling to the display industry is about hockey sticks

1 Where are the current opportunities?

- The hot spots for new material innovations move over time but for now the focus is on OLED and flexibles with a new hot area coming up around VR systems. When we talk about flexible displays, the implication is on the whole product, through to the touch solution/cover solution
- The trend of the last 2 years has been the emphasis on colour space and resolution: the QD agenda was in response to improving the colour performance of LCD. But there will be an ongoing materials agenda as resolution continues to increase: new metal lines, new black matrix material and other new approaches
- The emphasis on form factor reduction is important: materials and approaches that can reduce weight, reduce bezel and give the consumer something special as a product will be prized
- Refresh rate may be something new that emerges as being important given the VR-AR agenda and we may see novel materials being put into use to support this

Materials that support the flexibles agenda through the total product

Materials that support the VR (High refresh rate) agenda

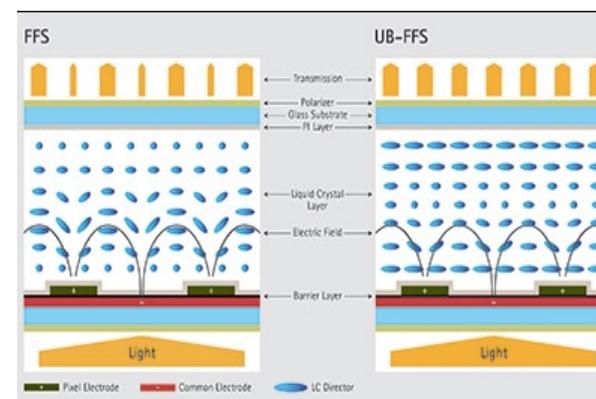
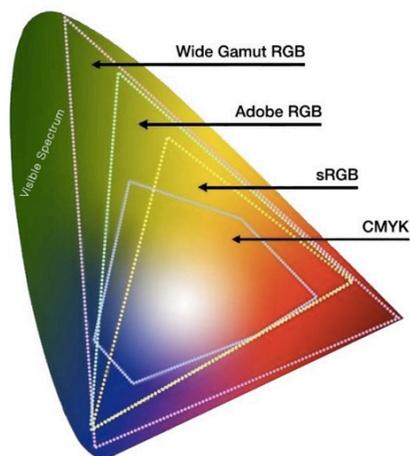
Materials that support higher and higher resolution

Materials that support smaller lighter form factor: new form factors

Materials that support increased colour gamut

Materials that support new pixel structures and LC modes

1 Where are the current opportunities?



Segment

- The segment dynamics of your material matter because they may be a very good leading indicator of which of the display firms to approach
- Let's say your material's benefits are to do with high resolution displays such as smartphones. This then would lead you towards SDC, LGD, Sharp and JDI, the key innovators in small panels
- Alternatively, let's say your material applies in all case where an IPS pixel is used and volume depends on area: then you are looking at LGD and the top Taiwanese
- In general we find the small-medium display segment more open to adoption of new approaches but not always the case

Competitive approaches

- With display making, it is rarely the case that a material is *the only way* of achieving the performance or cost change
- You need to be keenly aware of the other alternatives to achieving the same end. Especially those based on known materials (and especially known inorganics such as silicon oxide, nitride and the like)
- The known materials will nearly always win out even if they are slightly more expensive or of slightly less performance, because for a display player it is all about the total TFT stack and it is about process risk: known materials can be more easily debugged if there are problems

3

The link to the tool matters:

- This seems an obvious thing to say, but the detailed link to how your material is processed: in what tool, in what way, at what speed and with what uniformity matters
- Often development of a novel electronic material will depend critically on a partnership with an equipment partner
 - This sets up a three way market push and often the Achilles' heel for the project may be the speed at which the equipment partner is prepared to move
- We have tended to find that display R&D departments think of themselves as specialists in particular in PVD/CVD and therefore tend to lean towards materials deposited with these despite the fact that they do understand and use a variety of organics and coated/evaporated materials elsewhere in the line
- If your material can be put down in a way the industry understands: then great otherwise it is going to take longer for you to help them understand how the technology works

Most common material/tool combinations (decreasing popularity)

Vacuum processed (PVD) metals and inorganics

Evaporated materials (giving way to IJP materials)

Coated materials

Cured materials

Others

4

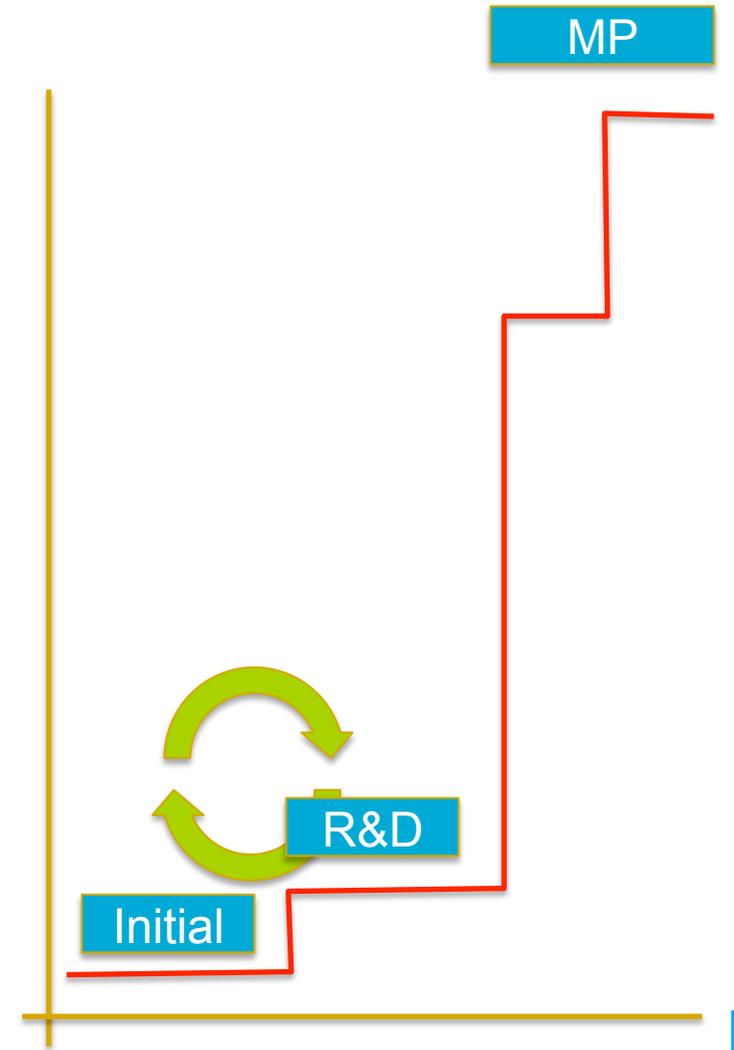
Incumbents have better chances. “Good enough” often wins. Relationship matters.

- Asian display companies are managing substantial technical complexity. For them it is not just about the potential gain for your specific material: this has got to be accommodated within the total TFT stack
- As a result current suppliers often have some understanding of the current TFT stack and implications for material changes which puts them in a better position to present new novel ideas
- More than this, Asian display firms value relationship and value knowing how each supplier is likely to behave commercially. This means that new suppliers, especially non-Asian suppliers are at a disadvantage. We have known for occasions for a Western supplier with a novel high performance material to be used purely as a “stalking horse” to help improve the response from their own established suppliers
- The final point to make is “good enough” (especially if it is a known material set) often wins out. Incrementalism is mostly the mantra except for periods of intense innovation (Say at SDC or LGD around the establishment of flex OLED). These periods however are usual in the big picture of things
- We have often seen Asian firms (well SDC and LGD) asking Western companies to work through a recognised Korean face (someone they know already). There are a number of small firms helping in this way. We think it would be better for a Western firm to hire someone who has established relationships

5

Adoption processes: A path through R&D experimentation into Mass production

- Newbies to the electronic materials industry tend to believe that they will be in volume production faster than actually transpires
- Many materials actually require an overall process change to the processes-of-record for the customer. Given that players have very finely balanced the tools in their fabs, then this often may require changes to the flow/balance (if floor space is available), or the design of a completely new fab
- Getting designed into a display operation is a period of initial experiments (that the supplier may have to help substantially with) that then lead to testing on an R&D line (Gen 3.5-6 typically). Once this is solid and working well then the conversation can be started on how this can be introduced to a mass production line environment



6

Persistence in Asia

Customers are siloed organisations

- Our own experience has shown that display firms are getting harder and harder to deal with (despite having open-innovation groups especially designed to help bring in new materials)
- In the last ten years, a number of the display firms suffered large leaks of proprietary IP and know-how by employees walking it out of the door and selling it to other firms
- As a result, the display firms cracked down hard on information sharing (becoming more like Apple) even within groups of the same firm
- More than that, a major display firm might likely have a couple or more teams working on alternative approaches to the same technical problem, if the result is important enough for them (a la Microsoft)
- This makes approaching a display major particularly difficult: Western executives do not necessarily get good information and the paths they are directed to follow may not be the ones that lead them to senior Korean decision makers
- All we can say is that persistence and relationship matter. Get your counterparts out of the office and over dinner and do it frequently. Try different parts of the organisation (and better, find yourself a local Korean or Taiwanese or Chinese guide)

7

Understanding process implications is critical. “LCD like” is not good enough.

- If we had a dollar for every client who told us their process was “LCD like” when on further investigation we find that there is a process change that needs line rebalancing we would be rich men!
- Understanding just how any process change might be implemented is critical to determining the speed of adoption and the potential value in use of any material
- The case example for a new IGZO related material could be shown on the next slide by way of an example: When considering the economics of a conversion say of an a-Si facility to IGZO the main economic driver is the speed at which the client can ramp the fab back up. This far more important than any incremental capex or material cost inherent in a new IGZO material
- A material which can be implemented with almost no process change (and we have not come across many of these) can be in mass production much more quickly than one that requires a line rebalancing (See theme number 5)
- The other point to make here is that there are different hot spots of innovation within LCD and OLED: the TFT stack has been the site of much more experimentation and change than the CF plate for example, and in OLED there has been work in particular on pixel layouts, emitters, evaporation and patterning approaches as well as fundamental work on transistor technology.

7

For example these are the IGZO conversion economics and could illustrate the economics surrounding a new IGZO material

- This is a case example based on the conversion from a-Si to IGZO at Sharp but could just as well describe the economics of the implementation of a new IGZO material approach
- The issue isn't the material cost or the capex involved but the time to ramp the fab back up

With IGZO conversion for Kameyama, rededication economics depend on getting the fab back to capacity fast

Sharp
Panasonic
Sony
Who pays?

Decline in Production of LCDs for TVs (Smaller Than 40") at Kameyama No.2

	Before	After
Revenue	\$1438m	\$1786m
EBITDA	\$200m	\$900m
Conversion time	6 months	
Conversion capex	\$20m, say	

- Let's assume we are converting a 80k sheet Gen 8 from 42" TV to 42" IGZO 4k2k TV
- Revenue before
 - $80k * 12 * \$220 * 8\text{-up} * 85\% = \$1436m$
- Revenue after (assuming you can get to 75% yield quickly)
 - $80k * (1-38\%) * 12 * \$500 * 8\text{ up} * 75\% = \$1786m$
- EBITDA before based on 14% EBITDA today: \$200m
- EBITDA after:
 - Assume fixed costs are the same absolute number
 - Assume material costs are higher (due to impact of yield) per panel on an absolute basis and due to higher absolute costs for drivers, optical films, LEDs etc
- Lost EBITDA during conversion: \$100m say in 6 months but also during this time you need to cover the additional fixed cost of \$115m
- Capex: \$20m for rebalancing and new equipment, say, with further debottlenecking capex later
- The incremental EBITDA is \$700m in the first full year (declining thereafter) against a loss of EBITDA/coverage of \$215m per 6 months and the conversion capex of \$20m
- The speed that you can bring the line back up to decent yields is the most critical driver in conversion economics. Next to this, overall pricing environment for IGZO panels: over time the premium will fall

8

Drivers of value in use for novel electronic materials:

- Many of the electronic materials that we have looked at so far have led to product performance advantages (that can be seen as increases in pricing or changes in gross margin)
- But the value in use of each electronic material can relate to yield improvement, quality improvement (in terms of the numbers of “A” grade panels) or in other areas
- The key to not leaving value on the table is to know which things a display player benefits from

New functional value

Product Performance

Yield

Quality

Cost

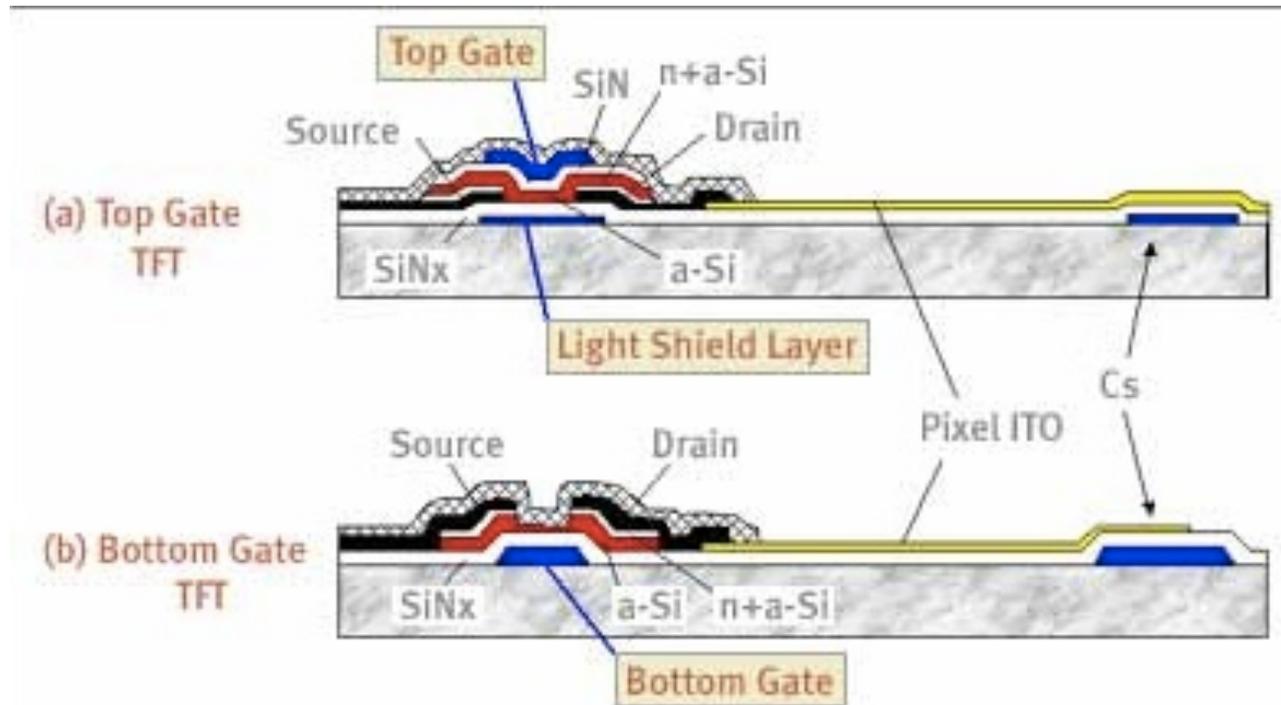
Shifts fixed
variable cost balance

Product or
process simplification

- In our experience the different firms do have very distinctly different ways of dealing with suppliers with new innovations
- For example, once Samsung decides to do something, things go fast and hard (many a small company has worried whether the pressure would suck up all their resources). LGD is a little easier to do with, but harder to convince at the starting point. Sharp has a reputation for inventing all their own solutions, but we wonder how that might change with the influence of Foxconn
- The different firms have different strengths in different markets and different needs for new capital-market stories and so they need new technologies to lesser or greater extents
- Being able to trade off their cultural affinity with dealing with International suppliers against their likely need for a new novel material becomes a matter of judgment

Understand value chain pressures and structures

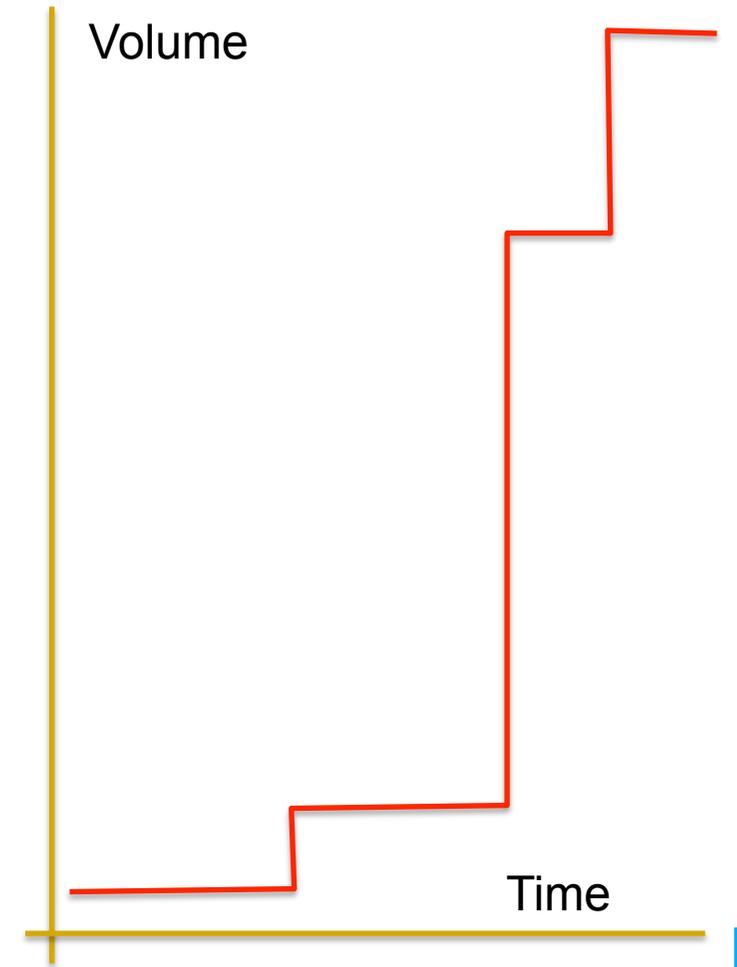
- The display industry is subject to continuous movements and value chain pressures that exert themselves differently between the small panel and large panel businesses
- Firstly the large panel business does quite a bit of “open cell” business: whereby naked panels are sold and the backlight and other parts to the display added in the latter part of the supply chain
- The second major value chain issue is the migration of value to and from touch panel solutions and cover glass function over time
- There are in some cases also sales of semi-finished cells from one player to another as an integral part of the business model
- You need to be able to understand the current and future potential value chains to know who your customers will be now and in the future



- We have made this point already but it is worth reiterating: in introducing a new material, you need to know the impact on the layer above and the layer below
- Display companies are managing the whole TFT stack and so how your material relates to the others around it becomes critically important

Selling to the display industry is about hockey sticks:

- One of the challenges (and the attractions) of selling electronic materials is the fact that in this industry there are hockey-sticks in terms of the impact on revenues if you can get designed into the whole company or a single fab!
- For start up firms this can pose a very serious problem: being able to put in place a manufacturing plan that could scale if need be to very large volumes (especially since Western management ethos does not like hockey-sticks)



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Our generic process to market validation: Typically 40 days of consulting to validate a new material and find its value in use

Phase 1: Desk research

- Opportunity sizing
- Segment approach
- Customer strategy
- Adoption issues
- Process issues/Tool issues
- Potential value in use
- Competitor approaches
- Relevant value chain issues
- Trends

Phase 2: Face to face customer validation

- Face to face customer interviews to validate our assumptions on the value of the opportunity
- Go to market recommendations
- Business planning
- Partnering approach

Our offerings:

Growth strategy <ul style="list-style-type: none">• Market entry strategy• Business unit strategy• Growth strategies for new technologies	Performance improvement <ul style="list-style-type: none">• Product portfolio management• Pricing strategy• Cost reduction	Equipment and Capex <ul style="list-style-type: none">• LCD/OLED factory capex decisions• Strategies for equipment makers	Sourcing strategy (Purchasing) <ul style="list-style-type: none">• Sourcing strategies, especially LCD and medical detectors• Make/buy decisions
Technology strategy and technology assessment <ul style="list-style-type: none">• Market and commercial strategies for new technology businesses• Market tracking services for companies monitoring technology	Partnering and alliances <ul style="list-style-type: none">• M&A candidates and assessments• Alliance formation support• Post merger integration planning	Professional advisory and business planning <ul style="list-style-type: none">• Specialist insights for bankers, equity investors and other consultancies• Reviews of business plans and models (Strategic audits)	Strategies for materials providers <ul style="list-style-type: none">• Strategy support for materials providers in the FPD, SSL, and PV markets• IP and pricing plans