
10 Economic themes for the European display industry: 2006 to 2011

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Bio: Ian Hendy

- Strategist and strategy consultant for nearly 20 years
- CEO of Hendy Consulting Limited, a strategy firm focused on the display and high tech markets (including SSL and PV). Clients from start-ups to multinationals and professional services firms
 - Network of display professionals
 - 40+ assignments completed
- Lead strategist for the Philips Components division in the area of displays (\$9bn in revenue)
- Core team member of LG.Philips LCD acquisition team
- Led a team at major LCD company to consider cross boarder merger
- Advised Ferrier Hodgson and JP Morgan on CRT bankruptcies
- Advice to Philips MDS on TPO formation
- Advised Philips to stop PDP activities
- Product and partnering strategy in OLED

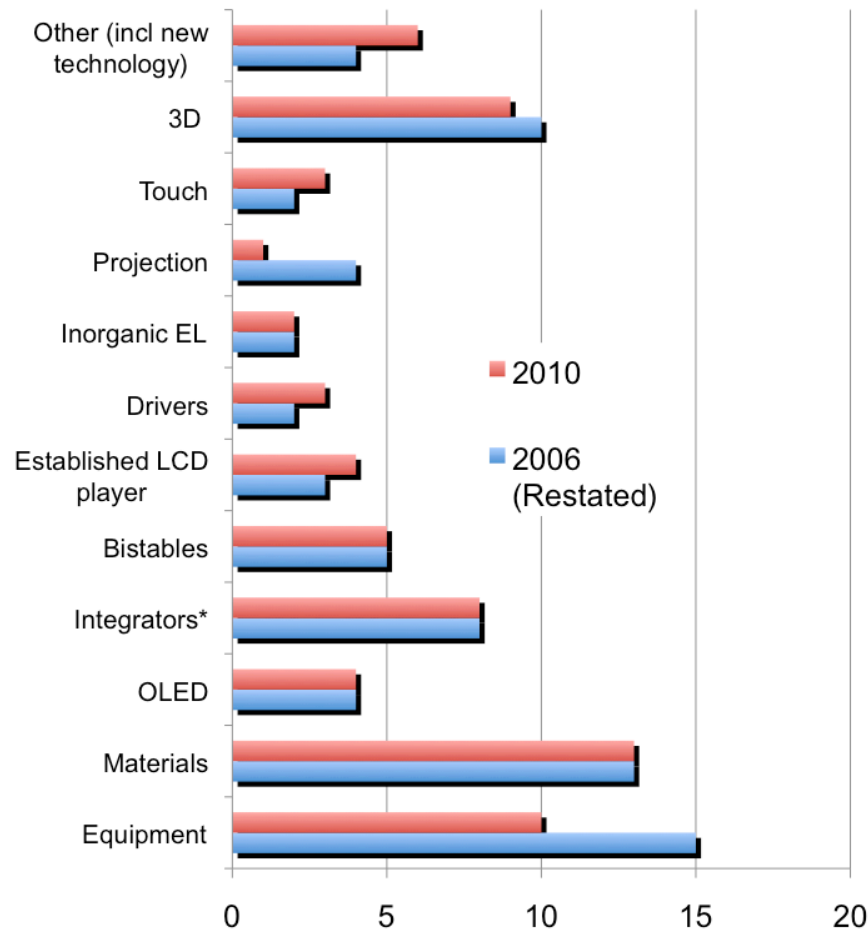
Executive Summary: 10 themes for the European Display market

- In 2006 we believed that 7 market opportunities represented the best ones for the European display industry. This was based on an assessment of our competitive strength against North America/Asia and of considerations such as profitability, risk, time to revenue and asset requirements. Unlike the current vogue which seems to be to look for strengths at R&D and use this to define policy decisions (for example the government support for printed electronics), we are concerned with the economics of the resulting businesses
- 5 years later, some of our thoughts have been validated, but on the whole Europe has not made much progress in the areas of promise
 - The equipment opportunity has really struggled and there is mixed news in the drivers/controllers space
 - At the top end of the leader board, SEC and LGD have put down module facilities in Eastern Europe and Merck and Barco continue to be important businesses. Philips has restructured its display assets leaving behind a number of venture firms that have been bought up by Asian multinationals. Below €500m sales and above €50m sales there are shockingly few businesses and then a large number of pre-revenue or small-revenue start-ups
- We maintain our view that Europe should:
 - We should continue to invest in materials, illumination and optics and specialist integration or touch
 - See printables and flexibles as longer term opportunities. We are concerned about value capture from most business models here other than straight materials plays
 - Stop worrying about complete display systems, since the value creation profile is not strong enough. Complete product solutions for outdoor signage and supermarket signage using bistable displays seem to be the exception
 - Concern itself with commercialisation questions as well as technology collaboration questions

What is the European display industry

- Businesses (or the revenue from larger groups directly related to displays) focused on the displays industry or any of the supporting materials, equipment and IP. OLED lighting is included to the extent that players are working on technology and commercialisation issues very similar to the display space.
- Flexible printed electronics for other applications (PV, Semiconductors) not included. Professional integrators of display products are included (where the result is still primarily a display module), but not manufacturers of PCs or TV sets.
- We have included touch component companies
- Companies with a centre of gravity of R&D, manufacturing or the HQ in Europe have been included (e.g. PlasticLogic could be claimed to be European given R&D and manufacturing in Cambridge and Dresden despite the HQ in California)
- The starting point has been those companies with at least 2 members of SID in Europe but then bolstered with additional research

Displays in Europe: Around 75 firms with average revenue of €45-60m*. Under heavy flux. On average only break-even without Merck


















Number of companies

- Many exits from businesses seemingly going under or redirected including:
 - MED
 - PolymerVision (but then the assets acquired by Wistron)
 - Micronas TV controllers business closed
 - Screen Technology Group PLC liquidated
 - Unaxis/Balzers display business redirected
 - Exitech display focus redirected
 - OLED-T shut down and some IP sold
- M&A deals with companies changing hands
 - CDT (bought by Sumitomo)
 - Pelikon (bought by MFLEX)
 - Elumin8 (bought by LMG International Hong Kong)
 - LOFO (bought by Shinkong Group)
 - Schott sale of glass fab and licensing agreement with LG Chem
 - PolymerVision assets sold to the Wistron group
 - Liquavista sold to Samsung Electronics (2011)
- New startups including Canatu, Orthocone and Nanoco Technologies among others
- A number of new public listings or new JVs
 - New JV Ledon OLED
 - Listing of Nanoco Technologies on AIM market
 - Listing of Zytronic on AIM
 - IPO of AZ-materials
- Additional strategic investment by Rusnano into PlasticLogic (2011)







In 2006 we came up with a point of view on which market opportunities could be the top ones for Europe to compete in. How well have we done?

Our view in 2006

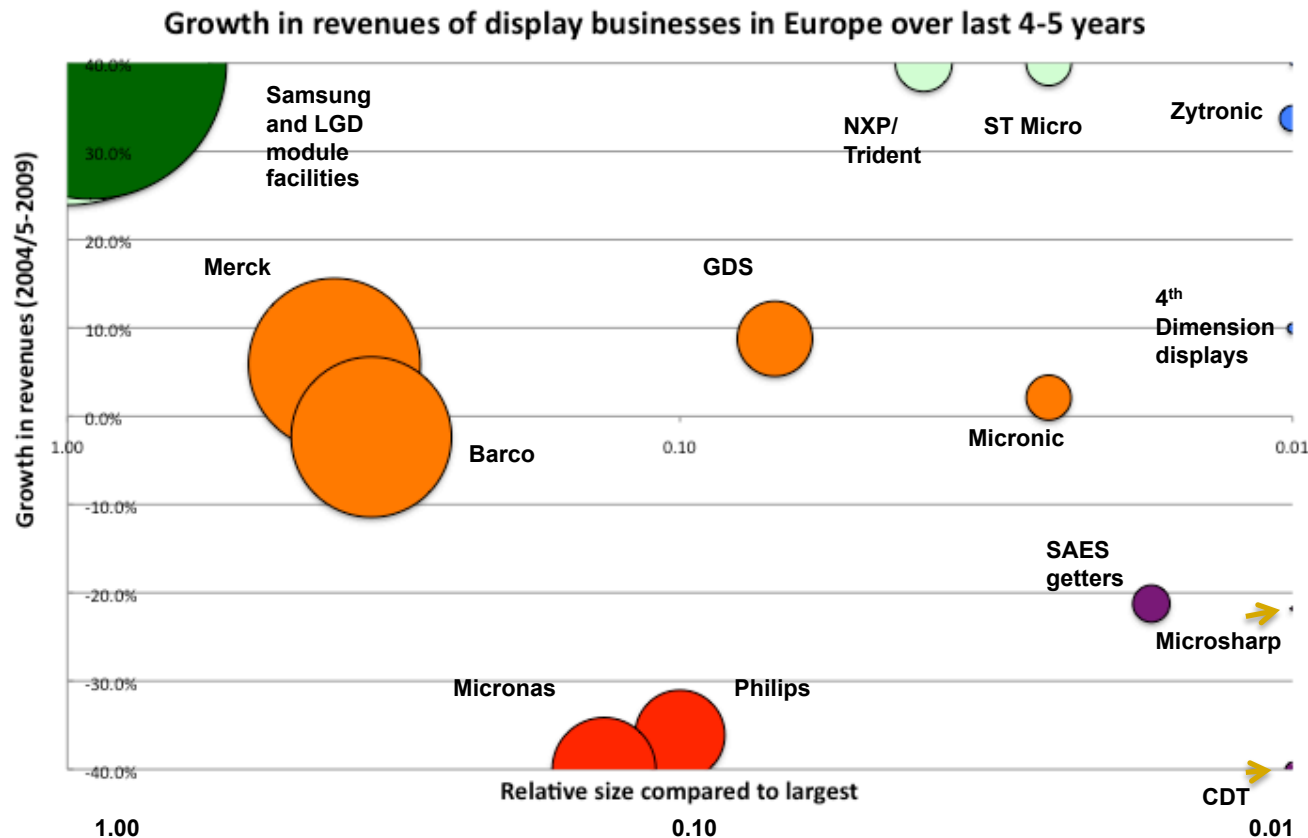
Progress '06-'11

<i>Top opportunities</i>	Size and growth of profit/value opportunity	Current European competitive position	Potential future competitive position	Key competitors	Key developments needed	Summary	
Materials (LC, Glass, OLED materials Plastics, Photoresist, Chemicals)				Asia (Dominant)	Entry of mainstream European Chemicals companies	Top opportunity	Some progress
Illumination, optics & films (Including optical films)				Asia (Dominant) USA (3M)	More competition with 3M. Philips to expand lighting franchise	Solid opportunity	Some progress
Drivers and image processing				Asia (Dominant) USA (Getting stronger)	European IC cos seize the Drivers opportunities	Solid opportunity	Disappointing on the whole
Processes and IP				Asia (E.g. SEL) USA (E.g. Kodak)	Polymer electronics and new printing based approaches create value	Solid opportunity (but more limited scale)	Some progress
Integration and specialist integration				Asia (mainstream integration svcs)	Europe expands its role in key segments	Solid "niche" opportunity	Some progress

Speculative opportunities

Display manufacturing				Asia (Dominant)	Cell+fill moves to Europe. Small in-line fabs play a role	New innovations might create new markets	Disappointing on the whole
Equipment				Asia (Dominant) USA (Also strong)	Small in-line fabs play a role. New processes	Speculative opportunity	Disappointing on the whole

In fact, the revenue growth plot of the changes in the industry (where data is available), shows 6 major stories:



- Story 1 (Dark green): Entrance of Samsung and LGD module facilities as the largest display businesses in Europe
- Story 2 (Orange): Solid mid range players deliver unit growth in markets with declining pricing (Merck, Barco, GDS, Micronic)
- Story 3 (Red): Exits or changes in strategy
— Micronas (exit), Philips (exit)
- Story 4 (Blue): Small businesses making onward progress (e.g. ZBD, 4th Dimension, Zytronic)
- Story 5 (Purple): Smaller businesses shrinking or have variable revenue levels (SAES getters, CDT, Microsharp)
- Story 6 (Light green): NXP/Trident and ST Micro enter the TV controller business

From our updated research, there are 10 themes that emerge:

We also think Europe's role in 3D is worth discussing and we will do so another time

1

Materials businesses doing quite well and are becoming of interest for acquisition

4

Processes and IP:
Some progress but much of this outside displays proper. CDT acquired

7

Fundamental new technologies (CNT, LC modes) creating new options

2

In Illumination and Optics, Europe has a strong position in OLED lighting, but only limited progress in optical films

5

Professional integration market ticking along but margins are challenging

8

Touch of importance for specific vertical applications

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Progress in Drivers/Controllers has been disappointing but we still have some participation

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Equipment industry very challenging

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E-Readers riding the wave but difficult commercial times ahead

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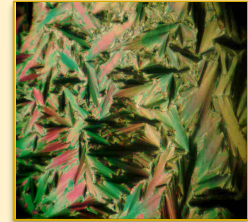
Bistables and polystables making progress once complete system offerings and value chains in place

In the materials space, Merck stays top. Other than Merck, the story is not so strong:

- Merck has retained its strong position, SAES and Schott have lost ground and other large chemicals majors retain small interests and hope for the future
- Merck stays at the top of the rankings as one of the most value creating businesses in the display industry
 - 2004 sales of Euro 583M and EBIT of 51%
 - 2009 sales of Euro 733M and EBIT of 31%
 - 2010 Jan-Sep sales of Euro 778M and EBIT of 51%
- Schott AG has effectively withdrawn from the display glass market by selling their Korean tank to Asahi and by licensing glass technology to LG Chem
- SAES Getters has seen a radical fall in their revenue line from getter solutions from CCFL backlighting for LCD displays and have sought to rebalance their portfolio with other businesses before revenues from OLED getters and flexible display getters arrive
- HC Starck, Ciba (now BASF) and Heraeus still in the displays materials businesses and/or looking to expand. AZ materials successful IPO in late 2010
- We like this space since Europe is competitive globally, margins are strong, but development horizons are long

Merck (Germany):

stays at the top of the rankings but has suffered price pressure and increased competition for its cocktails of liquid crystals. Profit level dipped in 2009 but back up in 2010 on the back of PS-VA, volumes and forex movements



Schott (Germany):

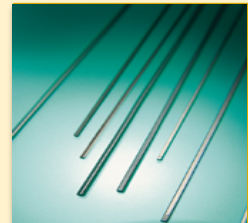
Sold Korean tank to Asahi glass and licensed glass technology to LG Chem.

Separately Saint Gobain active in R&D for flexible thin glasses



SAES Getters (Italy):

Falling sales from getter solutions for CCFL lamps have halved the profits from the SAES getters Information Displays business. Happily SAES getters have other businesses that will deliver cashflow long term and SAES have also diversified into shaped metals



In illumination and optics, some progress in OLED lighting but maybe not enough to compete with inorganic LED solutions.

Substrate market getting crowded

- Novaled still one of the industry leaders in OLED for lighting applications
 - Pursuing OLED lighting on metals and glass with 30 lumens/Watt output on active lamps up to 225 cm²
- LEDON OLED is a new 3 party joint venture set up between the Zumtobel group and two different parts of the Fraunhofer Institute including access to the Fraunhofer's Gen 2 factory
- DuPont Teijin remains one of the pre-eminent leaders of the flexible substrate pack, with its treated PET and PEN films but the market place is becoming increasingly competitive
- Lonza's electronic materials business acquired by the Shinkong group. Microsharp diversifying away from core display optical films business to include solar concentrators
- We continue to believe that the Illumination and optics space offers opportunities for Europe despite strong US and Asian competition. The economics of the materials space of LEDs and of optical films in particular has historically been solid (Cree and Nisssha all solidly profitable, Merck, 3M and Fuji also)

Novaled (Germany): Making progress towards 100 lm/Watt OLED lighting with a demonstrator able to emit 1,000 candelas per square meter for 50k hours and with appropriate colour coordinates. However, cost is not mentioned. The competitive threat is competing with LED based solutions



LEDON OLED (Germany):

A new JV formed in October 2009 to allow Zumtobel to harness additional resources for OLED lighting including access to Fraunhofer's Gen 2



DuPont Teijin (UK): Still one of the leaders in treated substrates for flexible display applications but subject now to many more competitors from steel and aluminium to performance packaging companies, 3M, Corning and others



Drivers business have had a really rough time with Micronas being the largest casualty

- In 2006, Micronas was the poster child for the European semiconductor industry in displays with its TV platform chips
 - In May 2009, Micronas restructured its TV ICs business, cutting away over €200m in revenue and over and focusing on its Automotive business
 - Increasing competition with Asia blamed, and the poor display sales during Euro 2008 and the Olympics
- CDT also announced in 2008 that it had stopped development of TMA, an IC technology aimed at increasing the potential pixel scope of passive matrix displays
- However, a number of players, including Dialog semiconductor remain in the market place. Dialog semiconductor makes drivers for E-Ink displays as well as supporting Qualcomm's Mirasol products
- NXP/Trident and ST Micro remain in the TV ICs business with market shares around the same level as Micronas before it exited. NXP/Trident maintaining market share but ST Micro losing share through 2008-2009
- While Europe still has a strong IC sector, we are concerned about the ongoing capability for European players to compete with design houses in Taiwan. Some of these Taiwanese are associated with specific display companies. Complex custom mixed-signal TV ICs play to our strengths but companies like Mediatek in Taiwan are fierce competitors

Micronas (Switzerland): Micronas had been one of the leading contenders for TV ICs but price pressure and weak sales for Euro 2008 and the Beijing Olympics led to the complete closure of the consumer electronics business unit and 800 jobs



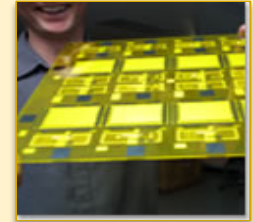
Dialog Semiconductor (UK and Germany): Positioned with key relationships with E-Ink (PVI in Taiwan) and Qualcomm for the Mirasol display technologies



The processes and IP space has seen most movement for OLED IP (CDT):

- CDT was acquired in mid 2007 by Sumitomo Chemical for over \$285m. Not a huge win for investors in CDT, we believe. Sumitomo now has a position in the AMOLED materials market
- A number of printing companies in Europe remain have jumped on the displays and printed organic electronics bandwagon, though most now seem more focused on printed electronics then displays. Examples include, Pixdro (previously part of OTB), Xennia and Xaar Some of these businesses will result in standard equipment businesses later, although others may be more mixed models including licensing
- Licensing business models for new processes are always going to be challenging to sell to Asia – display companies will pay for equipment and pay for high priced materials but don't like layers of IP payments and will only undertake them if there are patent fortresses.
- Our big concern for printed electronics is which businesses will make money? If the business develops like the display industry, then it might be the inks and other materials players (It is not the display players). Market structures and numbers of players at each part in the value chain will determine who gets which portion of the value, if there is any value

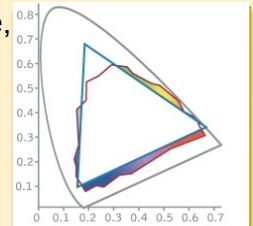
CDT (UK): Acquired by Sumitomo for \$285m
We do not believe that overall shareholders made huge financial returns



PixDro (The Netherlands):
Print heads and industrial printers for research and plastic R&D type environments.



Genoa Color (Israel): Along with Nuvoyance, Genoa Color is one of the innovators in new pixel formats to improve brightness and/or colour space. Genoa's model is based on an RGBCY construction that improves yellows in particular. The question is, are they getting paid for their work?



Professional display integration businesses seem to be ticking along

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- Barco maintains its leadership ranking in the top 5 display businesses in Europe and has strengthened its medical imaging franchise through the purchase of the FIMI business from Philips (for €19m and a €10m earn out for a business with revenues of €42m)
- There are quite a number of other display integrators in Europe, many of them sub €10m in revenue with specific single geography focuses
- Hatteland Displays and GDS have caught our eye as having interesting stories
 - Hatteland: A specialist marine display integrator based in Norway with revenues in excess of £35m
 - GDS: An Italian display integrator with revenues in excess of €140m focused on outdoor display applications
- The economics of the professional integration business seem to vary by market segment, with military and medical offerings more profitable than most. Occasional tough years plunge the industry as a whole into the red

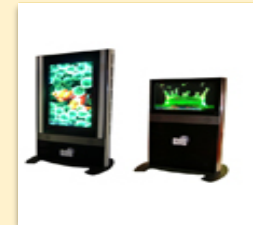
Barco (Belgium): Always one of the global leaders in display integration for professional markets (alongside the like of the US integrators like Planar Systems) and back in the black financially after a difficult 2009



Hatteland Displays (Norway): Venture funded professional display company focused on Marine applications. This has all the hallmarks of a professional integration business: a strong focus on solving specific market issues



GDS (Italy): GDS is a solid integration company with specialist expertise at station information displays and DOOH. Has capabilities in a range of display technologies (including LED signage) with a real understanding of the outdoors



The equipment industry has been turbulent but Micronic still has an interesting position in pattern generators for photomasks:

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- On the whole the position of European equipment players has been very tough
 - OTB exited the display space after failing to find customers for its in-line factory solutions, despite a revolutionary concept. The assets still exist in OLED Technologies BV
 - Oerlikon owns the Unaxis/Balzers display equipment businesses and purchased the laser assets of Exitech in Oxford but it not clear that any of these are now focused on the display industry
- Micronic remains an interesting business with a leadership position making pattern generator equipment machines for LCD photomasks and supporting Hoya, DNP and Toppan
- Elsewhere in the equipment world there has been further consolidation – to the Japanese leaders, the Korean localised solutions and Applied Materials
- We are more skeptical now of the ability for European players to get accepted by the majors: this is mostly about the way the leaders see equipment risk (“Incrementalism is better since incrementalism is proven”). Which is all the more the shame since profit margins range from -10% to +25% through the cycle with averages in the solidly positive range

OTB (The Netherlands): Radical in-line display equipment solution represented just too much technology and commercial risk for Asian players to get their head around and OTB ended up spinning out the business



Oerlikon (Switzerland): The proud former owner of both Unaxis/Balzers and the laser assets of Exitech from Oxford in the UK. Now it is not clear that either is being used for the display industry



Micronic Mydata (Sweden): Remains one of the leading pattern generator companies for LCD photomasks. Customer base includes Hoya, DNP and Toppan

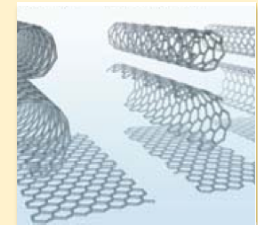


A few new businesses with revolutionary technology have been founded or spun out: some of them interesting

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- Canatu Oy of Finland has developed a new Carbon-nanotube based material. The challenge they will face will be the whole ecosystem needed to deliver their approach and capture enough value for themselves
- Orthocone is new anti-ferroelectric liquid crystal based on research at the Chalmers Institute in Sweden and seed funded by the. Potentially interesting, but like work on Optical Compensation Bend liquid crystals has proven, sometimes new modes take a long time before adoption for all the temperature and optical/contrast issues are fully understood
- Nanoco Technologies quantum dot company listed on AIM in 2008/2009, working on commercialising their quantum dot materials for LED lighting and other markets. Currently able to manufacture 1kg batches of material, a material that fluoresce at specific wavelengths dependent on the particle size. Have a range of non-Cadmium based materials that represent a breakthrough
- We like the economics of these businesses if they can build franchises similar to Merck's in liquid crystal though we understand that the challenges of building support ecosystems and partnering with Asia are never simple
 - Many of these businesses hit technical problems that mean that their promise is not delivered

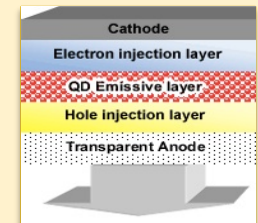
Canatu (Finland): Targeting their Nanobuds material as a replacement for ITO for a range of market places including displays, solar and touch. Recent Red Herring Global 100 winner now entering scale-up and commercialisation phase



Orthocone (Sweden): Pioneering a new anti-ferroelectric LC mode based on work at the Chalmers Institute in Sweden. Co-founder Per Rudquist recently awarded prize from the Swedish Academy of Sciences for this



Nanoco (UK): Recently AIM listed UK company working on quantum dots. Have a couple of JDAs in place with a couple of mid-to-large Japanese corporates.



Following the launch of the iPhone and investments by governments in e-classrooms, touch businesses seem to be doing well

- The iPhone changed business perceptions of the importance of User interface in modern electronics
- Zytronic took this as their cue to list on AIM with their portfolio of projected capacitance touch solutions
 - Have had a strong growth streak for the last 5 years growing from revenues of only £4m to £16m by time of listing
- Promethean, the UK based education touch solutions provider growing well and also sought a listing on AIM. Promethean is another company that has embraced that a complete solution offering is needed to build a market. Has invested into Flat Frog
- Flat Frog new multitouch technology and a production and integration deal with touch leader Kortek in Korea for gaming and entertainment
 - Recently received €12.5M funding from Promethean, Invus and Sunshine capital
- What makes the touch market so fascinating is that each touch technology has its strengths and challenges and underlying cost structure that fits it to its applications. The economics of resistive touch technologies are poor but companies like Wacom, Gunze and Synaptics have proved that touch can be a profitable (op margins between 10-20%) and growing space

Zytronic (UK) recent AIM listing: Leader in security projected capacitance touch solutions. Focus on entertainment and gaming markets. Growing nicely



Promethean (UK): Education touch solution company that has built up a global position competing with the likes of SMART Technologies in Canada (recent purchaser of NextWindow) by offering a complete customer solution



Flat Frog (Norway): New multitouch technology recently received VC funding of €12.5m to pursue their new multitouch solution in collaboration with Kortek in Korea, one of the global leaders in touch integration

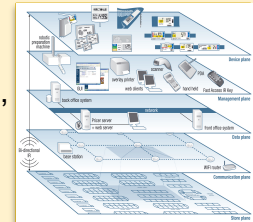


Bistables and Polystables are making good progress once a *complete* product solution is available for a specific end market

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- We have followed the bistable industry for over ten years with the concern that any display business in this space needs to have solved upstream commercial models
 - Ereader companies need to understand the economics and delivery of electronic books. Shelf label businesses need to understand the costs and economics of the retailers
- The following companies seem to be making real progress, based on having offered compete solutions to the value chain
 - Pricer: Claim 60% market share of the growing ESL label market based on segmented and matrix displays with the latter from SiPiX (that was recently purchased by AUO)
 - ZBD Solutions: Growing customer base by expanding its distributor network and innovative rF base station design
 - Polydisplay: Making real progress on road signage with road trials in Sweden for their polystable display technology
- While these businesses are long in gestation, there is the potential of large markets with quite high barriers to entry

Pricer (Sweden): One of the early ESL companies – has switched display provider from Bridgestone to SiPix, we believe, and claims dominant market position against SES of France



ZBD Solutions (UK): UK venture funded start-up based on an innovative “bounce” rF solution and bistable displays sourced from almost standard STN lines in Asia



Polydisplay (Norway): Making real progress towards road signage markets through a collaboration with Saab and working with Scandinavian Road Authorities. Lead investor’s “Ray of light” house shows off the potential of polystable materials



The eReader phenomenon has impacted Europe too, but we are concerned about pricing and commercial issues ahead: too little value in the value chain and publishers too powerful

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- It is clear now in 2010 that eReaders are here to stay but we are concerned about the economic issues coming in the future
 - Falling prices for display modules on the basis of increasing competition with PVI's E-Ink display modules
 - No one making money in the value chain other than the publishers, in the view from Amazon and given that, more difficult questions are coming
- In Europe, many display companies jumping on the eReader bandwagon
 - PlasticLogic: \$100m in organic TFT factory in Dresden with recent announcement of a major investment by Rusnano
 - Liquavista: Offering a portfolio of 3 different display implementations with the ability to switch between monochrome and colour and transmissive to reflective modes and with driving support built into IT OMAP or Freescale application processors. Recently acquired by Samsung Electronics
- We are not a fan of the economics of device making or ebooks – so look for challenges ahead. Moreover, consumers will decide whether the iPad or eReaders win
 - Confirming our concern is the bankruptcy of iRex Technologies a Netherlands based E-Reader company and spin-out from Philips. PlasticLogic withdrew their first product the QUE

PlasticLogic (UK and Germany): PlasticLogic took a bet that the first product, the QUE, but then withdrew it in the face of competition with fringing field IPS a-Si in the iPad. Recent strategic investments from Rusnano may indicate a change of direction



Liquavista (The Netherlands): Liquavista executing a multi-tier product/technology strategy. We like that they have integrated driving into common device application processors and that they have commissioned VDL-ETG to make custom equipment. Recently acquired by Samsung Electronics



Summary

- 2006 to 2011 has not been an easy period for the European display industry (or in fact for the Asian display industry either)
 - While Merck, GDS, Micronic and others have made revenue gains and Samsung and LGD have put down module facilities in Europe, there have been some loud exits: Micronas consumer division exits the market for TV ICs, OTB abandoned its in-line displays business and Schott exited the display glass business
- On the other hand some European businesses have done well and have been snapped up: CDT purchased for \$285m by Sumitomo Chemical, Elumin8 and Pelikon bought by corporates in the USA and Hong Kong respectively and other businesses also changing hands (many snapped up by Asian corporates). Successful IPO of AZ materials and sale of Liquavista to Samsung Electronics and new investment into PlasticLogic by Rusnano
- In considering what has gone well and what has gone poorly, we have down-rated our view on the equipment/manufacturing and drivers/controllers industries. However, there are still 4 markets where European companies have strong competencies and where the economics of the market space are solid
 - Display materials
 - Illumination and Optics
 - Processes and IP (subject to considering who will accrue the value)
 - Specialist integration and touch
- Plus also we have seen some really interesting things from bistable solution companies (including Pricer, ZBD and Polydisplay) and new technology innovations (from Canatu, Orthocone, Nanoco)
- We believe that Europe still has promise but that weightier effort and resources need to be committed

Background on the author:

Hendy Consulting Limited 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• Cost reduction• Pricing strategies• Validation of pro-forma plans	Equipment and Capex <ul style="list-style-type: none">• Display 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 corporates 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	Strategies for materials providers <ul style="list-style-type: none">• Strategy support for materials providers in the FPD, SSL and PV markets• Intellectual Property planning

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