Linking into the Value Chain for the Printed Electronics Industry

FuturePrint09

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Agenda

- Evolution of the Printed Electronics (PE) industry
  - A disruptive technology
  - Convergence of many industries
- Definition & importance of the Value Chain
- The Value Chain analysis
- Key considerations along the PE Value Chain
- Success factors

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PE is a disruptive technology

	2005	2010	2015
Status	Widely discussed as an emerging technology, RFID being implemented by retailers	Mainstream with most products sold containing RFIDs, similar to barcodes in 2000. Significant growth in printed electronic items including solar cells and batteries	Many intelligent tags in most retailed items, largely replacing barcodes.
Incremental or disruptive technology	Incremental	Disruptive	Disruptive
Impact on print / publishing supply chain		Will need to add RFIDs to many products being sold	Integrated into many printed products that are retailed
Benefits to printer / publisher	Specialist RFID and printed electronic supplies have high added value opportunity	Opportunities for printers to produce RFIDs as part of the high-value product mix	Will become an integral part of many print, and particularly, packaging products
Impact on print / publishing value chain	Higher value products	More information on products available	
Benefits to print / product user	Improved logistics for retailers and manufacturers		
Technology infrastructure requirements		Low-cost readers widely available	
Impact on print volume	Boost	Boost	Boost
Impact on print productivity		Boosts hybrid print lines with RFID print capability inbuilt	
New product / new market potential	New tags and labels for logistics	Printed solar panels and batteries widely adopted	Printed RFID a new capability for printers
'Gee-whiz' factor	Packages and labels that self-describe	Packages that broadcast	Packages that sing and dance
Likelihood of adoption	7	9	9
Impact	7	8	9

Source: Disruptive Technology Scorecard for RFID and Printed Electronics, "Impact of printed electronics on graphic arts industry" Written by Pira International, 2007

Printed Electronics is a Convergence

- A convergence of different industrial skill sets into joint activity
- Standards and protocols to communicate a common language
- The advancement of functional testing that is different from that used in any of the converged industries

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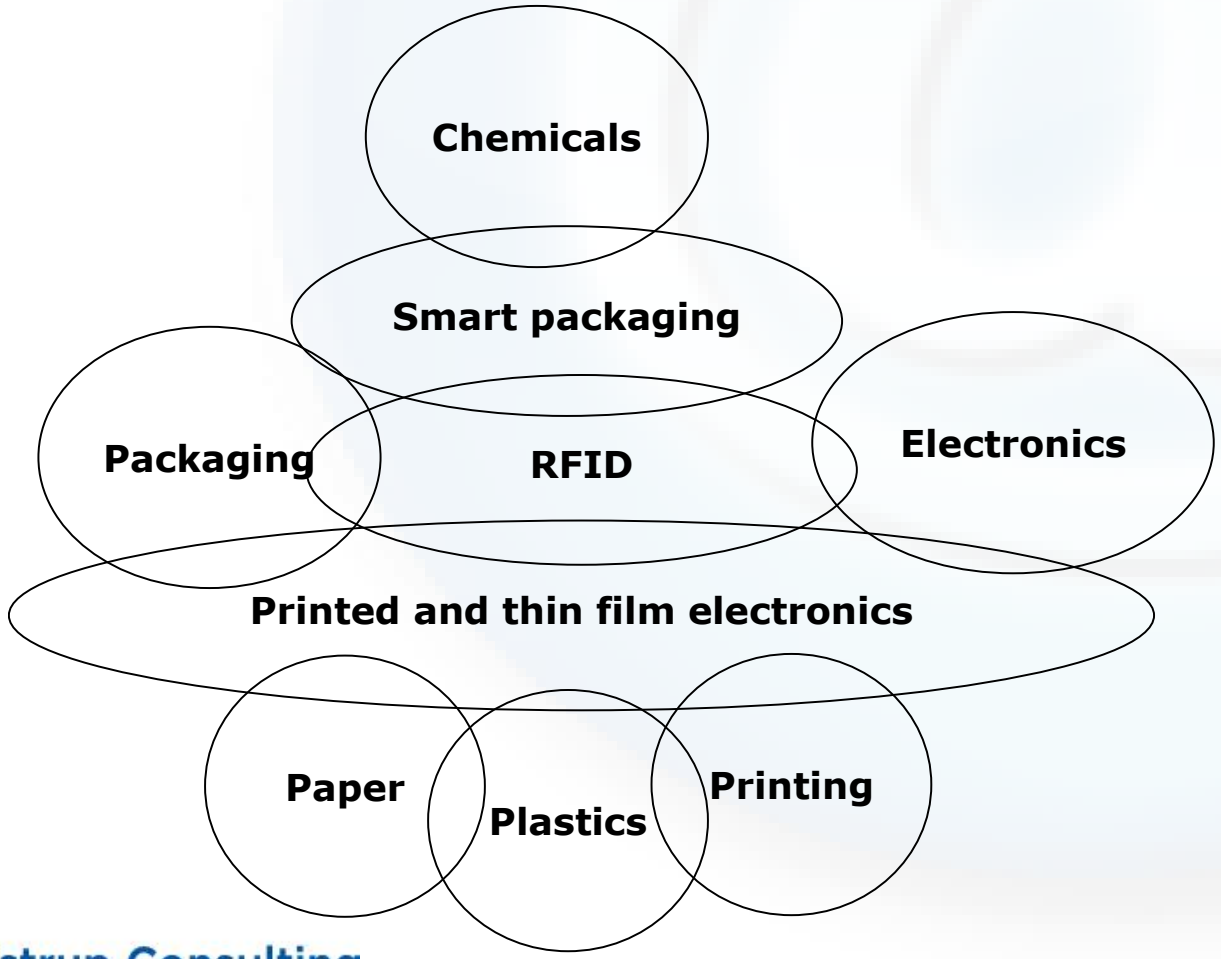
Convergence of skill sets

- The first piece, the convergence of the different industrial skill sets into joint activity, is occurring as technology, in particular items surrounding nanotechnology, mature. Companies are solidifying their value proposition, and therefore are able to better understand the skill sets needed to complete the offering suite to show electronics OEM a practical and realisable approach to the value proposition. This can be seen very clearly, especially in arenas like digital manufacture of circuitry. Inkjet head manufacturers are teaming with materials providers and system integrators to more efficiently solve the challenges facing the digital manufacture of circuits and bring a solution to market in the most efficient manner possible. This is starting in areas such as quality control and pinpoint circuit repair, gradually moving forward into the actual electronic equipment manufacture. In the case of higher-speed gravure printing processes, OEMs are looking at the close collaboration between gravure cylinder manufacturers and material providers in order to understand the best configuration/design of the cylinder to enable the fine feature printing demanded e.g. to enhance the printed electronics value proposition.

Convergence of PE Industries



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Source: IDTechEx

Why collaboration is key

The cascade of knowledge flowing from nanotechnology, biotechnology and ICT – to name only three recent developments – is far too complex for any one company to handle alone. In an industry with scale economies and a need for complementary innovation, firms need to expand the total value created by the value network rather than simply maximizing the share of the existing value. Regardless of the strategic problems for the economies of scale based firms there clearly seems to be a need for more radical innovations to generate niche products together with smaller new entrants.

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Convergence of standards

- ***Standardisation***
- The second item that is driving printing of components towards the mainstream of electronics manufacturing is the standardisation of testing protocols and procedures to enable OEMs and supply chain participants to be speaking a common language with reference to product characteristics and attributes. Quite a bit of these efforts are focused on the novel materials that can enable the widespread adoption of printed electronics manufacture. ASTM has significant efforts underway to define the characterisation protocols to dictate how these materials are tested and understood, and more industry-specific efforts like SEMI and IEEE have standardisation work groups focused on the development of these standards.

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Convergence of end-product-focused testing & qualification

The third important effort underway is to understand the 'real world' operation and behaviour of electronics that are printed. The most basic tests of electrical conductivity and other attributes that get you in the door towards qualification are evolving to encompass all aspects that make something 'manufacturable'. These include, amongst others:

- Component lifetime testing;
- Shelf life of materials;
- Temperature and humidity environmental testing;
- Industry-specific characteristics (e.g. optical qualities in the display industry).
- One of the most important facets of this effort is the evolving drive to understand not just how a manufactured component behaves in isolation, but how it behaves in concert with the other materials and processes necessary for the final product.

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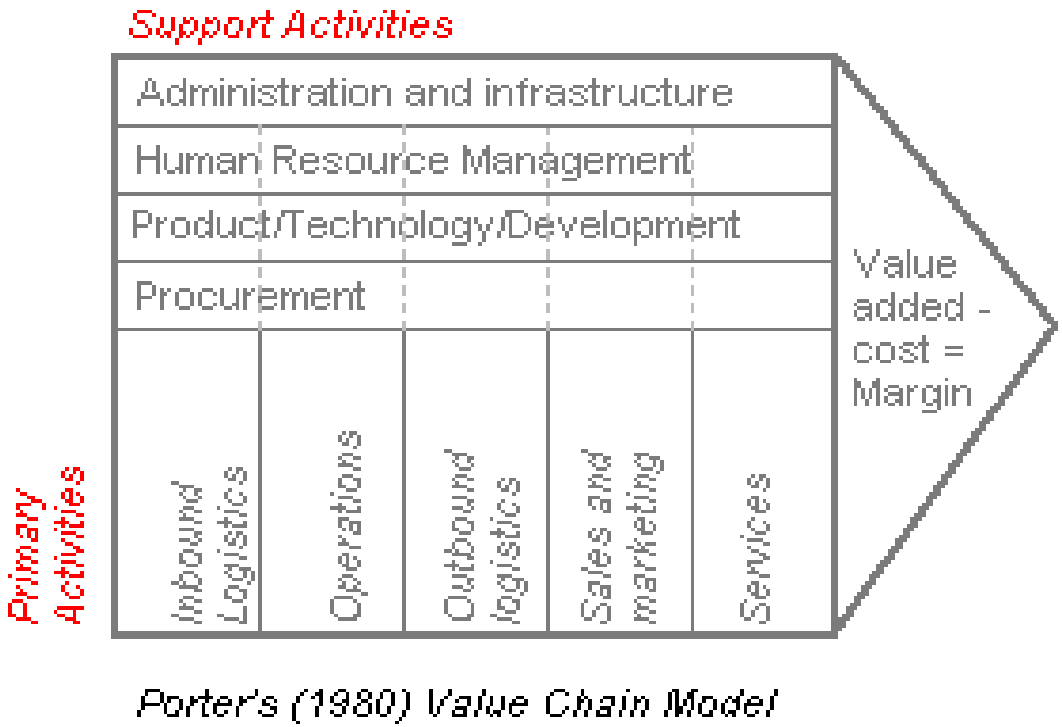
Value Chain Definitions



Porter's (1980) Value Chain Model

- A firm's value chain is the set of interrelated activities done to create a value that exceeds the cost of providing the product or service.

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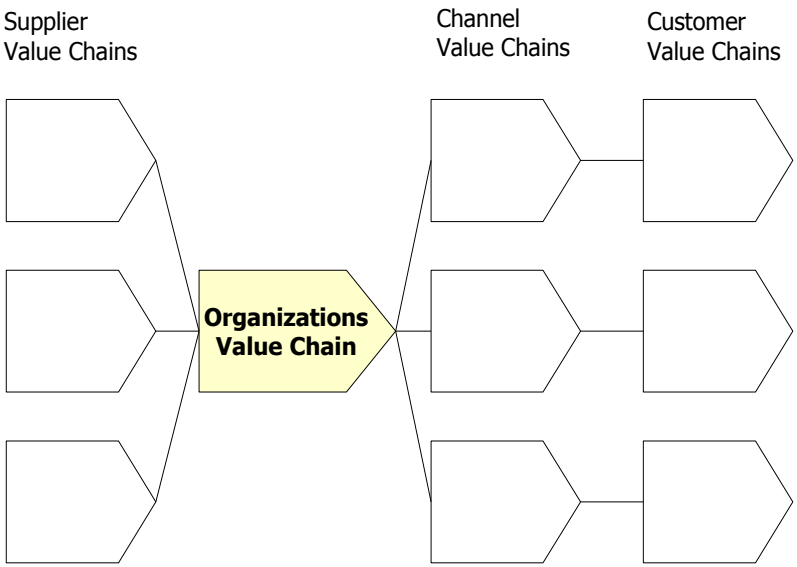
Value Chain Definitions



- An industry value chain is a stream of activities performed by a group of interdependent companies working together to satisfy market demands.

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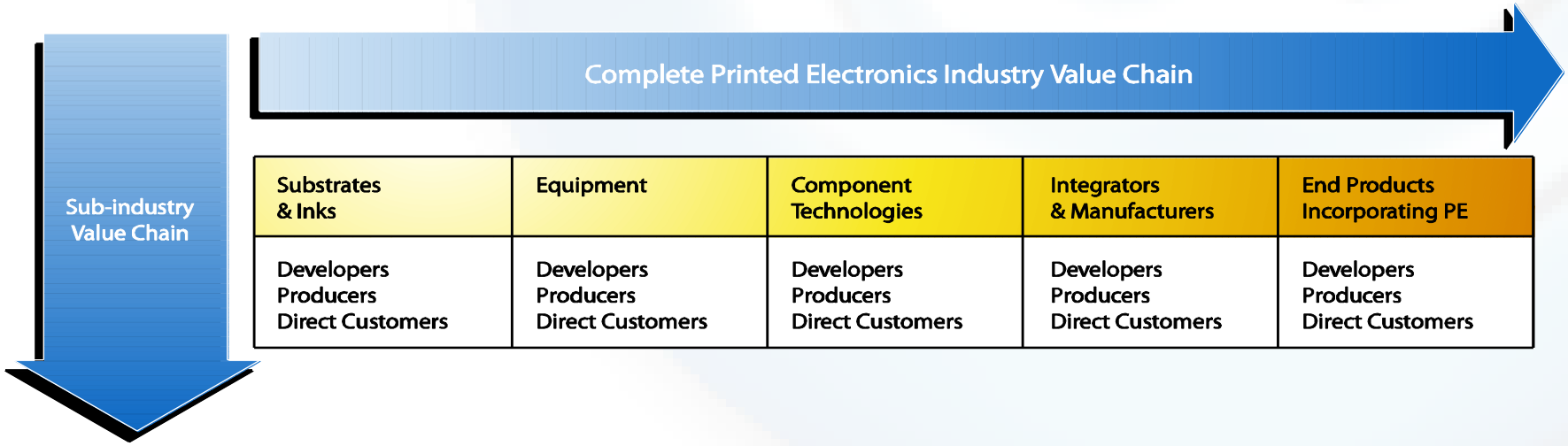
Printed Electronics Value Chain



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Why focus on the PE Value Chain?

The real advantage of understanding industry evolution is being able to generate strategic options ahead of competition. Achieving and sustaining superior performance depends on preparing the organization for forthcoming changes and capitalizing on their implications.

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Steps in Value Chain Analysis

- Analysis of your own company value chain – which costs are related to every single activity
- Analysis of immediate customers' value chains – how does our product fit into their value chain
- Identification of potential advantages in comparison with competitors
- Identification of potential value added for the end customer – how can our product add value to the customer's value chain (e.g. lower costs or higher performance) – where does the customer see such potential from PE

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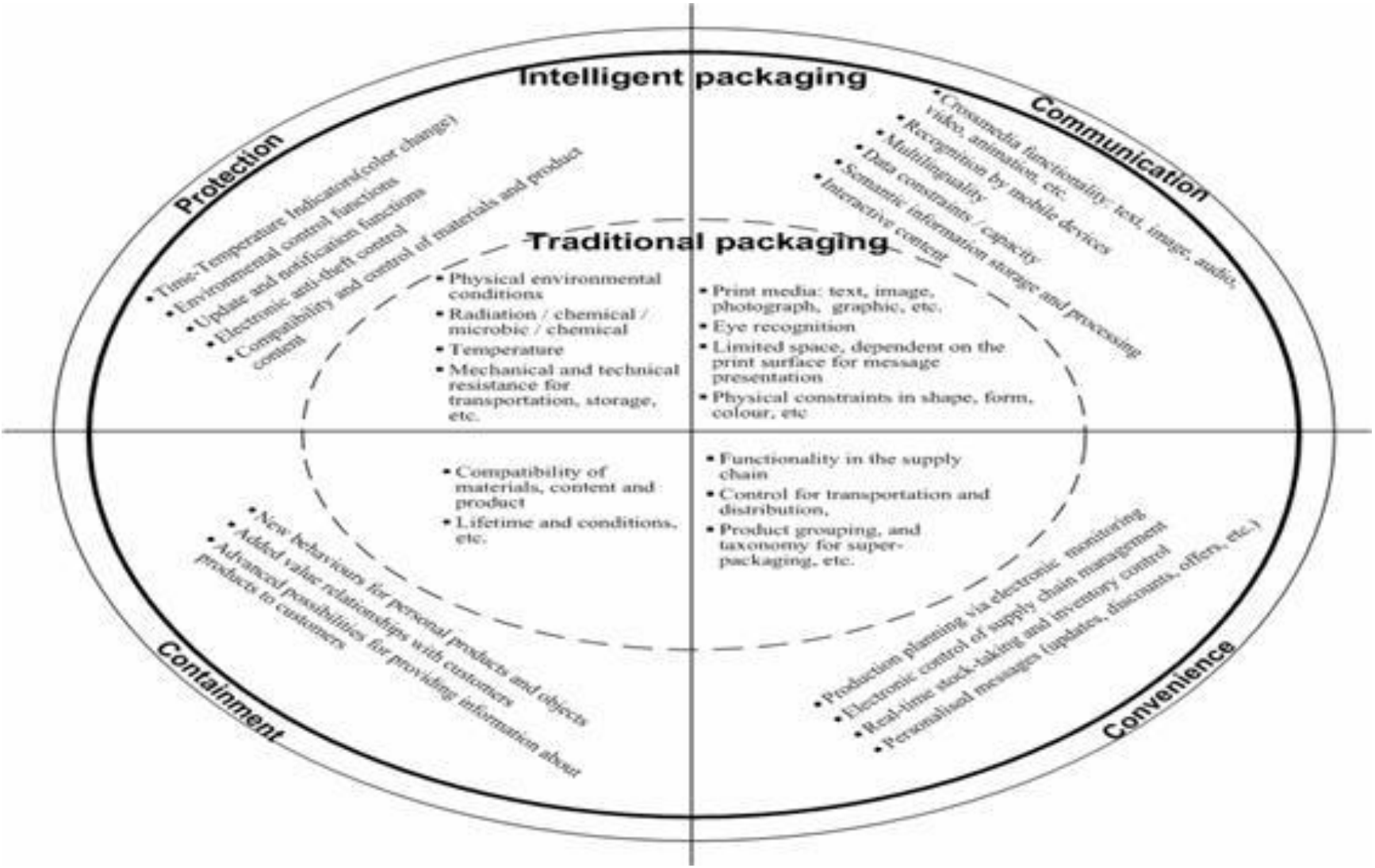
Value Added Example



SOURCE: "Exploring cross-media concepts for future packaging – Challenges for the printing industry"/ Spyridon Nomikos, Anastasios E. Politis, Jenny Darzentas, Thomas Spyrou, John Darzentas,Proceedings,32nd inter. Conf.Iarigai.4-7 sept 2005, Digitalisation and print media p.p.317-319

Component Technologies

- Connections
  - Printed silver, printed carbon, print & plate, conductive polymers, carbon nanotubes
- Resistors, capacitors, inductors
- Power
  - Batteries, solar cells, capacitors, energy harvesting
- Digital or analog circuits
- Memory
- Displays and lighting
  - Electrochromic, electrophoretic, electroluminescent, organic light emitting diodes
- Sensors
  - Temperature, humidity, pressure/force, chemical, biological
- Hybrid circuits
  - Printed Electronics + silicon components

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Manufacturing Constraints

- Incompatibility between materials and layers
- Form factor requirements of end product
  - Hybrid circuits and batteries add thickness and limit flexibility
  - Transparency of layers
  - ISO standards
- Operational voltages, drive currents required
- Substrate and materials temperature and humidity limits
- Materials constraints
  - May not be able to print all materials on the same substrate
  - Solvents may attack deposited materials
  - Subsequent converting steps may cause damage
  - Stability of materials during manufacturing run

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Materials Considerations

- Printing plates
  - Dimensional tolerances
  - Hardness
  - Distortion, alignment
  - Compatibility with ink and substrate
- Substrate and barrier materials
  - Stability
  - Surface energy and roughness
  - Interaction with solvents, inks and adhesives
- Inks
  - Formula differences
  - pH
  - Functional lifetime on the press
  - Cure requirements
  - Compatibility with plates and substrate

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Equipment Considerations

- Printing Equipment Parameters
  - Roll-to-roll or sheet fed?
  - Flexo, screen, gravure or ink jet?
  - Plate pressure, tension control, droplet size
  - Print speed
  - Cure time and temperature
  - Registration: lineal & transverse
  - Uniformity of ink deposition
- Converting Equipment
  - Form factor requirements of end product
  - Impact on substrate and PE component from heat, handling, stretching, abrasion, etc.
  - In-line or secondary operation?

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Quality Considerations

- Visual inspection
  - Particles, misprints or gaps
  - Line and space width
  - Ink thickness
  - Uniformity within a run & run-to-run
  - Color variations
- Performance testing
  - Electrical testing
  - Adhesion
  - Solderability, bondability
  - Specific function (operational voltage, drive current, capacity, contrast, shelf life, etc.)

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Convergence & Collaboration

- Printed electronics involves the convergence of many industries and scientific disciplines and sectors that do not conventionally choose to work together. Developments in printed electronics are relevant to the chemicals, printing, paper, plastics, and packaging industries as well as to the electronics industry.
- Printed functionality represents a remarkable example of industry convergence where previously followed distinct trajectories technologies from adjacent areas started to overlap and merge together to form new products of develop new applications and markets for converged products. Integration of different technologies becomes important for new product development and also challenging as technological choices span across various industries
- **Collaboration along the value chain.** The value chain in printed electronics begins with basic research in universities and with the development of materials and extends through the development of components to the final assembly of devices and their integration within applications. Collaboration is needed at all points along the value chain to identify new markets.

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Why this is important

- the rules are just forming within the forming industry and each participant is trying to play the game for their best benefit. That would also mean to form competitive value networks and business models that would extract the best out of those value networks. The current “players” are coming in to this new area from different industries and may use the business models they are using in their primary industry for initial entrance. The industry still seem to lack a business model that would kick it into a rapid growth stage, even though it taps to such technologies that could lure wide audiences. As such new business model will be discovered, there is a need for the older firms in the industry to rethink theirs if they want to get their shares of the growth and stay in the game.
- The process of radical transformation may take decades, but a company that recognizes transformation early generally has access to broader range of attractive options that a company that recognizes evolutionary path late in the process of change. A key for a company to hook on the transformation is to build and adjust appropriate business models.

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