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PU	Public	X
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RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1. Summary and objectives

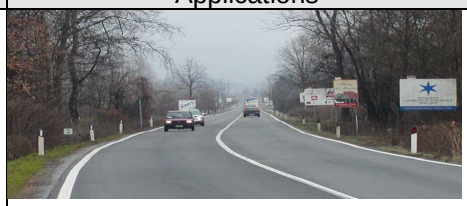
The objective of the deliverable is the identification of commercial and public applications beyond the PRIAM target applications. PRIAM technology brings considerable progresses to automotive lightings and signal panels for public information or warning signals for airports, railways, motorways and urban and working areas. However market sectors as medical, military, building, toys, transportation, food will be interested by a positive achievement of the project goals. For that a commercial analysis in respect to smart packaging, batteries, RFID tags, signage, displays, photovoltaic panels, smart shelving, smart textiles, printed memories, e-papers, e-books is reported.

2. The first PRIAM's objective

The first objective of PRIAM is the production of new devices used as signaling (**road-signs, signboards, info panels**). It is evident that the potential impact is tremendously huge, considering the large number of sign boards, info panels that are daily used in all worldwide roads, urban areas, households, airports, stations and working places.

At the same time the development of new lighting modules (**automotive lighting and taillight**) will reinforce automotive sectors and related markets improving performances with regard to compactness (stylistic premium), safety, comfort, efficiency, image quality and lifetime. All at once the design and upgrades of new production line based on roll-to-roll concepts will support reliable production and commercialization of new products that will start in few years.

The main applications are shown in the following table.

Main Project APPLICATIONS			
Application description		Concepts	Applications
Traffic signs and Road signs	Alfa-numeric symbols coupling with signals such as arrows, bare etc… with great impact on access and view to information to road users during the driving		
Lighting and taillight	Novel concepts of automotive interior and exterior lighting module with great impact on comfort, safety (novel reconfigurable icons, autonomous displays) and infotainment and entertainment		

Finally, the final outcomes primarily aim at the Green Car Initiatives addressing both efficiency of the forthcoming electrical vehicles and making the infrastructure with a higher degree of intelligence.

3. The commercial opportunities

The PRIAM's outcomes will reinforce several sectors by the improving of materials, processes and integration on single flexible devices. The development of enable manufacturing processes and contemporary the optimization of flexible electronics will lead to the major benefits. The capability to integrated energy harvesting, storage, intelligence, sensing and lighting will supports the development of innovative products, or part of them, in the next 5-6 years. Some other potential applications are listed in the following table.

Potential other APPLICATIONS			
Application description		Applications ([1])	
Lighting info panel	Autarkic Lighting road-signs and info panels with limited access of power supply	Improve visibility and safety due to illuminated info panels in many areas with limited access of electricity (such as mountain areas-hairpin curve), where self-sufficient autonomous signs offer advantages. Moreover markets in new EC countries, where traffic density is quickly increasing, cars are getting faster, but infrastructure is behind.	
Lighting signboard	Lighting signboards indicating a restriction area to enter	During the night, lighting signboards could usefully indicate certain restriction areas to not-enter. For examples: • In many EU cities (e.g. Germany) an environmental badge is obligatory for green zones. When pollution is increasing (due to e.g. bad weather condition) only vehicles fulfilling one of the pre-defined "low-emission standards" may enter the respective zones. • Working areas (e.g. in roads, sidewalks, platforms) will be left uncontrolled during the night, comporting dangers for pedestrian and people.	
Toys	Electro-chromic materials and flexible lighting systems	Design of new toys and childcare articles to improve functionalities: lighting (electrochromic, polymer dispersed liquid crystals and electroluminescent devices), flexible tactile devices (keys and pushbuttons), flexible plastic electronic track circuits (facilitate article design by wires safety)	

[1] All pictures are from internet websites

Fashionable Lightings	Lighting modules to enhance beauty in cities	To promote tourism and beauty of some EU cities (e.g. Torino, Fibonacci's serie onto Mole Antonelliana roof) local governments decide to light artistic monuments. PRIAM demonstrators will be more adaptable without cabling issues, reducing power consumption.	
Outside pillars	Outside pillars not-requiring cabling	Outside pillars for urban areas or houses' gardens should be based on PRIAM solutions integrating useful functions such as lighting, energy harvesting, energy storage and sensing	
Exhibition letters	Exhibition letters for "temporary architecture" used in trade show stands of market places in order to advertise about products, costs, slogans….	Further application may be found in the business of "temporary architecture" like trade show stands during exhibition or in market places. Exhibitors need to advertise products, showing different slogans in which regular characters are often overseen. PRIAM demonstrators will be more compliant and visible, without cabling issues	
Food Traceability	Food and beverage packaging: RFId and intelligent labelling	Smart labelling allows food traceability for monitoring of freshness, quality and due time	
Smart Textiles	Fabrics with integrated lighting and sensing	Smart fabrics may improve appeal, comfort and functionalities (light, humidity, temperature sensors) in wearable clothing, housing, automobile and aerospace interiors.	
Lighting characters/logos	Lighting ASCII characters making fancy/personal identification for mobile phones or laptops	Mobile phones/ Laptops could be equipped or upgraded with the PRIAM substrate holders enabling the selection by the user of a sequence of alphanumeric letters and post it on substrate to show, e.g., his name. Moreover not only characters could be defined, but any ASCII characters to generate logos or similar (smiles). e.g. kids could put their name or best friends, or fancy logo.	

3.1. Advertising articles

The advertising and promotion industry eagerly adopts new ideas and technology. Signage is an allied industry that can benefit. Winners will increasingly employ printed electronics to create more compelling and more easily deployable billboards, posters, tear-off promotions, mailings, giveaways and point of sale material and that is the subject of this white paper. Those not keeping

up with the staggering and rapid advances in printed electronics that PRIAM investigates and develops.

For example, electronics can be printed on smart substrates that variously act as a microphone and loudspeaker or change texture, colour or shape when electricity is applied. Imagine a poster that balloons out in the form of a talking face as you walk near. There are even new plastics that can be electronically unlocked.

A particular priority is to replace conventional print with alterable displays. For example, moving colour billboards – now possible with huge areas of plastic film – get ten times as much attention – and you can now make a conventional billboard into an electronic one just by sticking a plastic film on the surface. Again, shelf edge displays and promotional signs will be reprogrammed cost effectively for even the smallest price changes and most frequent changes in promotional offers yet they will all switch to show the nearest exit if the store is on fire. Colour video will be possible with them – and for that matter on the cornflake packet. “Wallpaper” electronics will increasingly merge signage and promotion by switching messages. Static printed billboards will become a thing of the past. This is just a glimpse of the versatility and eye catching capability that is arriving. Here are a few examples of uses of printed electronics so far.

Animated light emitting “wallpaper” POS by elumin8

Moving color poster displays up to 100 meters long by elumin8 for many major media companies

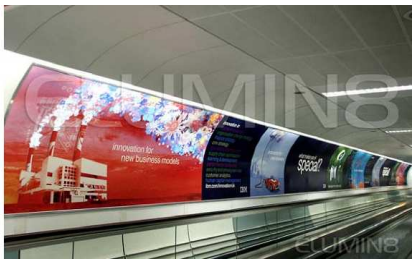


Figure 1 - Examples of wallpaper and posters by elumin8 [1]

Finally, in the frame of advertising articles, PRIAM will be useful in the field of large area processing and lighting encapsulation, encompassing microLEDs and TFEL integrations, plastic foils treatments and electrical interconnection development.

3.2. Healthcare and fabrics

Printed electronics is increasingly able to increase the safety, security, user friendliness, effectiveness and attraction of healthcare products. Many approaches to developing flexible electronics have targeted a class of organic light emitters, which can be assembled using electrically conductive polymers and deposited on bendable plastic substrates. Conventional,

inorganic LEDs are a more mature technology, with their own distinct advantages, but they are generally tethered to semiconductor wafers that limit their elasticity.

Diagnostic tests are an important part of health care. Currently, some 60-70% of medical decisions are based on diagnostic tests, and the diagnostics industry is now a multi- billion-dollar market. There is a growing requirement for low-cost, mass-manufactured, point-of-care (POC) solutions, however. These POC tests are needed in the building up of the health care systems in developing countries as well as for improving the efficiency of the systems in developed countries. They are used by medical professionals in hospitals, physicians' offices, ambulances and retail clinics as well as by the patients and consumers themselves at home.

For medical professionals, point-of-care testing enables faster decision-making and streamlining of health care processes, as fewer tests need to be conducted in central laboratories. For consumers, POC tests make it easier to monitor their own health and chronic conditions at home. On the whole, POC tests enable distributed testing and screening, which also make it possible to find medical conditions at earlier stages, lessening their negative impact. Roll-to-roll manufacturing provides a cost-effective and high-volume method for producing diagnostic products. It also enables better design of the test products, which can even be demonstrated by rapid prototyping with the same production method. Cost savings can be achieved both in materials and production methods. The reduction in cost allows for disposability of the tests, which in turn enables product and process innovation in health care and wellbeing. The use of printing processes also offers new possibilities in the design of diagnostics products. The tests can be designed for, e.g., ease of use when sampling or reading results. This versatility in design together with the potential for extremely high-volume production can also create opportunities for the diagnostics industry in completely new application areas.

In order to bridge the gap between organic and inorganic LEDs, by harnessing the light of conventional electronics in an elastic system, many improvements in research and innovation are coming. The first potential markets are biomedical and biological ones. Rogers and his colleagues printed an interlaced array of tiny light-emitting diodes, or LEDs, on a rigid wafer, then dissolved the top layer of the substrate to release a thin network of LEDs that can be transferred to a flexible, waterproof polymer sheet [2]. As a demonstration of the technology the researchers put LED arrays through any number of experimental implementations. They deposited LEDs on aluminium foil, the leaf of a tree, and a sheet of paper; they wrapped arrays around nylon thread and tied it in a knot; and they distended LED arrays by inflating the polymer substrate or stretching it over the tip of a pencil or the head of a cotton swab. The researchers also integrated light sensors alongside the LEDs and embedded the assembly in the fingertip of a vinyl glove. As the glove drew closer to a surface, the light sensors registered progressively more reflected light from the LEDs, producing a

sort of proximity sensor that could be used to guide a surgeon's hand during a procedure or to form an artificial sensory system for robots.

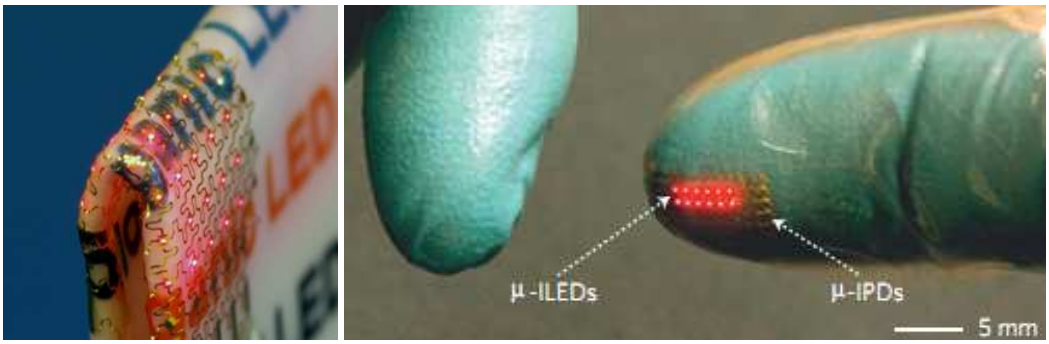
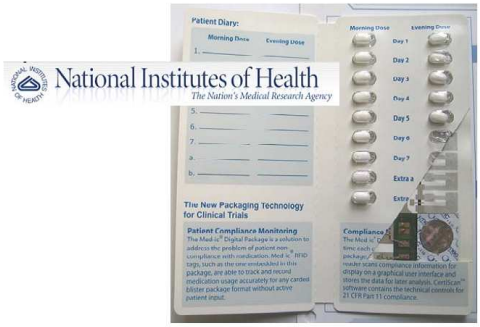


Figure 2 - Flexible array of LEDs on a folded sheet of paper and on vinyl gloves

Additionally ion-to-phoretic skin patches, employed to deliver cosmetics by electrically increasing skin porosity, will also be used for error free, non invasive drug delivery. They are low in cost and disposable. Astra Zeneca has used over 40 million RFID tags for error prevention in Diprivan™ syringes. These need no silicon chip, saving cost, and they can withstand sterilization unlike a silicon chip. They are not yet printed but are part of the roadmap to ubiquitous printed electronics in healthcare. Even though these examples involve batteries, sensors, conductors, displays and antennas that are printed, they are only a humble beginning compared to what is about to be possible. Printed transistors, memory, lasers, solar cells and many other printed components are becoming available and it is often possible to print them on top of each other. Printed lighting will look like rolls of wallpaper or sticky tape and be useful in smart packages and point of sale material. Here are a few of them, showing the technology supplier and brand involved.

Compliance monitoring blisterpack recording ID and which pill was removed when. Information Mediary Corporation



Diagnostic patch Power Paper

Figure 3 - Examples of healthcare application in compliance and directly on diagnostic patch

Finally, in the frame of smart textile and healthcare, PRIAM will contribute to the enhancement of specific electrical interconnections by enabling ink development, and plastic foils treatments by R2R processes.

Roll-to-roll manufacturing provides a cost-effective and high-volume method for producing diagnostic products. It also enables better design of the test products, which can even be

demonstrated by rapid prototyping with the same production method. Cost savings can be achieved both in materials and production methods. The reduction in cost allows for disposability of the tests, which in turn enables product and process innovation in health care and wellbeing. The use of printing processes also offers new possibilities in the design of diagnostics products. The tests can be designed, for e.g., ease of use when sampling or reading results. This versatility in design, together with the potential for extremely high-volume production, can also create opportunities for the diagnostics industry in completely new application areas.

3.3. Food traceability and freshness monitor

With integrated new functionalities or simple electronics, consumer packaged goods can be made more appealing, desirable or eye-catching. Products with, e.g., holographic figures or blinking LED lights will be noticed more easily by consumers. Future products could also be smarter and activate the eye-catching feature only when somebody approaches or touches them, with, e.g., integrated capacitive sensors. The consumer packaged goods themselves can also act as a user interface, helping the consumer to acquire more information on the product or other people's opinions and ratings, and thus help in decision-making. Consumers could also answer with a squeeze or give feedback using a user interface integrated into the product package, e.g., by means of printed touch buttons and memory elements.

Then, with the increasing global customer base, food retailing is transforming. However, with the move toward globalization, food packaging requires longer shelf life, along with monitoring food safety and quality based upon international standards. To address these needs, new technologies are enabling innovative food and beverage packaging technologies encompassing intelligent labels. Traceability in the Fresh Produce Supply Chain is growing for last years. A wide adoption of electronic traceability of every case of produce is expected by 2012. The producers industry will accrue benefits in supply chain traceability, efficiency, and operations while enabling an extra layer of protection should a food borne illness occur. Full visibility into where a "produce scare" product came from allows growers to identify and isolate the problem, reducing the outbreak severity. They can also build consumer trust by determining definitively that their produce is safe. To help better demonstrate the benefits, best practices, and logistics of produce traceability, the world wide companies and Countries commissions sponsor recently announced a series of pilot projects targeted at all segments of the supply chain from the grower, through the retailer, to the restaurant.

The traceability chain is providing the custom label for fresh fruit and vegetables that contain the traceability information about the commodity via a 2D barcode. For example HarvestMark (HarvestMark is the leader in fresh produce traceability systems) certified traceability

provider gives the opportunity to work with the premiere traceability solution to implement a traceability system, through traceability labels. The benefits of traceability labelling far outweigh the cost of adopting a system.

If everyone used a traceability system, food outbreaks would be reduced and contained because it would be much easier to trace-back potentially contaminated product. This strengthens the entire industry and gives consumers confidence in the products they are purchasing.

Figure 4 - Examples of labelling for food traceability and freshness control

In the frame of EU projects, FlexSMELL will take care the food traceability. The FlexSMELL concept is to realize a hybrid (organic-inorganic) very low-cost, ultra low-power olfaction system based on bio-receptor and implemented on a flexible substrate. Such a system is to be compatible with wireless read-out, setting the ground for the future development of smart sensing RFID tags. The FlexSMELL technology platform will be in principle suitable for different applications with the main ones envisaged for the in the field of logistics for the monitoring of perishable goods along their transport and storing, though smart packaging solutions. Teaching and training strategies will be implemented to prepare the next generation of scientists in this fast developing strategic research area.

In the frame of food and freshness traceability, PRIAM will contribute to the development of processes for labelling manufacturing and integration. PRIAM focuses on integration of circuitry on flexible substrates which can be used for labelling for several uses. Roll-to-roll production process enables freedom of design in terms of size, shape and colour of the flexible OLED light sources. As a result, the light sources can be used to add functionality and form factor, or address innovative, structurally integrated illuminating needs in many kinds of fast-moving consumer products.

3.4. Entertainment and Toys

The toy sector is one of the sectors being widely affected by the import of products from Asian countries. Designs are seemingly copied and the existing commercial rules do not give a real solution to the development of articles that do not obey the standards. Consequently, competency based on cost reduction is not feasible at this point.

Additionally, the design of new toys and childcare articles is being notably slowed down due to the economic crisis that is currently affecting many European and international sectors. The tools available to European enterprises to keep their market share is, invariably, their competitiveness by means of the research and development of new technologies that contribute dynamism and interactivity to the articles developed.

Plastic electronics, including PRIAM aims, have the potential to revitalize the economy, to generate new jobs and to contribute to public health, as they allow time and cost savings and give support to increase the functionality of diverse sectors (consumer electronics, building, the automotive sector, several lighting devices, logistics and even fashion). Manufacturers that introduce these devices into their articles, add to their products differing agents to the current market, enhancing innovation, competitiveness and sustainability in the sector.

As an example, the Spanish project Plas-e-Toy (granted within the framework of the National Plan of Scientific Research, Development and Technological Innovation 2008-2011, Ref. DEX-560540-2008-3), will produce three demonstrator products for electro-optical and interactive devices applying plastic electronics in toys: the demonstrators will be completed before the end of 2010 [3].

Figure 5 - Electrochromic sunglasses for a doll (CIDETEC and AIJU) and flexible electronic (CETEMMSA)

Devices developed in Plas-e-Toy[4] include electroluminescent (EL) substrates, electrochromic materials that can change colour, and integrated pressure sensors. The technology could be used to add new and more sophisticated levels of engagement and aesthetics to toys.

Adding a greater range of functions to a children's toy could add to the appeal of products - particularly interactive items, such as a play mat.

The play mat would be split into squares and have several functions working when children touch it - it's a dynamic toy. These new functions would allow European companies to compete with the mass-produced toy firms in Asia. The project is going to try and get manufacturers in the industry to adopt these materials to give added value to products.

Devices to be developed in this project:

- **Electro-optical devices**. Three types to be developed, electrochromic, polymer dispersed liquid crystals (PDLC) and electroluminescent. All produce a different optical effect and will give added value to final product while complying with the electrical standards applicable to toys.
- **Flexible tactile devices** will be developed to substitute for keys and pushbuttons, by contact areas on the piece, allowing homogenisation of the toy, making its design easier and avoiding mould production. It offers higher safety and avoids small breakable pieces.
- **Flexible plastic electronic track** circuits will save having to use wires and welding, facilitate article design, decrease waste and help in compliance with Directive RoHS, currently difficult to meet.

An online questionnaire at the beginning of the project, for European toy manufacturers and potential users, established that innovative functions and attractiveness are two primary means of adding value to toys.

The analysis of the questionnaires showed that producers of toys express, in principle, a great interest in incorporating of these devices in toys, especially with regard to electro-tactile devices and switches flexible considering that this would increase the degree of innovation and differentiation of the company, bringing more attractive and competitiveness. The toys on which they consider their inclusion stuffed animals and dolls would be on games and electronics, with which improve the interactivity of the toys.

In the frame of toys markets, PRIAM will contribute to develop new product by the enhancement of many technological aspects. PRIAM focuses on autonomous systems, encompassing PV cells and flexible batteries, flexible electronics, including intelligence and sensing functionalities, and lighting modules, such as microLEDs or TFEL or again OLEDs, which enable new toys manufacture

3.5. Public and Artistic lights

"*Contemporary Arts Torino Piemonte*" is the brand - promoted by the City of Turin, the Region of Piedmont and the Province of Turin - which groups together all the autumnal dates aimed to increase the value of the expressive contemporary arts.

The idea of enlightening the City came from a concrete requirement, a call for help from the world of commerce, traditionally in charge of the Christmas light decorations. The request was for a stronger support from local Institutions, as the shopkeepers' service could be considered, to all intents and purposes, a common good and a service to the citizenship. The Administration accepted the request and agreed to intervene, provided that this became an opportunity to raise the quality of the Christmas lighting. The shopkeepers, but also citizens and tourists, immediately welcomed the project.

Since 2001, Luci d'Artista has become the most prominent event in a programme dedicated to contemporary art, which has concentrated in the month of November and is bound to carry on until January in the next editions. The best of what contemporary art has to offer has been made to converge in this time of the year involving, from 2001 to 2005, contemporary art galleries on a billboard format project of works on the city's buildings.

The peculiarity of the event was, and still is, that of using or interacting with non-canonized (though accessible to all) spaces, such as the streets and squares in Turin, with artistic realisations obtained using light, an element which, apart from its practical utility, has always attracted and fascinated man, in the same way as its direct opposite, "darkness". Besides its immateriality, irradiation, different colours and chemical or physical process/principles, light has always been an expressive tool for artists and a source of inspiration. Optical fibres, high brightness LEDs, Electroluminescent Surfaces are used in different city sites creating a real open-air exhibition using the newest technologies. More than 20 installations are realised by international artists improving city appeal by very high quality and high visual impact.

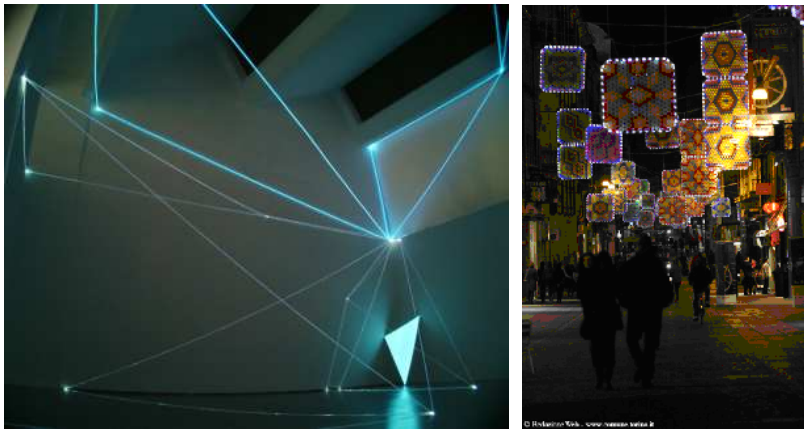


Figure 6 - “Luci d’artista” 2009: Carlo Bernardini installation (optical fibres and EL surface) and “Mosaico”, installation of E.Borghi[5]

The integration of lights, being LED, Inorganic Electroluminescent or simply optical waveguides, is allowed by the development of innovative lighting-technologies. Currently no-plastic electronics are used during the above mentioned event, but it is expected in 3-5 years the introduction of novelties and new solutions as well as smart textiles, flexible plastic lights or intelligent devices.

One of the most important topics of PRIAM is the development of new autonomous lighting systems. Such targeted outcome exactly fits with future prospects of public and building lights installations, or public events as well as “Artistic Light Exhibition”.

3.6. R2R printed backplanes for flexible displays

Flexible displays offer benefits of being lightweight, robust and bendable and thereby unique advantages over conventional display technology. Before flexible displays enter the markets, the ancillary electronics also need to be flexible. Flexible displays can be made using different technologies, such as liquid crystals, electrophoretics, electrowetting and organic light-emitting diodes (OLEDs). Regardless of the display technology, the electronic platform driving the display also needs to be flexible. This electronic platform, called the display backplane, consists of a grid of transistors that switch the display pixels on and off. The market interest in flexible displays originates from their properties of being lightweight, thin, bendable and enduring against mechanical impact. Compared with conventional rigid glass substrates, the use of flexible substrates gives freedom to backplane manufacturing technology. The current approach to realising them is based on conventional processing methods, such as photolithography, vacuum processing and etching steps. However, the fabrication method can also be based on printing, which is a large-area, low-cost technology and thereby a natural choice for flexible display

applications. Flexible displays will be seen in products such as e-readers, smart cards, labels, e-posters, mobile phones and watches. The market for flexible and printed displays was well below one billion euro last year but is expected to grow into a multi-billion euro market during this decade[6].

Market growth of this size would make flexible displays one of the fastest growing sectors in printed electronics. Also in the flexible display market hybrid manufacturing approach can be potentially applied leading faster time-to-market compared with fully printed products. According to the market research and analyst firm NanoMarkets, signage products manufactured using printed and organic electronics are expected to generate a 2.5 billion dollar worldwide market within the next five years[7]. While most of the attention on OLED technology comes from a lighting and display industry perspective

It enables fast and ultra-low-cost deposition of polymer light-emitting diodes by printing on flexible plastic substrates. Roll-to-roll printing as a deposition method has several distinct advantages compared with the vacuum deposition technologies, which are the traditional processing methods for small molecule-based OLEDs. The main advantages include high speed of fabrication, low material consumption and wastage, fabrication of large areas as well as the use of well established printing techniques and machinery.

Figure 7 - Full-colour OLED display built on organic TFT technology (Sony)

Roll-to-roll production process enables freedom of design in terms of size, shape and colour of the flexible OLED light sources. As a result, the light sources can be used to add functionality and form factor, or address innovative, structurally integrated illuminating needs in many kinds of fast-moving consumer products. Examples of such products include functional packaging, smart cards, smart textiles, medical disposables, cosmetic products, games, toys and novelties[8]. The generated effects can be supported by an integrated circuit and used to develop communication, authentication and access management features lacked by existing fast-moving consumer products. To give an example, OLED light sources could be integrated into conventional print

products such as point-of-sale displays, high-end product packages or promotional flyers used by many well-known brands in consumer marketing communication. System integration objectives in PRIAM will support also the future development towards replacement of inorganic LED components with OLEDs.

3.7. Printable memory cards

There are also other potential application areas potentially benefiting from PRIAM approach such as access codes to services (ePIN) and electronic questionnaires (storage-on-paper) which are developed e.g. in PriMeBits EU FP7 project coordinated by VTT. To demonstrate electronic pin-code (ePIN) applications, low-cost memory cards and reading/writing devices have been developed. The codes stored on the cards can link to personalised information on the internet or provide access codes to services (tickets, online services, etc.). The increasing availability of SD card slots in laptop PCs can provide a convenient interface to the memory cards. Also, electrical inquiry card demonstrator is developed together with Stora Enso. Possible applications for such products are in marketing, customer feedback collecting (such as conference feedback), and gaming. In this demonstrator a printed flexible battery (Enfucell™ SoftBattery by Enfucell Ltd., Finland) is used to sinter a memory bit when a corresponding answering button is pressed closing the circuit between the battery, bit and a feedback LED that are in series. Manufacturing of such an end product can also benefit from the manufacturing process development done in PRIAM.

3.8. Built environments

Printed intelligence offers some important benefits that can enable new sensing solutions in built environments, especially:

• High throughout, wide-area production by printing and roll-to-roll processing makes it economically viable to produce sensing and monitoring systems for large surfaces. This can be important for, e.g., monitoring industrial conditions or human activity in buildings.

• Cost-effective production

• A thin flexible form factor makes integration into various 3D surfaces possible without costly assembly and the wiring process typical of the integration of discrete sensors.

Strain gauges are commonly used in industrial monitoring systems to measure forces and tensions in structures. The gauges have been developed for decades and offer very high performance with high precision and excellent immunity to interference such as temperature variation. Roll-to-roll printed sensors cannot yet provide the same performance but already enable

event monitoring in very large surfaces. Alternatively, if printed sensors are arranged in arrays, distortion profile measurements, for example, can be used effectively. It is also possible to integrate a network of sensors directly by integrating one foil rather than wiring discrete sensors to inevitable measurement electronics. In other words, the strain gauge sensor matrix can be used to measure a bending or distortion profile of a large structure such as roof beams, masts of sailing boats, windmill wings, etc. Alternatively, large sensors can be used for integrated entrance monitoring in floor carpets or as safety switches in industry (locating people in hazardous zones). Printed strain gauge sensors can be manufactured to be compatible with most of the existing wired or wireless measurement infrastructure.

Wide-area capacitive sensing can be used in several industrial or home environment applications. For example, non-contact user interfaces can be manufactured using a combination of printed electrodes and capacitive measurement. With gesture-based light switch for example the lights can be switched on by waving a hand in front of the sensor from down to up, and switched off by waving a hand from up to down. The dimmer effect can be controlled by holding a hand in front of the sensing area. The printed sensor element can detect hand movements up to about half a metre away. This technology could be used in applications in which the switch needs to be integrated into the wall structure for hygienic or architectural reasons.

Alternatively, robust user interfaces can be embedded in walls, tables and other materials. Similar technologies can also be used to monitor human behaviour. For example integrated sensors are able to detect movements and positions on a couch. Applications can be built for living environments for the elderly.

4. Conclusions

The main objective of system integration development is to enable multifunctional plastic foils with high compactness, a high degree of autonomy, overall integration of several functionalities and reduced installation costs. System performance, reliability and cost optimum will be sought for the specified application requirements. Depending on the system requirements varying amount of post-processing is needed. This can be done by hybrid integration of the best-suited combination of functionality building blocks, such as lighting elements, photovoltaics, batteries, sensors, RF and CPUs, as well as high-throughput and high-yield manufacturing processes such as lamination, printing, bonding and encapsulation. The integrated manufacturing vision is combined with roll-to-roll-compatible, stop and go post-processing or component assembly on flexible foil. The main objective of system integration development is to enable multifunctional plastic foils with high compactness, a high degree of autonomy, overall integration of several functionalities and reduced installation costs. System performances, reliability and cost

optimum will be sought for the specified application requirements. Through the hybrid manufacturing approach, the printed electronics industry also benefits from faster time-to-market compared with fully printed products such as backplanes for flexible OLED displays. Roll-to-roll compatible bonding and assembly machinery in the market are mostly limited to RFID type of applications, while for more bonding and assembly of bigger variety of components needs still development on the machinery and process control.

With all the techniques on the same line, it is also possible to reduce the printing rounds and number of times the web reel is unwound and rewound in the roll to-roll stages of production. In addition to the large selection of techniques available in a single production line, the process capability in terms of registration accuracy and curing capacity will also be improved. With interchangeable printing units and a variety of post-processing capabilities, it is possible to find the best way to produce each application as well as a commercially suitable solution for use in mass production. New printed components, roll-to-roll processing, and the integration of post-printing assembly and integration processing offer unique potential for new products, and leaner and efficient logistics and value chains with less material loss and mechanical parts. This all leads to more compact and environmentally friendly products with new interesting functionalities, appealing design and intuitive and engaging user experiences.

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