White Paper
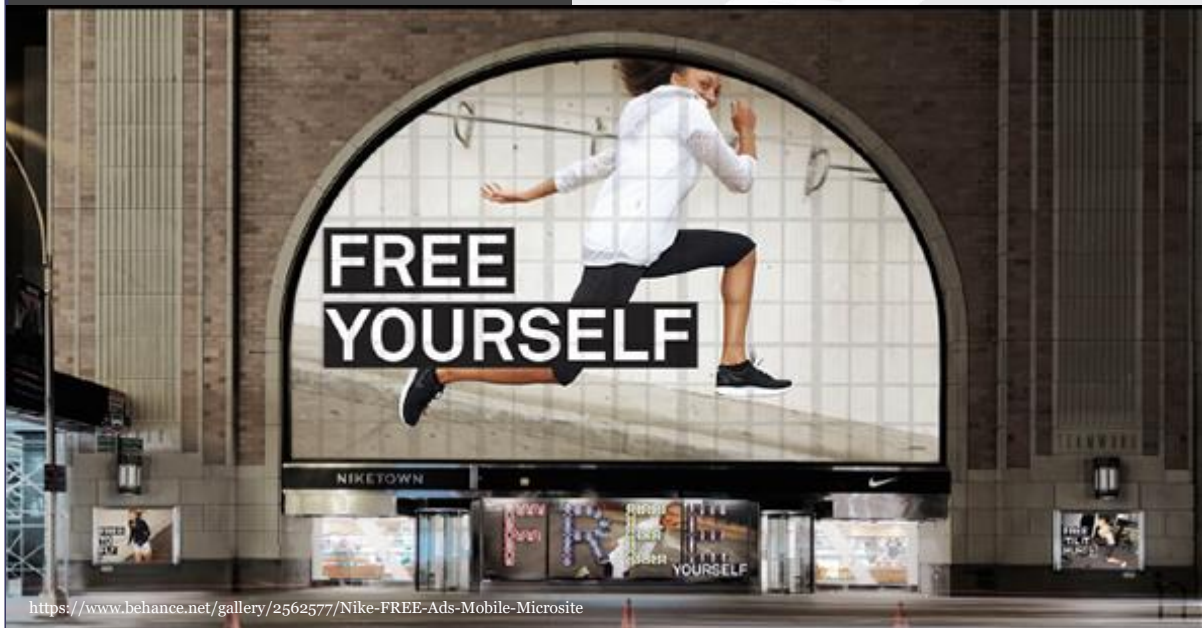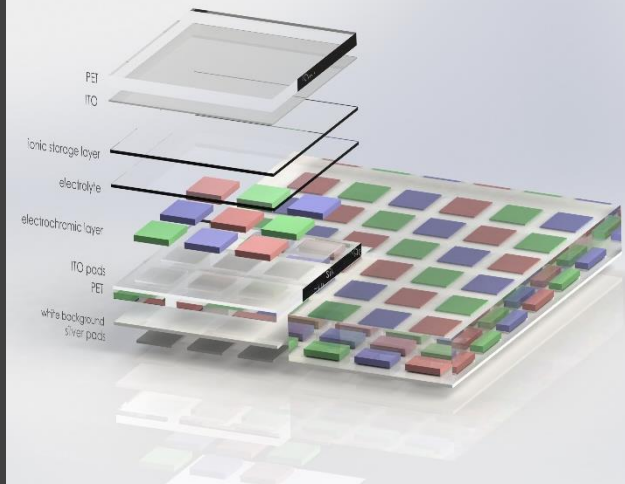
THE FUTURE OF OUT-OF-HOME ADVERTISING

Eco-friendly digital advertising display, based on novel printable electrochromic polymers

ECOPIX White Paper

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Summary

Advertisers have always looked to new and creative ways to reach their audience, via print media, billboards and retail signs, radio, television, or the internet. Today, despite the internet revolution, one of the fastest growing advertising mediums is outdoor advertising, otherwise known as "out-of-home" advertising or "OOH".

Digital "out-of-home" advertising (DOOH) is a major component of this growth. However, these displays, which are typically LED or LCD-based, have a high capital cost, a high electrical power consumption and represent an electronic waste issue at their end of life. The proposed ECOPIX technology will be a new state of the art eco-friendly alternative to existing out-of-home advertising methods.

This white paper describes a new out-of-home digital advertising technology based on state of the art eco-friendly multi-colour electro-chromic materials developed under the EU FP7 funded project **ECOPIX** - "Eco-friendly digital advertising display, based on novel printable electrochromic polymers". ECOPIX is a sustainable, low power solution, as the electro-chromic pixels only require power when changing colour states, and the materials can be recycled at product end-of-life.

Introduction

Advertising is one of the oldest methods of sales messages, promoting goods, services and information to the general public, specific target groups, and other enterprises. It maintains or raises awareness about an issue, event, person, product or brand, and supports choice and competition[1]. It is generally paid for by sponsors, and disseminated via newspapers, magazines, television, radio, outdoor advertising, direct mail, or the internet (Figure 1). Advertising forms part of the "creative industries" which are defined as "those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property"[2]. Other sectors of
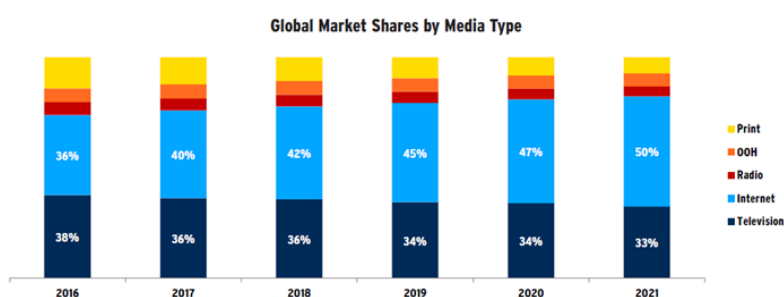

Figure 1. Forecast of global market shares by media type (source: MAGNA "Global Advertising forecast", Update Dec. 2016)

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[1] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Advertising_services_statistics
[2] UK Government Department for Culture, Media and Sport (DCMS)

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the creative industries include architecture, design, fashion, film, software, music, publishing, television and radio.

In the European Union, 210,100 enterprises are classified to advertising activities (NACE Group 74.4), employing an estimated 882,000 people and generating €38.6 billion of added value[1]. Globally, revenues on media advertising grew by +5.7% in 2016, to $493 billion. The biggest contributors to growth were the US (+6.9%), China (+7.2%), Australia (+7.4%) and the UK (+5.2%)[3].

DOOH growth is driven by new digital screens, sometimes converted from traditional paper-and-paste to digital - specifically in the traffic and street furniture environments – and delivering increased monetization for any given site. Unlike traditional billboards, where the printed sheets must be changed manually, DOOH displays may be updated on demand from a remote location. This is highly cost effective and it is known that DOOH billboards could generate 3-5 times more income than static billboards. Over the past decade DOOH has grown into a multi-billion-dollar industry and is the fastest growing OOH segment. It is expected that digital billboards will continue to attract clients, leaving traditional billboard agencies to accept lower margins.

However, despite market trends and consumer expectations on digital advertising, there are some limitations of existing DOOH and OOH technologies. LED and LCD based DOOH billboards consume too much energy. Although they are recyclable, their reuses are not always monitored and are a potential source of toxins and carcinogens[4]. On the other hand, traditional paper billboards have also environmental drawbacks, due to their use of non-recyclable paper, toxic inks and adhesives[4].

The aim of the ECOPIX project is to develop an out-of-home digital advertising technology based on new, state of the art eco-friendly multi-colour electrochromic (EC) polymers. ECOPIX is a low power solution, as the electrochromic pixels only require power when changing colour states. Furthermore, the media can be recycled at its end of life.

In a collaborative project with Universities and R&D renowned institutions, European small and medium sized companies involved in the **ECOPIX project** acquired a cutting-edge out-of-home digital advertising media technology which provides an affordable, environmentally-friendly alternative to traditional printed billboards, which is capable of remote updating, with significantly lower weight and power consumption than existing digital billboards.

This white paper highlights the objectives of the project, technological achievements, market trends and sector applications of the ECOPIX DOOH display technology.

Background

The European advertising sector is undergoing consolidation and modernization in the form of DOOH technologies, and this has a greater impact on SMEs, due to their limited resources. For example, SMEs in traditional billboards are losing market share to DOOH technologies, much of which is imported into the EU. The SME proposers of the project have identified an

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opportunity to develop, patent and commercialize the novel ECOPIX DOOH display technology which has a series of advantages compared to the state of the art, including: significantly reduced power consumption, reduced electronic and paper waste, lower cost of ownership, and other unique features compared to traditional billboards.

ECOPIX aims to develop an innovative digital display technology which provides a more cost effective and environmentally friendly alternative to traditional paper billboards and existing digital billboards.

The research that has been carried out in the ECOPIX project indicates that the proposed technology enables addressable electrochromic color pixels, based on RGB colour system, to be printed onto light-weight and flexible plastic sheets, using standard printing methods, to deliver a lower-power, light weight, digital color displays, for the high growth out-of-home advertising sector. Using this innovative solution, ECOPIX will develop a reflective DOOH colour display (with passive illumination via ambient sunlight during the day) which can offer market leading low power consumption for a digital display.

Solution

The overriding goal of the ECOPIX project is to improve SME partner competitiveness by developing an innovative DOOH display technology which provides a more cost-effective and environmentally friendly alternative to traditional paper billboards and existing digital billboards. ECOPIX therefore focused on a customized solution for the advertising sector, especially to the out-of-home advertising, although we note that the technology has a huge potential for application in indoor advertising as well. The project has developed an innovative digital out-of-home colour display system, based on the use of electrochromic (EC) materials. Via an electrochemical reaction, the colour of EC materials can be changed from a coloured state to a transparent ("bleached") state (or dark state) in response to an applied voltage. The solution uses conductive polymer electrochromic materials, which have three important advantages:

- They are fabricated as reflective (front-lit displays).
- They only require a small refresh charge to maintain a static (non-video) image.
- They are processed as solutions using established and emerging cost effective printing methods such as ink-jet printing, screen-printing, spray coating and low cost/high volume roll-to-roll (R2R) methods.

The ECOPIX display is based on the use of red-transparent, green-transparent and blue-transparent conductive polymer electrochromic materials. These and other materials are formulated into printable inks, and are printed onto flexible plastic film substrates (e.g. PET) using low cost printing methods, such as screen-printing, to deliver a low-power, light weight, digital colour display. ECOPIX exploits these advantages to develop a reflective DOOH color display (with passive illumination via ambient sunlight during the day) which can offer market leading low power consumption for a digital display. Front illumination will be added for viewing at night, in a similar manner to traditional billboards.

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The solution is completed with the development of display driver and player electronics and software to allow a new image to be uploaded from a web browser, rendered for the properties of the display, and displayed (Figure 2).

These features will allow ECOPIX to compete with traditional printed billboards and digital billboards, opening a range of new possibilities for the advertising sector, which are of great commercial interest to the participant SMEs.
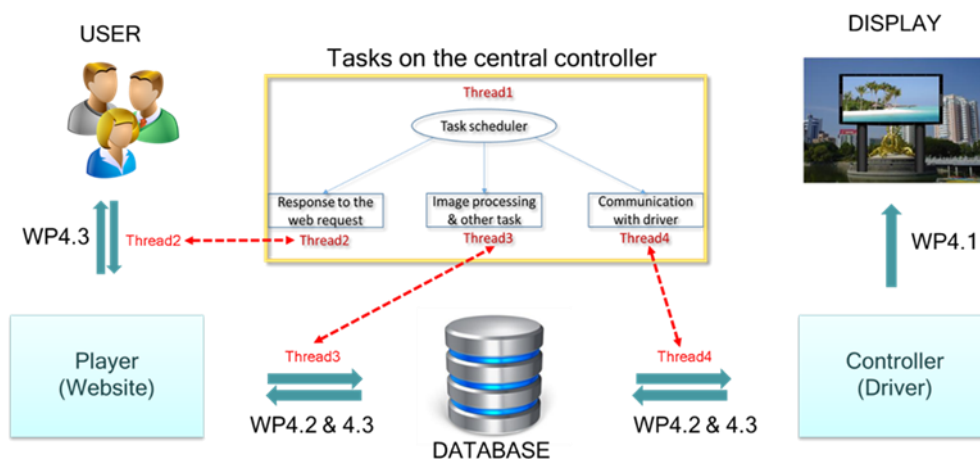

Figure 2. Layout of image processing and display in the ECOPIX DOOH system.

To ensure that the pre-competitive ECOPIX prototype resulting from this project fulfills the partners SMEs expectations and take this DOOH technology to a fully industrial scale in the post-project period, three specific milestones have been defined:

- Synthesis of Red, Green and Blue polymer electrochromic materials, and design and characterisation of electrochromic devices based on those materials.
- Formulation of printable inks and fabrication of electrochromic displays using low cost printing methods.
- Building of large area displays using passive matrix addressing, and rendering of images for display.

Finally, the consortium will ensure that the pre-competitive ECOPIX prototype resulting from this project fulfills the threshold requirements to ensure its further development post-project into a fully industrial system that is taken to market, where its beneficial impact will be felt at European level.

How it works

Electrochromic materials can switch between any colour and a transparent (or dark) state in a graduated manner via an electron-transfer (red-ox) reaction controlled by the applied voltage. Via an electrochemical reaction, the colour of EC materials can be changed from a coloured state to a transparent ("bleached") state (or dark state) in response to an applied

voltage. The solution uses conductive polymer electrochromic materials, which have three important advantages:

- 🟥 They are fabricated as reflective (front-lit displays)
- 🟦 They only require a small refresh charge to maintain a static (non-video) image
- 🟩 They are processed as solutions using established and emerging cost effective printing methods such as ink-jet printing, screen-printing, and low cost/high volume roll to roll (R2R) methods.

The electrochromic sheets used in the final display (Figures 3, 4 and 5) are composed of 12x12 pixels that correspond to 120x120 mm (with each pixel and gap having 1x1 cm). The employed electrochromic sheets make use of an active matrix structure to assure an independent control of each pixel.

They are composed of three square patterned bottom layers, namely the bottom conductive layer, the ECD layer and silver pads, and four continuous layers, namely the electrolyte layer, the counter-electrode layer and top conductive layer (Figure 3). A spacer frame is also utilized to contain the electrolyte and control its thickness.
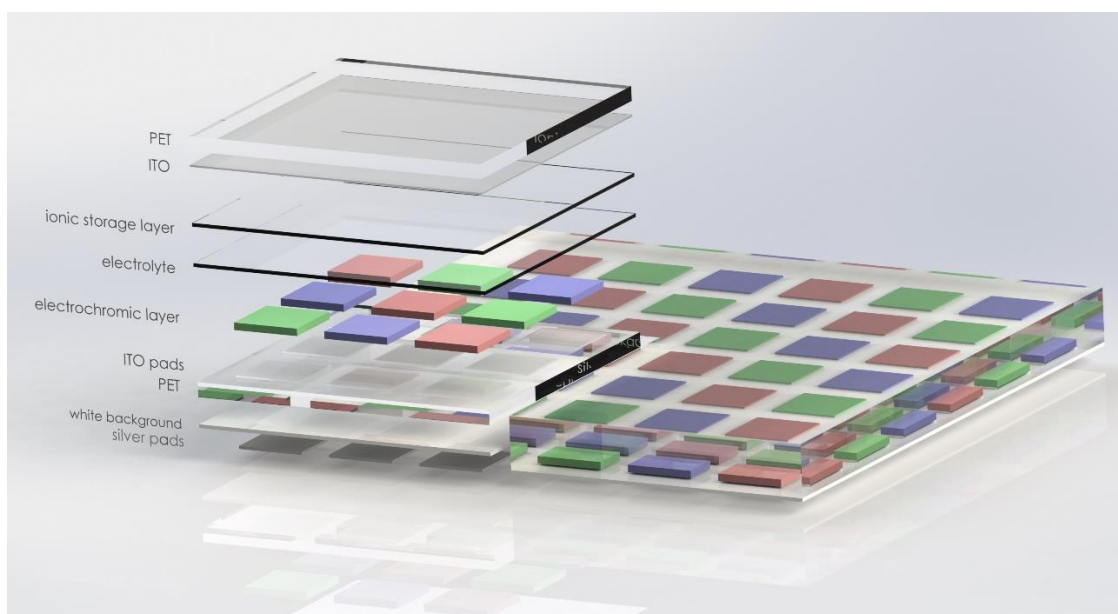
Figure 3. Active ECD matrix structure and identification of the different layers.

A PCB back board, is used to support the electrochromic sheets and the unit controllers and perform the connections between them. The controllers and the conductive tracks are placed on one side of the PCB backboard, while the electrochromic sheets are placed in the other side. The connection between both sides are made using the pathways created in the PCB.

The support structure is composed by a metallic aluminum frame with the same multiple-dimensions than the PCB backboard, so that the boards can be screwed to the frame and

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held in place. The dimensions of the frame can be adjusted to the dimensions of the display according to the client's needs. Beside the PCB backboard the "central controller" and the power controller are also installed in the back of the frame so that in the installation only one electrical connection is required, to power the entire system.
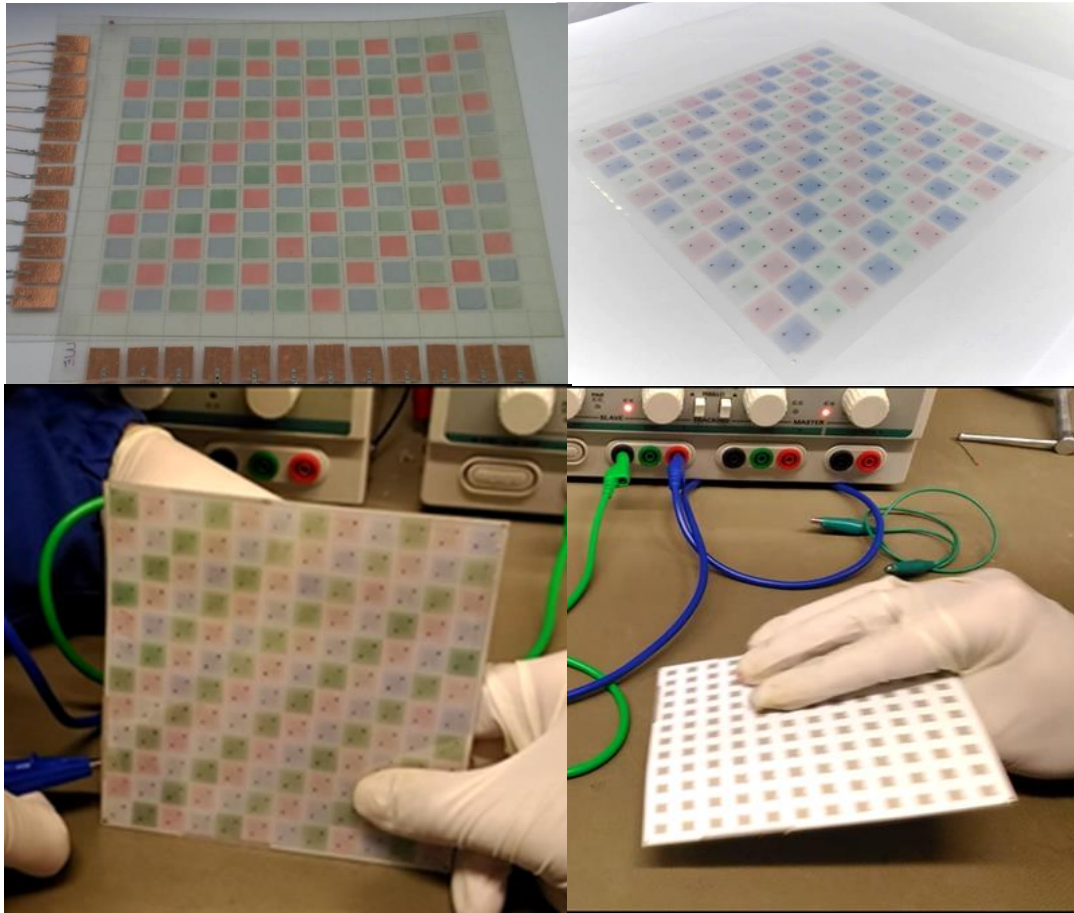

Figure 4. 120 x 120 mm EC display sheet prototype with single pixel addressing (front and white backplane sides).

Figure 5. Individual pixel addressing is possible by creating through holes in one of the PET/ITO layer, while the other ITO electrode is grounded; color changes upon applied voltage from complete saturation to almost transparent state (with white backplane).

The pre-competitive prototype

During the project, different scientific and technological barriers have been identified by consortium that could define innovative strategies to tackle some of the most critical points related to color contrast, individual pixel addressing and stability/durability of the EC devices. At the present stage of the project, most of the challenges have been solved, but in order to bring a competitive device to the market further actions must be taken either related to the performance of the materials and device or to the final optimization of costs including those of materials and processes. Significant improvements in terms of response time (meeting refresh rate specs for static billboards) have been achieved, namely by changing the pixels addressing method, and a better color contrast. Future developments will foster market implementation of the ECOPIX technology to take full advantage of its specific characteristics.

Market potential and sector applications

Extra large (OOH) billboard market is losing investor interest and is still not sensitive to adapt to more eco-friendly solutions. However, this is not a market with a dead end: in several recent industry bulletins and reports more clarity is being given on the equilibrium between (wide format) digital and traditional display demand. There is significant proof that with the increase of digitalization of smaller displays there is also an increase of a conscious choice not to over-digitalize large displays. Communication experts note that in graphical design, it is a standard technique to show less items on large screens and less movements, and therefore still images are not always a bad choice.

A second and even more favorable insight for the ECOPIX project, is that the **signage market**, which is more than just DOOH, is benefiting heavily from growth through digital demand but not all signage demand is optimally served by heavy digital solutions. 'Downgraded' versions of these solution (in functionality and in Capex/Opex cost) might suffice, and ECOPIX solutions could find a niche market right there. The digital signage market is big and growing (Figure 6). Revenue from **digital display signage systems is expected to surpass $27,34 billion in 2022**[5], and growth projections for the digital signage market range from the single-digits to more than 40% per year over the next few years.

- The United States is the largest regional market worldwide; Asia- Pacific is the fastest growing.
- It's estimated that there are more than two million digital signs in the U.S. alone and the numbers are growing by about 20 percent per year.
- There are an estimated 1,000 large networks (with ten or more displays) owned by organizations and used exclusively to support their internal communications needs, with a further 10,000 smaller networks.

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[5] http://www.marketsandmarkets.com/PressReleases/digital-signage.asp

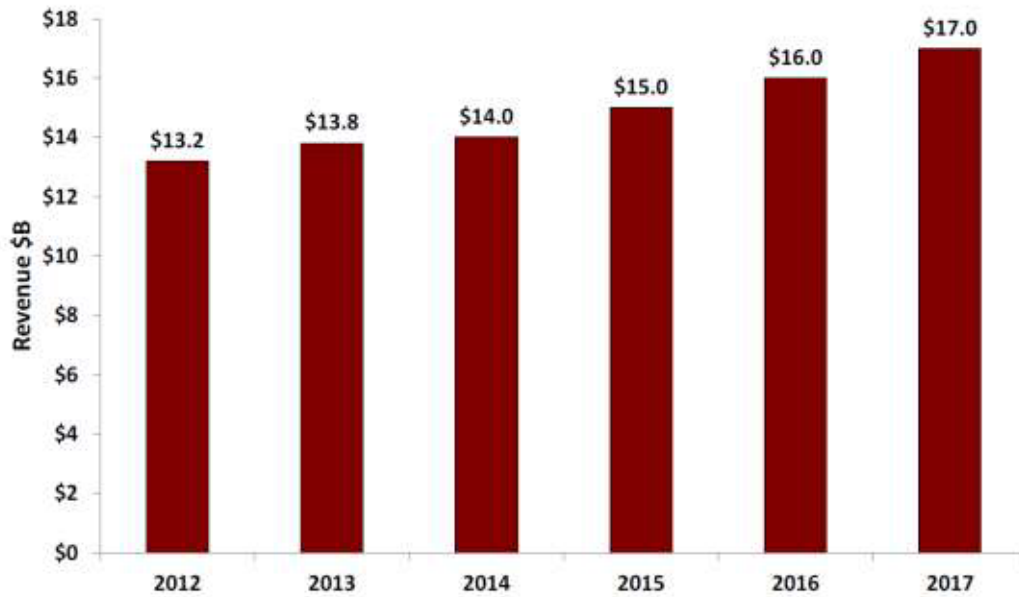ECOPIX White Paper "Eco-friendly display, based on novel printable electrochromic polymers"

Figure 6. Worldwide digital signage system revenues ($B) (source: HIS Inc.)

Electrochromic devices have unique properties that make them suitable for a large range of applications, especially for high added value niche market applications. Some of those are listed in Table 1. Particularly, we identify 2 niche market opportunities (Figures 7, 8 and 9):

■ **Niche 1:** Indoor and outdoor displays which do not have many image switches over a certain period and where the information to display is not heavily graphic (the image should be clear and simple).

Figure 7. Example of small area EC display systems.

■ **Niche 2a:** Indoor (occasionally outdoor!) displays which do not have many image switches over a certain period and where there is advertising/branding to display. If ECOPIX also delivers lightweight displays, this might be ideal for event booth builders that can either re-use or more easily transport their displays.

Figure 8. Example of medium to large area digital display systems.

▪ **Niche 2b:** Very large outdoor displays, commercialized and by demand only served for still images, which need to be replaced over time, depending on the advertising contracts sold.

Figure 9. Example of large area outdoor digital display systems.

ECOPIX technology niche market applications: small area EC display systems

Many sectors have been identified as potential users of the ECOPICX technology, particularly in the small area EC displays niche markets such as signage displays. In its reading, one can detect but not in majority, areas where this can be an option and where resolution (and viewing distance) can be determined as a key spec for ECOPIX commercial viability.

Table 1. Potential areas of usage of the ECOPIX technology.

Corporate	- Promote events and HR information - Supplement training or product announcements - Boost morale and improve communications - Deliver emergency announcements more effectively - Incorporate live information like weather, traffic, and stock price - Broadcast performance and inventory statistics - Display industry news or other RSS feeds

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	• Personalize visitor greetings • Show event schedules • Promote special offers • Supplement knowledge sharing • Advertise loyalty programs and sign up procedures • Dynamic reception area displays, welcoming guests and showing corporate information • Live sales performance figures • Corporate video presentations
Display company name	• Digital signage enables businesses to promote products and create brand awareness in lobbies, in offices, and at trade shows • Large, established corporations can use interactive kiosks to connect with customers on a more personal level. • Small, growing firms can use large screens to cast themselves as major players even on a limited budget • It's great for communicating with employees • Companies use it to save the time it takes to distribute and correct information, make operations more efficient, advise staff of the day's agenda, alert them to emergencies or critical information, motivate their workforce, and spotlight company achievements
Retail	• Generate revenues by advertising at point-of-purchase and point-of-service displays • Promote loyalty programs and registration benefits • Run entertainment programs target niche groups • Display community programs and charitable partnerships • Advertise upcoming events and product release schedules • Promote customer service, gift programs and warranty programs • Display store layout, shopping guides and other helpful store services • Share emergency alerts • Display live weather, traffic, stock and sports information • Supplement training and education efforts • Point-of-purchase or point-of-sale displays • Colorful, inviting storefront displays that draw in passers-by and turn browsers into buyers • In-store promotions for specials, sales, and new product launches • Deliver interactive content and information in real time, while increasing business process efficiency • Improving customer service by helping customers easily find locations within the store, such as fitting rooms, customer assistance, or various departments • Enhancing the store ambiance • Reinforce existing television, radio, print, and event marketing messages
Healthcare	• Orienting around facilities • Educating patients about their specific conditions • Entertaining patients during their stay • Coordinating key hospital constituents (families, doctors, nurses, specialists, etc.) to optimize the patient experience in the hospital • Health information communication

	• In hospitals, multiscreen presentations inform visitors of clinic hours, health screenings, and the latest medical offerings, as well as cafeteria hours and menus

The new technology enables hospitals to network their displays and manage content remotely from a centralized location change or schedule content they want on specific displays from a centralized location. It makes it possible to send out real-time emergency alerts to all the displays on their network if the situation calls for it. Hospitals can use the displays for digital signage applications such as providing information to patients, friends and families for educational purposes.

They can also be used for so-called "way finding" applications, as well as a communication point for urgent facility information. The displays can replace traditional whiteboards or chalkboards for nurse scheduling. Nurses can control everything from a computer at the nurse's station. It makes it easier to see and track what their responsibilities are, what their rounds are going to be, etc. Patient room displays can be configured to enable food service ordering, with menu screens tailored to the specific patient's dietary restrictions.

Financial institutions	• Combine video and bulletins
	• Advertise financial products, promotions and offers
	• Deliver important announcements as they happen
	• Enable critical financial decisions with on-time data
	• Post changing stock updates and rate information
	• Promote community outreach and partner programs
	• Respond quickly with emergency announcements

Government

Digital signage has brought some much-needed color to the staid government corridors of the past. Publicly owned buildings use state-of-the-art signage to provide visitors with directions, meeting, and event information, and help them navigate layers of bureaucracy. Because screen content in multiple offices can be controlled and updated via the network connection from a centrally administered console, an agency can ensure that the public receives consistent information in a timely fashion. Digital signage also helps keep people entertained and informed of schedules, weather, and news wherever they're forced to wait. What's more, government transit authorities depend on digital signage to deliver real-time and, if necessary, critical emergency override messaging alerts to subway or bus stations while also making the commuting experience more pleasurable for the public.

Hospitality and convention centers	• Welcome groups with personalized messages
	• Generate revenues with advertising
	• Promote loyalty programs and registration benefits
	• Deliver important announcements as they happen
	• Advertise upcoming events and entertainment schedules
	• Share emergency alerts and live weather, traffic, stock and sports information
	• Supplement education and training efforts

Transport	Riders get:
	• To see their buses (actually moving) online
	• A detailed map
	• Estimated arrival time
	• More time to relax, work, or grab some coffee
	• A safe, comfortable, convenient transit experience

	Transit Administrators get: • A real-time view of their transit system • Insightful reports • Fewer complaints • Less radio chatter • A better way to promote important announcements • A turnkey solution Airports: • High-contrast screens that show flight and baggage information • Panels that provide directions at security stations and inform travelers of wait times • Welcome center displays that promote local businesses and attractions
Restaurants & Bars	• Dynamic menus that update automatically from lunch to dinner • Advertisements for promotions on food or drinks and entertainment
Education, Houses of worship …	• Cfr. Safety, way-finding, scheduling, participation encouraging, display information
Detail on way finding (e.g. in big department stores, stadiums, malls, for exits, toilets, pay desks, etc.)	• Show area-wide, building-specific and area maps • Enable point-to-point directions and visual paths • Tie in personnel and department directories to map locations • Map your event locations • Incorporate ADA controls • Build-in support for multi-touch screens to allow pan and zoom • Include general facility information • Display digital signage announcement playlists • Show weather, news and other data and RSS feeds • Incorporate date and time • Ask for alert message support to override screens
Social Media	• Advertise social media efforts • Automate content for time-savings • Boost participation and awareness • Run contests to track ROI • Include QR tags for instant access via smartphones • Design full-screen layouts for impact • Insert feeds into traditional layouts
Room Signs	• Show conference and event schedules for one or more meeting room • Display greetings, announcements and speaker information • Incorporate interactive way finding maps for easy reference
Keep everyone informed with news, weather and RSS feeds	• Present live, streaming content from your network • Playback videos and other animated content • Deliver critical alert notifications

Main Players in the Market and market overview

Competition with the developed technologies comes from many angles depending on the type of application (Figure 10). Considering the market of **dynamic tintable glasses** or the so-called **smart glasses/windows** the main competitors are thermochromics glasses and e-switchable glasses with SPDs (suspended-particle device or electrophoretic) and PDLCD (Polymer dispersed liquid crystal display) which are mature technologies established in the market of smart windows. In this area, the main players are Saint-Gobain Glass, Nippon Sheet Glass Co. Ltd., SmartGlass International Ltd., Innovative Glass Corporation, PLEOTINT LCC, RavenBrick LLC, Vision Systems and Hitachi Chemical Co. Ltd. Application areas are numerous, including controlled shading of windows in buildings, aircraft, motor vehicles and boats – wherever optical quality, visual comfort and temperature comfort contribute to safe and efficient operation. The technology of electrochromism for these same applications has been under development for some decades, but it was only recently that the glass industry succeeded to bring **electrochromic smart windows** to the market. Key players in this field are SAGE Electrochromics Inc., View Co., EControl-GlasGmbH & Co.KG., Gesimat GmbH, ChromoGenics AB., Saint-Gobain Sekurit, and IP Glass Technology B.V.

In the field of digital imaging industry, recent technological roadmaps and market analysis have uncovered some interesting insights. Some of the main competitive technologies have long been the ones dedicated to the creation of static images that need to be maintained and temporarily refreshed such as "electronic paper" technologies, mechanical aided technologies and CTR. Within the electronic paper there are several technologies already in the market for some specific applications such as e-readers typically based in electrophoretic materials, that present some similar

Figure 10. Technologies that may compete with the electrochromic display technology.

advantages such as low power consumption and high stability, not requiring constant energy consumption. These technologies are not indicated to be used for video display due to low switching speed and color limitations that currently exist. Other technologies (such as electrowetting, electrofluidic and interferometric modulators) are also of high relevance but
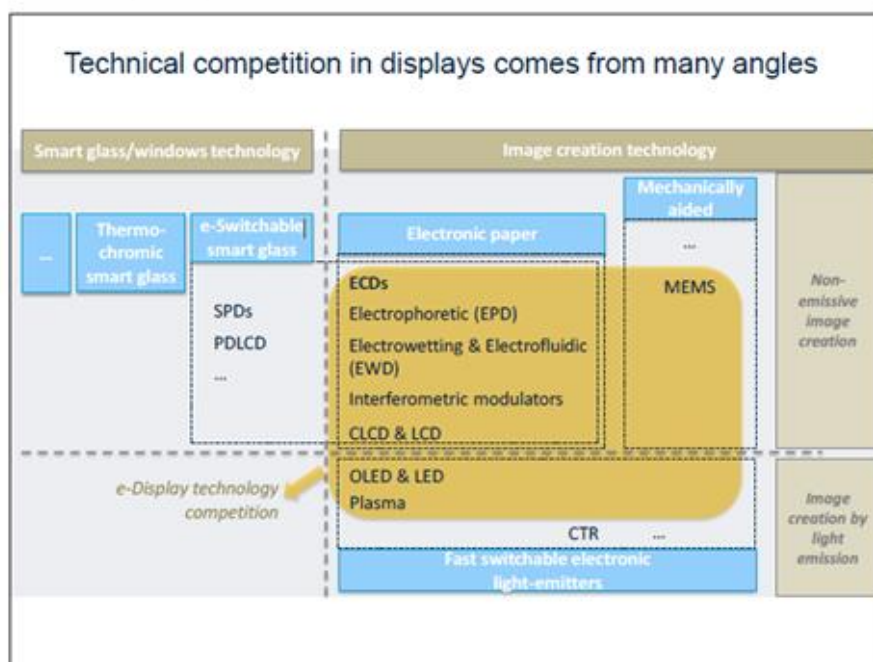
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currently still in a R&D stage and not in the market. The main competitive technologies that may compete with the electrochromic display technology for the different envisioned applications are highlighted in Figures 10 and 11.

Electrochromic Display Manufacturers: the competition

The market for electrochromic devices with similar properties to the ones being developed in this project is still in a very early stage, with very limited product availability. Most of the information that can be found regarding these technologies is related to fundamental research, either about materials or devices followed by a large number of published patents. The products that can be found in the market are of very limited production and all have in common the small area and limited color range (usually based in blue PEDOT:PSS polymer). In most of the cases they are based in a single color more suited for signaling and promotional advertising.

The main competitors include **Ynvisible[6]**, **Prelonic[7]**, **ACREO[8]**, **Zhuhai Kaivo Electronic Components Co., Ltd[9],** and **RICOH[10].**
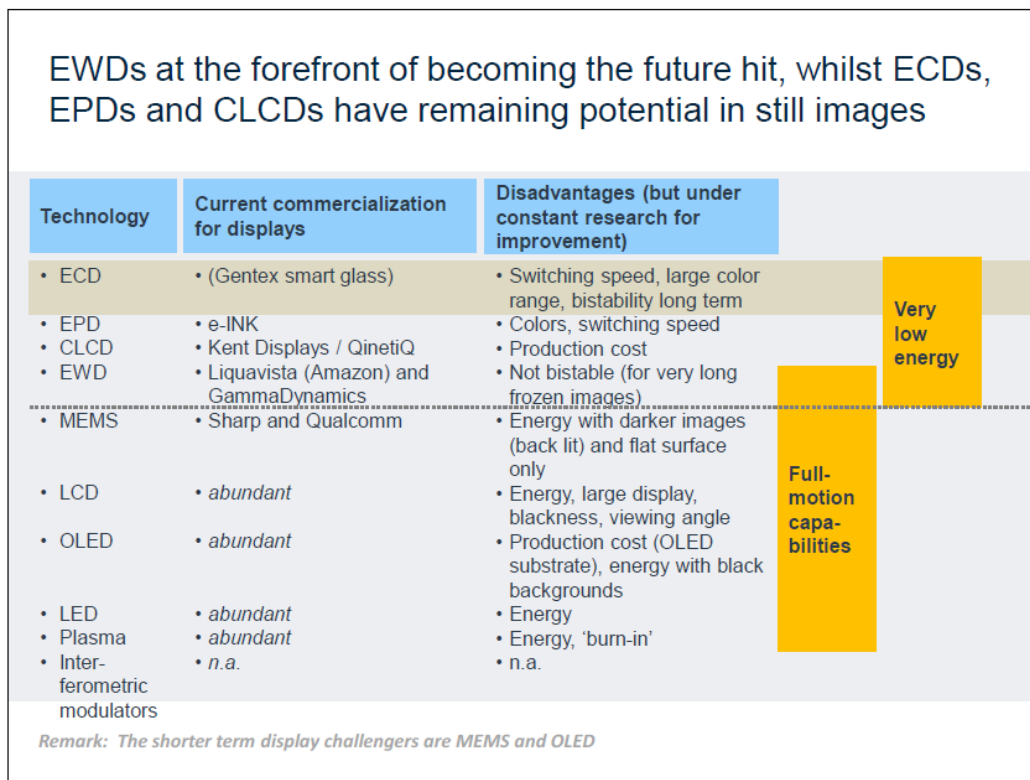
Figure 11. Display technology competition overview.

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[6] http://www.ynvisible.com/

[7] http://www.prelonic.com/products/electrochromic-displays.html

[8] https://www.acreo.se/tags/electrochromic-display

[9] http://www.zh-kv.com/kaivo_en/Products.asp?ID=29

[10] https://www.ricoh.com/technology/tech/031_epaper.html

Conclusion

ECOPIX exploit advantages of its novel technology to develop a reflective colour display (with passive illumination via ambient sunlight during the day) which can offer market leading low power consumption for a digital display. The ECOPIX solution offers unique features for a digital display: ultra thin (<2mm), ultra light weight (<500g/m^2), flexible/ conformable to rounded surfaces, and customisable at low cost to produce irregular shaped displays, in addition to square or rectangular. These features allow ECOPIX to compete with traditional printed billboards and digital billboards, opening a window of opportunities for the advertising sector which is composed of large industrial players but also of innovative SMEs.

The ECOPIX DOOH technology will significantly reduce the recurrent printing and installation costs of traditional printed billboards and enhance returns by supporting value adding "day-parting". The cost-effective technology will also generate minimal electronic waste. ECOPIX will result in direct economic benefits for consortium partners via new opportunities for the manufacture, distribution, installation and service of the outdoor display. Moreover, while the European OOH industry is dominated by large enterprises, there are 280,000 SMEs in advertising-related sectors as potential end users of ECOPIX.

The Consortium

ECOPIX, supported by European Commission, joins 8 European leading industrial and academic organisations from 4 different countries.

Gökser Makina (TR) – Coordinator	www.gokser.com
Nanolayer Coating Technologies (PT)	www.nanolayer.pt
Printed Electronics (UK)	www.printedelectronics.co.uk
iDklic (BE)	www.idklic.com
Letratec (PT)	www.letratec.pt
Middle East Technical University (TR)	www.metu.edu.tr
Centre for Nanotechnology and Smart Materials (PT)	www.centi.pt
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