Paper Evolutions

Exploring digital and physical paper futures

Anu Seisto

Heidy van Beurden

Paul Egglestone

John Mills

September 2015

Table of contents

Paper Evolutions

Exploring digital and physical paper futures

Anu Seisto

Heidy van Beurden

Paul Egglestone

John Mills

Paper is universal. We interact with it every day in a multitude of different forms, and it meets almost an infinite number of purposes. This exhibition looks to the future. It seeks to explore how paper and print can meet new demands, create new innovations and combine with digital platforms to create new opportunities. It spans re-invention of existing uses and explores new paper products and services. From super-rigid structures, the capacity to insulate against extreme noise or temperatures, combining the physical and digital and creating web-connected capacitive touch pages or smart packaging that links to your mobile phone, Paper Evolutions offers potential paper forms that could emerge in the near and distant future.

Provided by both the COST Action Network and the PAPER Breakthroughs exhibition, the 16 exhibits demonstrate a number of themes. These include exploring the ***physical-digital*** world and how paper can find a place and offer new value in a digital ecosystem. Examples include packaging that incorporates sensors and unique combinations of paper and audio/visual media that create novel user experiences or immersive environments. We also present here a strong thread of paper for ***social good***. These include products or prototypes that provide environmental benefit or complement health and wellbeing. We also explore how ***natural fibres and eco-friendly materials*** such as cacao shells or biodegradable sensors could be used as or within paper-based products. As you'll see, some examples span some or all of these themes, some are located firmly within their chosen field. All try to innovate with what is possible.

By looking beyond the areas of digital and print alone we stress the relevance of paper fibres for a wide range of social issues, demonstrating that innovation can come from unexpected (cross-sector) areas. For example, the inclusion of cardboard items are not simply about beautiful design but they emphasize the strength and flexibility of the material and hence the ability to replace commonly used plastic, foam or steel in production chains. This is relevant for engineering and architecture as well as for ICT and the 3D printing movement. The value of some of the objects on display lies mainly in the scientific research, exploring the characteristics of paper - tactility, recyclability, flexibility and lightweight - to the maximum.

List of exhibitors

VVT Technical Research Centre of Finland Ltd • Stora Enso • Bumaga • University of Central Lancashire • Novalia • Stuttgart Media University • Centre Technique du Papier • Welsh Centre for Printing and Coating • University of Surrey • Hysch • University of Pardubice • University of Exeter • Grano • The Greenery and Schut Papier • Callebaut

COST Action

In an EU funded COST Action FP1104, the focus has been on new possibilities for print media and packaging that may be achieved through combining print with digital. In this exhibition, some examples of innovative ways of utilizing the benefits of tangible products and digital services are provided. The Action has aimed at promoting discussion on the benefits that may be achieved from novel combinations of print and digital through bringing together experts from various fields. In our networking meetings, the topics have varied from technological opportunities to changing consumer behaviour and game research. The network has also supported active discussion between the academia and industry.

PAPER Breakthroughs

PAPER Breakthroughs is the title of both the publication and a travelling exhibition about European answers to societal challenges, made with paper and cardboard. The aim of this initiative (HVB Communicatie, Heidy van Beurden, Amsterdam) is to translate valuable and unexpected technological knowledge to various areas of expertise with an interest in innovation and sustainability. See also: www.paper-innovation.com

Our paper exhibits here hope to inspire, challenge and delight. Taken from a range of countries, companies and researchers, they demonstrate what is possible for products, services and digital connectivity. And, perhaps most importantly, they hope to fire the imagination.

Interactive travel catalogue

Tatu Harviainen and Anu Seisto
VTT Research

Are you ready to explore the possibilities of an interactive travel catalogue? We want to spark your imagination with an example, where a printed travel catalogue can take you to a winter wonderland to see the magnificent Aurora Borealis.

By browsing through tagged pages of the Insider's Guide to Finland, you are able to experience a whole new kind of printed product that literally brings the pictures alive. While reading this design brochure, you can almost smell the fresh air as you stand on a pier at one of the thousand lakes; or you can hear the pebbles underneath your bike wheels as you cycle through the countryside.

Operation of this interactive experience is based on optical recognition of marker tags from catalogue pages with two cameras embedded with the chair used in the installation. Music, sound effects, images and videos are composed as a continuous audio visual presentation that fluently synchronizes with the material a user is reading.

This cross-media concept was first created in collaboration with UPM, VTT Technical Research Centre of Finland and the Finnish Tourist Board.

Cookie box, Les Macarons

Interactive and safe

Simo Siitonen
Innovation and R&D Consumer Board
Stora Enso

Les Macarons cookie box from Stora Enso combines innovative design of traditional luxury confectionary and bakery packaging with interactive features to help customers ensure product safety for themselves and their end customers.

Designed by Stora Enso Consumer Board New Business Development team, the package structure enables a hidden NFC-label, separate antenna and IC structures to be printed directly on the luxury packaging board, and a laminated MFC (micro fibrillated cellulose) film to create a window into the packaging.

This premium packaging provides important allergenic information for customers via NFC tag and mobile phone application. The mobile app also demonstrates the future end use possibilities for customer interaction with packaging. Customers can enter their allergenic ingredients into application and it will alert if the product contains these harmful substances.

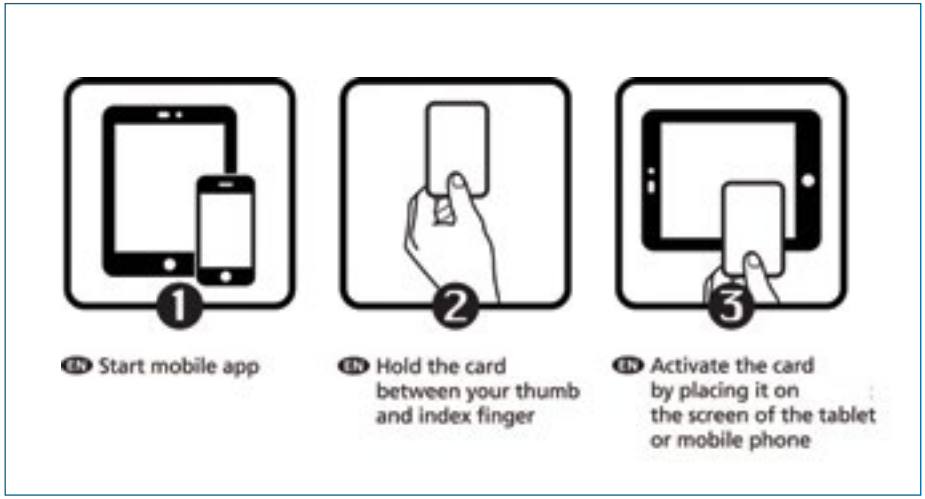
In addition to NFC interaction, the package also contains a UHF RFID antenna and chip with tamper evident functionality. This enables retailers to ensure that product is genuine, safe and hasn't been tampered with, for example during transportation.

Safe for the customer and for the environment
The cookie box demonstrates the importance of packaging to provide safe products for consumers. The packaging and its innovative features - such as mobile interaction - hopes to be an important enabler, especially for groups such as those with special dietary or persons with poor sight. Detailed information, such as nutritional value, can also be recorded electronically.

Natural fiber-based board packaging is made out of renewable material and provides a climate-friendly alternative to many products made from non-renewable materials. It also has a smaller carbon footprint. All the materials in the demonstrator packaging are recyclable in normal board recycling processes.

Papercode interactive cards

Sanne Tiekstra
Bumaga



Papercode Interactive cards provide an opportunity to release and distribute digital content on mobile devices and combine physical media in an interactive way on a digital platform. Based on signals from the market, content released through mobile devices will show a strong trend in the coming years.

The concept is based on a code that is embedded in the print on a card to unlock and release content on a mobile device.
With a mobile device and a code recognition app, the only thing users have to do is to make sure the card touches the screen to have the app recognise the code and unlock the content.

The code consists of a patented printing technology using a specially developed ink with a conducting property, which is not visible to the consumer. Also, the code cannot be copied or reproduced which makes it a perfect combination with security printing to electronically secure and verify for example tickets or value and security papers. The ink can be easily integrated in current printing processes, and does not need any new approaches.

During development, different print techniques as well as ink thickness, reproducibility and sustainability were optimised. Various coatings and base papers were tested to generate the best end result.

Since the content structure is linked to a database and can include different levels and available features, the next phase will be focused towards the development of the software to generate random codes and to link this to a database consisting of unique information.

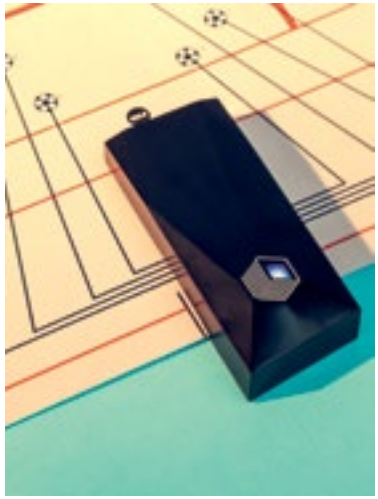
As different Papercode cards can activate different content, ultimately endless interactive experiences can be created. Future use examples are loyalty campaigns and incentives, mailings, product verification or product security, educative projects, and interactive card games.

Papercode is a cooperation between Netherlands-based companies Bergman Media Group and Drukkerij Hazenberg. Both companies are active in the graphical industry, where Bergman used to be an offset printer who now specialises in innovative projects, and Hazenberg has a huge reputation in security printing.

EKKO and Interface

Connecting print to the web

Paul Egglestone and John Mills
Media Innovation Studio
University of Central Lancashire



Harnessing conductive inks, 'affordable hardware' and the web connectivity, this collaborative project from the UK explores how physical print could offer a range of novel digital interactions. By connecting our 'EKKO' clip to a range of paper prototypes, each designed with a conductive ink matrix, print is transformed into digitally connected interfaces. Users can access audio material, vote or control a web-based game via the print via an accompanying app. Publishers also can manage the content, and generate analytic data from users, via the accompanying content management system - Interface.

Developed by the Media Innovation Studio in collaboration with creative agencies Uniform and Thomas Buchanan, the project has also teamed up with industry content partners spanning newspapers, magazines and book publishers to create a range of editorial experiences that re-imagine paper as a web-connected, and updatable platform.

Super 8 and Stuff

Our 'Super 8' prototype explores how a local newspaper - the Liverpool Echo - could offer audio and updatable content. Produced for footballer Steven Gerrard's final game for Liverpool, each football icon activates an audio report a special and important goal throughout his career. The MLS button offers something different. Taking advantage of 'Interface', and its ability to send content to a paper already printed and distributed, this button allows a newsroom to send updated editorial for users to consume and enjoy long after the publication date. In this case, for MLS updates over the course of the next season.

'Stuff' magazine utilises EKKO's properties to create a games controller. Once the clip is connected, it allows readers to access a simple online game that can be played by tapping the front cover of the magazine.

We're excited about the concept of paper being re-imagined as an emergent digital platform, and where this research can lead.
In the coming year we hope to explore a range of user-scenarios beyond spanning transport, healthcare and the music industry.

Interactive sound posters

Kate Stone
Novalia

Source
PAPER Breakthroughs, 2015

The interactive posters, created by Novalia from the UK, act as a printed sensor that react to the touch of your fingertips, triggering sound. Kate Stone, founder of Novalia, explains: "The digital soul is wonderful: the ability to touch, the connectivity and the ability to collect data. We aim to tap this soul into print, hidden within the surfaces of beautifully designed objects and through materials that we have been familiar with for ages."

Drum poster
You can touch the printed image of the drum on the paper with your fingertips and play real music. On the other side of the paper, the reverse of the drum image is printed with a circuit using conductive carbon ink, allowing electron flow. This circuit is connected to a battery powered electronic sound chip, running software to recognise which area on the paper is touched, and accordingly, allowing sound to play. Alternatively, a Bluetooth chip can be connected to the printed circuit. This allows the poster to wirelessly connect and control an app on mobile devices, which will also act as the speaker. Novalia use conventional printing processes such as screen print and flexo print, allowing flexibility and ease of manufacture.

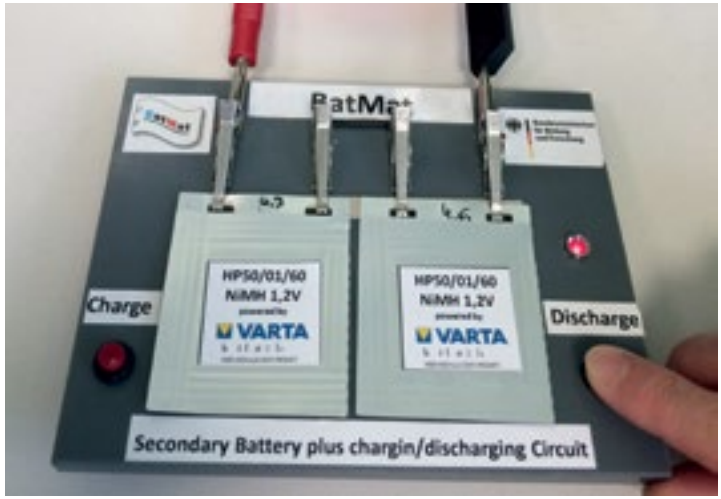
DJ Decks from a piece of paper
The world's first interactive paper DJ decks were created for scratching DJ QBert's album Extraterrestria. They wirelessly connect and control Algoriddim's DJAY application from a piece of paper with the use of conductive ink, Bluetooth and Apple MIDI, the digital interface to connect electronic music with computers and with each other. Users can scratch, mix and fade any songs they load into the software.

Piano on the move
You can use the piano to compose music on the move. This interactive paper sheet wirelessly controls applications from MIDI on Apple's mobile operating system iOS, with use of conductive ink, capacitive touch and Bluetooth.

BatMat

Printed batteries on paper

Professor Gunter Hübner
Stuttgart Media University



Batteries can be either non-rechargeable or rechargeable and have been well known for generations. Typically, they are housed in a metal cup or can. During the last few years, printing technologies have explored alternative ways to manufacture batteries. Printing processes offer flexible substrates and greater design freedom to shape the batteries.

During the BatMat research project in Germany (www.batmat.info) battery materials were investigated and improved when fabricated by print manufacturing processes. Materials included thin and flexible batteries, and both non-rechargeable (Zn/MnO2) and rechargeable (Ni/MH).

One of the requirements of battery housings is that they must provide a certain barrier to moisture since the battery contains an electrolyte that has to be kept humid during the battery lifetime to enable the necessary ion transport. Therefore, composite foils with barrier properties can be used, but also paper substrates that contain barrier layers.

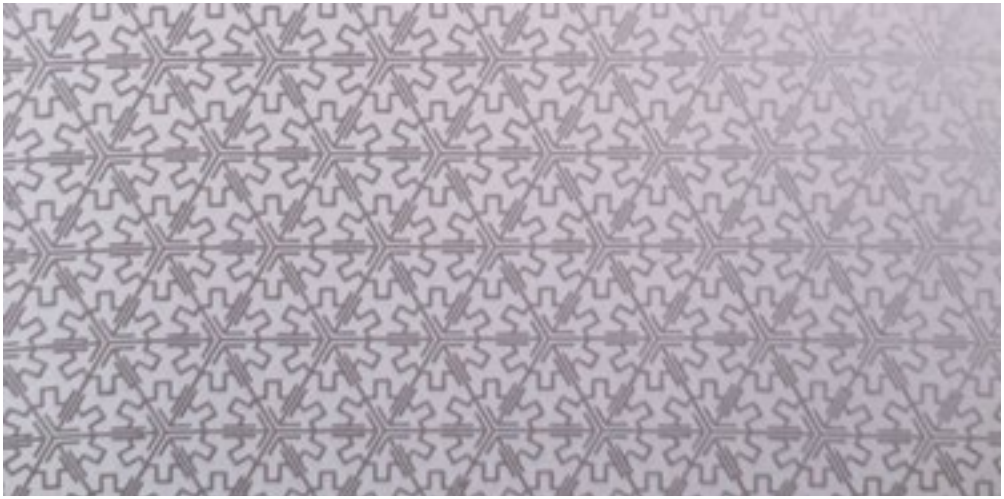
The exhibit shows samples of printed batteries on paper substrate that have been fabricated during the BatMat project.

WiFi-blocking wallpaper

Protecting data and health

Guy Eymin Petot Tourtollet
Centre Technique du Papier

Source
PAPER Breakthroughs, 2015



The benefits of abundant network connectivity are clear, but it also presents challenges to data security and health. Businesses and governmental organisations, for example, face an increased risk of hacked accounts and in hospitals patients can be exposed to signals, and areas free of electromagnetism are needed.

Centre Technique du Papier (CTP) in Grenoble, France, has created wallpaper that selectively blocks electromagnetic fields, whereas other waves such as those for mobile phone, radio or alarm clock continue to pass through. Special conductive ink is used on conventional paper, which is really only the carrier in this innovation. The differentiator is the pattern of the design, which looks like ice-crystals and is printed in such a way that one figure never touches another. By changing the size of the ice crystals you can shift frequencies and block, for example, waves for mobile phones, which could be relevant for theatres and schools.

“This know-how is the base for low-cost traditional or chip-less RFID manufacturing or other smart systems needing energy harvesting, and thus electrical conductive lines”, says Guy Eymin Petot Tourtollet from CTP.

Flexible printed electronics

Tim C. Claypole
Welsh Centre for Printing and Coating
Swansea University

The Welsh Centre for Printing and Coating demonstrates a range of printable electronics on flexible substrates which could be integrated into printed products or to add functionality to objects.

The first is a flexible light based on micro LED lamp. Micro LED (approx 27◂m) have a higher conversion efficiency than a conventional LED. The Micro LED with a top and bottom electrical connection have been made in a conventional silicon fabrication plants, sliced into individual shaped LEDs and dispersed into an ink. A conductive silver is printed as the base connection, and then a layer of the LEDs. The unique geometry of the LEDs leads to the fluid forces orientating them during curing to enable electrical connection and preferential light emission. Addition of dielectric and transparent conductor creates a fully-roll to-roll printable flexible light. This has potential in the production of area lighting or localised displays. The second is a flexible Electro-luminescent (EL) sign which was designed to fit on the visor of an emergency vehicle. EL has the potential to create signage over large areas. All the components on this sign were screen printed.

We have also developed a graphene-enabled pressure sensor array based on a patented novel design using graphene enabled inks. The sensor is the thin flexible film located on the top of the box. It has a pressure range that can be adjusted to cover variable responses from 0.1N to 3000N. The dynamic capability enables it to be use for the study of impacts forces. Potential applications include health care (patient monitoring and rehabilitation), elite sports (foot forces and impact loads), security, footfall analysis for market applications and seat sensors. A script was created by printing fine silver lines using the Optimec aerosol printer. These were then coated with micro phosphors from DST Innovations to create a Micro EL sign.This has potential for miniature signage that could be included into line of sight wearable devices and also into addressable displays. The addition of functionalised graphene nano platelets (GNPs) and carbon nanomaterials into a thermoplastic material has enabled the creation of 3D printed objects which have enhanced electrical and thermal properties. These can either be directly printed as in the sign and the sensor in the top corner or used to enhance the properties of a conventionally moulded product (albeit produced from a 3D printed mould). Current work is focused on improving the resolution of the 3D printed product and the formulation of the composite to create both conductive and semi conductor materials. This is the first step towards realising 3D printed electronics.

Light tags

Professor David Frohlich
Digital World Research Centre
University of Surrey

Paper has been with us for many thousands of years and still has properties that we continue to enjoy in the digital age. Rather than replacing paper with e-readers and screen technology, we aim in this project to connect paper to digital information, especially sound.

In a previous research project called Interactive Newsprint we explored the properties of connecting paper to the web through interactive regions which registered human touch and played back associated sound. One of the challenges of the project was in printing these regions and associated electronic components on the paper itself. Light tags is a new printed electronics technology from Surrey University which makes this easier. It has the potential to unlock a number of commercial applications of interactive paper in the print and packaging industry. In this project we aim to create proof of concept demonstrators of the technology, and collect feedback from both end users and industry representatives.

The project ran for 9 months from 1st July 2014 and involves a collaboration between Digital World Research Centre and the Advanced Technology Institute at the University of Surrey, and ran in partnership with the Welsh Centre for Printing and Coating at Swansea University.

Light tags is co-funded by the EPSRC Impact Acceleration Account (IAA) at Surrey University, and an Academic Expertise for Business (A4B) grant to Swansea University. We would also like to acknowledge the role of the EU COST FP1104 network on New opportunities for print media and packaging in facilitating this collaboration.

The project team is led by David Frohlich at Surrey, and includes Radu Sporea and Janko Calic at the University of Surrey, with Tim Claypole and Simon Hamblyn at Swansea University. University of Surrey patent was filed from this activity and three demonstration photobooks with sound were made and are shown on Vimeo (https://vimeo.com/album/3430190).

A follow-on ICURe project was granted entitled ‘Commercial applications of augmented print and packaging’. This is part of the ICURE programme funded by HEFCE and Innovate UK, and run by the SetSquared partnership.

Noise-absorbing paper

Malin Edlund
Hysch

Source
PAPER Breakthroughs, 2015

The Fibre Science and Communications Network and company Hysch from Sweden have joined forces in producing paper that can absorb sound. The fibres are also investigated in the broader context of insulation, particularly against temperature.

CEO Malin Edlund explains: “With paper banners around, the sounds echoing off the walls are softened and dimmed. Noise is not eliminated completely, but there is less fuzz. It works like a filter. This is effective in places with many people speaking, such as conferences, or in rooms where concentration is needed, such as classrooms at school. The paper reduces the noise inside a room, it does not reduce the noise from outside.”

Moreover, its value lies in scientific research. The technical feasibility of absorbing sounds (this is thicker, fluffier paper than copying paper) is relevant to other industries as well as the paper sector. This research fits in with the overarching context of fibres and insulation materials in buildings.

“If we understand how to absorb sounds, we can capture other non-tangible things like temperatures in paper, too,” suggests Edlund.

Flexprint

Smart labels, sensors and related printed functionalities

Tomas Syrový
Department of Graphic Arts and
Photophysics, University of Pardubice

The Flexprint project was started within the Centre of Competence programme in 2012 and is supported by Technological agency of Czech Republic. It addresses four areas – smart packaging, security systems, flexible electronic systems and smart textiles.

The aim of the project is development of functional printed electronic systems on flexible substrates and their fabrication using hybrid technologies (printing/coating techniques and NIL). The use of low-cost manufacturing processes (R2R printing/coating methods) allows a quick and flexible response to market needs with an emphasis on price/quality ratio.

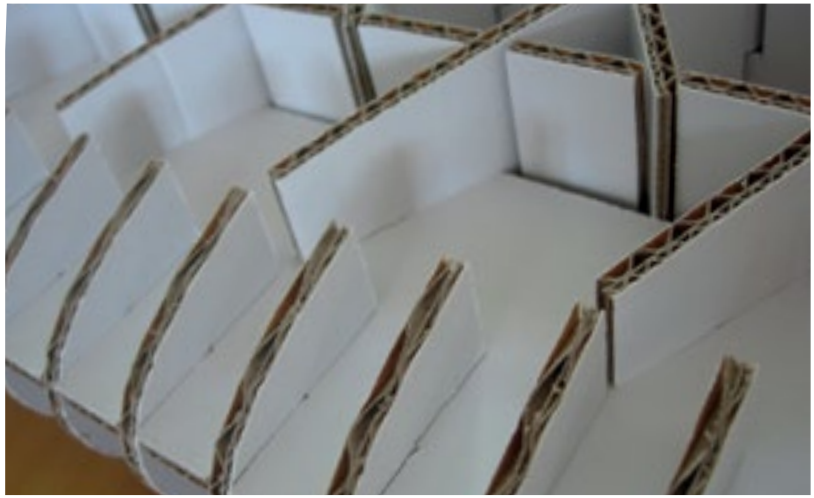
A selection of our prototypes include Smart Label with logging capabilities, which could be managed over NFC with Android based devices. Various fully printed sensors - such as relative humidity (RH), ammonia gas detection (NH_3), temperature and visible light - can also be integrated in Smart Labels. And we will also demonstrate fully printed electrochromic (ECD) and light emitting capacitor (LEC) displays.

Research activities of the project consortium also include the development of new type of materials such as conductors, conductive polymers, semiconductors, dielectrics and chromophores. We are also exploring the development of ink formulations and printing/coating technology processes, which are needed for fabrication various types of flexible electronic devices.

Cardboard surfboard

Arnaud Marmier
University of Exeter

Source
PAPER Breakthroughs, 2015



Who dares to hit the waves with a surfboard made from cardboard?

Many products currently made from foam can also be made with cardboard: helmets and baby seats or even bigger objects such as some wind turbine blades. Modern surfboards have a core made of foam, too. It is a light material that is easy to work with, but almost impossible to recycle. Replacing foam by cardboard slices makes disposable objects more recyclable.

This surfboard was made by cardboard engineer Arnaud Marmier from the University of Exeter in the United Kingdom (in Spring 2015).
He has built several working prototypes of different size, from short wakesurf to this funboard. The present board was damaged during waterproofing, but shows the detail of the internal structure and of the rail.

Cardboard products are part of the trends in current micro production by 3D printing within the 'maker' movement. But while 3D printing is primarily interesting for creating relatively small things, cardboard sliceforms can be used for much bigger shapes. The principles of creation, the digital model, are identical.

Water and moisture are challenging obstacles, but not impossible to overcome. The core of the board is covered with several layers of craft paper, itself coated by various waterproofing media.

In collaboration with cardboard packaging company Smurfit Kappa.

Re-board constructions

How strong is paperboard?

Sampsa Lilja and Janne Meskanen
Grano

Grano marketing executor company presents examples of printing products produced for different kind of events. They are printed on Re-board material, which is paperboard with a unique engineered fluted core. It is lightweight yet exceptionally strong. Therefore, it is possible to use it for very large printed constructions or for products that need to carry a lot of weight. The material is durable and can be recycled as paper.

For example, you don't have to travel to London to see the Big Ben. Big Ben can come to you. Big Ben printed on Re-board is stable and easy to build, even though it's nearly 5 metres tall. The tower is printed on several Re-board blocks that are easily assembled and can be taken down and rebuilt several times.

Another example is a stool printed on Re-board. This stool tolerates everything else but water. You may sit, stand or jump on it. It's light and folds into three parts in seconds, without having to use any tools.

Tomato box / book

Books and boxes
made with plant residues

The Greenery (box) and Schut Papier (book)

Source
PAPER Breakthroughs, 2015

The characteristics of paper inspire scientists to investigate the material for innovative solutions far beyond the opportunities of print versus digital alone. The nature of the papermaking process allows us to mix various fibres with paper pulp. This makes paper also valuable for the food, forestry, agriculture and horticultural sectors who are interested in re-using natural resources from their production processes in a more sustainable way, creating new value out of vegetal waste flows. For the paper industry it is interesting to be able to compensate for future shortages of cellulose, both from wood and other fibres.

Waste from various plants, which includes stems, shells and leaves, can quite easily be turned into packaging materials. The amount of the natural fibres that can be mixed with the regular paper pulp right now is 10 - 15%, depending on the plants and the length of the fibres.

"Connecting industries" is the first book printed on paper made with tomato plant residue. The paper was created by Schut Papier from the Netherlands and printed in the printing process for non-smoothened paper, demonstrating that the fibres would react well in the regular printing process.

The main advantage of this development may well be that, in the future, we will be able to make paper from local sources in a circular industry.

Cacao shells

Chocolate wrappers made with cacao shells

Callebaut
James Cropper Plc

Belgian chocolate manufacturer Barry Callebaut and paper manufacturer James Cropper from the UK have developed a paper in which cacao shells are incorporated into the normal paper-making process.

The aim of the paper is to reduce environmental impact and maximize waste recovery, and moreover, to increase awareness of the potential of raw materials.

The cacao shells are separated from the beans and ground to a fine powder. This powder is added to standard pulp stock and will automatically give the paper a light brown colour.

Active flower pot

Kaisa Vehmas and Maria Smolander
VTT Research

The market for sensors connected to cloud services is growing, and with roll-to-roll printed electronics it is possible to produce affordable sensors in large quantities. The ability to utilize biodegradable materials in products featuring a variety of sensors would help to increase the eco-efficiency of the whole concept.

This demo is targeted to show the potential of biodegradable sensing tools. The demo is a flower pot with a built-in moisture sensor. The pot is made of biodegradable materials and a moisture sensor is embedded in the soil. The sensor communicates with a mobile phone and the phone records the measurement data into a cloud server which can map the measurement results against e.g. daily weather reports. Various cloud based services and social media interaction could potentially be built in the system.

This demo combines VTT's competences in biomaterials, printed and hybrid functionalities and digital services into one tangible demonstrator.

Colophon

Production
VTT Technology Research Centre of Finland Ltd
Media Innovation Studio, University of Central Lancashire
HVB Communicatie, PAPER Breakthroughs

Editing
John Mills

Design
Nathalie Graafland

Print
University of Zagreb, Faculty of Graphic Arts

Espoo, 2015

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

iarigai
Helsinki 2015