Printed Electronics: The future of paper

by Dr. Gaël DEPRES
ARJOWIGGINS: Part of the Sequana group

- €1.5 bn in sales
- World leader in technical and creative papers
- High-profile brands including Conqueror, Rives, Cyclus, Cocoon
- 1.1 million T. of paper produced /year
- 18 production sites
- More than 5,200 employees

- €2.8 bn in sales
- #1 in Europe, #4 worldwide
- Operations in 44 countries
- 2 million tonnes of paper distributed every year
- 110 distribution centres
- More than 6,000 employees
Consumption of paper is decreasing since 2007 in developed countries

Consumption (--) and production (--) of paper in France*

* Source: Copacel
INTELLIGENT, INTERACTIVE AND CONNECTED OBJECTS ARE BOOMING

6.9 billion tags in 2014 vs. 5.8 billion (+19%) in 2013

Some key applications:
3 billion clothing tags / 700 million tickets / 400 million animals tags

Source: IDTechEx RFID Forecasts, Players & Opportunities 2014-2024
A REVOLUTIONARY PAPER FOR THE PRINTED ELECTRONICS INDUSTRY
KEY FEATURES OF POWERCOAT

POWERFUL PAPER FOR INTELLIGENT SOLUTIONS

- Unprecedented surface smoothness
- High thermal stability
- Excellent sintering behaviour
- Improved control over electronic layer adhesion
- Superior stability in roll-to-roll processing
- Reduced overall production costs as less ink is required for printing
- A recyclable and biodegradable solution for all your printed electronics needs

Roughness of PowerCoat™ < 10nm

Surface resistance of different substrates as a function of sintering temperature for silver inkjet printed squares of 1.3 μm in thickness
POWERCOAT®

THE ORIGINAL ULTRA-SMOOTH PAPER SUBSTRATE
DESIGNED FOR HIGH-DEFINITION PATTERNING SUCH AS
MICROELECTRONICS AND ELECTROPLATING.

- Perfect for high-definition patterning (<5μm)
- Reduced cost of circuit inks and materials (ink thickness <1μm)
- High sintering capabilities in air, photonic and thermal processes
- Excellent thermal stability
- Compatible with all printing techniques
- Available from 95μm
POWERCOAT XD IS OUR NEW MID-RANGE CELLULOSIC SUBSTRATE, WITH SUPERIOR SINTERING AND ALIGNMENT CAPABILITIES, SETTING A NEW STANDARD FOR HIGH-THROUGHPUT PRINTED ELECTRONICS APPLICATIONS.

- Perfect for roll-to-roll flexo, gravure, offset and screen printing techniques
- Superb sintering capabilities in air, photonic and thermal processes
- High thermal stability in colour and dimension
- Available from 95µm
POWERCOAT®
For what applications?

- Labels, packaging, tickets, smart objects
- RFID antennas with low silver ink consumption
- Components such as resistive circuitry, capacitors, coils, sensors, ...
- Circuitry for lighting and large surface flexible displays
- Secured documents
HOW THE CIRCUITRY IS PRINTED

- Antenna are screen printed with conductive and dielectric inks

- Inks are cured at high temperature

- Chips are pick and place directly from silicon wafer to paper (thickness of chip ~ 0.1 mm)

- Chips are tested and encoded
POWERCOAT® ALIVE
Packaging example
POWERCOAT® ALIVE
What applications for brandowners?

A packaging with PowerCoat® ALIVE can be programmed to:

- launch websites, videos, predefined URLs, facilitate communication on social networks, open link with additional content on the product...
- fight against counterfeiting and grey markets
- trigger a predefined action – e.g. ring, send an sms, light up-generating interaction between the customer and the packaging to enhance the consumer experience and increase brand recognition and visibility.
- give access to specific secured content (e.g. prompt persons to enter pin code to access specific information)
- store data depending on the location of the person who scans the packaging (geolocalisation)
KEY VALUE PROPOSITIONS

LABELLING

RETENTION / LOYALTY

TICKETING

GAMING
KEY VALUE PROPOSITIONS

INVITATIONS

BAGS

PACKAGING

AUGMENTED COM
BUSINESS CARDS
Tap into the Future

Business Cards+ with NFC technology

- High quality Conqueror® Alive paper
- Easily program Actions to the embedded NFC chip
- Trigger digital Actions with a single tap
- Make smarter, faster connections for your business

Business Cards+ from $29.99

Start Making

Business Cards+ from MOO – Online service for connected business cards
https://www.moo.com/uk/
BEATIE WOLFE’S NEW ALBUM AS A DECK OF CARDS
BOX WITH LED LIGHTING POWERED BY INDUCTION

- Single Energy Harvesting Antenna printed on the base of the box.
- PowerPad providing ON/OFF Inductive Power for glittering effect
- 8 LED picked and placed
- Box fully recyclable (no battery)
Demonstrators were done with LED soldered or glued on paper (lab)

Working screen with 128 LED on paper

Close view of soldered LED on paper
What can we do on our paper

- R, L, C components printed on our paper (in production)

- Components picked & placed: dies, chips, LED or other complex CMS components (in production)

- Sensors printed on our paper: temperature, pressure, bending,... (in R&D)

- Active components (loudspeaker,...) printed (in R&D)
Circuitry with conductors and resistors was manufactured by coupling laser patterning and screen printing.

- Carbon, screen printed
- Gold, laser patterned (30nm)
- POWERCOAT Paper
LASER PATTERNING/ETCHING

Printed with a 5 µm definition pattern, without degradation of the paper

gold (applied by CVD, 30 nm)

POWERCOAT Paper
Circuitry with conductors and capacitors was manufactured by coupling laser patterning, spin coating and screen printing.

- **Silver**, screen printed (10 µm)
- **Dielectric**, spin coated (1.45 µm)
- **Gold**, laser ablated (30 nm)
- **POWERCOAT Paper**
Excellent capacitors were manufactured with:

- very high Leakage Resistance (Rp)
- a dielectric constant (2,06) similar to that obtained on PEN

![Graph showing capacitance and resistance over frequency]

**Fréquence [Hz]**

- **7.3E+01**
- **7.2E+01**
- **7.1E+01**
- **7.0E+01**
- **6.9E+01**
- **6.8E+01**
- **6.7E+01**
- **6.6E+01**
- **6.5E+01**
- **6.4E+01**
- **6.3E+01**

**Capacitance C7 [pF]**

- **1.0E+11**
- **1.0E+10**
- **1.0E+09**
- **1.0E+08**
- **1.0E+07**
- **1.0E+06**
- **1.0E+05**
- **1.0E+04**
- **1.0E+03**
- **1.0E+02**
- **1.0E+01**
- **1.0E+00**

**Rp [Ohms]**
COMING SOON:
Printed sensors

Temperature sensors

64 bits memory

Connected to the antenna...

Temperature

14°C
COMING SOON:
Printed sensors and speakers

**Process:**
- Screen Printing.
- Piezotech FC Layer 2μm
- Annealing 5 min 100°C
- Poling 80V
COMING SOON:
Printed sensors

Replacement of double sided PCB by paper for Bluetooth label

Layout is printed directly on paper, antenna is also printed and components are soldered by using tin paste.
CONCLUSIONS

• **PowerCoat** bridges the gap between electronic and graphic printing, opening up a world of possibilities:
  - Integrating **intelligent functionality in disposable labeling and packaging**, especially RFID NFC communication with smartphones
  - **Lighting packaging** powered by smartphone or induction

• First paper with printed RFID technology, that is ready to print and available in 460x320 mm sheets or reels.

• R,L C components can be printed and more complex systems are picked & placed. Printed sensors are under development.

• This excellent result is thanks to the **very high smoothness, high thermal resistance and stability** of **POWERCOAT** making it possible to sinter at high temperature even when using a roll to roll technique
arjowiggins

Thank you for your attention

More information on
www.powercoatpaper.com/alive

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