

## João Conceição

Ph.D. thesis (2020-2023)  
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# SAVE Project – SepARation and Valorization of materials coming from the end-of-life of printed on paper Electronics devices

*SépARation et Valorisation des matériaux issus de la fin de vie des dispositifs Electroniques imprimés sur papier*

## Context

### Circular Economy

*Fibers and metal particles valorisation*

- Elimination of waste and pollution production;
- Keep products and materials in use;
- Regenerate natural systems.

Resulting in:

- Business and economic opportunities;
- Job creation;
- Environmental and social benefits.



### Waste of electrical and electronic equipments (WEEE)

Commonly designated as e-waste.



### Printed Electronics (PE)

- Low-cost production;
- Large-area flexible devices;
- Reduced resources usage;
- Global PE market (2020) = 7.8 b USD
- Expected to grow in 2050 = 20.7 b USD
- **Recyclable?**

*Electronics on paper*

- Low price substrate;
- Simple fabrication methods;
- Lightweight;
- Flexible and can be folded into 3D structures;
- Biocompatible, biodegradable, and environmentally friendly;
- Porous material (high surface area-volume ratio).

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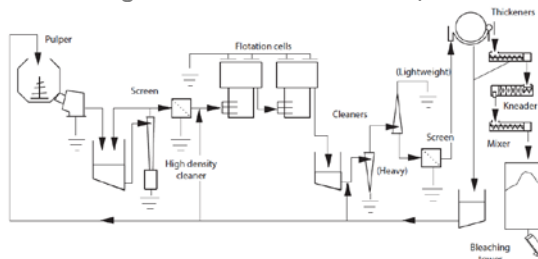
## Objectives

### Selection of the raw materials

- Functionalized inks;
- Paper grades;
- Production of model printed functionalized electronic device.

### Separation of inks from cellulosic fibers

*Deinking Process – several unit operations*



### Analysis of all produced fractions

*Evaluation by mass balance (MB)*

In separation processes, usually, there are no reactions, so MB can be described as:

$$Input = Output + Accumulation$$

### Separation, recovery and valorisation of all materials

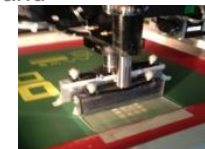
- Implementation of a new separation and recovery strategies;
- Valorisation study of recovered materials:
  - Papermaking ability of cellulosic fibers;
  - Quality of the recovered metal particles – possible valorisation

## Methods

### RFID tags study case

*E-printed paper production and characterization*

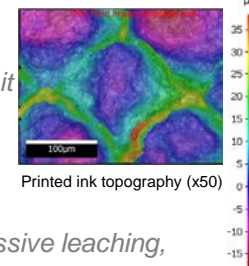
- Ink characterization;
- Screen-printing;
- Optical 3D measurement system for surface characterization (Alicona).



Screen printing press

*Development of Recycling Process – unit operation investigation*

- Mass balance;
- Ag tracking;
- Fiber analysis.



Printed ink topography (x50)

*Ag Extraction by successive leaching, concentration and Recovery*

Determination of Ag extraction efficiency (%EE):

$$\%EE = \frac{(C_{initial} - C_{final})}{C_{initial}} \times \frac{V_{initial}}{V_{final}} \times 100$$

where, C (mol·L<sup>-1</sup>) and V (L) correspond to concentration and volume, respectively.

Evaluation of the following parameters:

- Nature and concentration of leaching agent;
- Volume ratio;
- pH;
- Different molar ratios;
- Different metal ion concentrations;
- Multicycle extraction;
- Stripping (back-extraction) efficiency.



Biochip / FunPrint



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Grenoble - Chambéry