

## 1. - Publishable summary

The ultimate goal of the APPLE project is **to develop the next generation of sustainable paper-based products** with specific autonomous functionalities aiming at interacting with their users and/or reporting changes in their environment. A major focus is placed on **the development of flexible manufacturing concepts based on printing technology** to produce large area hybrid organic/inorganic papers with improved performance at competitive cost.

To this aim, the APPLE project is focused on 1) the integration of recent advances in functional materials (paper, fibres, inks) and functional components (battery, sensors, display, memory) and their production process upscale and 2) the development of innovative, flexible and cost-effective manufacturing processes based on printing and embedding techniques for the integration of all these functional components on the paper substrate.

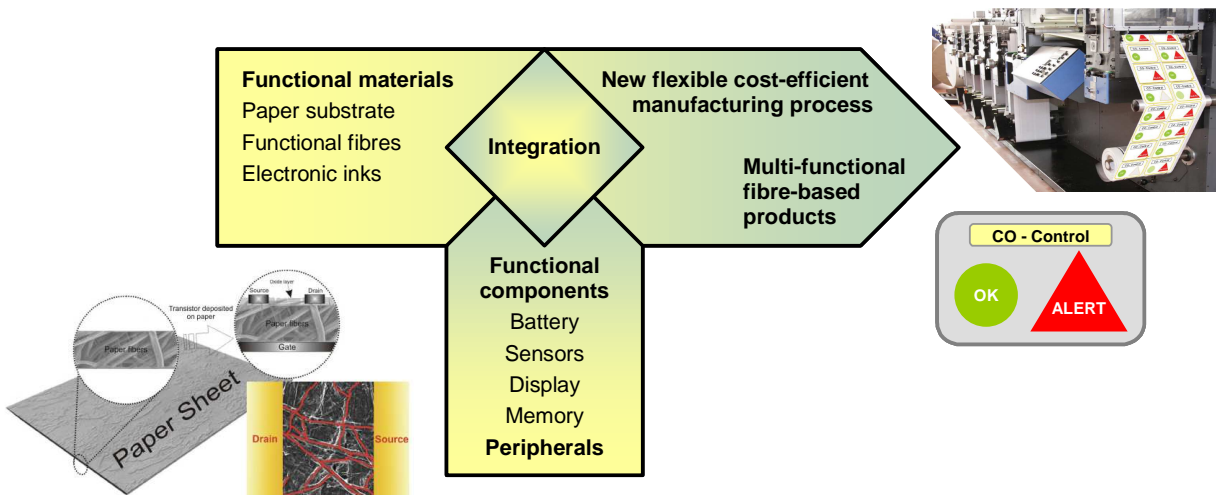


Figure: Concept of the APPLE project

APPLE project requires a multidisciplinary approach, involving 12 research and industry partners with different backgrounds, going from materials science and engineering, to chemistry, physics, electronics and micro/nano-technologies.

Table: Partners involved in APPLE

5 SMEs	
2 Industries	
4 Institutes 1 University	

The 4 main technical objectives are to:

- Develop new functional materials at industrial relevant scale (paper, fibers and inks)
- Develop printable functional components at industrial relevant scale
- Optimise design integration and develop a new manufacturing process
- Demonstrate the manufacturing process

### **Work performed**

First versions for (1) End-user and technical specifications and (2) materials and components specifications have been completed for the three targeted demonstrators. Main focus was made on electrical and printing specifications of demonstrator 1 (Environment & safety label).

Methodologies for testing LCA, recycling, environmental and reject issues of materials, components and demonstrators have been defined.

### **Functional materials**

Three reference papers were selected. They will be used for developing the functional and peripheral components. Papers development based on surface treatment (bio-sourced polymer coating and plasma) has already started. The influence of the paper properties onto the transistor behaviour has started; the first analyses lead to the request for further investigation.

Concerning the ink development, a first grade of 1) prime layer ink-jet ink and 2) ink-jet conductive ink has been produced and tested at laboratory scale. A second grade of these inks is under validation for flexographic printing.

Concerning the display, efforts have focussed on the development of a flexographic ink, taking into account the aspects of chemical security.

### **Functional components**

**Battery** structure has been defined. The manufacturing process has been discussed with different possibilities for the current collector deposition.

**Sensors:** the development of CO sensor based on CNT (Carbon Nano Tube) has started on a water base ink formulation. The H<sub>2</sub>S sensor is developed according to literature published recently (Crowley and all). At the moment, the results do not reach the expectation. The design of temperature sensor has been tested at lab and pilot scale. Further investigation is going on to improve the sensibility.

**Transistor** work has been focused on paper influence. Different concepts of transistor have been defined.

**Integration:** The electrical circuit regarding electrical behaviour of each printed component developed for Demo 1 has been designed. This circuit has been tested with Si based components. A first test-run of printing of electrical circuit with resistors and interconnections has been performed at laboratory and pilot scales.

**Peripheral components and flexible manufacturing process:** Resistors values range has been defined and printed using flexographic water base inks, at laboratory and industrial scale.

**Dissemination:** A public webpage [www.A3Ple.com](http://www.A3Ple.com) has been created. The finalised reports and deliverables are available there for APPLE partners and European Commission.