

# Design and Development of a RFID Assisted Flexible Printed Temperature Threshold Indicator

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## Problem statement, motivation and research objectives

### Problem statement:

Vaccines (Covid-19 and other), and cold food supply chain induces loss costing Millions of Euros due to heat exposure in logistics.

### Overall objective:

To create a smart, green, bio-degradable temperature indicator label for smart (active) packaging to indicate the heat exposure.

### Specific objective:

1. To print conductive (silver) interconnects and RFID antenna using Aerosol Jet Printing (AJP) on a fibre-based paper substrate.
2. Deposition of self-formulated Polyaniline ink (non-conducting) with AJP.
3. Trigger of an acid – as a stimulus - which transforms non-conducting Polyaniline ink into conductive ink. (turns blue color of the ink into green) – temperature dependent mechanism
4. Read out by a RFID reader – confirmation of an irreversible reaction

## Case study: Printing of a Temperature Threshold Indicator

### Materials and Methods

#### Aerosol Jet® Printing

- Non-contact printing
- High viscous and low viscous inks (1-1000 mPa.s)
- Rigid, flat, curved or flexible substrates due to Stand off (1-5cm)
- Thin (100 nm) and small (10 µm) structures

#### Inks and substrates

##### Inks:

- Novacentrix® Metalon JS-A221AE Silver ink.
- Polyaniline ink
- Acetic acid
- Curing: 60 mins @ 120 °C (Thermal)

**Paper:** Algo Baress from Sappi

### Device layered structure

#### Layer 1

Ag RFID antenna and interconnects

Aerosol Jet Printing

#### Layer 2

Polyaniline (dielectric ink)

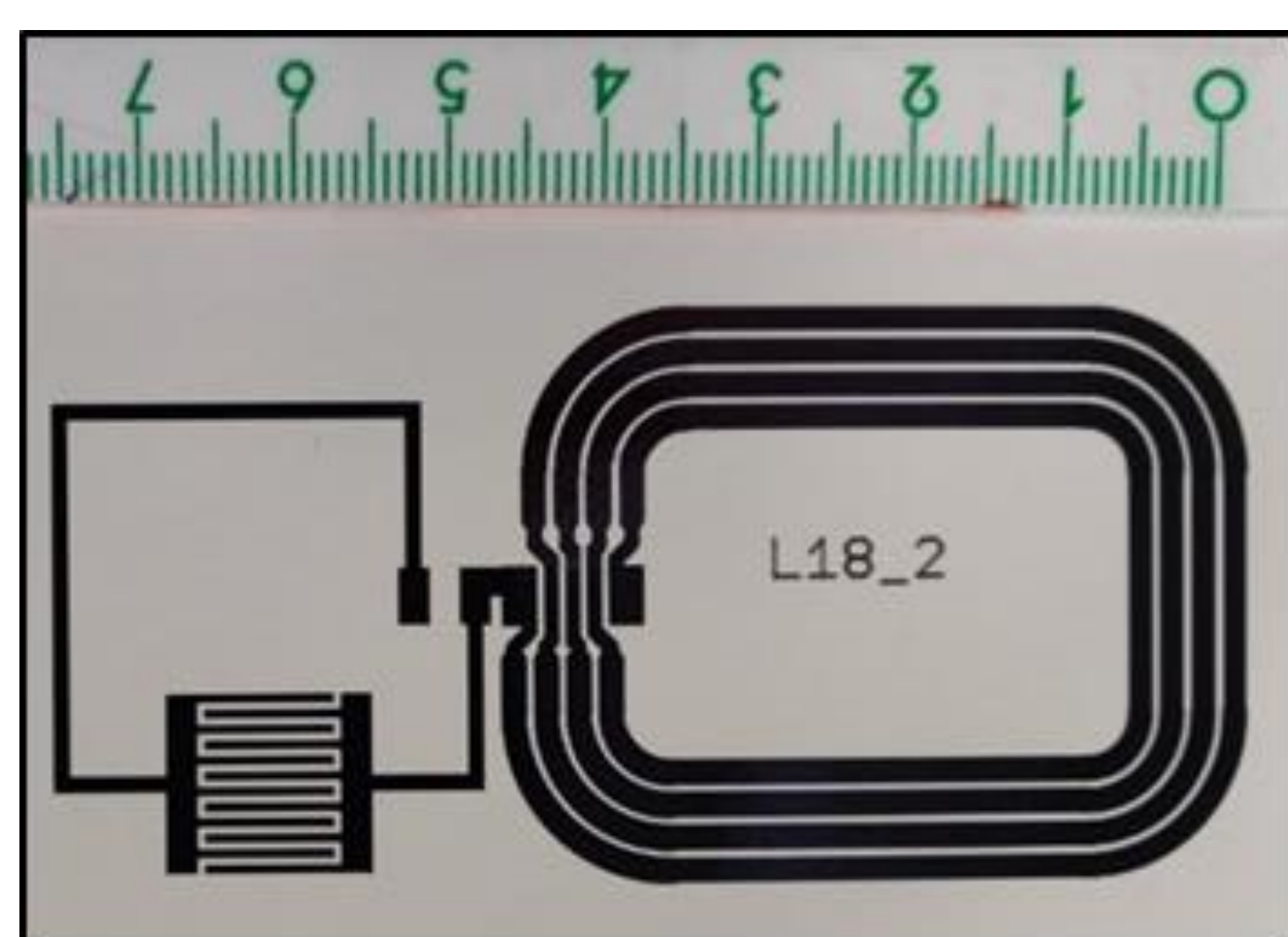
Blue appearance

#### Layer 3

Acid melt on heat stimulus – turns polyaniline into conducting

Green appearance

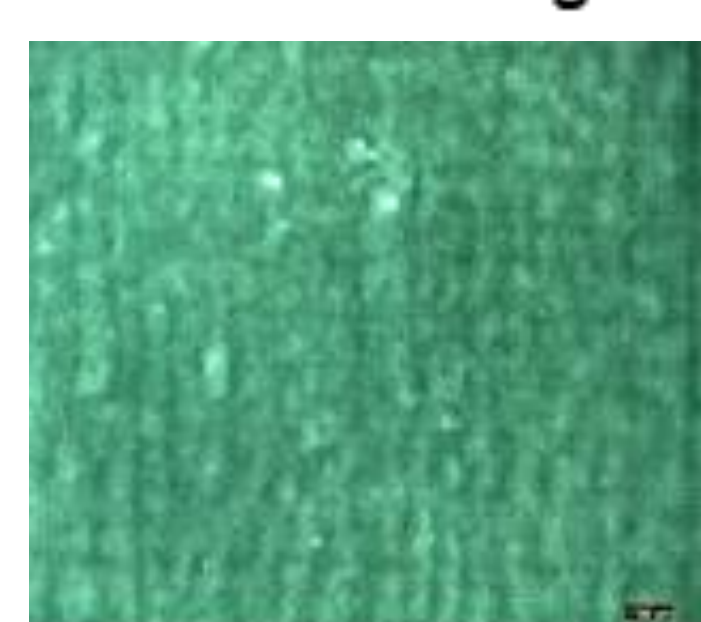
### Result: TTI indicator



RFID antenna  
 $F_{res} = 13.56 \text{ MHz}$



Non-Conducting



Semi-Conducting

Change in electrical property (appearance) of printed Polyaniline ink on a paper upon melted acid as a heat stimulus

### Conclusions & Future works

- (Un)-coated fiber-based substrates were studied regarding printability and ink compatibility.
- Functional HF RFID antenna was successfully printed along with other interconnects and tested.
- AJ®P visualized as a rapid prototyping technique to print silver and polyaniline.
- With reaction with acid (stimulus) – polyaniline starts to conduct which can be read out with RFID reader.
- **Future work:** Lamination and testing of a TTI label on a card box for smart (e)-packaging

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