

An Inkjet Printed RFID-enabled Humidity Sensor on Paper based on Biopolymer

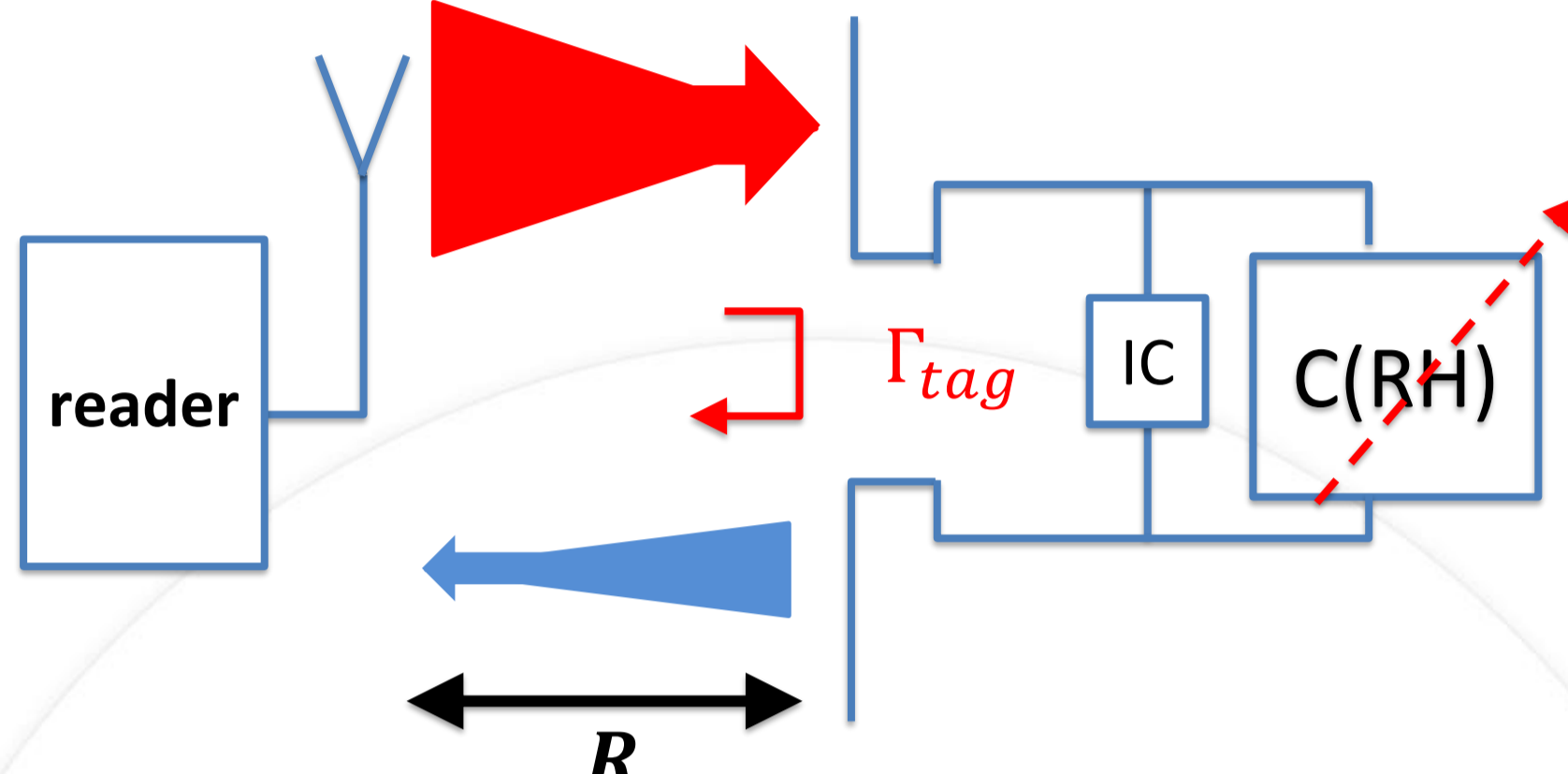
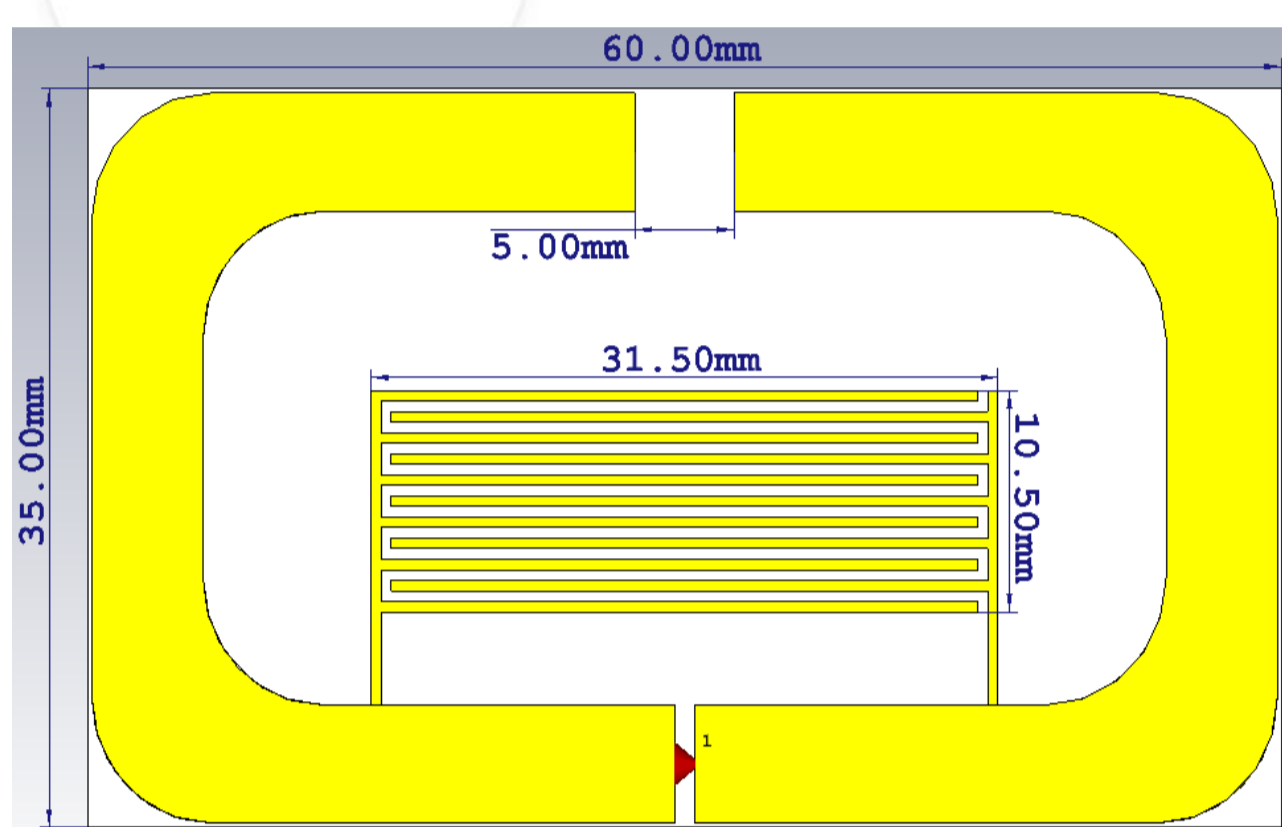
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INTRODUCTION - RFID enabled sensors are studied for several years because they can be deployed massively for a cheap cost and they don't need any maintenance in passive mode. In some applications such as food industry, there is a need to embed sensors to monitor food spoilage. The aim of this work is to prove the possibility of using paper substrate to realize an RFID enabled sensor that can be further integrated seamlessly within a food packaging. The realization of the tag involves inkjet printing technique on paper substrate and the use of wheat gluten for humidity detection which is a biopolymer already used in the food packaging industry.

UHF RFID Sensor Design

Folded dipole based UHF RFID sensor



Transmit power for tag activation

$$P_{tx}^{Activation} = \frac{P_{IC}^{Activation}}{G_{tag} \left(1 - |\Gamma_{tag}(RH)|^2\right) \left(\frac{\lambda}{4\pi R}\right)^2}$$

- Folded dipole-based Antenna design (900MHz)
- Interdigitated capacitor in parallel with the IC
- Biopolymer (Wheat gluten) deposit on the interdigitated capacitor
- Transmit power $P_{tx}^{activation}$ variation according to the mismatch between tag antenna and IC
- Mismatch is correlated with the relative humidity (RH)

Biopolymer and humidity variation

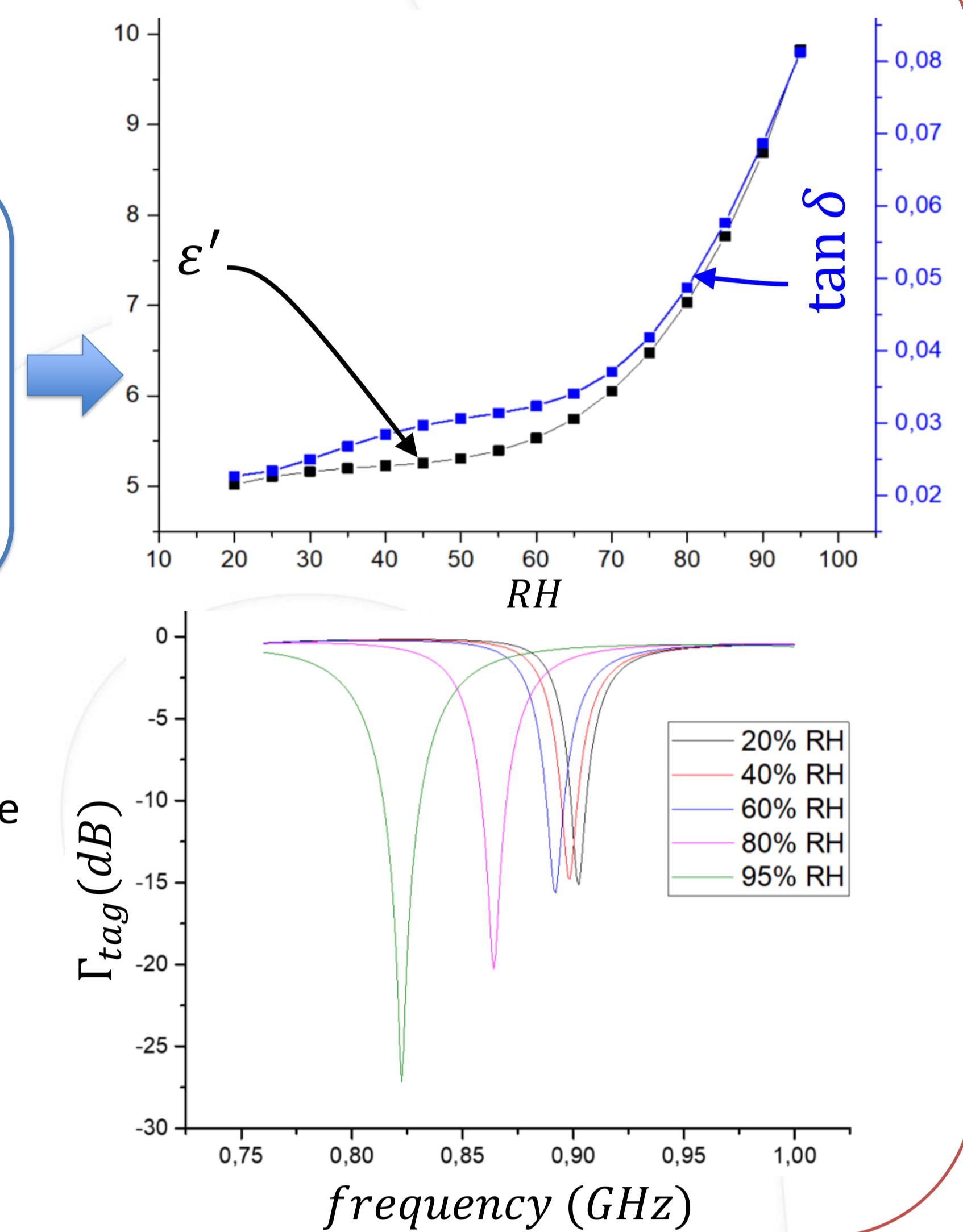
Dielectric parameter extraction of wheat gluten

Measurement at 900MHz

$\epsilon = \epsilon' + j\epsilon''$

$\tan \delta = \frac{\epsilon''}{\epsilon'}$

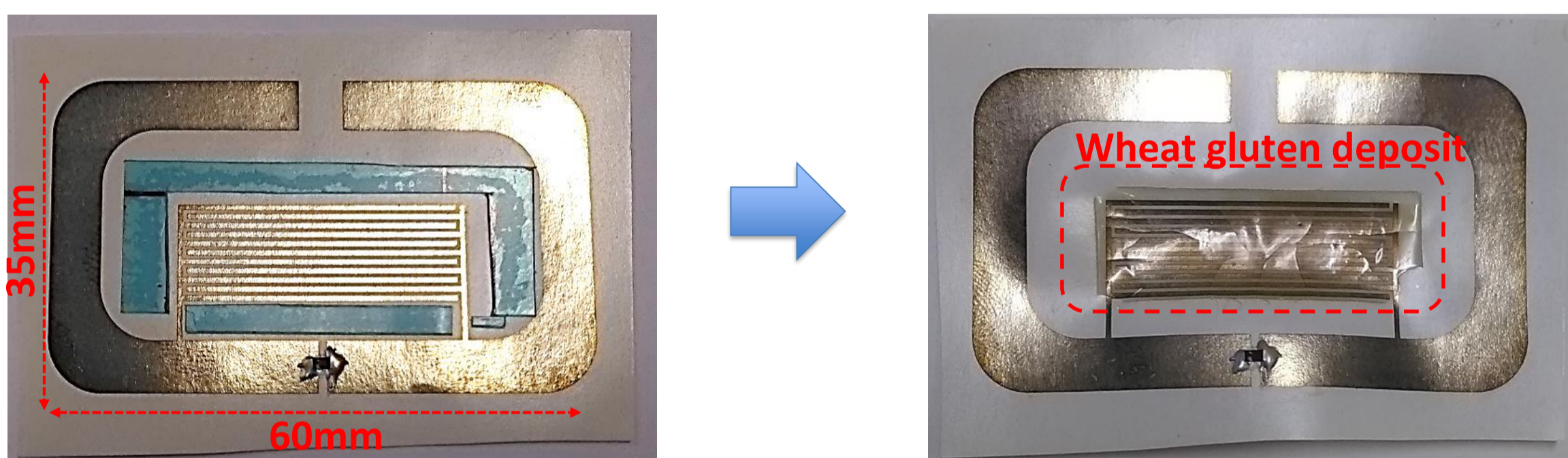
Logos: NEXT GEN PACK, URSI Ate, INRA SupAgro



- Simulation under CST MWS
- Variation of the complex permittivity according to the measured result to plot Γ_{tag} as a function of RH
- Optimization of the design (G_{tag}) for a low RH

REALISATION and EXPERIMENTAL SET-UP

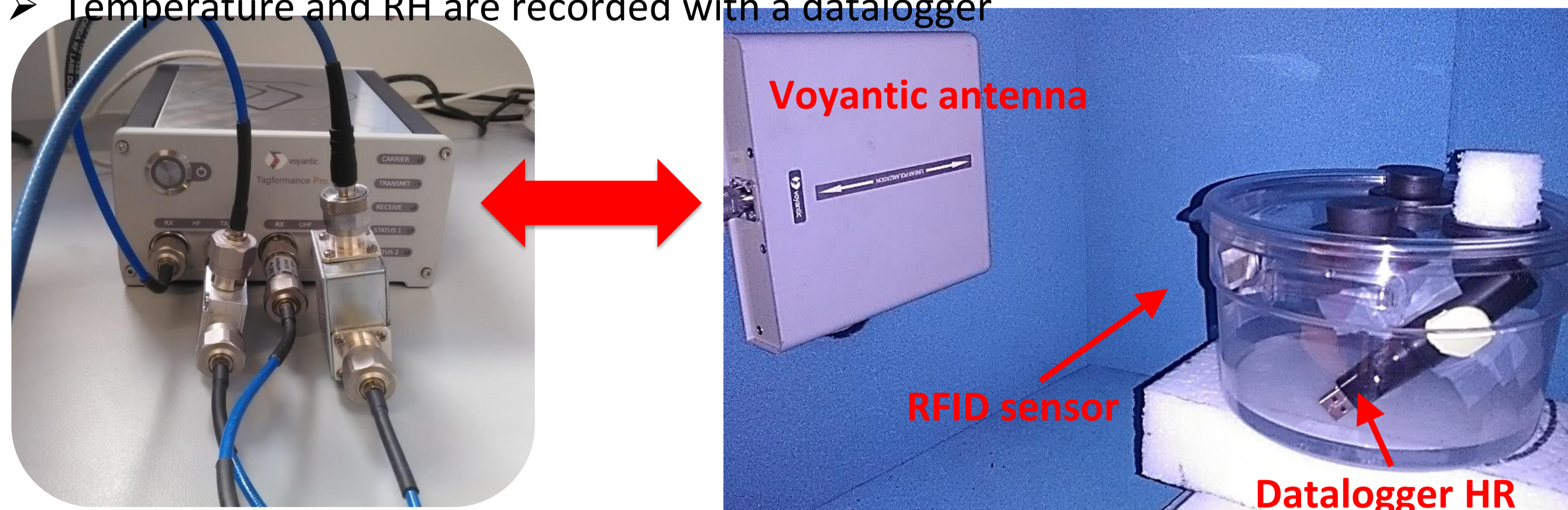
Fabrication of paper based RFID sensor



- Step 1 : Inkjet printing of conductive strips on a coated paper
- Step 2 : IC (Magicstrap Monza R6) bonding with conductive epoxy
- Step 2 : Deposit of wheat gluten solution and sintering (ambient temperature)

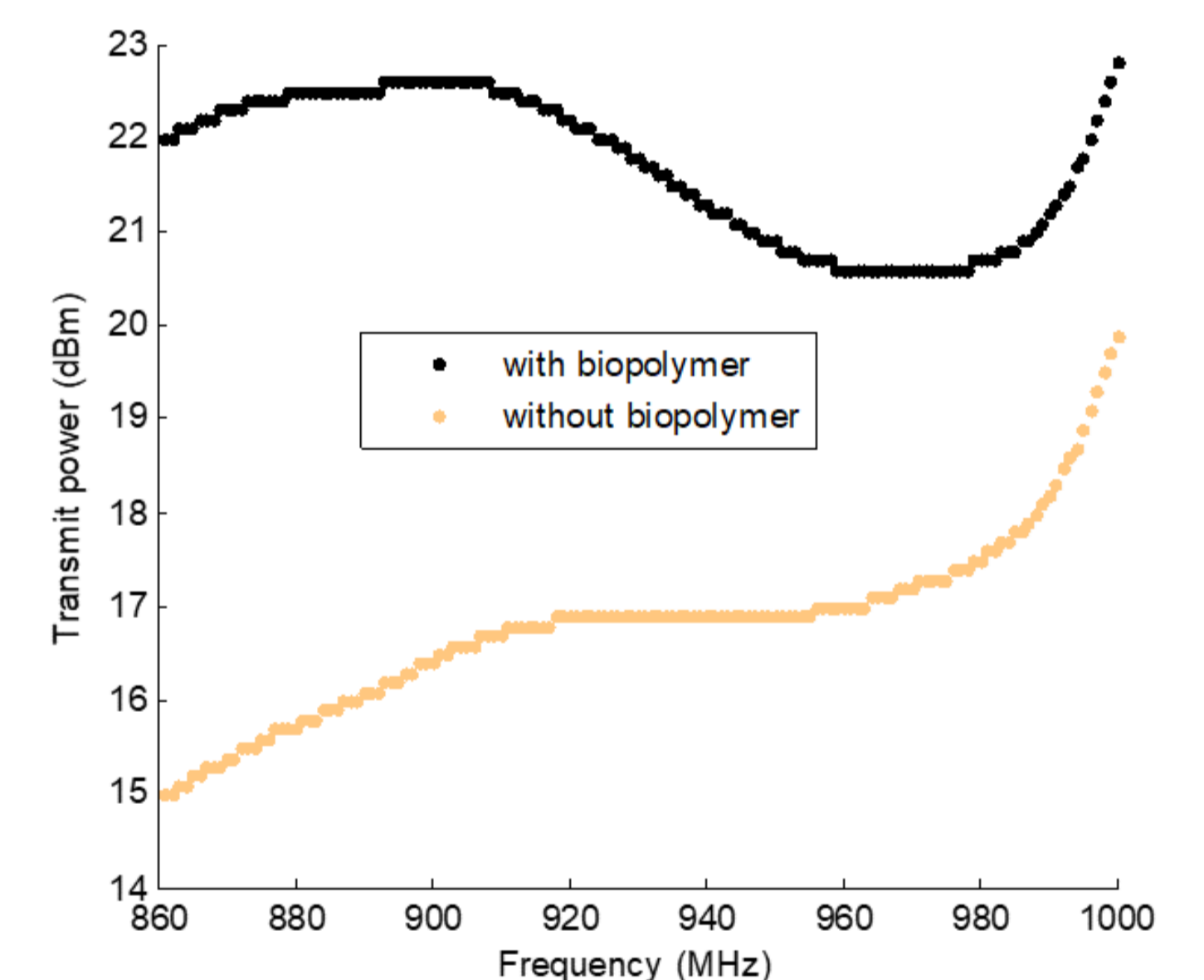
Experimental set-up

- Voyantic Tagformance Pro : Power cycling and frequency sweep to find $P_{tx}^{Activation}$ periodically
- Measurement done in anechoic chamber
- RFID sensor is placed within a box containing water and closed when measurement starts
- Temperature and RH are recorded with a datalogger

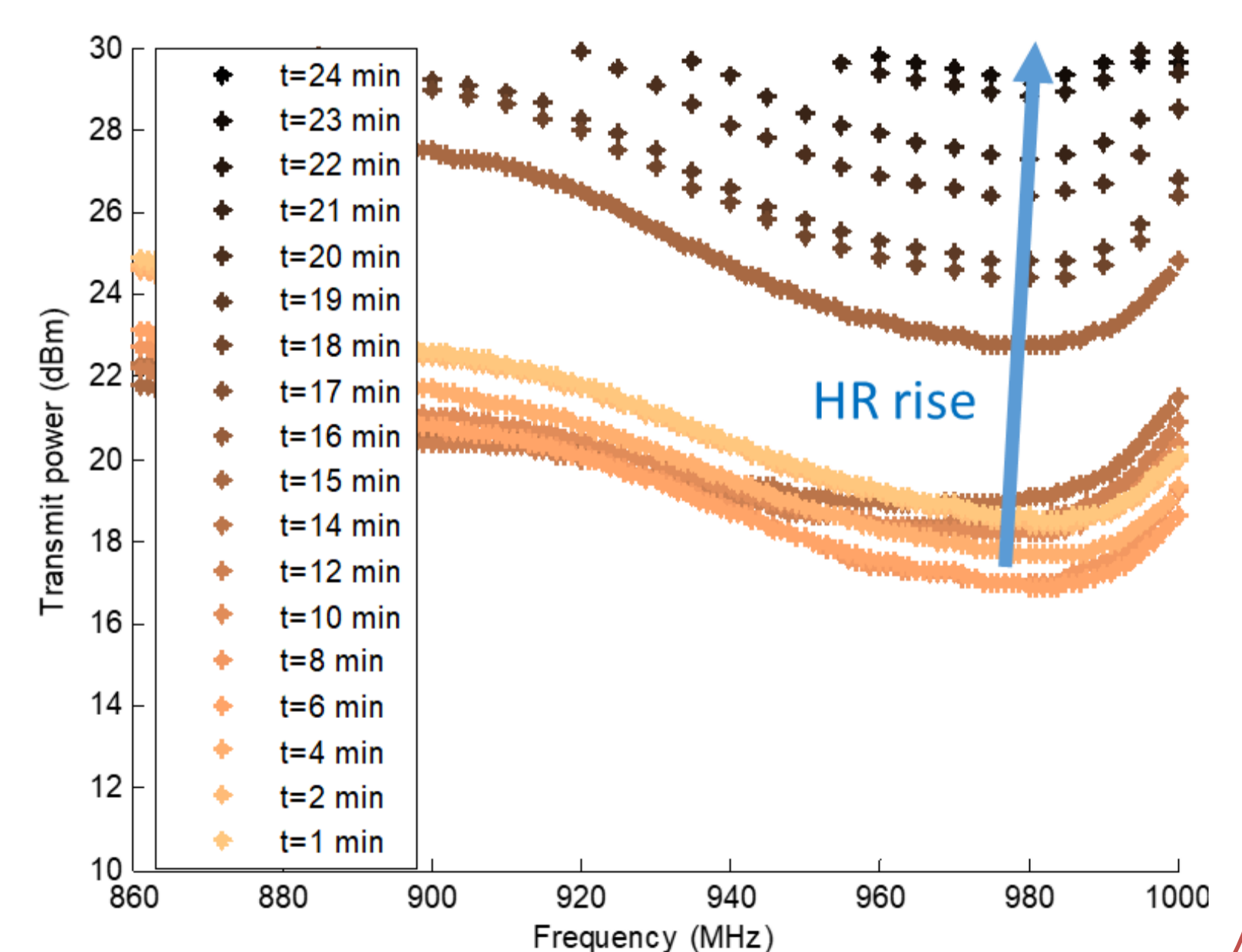
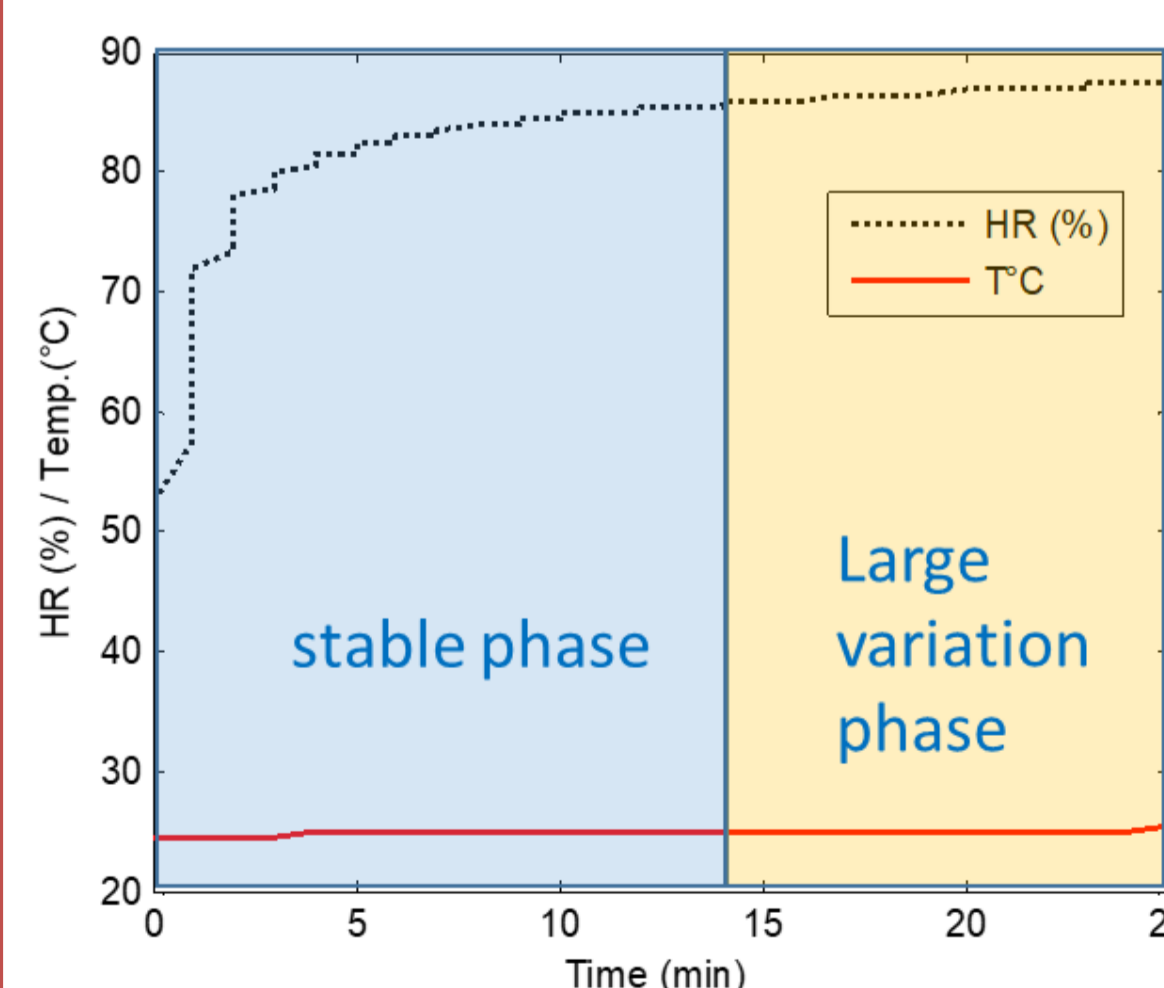


EXPERIMENTAL results

- The first $P_{tx}^{Activation}$ measurement is done with and without sensitive deposit to observe the effect of wheat gluten
- Second, the response of the RFID sensor is recorded according to RH rise cycle from 57.5% to 87%
- Meanwhile, temperature is stable and close to 25° C



Record of the datalogger (EL-USB-2, Lascar Electronics)



SUMMARY/PERSPECTIVES

- ✓ AN RFID-ENABLED SENSOR BASED ON BIOPOLYMER (WHEAT GLUTEN) CAN BE REALIZED ON PAPER WITH INKJET PRINTING
- ✓ WITH THE SENSITIVITY OF THE WHEAT GLUTEN TO RH, A STRONG FREQUENCY DEVIATION IS MEASURED AND INDUCES A 10 DB DEVIATION ON THE TRANSMIT POWER OF THE READER FOR CHIP ACTIVATION
- ✓ REPEATABILITY AND REPRODUCIBILITY TESTING IS THE NEXT WORK TO BE DONE BEFORE PRACTICAL TESTING IN FOOD PACKAGING