Master's Thesis Engineering Technology

2017-2018

Evaluation and comparison of printed and microtechnically fabricated moisture sensors for textile applications

Booten Matthias

Master of Energy Engineering Technology

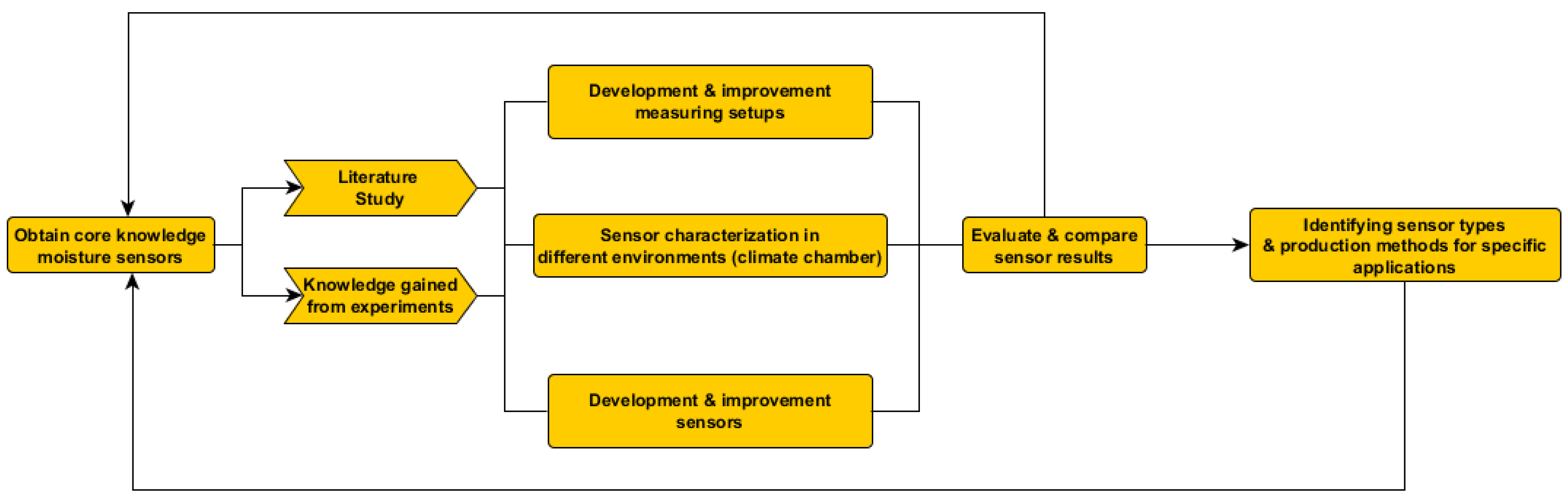
Abstract

Moisture content sensors for textiles exist in various forms and function according to different working principles. This master's thesis is the result of a comparative research of these sensors at two different institutions, namely the University of Applied Sciences Kaiserslautern in Zweibrücken and IMO-UHasselt.

In IMO-UHasselt the sensors were printed while at the University of Applied Sciences the sensors were manufactured in a micro technical fashion. From this difference a need was formed to gain knowledge and put into perspective the abilities and use cases of the sensors and their production technology. The research of this thesis takes in to consideration the different factors in design, production and characterization of each sensor. Alterations and improvements to these sensors and their respective measuring setups were also performed and discussed.

Measurements utilizing different setups and ambient conditions are used as the basis of comparison. The measuring setups were designed or improved accordingly to each type of sensor. This aides in choosing a type of sensor and production technology for a specific application.

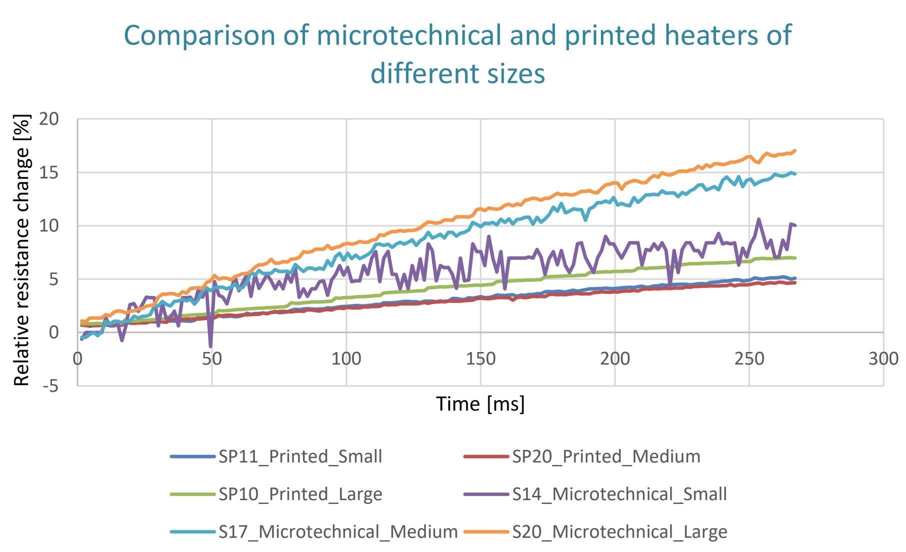
Methodology

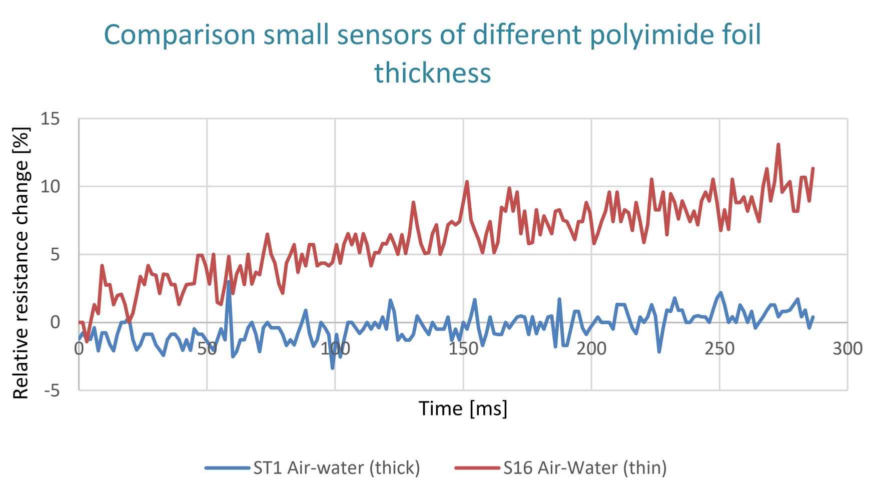


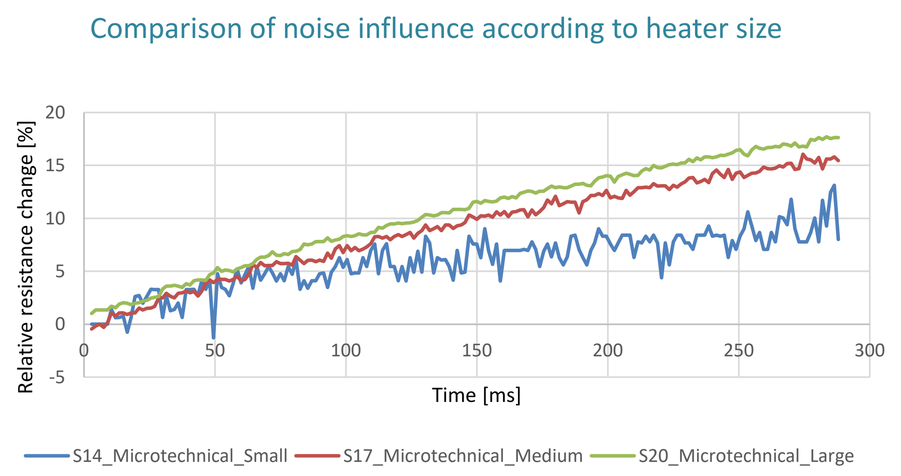
Air-water sensitivity tests

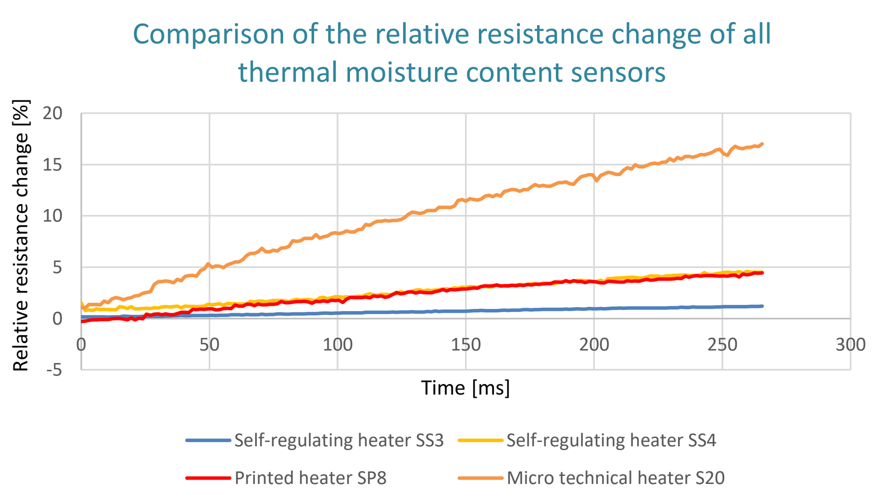
The air-water sensitivity tests were devised to measure the resistance change from the thermal type moisture sensors in conditions with varying climate. The resulting relative resistance change shows the sensitivity of individual sensors in measuring water content and can be used for comparison of different sensor types. The steeper the graph of a measurement, the higher the sensitivity of the individual sensor is. Measurements proved the following:

- influence of size: larger sensors showed more sensitivity;
- influence of thickness: Thinner sensors with thinner substrates proved more sensitive;
- influence of noise: larger sensors can handle more power and thus have a higher signal to noise ratio;
- being the thinnest sensor, the microtechnical sensor displayed the highest sensitivity from all compared types.









Capacitive moisture sensors

The capacitive moisture sensors were of a design of the students own choice and were altered over time for the sake of improvement. The sensor is able to measure changes in moisture content of the textile upon which it was printed as shown in figure 1. The double cloth measurement shown in figure 2 depicts a wet cloth laying on the textile substrate of the capacitive sensor. The moisture in the upper cloth will continue to evaporate leading the total weight to decrease. Although the moisture was first absorbed in the substrate of the lower cloth, it eventually evaporated. This led to the capacitance value first increasing after which it decreased again.

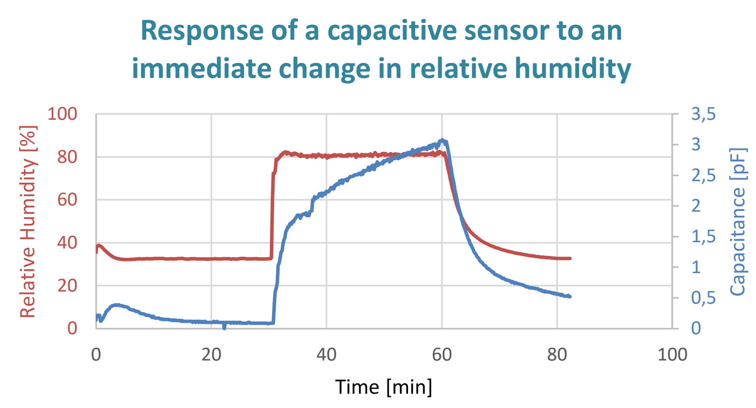


Figure 1 Measurement with shorter cables, sensor platform

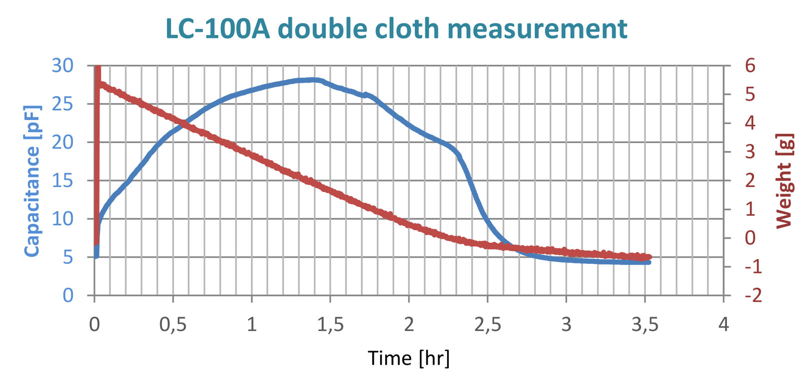


Figure 2 Double cloth measurements

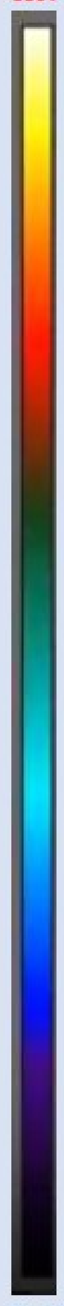
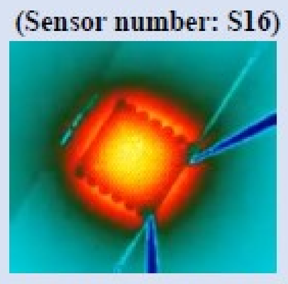
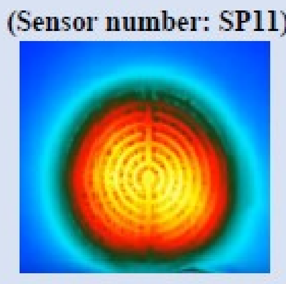
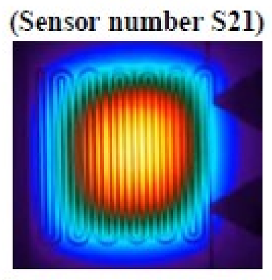
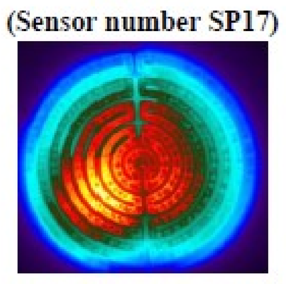
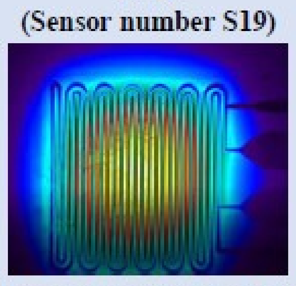
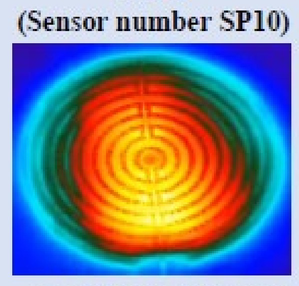
Thermal Images

Al micro technical and printed thermal type moisture sensors were compared under the thermal camera to study the heat up pattern and homogeneity of the heat dissipation over the heater structure. The comparison of micro technical and printed heaters can be seen in Table 1. In this table heaters of various sizes are compared.

As seen in Table 1 :

- square micro technical heaters show to have more heat in the centre than at their corners leading to uneven heat distribution;
- the round printed heaters are able to present a more even heat distribution from the center all the way to the edges of the heaters;
- screen printed heaters, as seen in the case of SP17, show "coldspots";
- the coldspots are due to the differences in height of the printed lines which were measured by Dektak.

Table 1 Overview of different heaters in varying sizes

Temperature scale	Micro technical heater	Regular printed heater
Hot  Cold *Temperature scale*	Small (Sensor number: S16)  *Thermal image small sized micro technical heater* Hottest temperature: 40.5°C Coldest temperature: 19.9°C	Small (Sensor number: SP11)  *Thermal image small sized printed heater* Hottest temperature: 39.5°C Coldest temperature: 20.7°C
	Medium (Sensor number S21)  *Thermal image medium sized micro technical heater* Hottest temperature: 135.3°C Coldest temperature: 43.3°C	Medium (Sensor number SP17)  *Thermal image medium sized printed heater* Hottest temperature: 78.0°C Coldest temperature: 23.7°C
	Large (Sensor number S19)  *Thermal image large sized micro technical heater* Hottest temperature: 76.2°C Coldest temperature: 24.3°C	Large (Sensor number SP10)  *Thermal image large sized printed heater* Hottest temperature: 44.8°C Coldest temperature: 21.4°C

Supervisors / Cosupervisors: Professor Deferme Wim and Professor Picard Antoni
PhD Jose Manoj and PhD Schönfisch David

Hochschule Kaiserslautern University of Applied Sciences

UHASSELT

KU LEUVEN