Abstract Thesis Topic – Philipp Macher

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1 Proposed Topic

Using Flexible and stretchable PCBs to develop print-in-place flex and stretch sensors for use in small embedded environments.

2 Abstract

I want to use a Voltera Nova[1] PCB printer to explore the capabilities of flexible and stretchable (f/s) electronics.

In the first step, I will get to know the printer, how it works, which materials can be used, and which substrates are available.

In the second step, I will try to develop a printable f/s sensor to sense flexing and stretching levels. The primary design goals will be size and simplicity. So the ideal sensor would be small and therefore easy to be integrated into many designs and easy to integrate, not needing any extra components, and readable by a common ADC as found in microcontrollers. I don't know how difficult, if possible, the design of such a sensor will be. It is to be expected that there will be drawbacks, like needing an operational amplifier, as first calculations show that in a first design, resistance changes in $\mu\Omega$ would have to be detected.

In the third step, I want to design a proof of concept to show the use of such a sensor in practice.

In an optional fourth step, development of a swarm robot, similar to the Kilobot[2] could be done. Such a robot would be designed with f/s electronics in mind, maybe as a connection between different robots, ideally paired with a f/s sensor to measure the distance and angle between two such robots.

3 First steps

If you think the above proposals are fine (or after some improvement iterations or another meeting), we would have to fill out the document for registration of a B.Sc. thesis. Parallel, for the first printer tests, we could order some inks. My two proposed inks are:

FS0142 (available from VOLTERA[3] and goodbot.de[4])

As this is the default ink to be shipped with the printer it is already present in the printer library. It is used in the VOLTERA getting started guide and in total should be a good first ink to print.

[1] https://www.voltera.io/nova
[2] https://en.wikipedia.org/wiki/Kilobot
[3] https://store.voltera.io/products/aci-fs0142-2ml-cartridge?_pos=1&_fid=abb6da623&_ss=c
[4] https://www.mybotshop.de/Voltera-NOVA-ACI-FS0142

SC1502 (available from VOLTERA[5] and ACI materials[6])

This ink has a fitting viscosity of 37 $Pa \cdot s$ and offers two properties that seem to fit our application:

1. A possible elongation of 200% with a fast recovery. This is crucial because not all inks offer elongation, but break when pulled apart.
2. A relatively high resistance. This may seem like a drawback, but when trying to measure changes in resistance due to physical stress (such as bending or stretching), a higher resistance results in a higher absolute resistance change. A higher absolute change is easier to detect and allows comparative resistors to be chosen higher, so there is less power used by the sensor.

[5] https://store.voltera.io/products/aci-sc1502-2ml-cartridge?_pos=3&_fid=abb6da623&_ss=c
[6] https://www.acimaterials.com/sc1502/