BITNG LAB UPDATE

Carl Demolder

Date 8/05/2021

Progress from last week

- Shriner's Project:
  - Strain sensor
    - Different substrates and encapsulations
- Shinjae Firmware:
  - ADS1299
  - ADS1292

SHRINER'S PROJECT

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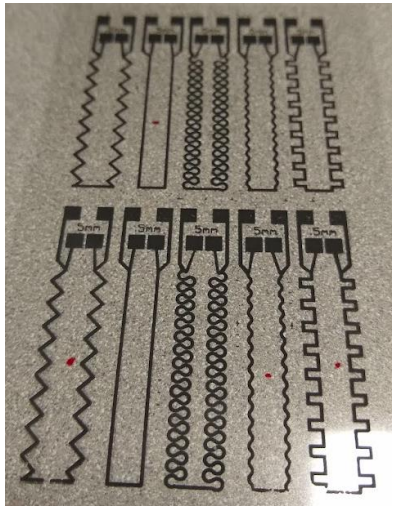
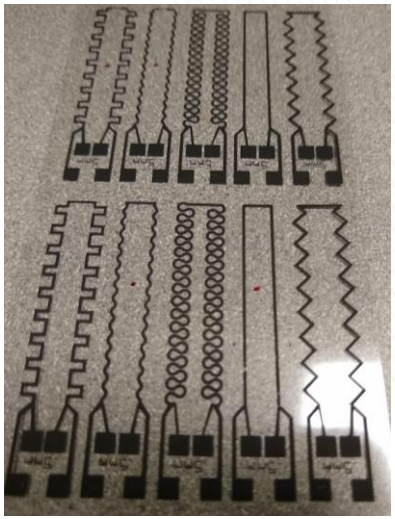
Screen printing: Strain Sensors

- Carbon Black
  - $\Delta R/R\ \% = 2.72\ \%$
- Graphene
  - $\Delta R/R\ \% = 4.4\ \%$
- Hybrid mixture: CB w/ AgNP
  - $\Delta R/R\ \% = 4.62\ \%$
- Goal:
  - Increase $\Delta R/R\ \%$
- Next Steps:
  - Going to research different inks that have a larger resistance change due to bending



Carbon Black



Graphene

Reference: “Highly sensitive screen printed strain sensors on flexible substrates via ink composition optimization” 2019

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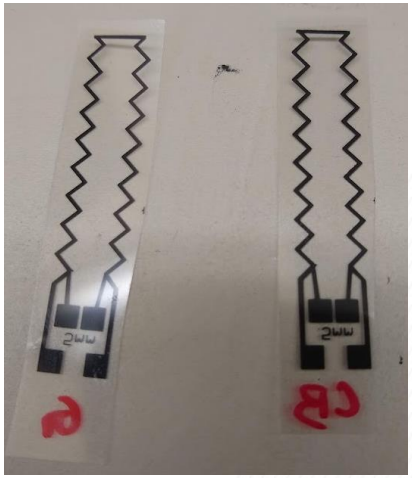
Strain Sensor: Multi-Layer Ink

- Possible solutions:
  - Multiple layers of ink deposition
    - Top layer = AgNP (low resistance)
    - Bottom layer = CB or Graphene (high resistance)

- Micro cracks are produced in the AgNP layer
  - Micro cracks create disconnections in AgNP
  - Current flows through high resistivity layer
  - Produces a higher $\Delta R/R$

AgNP on top



CB & Graphene on bottom

Reference: “Printability of the Screen-Printed Strain Sensor with Carbon Black/Silver Paste for Sensitive Wearable Electronics” 2020

Strain Sensor: Substrate

- Problem:
  - Substrate controls the amount of permitted strain
  - PET = Micro-strain only
    - Small $\Delta R/R$
  - TPU = Excessive strain on ink
    - Occasional loss of connection
    - Massive $\Delta R/R$
- Solutions:
  - Change substrate and encapsulation method

LDPE

PDMS

Strain Sensor Comparison

<table>
<tr><th>Manufacturing</th><th>Ink</th><th>ΔR/R</th><th>Substrate</th><th>Encapsulation</th></tr>
<tr><td>Commercial</td><td>Proprietary</td><td>89%</td><td colspan="2">Proprietary</td></tr>
<tr><td>Drop Casting</td><td>AgNW</td><td>< 1%</td><td rowspan="6">PET</td><td rowspan="8">EcoFlex</td></tr>
<tr><td rowspan="8">Screen Printing</td><td>AgNP</td><td>3.16%</td></tr>
<tr><td>Graphene</td><td>4.4%</td></tr>
<tr><td>CB</td><td>2.73%</td></tr>
<tr><td>CB + AgNP Mixture</td><td>4.62%</td></tr>
<tr><td>T-AgNP & B-Graphene</td><td>8.89%</td></tr>
<tr><td>T-AgNP & B-CB</td><td>10.74%</td></tr>
<tr><td>T-AgNP & B-CB</td><td>*52,214%</td><td rowspan="2">TPU</td></tr>
<tr><td rowspan="3">AgNP</td><td>*151,063%</td></tr>
<tr><td>**234%</td><td>LDPE</td><td rowspan="2">PDMS (4:1)</td></tr>
<tr><td>*224%</td><td>TPU</td></tr>
</table>

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Strain Sensor: Next Steps

- Screen printing
  - Substrate: stiffer (Too much strain with TPU)
    - Encapsulate in PDMS
    - PEN
    - Stiffer TPU material
- Goal:
  - Micro-strain + Strain

Firmware Development

- ADS1292
  - Initial firmware driver finished
  - Debugging firmware finished
  - Bluetooth Communication Protocol Documentation [WIP]

- ADS1299
  - Initial firmware driver finished
  - Debugging firmware [TO DO]

PATH FORWARD

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Path forward (8/02/21 – 8/09/21)

- Shriner's Project:
  - Strain sensor
    - Explore stiffer substrates
- Shinjae Firmware:
  - ADS1299
    - Debug firmware
  - ADS1292
    - Debug firmware

APPENDIX