Hybrid Electronic Construction for Wireless ECG Electrodes

Date: 05/01/2018

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Objectives

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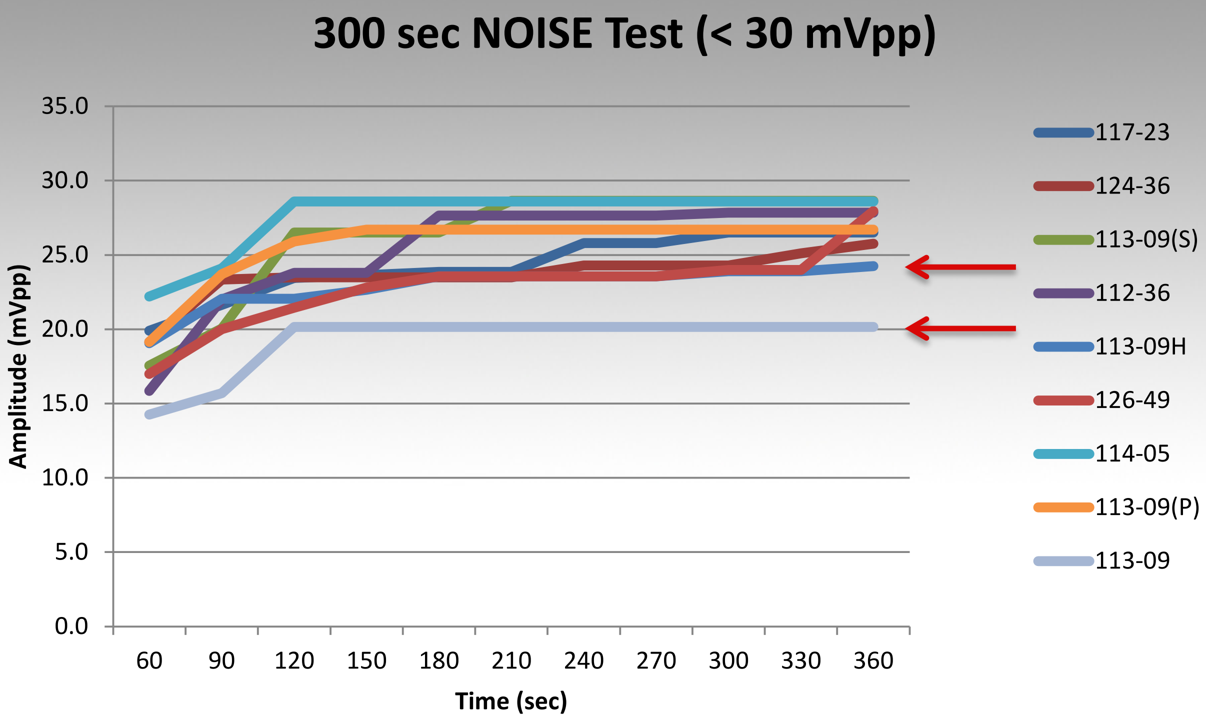
- Determine best Ag-AgCl ink for non-conventional ECG electrodes on elastomeric substrate to improve user comfort.

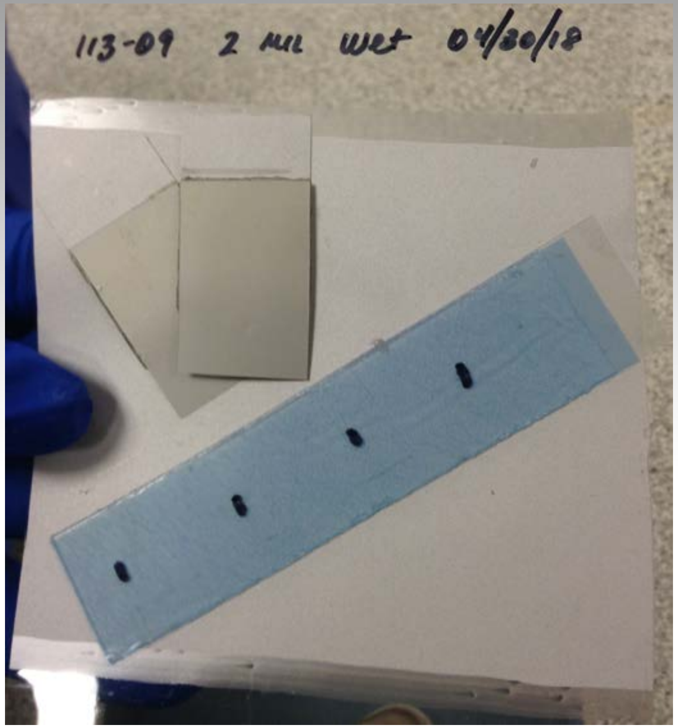
- Determine best hybrid adhesive to mitigate signal loss from poor connection to electrode after stretching.

Procedure for Ink Selection

1. Create films of various Ag-AgCl inks for signal noise testing
2. Assemble hydrogel and films to create disposable ECG electrodes
3. Perform 300 sec Noise tests on CALM SEAM ECG Electrode Tester
4. Compare results

Noise Test Results





- 113-09 and 117-23 were the two inks with lowest signal noise during testing

- These products also have similarities in resin chemistry while having different ratios of Ag:AgCl

Procedure for Adhesive Evaluation

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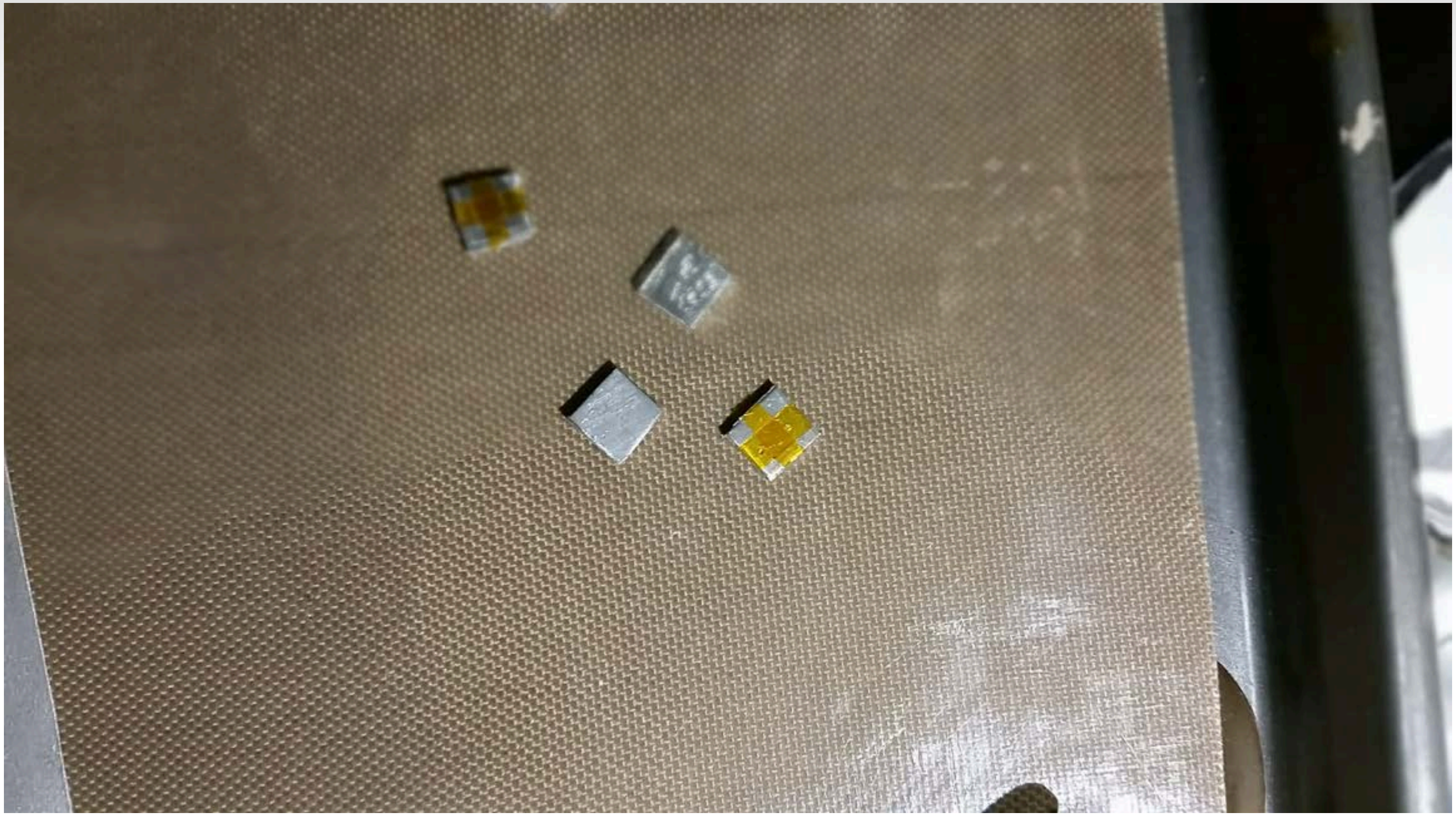
1. Measure and cut films into 2.5cm x 10cm strips for stretch testing
2. Machine aluminum panels to 0.25in x 0.25in to simulate chip on electrode
3. Dispense 3 adhesives of varying modulus (GPC-251, EXP 2652-186LV, 102-32) in center of film strip and bond Al panels to samples of each ink
4. Cure samples according to respective adhesive specifications
5. Perform elongation cycles at 10%, 20%, and 50%
6. Measure conductivity 2.5cm from center of "dummy chip" at 0, 10, 20, 50 and 100 cycles

Test Method

Elastomeric TPU on release paper coated with a film of Ag-AgCl ink and cut into strips for stretch testing

Test Method Cont.

- Kapton tape was added to the underside of panels to simulate 4 edge contacts between panel-adhesive-ink



Test Method Cont.

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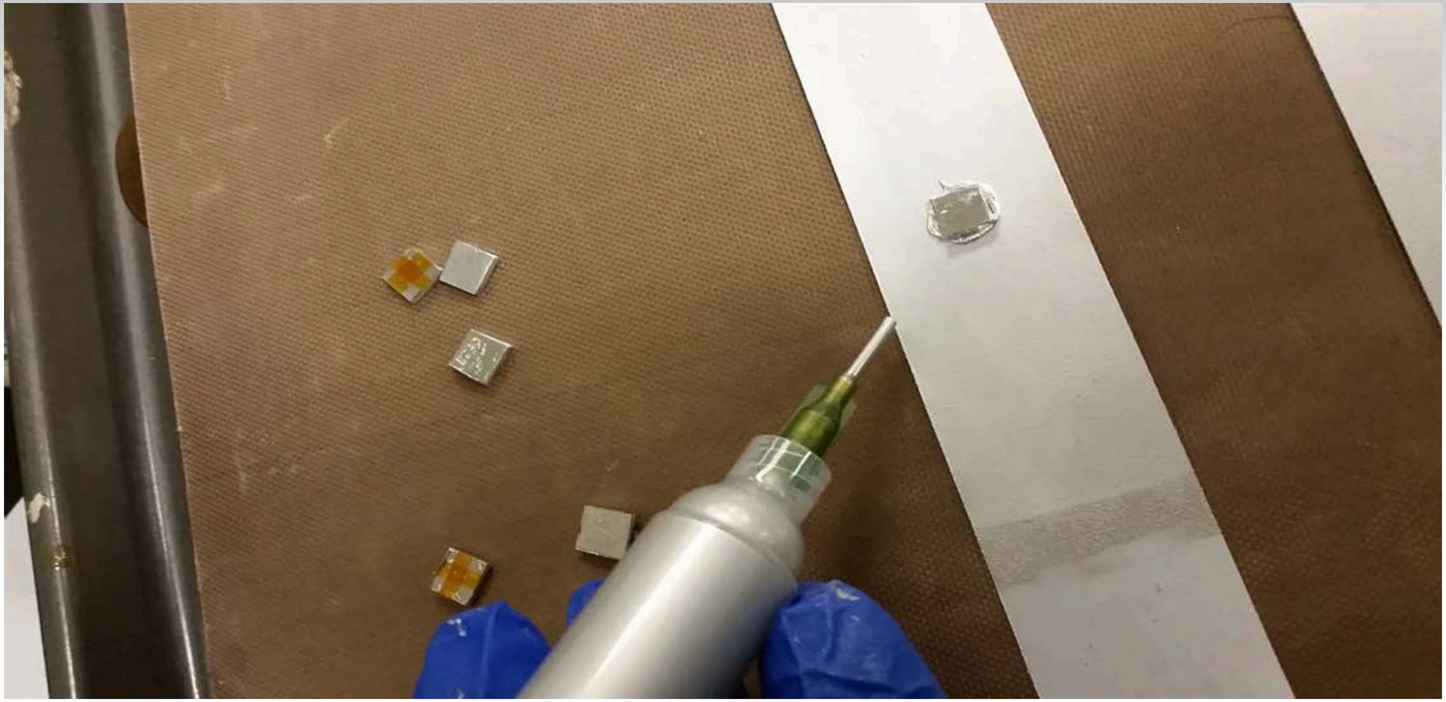
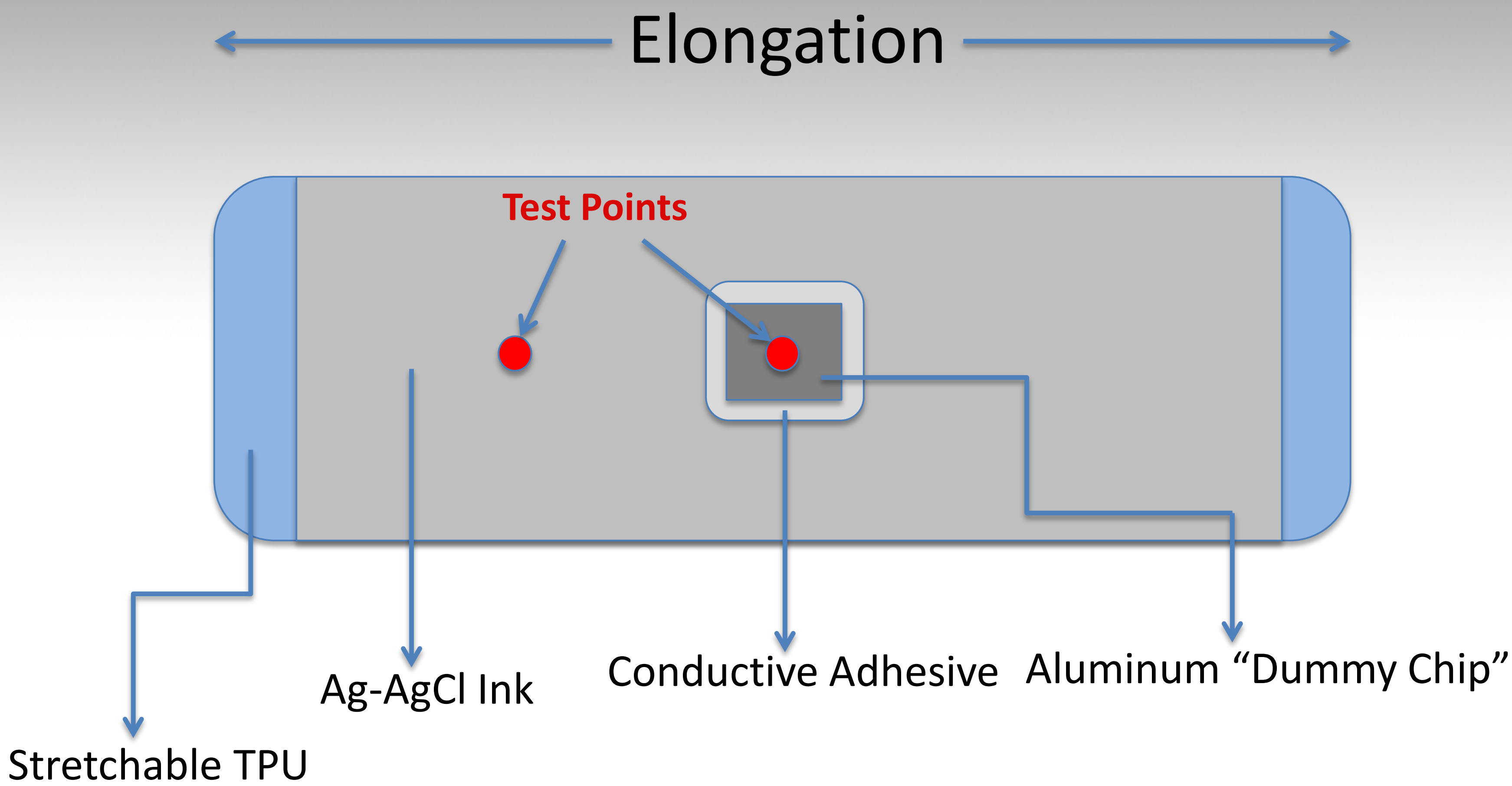
- Bonding of Al panels to the Ag-AgCl ink films using adhesives of varying modulus.



- Adhesives were syringe dispensed at constant time and pressure for consistent application

Schematic of Test Design



Test Method Cont.

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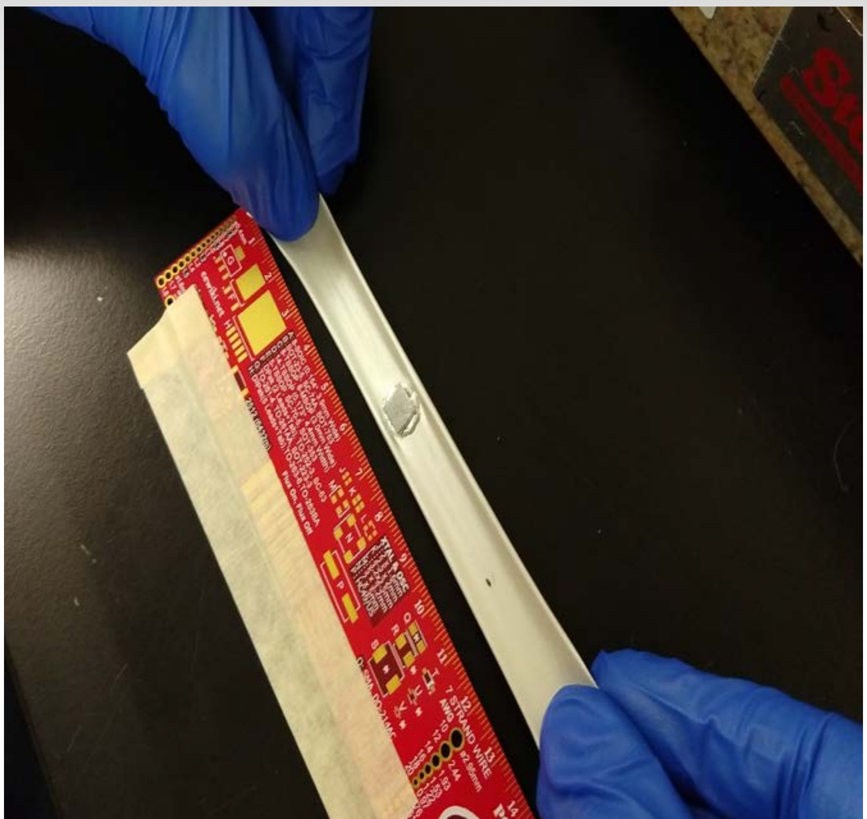
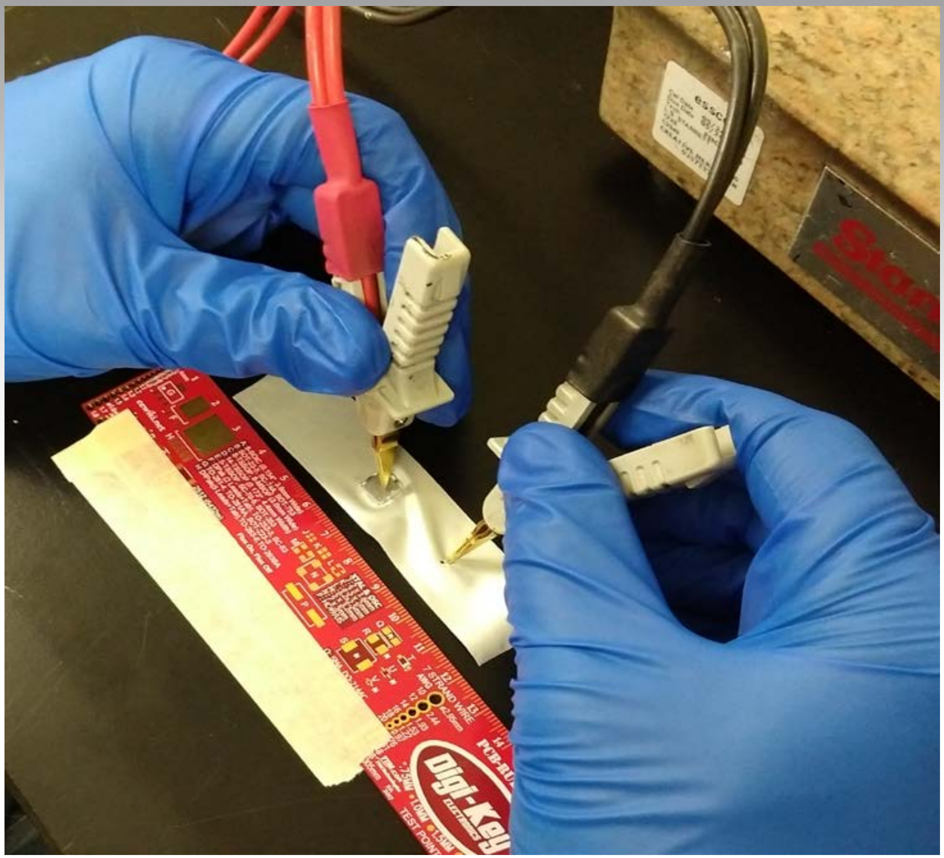
Samples were stretched to 10%, 20%, 50%





Tested at 0,10, 20, 50 and 100 stretches

Results and Analysis

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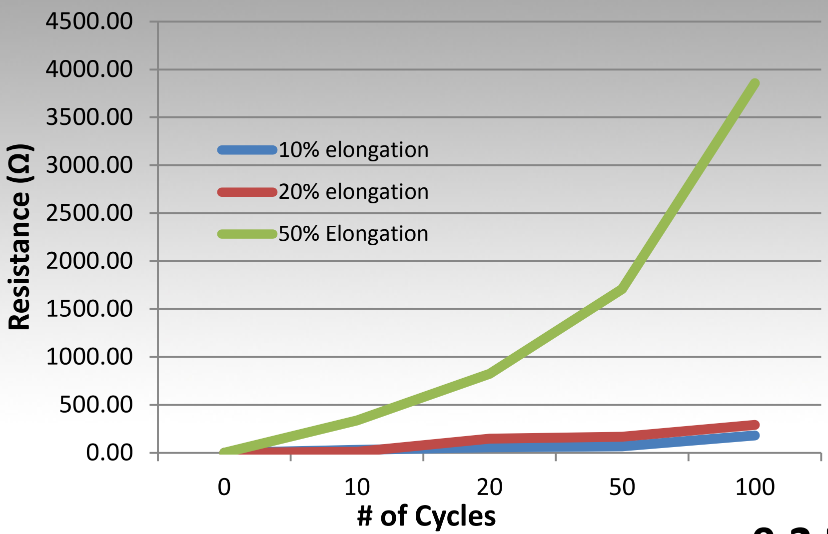
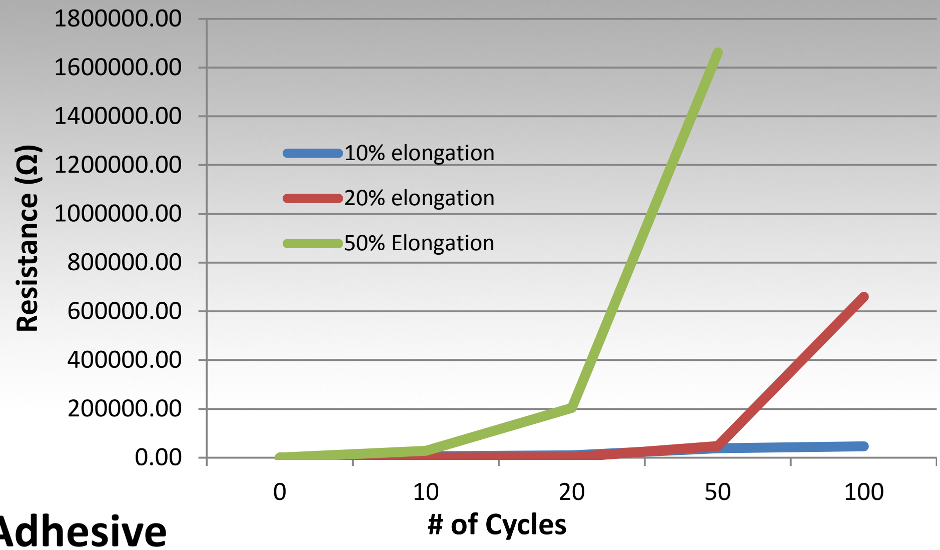
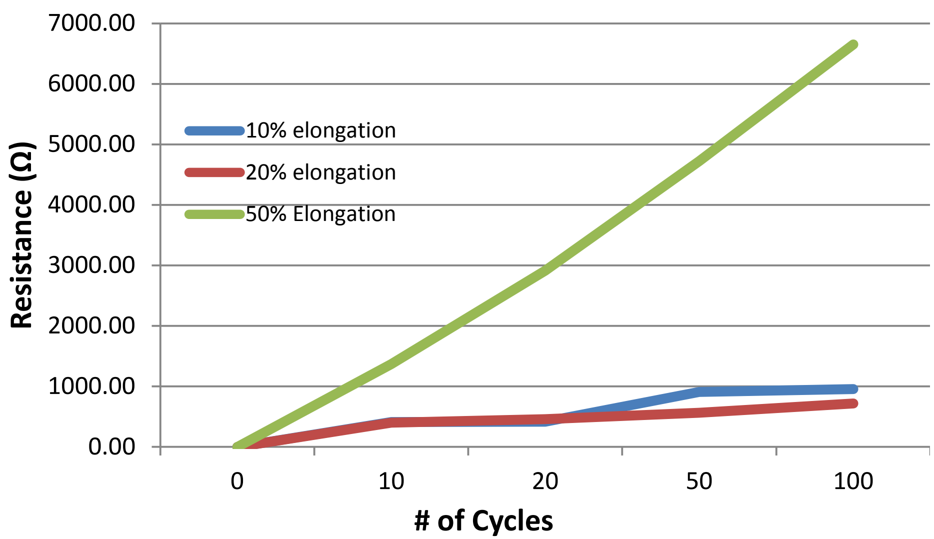
15.3 GPa Adhesive



485 MPa Adhesive



0.2 MPa Adhesive



Results and Analysis

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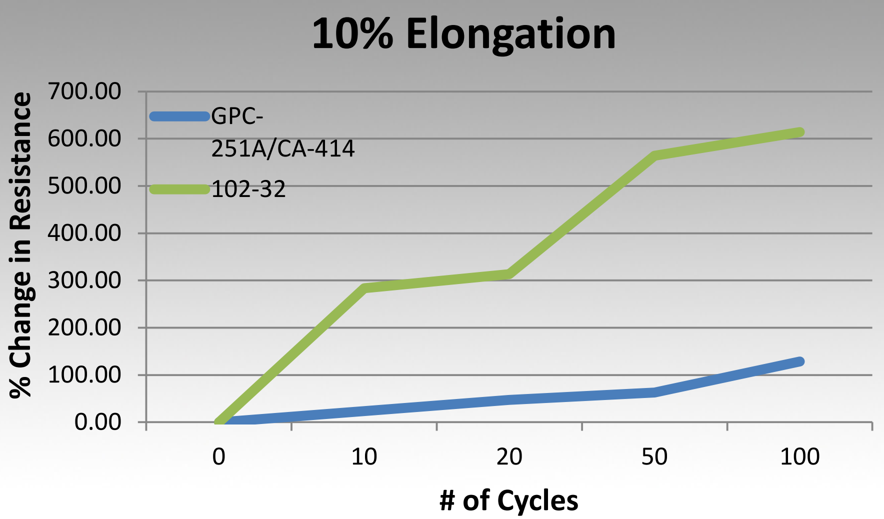
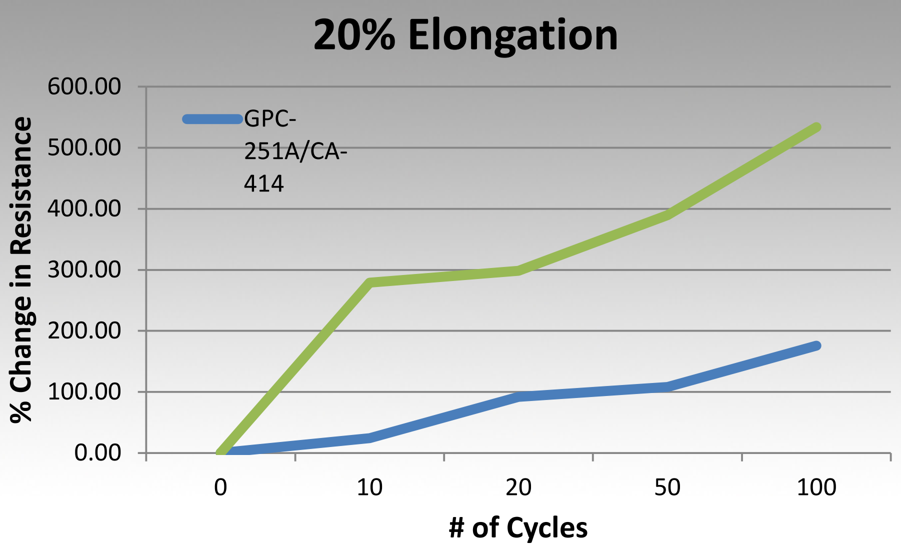
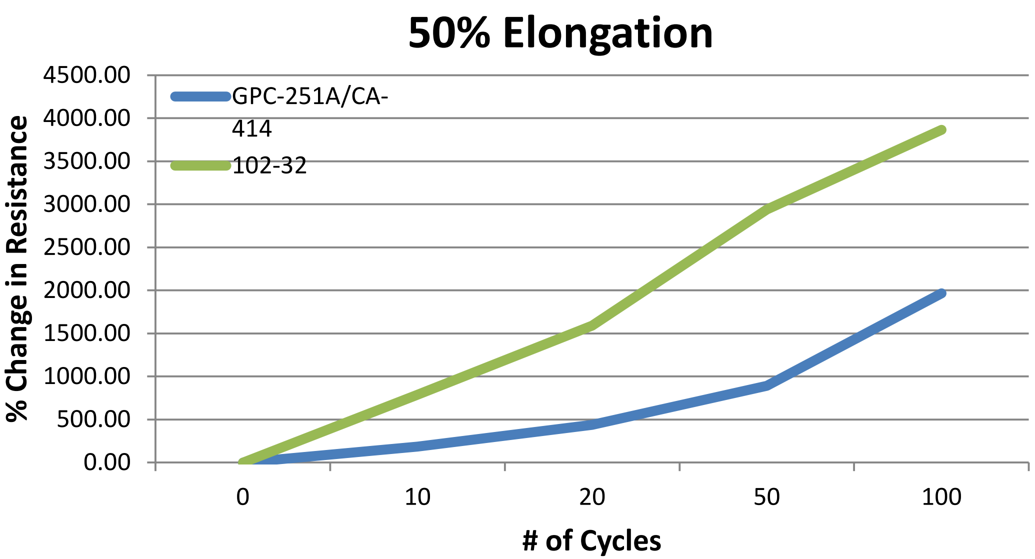
- The samples were stretched in ways that simulate different applications for a non-conventional ECG electrode
- The smaller elongation cycles (10%, 20%) are comparable to the stresses an electrode would endure in applications such as a wearable wireless patch
- The larger elongation cycles (20%, 50%) are similar to the stresses an electrode would endure while the user dresses/undresses from a wearable device

Results and Analysis







Highest modulus adhesive (GPC-251A/CA-414) showed less change in resistance after elongation than either of the more flexible adhesives

- EXP 2652-186LV omitted to show distinction between two best performing adhesives

Results and Analysis

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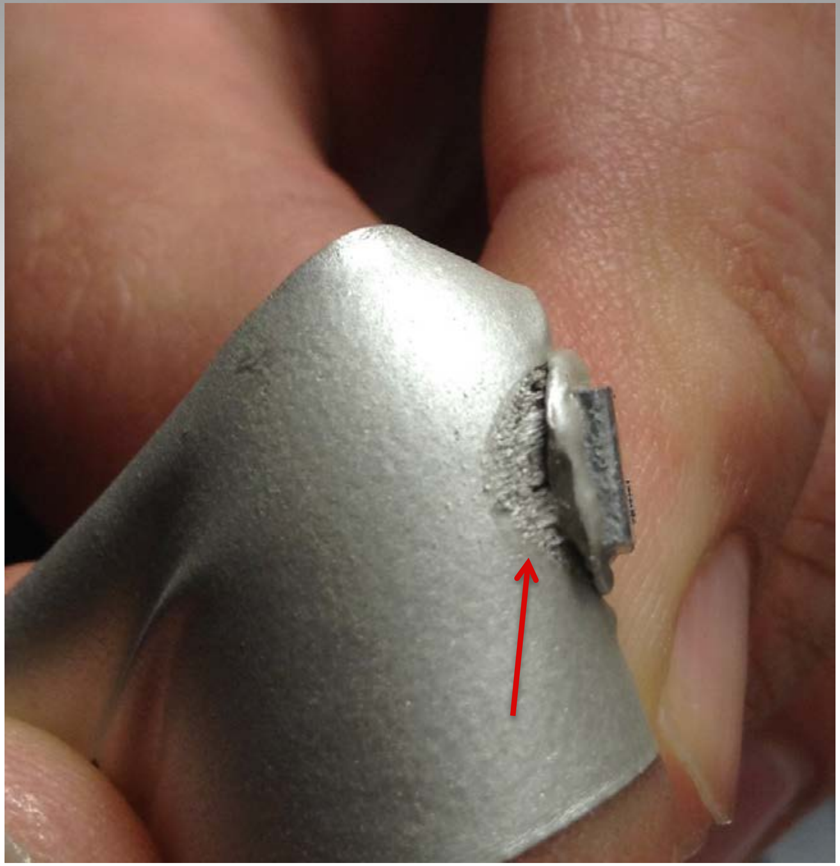
- GPC-251A/CA-414 provided the best dimensional stability during stretching
  - maintained the 4 edge contacts between the panels and the Ag-AgCl ink

- 102-32 showed the greatest amount of deformation
  - allowed the substrate to elongate without breaking contact between panels and Ag-AgCl films

- EXP 2652-186LV, while having a balance of flexibility and dimensional stability, did not have enough of either to survive cycles of elongation
  - after 100 cycles of stretching, the Al panels delaminated from the subtrate

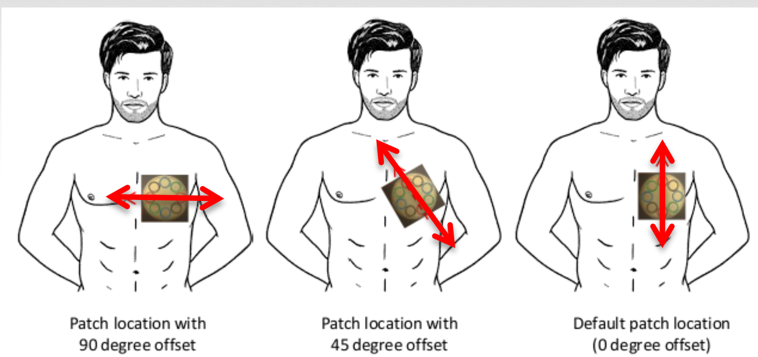
Results and Analysis



The more flexible adhesives showed delamination along the film after multiple elongations

Results and Analysis

- Lower modulus adhesives showed a lower bond strength leading to delamination and signal degradation



- The poor connection between the Ag-AgCl ink and dummy chips decreases the efficacy of constructed electrodes and diminishes quality of collected data

Conclusion

1. 113-09 and 117-23 were determined to have lowest signal noise of the 9 inks that were tested
   - Also having similar resin chemistries, they provided a controlled set of variables for evaluating the effects of stretching

2. GPC-251 (highest modulus) showed the smallest increase in resistance after cyclical elongation on an elastomeric substrate
   - This observation held true for both of the Ag-AgCl inks that were evaluated

Conclusion

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- There are many factors that contribute to the proper ink/adhesive selection for an ECG electrode:
    - » Solvent compatibility
    - » Resin/Substrate Adhesion
    - » Defib./Bias current tolerances, etc.
- Based on the need for signal clarity and durability of a wearable, non-conventional electrode, GPC-251A/CA-414 on 113-09/117-23 maintains a minimally hindered signal while providing the durability required for numerous progressive applications

Questions?

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Thank you for listening!

I'm happy to answer any questions!

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