Thermal Cycling Effects on Inkjet Printed Electronics

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Abstract

The objective of this research is to replicate the space environment to its closest ideal form in order to make the use of printed electronics in space a reality. The research focus is to develop a procedure to test the effects of extreme thermal cycling on electronics that are made with Kapton® and silver ink. After thermal cycling, it was found that the resistance of each sample was maintained within a margin of error of 5%.

Mission: Printed Spacecraft's

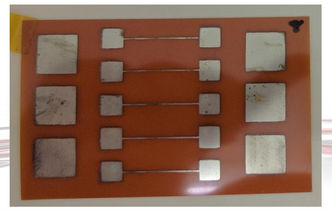
National Aeronautics and Space Administration (NASA), while looking into new research opportunities to increase space exploration, proposed using small electronics sensors that could travel through space like swarms of bees or confetti. They are appealing to many companies and organizations due to their size, weight, and cost of manufacturing. Being so versatile, they can be used in many imperative space missions. One of those missions is placing sensors on different surfaces such as solar sails for aerodynamic control or even on a rover wheel to determine interactions in many kinds of soil.

Objective

- Recreate temperature cycle produced in the space environment.
- Determine effects on mechanical and electric properties of printed electronics samples.

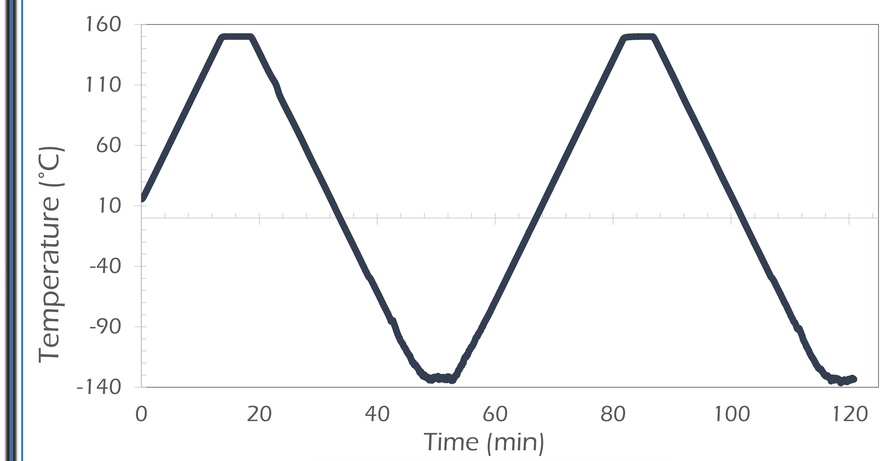
Process of Analysis

- Maintain constant temperature rates while cycling temperature using the Thermomechanical Analyzer Q400.
- Determine the temperature rates difference from the data collected and determine its efficiency.
- Measure Kapton® silver ink samples' resistance at 80°C after every thermal cycle.
- Determine the effects on the electrical resistance of samples.
- Determine the efficiency of printed Kapton® electronics for space application.

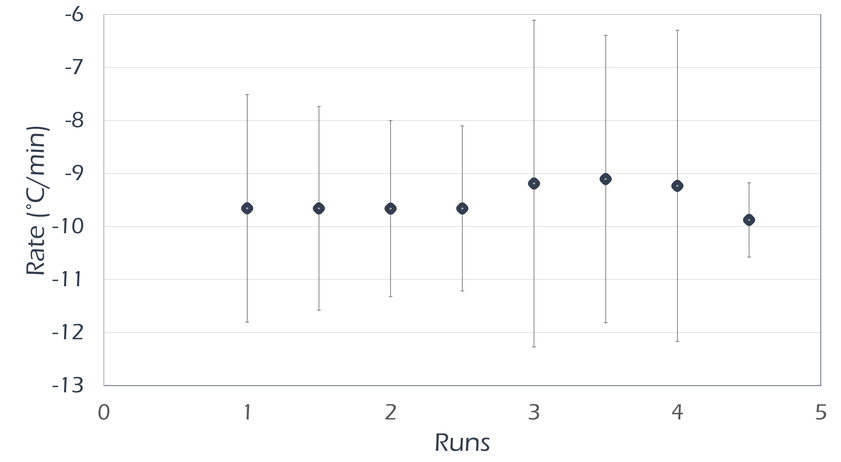


Kapton® Printed Sample

Results and Discussion



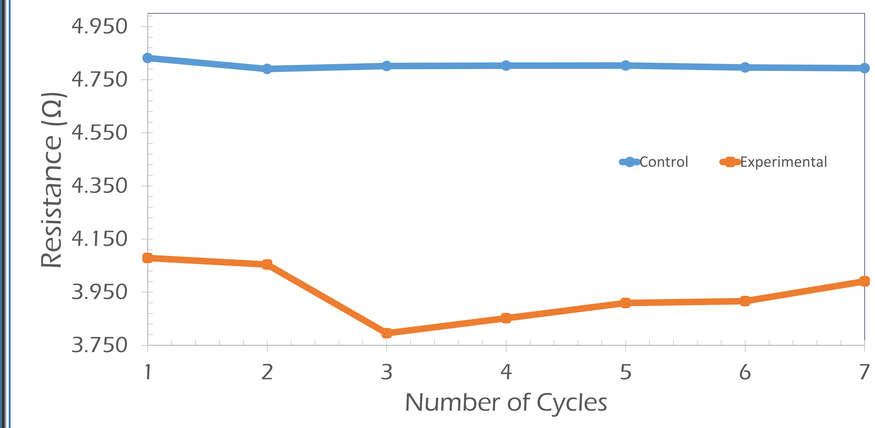
A1. 10°C Temperature Cycle



A2. Average Thermocycling Rates

B1. Resistance Readings of Dumbbell Sample (Ω)

	Control			Experimental B2		
1	4.829	4.833	4.833	4.082	4.076	4.078
2	4.794	4.788	4.790	4.058	4.058	4.047
3	4.798	4.806	4.801	3.806	3.795	3.785
4	4.802	4.802	4.805	3.843	3.855	3.858
5	4.814	4.800	4.796	3.904	3.920	3.904
6	4.789	4.799	4.800	3.881	3.914	3.954
7	4.800	4.790	4.791	3.995	3.980	3.998



B2. Shock Temperature Effects

- Constant temperatures were obtained during each run pouring liquid nitrogen at specific times as seen in image A1.
- The temperature rate remained at -9.5°C/min ± 0.27 during the cooling method of 10°C/min. A sample of errors per cooling cycle can be seen in A2.
- Table B1 shows that the resistances were measured three times in order to determine the efficiency and accuracy of the data.
- The change in resistance between the control sample and experimental are 17 to 20 % in error, due to difference in thickness of the silver ink. From the experimental sample the change in resistance from its original value was below 5% error.
- Graph B2 shows the changes in resistance of one experimental sample after one thermal cycle, against a control sample that wasn't placed on the temperature rates.

Conclusion and Future Work

- The samples maintained their resistance after a total of 7 cycles.
- The temperature rate can be maintained constant because it stays approximately at 10°C/min.
- Multiple samples should be tested in order to determine efficiency for space application.
- A new testing stage has been designed that can hold various samples, and it will be created in order to determine the effects for multiple samples instead of a single one.

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