Low-Power Heaters for a High School Experiment Bound for the International Space Station

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Resistive temperature detectors (RTDs) from Micro-Measurements, a brand of Vishay Precision Group (VPG), are used by Desert Christian High School's International Space Station (DCISS) team in an experiment that studies the effects of different dielectrics and heating on graphene-based supercapacitor (GBSC) performance. The team's goal was to create a low-power heating system to heat GBSCs to 140°F using only 0.5 W of power. In addition to monitoring the temperature of the GBSCs, the heat produced by the RTDs was also able to heat the components to the required temperature within the low-power constraints.

Company/Institute: Desert Christian High School International Space Station Team

Industry/Application Area: Low-power heating

Product Used: ETG-50B/W temperature sensors

The Challenge

Desert Christian's International Space Station (DCISS) team consists of eleven high school students with a goal of sending and monitoring an experiment onboard the International Space Station. Desert Christian is one of a handful of high schools worldwide that have been given an opportunity to design, fabricate, assemble, test, and analyze an experiment that is launched and integrated onboard the ISS for 30 days. The focus of the DCISS team's research is to investigate the behavior of graphene-based supercapacitors (GBSC) in a microgravity environment. This field of research can impact future space power systems for planetary rovers and satellites, along with potential earthbound power applications for cars, cell phones, and laptop computers.

The objective of the team's current experiment is the study of the effects of different dielectrics and heating on GBSC performance. The challenge has been the development of a low-power heating system to heat various GBSCs to 140°F given a power budget for the heating system of 0.5 W (5 V at 100 mA).

The Solution

After considerable thought and investigation, the DCISS team determined that resistive temperature detectors (RTDs) could be used to both heat the GBSCs and to monitor their temperature during the experiment. The RTDs used for the experiment were Micro-Measurements ETG-50B/W temperature sensors, which feature a polyimide carrier for flexibility and integral printed-circuit terminals. The GBSCs are the size of a CR2032 lithium battery and rather than glue down a separate foil heater, the team determined they could use the dissipated heat in the RTDs to heat the GBSCs. By developing the electronic controller and software, the RTDs could be periodically turned on to heat the GBSCs, then with the current turned off, the resistance of

the RTD could be measured to determine the temperature of the GBSCs. Preliminary tests of the low-power heater concept resulted in the GBSCs reaching the desired 140°F temperature for the experiment.

The User Explains

Given the low-power requirement (0.5 W) and the small volume available for the experiment (15 cubic inches), there was a need to develop a compact and low-power heating system for each of the eight GBSCs that would be part of the DCISS experiment. After some discussion, the students realized that RTDs provide temperature measurement but also produce heat. It was a natural step for the students to experiment with RTDs to determine if they could be used to heat the GBSC devices to the desired 140°F goal. A ground test using a breadboard circuit confirmed that the RTDs could be used as both a low-powered heater and temperature measuring device. This simple solution provided the DCISS team with the ability to heat up to eight GBSCs with only one being evaluated (heated and monitored) at any given time, thus meeting their experimental goals while remaining within power and volume restrictions. Each side of a GBSC will contain an RTD with the excitation of each heater being alternated at any given time. While one of the RTDs is heating one side of the GBSC, temperature measurements will be conducted on the RTD on the other side that is not being excited. This alternating method of heating and monitoring will allow the GBSC state to be both heated and monitored throughout the experimental time on the ISS. Figure 1 shows the various steps in the encapsulation process for each of the eight GBSCs used in the experiment. The GBSCs are manufactured by Dr. Richard Kaner's team at the University of California – Los Angeles.

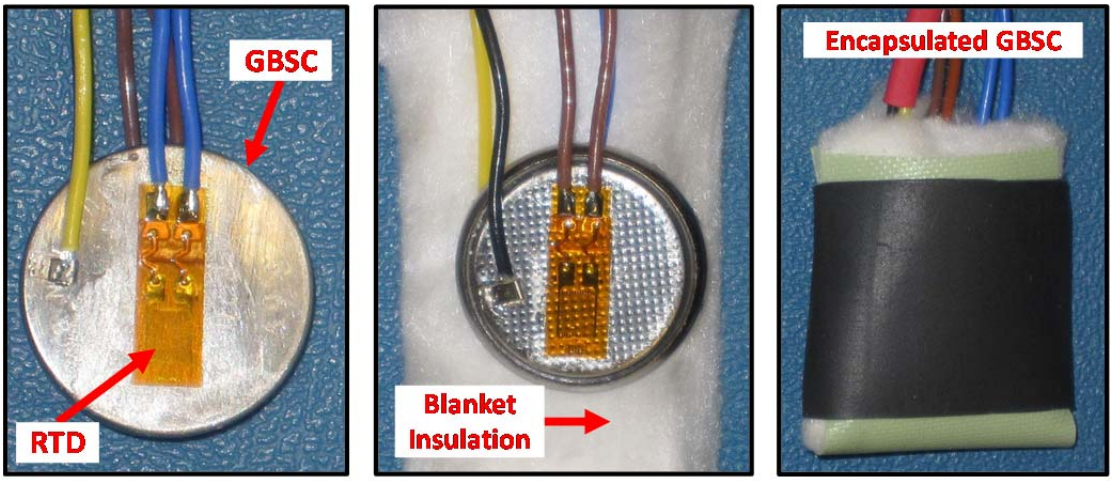

Figure 1: Assembly process for encapsulating the GBSCs

"By utilizing Micro-Measurements' RTDs, the DCISS team was able to develop a compact and low-power heating system for each of the eight GBSCs."

Acknowledgement:

The goal of the DCISS team is to expose high school students to science, technology, engineering, and math (STEM) activities through the opportunities available with the International Space Station Project. Through hands-on and problem-based activities, students are exposed to skills and knowledge that will help them in

the real world, but also may identify potential STEM education and career opportunities they may want to pursue.

The DCISS team would like to acknowledge Micro-Measurements for their generous donation of the ETG-50B/W temperature sensors required for this experiment. This donation was greatly appreciated by the DCISS team and helped keep the experiment development within our available budget.

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