Abstract No: PO-31 **Physical Sciences**

Investigation of electrically insulating and thermally conductive materials for a Peltier module with n-Cu_2O and p-Cu_2O electrodeposited semiconductors

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Thermoelectricity is a direct conversion of electrical energy into thermal energy and vice versa. Seebeck effect, Peltier effect and Thomson effect are thermoelectric effects observed for conductors during 1820-1920. After the development of semiconductors, a new era has begun in the field of thermoelectricity. Currently, the rare earth materials and their alloys are commonly used as semiconductors for constructing thermoelectric devices. In this research, copper based n-type Cu_2O and p-type Cu_2O semiconductors were used as thermoelectric materials. These semiconductors were deposited using potentiostatic electrodeposition technique in acetate bath. The study was carried out using two types of electrically insulating and thermally conductive material such as Thermal Heat Sink Transfer cooling pads (THST cooling pads) and mica. Multi stage Peltier modules were constructed using single stages assembling electrically in series and thermally in parallel.

For the THST cooling pads, two stage Peltier module was assembled and a temperature gradient of 0.52 $^{O}C\ mm^{-1}$ at 2.0 V dc voltage was observed. However, the current through the module was higher and higher compared to the previous measurements when the data was repeated. It was found that the appearance of the semiconductor samples were changed when disassembling the module due to some fluid secreted from the THST cooling pads.

The study was also done for both artificial and natural mica as electrically insulating and thermally conductive materials. For the artificial mica, a five stage Peltier module was built and it was observed 9.57 $^{O}C\ mm^{-1}$ temperature gradient for 2.0 V dc voltage. Having a three stage module of natural mica the temperature of the module decreases at the beginning and then increased while voltage was increased. A miniature temperature drop of 0.4 ^{O}C was able to achieve below the room temperature at 2.75-5.5 V range for the module with natural mica. In addition to that, a temperature gradient of 0.48 $^{O}C\ mm^{-1}$ was observed for this set up throughout the applied voltage.

Present study demonstrated Peltier effect for both electrodeposited n-type Cu_2O and p-type Cu_2O semiconductors. The heating effect was always detected for the set ups with THST cooling pads and artificial mica as an insulating materials. However, the experimental data were not repeated for the semiconductor samples assembling with THST cooling pads due to some secretion of fluid. Therefore, THST cooling pads are not suitable for this kind of study. When considering artificial and natural mica as an insulating material, a higher temperature gradient was observed for artificial mica whereas a temperature drop was achieved using natural mica. Outcome of this study indicates that electrodeposited n-type and p-type Cu_2O semiconductors along with mica as electrically insulating and thermally conductive materials can be used for a Peltier module.

Keywords: Cu_2O semiconductors, Mica, Peltier modules, Thermoelectricity, THST cooling pads