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Abstract

Electrical Contacts Characterization of Tetrahedrite-Based Thermoelectric Generators †

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Thermoelectric generators (TEGs) are devices capable of harvesting waste heat and directly converting it into electricity through the Seebeck effect. They have no moving parts and emit neither toxic nor greenhouse gasses. These devices have high modularity and low maintenance needs, making them very promising to fight against global warming. At the same time, with the rapid growth in energetic needs and the efforts from industries to become greener, the market for TEGs is boosting the search for more efficient and cheaper materials.

One such new material, seen as having great potential for thermoelectric applications, is copper antimony sulfosalts. These materials are very cheap (~USD 7 [1]), can be found in nature, have good thermoelectric properties (average $zT \geq 0.4$ between 350 K and 650 K [2]), and present low toxicities. However, tetrahedrite-based TEGs are still under development, with the fabrication of good electrical contacts between tetrahedrites and the copper electrodes (that form the device) being one of the biggest challenges to produce efficient and commercially competitive generators. Since high electrical and thermal resistivities can ruin the performance of TEGs, such problems can be also found in commercial devices. However, there are just a few public studies focused on measuring and characterizing the electrical contacts, with most of the jointing fabrication techniques being patented or classified [3].

In the present work, diverse contact fabrication techniques are explored to evaluate the most suitable methods to connect $Cu_{11}Mn_1Sb_4S_{13}$ tetrahedrites to copper electrodes. The tetrahedrite legs were synthetized by a solid-state reaction and sintered by hot-pressing. Then, the materials were shaped into small cubes (~7 × 7 mm) using a Diamond saw and connected to copper plates (~7 × 7 mm) using different techniques. Contact fixation methods such as cold-pressing (CP) and hot-pressing (CP) were used, with some legs also being prepared manually. Together with the different preparation methods, several paints and resins were used for jointing. In summary, Ni and Ag water-based paints and a Zn-Al 5 wt% solder were tested. The possibility of contact fabrication without the use of any paints or solders was also explored by using our hot-pressing equipment.

The contact resistance between the tetrahedrites and the copper contacts was measured in a custom-made set-up based on the three-point pulsed current method. To achieve a better understanding on how the contact quality affects the final performance of a tetrahedrite based TEG, several computer simulations were made using the *COMSOL Multiphysics* software. The previously measured contact resistance values were considered on the simulations, and the respective current-voltage (IV) and current-power (IP) plots for

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a thermocouple were obtained. The main results of this study on how different fabrication methods and jointing materials affect the electrical contact resistance and the performance of a tetrahedrite based TEG will be presented.

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