Application Note

Fusion™

Thermal Stability Study of LAST Thermoelectric Material in the SEM

Introduction

Thermoelectric materials are uniquely able to convert temperature gradients directly into electricity. Devices and applications based on these materials are being explored to harvest waste heat and convert it to usable energy. A popular material that exhibits excellent thermoelectric properties is lead antimony silver telluride or LAST. This compound possesses a ZT value, which is the dimensionless figure of merit for thermoelectric materials, as high as 1.7 at 425 °C. To maintain ZT the material must be stable at high operating temperatures.

The thermal stability and distribution of each elemental component is also important for optimal performance. The materials must withstand high processing temperatures without losing the desired properties. LAST material was studied using a heating and electrical biasing system in the SEM. Element maps were done using energy dispersive x-ray spectroscopy (EDS) at room temperature, 550 °C and 575 °C to determine how the elemental components evolved as a function of temperature.

Experiment

The LAST sample was taken from a cast ingot with a nominal composition of $Ag_{0.86}Pb_{19}SbTe_{20}$. It was crushed into micron-sized particles and placed on an E-chip™, which integrates the sample support and heating membrane into a semiconductor chip. The SEM was a Hitachi S-3400 equipped with an EDAX EDS system for elemental analysis.

Discussion

After heating the material to 550 °C there were no changes observed in the material (images not shown). The figure on the right shows a secondary electron image and three elemental maps of Te, Ag and Pb of particles at 575 °C.

Originally particles 3 and 5 were similar in size to particle 4. At 575 °C Pb evaporated preferentially from some particles (particularly in particles 3 and 5), which significantly shrank in size.

These particles may also have been in better contact with the heating membrane. LAST has poor thermal conductivity and heat transfer to particle 4 may not

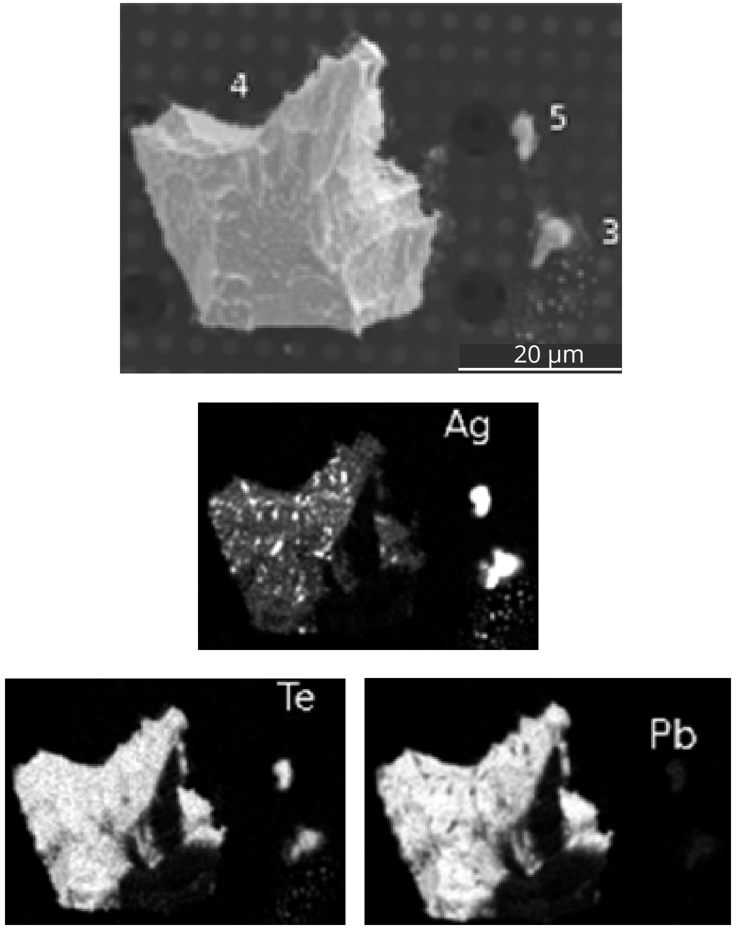

Figure: Secondary electron image and elemental mapping at 575 °C

Reference: F. Ren, et al. Phil. Mag. Lett. 91, pp. 443-451 (2011)

have been as efficient. It should be noted that not all EDS systems can take spectra at high temperatures.

Applications

Thermoelectric materials are a popular field with applications from automobiles to interplanetary space probes. Fusion is capable of measuring the thermal and electrical properties of these materials. It enables *in situ* heating from room temperature to 1200 °C, and electrical biasing from nA to mA and uV to V in the SEM or TEM. Fusion is compatible with analytical tools such as EDS, EBSD, STEM and EELS. Contact us to discuss the full range of capabilities of Fusion with E-chip specimen supports. We can be reached at (919) 377-0800 or contact@protochips.com.