SAND2012-3163C

Electroforming of thick film Bi_2Te_3-based Thermoelectrics

Christian L. Arrington[1], Peter A. Sharma[1], Dhego Banga[2], David B. Robinson[2], Vitalie Stavila[2], Adam Rowen[2], Jonathon J Coleman[1], Ehren Baca[1]

(1) Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185
(2) Sandia National Laboratories
7011 East Avenue
Livermore, CA 94551

Thermoelectric legs are conventionally assembled into modules using complicated vibe loaders or "pick and place" methods. Electrodeposition can be used to vastly simplify thermoelectric module assembly if appropriate thicknesses and material quality can be achieved. Electrodeposition is also a promising route towards fabricating scalable nanostructures [1, 2]. We demonstrate uniform electrodeposition of Bi_2Te_3 thermoelectrics several hundred microns in thickness over large areas. A custom 7 liter PVDF plating tank is constructed for the electroforming process. Plating conditions included short deposition times coupled with long rest times to allow for metal replenishment at the working electrode. We discuss film stress, stoichiometry, and morphology of our electroformed material in relation to electrodeposition conditions. Prospects for module assembly will also be discussed.

The most desirable thermoelectric films to date were reported using MOCVD growth of Bi_2Te_3 and Sb_2Te_3 [3]. Electrodeposition can offer advantages when compared to MOCVD, its ability to electroform into a mold, deposit over larger areas, and achieve significant increases in film thickness. Other benefits include cost, ease of use, and its ability to conform to difficult geometries, such blind holes.

Key challenges exist when growing thermoelectric films including stress, adhesion, stoichiometry, and crystal structure. Electrodeposition conditions have been investigated to surpass these challenges, including pulse conditions, potentials, bath setup, agitation, and metal concentrations in solution. Metrology of the deposited films has been performed using SEM, EDS, TEM, and XRD. We will discuss thermoelectric properties of our thick deposits in relation to plating conditions.

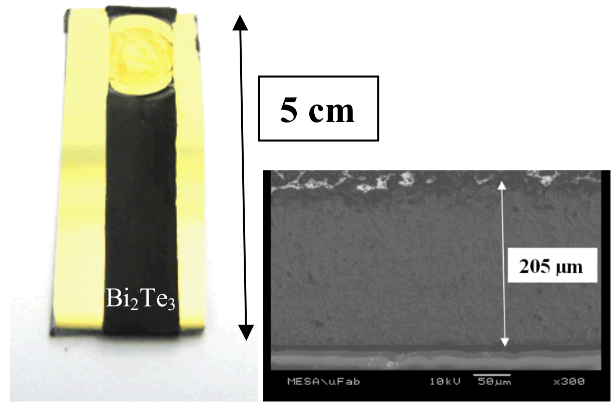

Figure 1: Bi_2Te_3 deposited film 205 µms in thickness, > 6 cm^2 in size. SEM image showing a cross sectional view of Bi_2Te_3, 205 microns thick after sub mounting in a conductive epoxy and CMP using diamond slurry.

1. Banga, D., et al., *Periodic Modulation of Sb Stoichiometry in Bi2Te3/Bi2-xSbxTe3 Multi layers Using Pulsed Electrodeposition.* Crystal Growth & Design, 2012. **12**(3): p. 1347-1353.
2. Glatz, W., et al., *Bi(2)Te(3)-Based Flexible Micro Thermoelectric Generator With Optimized Design.* Journal of Microelectromechanical Systems, 2009. **18**(3): p. 763-772.
3. R. Venkatasubramanian, E.S., T. Colpitts, B. O'Quinn,, Nature, 2001. **413**: p. 597.