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CONTACT (NAME ONLY): Katrina Morgan
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Abstract

TITLE: Tuneable sputtered films by doping for wearable and flexible thermoelectrics
AUTHORS (FIRST NAME, LAST NAME): Katrina Anne Morgan[1], Andrea Ravagli[1], Chris Craig[1], Ioannis Zeimpekis [1], JIN YAO[2], Ghada Alzaidy[1], Daniel W Hewak[1]
INSTITUTIONS (ALL):
1. Optoelectronics Research Centre, University of Southampton, Southampton, United Kingdom.
2. Chemistry, University of Southampton, Southampton, United Kingdom.
ABSTRACT BODY:
Abstract Body: An efficient, flexible power supply is in demand for the billion dollar wearable market. Thermoelectrics (TE) are the ideal choice, utilising body heat to produce green, uninterrupted energy.

Screen-printing, a complicated process requiring synthesis, is the common fabrication method for flexible TEs but suffers from limited material choices and low-throughput [1]. Sputtering, however, is able to deposit a large array of materials, is already used in fabrication lines and is easily incorporated into roll-to-roll manufacturing; a flexible device mass-production technique.

The limited efficiency of TE cells remains to be the main challenge and is related to material properties. Previous investigations into sputtered materials for flexible TE cells is sparse. This work will provide a comprehensive study of sputtered materials and doping effects, for efficient flexible TE cells.

An optimal bandgap for a TE material is dependent on the hot side of the application Th, given by Eg = 4kTh [2]. For body temperature regimes, BiTe, SnTe and GeTe exhibit energy gaps close to this optimum and were therefore chosen for this work.

BiTe, GeTe and SnTe were singly and co-sputtered with Ge, Si and Zn. Soda lime and polyamide substrates were used, with the latter demonstrating wearable applications. The Seebeck coefficient and electrical resistivity were measured.

For BiTe films, pure BiTe exhibited the lowest resistivity of 5 mOhm-cm and was found to be n-type. As both n- and p-types are required for TE cells, and as chalcogenides are naturally p-type, it is beneficial to have identified a high performance n-type material. Doping BiTe with Zn changed it from n-type to p-type but at the compromise of slightly increased resistivity. BiTe-Ge had the highest seebeck coefficient for BiTe films, S=-65.1uV/K.

Pure SnTe exhibited the lowest resistivity of 2 mOhm-cm for the SnTe films, whilst SnTe-Ge had the highest seebeck coefficient, S=50.8uV/K. Doping with Zn however reduced the Seebeck coefficient considerably to S=1.4uV/K.

Only pure GeTe and GeTe-Si were found to be TE compatible, with p-type behaviour and low resistivities ~ 3 mOhm-cm. Doping with Ge resulted in a resistivity increase of 8 orders of magnitude, whilst GeTe-Zn was beyond the measurement limit. This is a surprising as doping SnTe and BiTe with Zn and Ge had no such effect.

The most efficient TE material was identified by the power factor. BiTe had the highest power factor for n-type whilst GeTe had the highest for p-type, with 0.81 and 1.4 mW/mK^2 respectively. Whilst BiTe has been relied on previously

for TE cells, GeTe exhibited a much larger power factor, demonstrating its potential for use as a highly efficient TE material in the future. Further work will be conducted into the effects of doping seen in this work, whilst a flexible TE cell using BiTe and GeTe will be demonstrated.

[1] Raihan. A, et al., Ren. & Sus. Energy Rev., 73, 730-744 (2017)
[2] Wood. C, Rep. on Prog. In Phys. 51, 459-539 (1988)