Technology Offer

TLB
Technologie-Lizenz-Büro
der Baden-Württembergischen
Hochschulen GmbH

Universal p-type Cu2Se based bulk thermoelectric materials and printable flexible high power density TEG

Background

Thermoelectric generators (TEGs) convert heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect. This promising energy conversion technology is less bulky and uses no moving parts compared to conventional heat engines. Unfortunately, TEGs are typically more expensive, less efficient and not in a position to compete with other environmentally friendly energy conversion technologies like photovoltaics. Therefore, TEGs are not yet used to a large extent for real-life applications. High performance printable TE materials could offer low production cost, shape-versatility, and high output power density devices for rapid manufacturing of TE devices for large scale applications. Among the conventional TE materials, $(SbBi)_2Te_3$ based materials are commonly used for bulk TE devices. $(SbBi)_2Te_3$ based n- and p-type bulk TE materials have been targeted extensively to make them printable preserving their high performance at room temperature. Unfortunately, the disruption of charge carrier transport at the grain boundaries due to binders and additives lowers the overall *ZT*. Bi_2Te_3 based p- and n-type painted/3D printed TE films with *ZT* of approximately 1 were reported using an inorganic binder made of Sb_2Te_3-ChaM solution. However, the synthesis process is complicated and requires several steps. All of the above mentioned printed TE materials have only limited flexibility.

Problem

Pressure treatment free, high performance and environmentally stable flexible printable TE material for device applications are not available so far. This is mainly due to either low □ or poor printability. $(SbBi)_2Te_3$-based n- and p-type materials show good TE performance at room temperature, but poor printability and flexibility. In addition, an increase in resistivity during ink processing limits their use in printing technologies. Therefore, it is desirable to be able to produce environmentally stable high-efficiency inorganic TE materials with good printability, a high power factor (S^2□) and low thermal conductivity (□) at low cost. Furthermore, n- and p-type printed materials with similar performances should be available to manufacture an efficient printed TE device.

Solution

A new strategy has been developed for producing a flexible printed thermoelectric material comprising an inorganic binder (mixture of Cu, Se and S powder), which bridges the grains of TE materials with non-stoichiometric β-$Cu_{2-\delta}Se$ through a facile printing-sintering process. Unlike conventional inorganic powder based printed films containing grain boundaries, interruption of carrier transportation at the grain boundaries due to binders and additives has been minimized here, which results in high advantageous electrical conductivity σ, and thus in high TE performance. In addition, this novel p-type thermoelectric material can be combined with our recently developed corresponding n-type material based on Ag-Se (see our ref. 19/067TLB) for even more powerful TEG.

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Service

The Technologie-Lizenz-Büro GmbH is in charge of the exploitation of this technology and assists companies in obtaining a license.

Furthermore, the millisecond photonic curing technology has employed replacing traditional vacuum sintering to sinter pair of p- and n-type printed films on flexible substrates containing a Cu-Se-based inorganic binder. As a result improved mechanical flexibility with high-performance is achieved in the printed films. Consequently, a) printability b) high TE performance, and c) mechanical flexibility are achieved in a pair of p- and type printed films.

Advantages

- Novel universal p-type Cu_2Se based inorganic binder to prepare 2D/3D printable TE inks
- Flexible
- Environmentally stable
- Rapid processing
- High power density/high TE performance
- Moderate temperature post printing sintering procedure
- Low-cost manufacturing of high power density printable flexible TEG
- provide enough power for wireless energy-autonomous sensors and actuators
- can be combined with our novel n-type thermoelectrics (TE) material based on Ag-Se (our ref. 19/067TLB) for even more powerful TEG

Fields of application

Printable, flexible thermoelectric (TE) materials particularly for large scale applications and especially for waste heat recovery. Integratable into non-flat surfaces of different micro and complex electronic or mechanical systems. The printable TEGs can provide enough power for wireless energy-autonomous sensors and actuators.