UNIVERSITY OF LIVERPOOL

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Decoupling Electronic and Thermal Transport in n-type Oxide Thermoelectrics

Manipulating structural chemistry in thermoelectric materials offers enhanced efficiency in energy production.

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About **University of Liverpool**

By facilitating access to our expertise, facilities and networks, the University of Liverpool offers the means to transform ideas into creative solutions, improved performance, new technologies, strategies, applications, products or skills.

Background

Thermoelectric materials are highly important due to the ever-increasing demands for more efficient and environmentally-friendly methods of energy production. They offer enhanced energy efficiency across the industrial and automotive sectors through the harvesting of waste heat and conversion into electricity and are assessed by the figure of merit $ZT = (S2\sigma/\kappa)T$, which combines the Seebeck coefficient (S), electrical conductivity (σ), thermal conductivity (κ) and temperature (T).

Strong coupling between the above properties limits the improvement of ZT. The electronic (σ and S) and thermal (κ) transport properties are strongly coupled making it notoriously difficult to control them separately and maximise ZT through the design of new thermoelectric materials_. *An increase in* σ_, for example, would degrade S and increase the electronic component of κ, detrimental to ZT overall.

The decoupling of electronic and lattice transport, which allows for independent control over these properties has not yet been realised in oxide thermoelectrics.

Tech Overview

A team at the University of Liverpool has successfully separated the thermal and electronic transport properties through the introduction of chemical disorder within an n-type thermoelectric oxide (Figure 1). This chemical disorder resulted in an intrinsically low κ, reduced by a factor of four over materials with the same structure type. The structural chemistry makes it possible to further dope the material using chemical substitution to independently tune the electronic properties whilst retaining the low κ. The ability to decouple the electronic and thermal transport is intrinsic to the material and structure, and is not a result of microstructure effects.

Benefits

- Decoupling of electronic and thermal transport within an oxide.
- Reduced thermal conductivity is intrinsic to the material, and not a result of microstructure effects.
- Ability to independently influence the electronic and thermal properties through chemical substitution.
- Low cost, low toxicity and superior chemical stability of oxide materials over classical intermetallics is a major advantage.

Opportunity

The University team has synthesised, characterised processed and measured dense ceramics of such materials in-house to explore the above concept.

Currently the team are investigating the applicability of this method to a broad range of materials.

Appendix 1

Figure 1