VIDEO ARTICLE

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Synergetic Enhancement of Thermoelectric Performance by Selective Charge Anderson Transition and Topological Phase Transition

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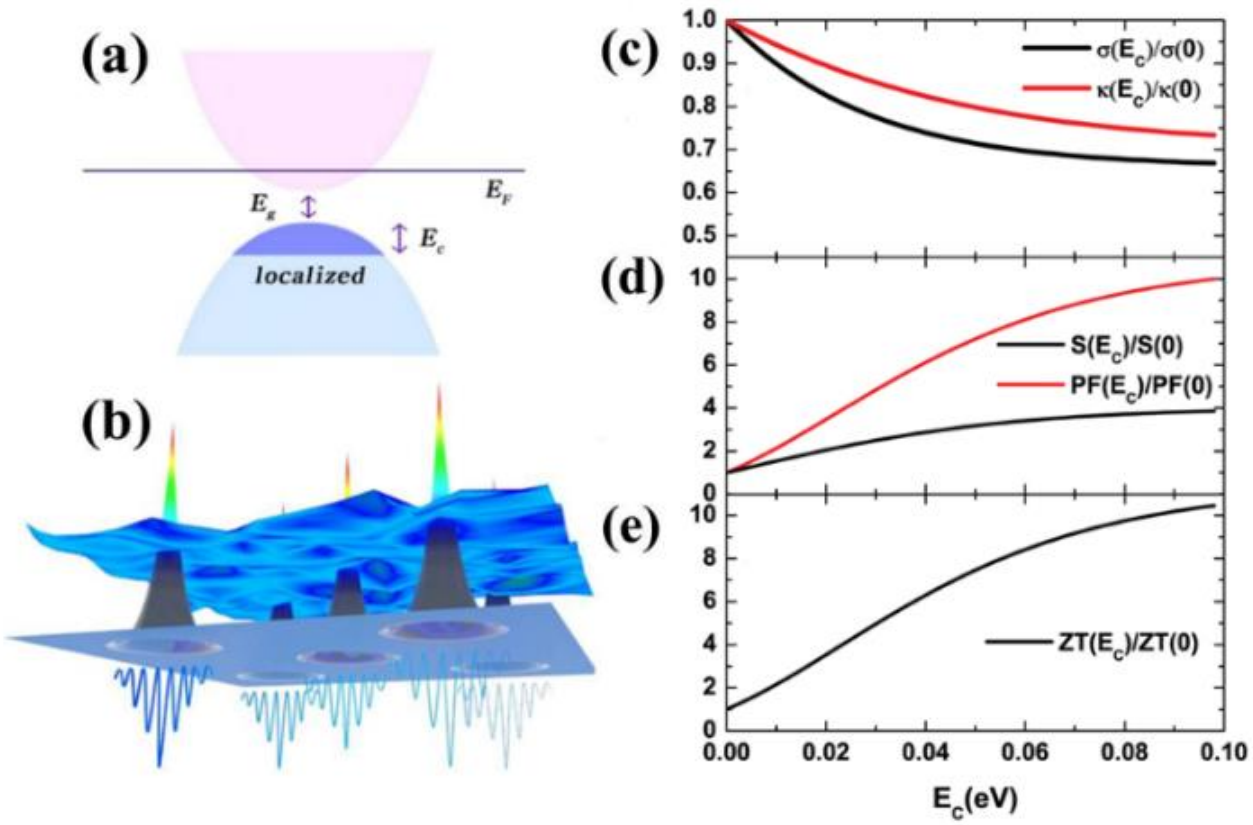
Graphical Abstract



Schematic representation of minority carrier Anderson localization (a, b) and Boltzmann transport calculation results (c ~ e).

Abstract

Considerable efforts have been devoted to enhancing thermoelectric (TE) performance, by employing phonon scattering from nano-structural architecture, and material design using phonon-glass and electron-crystal concepts. The nanostructural approach helps to lower thermal conductivity but has limited effect on the power factor. Here, we demonstrate selective charge Anderson localization as a route to maximize the Seebeck coefficient while simultaneously preserving high electrical conductivity and lowering the lattice thermal conductivity. We confirm the viability of interface potential modification in an n-type Bi-doped PbTe/Ag_2Te nanocomposite, and the resulting enhancement in thermoelectric figure-of-merit *ZT*. The introduction of random potentials *via* Ag_2Te nanoparticle distribution using extrinsic phase mixing was determined using scanning tunneling spectroscopy measurements. When the Ag_2Te undergoes a structural phase transition ($T > 420$ K) from monoclinic β-Ag_2Te to cubic α-Ag_2Te, the band gap in the α-Ag_2Te increases due to the *p-d* hybridization. This results in a decrease in the potential barrier height, which gives rise to partial delocalization of the electrons, while wave packets of the holes are still in a localized state. Using this strategic approach, we achieved an exceptionally high thermoelectric figure-of-merit in n-type PbTe materials, a *ZT* greater than 2.0, suitable for waste heat power generation.

References

1. Min Ho Lee and Jong-Soo Rhyee *et al.*, ACS Nano DOI: 10.1021/acsnano.8b08579.
2. Y. Imry and A. Amir, in *50 Years of Anderson Localization*, ed. E. Abrahams, World Scientific, Singapore. **2011**, Ch. 9, 191-212.

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Biography of Presenting Author

Jong-Soo Rhyee, Department of Applied Physics and Institute of Natural Sciences, Kyung Hee University, Yong-In 17104, Korea

Education:

- Ph.D, Dept. of Materials Science and Engineering, Gwangju Institute of Science and Technology (GIST)
- M.S., Dept. of Physics, Pohang University of Science and Technology (POSTECH)
- B.S., Dept. of Physics, Chungbuk National University

Honors and Awards:

- IAAM Scientist Medal, International Association of Advanced Materials (February 5, 2018)
- 2017 Outstanding Achievement in Research, Kyung Hee University (2017)
- Overseas Research Professor Fellowship, SBS Cultural Foundation (January 2015 ~ December 2015)
- TJ Park Junior Faculty Fellowship, POSCO TJ Park Foundation (October 2011 ~ September 2013)
- Bombi Physics Award, April meeting on Korean Physical Society (April 21, 2010)
- World Best Paper Award, by SAIT President Sang-wan Lee (October 22, 2009)
- Young Investigator Award, by International Thermoelectric Society (ICT2009/ECT2009 joint conference, 30th July 2009, Freiburg, Germany)

Research Interests:

- Thermoelectric materials (Chalcogenides and new materials)
- Topological materials such as Dirac and Weyl semimetals
- Unconventional superconductivity and magnetism

Representative Publications: (Published 118 SCI papers)

- Jong-Soo Rhyee et. al., Nature 459, 965-968 (2009).
- Jong-Soo Rhyee et. al., Advanced Materials 23, 2191-2194 (2011).
- Jong-Soo Rhyee et. al., Advanced Materials 28, 2316-2321 (2016).
- Dianta Ginting and Jong-Soo Rhyee et. al., Journal of Materials Chemistry A 6, 5870-5879 (2018)
- Chan-Chieh Lin and Jong-Soo Rhyee et. al., ACS Applied Materials & Interfaces 10, 10927-10934 (2018)
- Min Ho Lee and Jong-Soo Rhyee et. al., ACS Nano 13, 3806-3815 (2019)