Gwangju Institute of Science and Technology

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Professor Ji Young Jo's research team improves heat-to-electrical conversion efficiency by controlling barrier energy of nanomaterials

☐ GIST (President Kiseon Kim) School of Materials Science and Engineering Professor Ji Young Jo's research team simplified and optimized the thermoelectric efficiency of materials by controlling and optimizing the barrier energy of thermoelectric organic/inorganic nanocomposites.

- It is expected that this method will solve the problem of low efficiency, which is the fundamental drawback of wearable and flexible thermoelectric materials in the future, and easily optimize the performance of different materials.

☐ Thermoelectric materials are drawing attention as an environmentally friendly renewable energy system that is an alternative to the global fossil fuel shortage causing climate change problem. However, thermoelectric materials have a disadvantage in that they are very inefficient. Therefore, making a composite composed of two or more materials has been attracting attention as one of the representative methods for improving the performance of thermoelectric materials.

- The energy filtering effect *, which affects the rise of the Seebeck coefficient **, an important determinant of thermoelectric performance, is formed by the introduction of barrier energy *** in the composite when the electronic band structure of two or more different materials is bonded.

* energy filtering effect: Complexes made from two different materials create energy barriers due to the joining of different van de structures, which cause carriers with higher energy than these barrier energies to block carriers with lower energy. This effect increases the mean heat transferred by the carrier and increases the mean carrier energy, increasing the Seebeck coefficient without significantly reducing the conductivity.

** Seebeck coefficient: When the temperature difference occurs at both ends of the material, the thermoelectric power is generated The value of heat power generated by the unit temperature difference (μV/K).

*** barrier energy: minimum energy required to move between dissimilar materials in the composite

- This effect is largely influenced by the magnitude of the barrier energy, and it is difficult to improve the Seebeck coefficient in a given composite material because it is necessary to change materials or doping * to change the barrier energy size of the composite. If it is possible to change the magnitude of the barrier energy simply and freely, it is expected to make the thermoelectric efficiency even higher.

  * doping: To change the main carrier type and carrier concentration by adding a small amount of another material to one material

☐ Polar Solvent Vapor annealing (PSVA) was originally used to control the work function * of organic electrode in the solar cells. This phenomenon was applied to thermoelectric organic/inorganic composite materials to maximize barrier energy control and energy filtering effects.

  * work function: the minimum energy required to pull one electron out of a solid surface

- As a result, heat transfer characteristics can be seen depending on the different barrier energy sizes in a single material, and it is possible to be released as the highest performing material when the material that can be applied in real life.

☐ In this study, organic/inorganic composite thin films were fabricated using PEDOT: PSS (poly (3,4-ethylenedioxythiophene) poly sulfonate) widely used as a conductive polymer and Bi2Te3 nanowire, a representative thermoelectric material.

- The electrical conductivity is inversely proportional to the decrease in the original Seebeck coefficient, but it also has the largest electrical conductivity by improving the PEDOT: PSS structure through the polar solvent vapor phase annealing method used in this study.

  * power factor: calculated as (2) x (electric conductivity) and is mainly used for evaluating thermoelectric performance except effect of thermal conductivity (unit: μW/mK2)

☐ Professor Ji Young Jo said, "Through this research, we found a new way to more easily increase heat-electric conversion efficiency. This is expected to contribute to the significant increase in system power efficiency that utilizes the heat of our bodies or the waste heat of homes or industrial sites as energy, and the development of wearable and flexible thermoelectric materials and devices in the future."

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