An Innovation to Raise the Efficiency of Thermoelectric Materials via Simple and Green Techniques

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It has been reported that more than 50% of the energy produced worldwide is wasted in the form of heat. This implies that almost everywhere around us, there is energy that should be harvested and utilized. For instance, the heat from direct sunlight, especially in Qatar, where the temperature reaches more than 40 ºC during the summer. Even the heat coming out from your car parts during operation, such as the engine and exhaust system. Imagine being able to recover this waste heat and employ it to power other parts of your car, like the radio or the lights, and even use it to run your wristwatch or charge your mobile phones and laptops.

In fact, thermoelectric devices, which directly convert heat to electricity, are a promising technology to capture abandoned waste heat while being environment friendly. The prominent advantages of thermoelectric devices are all-solid-state, noise-free and portable. To generate electricity from a thermoelectric module, it is only required to have a temperature difference between its hot and cold surfaces (Figure 1).

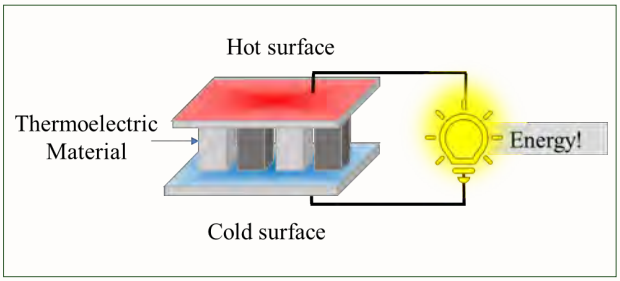

Figure 1. Schematic representation of a thermoelectric device.

Bismuth telluride represents the benchmark of outstanding thermoelectric materials used for near room temperature applications. However, the application of this material is highly restricted by the low energy conversion efficiencies. In order to improve the efficiency of bismuth telluride materials and get them commercialized, the research team from Material Science and Technology program including Dr. Khaled Youssef, the program coordinator, and Eng. Farah El-Makaty, a research assistant and a current PhD student, reported a simple, cheap, and economical process for producing highly-efficient bismuth telluride thermoelectric materials. The novelty combines usage of nanofillers and simple existing processing methods (mechanical milling and hot pressing) in a unique manner to provide high enhancements to the thermoelectric properties of the bismuth telluride materials (Figure 2).

Researchers have been able to produce marginal improvements in bismuth telluride nanomaterials this far, through using either chemical-based synthesis techniques or complicated methods; but the reported efficiency for their materials is low and does not meet the market requirements. The novelty in this work covers the first-ever production of a bulk bismuth telluride with a high efficiency via a simple and existing processing technique. The work was based on optimizing the process parameters systematically, including milling time of nanofiller, sample heating rate, operating pressure, and temperature. The obtained results showed how choosing the proper parameters, leads to huge improvements in the thermoelectric properties of bismuth telluride, hence enhancing the efficiency of the final device.

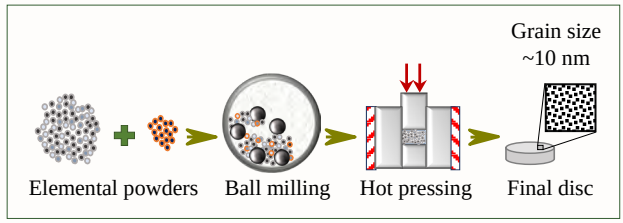

Figure 2. Production of bismuth telluride alloys using economical and green methods.

The need for clean, sustainable, and renewable energy technologies is crucial in this century to meet the increasing demands while reducing the environmental pollution. Each move taken in this field represents a step further towards a more energy-efficient world that meets with the high standards of Qatar National Vision 2030 for environmental and economically sustainable developments.

The research group of Dr. Khaled Youssef at the Material Science and Technology program has published several journal articles in the field since the beginning of their journey on bismuth telluride thermoelectric materials. Scan the barcodes and explore more about these developments.

The effects of structural integrity of graphene on the thermoelectric properties of the n-type bismuth-telluride alloy.

Review: The effect of different nanofiller materials on the thermoelectric behavior of bismuth telluride.

Experimental and modeling analysis of p-type Bi0.4Sb1.6Te3 and graphene nanocomposites.