TEOX: Thermoelectric Materials based on Earth-Abundant Oxides

The increasing world-wide demand for energy and the resultant depletion of fossil fuels (not to forget the environmental burden associated with their use) have brought new challenges for the scientific community. One of the major challenges is to develop high-efficiency means for capturing energy from the excessive naturally-occurring sources such as solar energy. Another excessive but mostly unused source of energy is the waste heat. There are ***huge waste heat sources*** in our environments, such as industrial processes, home heating, lighting, utility pipelines, electrical substations, subway networks, and automotive exhaust tubes, just to mention few examples. According to the U.S. Department of Energy, over 60 % of the 100 quadrillion BTU's of energy the USA consumes every year is lost as waste heat.

A highly promising method for ***energy recovery from such heat sources*** is the utilization of ***thermoelectric* (TE) *materials*** that are capable of converting various types of waste heat flows directly into electricity. Unfortunately, the currently employed TE materials are exotic semiconducting alloys with rare, expensive, and/or environmentally not-so-friendly elements such as ***antimony***, ***bismuth***, ***lead***, ***selenium*** and ***tellurium***. This is one of the main reasons why thermoelectric energy solutions are being used only in niche applications instead of electricity production in massive scales.

The driving force behind the **TEOX** project is the vision that to enable true revolution in thermoelectric power generation and more sustainable energy infrastructure, we need to ***substitute the current supply-limited TE materials*** such as bismuth telluride with novel, Earth-abundant and non-toxic materials composed solely of non-critical elements.

We will focus on substituting the present-day TE materials with several promising metal oxides and sulphides, whose thermoelectric efficiency can be significantly improved by nanostructuring. The nanostructuring is achieved *via* fabrication of novel hybrid inorganic-organic modifications of the bulk materials. The TEOX project combines state-of-the-art materials synthesis with high-level quantum chemical calculations, which are used to rationalize the design principles towards more efficient thermoelectric materials. In addition to searching and fabricating novel thermoelectric materials composed of abundant and non-toxic elements, we will engineer the novel materials to achieve maximal TE performance, fabricate and optimize actual TE modules, and assess the total life cycle of these TE modules from the point of view of safe disposal, recycling and environmental effects.

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