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Recent advances in renewable energy technologies for Sustainable development

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Driven by the increasing global demand for electricity, and raising concern of environmental issues of emissions, in particular global warming and has resulted in extensive research into several alternative green energy technologies have been developed over the years. The electricity consumption that derived from renewable technologies including combination of solar photovoltaic, wind, hydroelectric, geothermal, oceanic power (tidal and wave), and modern biofuels have all been explored extensively. Therefore, electricity generation from the renewable energy sources becoming a mainstream solution to provide economically viable, socially acceptable, and environmentally sound power supply towards achieving the United Nations Sustainable Development Goal 7 of *Affordable and Clean Energy*, which aims at ensuring access to affordable, reliable, sustainable and modern energy for all. In addition to the technologies developed to derive electricity from the indigenous renewable energy sources, a novel technology for generating thermoelectric power from waste-heat energy has emerged as a promising alternative green technology due to its distinct advantages. The thermoelectric technology offers opportunity for harvesting and recovering low-grade thermal energy, such as waste-heat energy, which is directly converted into usable electrical energy by thermoelectric generators (also known as thermoelectricity). Thermoelectric generators are basically semiconductor-based solid state devices, which directly convers a temperature gradient into an electric voltage based on *Seebeck effect*. Thermoelectric generators recovers waste heat as renewable energy source, and that operates very reliably, continuously and optimally with self-heating, and silence in operation due to the absence of moving parts. Application of thermoelectric generator as low power generation are widely used in biomedical, military, mobile communications, and space satellites, whereas the high-power generation of thermoelectric generator is mostly used in automobiles, industries, and small-scale and remote applications typically of rural electrification. Thermoelectric generators are also used for enhancement of power generation in systems using abundant solar and geothermal heat.

The thermoelectric generators provide a feasible solution for the sustainable energy, and new and exciting materials that can enable this technology to deliver higher efficiencies. The efficiency of a thermoelectric material is defined by the dimensionless figure-of-merit $ZT = (S^2\sigma/\kappa)T$, where S is the thermoelectric power, σ is the electrical conductivity, T is the operation temperature, and κ is the total thermal conductivity that is composed of carrier contribution κ_{car} and lattice contribution κ_{lat}. The developments on thermoelectrics from *strongly correlated cage compounds* (SCCC) currently receive intensive international research efforts [1-4] due to the prospect of devising novel strongly correlated compound materials for clean renewable electrical energy due to the variety of physical properties and fascinating ground state properties that are found in *strongly correlated electron systems* (SCES) in general. Several novel proof-of-principle approaches such as phonon disorder in *phonon-glass electron crystals* (PGEC), low dimensionality in nanostructured materials and charge-spin-orbital degeneracy in SCES have been confirmed on improving thermoelectric efficiency in reality. An efficient thermoelectric device should not only have large electrical conductivity and thermoelectric power but also low thermal conductivity. Recently attention has been focused on SCCC as an emergent class of materials conceived to unify within a single material, the specific properties of SCES and cage compounds. According to Slack's criterion [2] cage compounds hold promise to behave as PGEC. The rattling of loosely bonded guest atoms that are encapsulated within oversized cages are supposed to strongly scatter heat-carrying phonons, thereby reducing the phonon thermal conductivity (*glass-like*) of the material. The charge carries are much less affected by the rattling modes then the heat carriers (*crystal-like*), thus leading to an enhanced ratio of electrical to thermal conductivity (σ/κ). These specific properties are aimed to be connected in representatives of the new class of SCCC for developing efficient thermoelectric materials with favorable figure-of-merit. Therefore, resurgence in the search for new materials with enhanced thermoelectric performance are requisite for advanced thermoelectric energy conversion applications.

References

[1] S. Paschen, Thermoelectric aspects of strongly correlated systems, *Handbook on Thermoelectrics* (ed. D.M. Rowe, CRC Press, Boca Raton, FL) Chap. 15, (2006).
[2] G.A. Slack, New Materials and Performance Limit for Thermoelectric Cooling, in *Handbook on Thermoelectrics* (ed. D.M. Rowe, CRC Press, Boca Raton, FL) Chap. 34, (1995) 407.
[3] S. Paschen, A. Bentien, S. Budnyk, A.M. Strydom, Yu. Grin, and F. Steglich, in the *International Conference on Thermoelectrics*, Vienna (2006). **DOI:** 10.1109/ICT.2006.331325.
[4] T.M. Tritt, *Annual Rev. Mat. Research,* **41** (2011) 433.

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