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Nanostructured thermoelectric generators

Providing a sustainable supply of energy to the world's population will become a major societal problem for the 21st century. Thermoelectric materials, whose combination of thermal, electrical, and semiconducting properties, allows them to convert waste heat into electricity, are expected to play an increasingly important role in meeting the energy challenge of the future. Recent work on the theory of thermoelectric devices has led to the expectation that their performance could be enhanced if the diameter of the wires could be reduced to a point where quantum confinement effects increase charge-carrier mobility (thereby increasing the Seebeck coefficient) and reduce thermal conductivity. The predicted net effect of reducing diameters to the order of tens of nanometers would be to increase its efficiency or ZT index by a factor of 3.
Our project in the field has been recently funded by the European ERC program "IDEAS"under ERC contract 240497, granted to Dr. Marisol Martin at IMM-CSIC, and a bilateral collaboration (NanoTherma) within the Spanish team and a NIMS group in Japan.
Its main objective is to investigate and optimize nanostructures influencing ZT in order to achieve a power conversion efficiency >20%. For that, nanowire arrays of state of art n and p-type semiconductor materials will be prepared by cost-effective mass-production electrochemical methods and fabricate devices with a ZT >2 for applications in energy scavenging and as cooler/heating devices. Three lines of research are followed:
a) determination of the best materials for each temperature range (n and p type) optimizing composition, microstructure, shapes (core/shell, nanowire surface texture, heterostructures), interfaces and orientations,
b) advanced characterization, device development and modeling will be used iteratively during nanostructures and materials optimization, and
c) nano-engineering less conventional thermoelectric like "cage compounds"by electrodeposition methods.
This project opens a door to practical thermoelectric application of nanowires and nanowire arrays by means of a bilateral Spain-Japan cooperation in the thermoelectric field and, if successful, will lead to a more efficient way to harness precious, but nowadays wasted energy.

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