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Nanostructured Oxides and Sulfides for Thermoelectrics

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Thermoelectric power generation can be applied to various heat sources, both waste heat and renewable energy, to harvest electricity. Even though each heat source is of a small scale, it would lead to a great deal of energy saving if they are combined and collected, and it would greatly contribute to reducing carbon dioxide emission. We have been engaged in developing novel thermoelectric materials to be used for energy saving and environmental protection and are currently developing nanostructured ceramics for thermoelectric conversion. We have demonstrated a quantum confinement effect giving rise to two dimensional electron gas (2DEG) in a 2D superlattice, STO/STO:Nb (STO: strontium titanate), which could generate giant thermopower while keeping high electrical conductivity. One unit-cell thick Nb-doped well layer was estimated to show ZT=2.4 at 300K. Then, a "synergistic nanostructuring" concept incorporating 2DEG grain boundaries as well as nanosizing of grains has been applied to our STO material and 3D superlattice ceramics was designed and proposed. It was verified by numerical simulation that this 3D superlattice ceramics should be capable of showing ZT=1.0 at 300K which is comparable to or even higher than that of conventional bismuth telluride-based thermoelectrics. We have recently proposed titanium disulfide-based misfit-layered compounds as novel TE materials. Insertion of misfit-layers into the van der Waals gaps in layer-structured titanium disulfide thus forming a natural superlattice gives rise to internal nanointerfaces and dramatically reduces its lattice thermal conductivity. ZT value reaches 0.37 at 673 K even without optimization of electronic properties. Our challenge to further increase ZT by controlling their electronic system and superlattice structures will be presented.