NOVEL THERMOELECTRIC MATERIALS FOR PHOTOVOLTAIC/THERMOELECTRIC HYBRID POWER GENERATORS

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Abstract: We have recently proposed a photovoltaic/thermoelectric hybrid power generator consisted of three parts: dye-sensitized solar cell (DSSC), selective sunlight absorber (SSA), and thermoelectric (TE) module, which can convert both VIS light and IR light into electricity with high conversion efficiency as high as 13 % or higher. Even though TE module based on conventional bismuth telluride (BT) materials is beneficial for this hybrid generator, they must be replaced by other good TE materials because BT materials have many problems in terms of toxicity, low natural abundance, heavy weight, high cost, etc. We have been engaged in developing novel thermoelectric materials to be used for harvesting electricity from solar heat and are currently developing nanostructured TE materials. We have demonstrated a quantum confinement effect giving rise to two dimensional electron gas (2DEG) in a 2D superlattice, $SrTiO_3$/$SrTiO_3$:Nb, which could generate giant thermopower while keeping high electrical conductivity. Then, a "synergistic nanostructuring" concept incorporating 2DEG grain boundaries as well as nanosizing of grains has been applied to our $SrTiO_3$ material and 3D superlattice ceramics was designed and proposed. This 3D superlattice ceramics was verified by numerical simulation to be capable of showing ZT>0.8 @300K. We also have recently proposed TiS_2-based misfit-layer compounds as novel TE materials. Insertion of misfit-layers into the van der Waals gaps in TiS_2 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.