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Functional Oxide Thermoelectrics: The Case of ZnO Nanowires

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Civilization is facing to develop alternative renewable energy sources, because of the limited fissile fuels and their impact on the environment. Functional oxide nanowires are expected to play an important role in scavenging waste heat and converting it into electricity. Some complex superlattices in nanostructures contain periodic compositional and structural features, typically on the nanometer scale, making them promising materials for thermoelectric applications. In this presentation, I will discuss our recently discovered a novel method to produce $M_2O_3(ZnO)_n$ polytypoid nanowires (M=In, Ga, Fe,..) by a facile solid state diffusion process. This is in agreement with the theoretical prediction that it is possible to increase the material-dependent figure of merit, zT , by using low dimensional materials, attributed to electronic band structure changes and enhanced interface phonon scattering. Atomic resolution HAADF imaging is used to perform a detailed structural analysis on the $M_2O_3(ZnO)_n$ nanowires, unambiguously determined the location of indium within the structure and to evaluate lattice strain and the presence of defects. Based on this analysis we propose that the superlattice structure is generated through a defect-assisted process. One of the greatest advantages of this novel synthesis is the ability to tune the nanoscale features of the polytypoid wires by simply adjusting the amount of metal precursor. We also performed a quantitative analysis of the change in superlattice inclusion density and periodicity with metal deposition. Compare to ZnO nanowires, these new oxide thermoelectric nanostructures exhibited almost three orders of magnitude increase in efficiency. This will enable future studies on structure-dependent thermoelectric properties and possibly lead to further enhancements in thermoelectric efficiency.