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III-nitrides: A universal semiconductor for energy applications thermoelectric and solar cells

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The development of wide-band gap compound semiconductor materials and structures has been led by the III-nitrides and they are fueling a revolution in solid state lighting, solar cells, thermoelectric and other applications. The talk will review many of the contributions that the III-nitrides have made to date before focusing on the development of InGaN for high temperature thermoelectric materials and a new generation of high efficient solar cells. Specifically, we will talk the various approaches to increase thermoelectric efficiency of III-nitrides, including electron quantum confinement, and phonon scattering to increase the power factor and decrease the lattice thermal conductivity. Additionally, high density-of-states (DOS) by size reduction, resonant states by impurity doping, and multi-valley band structure by band degeneracy have been utilized to further enhance its figure of merit (ZT) value. The impact of doping, and crystallographic defects on electrical and thermal properties on the TE properties of nitride thin films grown by metal organic vapor deposition (MOCVD) will be systematically analyzed. Additionally, we will talk the III-nitrides for a new generation of highly efficient solar cells. For instance, InGaN with indium compositions up to 30% have been developed for photovoltaic applications by controlling defects and phase separation. InGaN solar cell design involving a 2.9 eV InGaN p-n junction sandwiched between p- and n-GaN layers yield internal quantum efficiencies as high as 50%; while devices utilizing a novel n-GaN strained window-layer enhanced the open circuit voltage. These results establish the potential of III-nitrides in ultra-high efficiency photovoltaics.

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