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III-Nitrides for Energy Applications

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The development of wide-band gap compound semiconductors materials and devices led by the III-Nitrides are fueling a revolution for energy related applications. The III-Nitrides can provide a universal solution for many applications were traditionally III-V devices are used. This presentation will highlight the use of the III-Nitrides in illumination, solar cells and thermoelectric applications.

Light emitting diodes (LEDs) have been very successful in niche markets are beginning to experience some use in generation illumination. To achieve high quality white light gaps in the power spectrum of typical LED sources have to be eliminated. Broadband spectrally dynamic solid state illumination source comprising of a two terminal dual LED structure has been developed. A combination of multiple phosphors are then "pumped" by either or both of the wavelengths emitted from the dual LED to produce white light of a variable power spectrum. Such innovations will help further increase the competitive advantage over conventional illumination sources.

The III-Nitrides are also the basis for a new generation of highly efficient solar cells. InGaN with indium compositions up to 30% (2.5 eV band gap) 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 yields 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.

Thermoelectric (TE) conversion of waste thermal energy into electrical energy have seen pioneering developments over the past 20 years. A figure of merit ZT, used to measure the efficiency of the TE materials. Various approaches have been taken to increase the efficiency of TE materials such as; electron quantum confinement, and phonon scattering to increase the power factor and decrease the lattice thermal conductivity, respectively. Some recent measurements of the thermoelectric properties–the Seebeck coefficient, the electrical conductivity and the power factor – of GaN and InGaN thin films will also be reported.

Keywords: III-Nitrides, ilumination, solar cells and thermoelectric devices