SUMMARY

Title: Role of Spontaneous and Piezoelectric Polarization on Thermal Properties of Wurtzite Nitrides (2164/CCOST/MRP/2013)

Achievements

- Polarization mechanism enhances elastic constant and Debye temperature of III-V nitride semiconductors. The polarization field suppresses phonon scattering mechanisms and enhances thermal properties. Polarization field enhances thermal conductivity by more than 30% at room temperature.
- The unusual increase of thermal conductivity with temperature around room temperature observed in experiment has been attributed to effect of polarization field.
- Investigation predicted pyroelectric transition temperature of AlN, GaN and AlGaN alloy as 100, 60 and 250^0K respectively.
- Enhanced thermal properties of AlGaN/GaN heterostructures have been achieved by Phonon engineering via polarization field.

Novelty

- Thermal conductivity analysis can reveal the pyroelectric behaviour of III-V nitrides.
- The transport of charge less phonons can be tailored by electric fields in strained nitrides. The polarization field modifies transport properties of both phonon and electron; and proposed that polarization field will modify thermoelectric properties.
- Thermal properties which are attributed to charge less phonon can be judiciously modified by electrical means to achieve desired value.

Suggestions for Utilization

- Polarization mechanism enhances thermal properties of III-V nitride semiconductors. Thus it is suggested that these materials can be utilized for heat sink substrate in addition to active layers in optoelectronics devices.
- Enhanced thermal conductivity can resolve a number of technological issues. III-V nitride semiconductor made FET, LED, LD, Solar Cells, Thermoelectric Modules and Biosensors suffer efficiency and performance droop due to self heating effect.
- So it is suggested to scientific and technological communities to introduce polarization mechanisms intentionally in the interfaces during growth of devices. Polarization mechanism will enhance thermal conductivity which can minimize the self-heating effect and can enhance performance of the device.
- Continuous scaling down of feature sizes in microelectronic devices and circuits leads to an increase in power dissipation per unit area of the semiconductor chip. Thermal management at nanoscale can be achieved by Phonon engineering via polarization field. It is suggested that polarization effect should be taken into account in heat transport simulation to optimize optoelectronic nitride devices.

Future scope

- This study has scope in Solar cells where thermal properties control the efficiency of pn junctions. This work can be extended to study efficiency of thermoelectric modules where electrical energy is obtained from thermal energy. The work can play important role in resolving a number of scientific and technological issues in real devices relating to thermal properties.