

The Physics of Solid State Lighting

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Artificial lighting has been of paramount importance in the development of human civilizations. Most of our current internal lighting depends on incandescent and fluorescent devices. In the last decade, solid-state lighting has become available and competitive in terms of reliability, energy efficiency and price. This is due to the development of nitride semiconductors, initially by clever engineering research. This talk will review the development of these materials, explain their puzzling nanometer-scale properties, and describe the current challenges in realizing their potential.

The nature of these materials has been found to be quite different from other optoelectronic materials. Films with high optoelectronic properties exhibit extremely high densities of dislocations, contrary to other semiconductors where dislocations play a highly detrimental role. This is due to the strong, short chemical bonds associated with nitrogen in the wurtzite structure. The dislocations form a columnar structure that allows flexibility for growth of strain free crystallites. Large lattice mismatch and an absence of center of symmetry in these hexagonal semiconductors result in piezoelectric fields, of the order of MeV/cm, in the active region of light emitting diodes and diode lasers. These piezoelectric fields produce electronic band displacement that in highly mismatch materials (such as for green and yellow emission) leads to poor carrier capture cross section and low internal quantum efficiencies. Nevertheless, the impressive device performance and the unexpected materials properties are puzzling to the physicist and the materials scientist.