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TOPIC:

N-lightenment: The bright world of nitride semiconductors

ABSTRACT:

The award of the 2014 Nobel Prize in Physics for "efficient blue light-emitting diodes leading to bright and energy-saving white light sources" is the culmination of painstaking research over many decades into basic materials physics and crystal growth combined with an understanding of advanced heterostructure device design and optimized light extraction techniques. At the heart of the spectacular progress in LED-based solid-state lighting are the group-III nitride materials – GaN and its alloys with InN and AlN. A key enabler of rapid developments in this field has been advances in epitaxial thin film growth techniques that have dramatically improved material quality.

Two important physical limitations that hinder device performance in nitride materials are the difficulties in obtaining bulk GaN substrates, and the presence of large internal electric polarization fields in heterostructures grown on the basal plane. I will discuss our ongoing work on the use of 2D layered materials such as graphene and transition metal chalcogenides as potential substrates for GaN growth. Further, I would introduce the area of nonpolar and semipolar nitride semiconductors, where, by growing on appropriate crystal planes, some of the deleterious effects of internal polarization fields can be avoided or minimized. I will present some recent work exploring the epitaxial growth and characterization of these materials. We have developed techniques for a comprehensive structural charac¬terization of such III-nitride layers under anisotropic in-plane strain using high-resolution XRD. Polarization-resolved optical transmission measurements show interesting features that depend on the valence band ordering in the AlInN and AlGaN alloy systems.

Before discussing our ongoing research I will provide a short review of the challenges and current status of nitride semiconductor materials as well as optoelectronic and high-power/high-frequency electronic devices. I will also highlight the research in the Indian context, where despite a rather late entry into the

field there is now a robust community of researchers investigating various aspects of III-nitride materials and devices.

PROFILE:

Prof. Arnab Bhattacharya is a scientist working in the area of semiconductor optoelectronics at the Tata Institute of Fundamental Research (TIFR) in Mumbai. Arnab has a B.Tech degree from IIT-Bombay, a Ph.D. from the University of Wisconsin-Madison, and worked on an Alexander-von-Humboldt fellowship at the Ferdinand-Braun-Institut in Berlin, before setting up a research group in TIFR for novel semiconductor materials and devices. His work has focused on III-nitride semiconductors, in particular synthesis of materials via metalorganic vapour-phase epitaxy. Arnab is on the editorial board of the Journal of Crystal Growth and a senior member IEEE. Apart from semiconductors, Arnab is passionate about science outreach, and enjoys talking about science and demonstrating science experiments to all audiences, particularly school/college students and teachers. Arnab pioneered "Chai and Why?" Mumbai's popular science café, and received the 2010 Homi-Bhabha-Award in Science Education, and the 2012 Chevening Rolls-Royce Fellowship for Science and Innovation Leadership and is presently the chair of Science Popularization and Public Outreach at TIFR.