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Hexagonal boron nitride materials – growth, properties, and applications

III-nitride wide bandgap semiconductors have been at the center stage of the semiconductor R & D effort over the last two decades. Photonic/electronic devices based on III-nitrides, including UV/blue/green/white light emitting diodes (LEDs), violet/blue laser diodes (LDs), UV detectors, and high power/temperature transistors, have been successfully realized and commercialized.

Among the members of the III-nitrides, BN is the least studied and understood. BN exists in three crystalline forms (hexagonal, cubic and wurtzite). The sp^2-bonded hexagonal form (h-BN) is the most stable phase when synthesized at any temperature under ambient pressure. Its extraordinary physical properties, such as ultra-high chemical stability, thermal conductivity, electrical resistivity, and band gap (E_g ~ 6.5 eV) make h-BN the material of choice for many emerging applications. Due to its close lattice match to graphite, h-BN is being recognized as the most suitable substrate/dielectric/separation layer for 2D electronics and optoelectronics. As such, much efforts in the *s*ynthesis of h-BN have been largely focused on mono- or a few layers of h-BN in the past.

In this presentation, I will first discuss the development and current status of nitride blue/green/white light emitting diodes (LEDs) for lighting. I will than summarize recent progress in the growth of wafer-scale h-BN epilayers with a few um in thickness by metal-organic chemical vapor deposition (MOCVD). The basic properties of h-BN epilayers will be discussed in comparison with other nitride semiconductors, in particular AlN. H-BN shows the unique qausi-2D nature with exceptionally high density of states (DOS) and large exciton binding energy (around 740 meV), which results in high optical absorption and emission intensity. P-type conduction in h-BN and diode behaviors in the p-n junction structures consisting of p-type h-BN and n-type Al-rich AlGaN heterostructures have been demonstrated, which could potentially address the intrinsic problem of low p-type conductivity in Al-rich AlGaN for DUV photonic devices. The potential applications of h-BN for deep UV emitters and detectors, 2D templates/ dielectric/separation layers, and solid-state neutron detectors will also be discussed.

Dr. Hongxing Jiang received his B.S. in Physics in 1981 from Fudan University, China and Ph.D. in Physics in 1986 from Syracuse University. Dr. Jiang devotes his research efforts to the advancement of III-nitride technologies. His team has developed micro-LED technology leading to the realization of self-emissive microdisplays and single-chip AC-LEDs. Currently, he directs the Nanophotonics Center at Texas Tech University and is the inaugural Edward E. Whitacre Jr. endowed chair and Horn distinguished professor. Dr. Jiang has 390 journal publications and 20 patents in the area of nitride semiconductors with over 12,000 citations and an h-index of 63, edited 11 books, and delivered more than 120 invited talks. He relocated his research group to TTU in 2008 from Kansas State University where he was a university distinguished professor of physics. Dr. Jiang is a Fellow of APS, OSA, and SPIE.

Wednesday, November 11, 4:00 pm | 136 Jorgensen Hall
3:45 – Refreshments in Jorgensen Atrium

Host:
Professor Yongfeng Lu

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