Solid State Technology and Devices Seminar

(U)Wide Bandgap Materials and Devices for Communication and Sustainability

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Abstract: In the era of internet of things, and autonomous electric cars, highly efficient, reliable, low latency communication has become more important than ever. At the same time, climate change, which is in part due to technological advances, is an existential threat to humanity which calls for efficient, low-waste electronics and renewable energies. The goal of my research group at University of Michigan is to contribute to finding solutions to these challenges by working on (ultra)wide bandgap materials and devices. In my talk, I will go over three main projects that we are currently working on: (i) Ga_2O_3 power electronics (ii) Epitaxial growth of Relaxed InGaN films (iii) N-polar GaN HEMTs.

The need for efficient power generation, distribution, and delivery is quickly expanding in different sectors of industry. This includes transportation, industrial automation, and renewable energy. Power electronics is the heart of this industrial revolution, which can be found in various applications ranging from power amplifiers in servers, solar invertors, electric vehicles, and motor drives/servos in industrial robotics. The power electronics market as a whole was about $20 billion in 2012 and is expected to increase to $41.7 billion by 2022. Silicon can no longer provide the efficiency and reliability needed for many emerging applications and requirements. β-Ga_2O_3 has recently attracted a great deal of attention due to its wide bandgap of ~4.8 eV, and availability of melt growth techniques to produce high quality substrates cost-effectively. In my talk, I will give an overview of our current efforts in this field. As an example, I will discuss our recent work on trench Schottky barrier diodes (SBD). In this work, we studied thermal stability of these devices and compared that with thermal stability of planar SBDs.

(In,Al,Ga)N material system has revolutionized electronics and optoelectronics devices due to its unique material properties. The combination of large bandgap (3.4 eV), high electron mobility (>2000 cm^2/Vs), and high saturation velocity makes this material system attractive for high power, high frequency RF applications. The (In,Ga,Al)N crystal structure lacks inversion symmetry, with the polarization field in the material depending on the crystal orientation (N-polar vs Ga-polar). Nitride-based optoelectronic and electronic devices for commercial applications have been mainly developed on Ga-polar GaN templates due to less complexity of epitaxial growth compared with that on N-polar. Nonetheless, recent results on N-polar GaN high electron mobility transistors (HEMTs) have proven their superiority over conventional Ga-polar GaN HEMTs. To further increase the operating frequency while maintaining high output power in HEMTs, the gate-to-channel distance needs to be reduced significantly. Additionally, electron mobility and velocity in the channel must be enhanced. In this talk, I will discuss our recent work on growth of ultra-scaled GaN channel N-polar HEMT structures by Plasma-assisted molecular beam epitaxy (PMABE). The advantage of relaxed-InGaN pseudo-substrates for enhancing electron

mobility and velocity in GaN channel will be explained. I will introduce our recent breakthrough in the epitaxial growth of relaxed InGaN pseudo-substrates.

Bio: Elaheh Ahmadi received her B.S. and M.S. degrees both from Sharif University of Technology, Tehran, Iran in 2008 and 2010 respectively. She then moved to USA and joined Prof. Mishra's group at UC Santa Barbara in 2010, where she worked on epitaxial growth and characterization of GaN-based electronic devices. After earning her PhD degree in 2015, she started her postdoctoral research on epitaxial growth and characterization of Ga2O3 devices. She joined University of Michigan as an Assistant Professor in Jan 2018 where she has established and is leading the Wide Bandgap Materials and Electronics (WBME) lab. She is the recipient of 2020 AFOSR Young Investigator Program (YIP) and 2020 ONR YIP awards.