October 13, 2010

Brown NRI-MRSEC site visit

Attendees:

NRI liaison team	Brown University
Luigi Colombo (TI)	Rod Beresford (PI)
James Hannon (IBM)	Rashid Zia
Steve Kramer (Micron)	Vivek Shenoy
Zoran Krivokapic (GlobalFoundries)	
Albert Davydov (NIST)	
Ajey Jacob (Intel) – dial in	
Allison Hilbert (SRC) – dial in	

Meeting Agenda

Barus+Holley Building, Room 190

9:45-10:00	Welcome and introductions
10:00-10:30	Graphene I: Epitaxial growth Rod Beresford
10:30-11:15	Graphene II: Laser processing and spectroscopy Rashid Zia
11:15-12:00	Graphene III: Multiscale modeling Vivek Shenoy

Barus+Holley Building, Room 631

12:00-1:00	Working lunch — follow-up questions and open discussion
1:00-2:30	Industry caucus: feedback to Brown PIs

Concept Overview (from proposal):

Novel epitaxial routes to graphene are proposed, based on existing success with annealing SiC to volatize Si at the surface [1]. Key features of the proposed program include:

- Molecular beam epitaxy of SiC on Si, and the use of epitaxial aluminum nitride (AlN) on Si to provide a flat lattice- and thermal-matched template for SiC monolayer growth, enabling epitaxial graphene on insulator (Beresford).
- Resonant CO_2 laser excitation of surface phonon-polariton resonances to locally convert SiC to graphene, allowing direct laser writing of sub-diffraction limited graphene features with “embedded” edges (Zia).

- Multiscale modeling of graphene interfaces, defect structures, shape evolution, and transport properties to correlate device behavior with atomistic structure (Shenoy).

Many results with graphene devices imply that extrinsic effects (doping, edges and defects) dominate electrical behavior. Exploitation of intrinsic graphene properties requires synthesis methods producing material with well controlled interfaces and edges. The focus on Si and selective-area regrowth is important for the ultimate goal of integration of graphene demonstrations with CMOS processing.

October Feedback from liaison team:

Thank you very much for the review. There has been significant progress in the area of modeling and laser annealing and this can form the basis for future experiments to demonstrate the growth of graphene on SiC/AlN substrates. The team is now ready to focus on the growth and characterization of graphene.

A few issues need attention:

1. Reproducible growth of AlN by MBE on Si (111) substrate
2. Precursor selection for SiC growth in MBE
3. Microstructural and compositional characterization of the AlN, SiC and graphene layers.

It is important to establish a basic understanding of the SiC growth process on AlN/Si and the microstructure of the grown films. We recommend that the following techniques be used to characterize the films:

1. AlN and SiC: XRD, SEM/EBSD/EDS, TEM, AFM
2. Graphene: Raman spectroscopy, Raman mapping, SEM/EBSD, LEED

Given that some of the characterization techniques may not be available at Brown we recommend that you leverage resources outside of the university, perhaps at other universities, government labs or industry. This will give an opportunity to the students to learn about collaboration outside the academic environment and experience laboratories and characterization methods outside the university.

Based on the presentations and discussions during the meeting we believe that reproducibility of epitaxial AlN film growth on Si in MBE needs to be demonstrated by the new students with the development of SiC deposition thereafter.

We would also appreciate to get a quarterly update on the progress of the program either through a report, presentation or teleconference.