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Dr. Kurt Gaskill

Advanced SiC Epitaxial Research Laboratory,
U.S. Naval Research Laboratory, Washington, DC

Controlling Epitaxial Graphene Growth

Graphene, discovered less than 7 years ago and subject of the most recent Nobel Prize in Physics, is the thinnest known substance in the universe and has properties superior to all other materials known to man. For this reason, it has rapidly risen as a leading candidate material for transparent conductors; ultra-strong membranes for electron microscopy; touch screen and flexible electronics; atom-sensitive balances; individual gas molecule sensors; and low power, high frequency mm-wave/THz receivers for sensing applications. Recently, there has been tremendous progress in the fabrication of epitaxial graphene (EG) RF devices [1]. Understanding the initial steps of graphene growth is paramount to future EG growth control strategies for continued device progress. In this regard, we present recent results in two areas of EG synthesis: graphene "island" formation on (000-1) [C-face] 6H-SiC and single layer graphene growth on (0001) [Si-face] 4H-SiC step-free mesas (SFMs).

Through control of temperature and Ar pressure, graphene epitaxy can be slowed, resulting in local areas of growth on the C-face of SiC [2]. These "islands" are thought to represent early stages in graphene growth. In all cases examined, the islands nucleated from threading screw dislocations associated with the substrate. We used optical and scanning electron microscopy, electron channeling contrast imaging and Raman spectroscopy to take "snapshots" of the growth process from island to complete film.

To aid in understanding EG synthesis on the Si-face of SiC without the impact of substrate defects, we investigated its growth on SFMs. SFMs were formed by a kinetically-controlled lateral step-flow SiC growth process at 1580^0C on (0001) 4H-SiC substrates patterned with mesas [3]. When threading screw dislocations are not present on a mesa, the SiC growth process results in atomically flat surfaces. Subsequently, EG was grown in a 100 mbar Ar ambient at 1620°C on an array of SFMs with side lengths ranging from 40 µm to 200 µm. For short growth times, partial graphene coverage of SFMs was observed suggesting a growth mechanism limited, in part, by C surface diffusion. For long growth times, complete EG mesa coverage was established and the step bunching morphology typically observed on conventional basal plane substrates was not found. In addition, mesa graphene was found to have other properties that differ substantially from EG grown on conventional basal plane substrates, e.g., Raman spectroscopy implied that bilayer graphene can be naturally formed.

References

[1] J.S. Moon, *et al*, *IEEE Electron Device Letters* **31**, 260, (2010).
[2] J.L.Tedesco, *et al*, *Appl. Phys. Lett.* **96**, 222103 (2010).
[3] P.Neudeck, *et al*, *Mater. Res. Soc. Symp. Proc.* **911**, 85 (2006).

Monday, March 28, 2011
UNL City Union Auditorium, 1:00 p.m.
(see attached schedule)

Host:
Dr. Mathias Schubert
Department of
Electrical Engineering

Please Post

NEBRASKA CENTER FOR MATERIALS AND NANOSCIENCE &
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Graphene Colloquium

University of Nebraska-Lincoln,
City Campus Union
Auditorium

Monday March 28, 1:00 pm – 4:00 pm

1:00-1:45 pm	Kurt Gaskill Naval Research Laboratory	Controlling Epitaxial Graphene Growth
1:45-2:00 pm	Xia Hong University of Nebraska-Lincoln, Department of Physics and Astronomy	Effect of Dielectric Environment on the Transport Properties of Graphene
2:00-2:15 pm	Tino Hofmann University of Nebraska-Lincoln, Department of Electrical Engineering	THz Optical Hall Effect in Epitaxial Graphene
Break 2:15-2:45 pm	*Coffee and Refreshments*	*Coffee and Refreshments*
2:45-3:00 pm	Alexander Sinitskii Rice University, Department of Chemistry	Synthesis and properties of graphene nanostructures
3:00-3:15 pm	Jongbok Park University of Nebraska-Lincoln, Department of Electrical Engineering	Laser Direct Writing of Graphene Patterns
3:15-3:30 pm	Axel Enders University of Nebraska-Lincoln, Department of Physics and Astronomy	State of Art of Epitaxial Graphene and Scanning Tunneling Microscopy
3:30-3:45 pm	Peter Dowben University of Nebraska-Lincoln, Department of Physics and Astronomy	Substrate Interaction and Band Gap Properties in Graphene
3:45-4:00 pm	Yu Zhao University of Nebraska-Lincoln, Department of Chemistry	A Density Functional Study On the Oxidation of Two-dimensional Hexagonal Boron Nitride Sheet