CVD Graphene Nanoribbons by Silver Nanowire Shadowmasking

Benjamin Piazza,1,2 Aoki Kensuke,3 and Aoki Nobuyuki3

1Dept. of Physics, The Pennsylvania State University, University Park, Pennsylvania, United States of America
2Nakatani RIES: Research & International Experiences for Students Fellowship in Japan, Nakatani Foundation, Tokyo, Japan
3Dept. of Materials Science, Chiba University, Inage, Chiba, Japan

The aim of this project is to determine if CVD graphene nanoribbons are a plausible candidate for FET (Field-effect Transistor) devices. Owing to its remarkably high mobility, a CVD graphene FET would boast better performance and energy efficiency than any conventional transistor device. However, graphene in its natural, sheet form lacks a band gap, which is a prerequisite to device applications. By fabricating graphene in nanoribbon structures, a band gap is induced that is inversely proportional to nanoribbon width. Using photo-lithography and thin film deposition techniques, gold electrodes are built over thirty nanometer diameter silver nanowires on CVD graphene. Silver nanowires provide a shadowmask for CVD graphene from oxygen plasma etching and are subsequently removed via nitric acid treatment, leaving CVD graphene nanoribbons as confirmed by AFM and electrical transport measurements. These results may serve as the precursor to fabrication of ultra-fine, large band gap CVD graphene nanoribbons by ultra-thin nanowire shadowmasking.
CVD Graphene Nanoribbons by Silver Nanowire Shadowmasking

Benjamin Piazza,1,2 Aoki Kensuke,3 and Aoki Nobuyuki3

1The Eberly College of Science, Pennsylvania State University, 2Nakatani-RIES: Research and International Experiences for Students Fellowship, Rice University, 3Department of Materials Science, Chiba University

Graphene as a MOSFET Device

- Graphene boasts highest electric mobility of all materials
- High utility for device applications
- Requires a band gap to be usable in MOSFET transistor devices
- Thin nanoribbon structures of graphene have band gaps
- Size of band gap inversely proportional to width

Material Properties

- Silver nanowire height profile
- Width measurement is unreliable owing to AFM tip curvature
- Confirmed to be about 30nm in radius via height profile
- Therefore fabricated CVD graphene nanoribbon should also be about 30 nm

Results and Analysis

Raman Spectroscopy

- Via Raman Spectroscopy, characteristic intensity peaks of CVD graphene are confirmed prior to O2 plasma etching (20 W for 3 seconds)
- Post-treatment, characteristic peaks are lost, indicating loss of CVD graphene near channel

Future Work

- Determine whether thinner nanoribbons can be fabricated from thinner nanowires
- Measure energy band gap against temperature for nanoribbons

References


Acknowledgements

This research was conducted as part of the Nakatani Foundation 2018 Nakatani-RIES Fellowship for U.S. students in Japan. Special thanks to Prof. Nobuyuki Aoki and the members of the Nakatani-RIES Foundation for their mentorship and support of my research project. I would also like to thank Prof. Chris Steeneken, Sarah Phillips, and Anna Shapiro for their guidance and support. Special thanks to my parents, as their love and support has been critical in helping me pursue my dreams.