Nanostructured Carbon Materials

MATE 580 (Winter 2007)

Welcome to the graduate course on Nanostructured Carbon Materials. Our goal is to introduce students to the "state-of-the-art" in the area on advanced carbon materials ranging from diamond to nanotubes. Particularly, issues related to novel nanostructured carbons (fullerenes, nanotubes, graphene and DLC) and their applications in nanotechnology will be addressed. Students are expected to gain knowledge of structure, properties, manufacturing, and applications of carbon materials. Structure control at the nanoscale and effect of structure on properties will be discussed. Students will also obtain experience of reviewing scientific articles and presenting their opinion in a seminar-type environment.

Class Hours

Lecture:	3.0 hrs	Tuesday at 6 PM – 8:50 PM Room 329 Randel Building at Drexel

Web page http://nano.materials.drexel.edu/teaching.html

Instructor

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Textbook

1. Y. Gogotsi (Editor), *Carbon Nanomaterials* (CRC Press, Boca Raton) 2006.
2. Hugh O. Pierson, "Handbook of Carbon, Graphite, Diamond and Fullerenes," Noyes Publications, Park Ridge, NJ, 1994 (available online from Drexel)

Additional reading:

3. P.J.F. Harris, "Carbon Nanotubes and Related Structures," Cambridge University Press, Cambridge, 1999.
4. O.A. Shenderova, V.V. Zhirnov, and D.W. Brenner, Carbon Nanostructures**,** *Critical Reviews in Solid State and Materials Sciences*, v**. 27**(3/4) 227–356 (2002)

Course material:

PowerPoint slides for each lecture will be available online on course blog at http://in.materials.drexel.edu/ Please download and print before each class.

Proposed papers for discussion:

1. S. Stankovich, D. A. Dikin, G. H. B. Dommett, K. M. Kohlhaas, E. J. Zimney, E. A. Stach, R. D. Piner, S. T. Nguyen, and R. S. Ruoff, Graphene-based composite materials, *Nature*, **442**, 282-286 (2006)
2. Gogotsi, Y., Libera, J. A., Kalashnikov, N. & Yoshimura, M. Graphite Polyhedral Crystals. *Science* **290**, 317-320 (2000).
3. J. Chmiola, G. Yushin, Y. Gogotsi, C. Portet, P. Simon, and P. L. Taberna, Anomalous Increase in Carbon Capacitance at Pore Sizes Less Than 1 Nanometer, *Science*, **313**, 1760-1763 (2006)
4. Kroto, H. W., Heath, J.R., O'Brien, S.C., Curl, R.F. & Smalley, R.E.. C_{60} Buckminsterfullerene. *Nature* **318**, 162-163 (1985).
5. Iijima, S. Helical Microtubes of Graphite Carbon. *Nature* **354**, 56-58 (1991).

6. S. J. Tan , A.R.M. Verschueren, C. Dekker, Room-temperature transistor based on a single carbon nanotube, *Nature* **393**, 49-52 (1998)
7. Bundy F.P., Hall, H.T., Strong, H.M., & Ventorf, R.H. Man-Made Diamonds, Nature, 176, 51-56 (1955).

Schedule

Week 1	Course Organization The Element Carbon – Structure, Chemistry, Phase Diagrams, Raman of Carbon Materials
Week2	Graphite: Structure, Synthesis, Properties and Applications Graphene Article Discussion - Stankovich
Week3	Non Planar Graphitic Structures: Carbon Onions, GPC Cones Article Discussion - Gogotsi
Week 4	Advanced Carbon Materials: Glassy Carbon, Activated Carbon, CDC, Nanotextured materials fir energy applications Article Discussion - Chmiola
Week 5	Quiz I
Week 6	Fullerenes Article Discussion - Kroto
Week 7	Nanotubes 1: Structure Article Discussion - Iijima
Week 8	Nanotubes 2: Properties and Applications Article Discussion - Tan
Week 9	Diamond, DLC Nanodiamond Article Discussion - Bundy
Week 10	Summary Quiz II Term papers due

Each student will perform a critical analysis (review) of a published article and write a term paper on a given topic.

Proposed paper topics

1. Carbon tribology – graphite vs. carbon onions, nanodiamond and fullerene
2. Activated carbon vs. zeolites – is it possible to control porosity in nanoporous carbon?
3. Hydrogen storage – nanotubes vs. nanoporous carbon
4. Field emission devices – nanotubes vs. diamond
5. Nanotube-based electronics vs. silicon electronics
6. Carbon electrodes in supercapacitors – nanotubes vs. graphite
7. Carbon in lithium batteries
8. Medical applications of carbon
9. Carbon reinforcements for composites – nanotubes vs. carbon fibers
10. Carbon nanofibers – the strongest fiber known?
11. Diamond as an electronic material
12. Raman spectroscopy of carbon - can it provide all answers we need?
13. What can be harder than diamond?
14. Carbon nanotubes for space elevator – science fiction of the future of space exploration?

Weekly Article Review Format

Template will be posted on course blog

Paper Format

These are 5 pages in length (single spaced, 12 pts font), not including tables, figures and references. Illustrations in the term paper should be in tables and/or figures AND INSERTED AT THE APPROPRIATE POINT IN THE TEXT. Try to EXPLAIN what you read and prove that author's explanation is correct (or wrong, if you disagree). Try to find alternative explanations. You should BEGIN your paper with 3 or 4 short sentences summarizing what you prove in the discussion.

Notes:

References - Make sure you have at least five journal articles and that you reference them properly. Number references consecutively throughout the text. List all references by number under 'References'. If a reference is repeated, it retains the original number. Each reference must include author(s), volume, page, and year. For books, include the title, publisher, and editor (if applicable). WEB SITES CANNOT SERVE AS THE EXCLUSIVE BASIS FOR YOUR REPORT!

Tables - Put a caption at the top and number them I, II, II...

Figures - Put a caption at the bottom and number them 1, 2, 3, ...MAKE SURE ALL THE AXES ARE LABELLED!

DUE DATES – Article review (1 page) is due on the day of its presentation in class. Term paper is due on March 16.

Grading Scheme

Quiz I	25%
Quiz II	25%
Article Reviews (homeworks)	20%
Term paper	20%
Article discussion in class	10%