

Nanostructured Carbon Materials

MATE 580 (MatPAC course – Winter 2005)

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 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 Wednesday at 6 PM – 8:50 PM

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

Instructor

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Textbook

Hugh O. Pierson, "Handbook of Carbon, Graphite, Diamond and Fullerenes," Noyes Publications, Park Ridge, NJ, 1994

Can be found in the Knovel electronic database that Drexel University is subscribed to. It can be downloaded from: <http://www.knovel.com/knovel2/Toc.jsp?SpaceID=10089&BookID=242>

Free!!!

Additional reading:

1. P.J.F. Harris, "Carbon Nanotubes and Related Structures," Cambridge University Press, Cambridge, 1999.
2. 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)

Proposed papers for discussion:

1. Kroto, H. W., J.R. Heath, S.C.O'Brien, R.F.Curl & R.E.Smallley. C₆₀ Buckminsterfullerene. *Nature* **318**, 162-163 (1985).
2. Iijima, S. Helical Microtubes of Graphite Carbon. *Nature* **354**, 56-58 (1991)
3. Smith, B. W., M. Monthieux, and D. E. Luzzi. Encapsulated C₆₀ in carbon nanotubes. *Nature* **396**, 323 (1998).
4. Rao, A.M. et al., Diameter-Selective Raman Scattering From Vibrational Modes in Carbon Nanotubes. *Science* **275**, 187-190 (1997)
5. Wong, E. W., Sheehan, P. E. & Lieber, C. M. Nanobeam Mechanics: Elasticity, Strength, and Toughness of Nanorods and Nanotubes. *Science* **277**, 1971-1974 (1997).
6. Gogotsi, Y., Libera, J. A., Kalashnikov, N. & Yoshimura, M. Graphite Polyhedral Crystals. *Science* **290**, 317-320 (2000).
7. Kutznetsov, V. L., Zilberberg, I. L., Butenko, Y. V. & Chuvilin, A. L. Theoretical study of the formation of closed curved graphite-like structures during annealing of diamond surface. *J. Appl. Phys.* **86**, 863 - 870 (1999).

8. Yildirim, T. et al. Intercalation of sodium heteroclusters into the C₆₀ lattice, Nature **350**, 568-571 (1992).

Schedule

5 Jan	Organization, Introduction. The Element Carbon – Structure, Chemistry, Phase Diagrams
12 Jan	Graphite: Structure, Synthesis, Properties and Applications. Advanced Carbon Materials - Exfoliated Graphite and Carbon Fibers Article Discussion.
19 Jan	Diamond Synthesis, Properties and Applications Article Discussion.
26 Jan	Quiz #1.
2 Feb	Nanodiamond, Amorphous Carbon and DLC. Article Discussion.
9 Feb	Fullerenes. Article Discussion.
16 Feb	Carbon Onions and Related Structures. Article Discussion.
23 Feb	Carbon Nanotubes: Structure, Synthesis and Properties. Article Discussion.
2 Mar	Carbon Nanotubes: Applications. Non-carbon layered structures: Inorganic Fullerenes, nanotubes, etc. Article Discussion.
9 Mar	Quiz #2. Summary and Overview.
16 March	Term papers due.

Each student (or a student group in case of a large number of students in class) will perform a critical analysis (review) of a published article and write a term paper on a given topic. The students are also expected to make two conference style presentations in which they give a complete account of what they studied.

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?

Paper Format

These are 5 pages in length, 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.

Presentation Format

You will present all the insights you have developed after reading and critically reviewing the articles. The best approach is to think of this as a conference presentation. The recommended format is described below. You will have 10 minutes to present the article review, and there will be ample time for questions and discussion.

Grading Scheme

Quiz I	25%	
Quiz II	25%	
Article Review		10%
Term paper	20%	
Homeworks	20%	