MATERIALS SCIENCE OF NANOSTRUCTURES – MSE/ME 1469/2069

Department of Mechanical Engineering &Materials Science,University of Pittsburgh

A. INSTRUCTOR

Dr. John P. Leonard, 831 BEH, x4-3512, jleonard@engr.pitt.edu
Office hours: M 3-5p, or other times by appointment. Email correspondence is also encouraged.

B. LECTURES

W 4:00-6:25p, 1220 BEH

Each week the lecture will cover a different aspect of nanoscience and nanotechnology from a materials science perspective. This means we will look at the various processes and techniques by which nanostructures are created, as well how the composition and structure affects the functionality. Specific topics concerning nanostructure materials issues and challenges will be discussed.

C. TEXTBOOK

Required: C.P. Poole, F.J. Owens, Introduction to Nanotechnology, Wiley Interscience, (2003).

Recommended: M. Kohler, W. Fritzsche, Nanotechnology - An Introduction to Nanostructuring Techniques, Wiley VCH, (2004).

As the course is given as a graduate elective, the emphasis will be on attendance and active participation in the lecture discussions and independent background reading outside the course. Each week a reading list will be given, and selected articles posted at http://www.engr.pitt.edu/jleonard/MSE2069/home.htm Each student will be responsible for the readings before the lectures to participate in discussions.

D. PROBLEM SETS

Several problem sets will be assigned during the semester, corresponding to a various aspects of nanostructures. Each set will consist of a number of 'challenge' problems applying physical science fundamentals on a nano-scale. Students are encouraged to discuss the problems, but the work handed in should be your own.

E. GRADING

Although it isn't possible to know the actual basis of the course grade definitively beforehand, we can assume it will be approximately:

ATTENDANCE/PARTICIPATION 25%
PROBLEM SETS 25%
TERM PAPER/TALK 50%

F. TERM PAPER

Each student will conduct a literature-based research project on a specific area of nanotechnology, and write an original 'journal quality' review article which will be turned in at the end of the semester. To spread the workload more evenly throughout the semester, a series of deadlines leading up to the final manuscript (or talk) are specified in the attached calendar. These include the Abstract, Outline, Draft, and Final versions. You will be given more details on the format as the semester progresses.

A small subset of students— selected by popular vote among the members of the class— will be asked to give a 30 minute (Powerpoint) talk on their chosen topic. These students will not be required to submit a review article—they will be graded on the quality of their talk.

G. UNDERGRADUATES

All undergraduates are encouraged to participate in the lecture discussions, and will also be responsible for the assigned readings, problem sets, and term paper. They will, however, be exempt from the oral presentation 'popularity contest' and their problem sets and term papers will be graded on a separate scale.

H. SYLLABUS

DATE	TOPIC	ASSIGN
3-Jan	Introduction - Nanostructures	
10-Jan	Nanolithography	Handout PS1
17-Jan	Nanolithography	
24-Jan	Nanostructures from the Vapor	PS1 Due, Handout PS2
31-Jan	Nanostructures from the Vapor	Abstracts Due
7-Feb	Nanostructures from the Solid	PS2 Due, Handout PS3, Voting
14-Feb	Nanostructures from the Solid	
21-Feb	Nanostructures from Solution	PS3 Due, Handout PS4
28-Feb	Nanostructures from Solution	Outline Due
7-Mar	Nanostructures by Assembly	PS4 Due, Handout PS5
14-Mar	*Spring Break*	
21-Mar	Nanostructures by Assembly	First Draft Due
28-Mar	Nanotechnology Outlook	PS5 Due
4-Apr	Talks	
11-Apr	*Spring MRS*	
18-Apr	Talks	Final Draft Due

Note: Some due dates and lecture topics may be subject to change.

I. ASSISTANCE

If you have a disability for which you are or may be rquesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 216 William Pitt Union, (412)648-7890, TTY(412)383-7355, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

J. REFERENCES

A large number of books (a few hundred !) on nanotechnology have appeared in the past 10 years— obviously of varying quality. The course draws on materials from the following texts. Entries marked by the '⌘' symbol are on reserve at the Engineering Library, while most others are available from the Pitt or CMU libraries. Please be mindful of other students in the course and return any books promptly when finished with them.

J.1. GENERAL TEXTBOOKS

1. A. Nabok, "Organic and Inorganic Nanostructures", Artech House, (2005).
2. M. Kohler, W. Fritzsche, "Nanotechnology - An Introduction to Nanostructuring Techniques", Wiley VCH (2004).
3. M. Di Ventra, S. Evoy, J.R. Heflin, “Introduction to Nanoscale Science and Technology”, Kluwer Academic (2004)
4. V.A. Shchukin, N.N. Ledentsov, D. Bimberg, "Epitaxy of Nanostructures", Springer (2004).
5. C. Delerue, M. Lannoo, "Nanostructures Theory and Modeling", Springer, (2004).
6. B. Bhushan (ed.), "Handbook of Nanotechnology", Springer Verlag, (2004).
7. C.P. Poole, F.J. Owens, "Introduction to Nanotechnology", Wiley Interscience (2003).⌘
8. V. Balzani, A. Credi, M. Venturi, "Molecular Devices and Machines", Wiley VCH (2003).
9. J.G. Korvink, A. Greiner, "Semiconductors for Micro and Nanotechnology-- An Introduction for Engineers", Wiley-VCH (2002).
10. P. Milani, S. Iannotta, "Cluster Beam Synthesis of Nanostructured Materials", Springer Verlag (1999).
11. D.K. Ferry, S.M. Goodnick, "Transport in Nanostructures", Cambridge University Press (1997).
12. A.S. Edelstein, R.C. Cammarata, "Nanomaterials-- Synthesis, Properties, and Applications", Institute of Physics Publishing, (1996).
13. K.E. Drexler, "Nanosystems-- Molecular Machinery, Manufacturing, and Computation", Wiley Interscience, (1992).

J.2. EDITED REVIEWS

14. W.R. Fahrner, "Nanotechnology and Nanoelectronics", Springer, (2005).
15. C.N.R. Rao, A. Muller, A.K. Cheetham (eds.), "The Chemistry of Nanomaterials", Wiley VCH, Vol. 1, Vol. 2 (2004).
16. H. Baltes, O. Brand, G.K. Fedder, C. Hierold, J.G. Korvink, O. Tabata, "Enabling Technology for MEMS and Nanodevices", Wiley VCH, (2004).
17. L.M. Liz-Marzan, P.V. Kamat, "Nanoscale Materials", Kluwer Academic Publishers, (2003).
18. H. Fujita, "Micromachines as tools for nanotechnology", Springer, (2003).
19. A.L. Effros, D.J. Lockwood, L. p, "Semiconductor Nanocrystals, From Basic Principles to Applications", Kluwer Academic Publishers (2003).
20. Z.L. Wang, Y. Liu, Z. Zhang, "Handbook of Nanophase and Nanostructured Materials", Kluwer Academic Publishers, Vol. I: Synthesis (2003).⌘
21. Z.L. Wang, Y. Liu, Z. Zhang, "Handbook of Nanophase and Nanostructured Materials", Kluwer Academic Publishers, Vol. II: Characterization (2003).⌘
22. Z.L. Wang, Y. Liu, Z. Zhang, "Handbook of Nanophase and Nanostructured Materials", Kluwer Academic Publishers, Vol III: Materials Systems and Applications (2003). ⌘
23. Z.L. Wang, Y. Liu, Z. Zhang, "Handbook of Nanophase and Nanostructured Materials", Kluwer Academic Publishers, Vol. IV: Materials Systems and Applications II (2003). ⌘
24. Z. Tang, P. Sheng, "Nano Science and Technology-- Novel Structures and Phenomena", Taylor and Francis, (2003).
25. P. Knauth. J. Schoonman (eds.), "Nanostructured Materials Selected Synthesis Methods, Properties and Applications", Kluwer Academic Publishers (2002).
26. T. Chakraborty, F. Peeters, U. Sivan, "Nano-Physics and Bio-Electronics: A New Odyssey", Elsevier (2002).
27. P. Knauth. J. Schoonman (eds.), "Nanocrystalline Metals and Oxides Selected Properties and Applications", Kluwer Academic Publishers (2002).
28. V.M. Shalaev (ed.), "Optical Properties of Nanostructured Random Media", Springer (2002).
29. C.C Koch, "Nanostructured Materials", Noyes Publications (2002).
30. M. Grundmann, "Nano-Optoelectronics", Springer (2002).
31. M. Ohtsu, "Optical and Electronic Process of Nano-Matters", Kluwer Academic Publishers (2001).
32. M.S. Dresselhaus, G. Dresselhaus, P. Avouris (eds.), "Carbon Nanotubes", Springer (2001).
33. T. Tsakalakos, I.A. Ovidko, A.K. Vasudevan, "Nanostructures: Synthesis, Functional Properties and Applications (eds.)", Kluwer Academic Publishers Proceedings, NATO Advanced Study Institute on Synthesis, Crete GREECE (2001).
34. N. Garcia, M. Nieto-Vesperinas, H. Rohrer (eds.), "Nanoscale Science and Technology", Kluwer Academic Publishers (1998).
35. G. Timp, "Nanotechnology", AIP Press (1998).
36. L.V. Interrante, M.J. Hampden-Smith, "Chemistry of Advanced Materials", Wiley-VCH, (1998).
37. J.H. Fendler, "Nanoparticles and Nanostructured Films", Wiley VCH, (1998).
38. A.N. Goldstein, "Handbook of Nanophase Materials", Marcel-Dekker (1997).
39. V.M. Shalaev, M. Moskovits (eds.), "Nanostructured Materials Clusters Composites and Thin Films", American Chemical Society 679 (1997).
40. N. Taniguchi, "Nanotechnology", Oxford University Press (1996).

J.3. TOPICAL

41. K. Seshan (ed.), "Handbook of Thin-Film Deposition Processes and Techniques", Noyes Publications 2nd edition (2002).
42. D. Attwood, "Soft X-Rays and Extreme Ultraviolet Radiation", Cambridge University Press (2000) .
43. P. Rai-Choudhury, "Handbook of Microlithography, Micromachining, and Microfabrication", SPIE Optical Engineering Press Vol. 1 (1997).
44. P. Rai-Choudhury, "Handbook of Microlithography, Micromachining, and Microfabrication", SPIE Optical Engineering Press Vol. 2 (1997).
45. M.A. Herman, H. Sitter, "Molecular Beam Epitaxy: Fundamentals and Current Status", Springer Series in Materials Science, Vol. 7, 2nd Ed. (1996).
46. S.K. Ghandhi, "VLSI Fabrication Principles: Silicon and Gallium Arsenide", Wiley Interscience (1994).
47. J.Y. Tsao, "Materials Fundamentals of Molecular Beam Epitaxy", Book, Academic Press, (1993).
48. K.N. Tu, J.W. Mayer, L.C. Feldman, "Electronic Thin Film Science", Macmillan Publishing, (1992).
49. M. Ohring, "The Materials Science of Thin Films", Academic Press (1992).
50. A. Goswami, "Quantum Mechanics", WC Brown, (1992).
51. J.W. Mayer, S.S. Lau, "Electronic Materials Science: For Integrated Circuits in Si and GaAs", Macmillan Publishing, (1990).
52. K. Jain, "Excimer Laser Lithography", SPIE Optical Engineering Press (1990) .
53. A. Zangwill, "Physics at Surfaces", Cambridge University Press, (1988).
54. G. Burns, "Solid State Physics", Academic Press, (1985).

J.4. PROCEEDINGS

55. H.J. Fecht, M. Werner, "The Nano-Micro Interface", Wiley-VCH, (2004).
56. E.V. Dirote, "Focus on Nanotechnology Research", Nova Science Publishers, (2004).
57. H. Knobloch, Y. Kaminorz (eds.), "MicroNano Integration", Springer (2004).
58. L.L. Shaw, C. Suryanarayana, R.S. Mishra, "Processing and Properties of Structural Nanomaterials", TMS, (2003).
59. M.Z. Hu, M.R. DeGuire, "Ceramic Nanomaterials and Nanotechnology", American Ceramic Society (2003).
60. T.M. Orlando, L. Merhardi, D.P. Taylor, K. Ikuta, "Three-dimensional nanoengineered assemblies", Materials Research Society 739 (2003).
61. G.M. Chow, I. A. Ovid'ko, T. Tsakalakos, "Nanostructured Films and Coatings", Kluwer Academic Publishers, (2000).
62. S. Yang, P. Sheng, "Physics and Chemistry of Nanostructured Materials", Taylor and Francis, (2000).
63. G.M. Chow, N.I. Noskova (eds.), "Nanostructured Materials Science and Technology", Kluwer Academic (1998).

J.5. JOURNALS

64. Advanced Materials, Wiley, Online (1998-Present).
65. Nanostructured Materials, Elsevier, Online (1995-Present).
66. Nanotechnology, IOP, Online (1990-Present).
67. Sensors and Actuators A/B, Online (1989-Present)