

CE 597N

Nano-Cleanroom Design & High-Tech Construction

Spring, 2005

Purpose: The purpose of this course is to provide basic knowledge needed for designing, and building facilities that supplement nano-manufacturing and nano-research. Nano-Tech/High-Tech includes, not limited to, the advanced technologies applied in the fields of microelectronics, nanotech, biotech, pharmaceuticals, optoelectronics, micro/nano electron mechanical system, and telecommunication. The processes undertaken in high-tech manufacturing plants and research labs require extremely stringent environmental control.

The environmental control includes the control of temperature and humidity level, air/water quality, purity of chemicals and gases, noise and vibration degree, electromagnetic and radio frequency interference, electrostatic discharge, materials out-gassing, safe grounding, personnel health, safety and security.

The focus of this course is on designing cleanroom and engineering its associated facilities. Students will gain skills needed to meet ever-changing challenge of delivering an ultra pure clean room and ultra pure utilities. Moreover, this course will strengthen students' understanding and background in managing high-tech manufacturing and research facilities.

Scope: This course is intended to offer to both graduate students and undergraduate seniors. Students in engineering, science, biology, pharmacy, and life science will be exposed to fundamental theories and their applications in the design/build/certify of the high tech manufacturing plants and research labs. Academic faculty will teach basic theories and principles. Professional industrial experts will be invited to cover the application of theories and principles in the real world practices. The contents will include lectures, home works, a semester team project with an oral presentation and a written report, and a final examination. Field trips to visit high-tech plants and research labs, and cleanrooms will be arranged. Moreover, laboratory experiments will be conducted to enable students to have hands-on experiences in the environmental impact on high-tech manufacturing and research.

On-campus students are required to attend the field trip(s) and laboratory experiment(s.) Off-campus students are welcome to participate if their times are permitted. If there are schedule conflicts, either off-campus students or excused on-campus students can learn through the steaming videos provided after the class.

Objectives: The course will enable the students to:

1. Differentiate the typical processes in semiconductor, biotech, medical device, and drug manufacturing.
2. Explain the interdisciplinary nature of high tech manufacturing and research
3. Perform architectural design for cleanroom and schematically layout factory.
4. Use the basic theories and principles to design systems for heating, ventilation and air conditioning (HVAC,) water/air treatment, noise and vibration mitigation.
5. Classify cleanrooms in terms of various international standards.
6. Specify the environmental control criteria for cleanroom in terms of temperature and humidity level, air/water quality, purity of chemicals and gases, noise and vibration degree, electromagnetic and radio frequency interference, electrostatic discharge, materials outgassing, and safe grounding.
7. Apply the knowledge in testing and commissioning cleanroom and its associated facilities.
8. Establish contamination control programs for constructing, operating, and maintaining the high-tech facilities.
9. Address the issues in automatically managing the emergency, safety, and security systems.
10. Link to the information sources for further studies in nano/micro fabrication and research.

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Faculty Experts

Prof. Jim Alleman, School of Civil Engineering, Purdue University
Prof. Robert Bernhard, School of Mechanical Engineering, Purdue University
Mr. Keith Brennan, Vice President, BMW Constructors
Prof. Vince Drnevich, School of Civil Engineering, Purdue University
Prof. James Cooper, Director of Purdue Birck Nano-Technology Research Center
Prof. Daniel Hirlerman, Head of Mechanical Engineering School
Dr. Bryan Hubbard, Purdue Division of Construction Engineering & Management
Prof. Dave Janes, School of Electrical and Computer Engineering, Purdue University
Prof. Alex King, Head of Purdue School of Materials Engineering.
Mr. Alex Konopka, Engineering Consultant, Eli Lilly and Company
Mr. Dave Lubelski, Lab Coordinator, Purdue School of Electrical and Computer Engineering
Mr. Donald Moore, Jr., Engineering Consultant, Eli Lilly and Company
Prof. Kenneth R. Morris, Department of Industrial and Physical Pharmacy, Purdue University
Mr. Tim Puls, Associate Engineering Consultant, Eli Lilly and Company
Prof. R. Reifenberger, Department of Physics, Purdue University
Mr. John Weaver, Manager, Contamination Control, Delphi Delco Electronics
Mr. Greg Weddle, Global Manager of Validation, Johnson Controls

Textbook: Whyte, W., Cleanroom Design, John Wiley, 2nd ed., New York 1999.

Class Hours: Tuesday and Thursday, 1:30pm-2:45pm

Course Requirements

There will be approximate 10 home works in spring 2005. In the last, there were 8 in spring 2003 and 12 in spring 2004. Homework counts 20% of "Total Grade." Students will have reading assignments. The homework is to answer the questions derived from the reading assignments, lectures, lab experiments, cleanroom tour, and field trip..

There is one (1) group term project. The group term project tests the student understands of the principal concepts covered in the course within the context of a comprehensive "real-world" problem. It also provides an opportunity to develop skills for working in a project team context and communication skills. The term project counts 50% of the final grade. Off-campus students are encouraged to form a virtual group working on job-related topics through internet and/or other means.

A Final Exam is required in the final exam week of May 2-7. The Final Exam will be comprehensive and counted as 20% of "Total Grade." Another 10% is for class participation.

References:

1. Chang, C.Y., and Sze, S.M., ULSI Technology, McGraw-Hill Company, Inc., International Edition, 1996, New York.
2. Food and Drug Administration, Guideline on Sterile Drug Products Produced by Aseptic Processing, FDA, Information Branch, Rockville, Maryland, USA.
3. International Organization for Standards, ISO Standard 14644-4, part 4: Design, Construction, Start up, Geneva, Switzerland, 1999.
4. International Society of Pharmaceutical Engineering, Pharmaceutical Engineering Guide – A Guide for New Facilities, Volume 3: Sterile Manufacturing Facilities, ISPE, 2000.
5. Lurgi, S., Xu, J., and Zaslavsky, A., Future Trends in Microelectronics, Wiley, N.Y., 1999.
6. Mulhall, D., Our Molecular Future: How Nanotechnology, Robotics, Genetics, and Artificial Intelligence Will Transform Our World, Prometheus Books, Amherst, N.Y., 2002.
7. Nishi, Y., Doering, K., and Wooldridge, T., Handbook of Semiconductor Manufacturing Technology, Marcel Dekker, New York, 2000.
8. Scherge, M., Biological Micro- and Nanotribiology: Nature's Solutions, Springer, New York, 2001.
9. Van Zant, Peter, Microchip Fabrication: A Practical Guide to Semiconductor Processing, 4th ed., McGraw-Hill, New York, 2000.
10. Whyte. W., Cleanroom Technology: Fundamentals of Design, Testing, and Operation, Chichester, New York, 2001.

Tentative CE 597N COURSE OUTLINE –SPRING 2005

WEEK	SUBJECT
1	Course Introduction Nano/Micro Manufacturing and Research Semiconductor Manufacturing Processes
2	Drug, Medical Devices, and Biotech Manufacturing Processes Cleanroom and Facilities Overview
3	On Campus Cleanrooms and Research Facility Tour Cleanroom for Pharmaceutical and Biotech Industries
4	Factory Layout, and Architectural Design Vibration Source, Measurement, & Mitigation
5	Noise Source, Measurement, & Mitigation HVAC Basics
6	HVAC Design Air Quality, Contamination and Treatment
7	Distributed Gas & Chemical Systems Contaminated Water and City Water Treatments
8	Ultra Pure Water for Semiconductor Manufacturing and Nano-Technology Research Ultra Pure Water for Pharmaceutical, Medical, and Life Science Use

9	Ultra Pure Piping Systems Electrical Systems, and Power Stability,
10	SPRING BREAK – NO CLASS
11	Eletromagnetic and Radio Frequency Interferences, Electrostatic Discharge and grounding Safety. High Performance Microscopes
12	Laser/Optical Measurement Methods and Defects Laboratory Experiment in Environmental Impact on Sensitive Tools II (Atomic Force Microscope)
13	Emergency, Security Systems and Automatic Control and Intelligent Plants Field Trip Cleanrooms and Factory Facilities
14	Cleanroom Testing and Certification Cleanroom and Factory Commissioning
15	Clean-Build and Clean-Operate Protocols Management and Contract Strategy on High-Tech Constructed Projects
16	Term Project Report Due and Presentation Course Summary, Review & Evaluation

1. The course outline may be adjusted to students' interests and learning progress.
2. Guest Speakers may be invited to reinforce students understanding of applying theories into real world practice.

**GROUP
PROJECT:**

There is one (1) group term project. The group term project tests the student's understanding of the principal concepts covered in the course within the context of a comprehensive "real-world" problem. It also provides an opportunity to develop skills for working in a project team (on campus students)/ a virtual project team (off campus students) context and communication skills.

Student term project may select, but not limit to the following subjects:

1. Cleanroom Design/Build/Certification
 - A. Design/Build Process management
 - B. Building Automation and Modulization
 - C. Energy Conservation and Pure Water Reclaiming
 - D. Clean Air Supply, Distribution, Assessment and Improvement
 - E. Analysis and Improvement of Clean Build Protocol
 - F. Benchmarking Construction Time and Cost
 - G. Cleanroom Testing and Commissioning
2. Automation of Integrated Design/Build Information
 - A. Information, Technology Application in Plant Facility – Design, Build, Operate, Maintain and Manage
 - B. Seamless Integration
 - C. Paperless Manufacturing
 - D. 4D CAD Time/Cost Integration.
 - E. Virtual Reality for Planning, and Interference Checking
 - F. Tool-up strategy and optimization
3. Vibration Criteria and Mitigation Strategies
 - A. Structure Stiffness Enhancement
 - B. Micro and Nano-Scale Vibration Measurements
 - C. Noise and Vibration Control
 - D. Isolated Foundation
 - E. EMI & RF mitigation on sensitive tools.
 - F. Move-in of equipment and tools on raised Floor
4. Safety and Environmental Protection
 - A. Construction, Operation, and Maintenance Safety
 - B. Contaminated Water and Air Treatments
 - C. Fire, Flood, Earthquake, and Wind Mitigation
 - D. Contamination Management
 - E. Ultra Pure Piping System Installation and Waste Treatment
 - F. Industrial Hygiene
 - G. Security and safety system

5. Plant Life Cycle Cost Analysis
 - A. Finance and Cost Analysis
 - B. Timely Feedback System
 - C. Economic Effectiveness
 - D. Assessment of Operation Performance
 - E. Simulation
 - F. Protocols for Clean Design, Clean Build, and Clean Operation.
 - G. Dynamic Impact of Periodical Maintenance

6. Case Studies on:
 - A. Purdue ECE Cleanroom Design
 - B. Purdue Birck Nanotechnology Center and Cleanroom Design
 - C. Eli Lilly Cleanroom and Factory Design
 - D. Delco Electronics Cleanroom and Factory Design
 - E. National Institute of Standards and Technology Advanced Measurement Lab (NIST AML) Cleanroom Design
 - F. Other Designed Cleanrooms.
 - g. Combined cleanroom for both semiconductor and life science research

7. Job Related:

Any topic related to High-Tech Fab and Lab: Business Decision, Design, Construction, Start-up, Certification, Commissioning, operation, and/or Maintenance.

Preplanning,