Use of Flash Simulations to Enhance Nanotechnology Education

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Abstract

The numerous developments in the field of nanotechnology underscore a need for educating the technical workforce in nanoscience and technology. Thus, it is necessary that science and technology graduates should be able to integrate the key concepts of nanotechnology into their knowledge bases.

Realizing the need for providing nanotechnology education and training at the undergraduate level to technicians and engineering technologists, Excelsior College has recently developed a Nanotechnology Concentration within its on-line Bachelor of Science in Electrical Engineering Technology Program (BSEET). In this concentration, students are required to complete five on-line, 3 credit-hour upper division courses.

The first one in the above mentioned list of five nanotechnology courses is titled “Introduction to Nanotechnology” (ELEC 305). The course focuses on the conceptual fundamentals of nanoscience and technology and covers topics such as nanotechnology fundamentals, quantum dots, nanosensors, nanomachines, and the nanotechnology applications in engineering, physics, chemistry, and biology.

The second core course in the above mentioned list of nanotechnology courses is titled “Introduction to Nanofabrication Processes” (ELEC 310). This course provides an introduction to the basic principles and methods of nanofabrication and the associated metrology/characterization methods used in industrial and research applications of nanotechnology.

This manuscript focuses on the use of flash simulations to make instructional enhancements in the content of ELEC 305 and ELEC 310. Both these on-line courses combine virtual reality, graphics, text, and sound.

Introduction

With the advancement of the Internet, on-line instruction is becoming popular in engineering education [1]. Traditional and non-traditional colleges and universities are now using a variety of instruction tools to deliver on-line instruction to their students. Bb9 (Blackboard 9) is an on-line tool that facilitates the development of web-based educational environments. In the case of Excelsior College, delivery of instruction is achieved primarily through the use of Bb9 distance learning tool. The key features of Blackboard are listed in [2].

The key advantage of offering on-line nanotechnology courses is a virtual classroom that is available anywhere: at school, at work, at home, or even on a trip. In addition to the geographic and temporal independence, the on-line nanotechnology courses offered by Excelsior College are of significant help in enhancing the communication skills of students. The students taking these

courses are able to communicate both synchronously and asynchronously using web-based electronic mail, chat rooms, and electronic whiteboards.

As mentioned before, the Nanotechnology Concentration comprises five on-line upper level undergraduate courses which include:

- Introduction to Nanotechnology
- Basic Nanofabrication Process
- Nanotechnology Process Equipment
- Introduction to Nanofabrication Manufacturing Technology
- Micro-electro-mechanical systems (MEMS)

Course Content

At Excelsior College, the on-line instruction in nanotechnology is being phased in gradually. At present, two on-line nanotechnology courses have been developed. The first one, titled “Introduction to Nanotechnology” was developed during Spring 2008. This on-line course was offered to the Excelsior College Engineering Technology students during Fall 2008 semester. The second on-line course titled “Basic Nanofabrication Processes” was developed during summer 2009 and will be offered during Spring 2010. Three additional on-line nanotechnology courses will be developed and offered during the 2010 and 2011.

The BSEET Nanotechnology Concentration core course titled “Introduction to Nanotechnology” is a 3 credit-hour on-line course. The course is offered at the junior level of a 4-year undergraduate degree. The topical coverage for this course consists of:

- Manipulation of Materials at Nanoscale
- Carbon Nanotubes
- Semiconductor Quantum Dots
- Nanoparticles
- Nanoshells
- Nanobiology Applications
- Nanosensors Applications
- Nanomedicines
- Molecular Naomachines

Since this is an on-line course, all the students are required to have access to the following computing resources:

- A reasonably up-to-date personal computer that runs Windows 98 or later.
- Availability to MS-Office, especially Word
- Capability to open and display PDF files
- A working and reliable internet connection with a current Web Browser.

The second on-line nanotechnology course offered by Excelsior College is titled “Introduction to Nanofabrication Processes” (ELEC 310). This 4 credit-hour course provides an introduction and basic understanding of the fundamental principles of nanofabrication processes used in industrial and research applications of nanotechnology. This course describes the industrial scaling of nanofabrication techniques and showcases examples of specific industrial applications in electronics, photonics, chemistry, biology, medicine, defense, and energy.

Course Enhancements

In order to enhance the course content and to improve the instructional effectiveness of ELEC 305 and ELEC 310, Excelsior College has recently implemented the use of flash simulations in these on-line courses. Flash simulations are effective educational media. They are:

- Interactive
- Show objects in 3D by rotating them on the screen.
- Dynamic
- Make use of virtual reality.

As described in [3], the use of a web technology, such as Flash, Java, or Java Script, to create an animation of a system moving dynamically, is very helpful in developing a clear understanding of the course concepts. Many students are visual learners and thus animation of a physical system can be an important tool to help them learn.

The flash simulations are used in ELEC 305 and ELEC 310 on-line courses to explain the key concepts of nanoscience and technology. As shown in Figures 1 to 14, the flash simulations illustrate the following concepts:

- Lattices (Figure 1)
- Quantum dots (Figure 2)
- Chirality (Figure 3)
- Medical Applications of Nanotechnology (Figure 4)
- Protein Nanosensors (Figure 5)
- Nanomachines (Figure 6)
- Donor & Acceptor type doping in a semiconductor crystal lattice (Figure 7)
- Rotation Speed effect on Silicon Ingot Quality(Figure 8)
- Clean Room Contaminants (Figure 9)
- Silicon Wafer Size/Die Size Yield Ratios (Figure 10)
- Silicon Dioxide Growth Parameters (Figure 11)
- Silicon Wafer Lithography (Figure 12)
- Silicon Wafer Lithography (Figure 13)
- Lithography Resolution Process Roadmap (Figure 14)

Conclusion

Virtual reality simulations, such as flash simulations make the nanoscale object “visible” to students. The use of these simulations helps students understand the concepts of nanoscale science. It is due to this realization that flash simulations are being used in two core on-line courses included in the course list for the BSEET Nanotechnology Concentration offered by Excelsior College. As shown in the Figures 1-14, these simulations are very helpful in providing a clear understanding of key nanoscience and technology concepts such as quantum dots, chirality, nanosensors, and nanomachines. The two courses described in this manuscript focus on the nanotechnology fundamentals and the nanofabrication processes.

Bibliography

1. Anwar, S., J. A. Rolle, and A. A. Memon. “Development and Delivery of On-line Upper Division Engineering Technology Courses”. *Proceedings of the 2005 ASEE Annual Conference*.
2. Yaprak, E. and L. Anneberg. “Laboratory-Oriented Distance Learning”. *Proceedings of the 2003 ASEE Annual Conference*.
3. Bielenberg, A. and E. Cheever. “Web-Based Scripts for Animating System Simulations”. *Proceedings of the 2011 ASEE Conference*.

Figure 1: Lattices

Figure 2: Quantum dots

Figure 3: Chirality

Figure 4: Medical Applications of Nanotechnology

Figure 5: Protein Nanosensors

Figure 6: Nanomachines

Donor & Acceptor type doping in a semiconductor crystal lattice

Figure 7: Donor & Acceptor type doping in a semiconductor crystal lattice

Figure 8: Rotation Speed effect on Silicon Ingot Quality

Clean Room Contaminants

Below are two magnified views through a window into a clean room. The room on the left is a control group showing a well-maintained clean room. The window on the right shows the impact of adding various contaminants to the cleanliness of the room air. Click on the various contaminant types to see what impact they have on air quality.

Control Group

Test Group

- ☒ Normal Breath
- ☐ Smoker's Breath
- ☐ Sneezing
- ☒ Sitting Quietly
- ☐ Rubbing Hands on Face
- ☐ Walking
- ☒ Stamping Foot on Floor

Figure 9: Clean Room Contaminants

Figure 10: Silicon Wafer Size/Die Size Yield Ratios

Figure 11: Silicon Dioxide Growth Parameters

Silicon Wafer Lithography

Drag the steps to their proper order

✓	Surface Preparation
✓	Photoresist Apply
✓	Softbake
⬆	Hard Bake
⬆	Develop Inspect
⬆	Alignment and exposure
⬆	Development
⬆	Photoresist Removal (strip)
⬆	Etch
⬆	Final Inspection

Softbake
Partial evaporation of photoresist solvents by heating.

Completed Steps

1. Surface Preparation
Clean and dry wafer surface.

2. Photoresist Apply
Spin coat a thin layer of photoresist on surface.

3. Softbake
Partial evaporation of photoresist solvents by heating.

Figure 12: Silicon Wafer Lithography

Figure 13: Silicon Wafer Lithography

Figure 14: Lithography Resolution Process Roadmap