Interactive Online Curricula and Resources for 125,000 nanoHUB.org Users

Gerhard Klimeck
Director
Network for Computational Nanotechnology (NCN)
Electrical and Computer Engineering
gekco@purdue.edu

University Materials Council Meeting
Northwestern University, June 23, 2010

1965
Gordon Moore

http://www.intel.com/technology/mooreslaw

Number of Components per Integrated Circuit

Relative Manufacturing Cost per Component
Intel in 2009

Device Size:
Tens of nanometers

Stanford SUPREM

Device Integration:
>2 Billion

Berkeley SPICE

Berkeley
Simulation Program with Integrated Circuit Emphasis.

from: Larry Nagel, BCTM ’96
- Started as a class project
- Developed as a teaching tool
- Quality control: pass Pederson
- Dissemination:
  - Public domain code
  - Pederson carried tapes along
  - Students took it along to industry and academia
- Released 1972
Stanford University Process Modeling

- Stanford wanted to mimic Berkeley success
- Combine various existing models
- Dissemination:
  - Public domain code
  - Community workshops
  - Students took it along to industry and academia

Birth of an Industry

Intel Capitalization: $85B
Total Industry: $280B
Moore’s Law for Other Disciplines?

Nano Initiatives

Research

Electronics

Materials

Photonics

Mechanics

Bio/Medicine

Device Size

nano-scale structures

Years

Transistors

Billions of nano structures

It Happens Here

[Image of a website called nanohub.org with various links and resources related to nanotechnology]
Over 2,100 Resources!

- 170 tools
- 43 courses
- 1,557 seminars and teaching materials

World-Wide Community

- 116,000 users worldwide
- As much traffic as www.purdue.edu
- Users at all Top 50 US Engr Schools
- 19% of all .edu domains
- 116 classes at 76 institutions in 2009
- 8,200 users ran 345,000 simulations
- 172 countries

Demo>>
A course on nanophotonics

Introduction to semiconductor device education with ABACUS

Assembly of Basic Applications for Coordinated Understanding of Semiconductors

What is the silicon crystal structure

What is the band structure

What are highly doped P/N-junctions

Where is voltage drop in a MOSFET

tutorials  all lessons  main
Advancing Quantum Mechanics for Engineers with AQME

What is resonant tunneling?

What is an artificial atom?

What is the relation between confinement potential and the state spectrum?

What are MOSFET subbands?

Tool Powered Curricula

“make abstract concepts more concrete”
Use in the classroom

In the year 2009:
116 classes; 76 institutions; 23 countries

Work with Teachers

*Educational workshop:*
- November 5-6, 2009, Chicago Airport
- 11 faculty
- 11 institutions / 8 primarily serving minorities
Immediate Impact

Hasina Huq
UT Pan Am.
11 Simulation users

Tanya Faltens
Cal Poly Pomona
53 Simulation users

NanoHUB on iTunes U

Exclusive - Apple VP
OK’ed
- one of 68 orgs

- apple.png
nanoHUB on iTunes U

Nov 2009 start
350 content items today
55,000 downloads
~10,000 downloads/month

Wikipedia Contributions

16 animations deployed Jan 2010 on ~30 pages
Brings 2,000 visitors for 3,300 visits monthly
575 nanoHUB citations
469 in nano research

each dot is a paper
line is common
author

469 82% nanoresearch
142 30% expt. data
55 12% experimentalists

575 nanoHUB Citations
Research: Publish or Perish

575 nanoHUB citations
>3,200 secondary citations
h-index: 27
Use by Experimentalists: Schred

TCAD simulations using SCHRED [15] or ISE, …., were used to support our analysis and compute the inversion carrier profiles in the devices.

Effect of channel positioning on the 1/f noise in silicon-on-insulator metal-oxide-semiconductor

M von Haartman, M Oestling,
Journal of Applied Physics, 2007 - link.aip.org...

Dual Use in Research and Education

TCAD simulations using SCHRED [15] or

User Interfaces are absolutely critical!

- Same behavior across all similar converted tools
- User’s don’t have to download/install software
Recently Dr. Ahmed was promoted to tenured Associate Professor. I would like to emphasize that Dr. Ahmed's use of nanoHUB in education and research, which earned him national and international visibility, did play a significant positive role in his early promotion case.

Glafkos Galanos
Chair, Dept. of Electr. and Comp. Eng., SIUC
Any Science Gateway’s Dream
Why is it so hard?

Any Science

Any Engineering

Research

Change...

...the...

...world

Any Science Gateway’s Dream
There are worlds between...

Basic Research; Invention

Applied Research; Innovation

“Valley of Death”
5 Criteria for Successful Science Gateways

1: Outstanding Science

“Stuff the world wants”

Leveraged Research

$5.1M

Basic Research; Invention
2: Commitment to Dissemination

“faculty that want to give it away”

46 faculty

+ 6 site leads

106 grad students

3: Technology for Dissemination

Basic Research; Invention

Applied Research; Innovation

“Valley of Death”
Typical Dissemination Paths

Problems:
- REALLY LONG stove pipe
- Web content: afterthought usually stale
- Data shared by email
- Tools spread by hiring

nanoHUB Technical Solution

Problems:
- REALLY LONG stove pipe
- Web content: afterthought usually stale
- Data shared by email
- Tools spread by hiring

Michael McLennan>>
3: Technology for Dissemination

“simple and utterly dependable”

Basic Research; Invention

$n1M/year operation and bridge building

$1M/year operation and bridge building

Valley of Death

Applied Research; Innovation

Hubs ‘R Us

- Feb 2007: 1 hub
- Feb 2008: 5 hubs
- Feb 2009: 8 hubs
- Feb 2010: 21 hubs

Each hub has its own funding stream

Outside institutions: EPA, NYSTAR, Rice
4: Tech Transfer Processes
“dedicated technical site leads”

Content Creation and Support
$2.2M

“Valley of Death”

Knowledge Transfer Research
“educational research team”

Purdue Cost Share $100k
CAREER Leverage

“Valley of Death”
5: Open Assessment / Incentives

“gather, understand, disseminate stats”

Access, Use, Impact

World-Wide Learning Community

116,000 users worldwide

As much traffic as www.purdue.edu
Users at all Top 50 US Engr Schools
19% of all .edu domains
116 classes at 76 institutions in 2009
8,200 users ran 345,000 simulations

172 countries