

# *"A Hands on Introduction to Nanoscience"*

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Cumulative product of three NSF grants on which I've served as PI:

1999 – Course Curriculum and Laboratory Improvement (CCLI)

Interactive Tools on Microelectronics for Early Science and Engineering Students

2005 – Nanoscience Undergraduate Research (NUE)

"We're Not in Kansas Anymore!"

A Hands-on Introduction to the New World of Nanoscience and Technology

2007 – Nanoscience Interdisciplinary Research Team (NIRT)

"Surface State Engineering"

Charge Storage and Conduction in Organo-Silicon Heterostructures as a Basis for Nanoscale Devices

*Common educational theme? Combating what I call the "Heathkit Effect"*

*"We're not in Kansas Anymore!" - A Hands-on Introduction to Nanoscience*

*As adolescents, many of us were able to build our OWN hi-tech:*

Shortwave Radios, TV's, PC's . . . .through Heathkits, Dynakits . . .

Or at least got to *(or had to!)* help maintain the family car



*My Heathkit Shortwave*

***No longer possible: Microtech shrank it all into hermetically sealed chips!***

Students have lost kit-building experience. Many are even losing the basic curiosity!

### **OUR FIRST IDEA:**

Take things apart in VIRTUAL REALITY using online 3D computer animations

Also use this to show the invisible (e.g. forces and fields) or the infinitesimally small

*Example: Explain semiconductors and transistors from the atomic level upward*

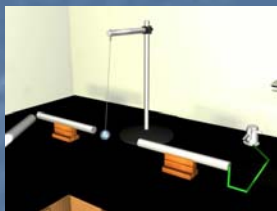
*(→ [webpage](#))*

*Grew into the "UVA Virtual Lab" website: [www.virlab.virginia.edu](http://www.virlab.virginia.edu)*

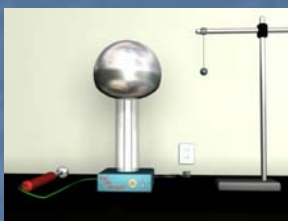
Now contains **over fifty presentations**, each with up to two-dozen animated scenes:



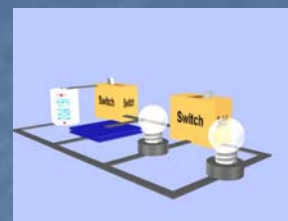
Magnetics



Electrostatics



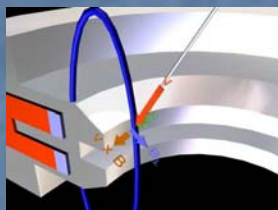
Van de Graaff



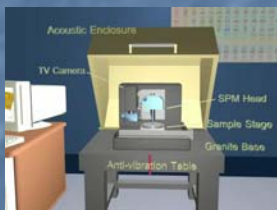
Circuits



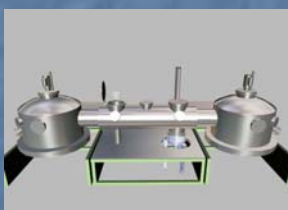
H<sub>2</sub>O Circuit Analogies



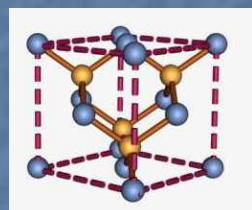
SEM



SPM



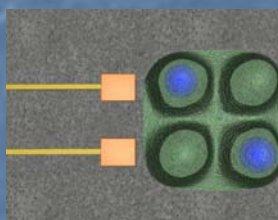
MBE



Semicond. Xtals



IC fabrication



Q-dot memory



Q-dot logic



Student IC Lab



Industrial IC Fab



IC Fab tools

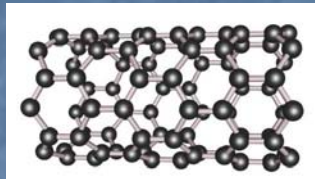
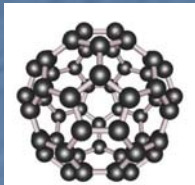
*Website has accumulated **3,600,000 hits** including visitors from over:*

***400 U.S. Universities 600 International Universities 300 K-12 Schools***

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## 2005 NUE: Expanded Nanoscience / Nanotech content:

Nanocarbon (→ [webpage](#))

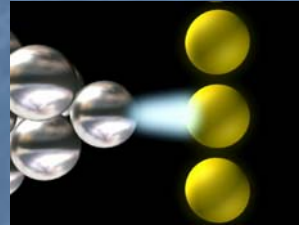
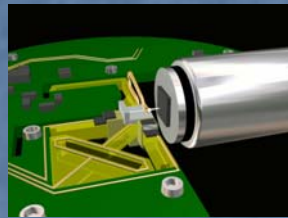
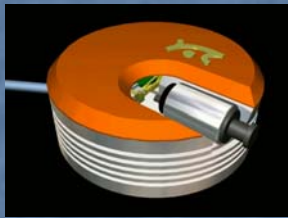


DNA: Big Picture / Do-it-yourself (→ [webpage](#))

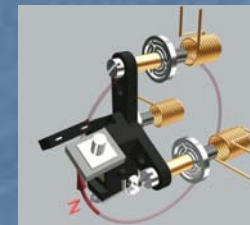


Additional Nanoscience instruments (OUR SECOND IDEA):

"easyScan" STM (→ [webpage](#))



"easyScan" AFM (→ [webpage](#))



Particular reason for the latter: Used NUE grant money to purchase three of each

for use by *freshman* and *sophomores* - of all majors - in new class:

***"A Hands on Introduction to Nanoscience"***

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## *Full semester of labs including:*

- STM of atoms on graphite and gold
- AFM of CD/DVDs, submicron IC's, self-assembled Q-dots . . .
- And student suggestions of: leaves, egg shells, glass, teeth, fingernails . . .

Supported by not only animations (above) but online guides we've written

*Result: This semester every single student succeeded in "seeing atoms"*

For next fall: Planning to add nano synthesis including

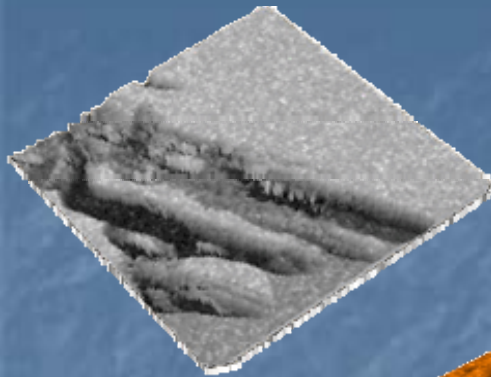
CVD of nanotubes, DNA assembly, Langmuir-Blodgett ML growth



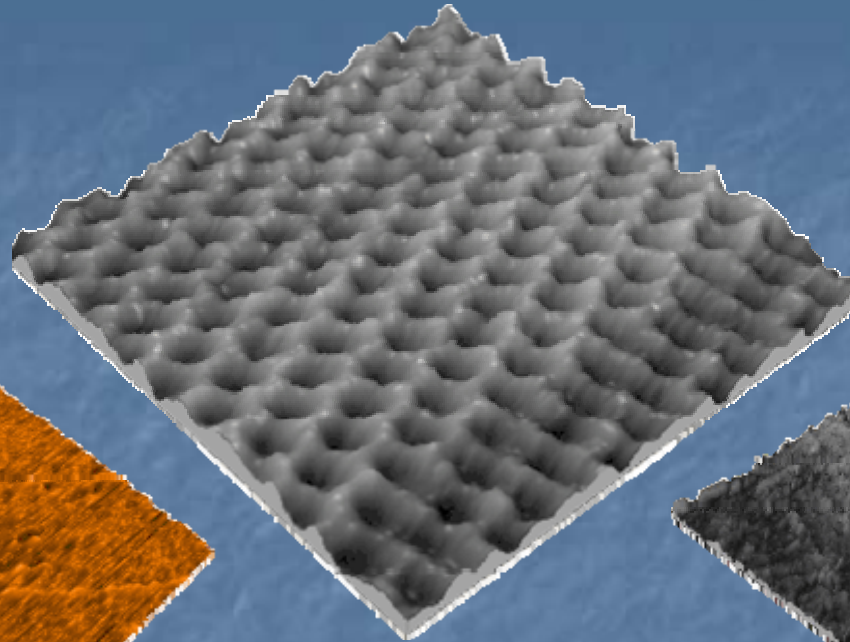
*Description of lab in Spring 2007 "Nanoadvisor" newsletter published by Nanoscience Inc. for Nano Educators*

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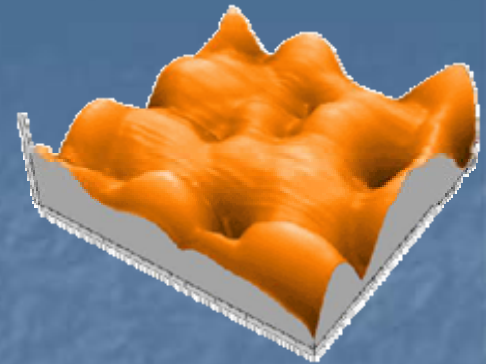
*Student STM & AFM images from this semester:*



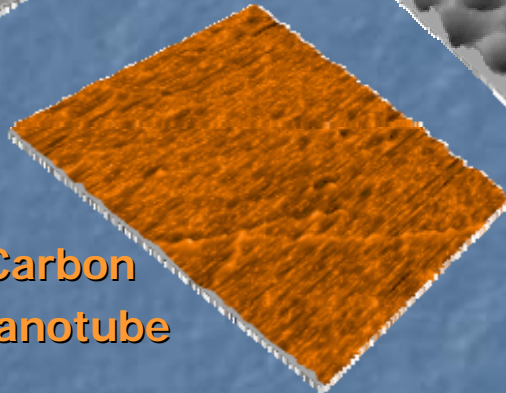
Glass Slide



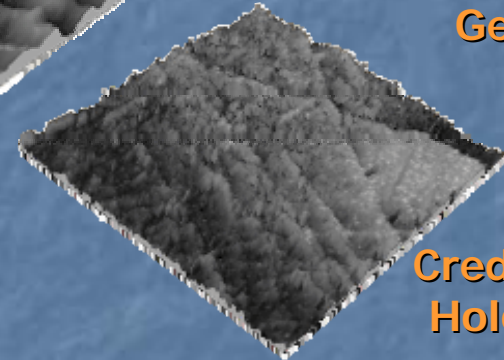
Graphite atoms



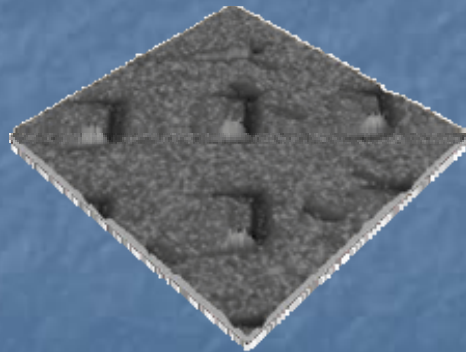
GeSi Q-dots



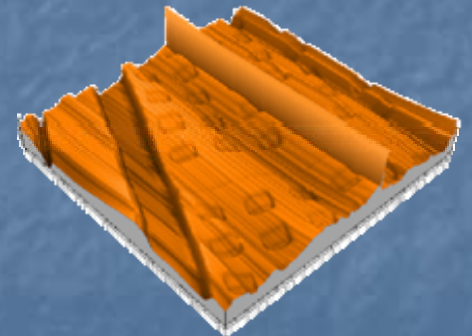
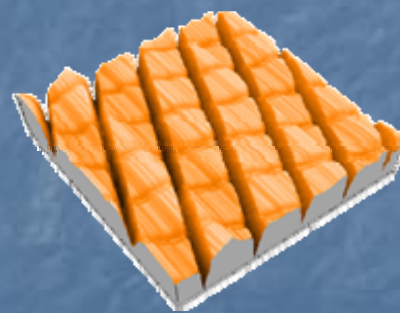
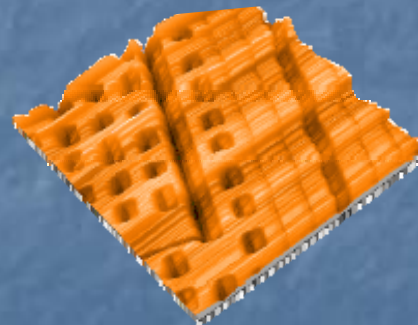
Carbon Nanotube



Credit Card Hologram



Micron Technologies Deep Sub-Micron Integrated Circuit



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## *Full semester of lectures & discussions including:*

What is Nanoscience?

Waves: Generic and Electron (parts I and II)

Microfabrication / Micromachining

**Great Science vs. Viable Technology**

**The Need for Self-Assembly**

**Molecular Self-Assembly** (parts I and II)

**DNA based Self-Assembly**

How we see at the Nanoscale

Nanoelectronic Device Research

The Fictions of Nano Science Fiction

Fears & Challenges of Nanoscience

Supported by ~300 pages of illustrated & animated PowerPoint slides:

Certain note sets in turn supported by links to a dozen or more readings

E.G. Set of readings for case-study on nano particles in sunscreens

Disclaimers: It's a work in progress - I WILL revise and augment in semesters to come

I apply the critical industrial perspective I developed at Bell Labs

*Lecture notes, lab manuals, all equipment specs posted on class website  
linked from "UVA Virtual Lab" Homepage: [www.virlab.virginia.edu](http://www.virlab.virginia.edu)  
(→[webpage](#))*

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*2007 NIRT - Education and Outreach:  
Added collaborations with the "Science Museum of Virginia" & VA Colleges*



Museum founded 1977:

4,000,000 cumulative visitors, now over 250,000 per year

Multiple sites in state including converted Richmond VA classic RR station (above)

Exhibits + K-12 school visitation programs + Summer programs of science teacher training

We are now collaborating with them to:

Develop new museum exhibits

Help in design of new *school-centered / project-based* suburban DC museum site

Develop summer programs for K-12 Science Teacher Training. Specifically:

*Plan to offer our "Hands on Intro to Nano" class for K-12 teachers next summer!*

*(Museum staff visiting our class & lab this week – reason I must leave early)*

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*Also joined Commonwealth effort to wean SW VA off Tobacco Farming*

Example: Danville VA has Nanotech incubator that has drawn Luna Innovations Inc.

And is working with Commonwealth to draw more companies

Danville C.C. wanted to offer Nano A.A. degree but lacked instructor expertise

So, this semester I've worked with the college and Luna Inc. to adapt our class:

Ongoing consultation with Luna and would-be instructor on class material

Instructor has traveled to UVA to attend many of our labs

My lectures are being videotaped as resource for that instructor

Helping them to develop state and NSF grants for equipment

*With this, Danville C.C. decided to proceed with Nano degree program fall '08*

**FIN**

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