2.674
"(Hands on) Micro- and Nano- Engineering Laboratories"

Sang-Gook Kim

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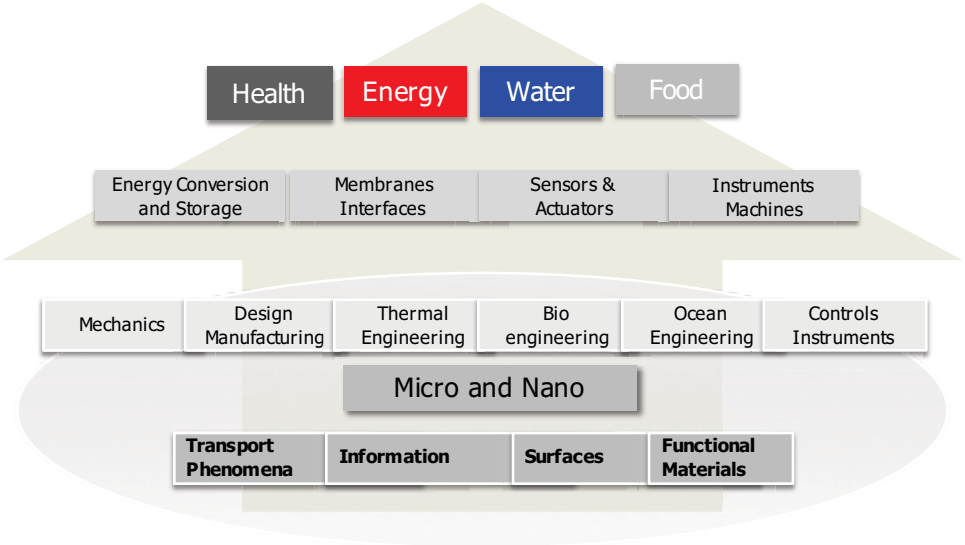
Grand Challenges (ME in 10-15 years)



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2.674 Teaching Staffs

- Instructors

  Prof. Sang-Gook Kim

  Prof. Jeehwan Kim

  Dr. Benita Comeau,

  Dr. Asmaa ElFaer

- Safety Instructor:

  Daniel Herrick

- Teaching Assistant:

  Mr. Andrew D Jones

Safety Lecture

- Safety
- Safety
- Safety

Safety Education Certificate

- EHS Chemical Hygiene Web Training certificate
  - Two weeks from today, 2/016/2016, by noon
  - e-mail to Benita
  - Already have a certificate ? Just email us a pdf copy.

Today's schedule

- Safety Lecture (dh)
- Course Outline (sk)
- Lecture-0: Why learn small things? (sk)
- Lab sections arrangement, Labs start next week

Lecture and Lab Modules

- 1 hour lecture

  Just a brief introduction for each lab modules and related technology

- 3 hour lab

  Lab manual will be handed out during lecture. (11 lab modules in 5 bindings)

- Lab Reports

  Due **at the lab one week after the module.**

  Submit a hard copy of a word processed document.

Lab sections

- Lab sections,
  - Thursday (A) 9-12 AM, (B) 1- 4 PM
  - Friday (C) 9-12 AM, (D) 1-4 PM
- Even distribution of lab sections will be beneficial to all of us.

Grading Policy

- **Grading Points**

11 lab reports:		20 points each, 220 points total
Class and lab participation		30 points
Short Answer Quiz	50 points	
Total		**300 points**

✓Late submission of reports/assignments will lead to a 10% decrease in points per day.

✓Instructors may fail students who miss any single laboratory session or fail to turn in a report.

Course Outline

- Three technology streams (in 11 lab modules)
  - Micromachining and MEMS fundamentals: material properties, fabrication technologies, basic structural mechanics, sensing and actuation principles.
  - Microfluidic fundamentals: design and fabrication of microfluidic devices, physics of pressure-driven, viscous, laminar flow, electrokinetic flow, thermo-fluid systems.
  - Nanomaterials: Self-assembly, CNT growth and observation, structural characterization techniques such as SEM, STM, AFM (and TEM).

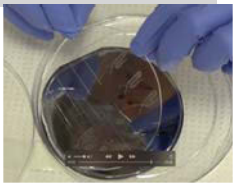
Lab Overview

1 hr lecture, 3 hr lab, 2 hr report prep

Micromachining and MEMS fundamentals:

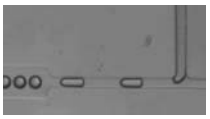
Benchtop photolithography

Microfluidic fundamentals :

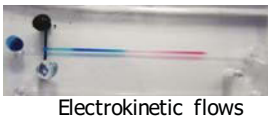


Fun with molding

Nanomaterials and imaging



Droplets and Diffusion



Electrokinetic flows

Surface engineering with soft materials

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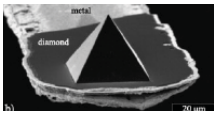
Lab Overview

Micromachining and MEMS fundamentals:

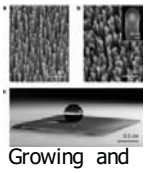
Microfluidic fundamentals :

Surface engineering with soft materials



Scanning electron microscope (SEM)‡

Nanomaterials and imaging



Growing and touching carbon nanotubes

Micro 3D printing

Atomic Force Microscope

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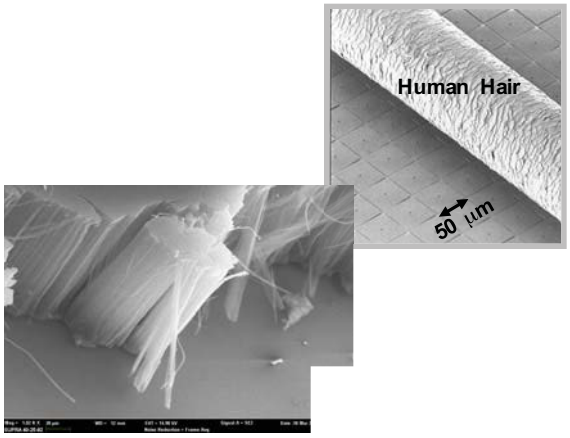
"Why learn small things"

Scales of things around us

- Human hair
  - Diameter
  - UTS
- Carbon Nanotube
  - Diameter
  - UTS
- Intel Dual Core Chip
  - How many transistors inside?
  - Critical line width



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No limit in the scale of integration

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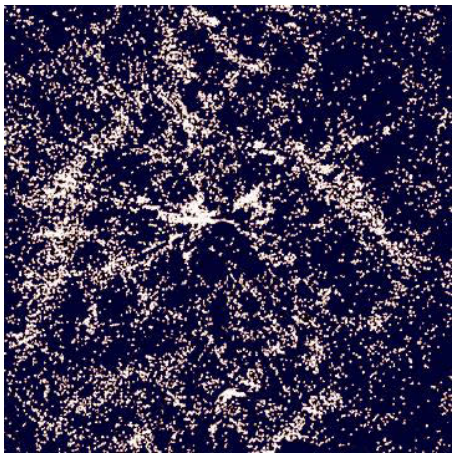
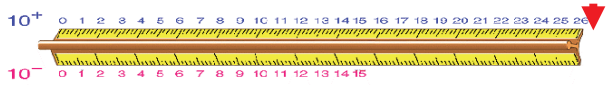
Powers of Ten (CERN)

10^{26} meter Scale

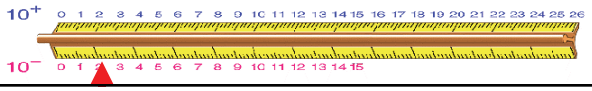


The largest scale picture ever taken. Each of the 9325 points is a galaxy like ours. They clump together in 'superclusters' around great voids which can be 150 million light years across.

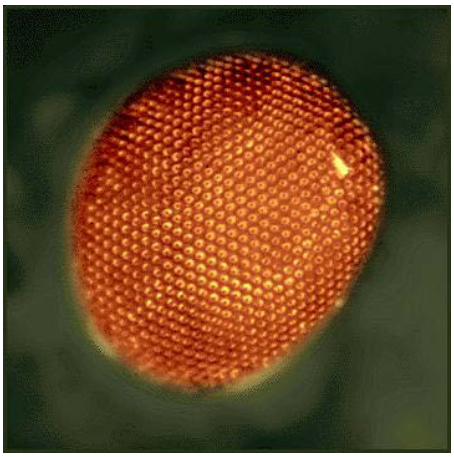


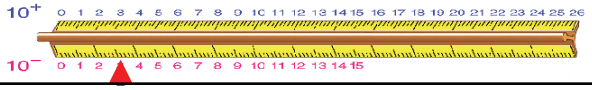
10^6 (1,000,000) meter

0.01 m, or 10 mm

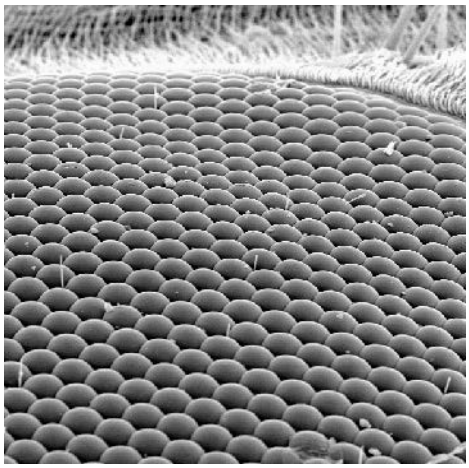


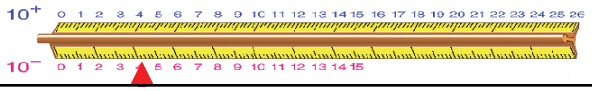
0.001 meter, or 1 mm



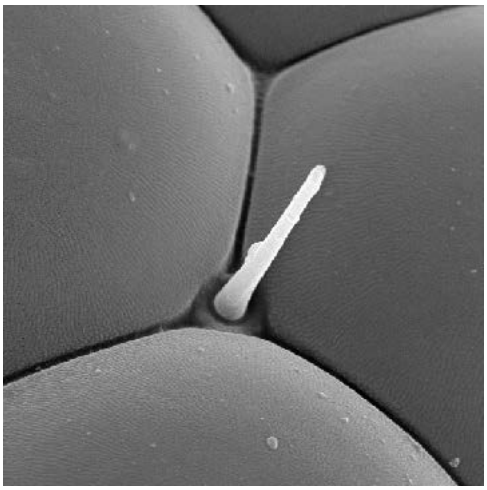


0.1 mm, or 100 micrometer

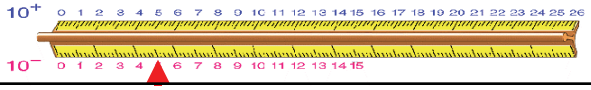




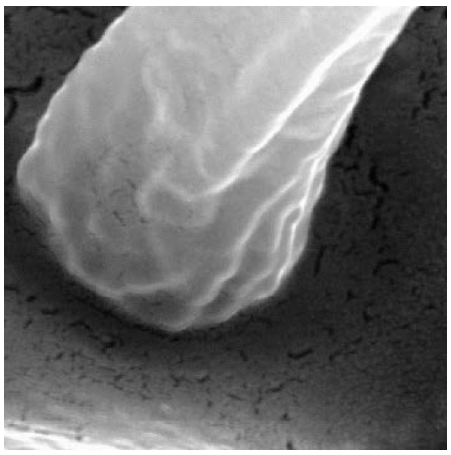
10 micrometer

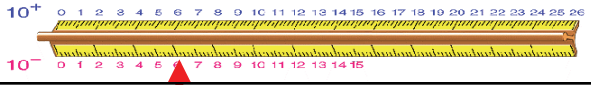


In between the facets are bristles which give sensory input from the surface of the eye.

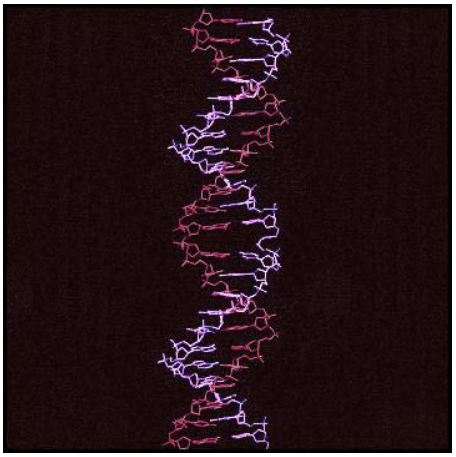


1 micrometer





0.01 micrometer, or 10 nm



- The realm of molecules, DNA, proteins, and atoms.

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Source: C. Liu, UIUC

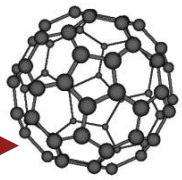
Soccer ball and bucky ball (C60)

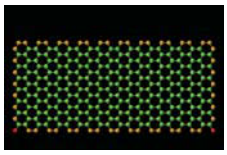
ϕ 1.2X10^{7}m

Image courtesy of NASA.

ϕ 22 cm

ϕ 0.7 nm





Buckyballs

-spherical fullerenes (C60 is most stable and symmetrical and resembles a soccer ball)
- named after architect R. Buckminster Fuller
-1996 Nobel prize in Chemistry awarded for their discovery, R. Smalley, R. Curl, H.W. Kroto

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The Scale of Things -- Nanometers and More

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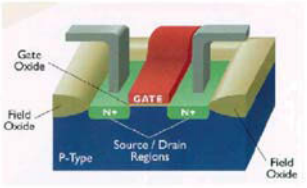
Please see the images on Page 4 of http://www.ogs.ou.edu/MEETINGS/Presentations/2013Shale/2013ShaleCurtis.pdf.

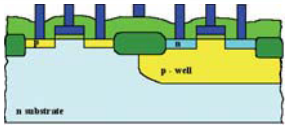
Tyranny of numbers – a history of Silicon Valley

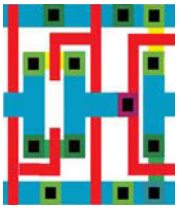
J. Kirby of TI (1958), Nobel Prize 200(

R. Noyce (1959), Fairchild, Intel

Monolithic Idea







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Spring 2016