Nanomanufacturing and Fabrication

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http://www.cnm.es/imb/pages/services/images/Nanofabrication%20laboratory_archivos/image007.jpg

What we will cover

- Definitions
- Top Down Vs Bottom Up
- Lithography, present past and future
- Society and making stuff

Definitions

- Manufacturing
  - **"Manufacturing** is the transformation of raw materials into finished goods for sale, or intermediate processes involving the production or finishing of **semi-manufactures**. It is a large branch of industry and of secondary production." Wikipedia
- Fabrication
  - "Some industries, like semiconductor and steel manufactureres use the term fabrication" to basically mean manufacturing. Wikipedia

Top Down Vs Bottom Up

Top Down

- When you start with something large and chop, sculpt or otherwise remove and reshape parts until you arrive at your desired object.

http://site.voila.fr/louispages/wallpaper1024/sculture1024.jpg

Bottom Up

- When you start with small pieces and build up to larger objects.

http://bellauto.turboblog.fr/photos/uncategorized/toyota_prius.jpg

Lithography

Old Lithography

- Invented in 1798 by Alois Senefelder.
- Used to replicate an image
  - Water and greasy ink repel each other so make an image with grease and then wet the entire stone. Ink applied thereafter will only stick to the greased areas.

http://www.drexel.edu/coe/enggeo/rocks3/lithographic_limestone800.jpg

Modern photolithography

- Still used to transfer an “image”
- Optical in nature
- Used to etch silicon chips to produce integrated circuits like computer processors

Steps of photolithography

- Setup
  - Apply SiO_2
  - Apply photoresist
    - Positive photoresist: more soluble after exposure
      - Allow for smaller features so it is a more popular method now
    - Negative photoresist: less soluble after exposure
  - Soft Baking: makes the photoresist photosensitive.
  - Mask alignment
    - Mask is a plate with a metal film pattern on one side

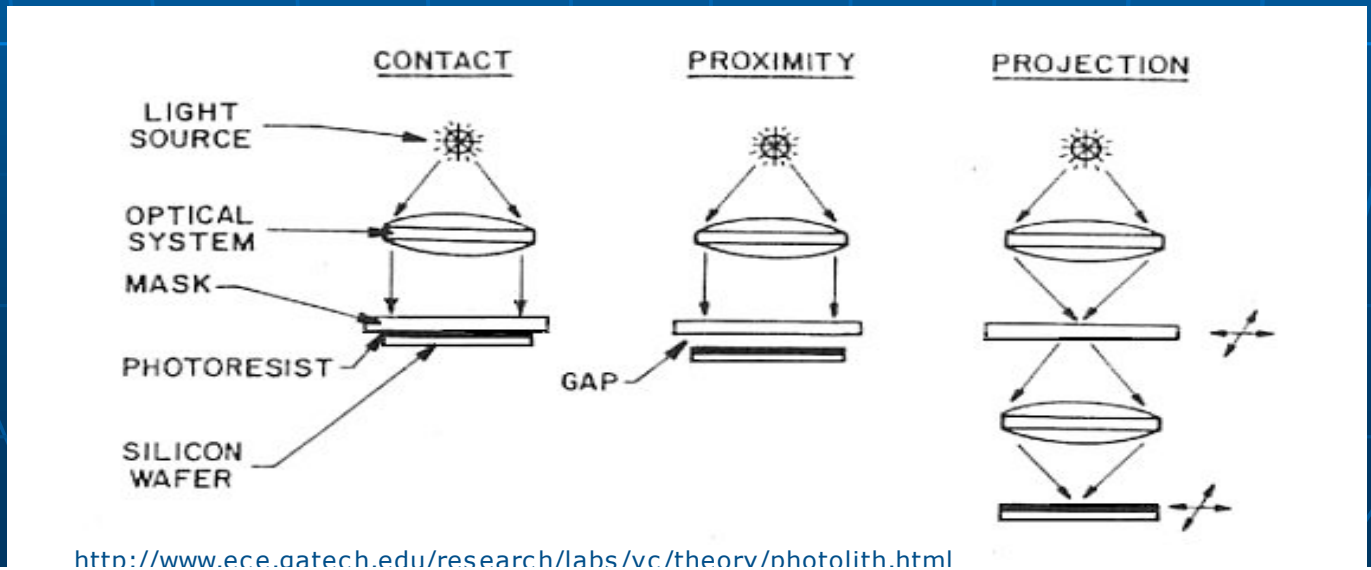
Photolithography continued

- Exposure

  1. Contact: high resolution but risk mask damage

  2. Proximity: A distance on the order of 10 to 25 microns is created between the mask and the wafer. Lower resolutions but safer for the mask.

  3. Projection: Mask if far away from the chip. To increase resolution the wafer is exposed piece by piece. Comparable to contact exposure.



http://www.ece.gatech.edu/research/labs/vc/theory/photolith.html

Photolithography continued

Last two steps

1. Developing
2. Hard Baking

These two steps remove excess photoresist and harden the wafer. Once hard baking is completed the lithographic process is done.

Problems with photolithography

- Masks are hard to make and expensive
- We are approaching the physical limits of light based exposure

  -Moore's Law ending?

Nanolithography To The Rescue

- Nanoimprint lithography
- E beam lithography

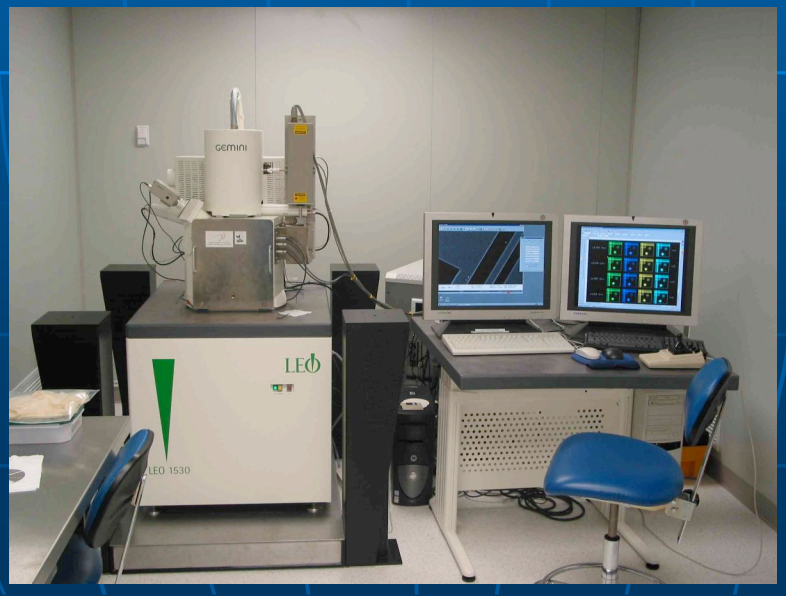
Nanoimprint Lithography

- nanoimprint lithography you create a mold with nanoscale features and then press that mold into a soft polymer.
  - Like when you make a waffle.
- The polymer is then cured using UV light.
- Features as small as 10 nanometers can be achieved with nanoimprint lithography.
- Can be as much as 10 times cheaper than traditional projection photolithography tools.
- Motorola is interested in this technology and has already thrown some money at it.

http://www.nanonex.com/Product2.jpg

E Beam Lithography

- Developed at IBM in the 1970s
- Maskless
- Can take more than 10 hours to complete a single 200mm wafer
  - Not ready for commercialization yet
    - Possible solution is many rays and a programmable mask



http://www.uwo.ca/fab/images/elitho.JPG

No science is an island

The Societal Stuff

The obvious stuff

- Faster computers
  - Solve medical problems, improve communication systems
- Cheaper electronics
  - More people can buy more stuff

http://www.llnl.gov/pao/news/asc/images/asc_q_hires.jpg

The Albany Nanotech Initiative

- Combination of university reasearch labs and industry giants like IBM and AMD.
- Largest nanotech initiative in the country
  - Raised 1.2 billion by 2003
- Jobs are moving east.
  - From California (budget problems) to Albany (lots of funding)

Overseas Competition

- A new fabrication plant costs more than a billion dollars to build.
  - Intel has stopped building new facilities
    - Just retooling existing fabrication plants
- Foundry Businesses
  - Fabrication facilities that are shared by many companies to reduce operating cost for any one business.
    - Big in China
      - ATI, NVIDIA, Broadcom
    - May cause job loss in the US