CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
www.lithoguru.com/scientist/CHE323

Lecture 38 Lithography: Introduction

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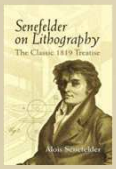
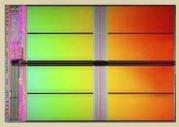
Reading:
Chapter 7, *Fabrication Engineering at the Micro- and Nanoscale*, 4th edition, Campbell

What is Lithography?

- In the art world, lithography is a two-century-old printing technology used to make prints and posters



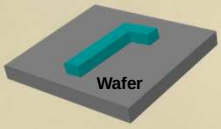
- In the semiconductor world, lithography is the printing technology used to mass-produce chips like microprocessors, memory and flash that are at the heart of electronic devices



Flash chip circa 2009

Defining Lithography

li · thog · ra · phy, n. [<Gr. *lithos*, stone + *graphia*, to write] 1. a printing technique based on the production of a three-dimensional relief image on a substrate (writing on stones).

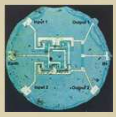
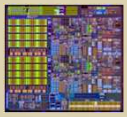


Lithography for chip making is so impressive because it mass-produces things that are incredibly small.

Motivation
(Why care about lithography?)

- Why is lithography so important?
  - 50% of the cost of making a modern chip (integrated circuit) is litho cost
  - Improvements in chip cost and performance (Moore's Law) have historically been gated by lithography capability
- Chip companies, governments, and universities continue to invest large sums in lithography R&D
  - The hope is to keep Moore's Law going

Why Size Matters

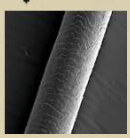
1961  →  2011

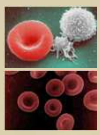
Feature size = 25 microns
(one thousandth of an inch)

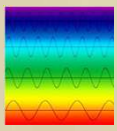
Feature size = 25 nanometers
(one millionth of an inch)

- We cram more transistors onto a chip by making each transistor smaller
  - Lithography improvements must enable the printing of smaller features *without* significantly increasing the cost of making the chip

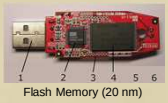
A Note on "Small"


Human Hair
~70 micron
(www.ualberta.ca/~mingchen)


Red Blood Cell
~7 micron


Red Light
Wavelength
~700 nanometer

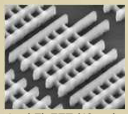

Retrovirus
~70 nanometer



Flash Memory (20 nm)

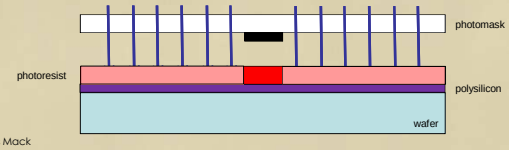
Patterns printed with lithography to make transistors are as small as 20 nm today, and still getting smaller!

(some images from Wikimedia Commons)


Intel FinFET (40 nm)

Subtractive Patterning

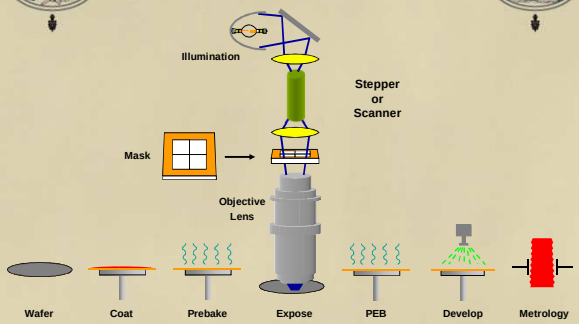
- Patterning Sequence (example)
  - Deposit polysilicon (for example) on wafer
  - Deposit photoresist layer on top of polysilicon
  - Expose and develop photoresist to create pattern
  - Etch pattern into polysilicon using resist as mask
  - Strip away the resist
  - Repeat 20 – 60 times to make a chip



Lithography – The Basics

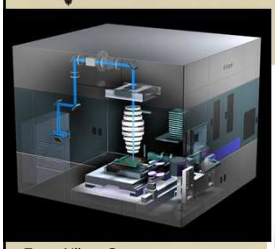
- Ingredients of a Lithography System
  - A master pattern to be reproduced called a photomask
  - A photosensitive film called a photoresist
  - A special camera (called a stepper or a scanner) that projects an image of the photomask into the photoresist
  - A tool for processing the photoresist (coating, baking, developing) called a track

Lithography Sequence



Track and Stepper/Scanner combined into a "photocell"

Example Lithography Tools



From Nikon Corp.

From ASML

Example Tracks

TEL Lithius Plus (from Tokyo Electron)

SVG 88 (Silicon Valley Group)

Lecture 38: What have we Learned?

- Give two important reasons why lithography is one of the most critical technologies in semiconductor manufacturing?
- What are the basic steps in a lithography sequence?
- What are the ingredients (tools and materials) of a lithography process?