EE C245 – ME C218
Introduction to MEMS Design
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Lecture Module 4: Lithography, Etching, & Doping

Lecture Outline

- Reading: Senturia, Chpt. 3; Jaeger, Chpt. 2, 4, 5
  - Lithography
  - Etching
    - Wet etching
    - Dry etching
  - Semiconductor Doping
    - Ion implantation
    - Diffusion

Lithography

Lithography

Lithography
- Method for massive patterning of features on a wafer → pattern billions of devices in just a few steps

Four Main Components (that affect resolution)

I. Radiation Source

II. Mask

Designated pattern (clear or dark field)
emulsion chrome
- Generated from layout

Mask (glass/quartz)
Photoresist (~1μm-thick)
Film to be patterned (e.g., poly-Si)

III. Photoresist

IV. Exposure System ⟹ contact, step and repeat
optics → this is where the real art is!

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Lithography (cont.)

The basic Process – (Positive Resist Example)

Exposed PR → converts to another form after reaction with light (e.g., (+)-resist: polymer → organic acid)

Dip or spray wafer with developer → if (+) resist, developer is often a base

Etch → PR protects film; open areas of film get etched

light
PR
Film
Si
PR
Film
Si
PR
Film
Si
Remove PR

Lithography (cont.)

With each masking step usually comes a film deposition, implantation and/or etch. Thus, the complexity of a process is often measured by # masks required.

NMOS: 4-6 masks
Bipolar: 8-15 masks
BICMOS: ~20 masks
CMOS: 8-28 masks
↖ Multi-level metallization
Comb-Drive Resonator: 3 masks
GHz Disk: 4 masks

Now, take a closer look at the 4 components:

I. Radiation Source

I. Radiation Source
- Several types: optical (visible, UV, deep UV light), e-beam, X-ray, ion beam
  The shorter the wavelength → Better the resolution
  Today's prime choice due to cost and throughput.
  Can expose billions of devices at once!

Optical Sources:
- Mercury arc lamp (mercury vapor discharge)

200 365 405 435 546 nm

we have all of these in our μlab
I-line
G-line (we have both in our μlab)
- For deep UV, need Excimer laser (very expensive)
  Glass opaque, so must use quartz mask and lens

II. Mask

II. Mask → has become one of today's biggest bottlenecks!

Electronic computer representation of layout (e.g., CIF, GDSII) ⇒ A single file contains all layers

tape → mask generator

Masks for each layer

Mask Material:
- Fused silica (glass) → inexpensive, but larger thermal expansion coeff.
- Quartz → expensive, but smaller thermal expansion coeff.

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