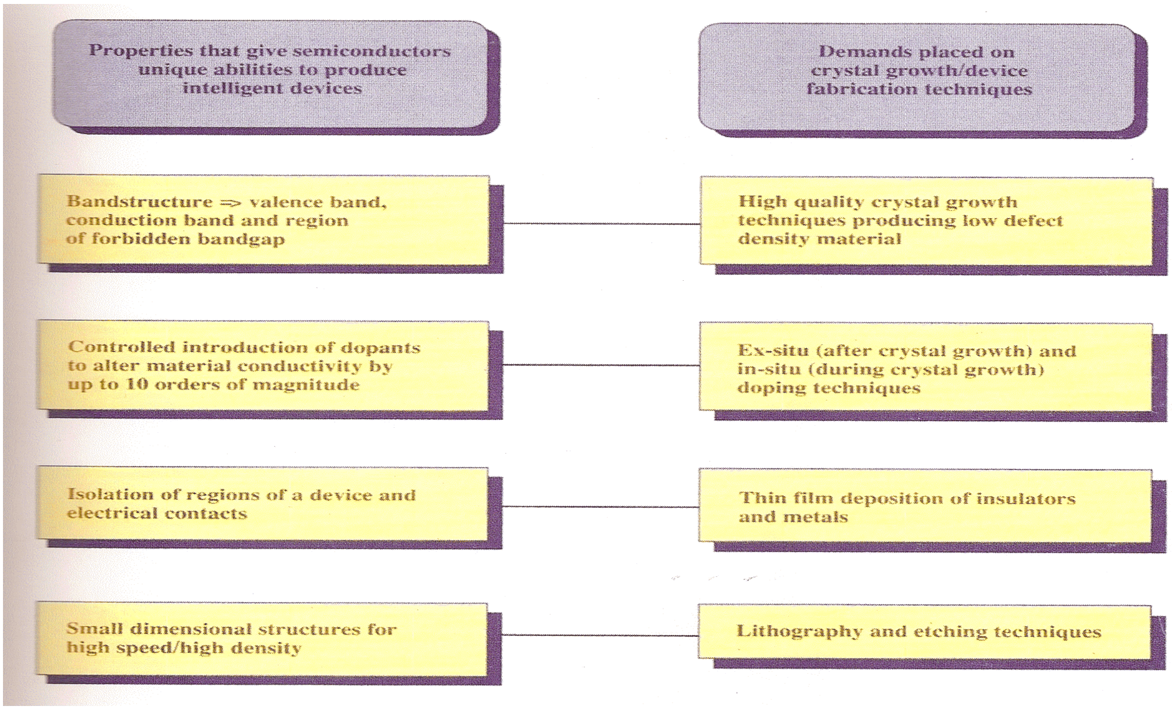
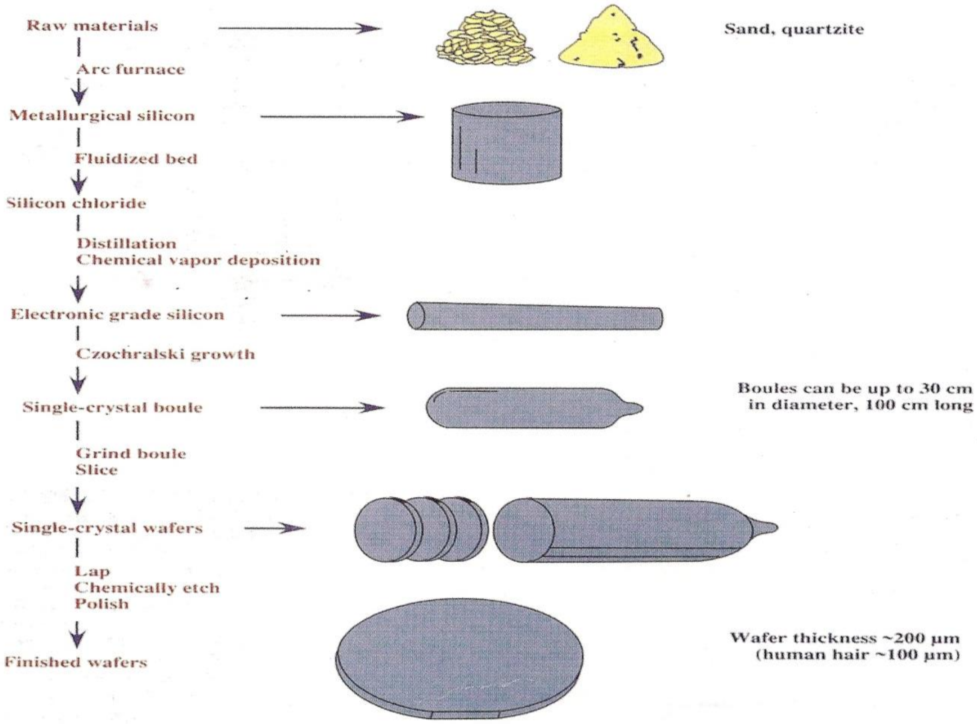
Processing and Technology Issues

This chart shows the properties than make semiconductors the materials of choice for devices. These properties also place a tremendous burden on manufacturing processes.



Processing and Technology Issues

Silicon is the most important semiconductor material. It's abundance in nature, ease of processing, occurrence of an excellent oxide which is a good insulator, and remarkable electronic properties make silicon the material of choice for mass electronic devices.



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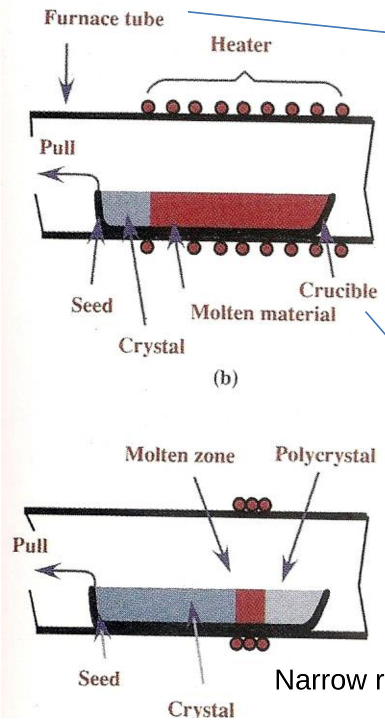
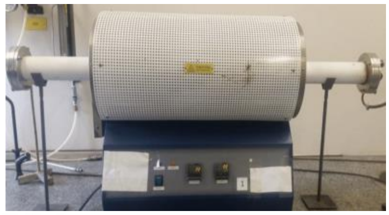
Processing and Technology Issues:

Growth of Bulk Semiconductor Crystals

These approaches are used to fabricate substrates on which microelectronic devices are fabricated.





BRIDGEMAN GROWTH TECHNIQUE: In the Bridgeman approach the melt is in a boat which is pulled through a high temperature region. Two approaches are shown: one in which the entire polycrystalline material is molten; and the second in which the molten region forms a narrow region which slowly moves as the crystal is grown.

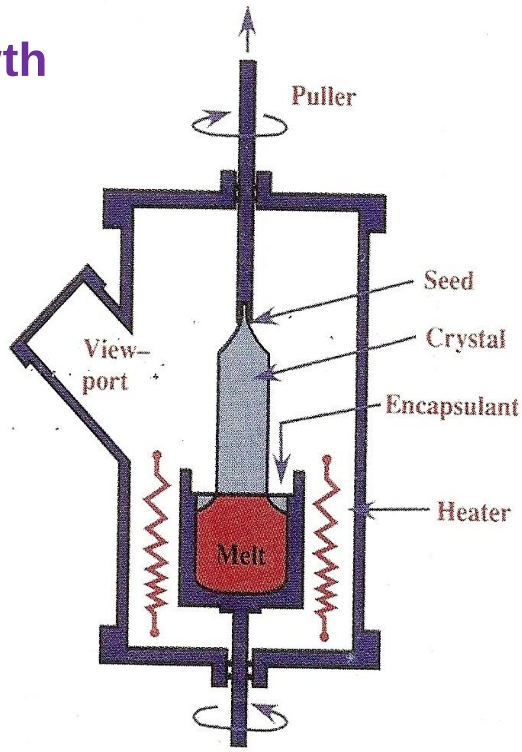
Narrow region

.89

Growth of Bulk Semiconductor Crystals

Czochralski (CZ) growth

CZOCHRALSKI GROWTH TECHNIQUE:
In this approach, widely used for Si, GaAs and InP, a seed of the crystal is slowly pulled from a melt. The crystal being pulled is rotated to ensure uniform crystal growth.



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CZ Growth Video

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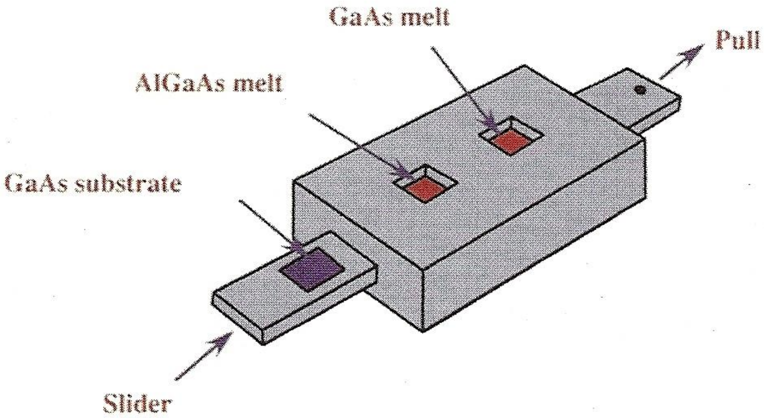
Processing and Technology Issues:

Epitaxial Crystal Growth Techniques

Epitaxial techniques are used to deposit thin (few microns) high quality crystals.

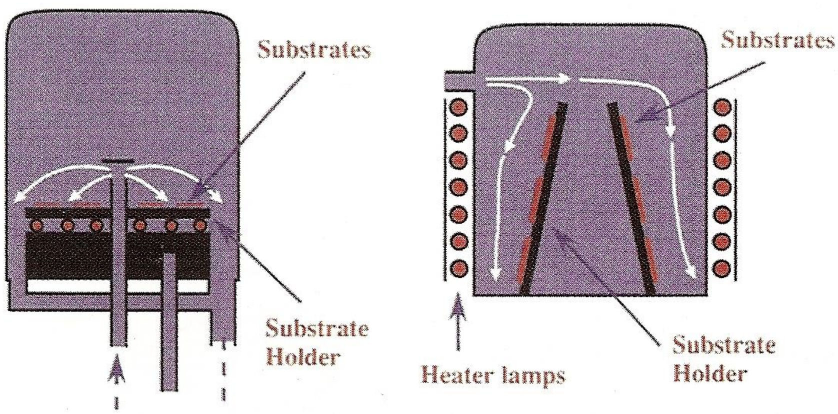
Liquid Phase Epitaxy

LIQUID PHASE EPITAXY: In this approach a slider is moved with a substrate to come in contact with a molten region. Very high quality material can be grown.



Vapor Phase Epitaxy

VAPOR PHASE EPITAXY: The material to be deposited is injected as a vapor onto a heated substrate. Chemical reactions take place on the substrate and thin film growth occurs.



(a) Vertical Reactor

(b) Horizontal Reactor

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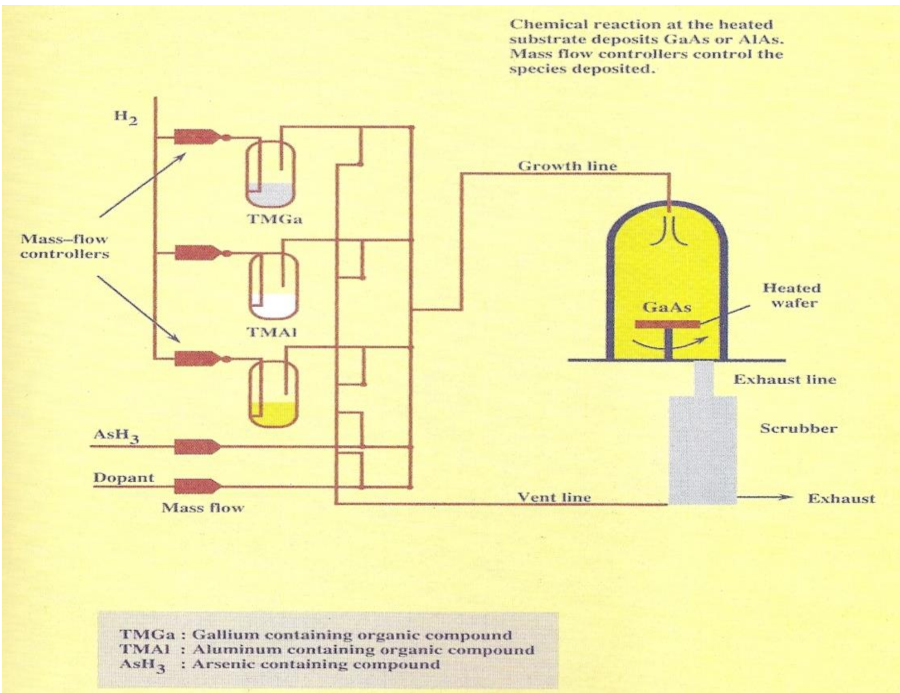
Epitaxial Crystal Growth Techniques

Techniques like metal organic chemical vapor deposition (MOCVD) shown below and molecular beam epitaxy (MBE) are capable of depositing semiconductors with one monolayer (~3Å) control. These techniques are responsible for fabrication of heterostructures such as GaAs/AlAs quantum wells.

MOCVD



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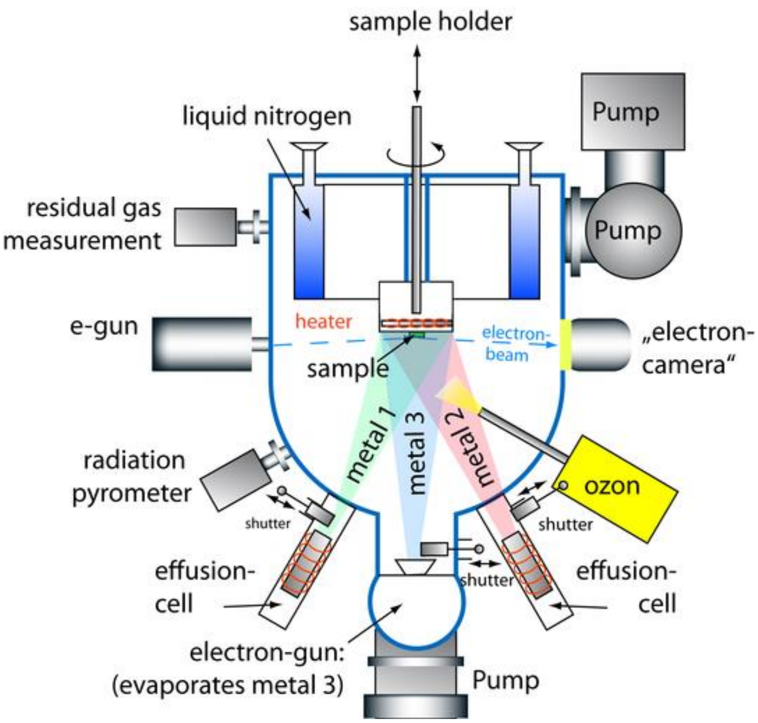
MBE Growth Technique



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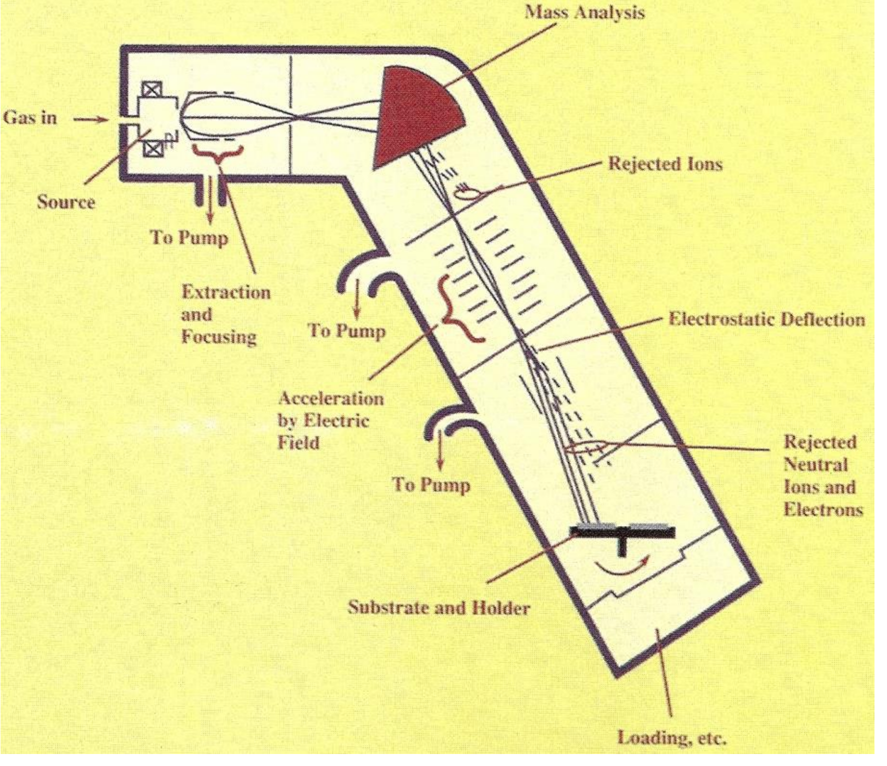
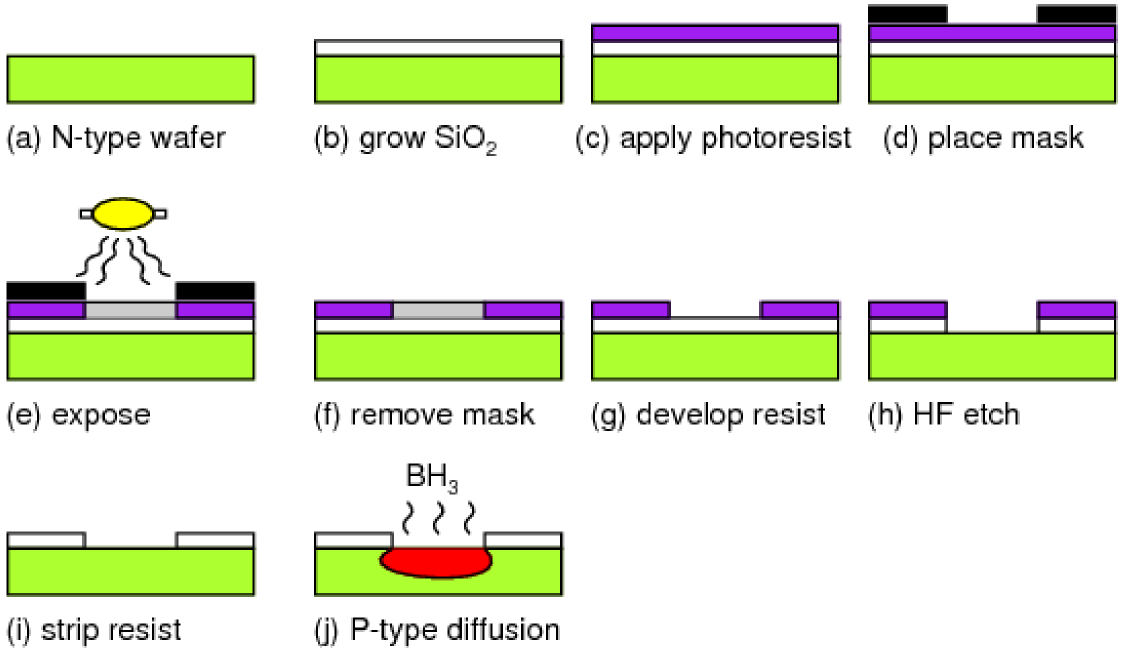
Processing and Technology Issues:

❻ Doping of Semiconductors

Doping is a crucial ingredient of any device fabrication process. Ion implantation, diffusion and in-situ doping is used. A typical ion-implanter configuration is shown in the figure. Ions of the dopants are driven into the wafer at high energies. After the ion implantation, the material is annealed to remove the damage created. By varying the implantation energy, the ions can be placed at a pre-chosen depth with a spread. Doping by diffusion produces a doping profile which is maximum on the surface and decreases into the wafer. In-situ doping where dopants are deposited during crystal growth produces the most comfortable doping profiles.



How a p-n junction is made?



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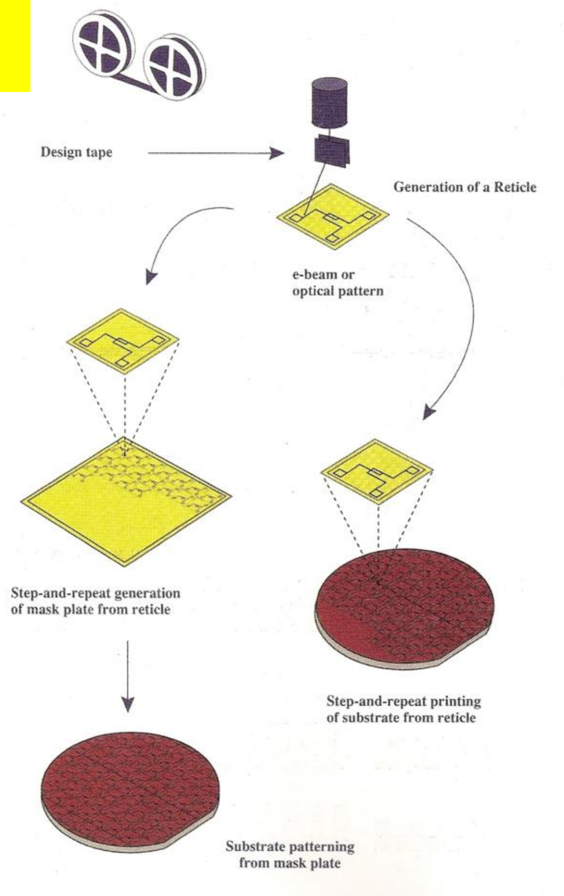
Processing and Technology Issues:

Mask generation for complex circuits

The pattern to be generated is produced in a computer and transformed to create a reticle. The reticle can be multiplied to form a mask or be used directly to transfer the image to the wafer.

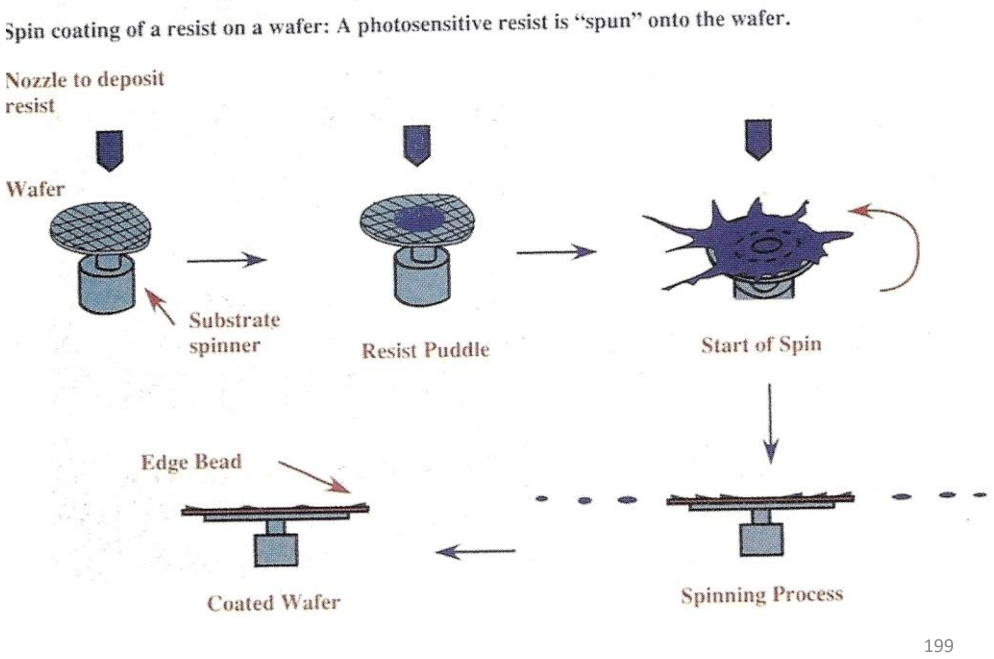


Processing and Technology Issues:

Lithography and Etching

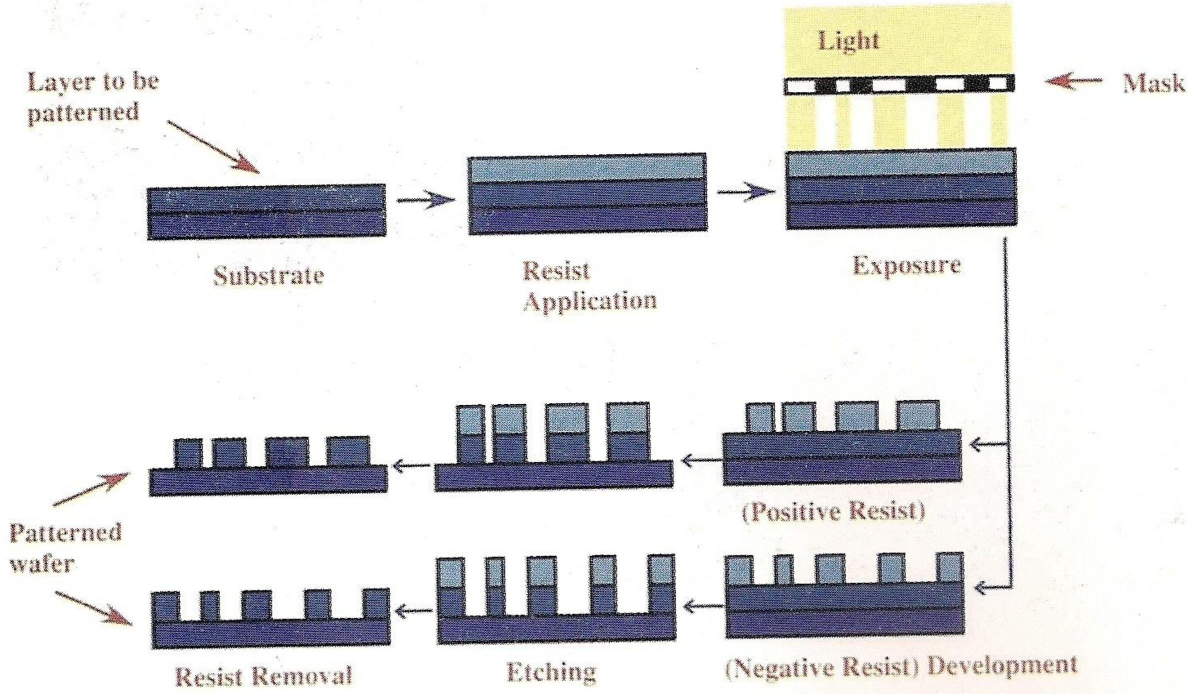
Spin coating

Device fabrication involves transferring an image of the device components into a wafer. This involves spinning a photo resist on the wafer, transferring a pattern and finally etching a pattern.



Pattern Transfer

Transference of an image to the resist by using a mask and etching of the exposed regions.

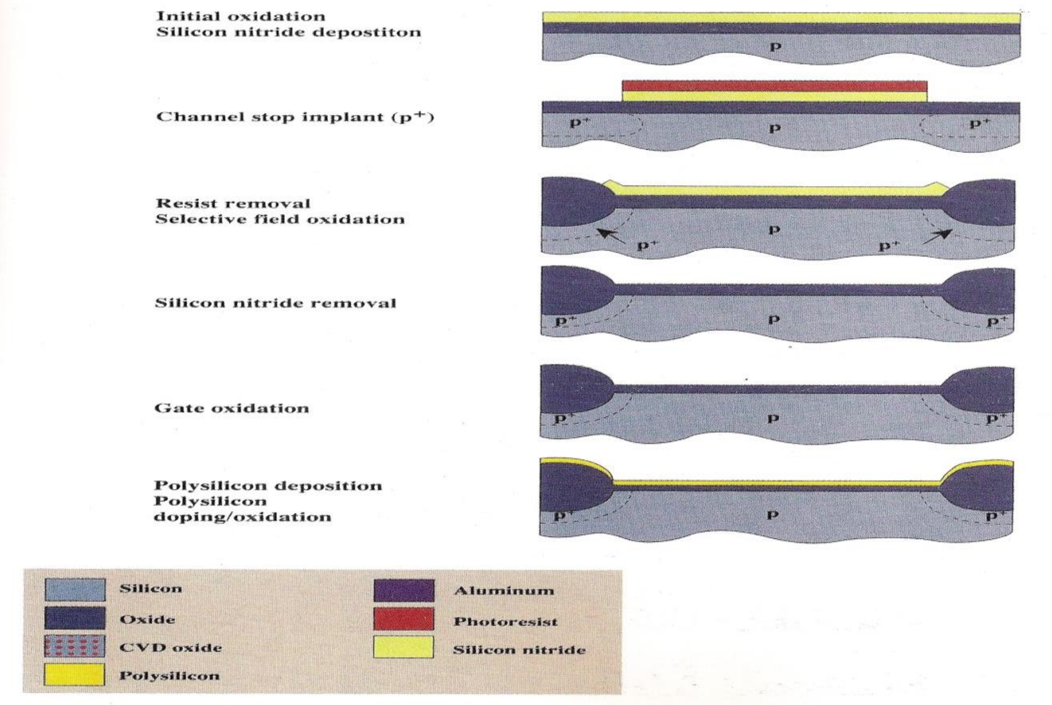


Processing and Technology Issues

Steps in Fabrication of an N-MOS

❾

State-of the art devices use much more intricate steps



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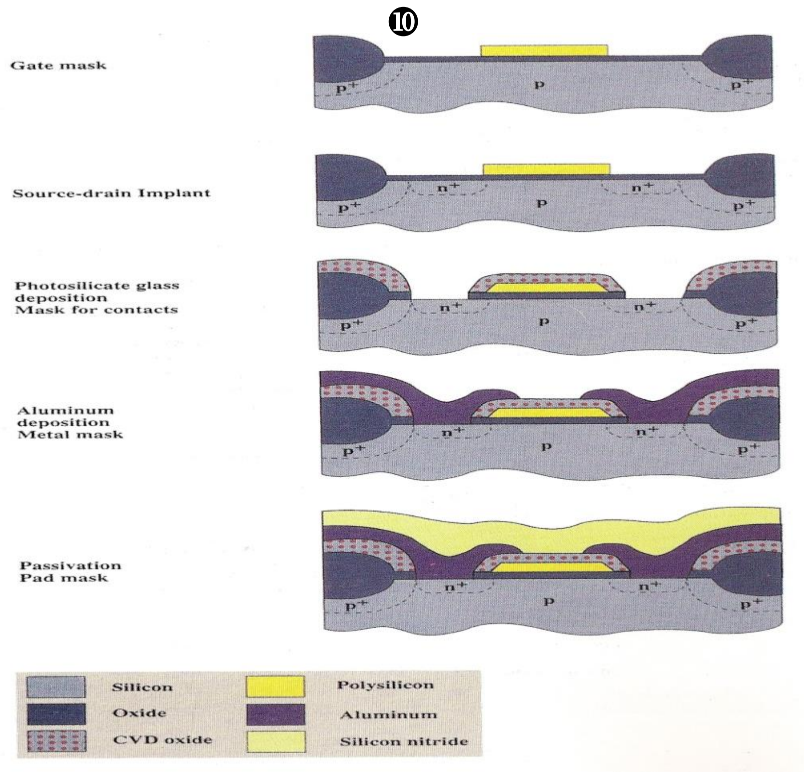
Processing and Technology Issues:
Steps in Fabrication of an N-MOS (continued)



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Processing and Technology Issues:

State-of-the-art Semiconductor Laser Structures

The devices are designed at produce highly collimated optical beams