

Diffusion

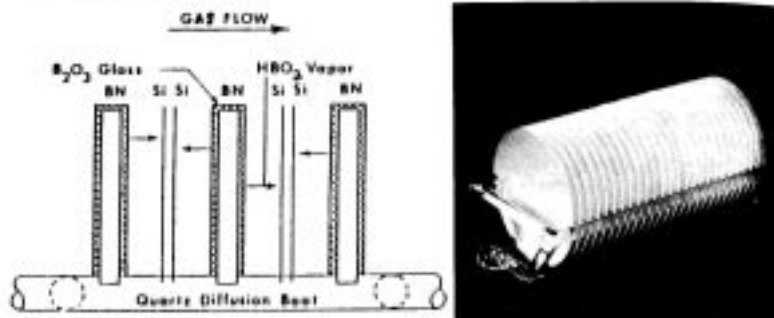
- Process by means of which a species moves as a result of a concentration gradient
- Method of introducing dopants in a semiconductor
- Conducted in systems called diffusion furnaces
- Three main sources of Dopants: Gaseous , Liquid , Solids
- Gaseous Sources (most widely used)
 - Reliable, convenient BF_3 , PH_3 , AsH_3 .
- Source gas reacts with oxygen at the wafer surface to form a dopant oxide , the dopant then diffuses from the oxide into silicon resulting in a uniform dopant concentration across the surface

Liquid and Solid Sources of Diffusion

- Liquid sources are available in two forms
 - Bubblers and spin on dopants- POCl_3 , BBr_3
 - Bubblers convert the liquid to vapor, which then reacts with oxygen to form dopant oxides on the wafers
 - Spin on dopants are solutions which on drying form doped SiO_2 layers
- Solids are available in two forms
 - Tablet / Granular and Disc /Wafer form
- BN discs are most commonly used oxidized at 750 - 1100 C to serve as the diffusion source

Stacking Pattern for Solid Disc Type Dopants in a Diffusion Furnace

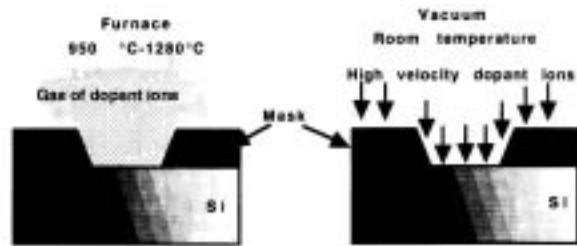
266 SILICON PROCESSING FOR THE VLSI ERA



Ion Implantation

- An alternative to high temperature diffusion for introducing dopants
- A beam of highly energetic dopant ions is aimed at the semiconductor target
- Collision of the ions with the lattice atoms distorts the crystal structure
- Annealing is performed to rectify the problem
- Ion Implantation is now preferred and extensively used by companies like INTEL.

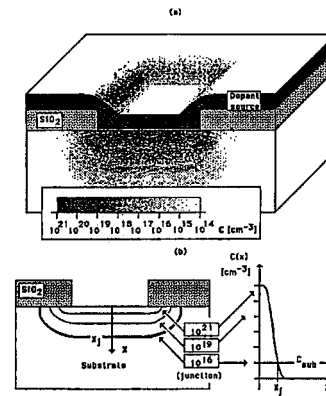
Diffusion vs. Ion Implantation.



Dopant: uniformity and reproducibility	±5% on wafer, ±15% overall	±1% overall
Concentration: danger	High	Low
Defectives	Refractory insulators and refractory metals, polysilicon	Refractory and nonrefractory materials, metals
Environment	Furnace	Vacuum
Temperature	High	Low

Profiles

Diffusion



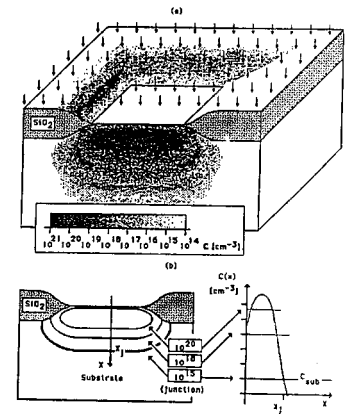
$$D = D_0 \cdot \exp\left(\frac{Q}{kT}\right)$$

D = Diffusion Constant

Q = Activation Energy

T = Temp in °K (D↑ as T↑)

Ion Implantation



Precise dose control and good uniformity.

Dopant Effect on Etching

