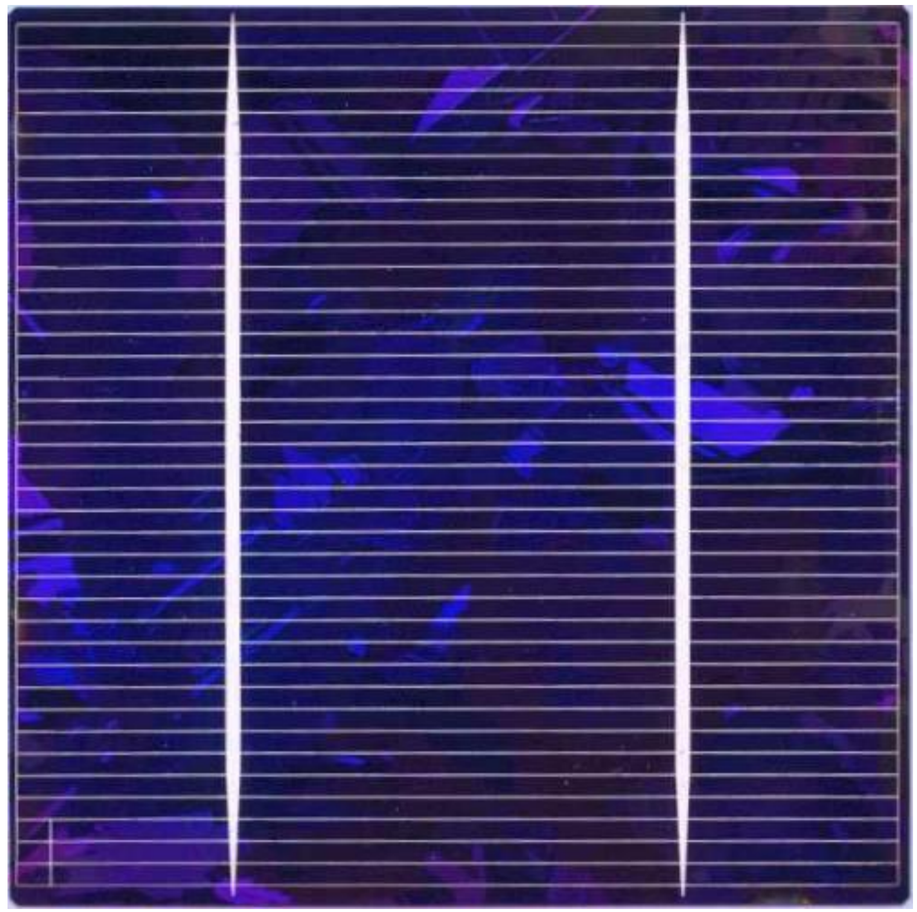
PV TECHNOLOGIES
Silicon solar cells



PV TECHNOLOGIES
Silicon solar cells

Typical screen printed silicon solar cell manufacturing process

- Saw damage etch
- Phosphorous diffusion
- Edge isolation
- Back contact print
- Firing
- Anti reflective coating
- Front contact print
- Firing
- Testing & sorting

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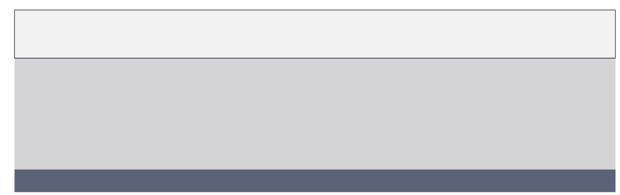

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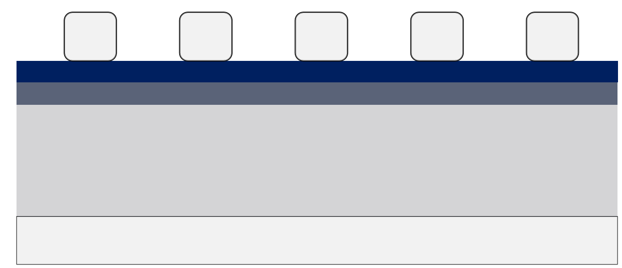

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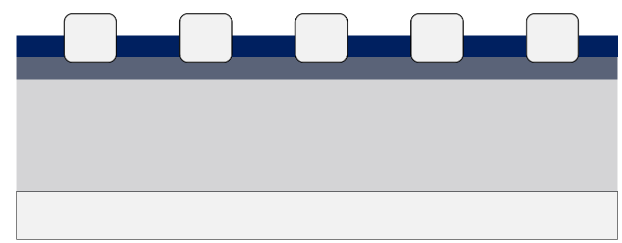

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Phosphorous diffusion can be inline continuous or batch type

P source: $POCl_3$

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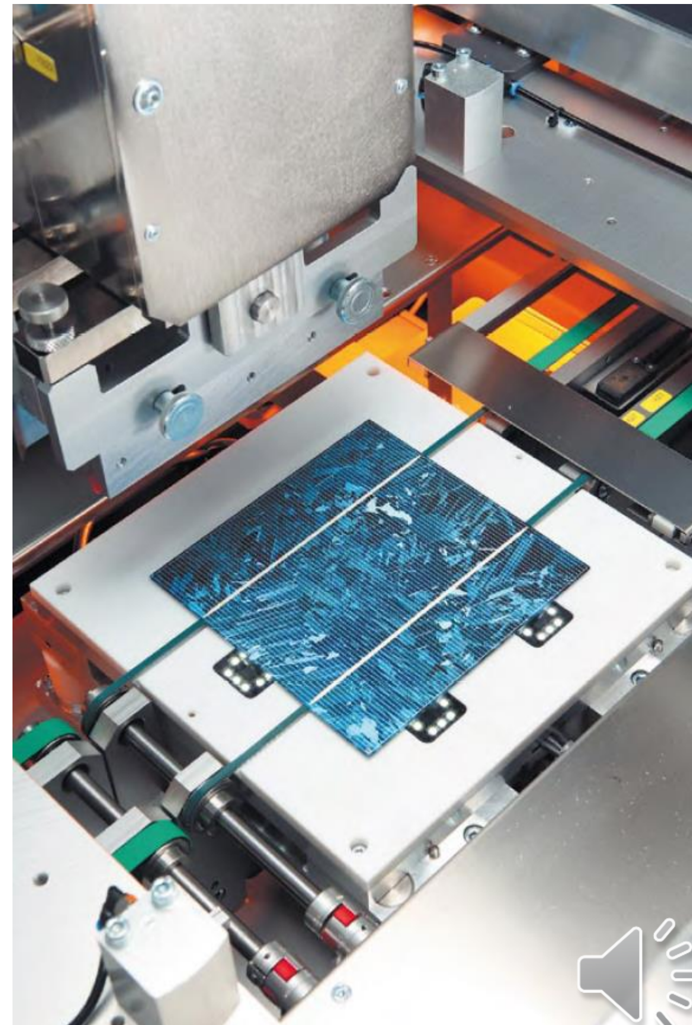
Screenprinting using silver paste is standard.

Inkjet alternatives and/or other materials are fashionable research topics.



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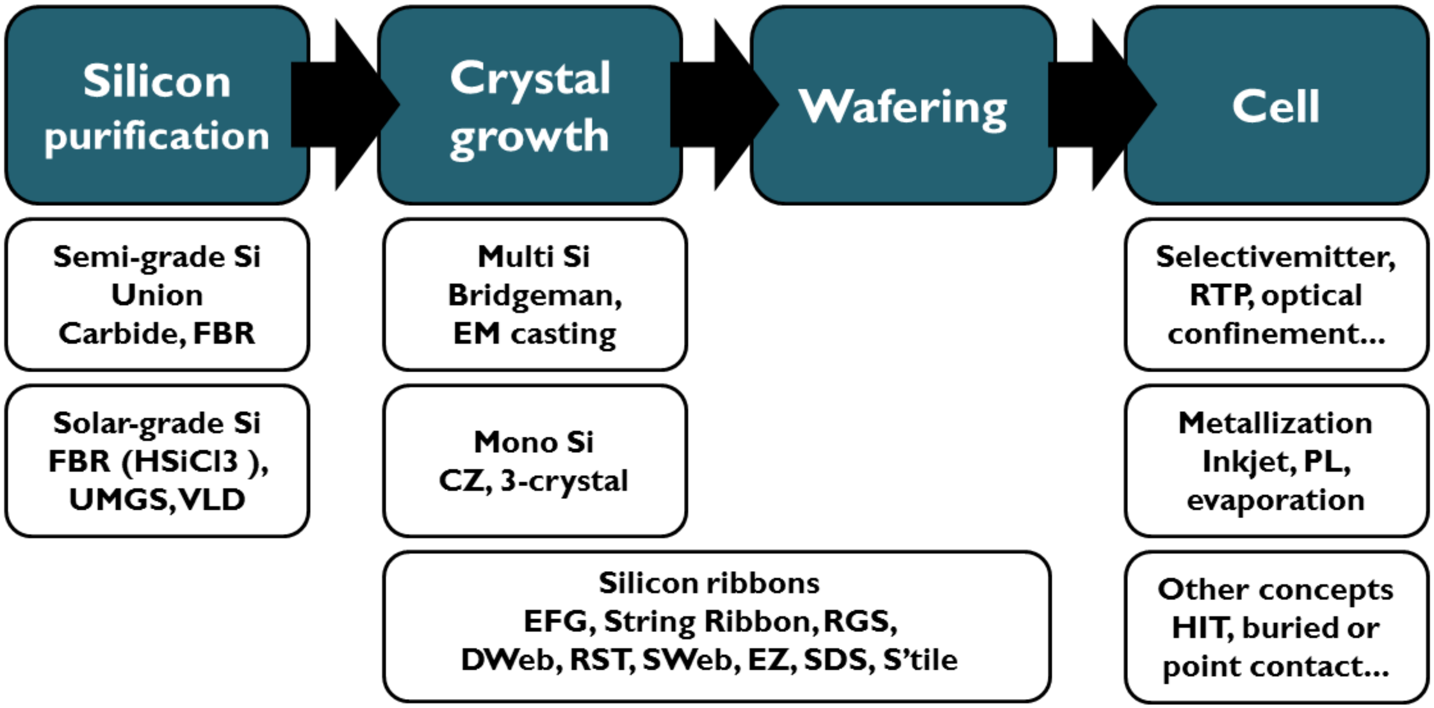
Technology overview



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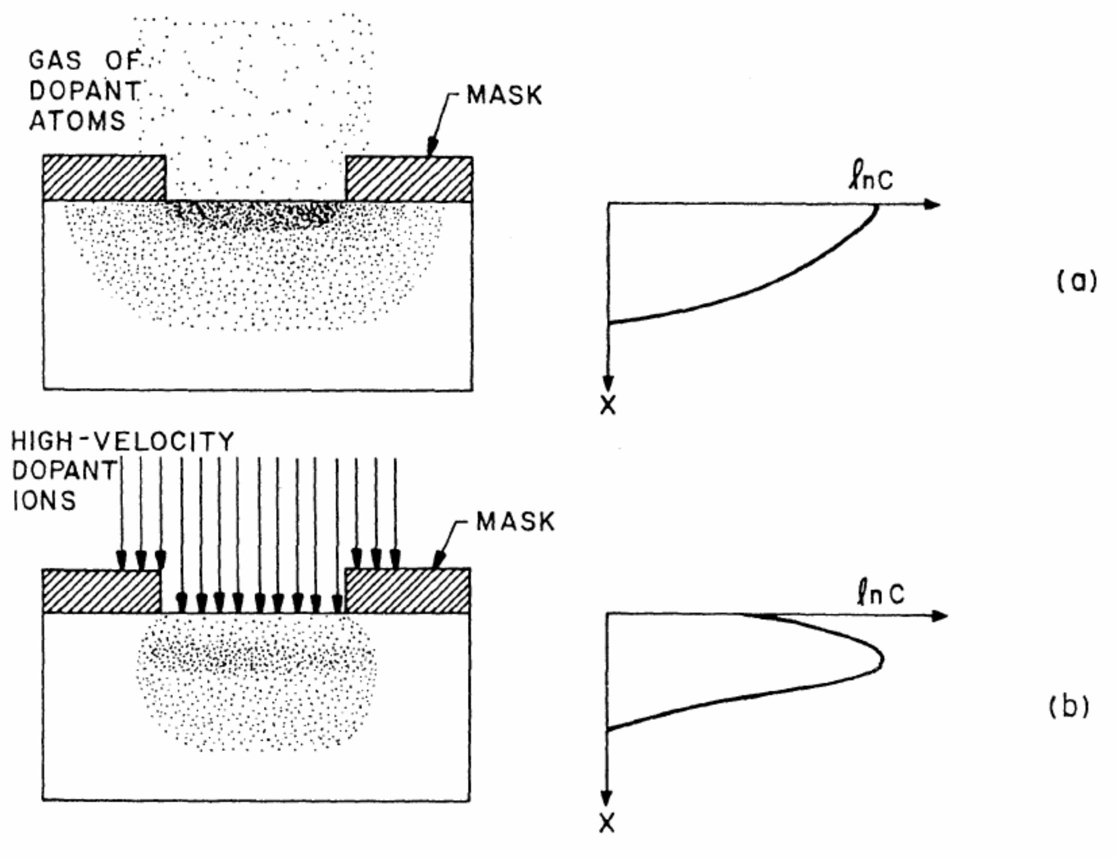
Diffusion

Diffusion (deep junctions such as an n-tub in a CMOS device

Ion Implantation (shallow junctions like source / drain junctions of a MOSFET)



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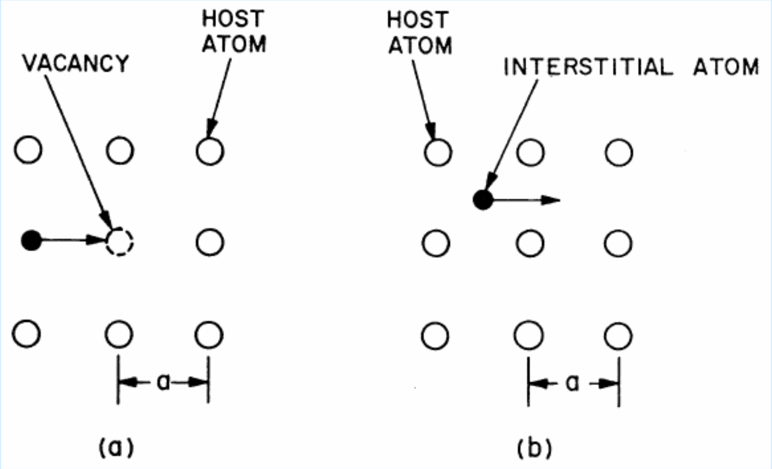
Diffusion



(a) Vacancy diffusion: Neighboring impurity migrates to the vacancy site

(b) Interstitial diffusion: Interstitial atom moves from one place to another without occupying a lattice site

- Diffusion in a semiconductor can be envisaged as a series of atomic movement of the diffusant (dopant) in the crystal lattice
- At elevated temperature, the lattice atoms vibrate around the equilibrium lattice sites.
- There is a finite probability that a host atom can acquire sufficient energy to leave the lattice site and to become an interstitial atom thereby creating a vacancy

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Diffusion

$$F = -D\frac{\partial C}{\partial x}$$

The flux is proportional to the concentration gradient, and the dopant atoms will diffuse from a high-concentration region toward a low-concentration region. The negative sign on the right-hand-side of the equation states that matters flow in the direction of decreasing dopant concentration, that is, the concentration gradient is negative.

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2}$$ **(Fick's Second Law of Diffusion)**

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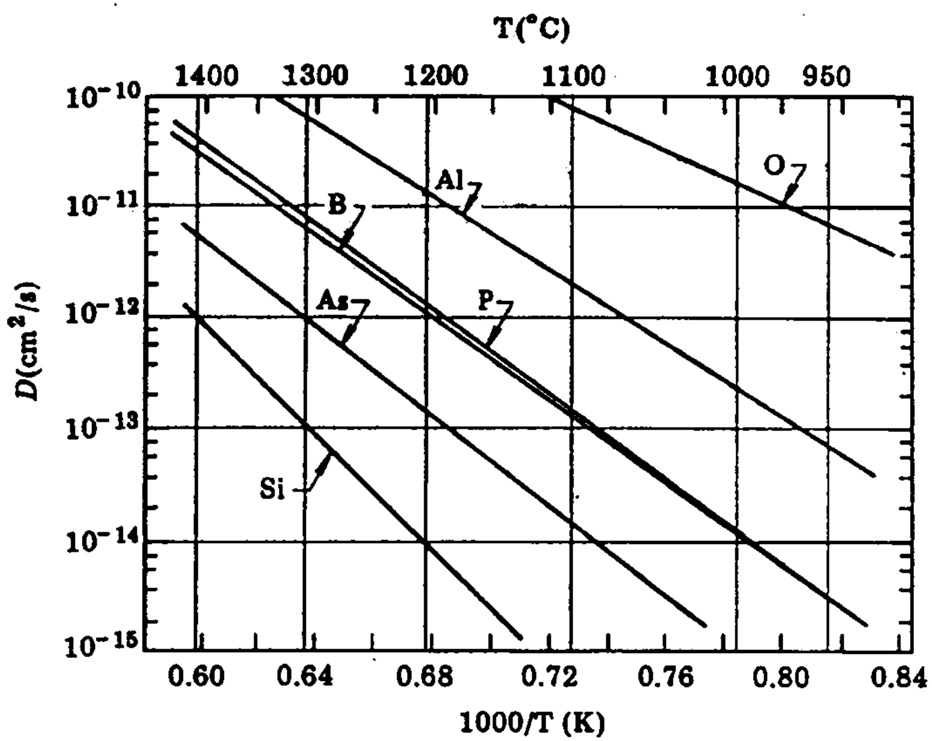
Diffusion



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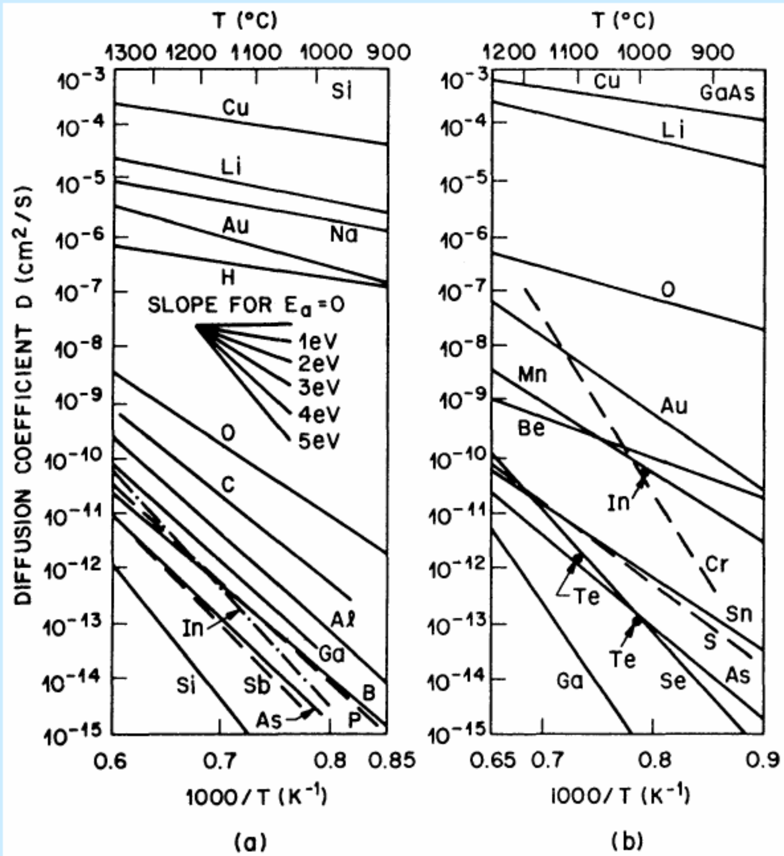
Diffusion



Si **GaAs**

The diffusion coefficients can be expressed as

$$D = D_o e^{-\frac{E_a}{kT}}$$

where D_o denotes the diffusion coefficient extrapolated to infinite temperature and E_a stands for the Arrhenius activation energy

Constant-Surface-Concentration Diffusion

The initial condition at $t = 0$ is $C(x, 0) = 0$ which states that the dopant concentration in the host semiconductor is initially zero. The boundary conditions are: $C(0, t) = C_s$ and $C(\infty, t) = 0$ where C_s is the surface concentration (at $x = 0$) which is independent of time. The second boundary condition states that at large distances from the surface, there are no impurity atoms. The solution of the differential equation that satisfies the initial and boundary conditions is given by:

$$C(x,t) = C_s erfc\left\{\frac{x}{2\sqrt{Dt}}\right\}$$

erfc stands for the **complementary error function**, $\sqrt{Dt}$ is the diffusion length, x is the distance, D is the diffusion coefficient, and t is the diffusion time.

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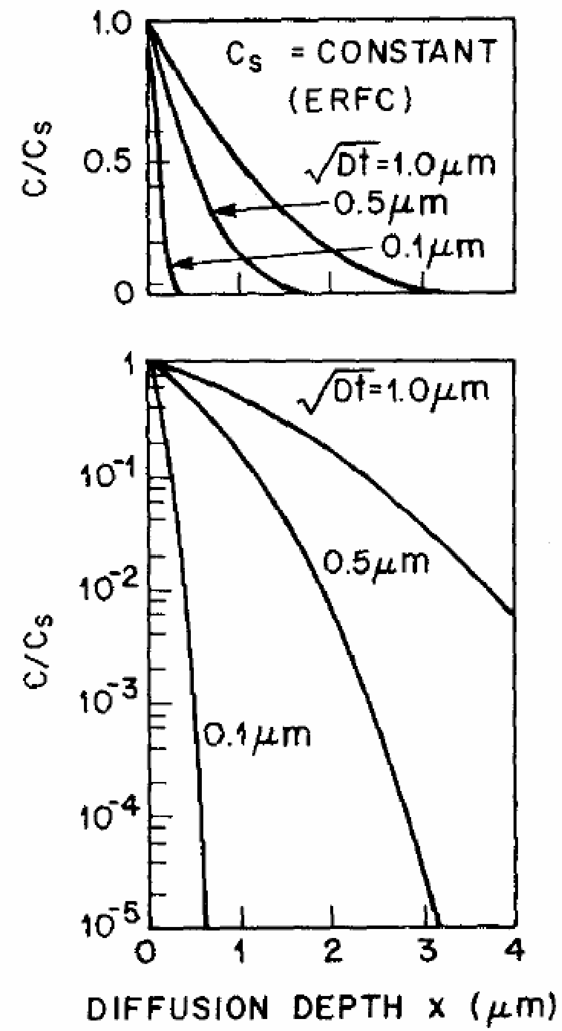
Diffusion



Constant-Total-Dopant Diffusion

A fixed (or constant) amount of dopant is deposited onto the semiconductor surface in a thin layer, and the dopant is subsequently diffused into the semiconductor. The initial condition at $t = 0$ is again $C(x, 0) = 0$. The boundary conditions are:

$$\int_0^\infty C(x,t)\ dx = S \quad and \quad C(\infty,t) = 0$$

where S is the total amount of dopant per unit area. The solution of the diffusion equation satisfying the above conditions is:

$$C(x,t) = \frac{S}{\sqrt{\pi D t}} \exp\left\{\frac{-x^2}{4Dt}\right\}$$

Gaussian distribution

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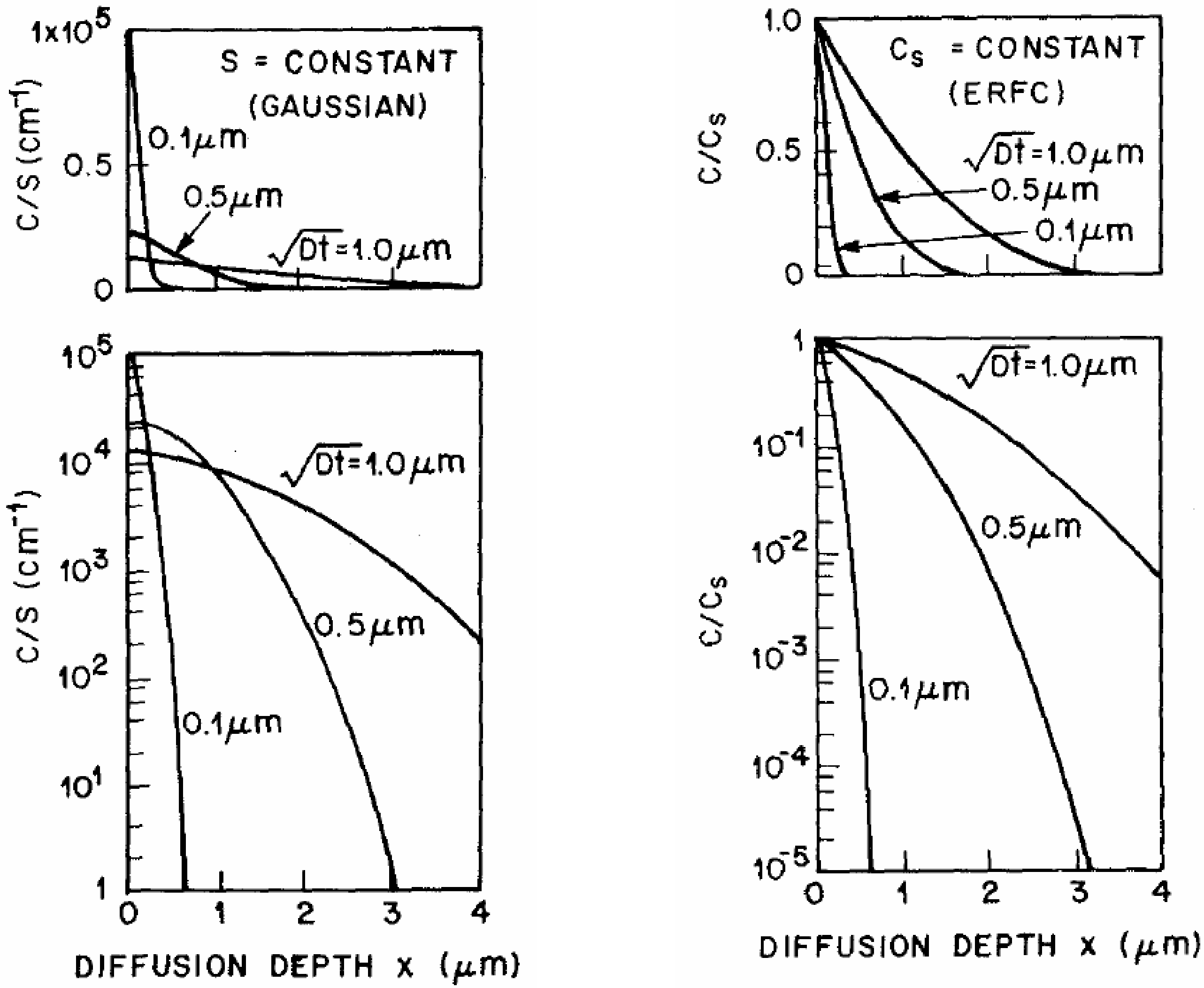
Diffusion



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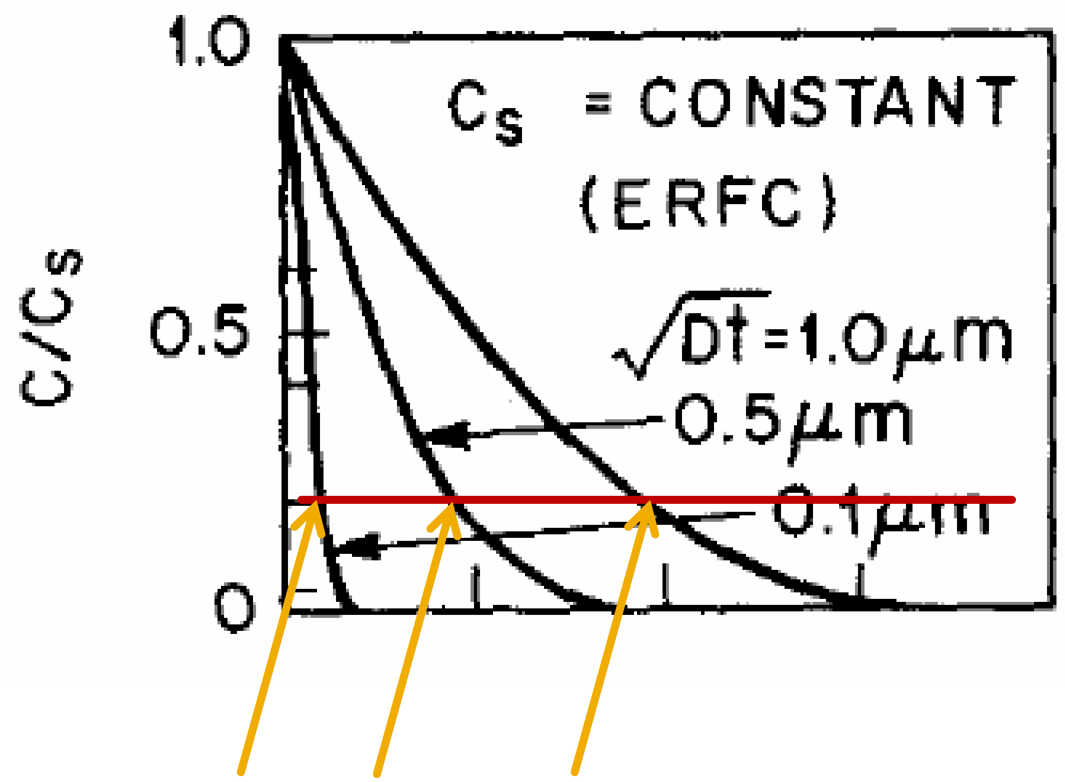
Diffusion



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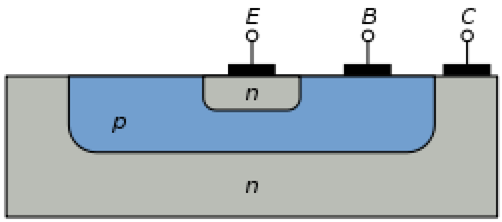
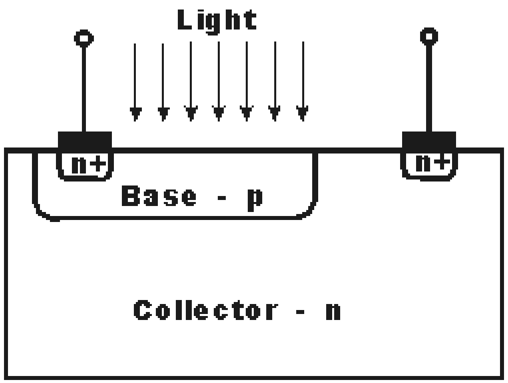
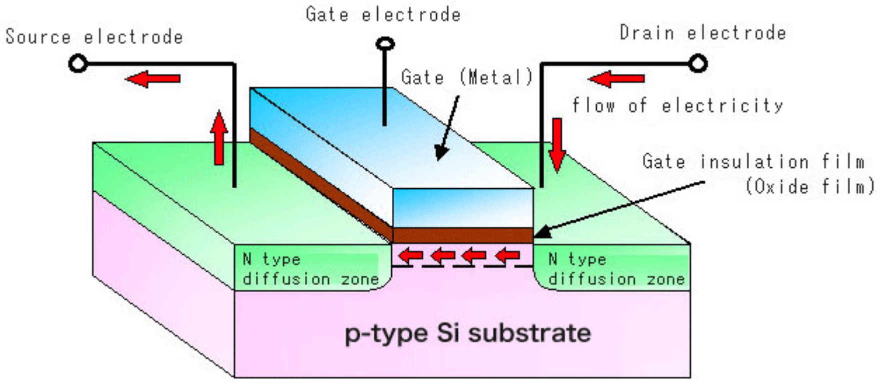
Diffusion







Construction of MOSFET