Fabrication

*) **Photolithography** → is basically the transfer of image from the mask to the surface of the wafer.

<patterning of the surface to the wafer>

[In this process UV radiation of light rays are used to patter the wafer.]

Here, the term ⇒ photo + lithos + graphy

photo ↓ Light

lithos ↓ Stone (Greek word)

graphy ↓ writting

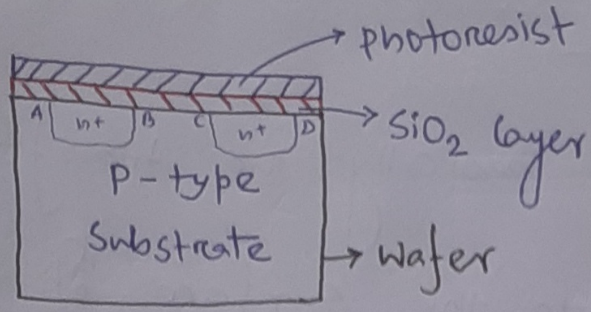
{In the ancient age, people used to write something on the surface of the stone manually.}

But, here → used to pattern some image / structure using UV light on the surface of wafer.

→ Transfer light rays from photomask to the light sensitive polymer called photoresist.

So,

when light sensitive polymer (photoresist) exposed by UV light, its properties changes chemically.

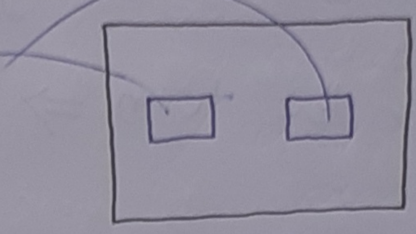


⟨side view⟩

Here, if we would like to diffuse n+ region ⟨to make source, & drain⟩
→ it is not possible untill & unless we remove SiO_2 layer from {(A to B) & (C to D)} region.

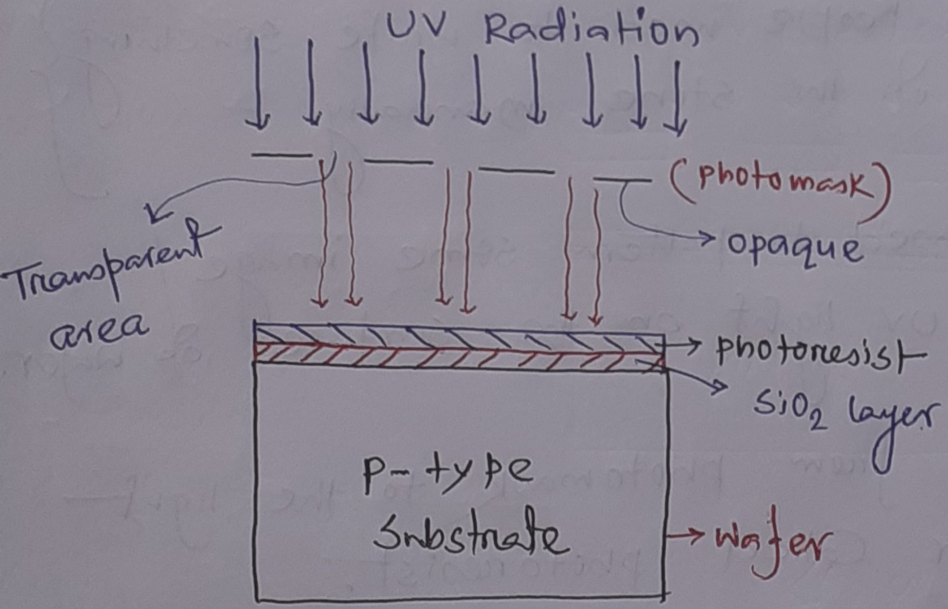
(*) Here, SiO_2 layer act as a mask.

{Need to remove SiO_2 layer from that area}



⟨Top view⟩

So,



(*) photomask is nothing but a glass material in which Chromium is Coated.

→ Act as a master image, which need to draw | pattern on the surface of the wafer.

Steps involved in photolithography

i) photoresist Coating → Coat the oxidized wafer with light sensitive material called photoresist.

[* Drop photoresist material on surface & spin at 3000 rpm; so that photoresist] liquid should uniformly coated througout the surface area.

ii) Exposure → Expose the wafer coated with photoresist with UV radiation.

[* photomask :- Master image of the pattern that has to be trasferred on the surface of the wafer.]

* This mask is selectively opaque & transparent.

→ So, after this whole process, where UV radiation fall, the exposed area of photoresist changes chemically.

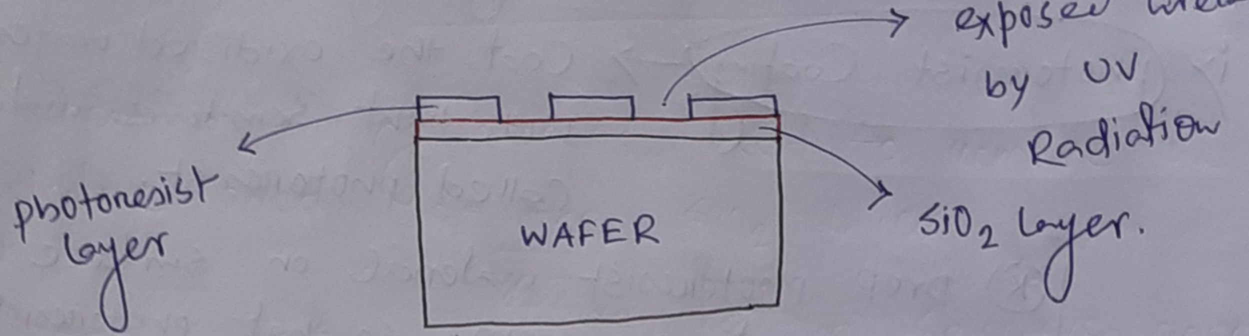
means, that exposed area become depolymarized. <which can be removed further>

iii) Development → Developer solution to remove the exposed area from the photoresist.

<This is nothing but Aqueous solution>

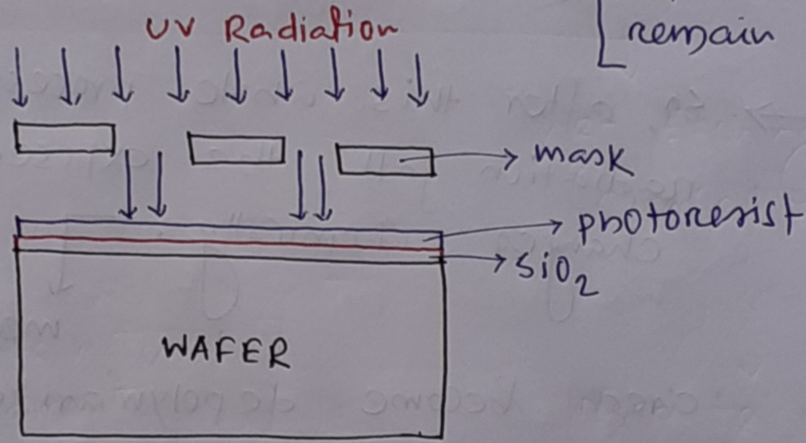
When the exposed erea of photoresist comes in contact with developer solution, it can be easily removed.

Now, it looks like, —

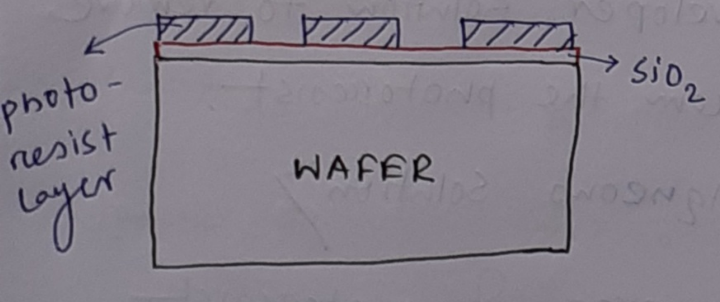


⊕ photoresist materials are basically two types, —

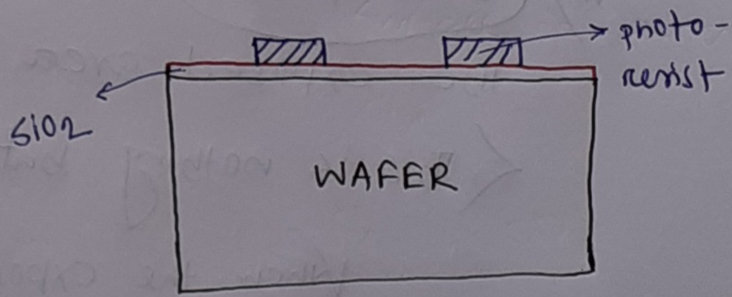
- positive photoresist
  ⟨ exposed area removed ⟩
- Negetive photoresist
  ⟨ un-exposed area removed; ⟩
  [exposed area remain intact.]



⇓ ⟨ After using developer sol... ⟩



⟨ positive photoresist ⟩



⟨ Negetive photoresist ⟩

*) In industry, mostly we positive photoresist.
< easy way to design a mask >
and, achieve better resolution compared to negative photoresist. (leakage is less)

iv) post baking → Heat treatment.

{ Wafer is heated at 100 to 120°C ; to make good connection between polymer to polymer }
→ linkage become good; Give/provide hard structure of photoresist on the surface of wafer.

→ provide chemical stability to photoresist; It also provide thermal stability also.

< better adhesion with substrate >

Etching

To perform doping process, need to remove the selective area of the SiO_2 layer.

To remove the selective area of SiO_2 layer, called Etching process.

N.B → Etching process not only applicable to remove selective SiO_2 region, but also applicable for removing photoresist layer, Si layer etc.

So,

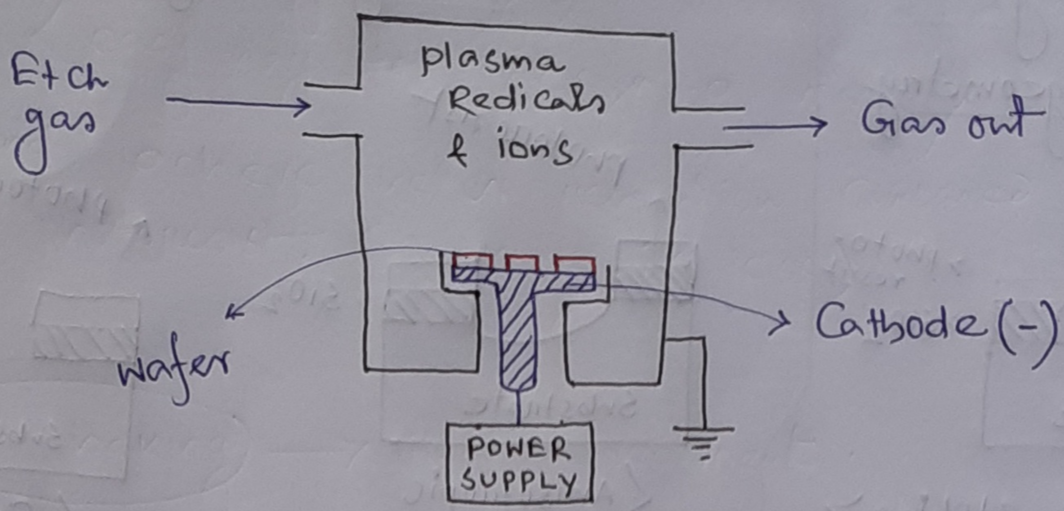
Etching is → Removal of material from the surface of wafer.

↓ Dry Etching (physical etching)

Etching of the material due to the bombardment of ions from the surface of the wafer. <Sputtering>

↓ Wet Etching (chemical etching)

Need to use etchant, which perform chemical reaction with the surface of wafer.



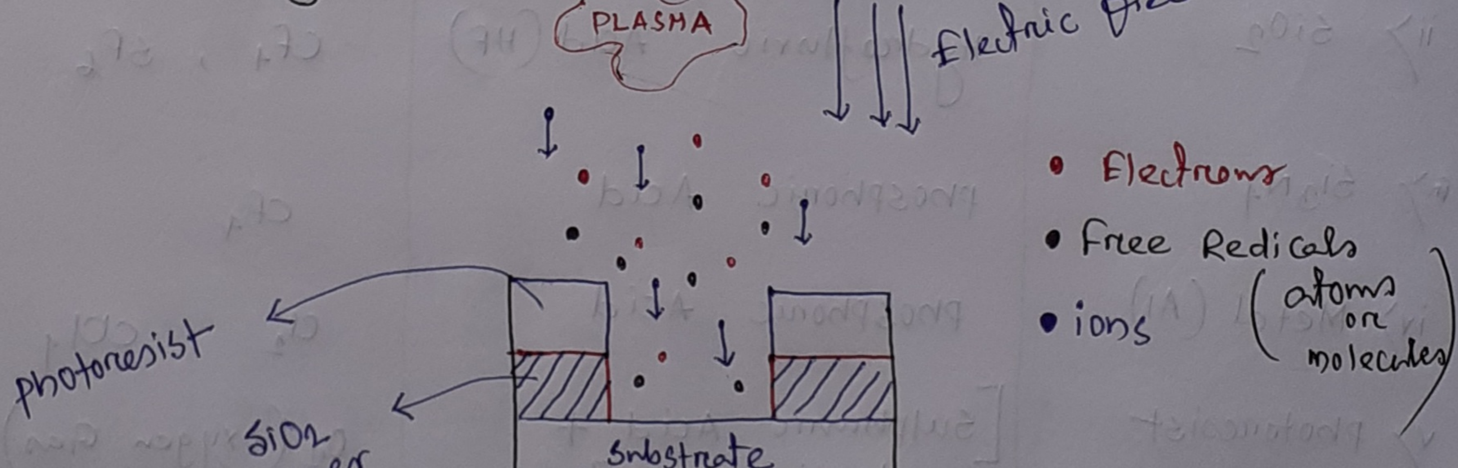
<Dry Etching>

Plasma $\longrightarrow$ 4th stage of matter < When gaseous material is heated up with very high temparature, then converted into plasma.

$$\left\{ Ar \text{ gas} \xrightarrow[\text{high temp.}]{\text{Heated up}} \underbrace{Ar^{+}}_{\text{ions}} + e^{-} \quad \text{plasma} \right\}$$

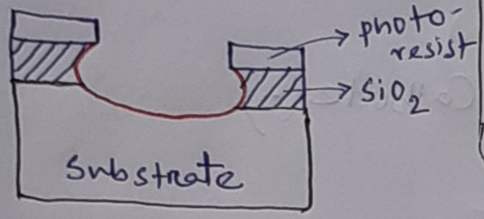
Due to the high electric field between Ar^{+} (ion) & negetively charged cathode $\longrightarrow$ it has a ability to dislodge the material from the surface of the wafer. (because of high kinetic energy of ion)

⊕ plasma etching process $\rightarrow$



Wet etching

Surface geometry

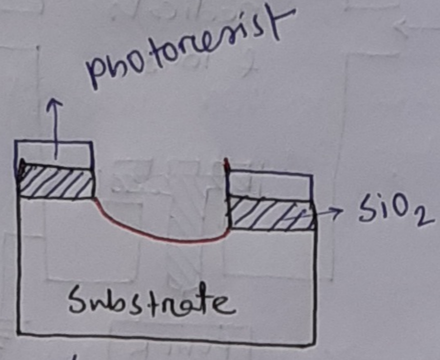


⟨isotropic etching⟩

↳ here we Hydroflurie Acid (HF) as etchant.

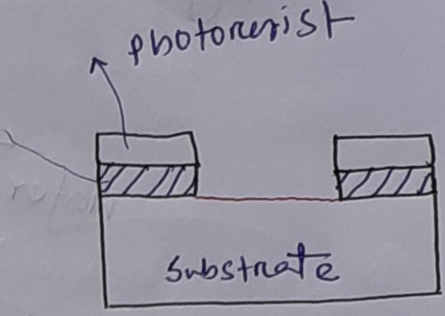
(Etching perform in all direction equally.)

Dry Etching Surface geometry



⟨Anisotropic etching⟩

↳ Etching performed in the particular direction.



⟨Completely Anisotropic⟩

⊕ Etchant used →

Material	Wet Etchant	Dry Etchant
i) Silicon	potasium Hydroxide (KOH)	CF_4 , SF_6
ii) SiO_2	Hydroflurie Acid (HF)	CF_4 , SF_6
iii) Si_3N_4	phosphoric Acid	CF_4
iv) Metal (Al)	phosphoric Acid	Cl_2 , CCl_4
v) photoresist	[Sulphuric Acid + Acetic Acid]	O_2 (oxygen Gas)

Difference between Dry Etching & Wet etching ⇒

Dry Etching	Wet Etching
i) Etching done at plasma phase.	i) Etching done at liquid phase.
ii) Uses gaseous phase chemicals.	ii) uses liquid phase chemicals.
iii) Much safer than wet etching.	iii) Not safe since disposing of hazards chemicals.
iv) More precise	iv) Less precise.
v) use few chemicals.	v) Uses many chemicals.
vi) Expensive, because specialized equipments are required.	vi) Not expensive, because needs only chemical bath.
vii) Anisotropic type	vii) Isotropic type
viii) poor selectivity	viii) Good Selectivity.

{ ability to select a particular area for the removal of undesired layer. }