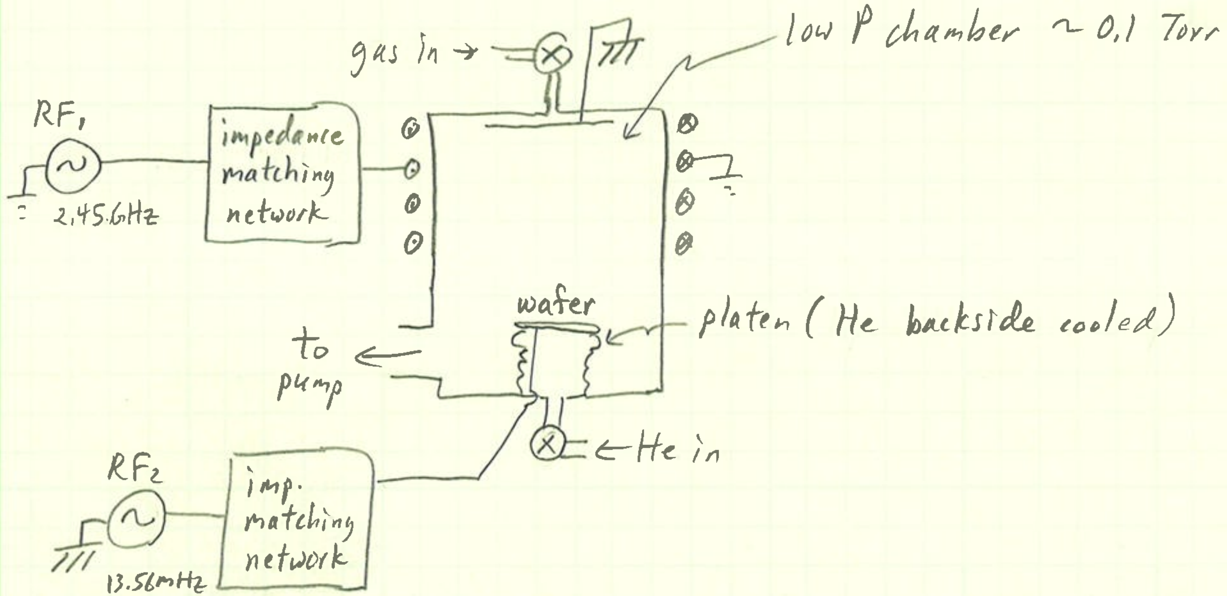
1. Reactive Ion Etching (RIE)

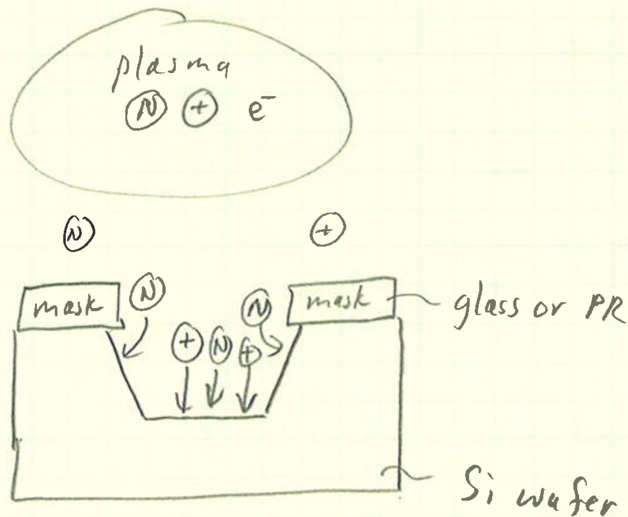
→ combines chemical etching using reactive neutrals with sputtering to produce better anisotropic etching



wafer is held on the platen either mechanically or electrostatically

RF_1 → produce plasma

RF_2 → provide an effective large negative bias on the platen to accelerate positive ions to the wafer for sputtering



Ⓝ → chemically convert Si to a gas

⊕ → sputter Si from exposed horizontal surfaces (Ⓝ react w/ sputtered Si too)

Sputtering heats up the wafer → He backside cooling is used

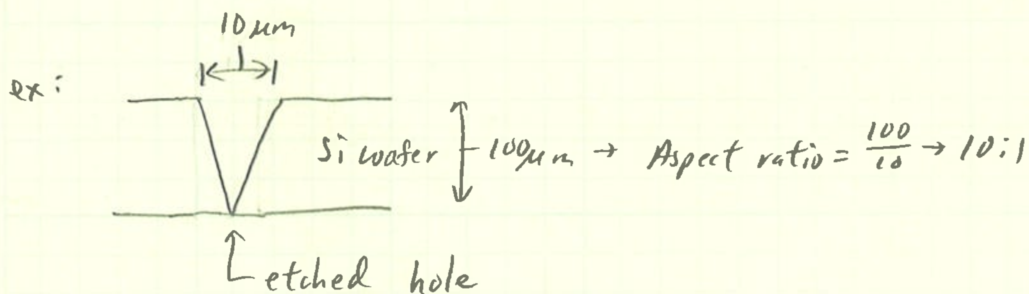
→ sputtering results in a more anistropic etch than plasma etching alone with reactive neutrals

→ <u>Aspect Ratio</u> – a measure of the anisotrophy of the dry etch

→ a ratio of vertical etch to the horizontal etch

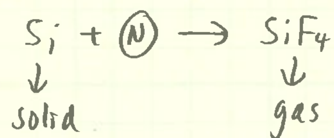
→ the limit of what a process or machine can achieve → is a metric for that process or machine

ex:



RIE gas chemistries : various chemistries can be used

→ typical used gases: SF_6, CF_4, NF_3



RIE → aspect ratios of 10 - 15 can be achieved

2. Deep Reactive Ion Etching (DRIE)

RIE based on the Bosch Process

→ uses a sequential alternating process of etching and passivation

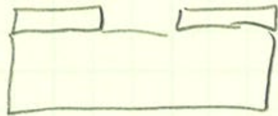
Etch Step → SF_6/Ar plasma (300-1200W 2.45 GHz RF power) with a −5V to −30V platen bias (2-10W 13.56 MHz RF power)

↓

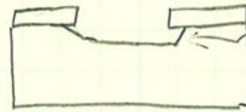
accelerates pos ions ~90° toward substrate → sputtering

→ short etch step

start



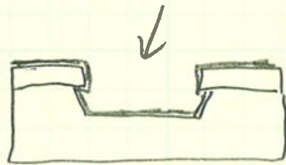
stop



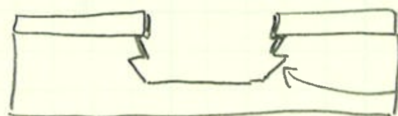
slight undercut

Passivation Step → all surfaces coated with ~50nm thick polymer coating (~Teflon) → $C_4F_8 + SF_6 \rightarrow CF_2$

↓



next etch step → sputtering ions quickly removes passivation coating from horizontal surfaces (so Si etching continues) but not from vertical surfaces (prevents lateral Si etching)



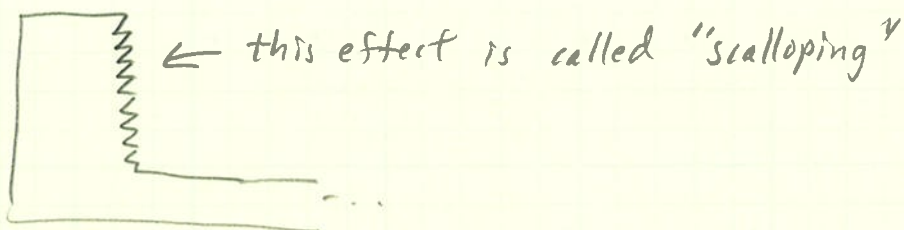
more undercutting

next passivation step, etc...

Result → Aspect ratios as high as 30 can be achieved.

→ vertical etched sidewalls are not smooth

ex:



Ex: STS ASE (Advanced Silicon Etcher)

→ etch rate : 1.5 to 3.0 μm/min

aspect ratio : up to 30 (10 is typical)

selectivity to SiO_2 : 120 to 200:1

mask : PR or SiO_2 typically used

→ etches (100), (110) or (111) ~ equally

How can scalloping be removed?

→ dip in an alkaline etchant : KOH or TMAH

→ thermal oxidation followed by SiO_2 removal (BOE or HF)