EE669: VLSI Technology

Apurba Laha
Department of Electrical Engineering
IIT Bombay 400076

Email: laha@ee.iitb.ac.in, Tel: **022 25769408**

Office hour: Friday 10:00 – 11.00 AM, EE Annex, Room: 104

Contamination removal: Gettering

The idea

The technical use of the term "gettering" (derived from "getting") goes back to the good old time of vacuum tubes that enabled early electronics, in particular radio and TV. Parts of the inside of the glass tubes was coated with a "getter" (**typically titanium**) that "**got**" the remaining gas molecules by reacting with them, thus improving and maintaining vacuum conditions.

~1950/60

~1930

- **A decent radio needed 5 - 10**
- **Your i-phone would need about 100,000,000,000**
- **Major power plant would be needed to supply the needed energy!!!**

Such kind of "gettering" is still used in vacuum technology

Contamination removal: Gettering

- **Gettering in silicon** is somewhat different
- The idea is to "**get" or getter itinerant** metal atoms that are still present in the silicon crystal - **albeit at very low concentrations**.
- Confine these metal atoms somewhere in the bulk of the crystal and thus keep them from creating any disturbance in the active layer close to the surface

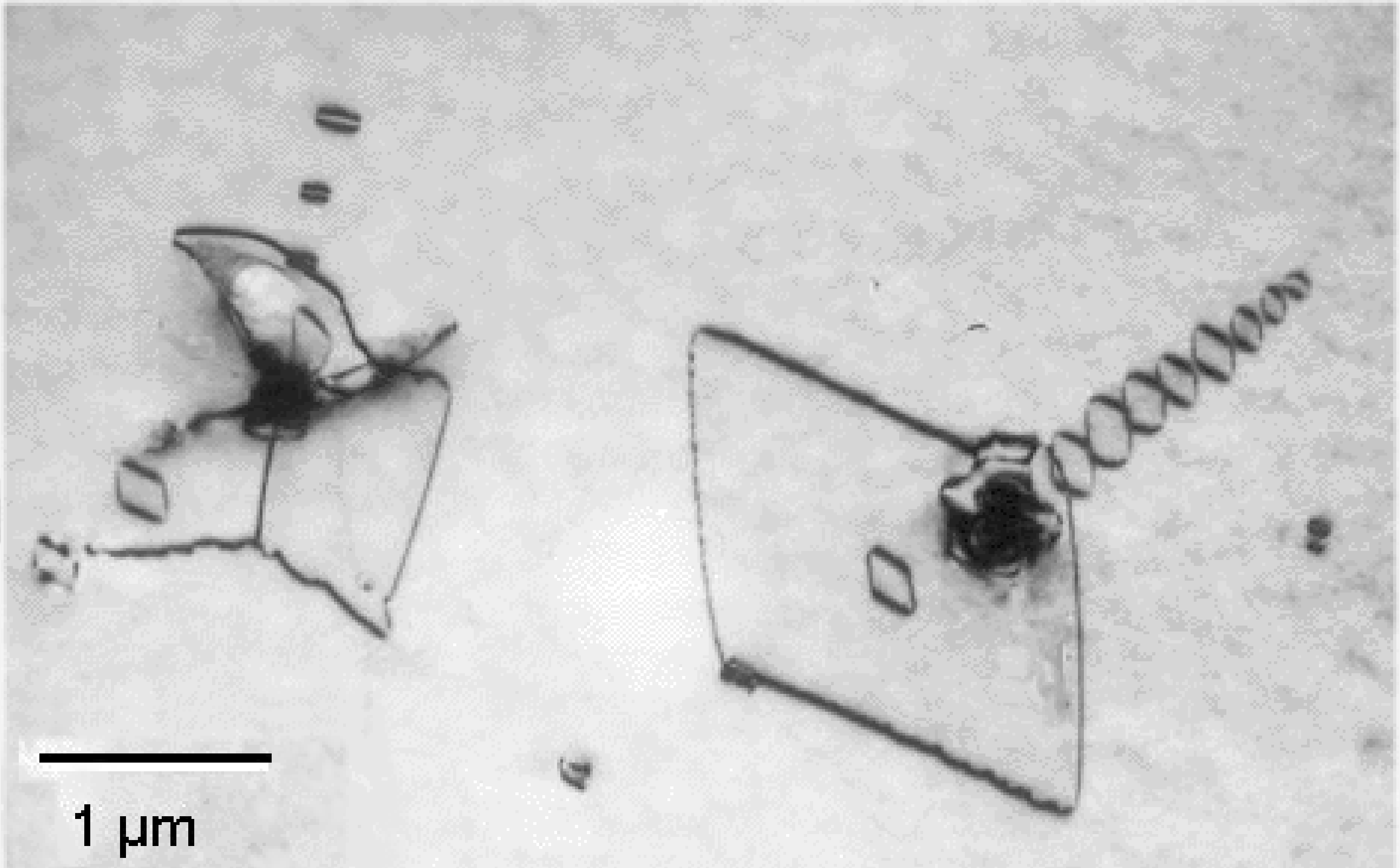
What could we use as "getter"?

Internal or ***intrinsic*** **gettering**, is far more effective.

The getter in this case consists of intrinsic defects that are distributed all over the bulk of the silicon wafer - but not in the first (10 - 20) µm below the surface. This is important because these getter defects would definitely kill transistors and thus must be avoided in the active region.

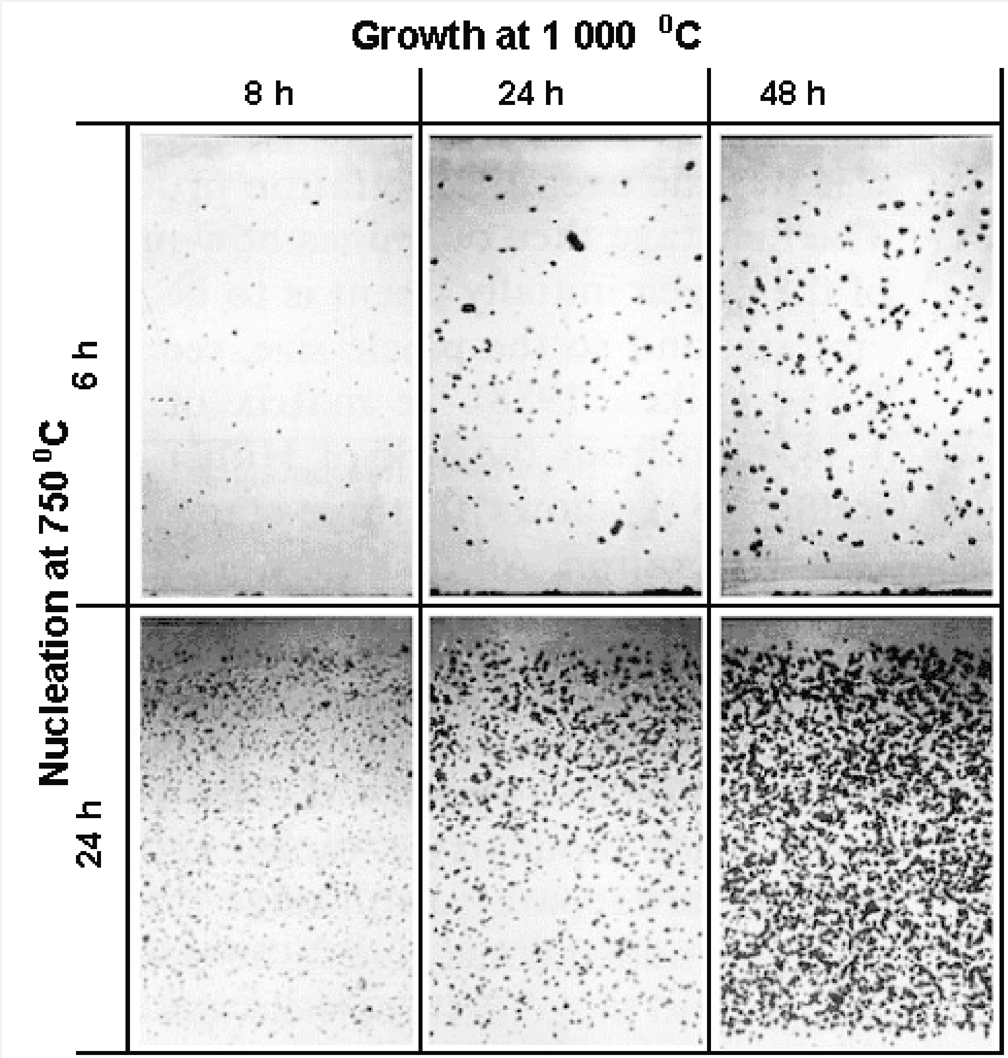
Intrinsic defects? **oxygen precipitates** plus, perhaps, some dislocations created by these precipitates in their immediate environment.

Here is what this might look like:



SiO_2 precipitates plus some dislocations as seen in TEM.

Defects generally attract point defects and incorporate them into their structure, effectively **immobilizing** them.



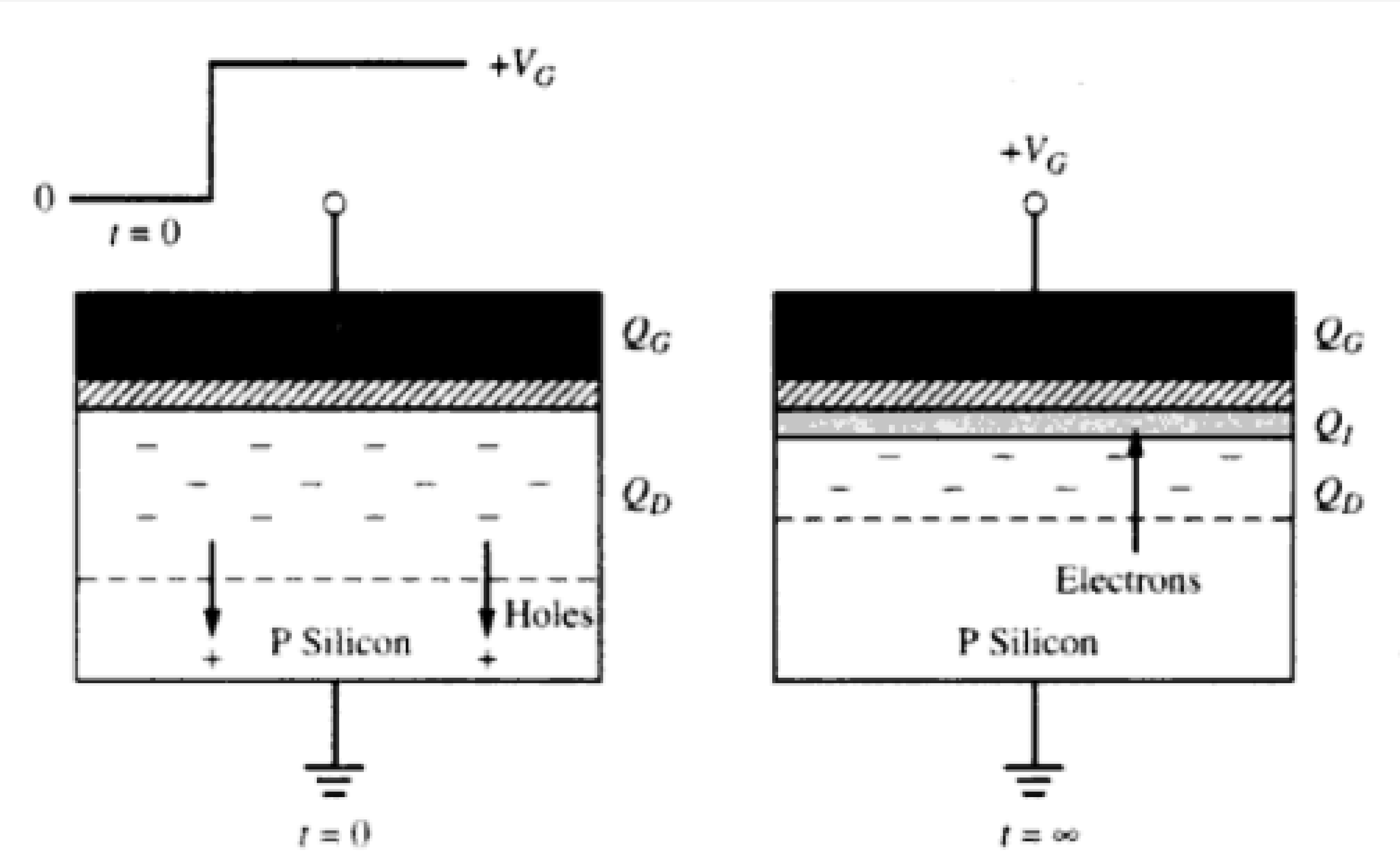
- **Development of SiO_2 precipitates**
- **Cross-section through complete wafer**

The initial oxygen concentration was **$8.15 \cdot 10^{17}$ cm^{-3}**. The precipitates were rendered visible by defect etching.. Note the denuded zone obtained by a first out-diffusion treatment at **1100 °C** for 10 hours.

Identifying the defects by looking at various properties (electrical)

- **Measurements of fundamental parameters: Carrier lifetime**
- **Hypothesis: Better carrier lifetimes better is the gettering**
- **Both: Generation time and Recombination time are important**
- **Methods for measuring the lifetime: Dominated by bulk carrier life time or surface recombination or both**
- **One of the oldest and simplest method: Photoconductive decay**

Measurement of generation time

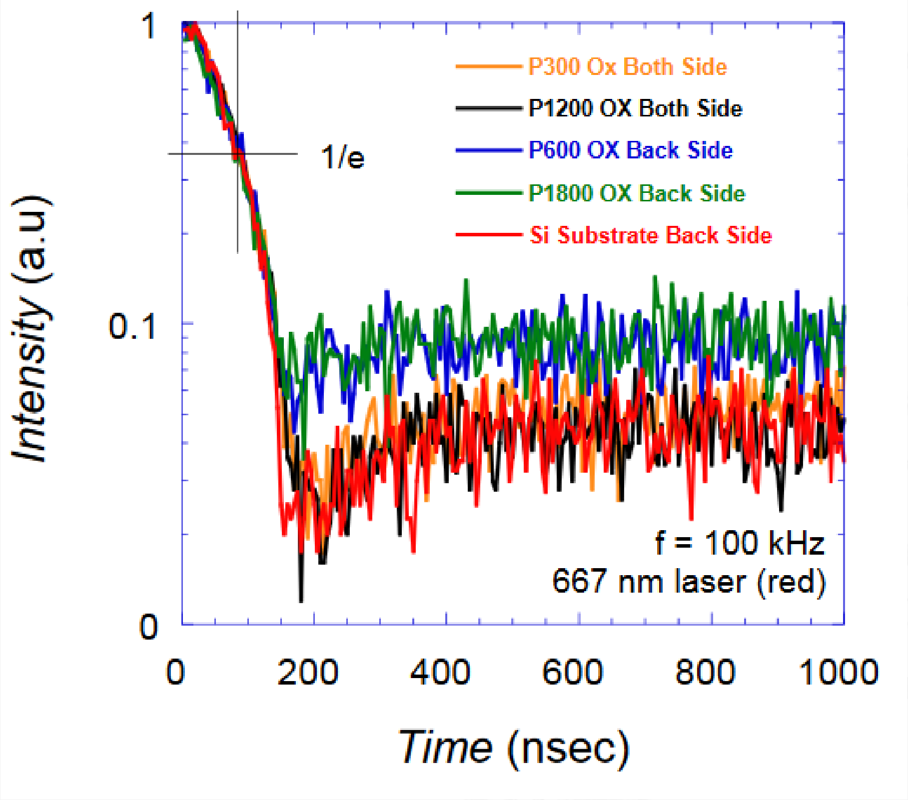


MOS CV measurement to extract carrier generation life time. At t=0, the gate bias Is stepped to +Vg. The capacitor goes into deep depletion. As the carrier are generated to form the inversion layer, the depletion layer shrinks

Measurement of recombination time:

Time-Resolved Photo Luminescence (TRPL)

Time resolved photoluminescence is based on PL technique where an optical laser pulse is applied to the semiconductor and the decay in photoluminescence with time is measured to determine the minority carrier lifetime.



TRPL measurement of epitaxial silicon samples using a 667 nm (red) pulsed laser.

Contactless non-destructive optical method to measure purity, crystalline quality and identify certain impurities in semiconductors