

5.1.6 Summary to: 5.1 Basic Considerations for Process Integration

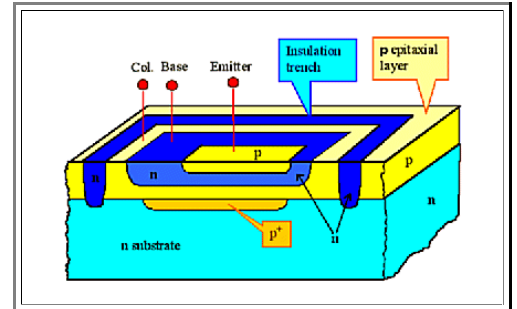
Integration means:

1. Produce a large number (up to **1.000.000.000**) of transistors (bipolar or **MOS**) and other electronic elements on a **cm²** of **Si**
2. Keep those elements electrically insulated from each other.
3. Connect those elements in a meaningful way to produce a system / product.

It ain't easy!

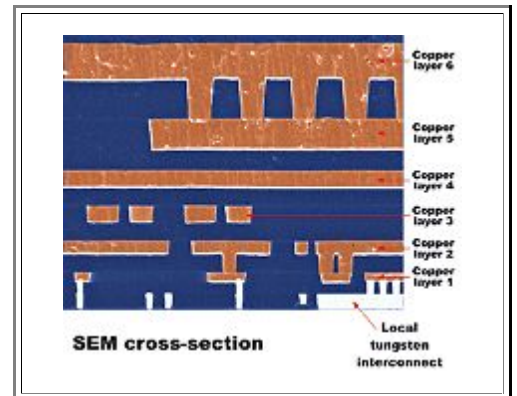
An integrated bipolar transistor does not resemble the textbook picture at all, but looks far more complicated $\Rightarrow$.

- This is due to the insulation requirements, the process requirements, and the need to interconnect as efficiently as possible.
- The epitaxial layer cuts down on the number of critical diffusions, makes insulation easier, and allows a "buried contact" structure.



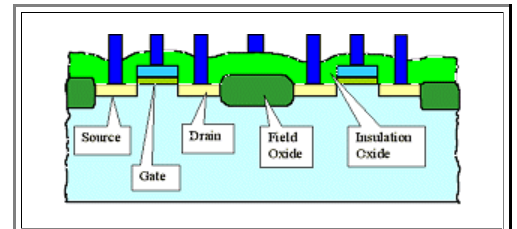
Connecting transistor / elements is complicated; it has to be done on several levels

- Materials used are **Al** ("old"), **Cu** ("new"), **W**, (highly doped) poly-**Si** as well as various silicides.
- Essential properties are the conductivity σ of the conductor, the dielectric constant ϵ_r of the intermetal dielectric, and the resulting time constant $\tau = \sigma \cdot \epsilon_r$ that defines the maximum signal transmission frequency through the conducting line.



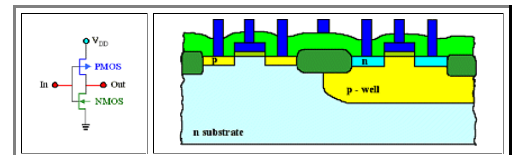
Integrating **MOS** transistors requires special measures for insulation (e.g. a field oxide) and for gate oxide production

- Since a **MOS** transistor contains intrinsically a capacitor (the gate "stack"), the technology can be used to produce capacitors, too.



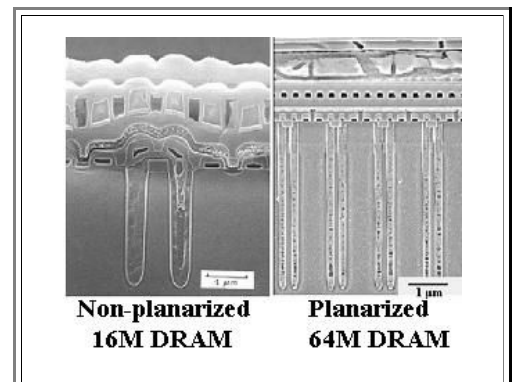
CMOS allows to reduce power consumption dramatically.

- The process, however, is more complex: Wells with different doping type need to be made.



Using the third dimension (depth / height) might become necessary for integrating "large" structures into a small projected area (example: trench capacitor in **DRAMs** $\Rightarrow$).

- Unwanted "topology", however, makes integration more difficult.
- Planarized technologies are a must since about 1995! $\Rightarrow$



 It ain't neither easy nor cheap!

Property	Number
Feature size	0,2 μm
No. metallization levels	4 - 7
No. components	$> 6 \cdot 10^8$ (Memory)
Complexity	> 500 Process steps
Cost (development and 1 factory)	ca. \$ $6 \cdot 10^9$

Questionnaire

Multiple Choice questions to all of 5.1