Structure of Matter
The Solid State

WS 2013/14

Lectures (Tuesday & Friday)

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Last time:

Band structure cont'd, semiconductors

Today:

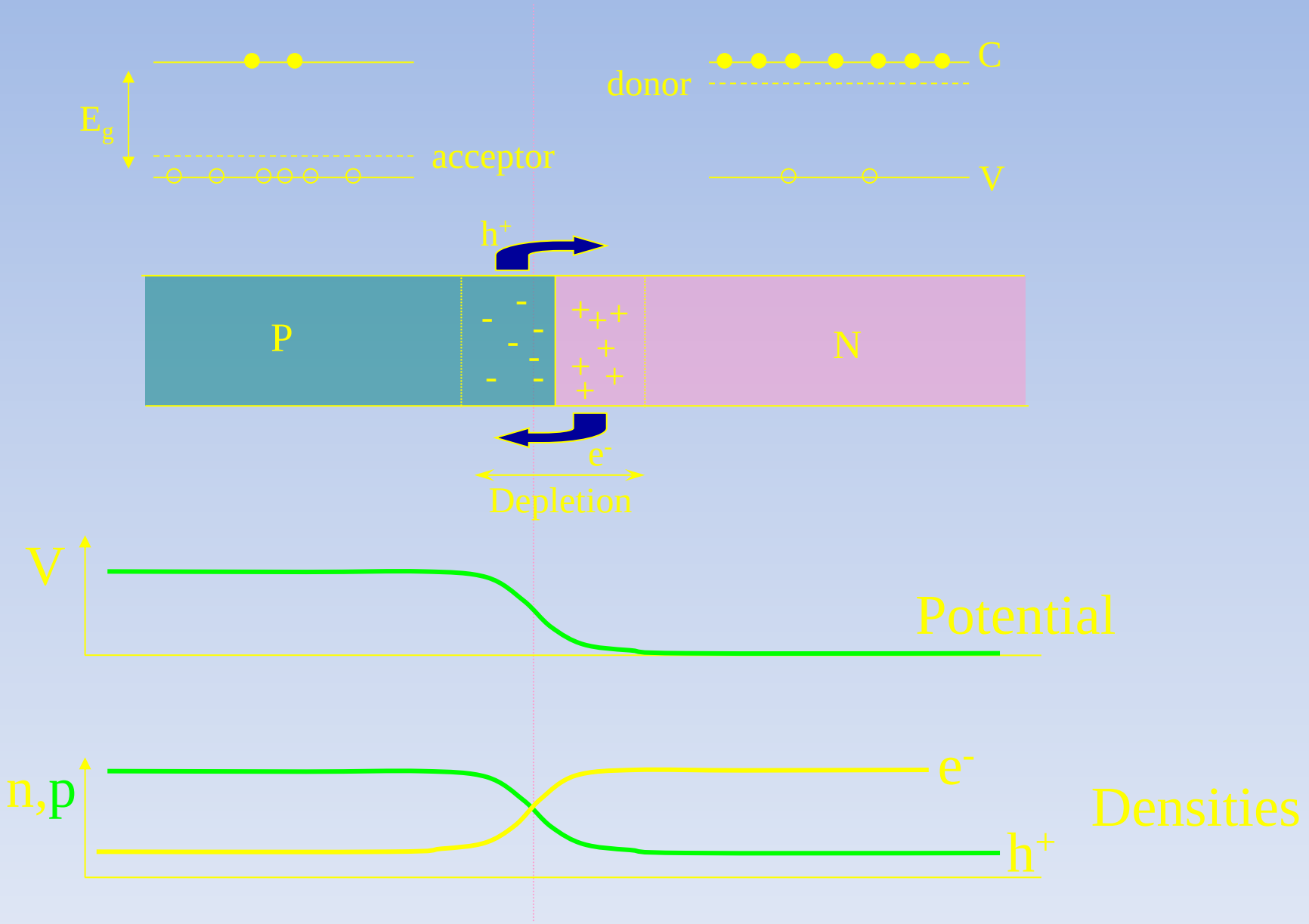
Semiconductor devices

Superconductivity

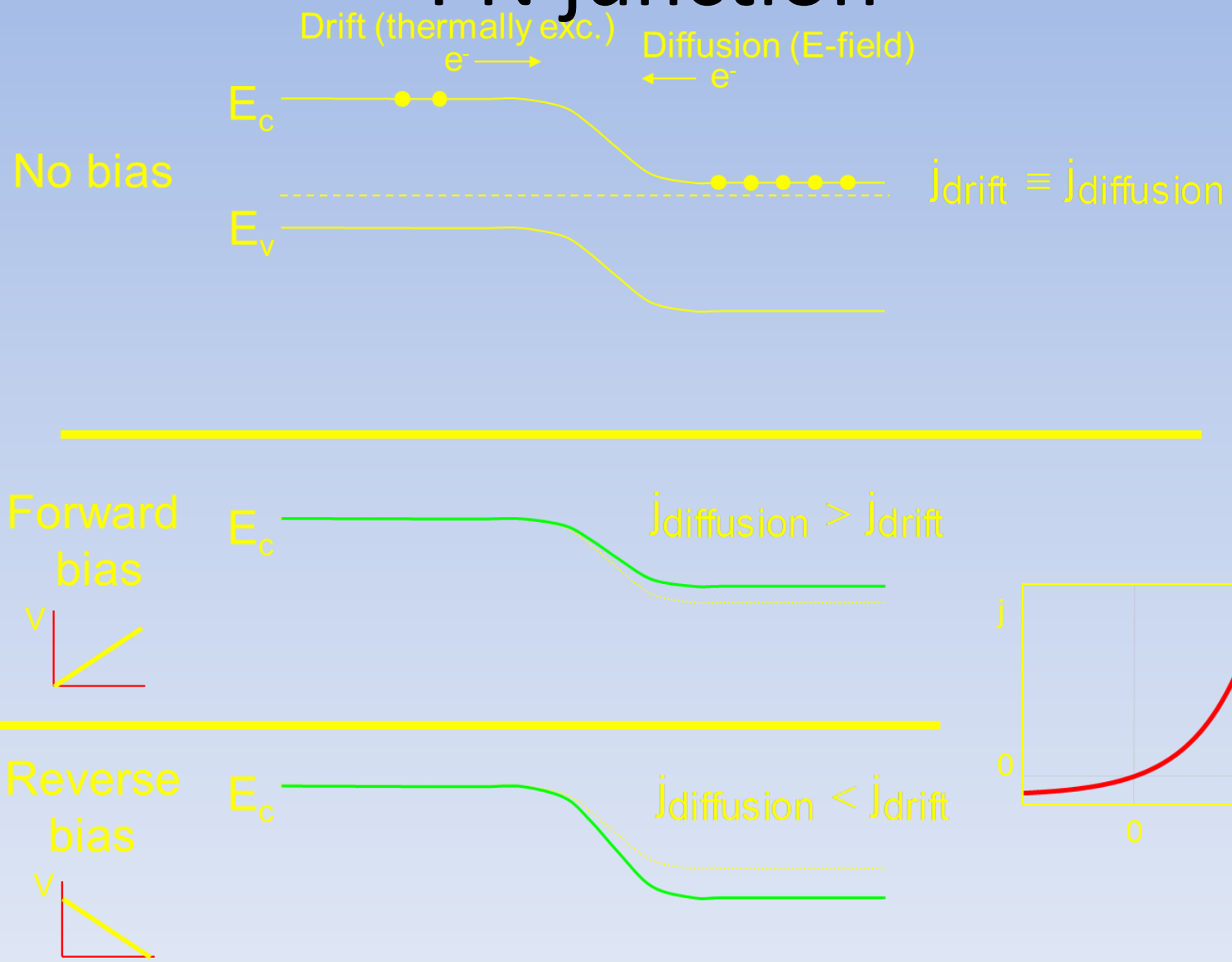
Heterogeneous semiconductors, devices

- PN junction
- Transistor
- Lasers
- Heterostructure & MOSFET 2DEG
- Integer & Fractional Quantum Hall effect

P-N Junction


C
donor
E_g
acceptor
V
h^+
P
N
e^-
Depletion
V
Potential
n,p
e^-
Densities
h^+

PN junction


Drift (thermally exc.)
e-
Diffusion (E-field)
e-
Ec
No bias
Ev
jdrift ≡ jdiffusion
Forward bias
Ec
jdiffusion > jdrift
V
Reverse bias
Ec
jdiffusion < jdrift
V
j
0
0
V

Other heterogeneous S.C.

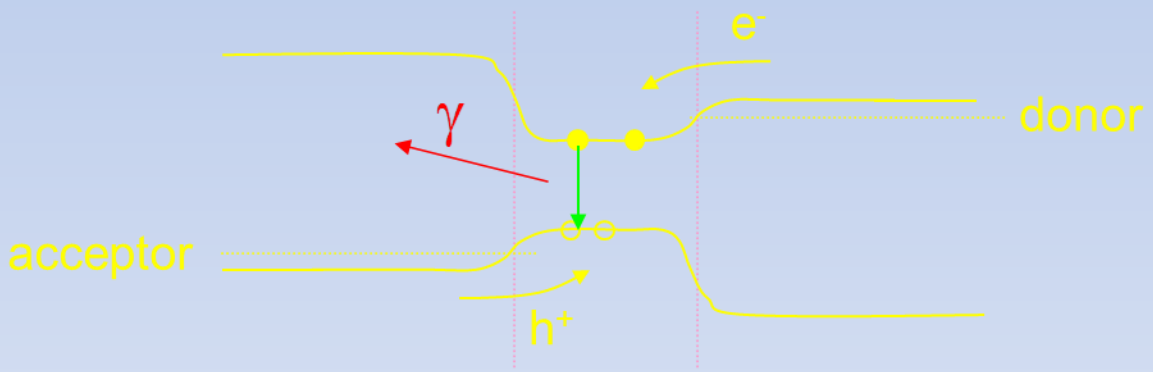
NPN junction (bipolar transitor), JFET transitors

Recombination: $e^- + h^+ \rightarrow \gamma$

LED and Semiconductor laser

$GaAs_{1-x}P_x$

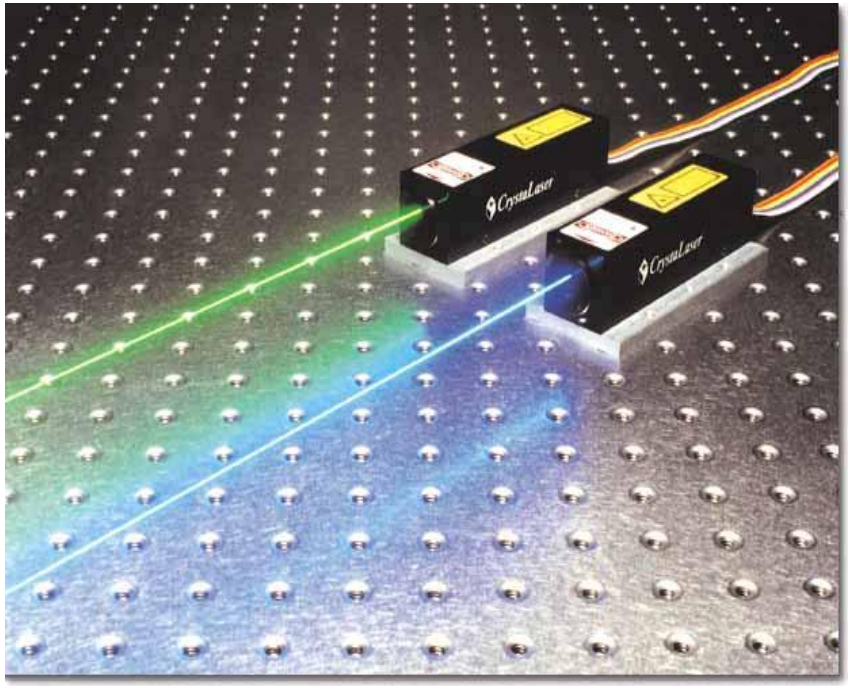
$In_xGa_{1-x}N/Al_yGa_{1-y}N$



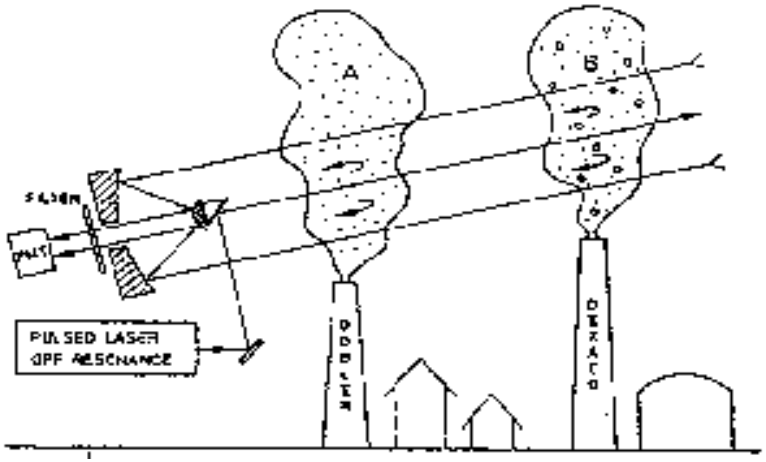
p-type

n-type

SC lasers

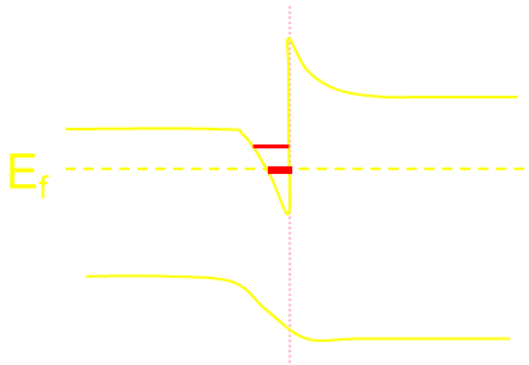


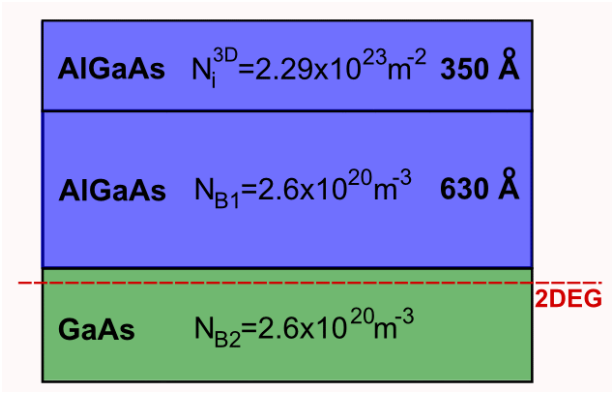
- Storage CD/DVD, MO
- Eye, artery, dental Surgery
- Diagnostic (Caries, Cancer)
- Environmental monitoring
- Remote sensing (speed, chemicals)
- Motion control
- … …
- …

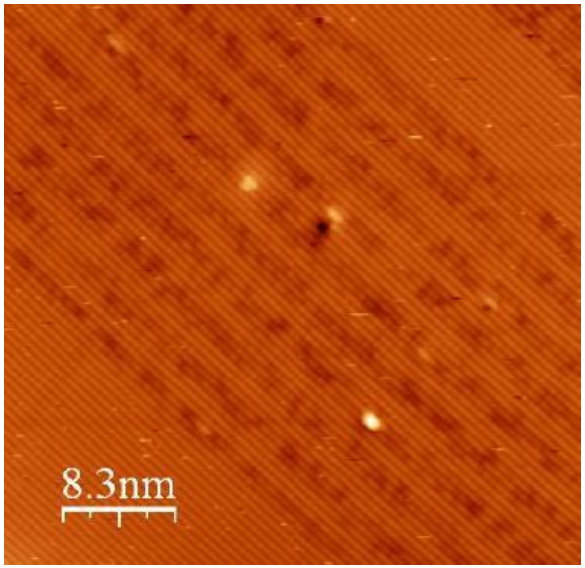


2D electron gases: Heterostructures

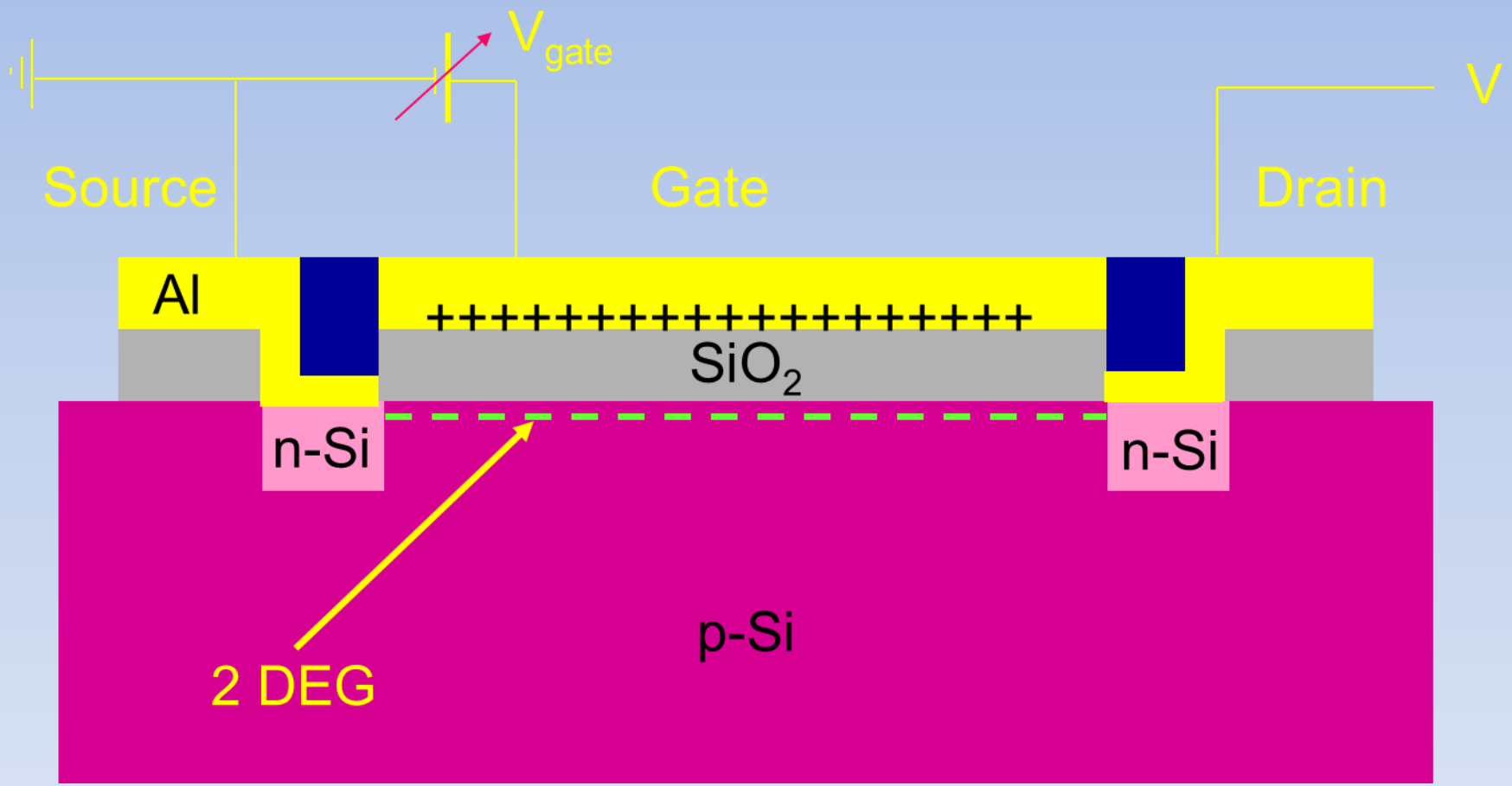
Heterostructure: Lateral confinement => 2 DEG



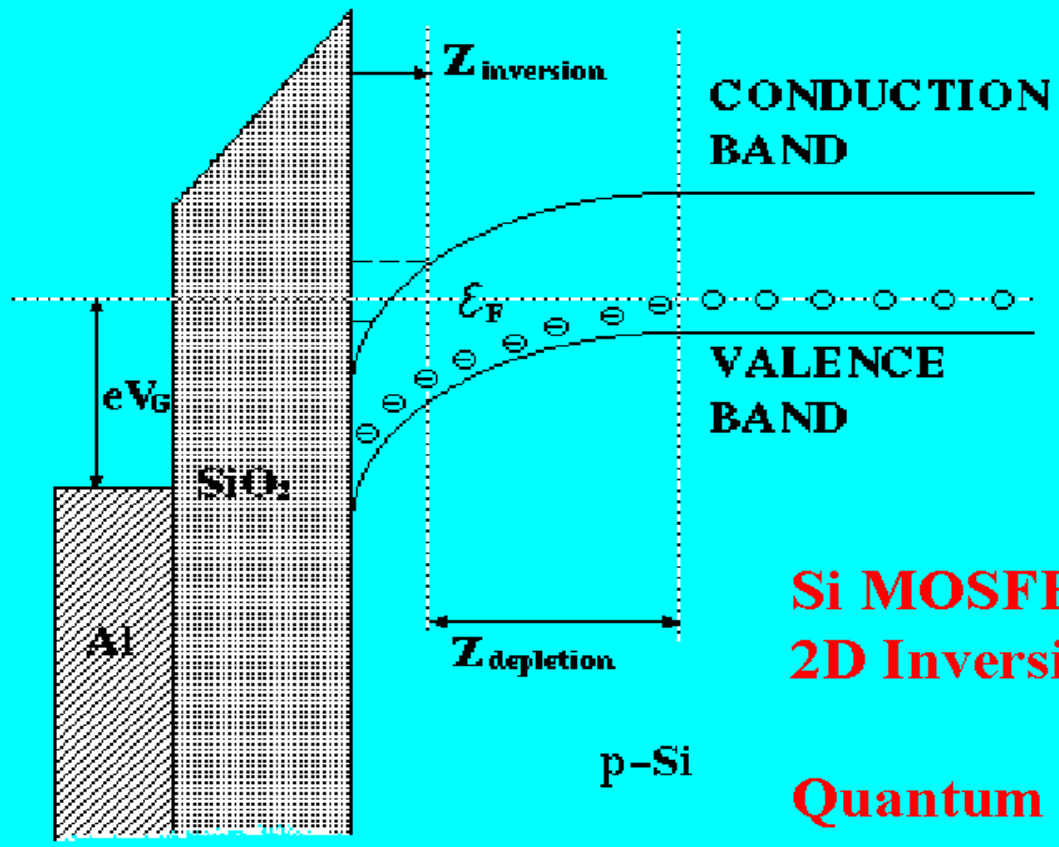




MOSFET 2DEG

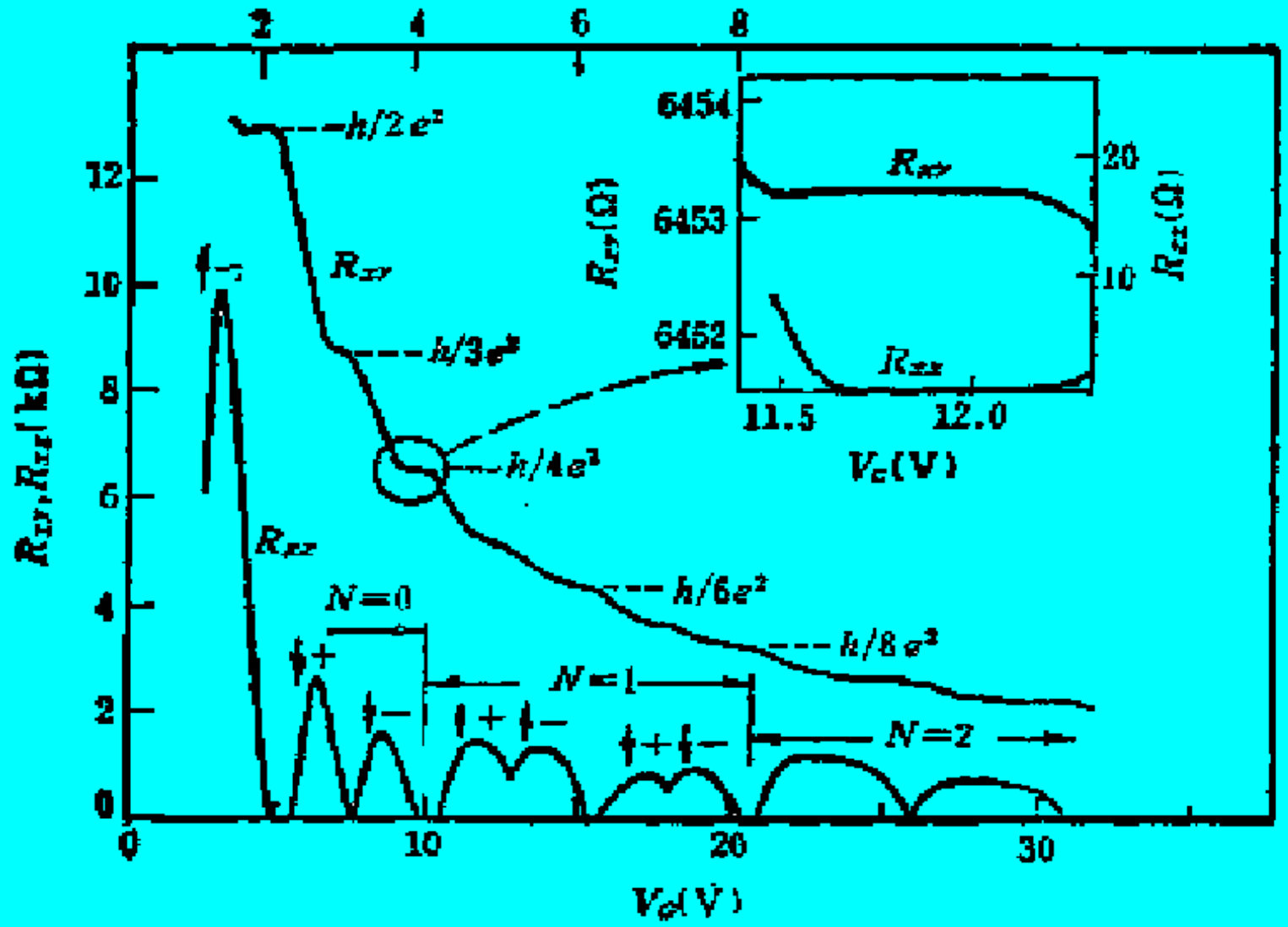


Band diagram MOSFET



Si MOSFET with 2D Inversion Layer

Quantum Confinement

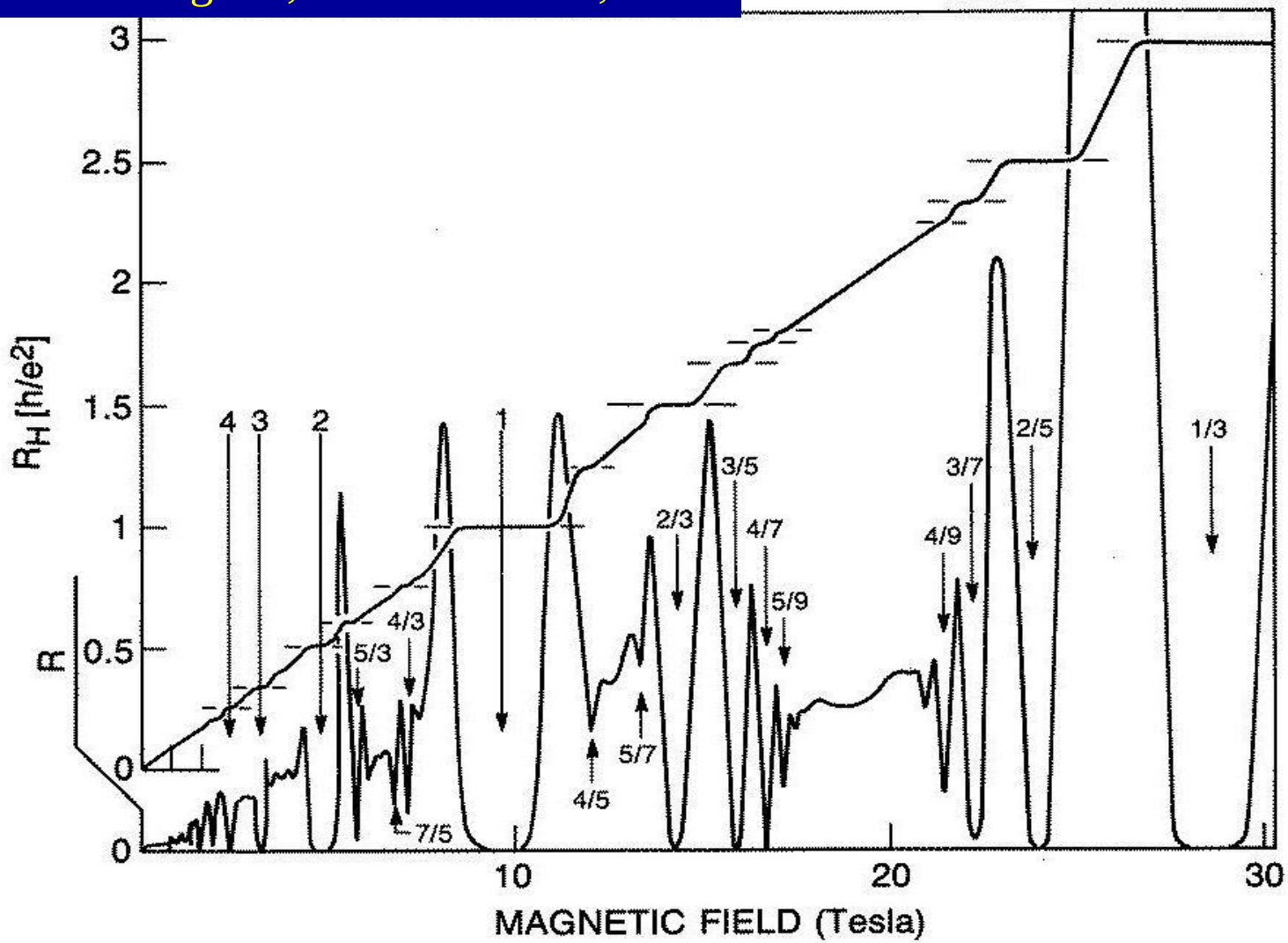


Nobel prize von Klitzing, 1985

Integer Quantum Hall effect on Si-MOSFET

Fractional quantum hall effect

Nobel prize von Laughlin, Tsui & Stormer, 1998



Composite fermions