Lecture2:
Diode

Sung-Min Hong (smhong@gist.ac.kr)

Semiconductor Device Simulation Lab.
School of Electrical Engineering and Coumputer Science
Gwangju Institute of Science and Technology

Diode

- Di(2) + ode(Electrode): Two-terminal device
  - There are many two-terminal devices.
  - Voltage source: $V_1 - V_2 = V$
  - Current source: $I_1 = -I_2 = I$
  - Resistor: $I = \frac{V}{R}$
  - Capacitor: $I = C\frac{dV}{dt}$
  - Inductor: $V = L\frac{dI}{dt}$
  - How about the diode?

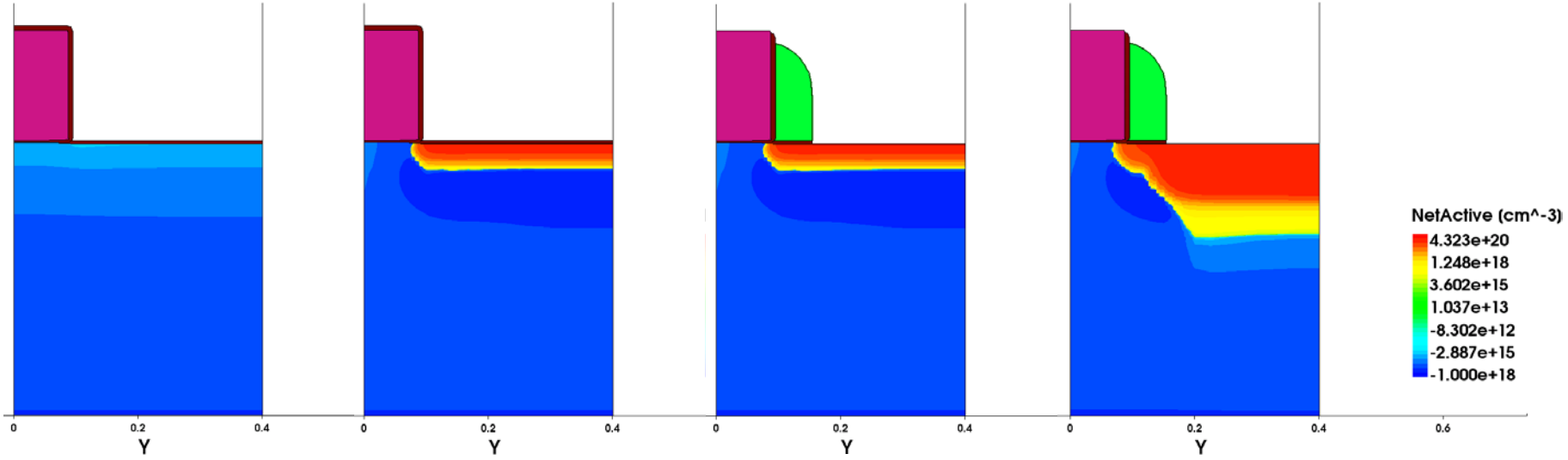
Forward/reverse

- A diode shows a strong polarity.
  - Does a resistor have a polarity?
  - In diodes, the following two cases are completely different.
- Forward bias
  - The voltage at the n-type side is higher than the p-type one.

- Reserve bias
  - The voltage at the p-type side is lower than the n-type one.

How to realize(/fabricate) it

- PN junction
  - Results of the process simulation are shown.



IV characteristics

- In forward bias,
  - The external voltage opposes the built-in potential, raising the diffusion currents substantially.
- In reverse bias,
  - The applied voltage enhances the field, prohibiting current flow.

$$I_D = I_S\left(\exp\frac{V_D}{V_T} - 1\right)$$

  - Here, the “reverse saturation current” is given by

$$I_S = Aqn_i^2\left(\frac{D_n}{N_A L_n} + \frac{D_p}{N_D L_p}\right)$$

  - L_n and L_p are electron and hole “diffusion lengths,” respectively.

An example

- Determine I_S.
  - The cross section of 100 μm^2
  - L_n and L_p are 20 μm and 30 μm, respectively.
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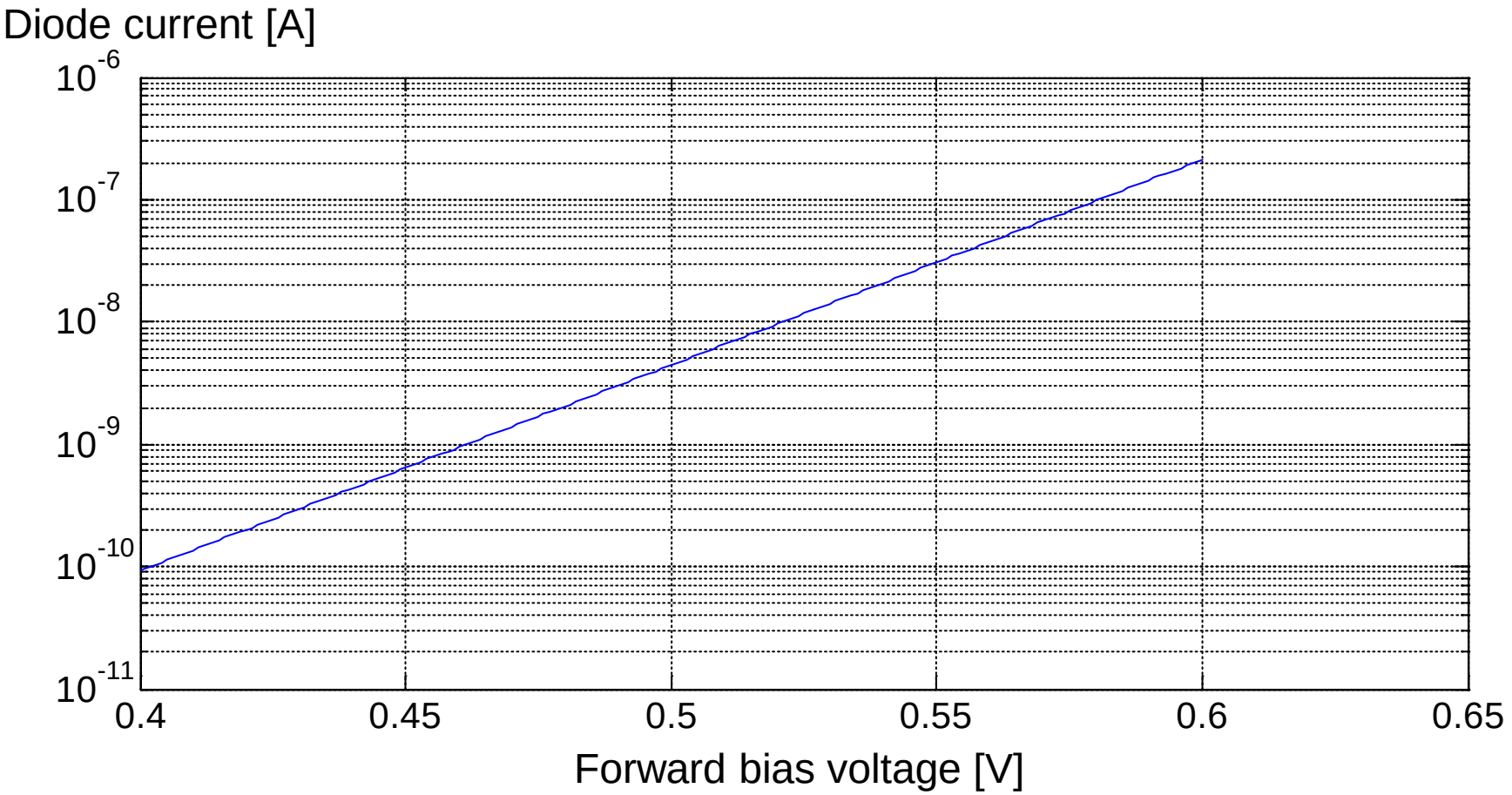
- When $I_S = 1.77 \times 10^{-17}$ A,
  - Determine the forward bias current.
  - For $V_D = 300$ mV, $I_s \left(\exp \frac{V_D}{V_T} - 1 \right)$ = 3.63 pA
  - For $V_D = 800$ mV, 820 μA

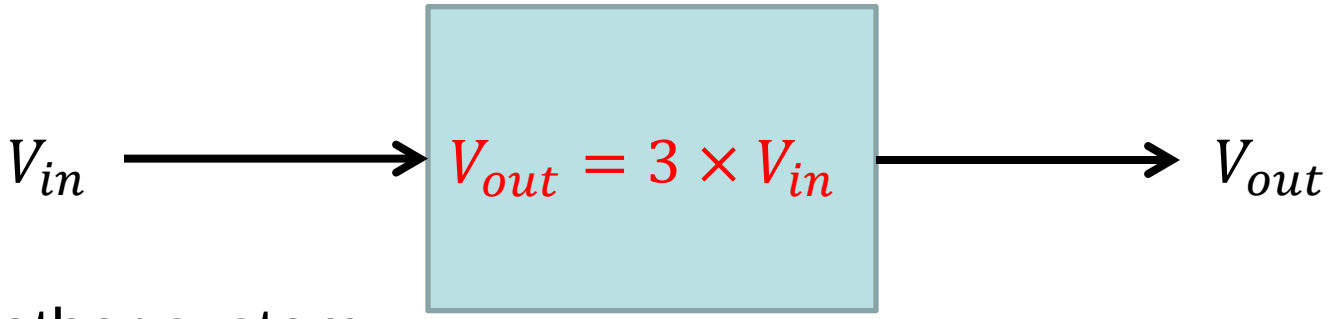
60 mV/dec, what is it?

- Calculate $V_T \ln 10$ at 300K.
  - Approximately 60 mV

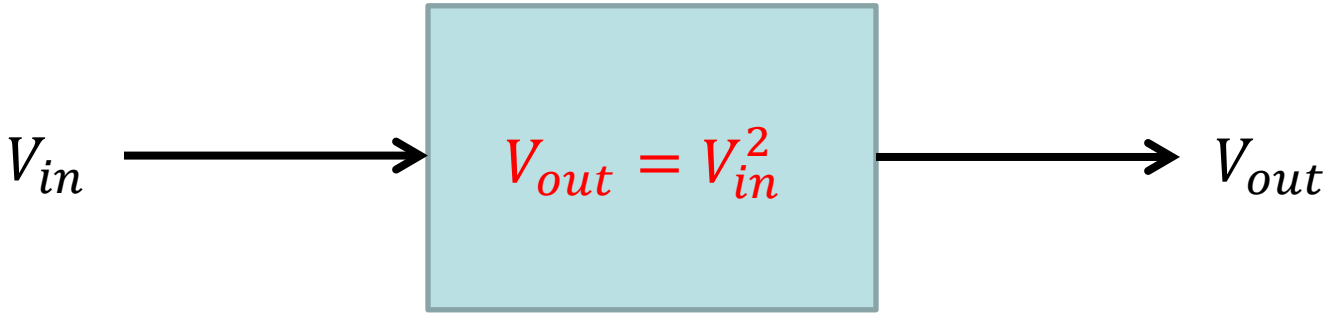


A simple math

- An input voltage, $V_{in}(t) = \sin \omega t$
- A system

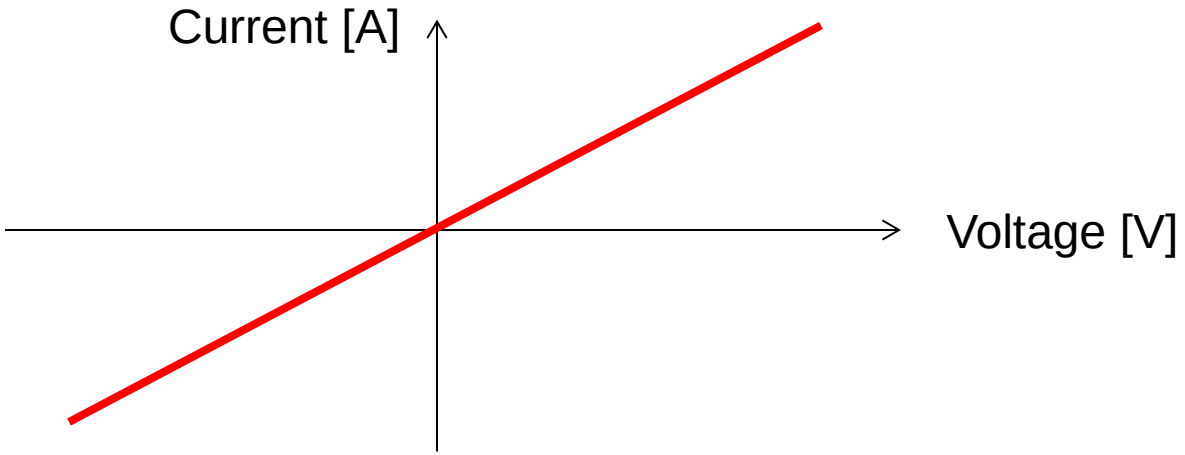


- Another system

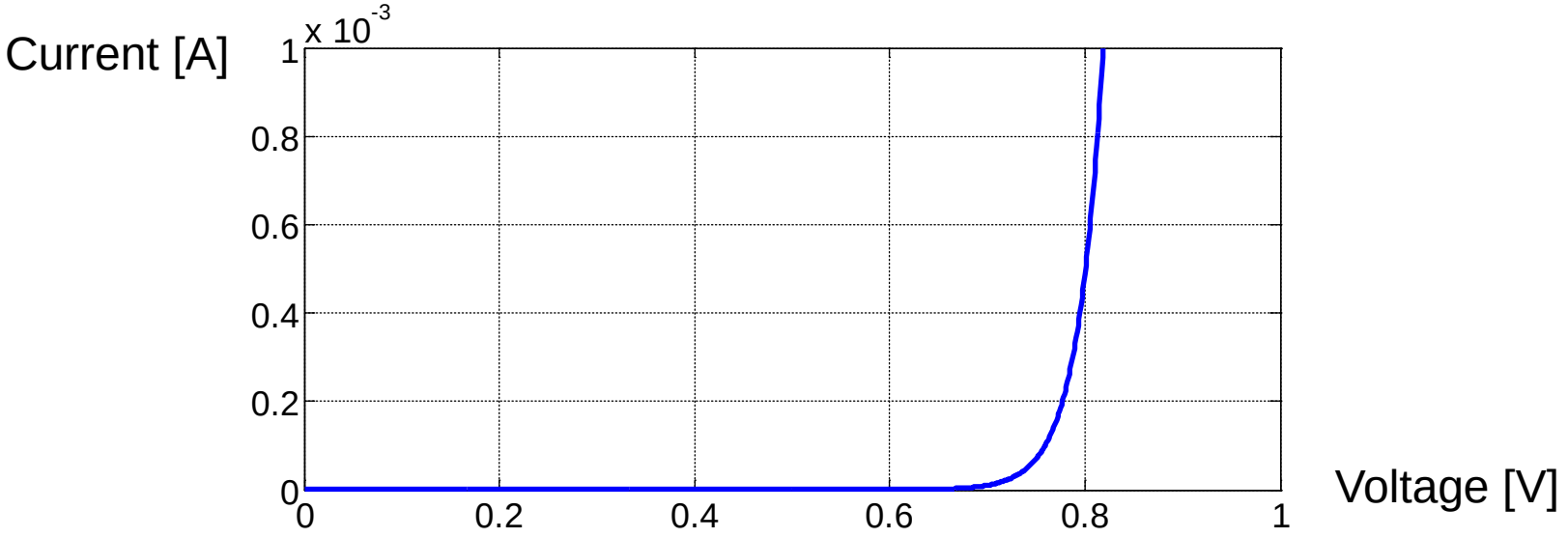


Which is nonlinear?

- A resistor

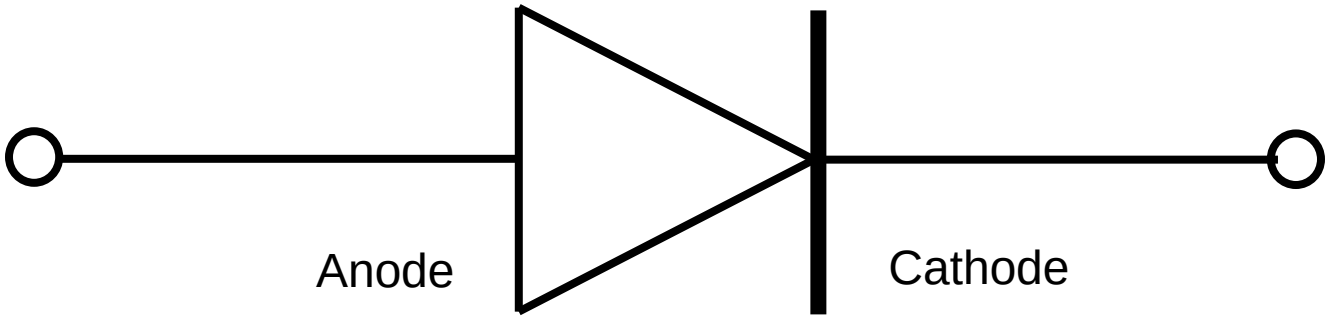


- A diode

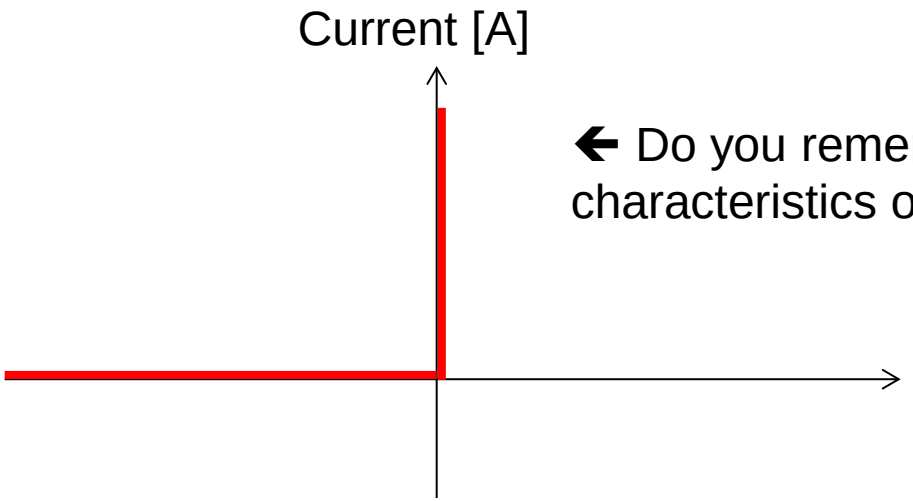


Diode

- Its symbol



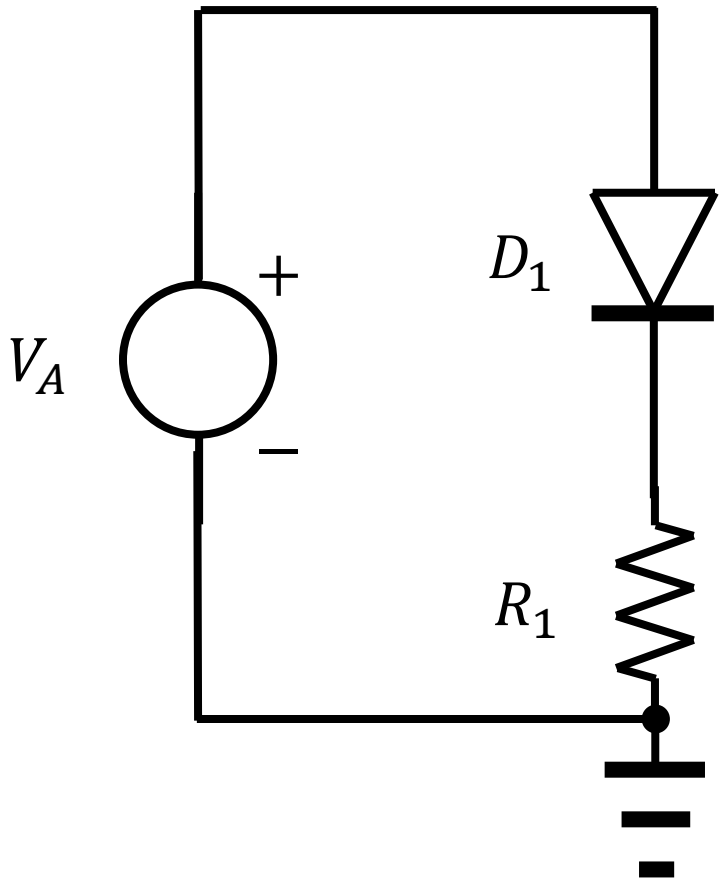
- Ideally, a perfect rectifier



← Do you remember the IV characteristics of a pn diode?

Example 3.4

- A diode-resistor combination



- Consider two cases, $V_A > 0$ and $V_A < 0$.
- Draw the IV curve.