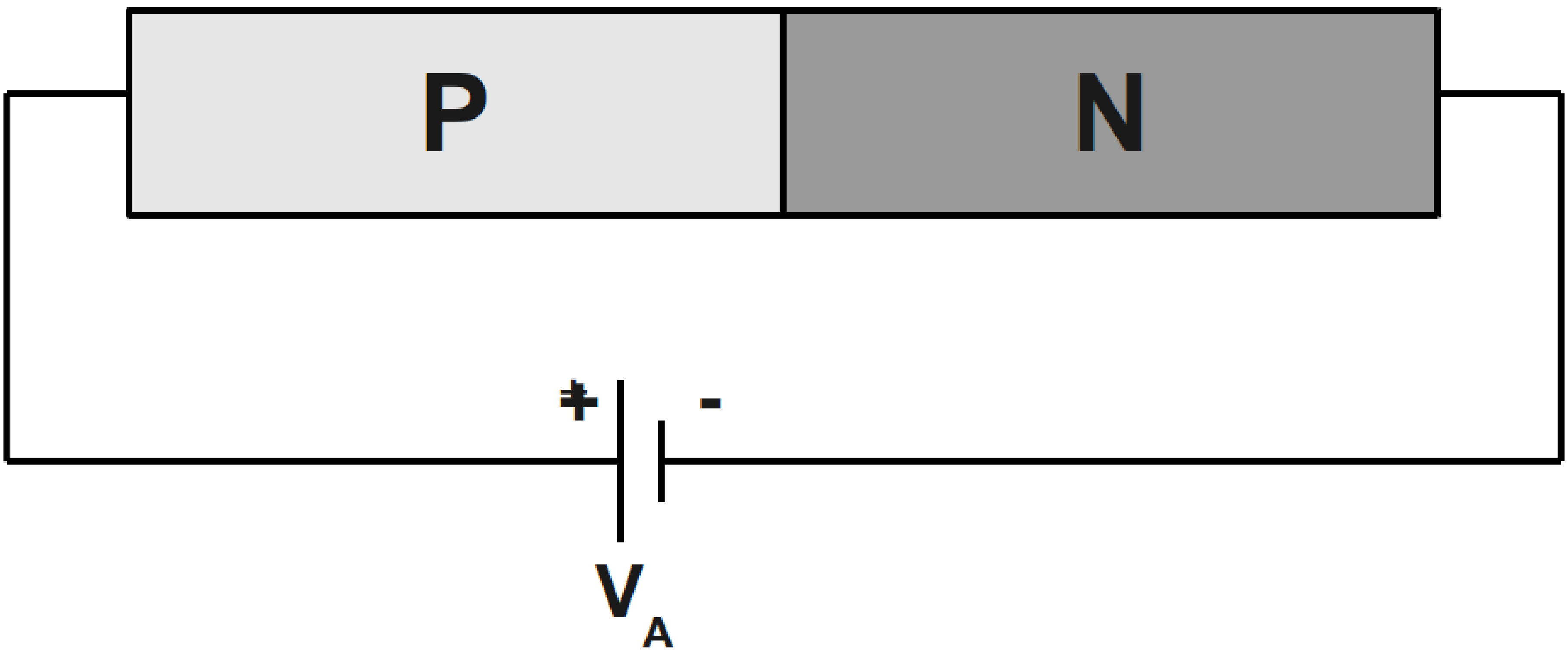
# PN JUNCTION CAPACITANCE

# PN JUNCTION.. again!



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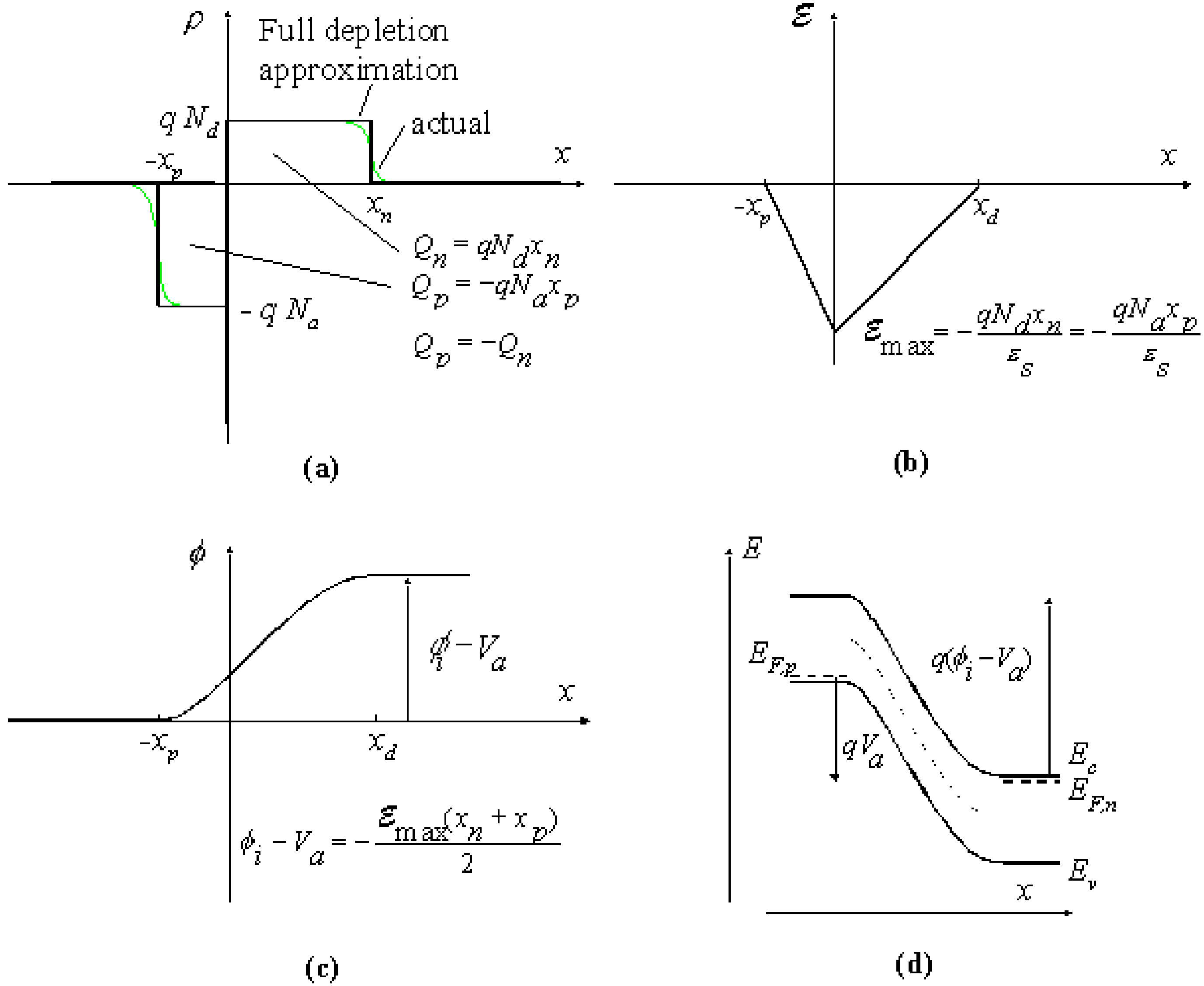

# PN JUNCTION CAPACITANCE

- Any variation of the charge within a p-n diode with an applied voltage variation yields a capacitance which must be added to the circuit model of a p-n diode

- The capacitance associated with the charge variation in the depletion layer is called the junction capacitance, while the capacitance associated with the excess carriers in the quasi-neutral region is called the diffusion capacitance

- Both types of capacitances are non-linear so that we will derive the small-signal capacitance in each case

- The junction capacitance dominates for reverse-biased diodes, while the diffusion capacitance dominates in strongly forward-biased diodes. The total capacitance is the sum of both

- Expressions for the capacitances are obtained by calculating the change in charge for a change in applied voltage, or:

$$C = \frac{dQ}{dV}$$

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$$C\left(V_a\right)=\left(\frac{dQ\left(V_a\right)}{dV_a}\right)$$

- The absolute value sign is added in the definition so that either the positive or the negative charge can be used in the calculation, as they are equal in magnitude

$$Q\left(V_a\right)=qN_d x_n=qN_a x_p$$

- A comparison with the expression for the depletion layer width, as a function of voltage, reveals that the expression for the junction capacitance, Cj, is identical to that of a parallel plate capacitor with the depletion layer acting as dielectric layer, namely:

$$x_d=x_n+x_p$$

VALIDA SOLO NEL PUNTO DI RIPOSO!!! →

$$C_j=\frac{\varepsilon_{si}}{x_d}$$

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- The junction capacitance is calculated using the expression for the parallel plate capacitance
- This might at first seem unexpected since the charge is distributed throughout the depletion layer
- However, when applying small voltage variations one finds that charge is only added and removed at the edge of the depletion region so that the capacitance simply depends on the dielectric constant, the area and the depletion layer width, yielding:

$$C_j = \frac{\varepsilon_s}{w} = \sqrt{\frac{q\varepsilon_s}{2(\phi_i - V_a)}\frac{N_a N_d}{N_a + N_d}}$$

where the depletion layer width, w, was obtained from the electrostatic analysis

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- A capacitance versus voltage measurement can be used to obtain the built-in voltage and the doping density of a one-sided p-n diode

- Plotting one over the capacitance squared one expects a linear dependence as expressed by:

$$\frac{1}{C_j^2} = \frac{2}{q\varepsilon_s}\frac{N_a + N_d}{N_a N_d}(\phi_i - V_a)$$

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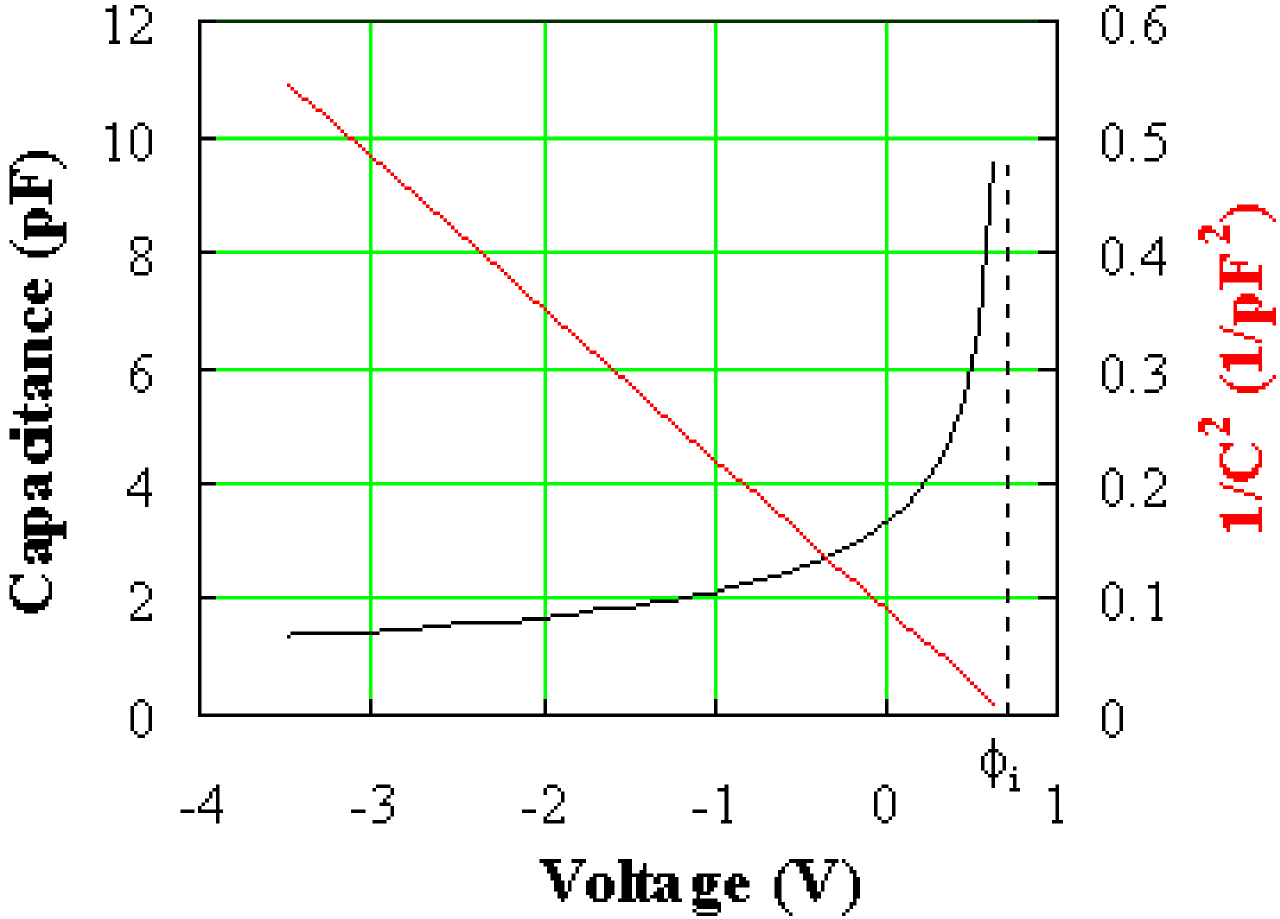


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