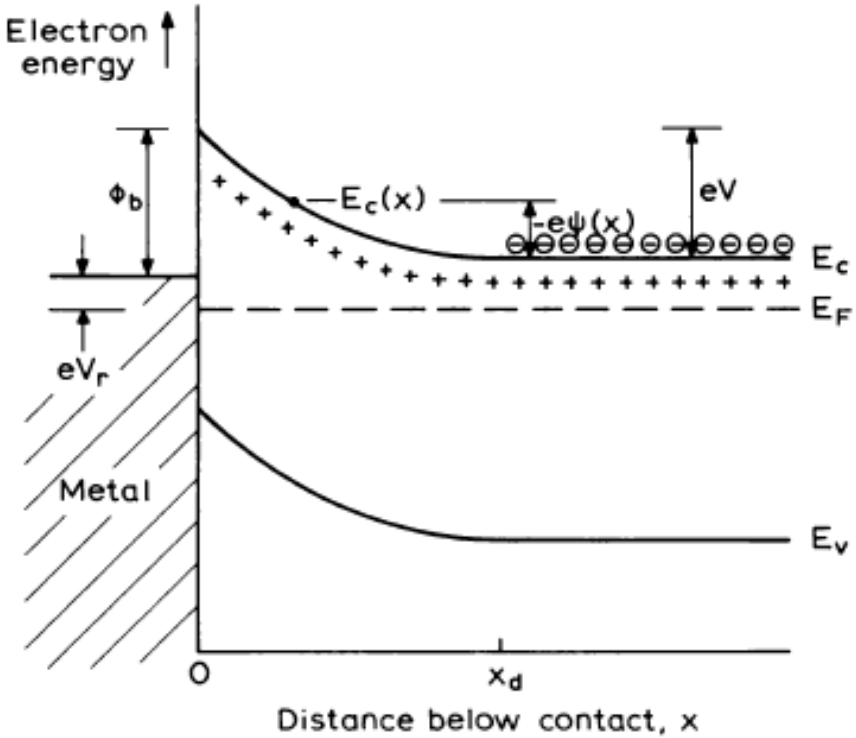
Wykład 6
12.05.2025 r.
Zastosowanie równania Poissona w eksperymencie

Katarzyna Gwóźdź

Pojemność



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

Złącze Schottky'ego typu n

W równowadze termodynamicznej:

$$V(x) = \frac{eN_d}{\varepsilon}\left(x_d - \frac{x}{2}\right)x - \frac{eN_d x_d^2}{2\varepsilon}$$

$$V_{bi} = \frac{eN_d x_d^2}{2\varepsilon}$$

$$x_d = \left(\frac{2\varepsilon V_{bi}}{eN_d}\right)^{\frac{1}{2}}$$

Z napięciem zewnętrznym w kierunku zaporowym V_r:

$$x_d = \left(\frac{2\varepsilon(V_{bi} - V_r)}{eN_d}\right)^{\frac{1}{2}}$$

Pojemność złącza dla jednorodnego, skokowego domieszkowania

$$|Q| = \rho x_d A \qquad x_d = \left(\frac{2\varepsilon(V_{bi}-V_r)}{eN_d}\right)^{\frac{1}{2}}$$

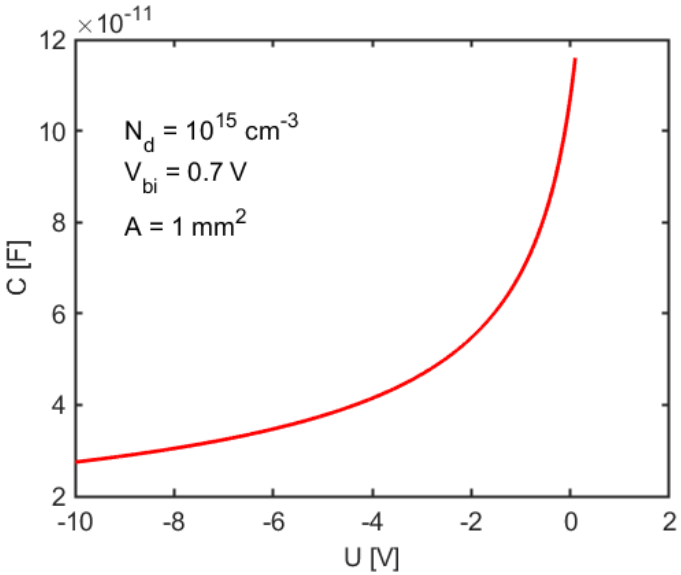
$$|Q| = eN_d x_d A = AeN_d\left(\frac{2\varepsilon(V_{bi}-V_r)}{eN_d}\right)^{\frac{1}{2}} = AeN_d\left(\frac{2\varepsilon}{eN_d}\right)^{\frac{1}{2}}(V_{bi}-V_r)^{\frac{1}{2}}$$

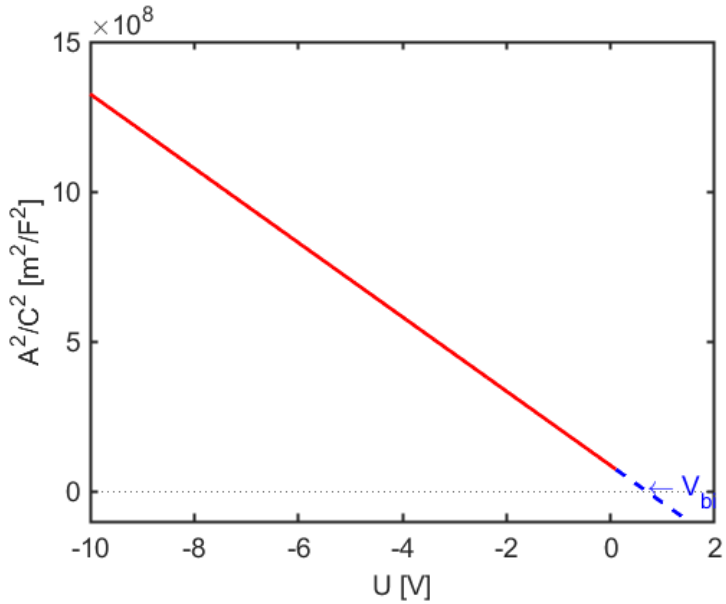
$$C = \frac{dQ}{d(V_{bi}-V_r)} = \frac{1}{2}AeN_d\left(\frac{2\varepsilon}{eN_d}\right)^{\frac{1}{2}}(V_{bi}-V_r)^{-\frac{1}{2}} = \left(\frac{A^2\varepsilon eN_d}{2(V_{bi}-V_r)}\right)^{\frac{1}{2}}$$

$$C = \frac{A\varepsilon}{\left(\frac{2\varepsilon(V_{bi}-V_r)}{eN_d}\right)^{\frac{1}{2}}} = \frac{A\varepsilon}{x_d}$$

Kondensator płaski

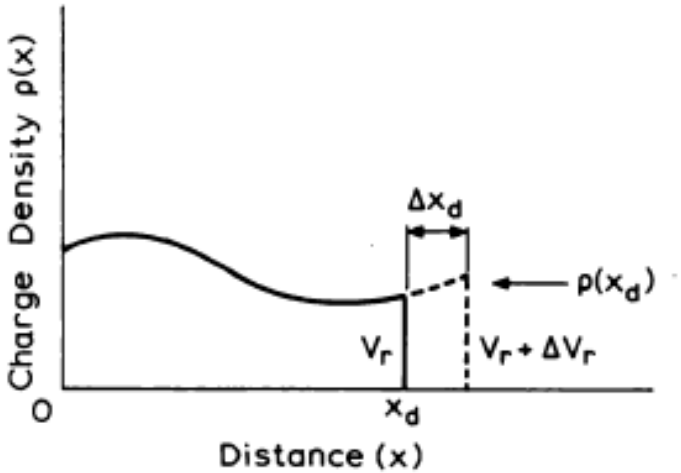
Charakterystyka C-V





$$\frac{A^2}{C^2} = \left(\frac{2(V_{bi} - V_r)}{\varepsilon e N_d}\right)$$

Niejednorodny rozkład domieszkowania

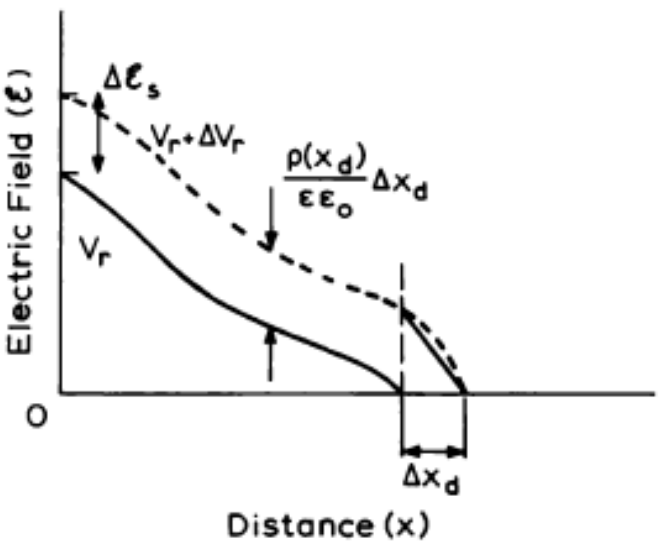


$$dQ(x_d) = A\rho(x_d)dx_d \qquad \rho(x_d) = eN_d(x_d)$$

$$\Delta V_r = \frac{1}{\varepsilon}\int_{x_d}^{x_d+\Delta x_d} x\rho(x)dx$$

$$\Delta V_r = \frac{\rho(x_d)}{2\varepsilon}(2x_d\Delta x_d + (\Delta x_d)^2)$$

$$\Delta V_r = \frac{\rho(x_d)}{\varepsilon}(x_d\Delta x_d)$$ Dla $\Delta x_d << x_d$



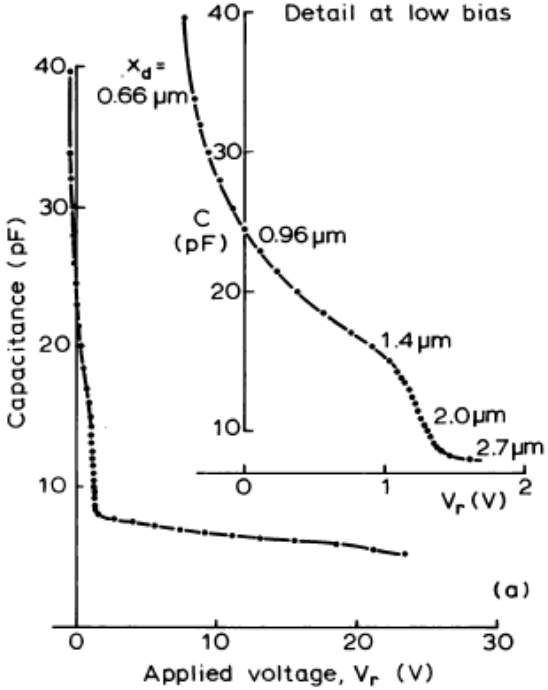
Niejednorodny rozkład domieszkowania

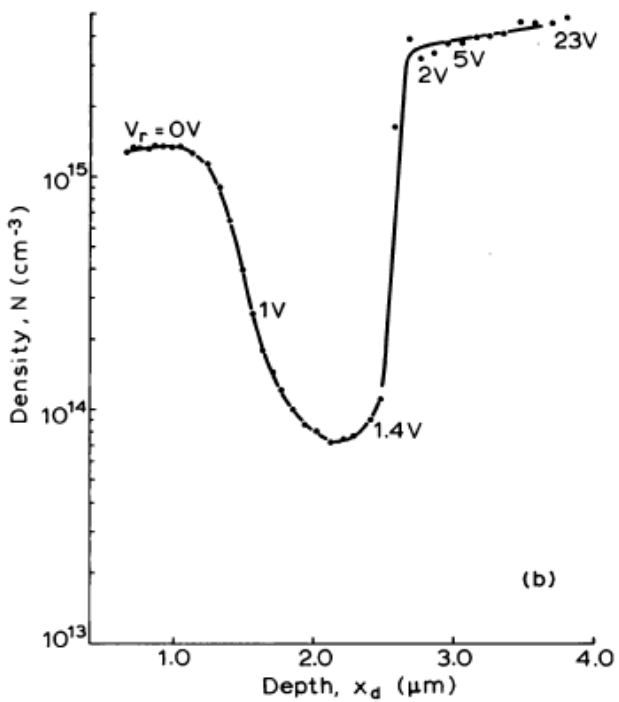
$$\Delta V_r = \frac{\rho(x_d)}{\varepsilon}(x_d \Delta x_d) \qquad C = \frac{A\varepsilon}{x_d} \qquad \rho(x_d) = eN_d(x_d)$$

$$\frac{\Delta C}{\Delta V_r} = \frac{\Delta C}{\Delta x_d}\frac{\Delta x_d}{\Delta V_r} = -\frac{A\varepsilon}{x_d^2}\frac{\varepsilon}{x_d \rho(x_d)} =$$

$$= -\frac{A\varepsilon^2}{x_d^3 e N_d(x_d)} = -\frac{A^3\varepsilon^3}{x_d^3}\frac{1}{A^2\varepsilon e N_d(x_d)} = -\frac{C^3}{A^2\varepsilon e N_d(x_d)}$$

$$N_d(x_d) = -\frac{C^3}{A^2\varepsilon e}\left(\frac{\Delta C}{\Delta V_r}\right)^{-1} = -\frac{2}{A^2\varepsilon e}\left(\frac{\Delta C^{-2}}{\Delta V_r}\right)^{-1}$$





Profilowanie C-V

$$x_d = \frac{A\varepsilon}{C}$$

$$N_d(x_d) = -\frac{C^3}{A^2 \varepsilon e}\left(\frac{\Delta C}{\Delta V_r}\right)^{-1}$$

Pochodna numerycznie

Metoda różnic skończonych:
Przybliżamy wartość funkcji f w punkcie x na podstawie wartości punktów sąsiadujących

Różnica w przód:

$$\frac{df}{dx} = \frac{f(x_{i+1}) - f(x_i)}{x_{i+1} - x_i}$$

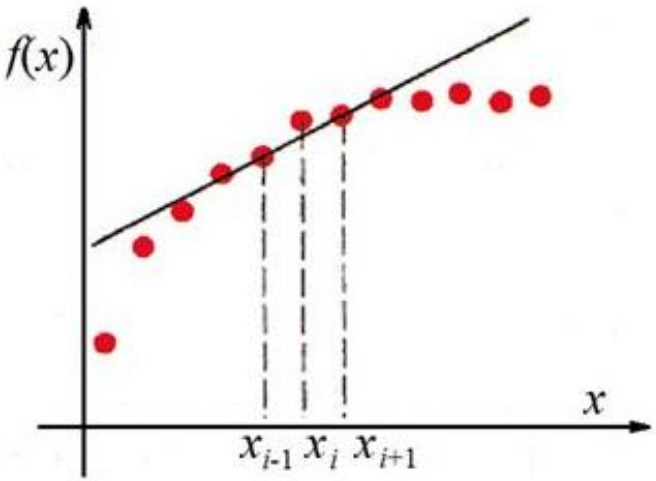
Różnica w tył:

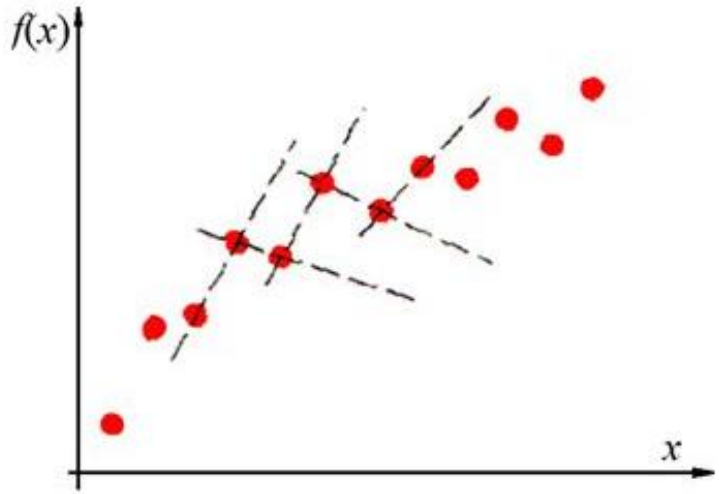
$$\frac{df}{dx} = \frac{f(x_i) - f(x_{i-1})}{x_i - x_{i-1}}$$

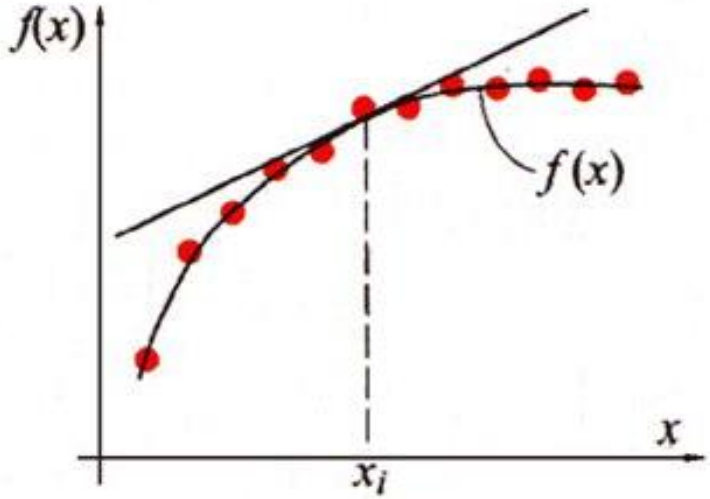
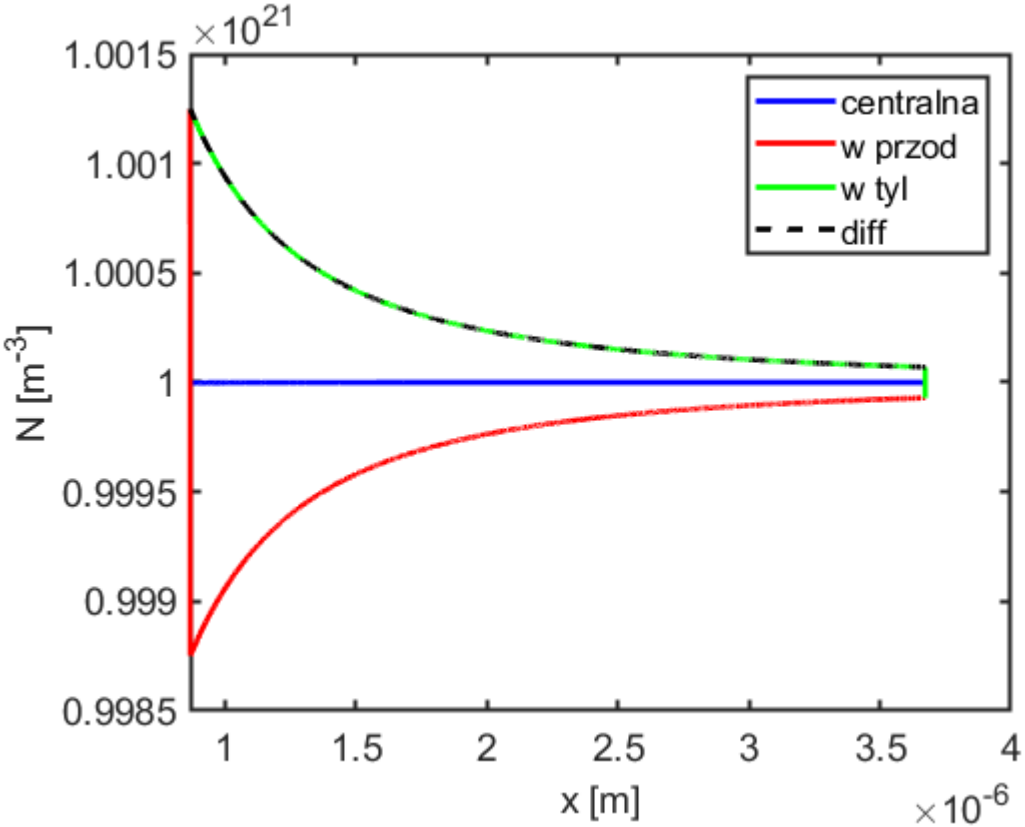
Różnica centralna:

$$\frac{df}{dx} = \frac{f(x_{i+1}) - f(x_{i-1})}{x_{i+1} - x_{i-1}}$$

Pochodna numerycznie a dane pomiarowe







Przykład w Matlabie