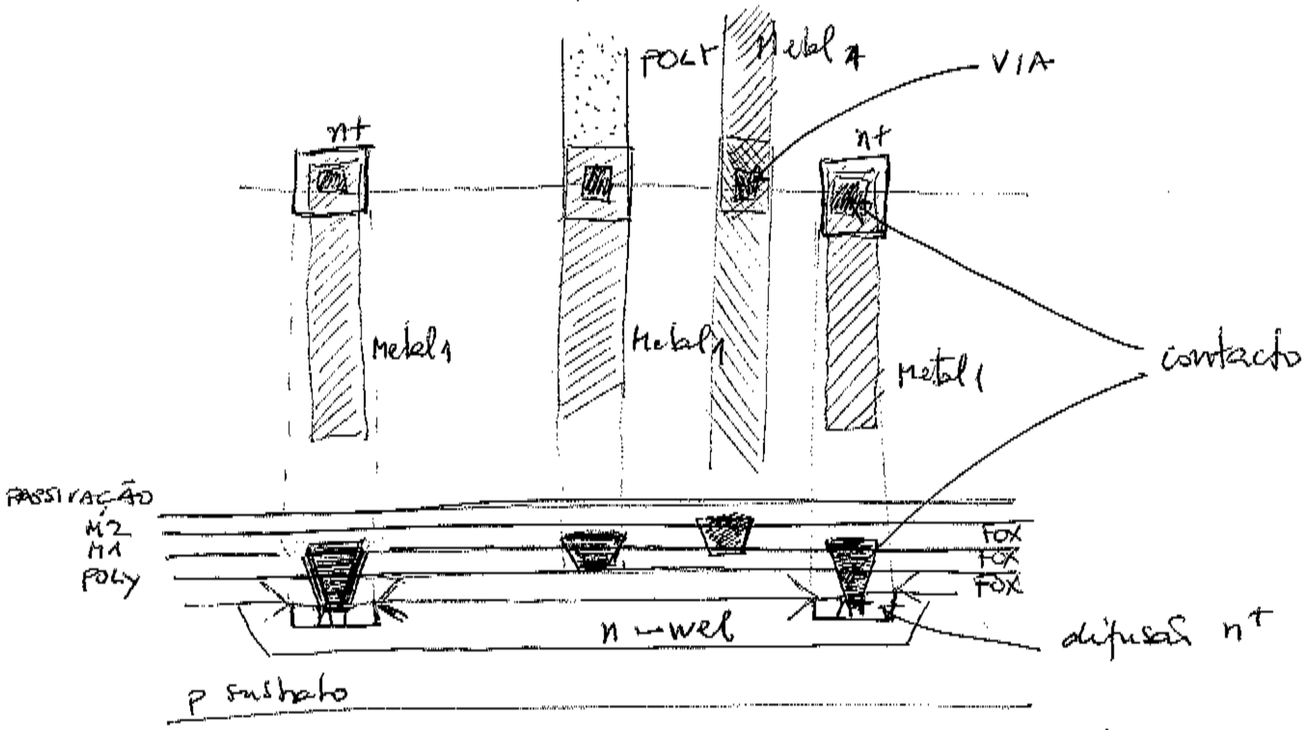
MICROELECTRÓNICA AULA 2

CAMADAS DE METAL. CAMADA DE POLISILICIO. REGIÃO ACTIVA TIPO P e N. LAYOUT DO MOSFET

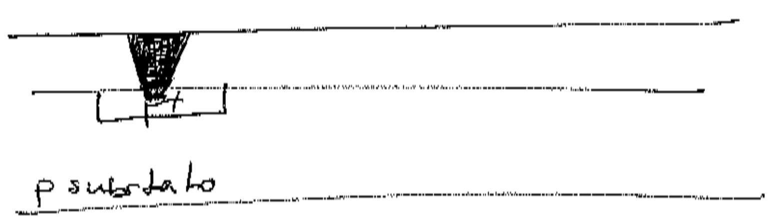
Camadas de metal – utilizadas essencialmente para fazer ligações

Camada de polisilicio –
- ligações
- porta dos MOSFETS
- condensadores

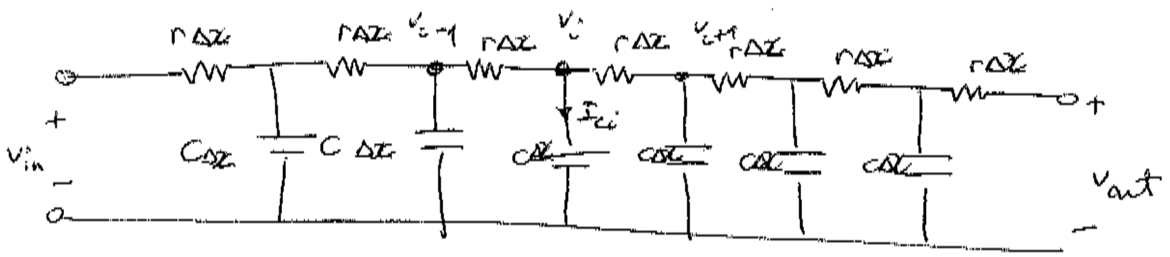


muito importante para evitar diodo schottky

no caso de se fazer uma ligação ao substrato



As linhas de metal e de polisilicio têm capacidades parasitas para o substrato (e entre elas) e resistência. Podem ser modelizadas por um circuito RC distribuido:



$$I_{ci} = c\Delta x \frac{dv_i}{dt} = I_{i-1} - I_i$$

$$= \frac{v_{i-1} - v_i}{r\Delta x} - \frac{(v_i - v_{i+1})}{r\Delta x}$$

$$rc \frac{dv_i}{dt} = \frac{(v_{i-1} - v_i) - (v_i - v_{i+1})}{\Delta L^2}$$

$\lim \Delta L \to 0$ $$\boxed{rc \frac{\partial v_i}{\partial t} = \frac{\partial^2 V}{\partial x^2}}$$ eq da difusão

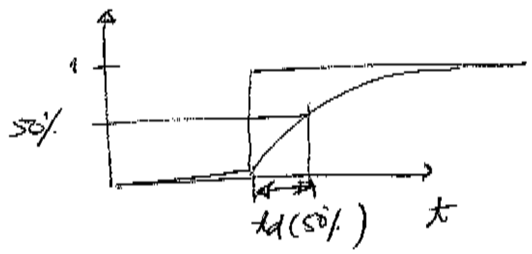
É possível encontrar uma constante de tempo τ dominante dada por

$$\tau = rc (\Delta x)^2 \frac{N(N+1)}{2}$$

onde $\Delta x = \frac{\ell}{N}$

com $\Delta x \to 0 \Rightarrow N \to \infty$ vem $$\boxed{\tau = \frac{rc\,\ell^2}{2}} = \frac{(r\ell)(c\ell)}{2} = \frac{RC}{2}$$

o tempo de propagação $t_d(50\%) \simeq 0.35\, RC$ (e não $0.69\, RC$)



Exemplo

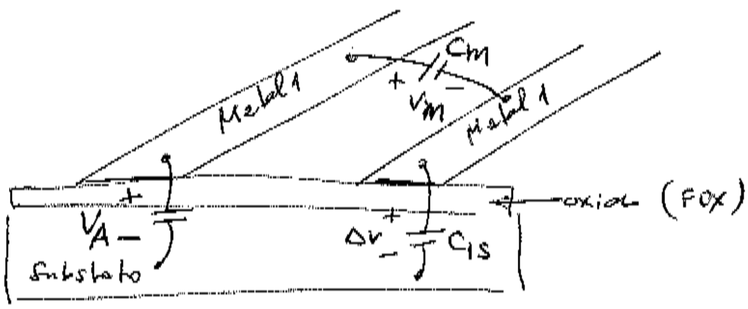
Calcular o tempo de propagar num condutor de Metal 1 de comprimento $\ell = 10\,mm$ e largura $W = 3\,\mu m$

$R_{\square\, metal1} = 0.06\,\Omega/\square$ $\qquad R = 0.06 \times \frac{10 \times 10^3\,\mu m}{3\,\mu m} = 200\,\Omega$

$C_{\square\, metal1} = 26 \times 10^{-18}\,F/\mu m^2$ $\qquad C = \frac{26 \times 10^{-18}\,F}{\mu m^2} \times 10^4\,\mu m \times 3\,\mu m = 780\,fF$

logo $t_d = 0.35\,RC = 0.35 \times 200 \times 780 \times 10^{-15} = \underline{55\,ps}$

Cross Talk



$V_A = V_m + \Delta V$ $\qquad V_A = \frac{Q}{C_m} + \Delta V$ $\qquad V_A = \frac{C_{1S}}{C_m}\Delta V + \Delta V$

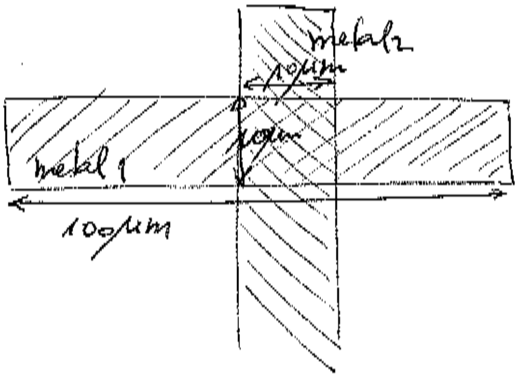
$Q = C_m V_m = C_{1S}\,\Delta V$

$$V_A = \left(\frac{C_{1S}}{C_m} + 1\right)\Delta V = \frac{C_m + C_{1S}}{C_m}\Delta V$$

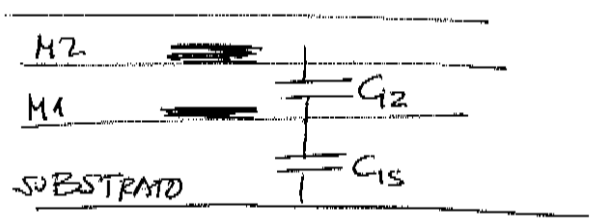
$$\boxed{\Delta V = \frac{C_m}{C_m + C_{1S}} V_A}$$

Exemplo

Calcular a variação de tensão na pista de metal 1 quando na pista de metal 2 a tensão varia de 0 para 5V



secção transversal



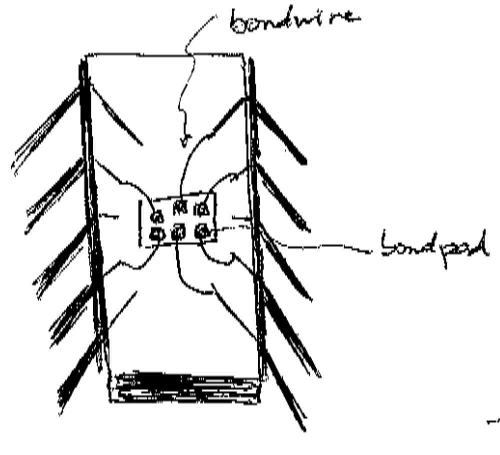
$$\Delta V = \frac{C_{12}}{C_{12} + C_{1S}} \times 5V$$

$$C_{12} = \frac{38 \times 10^{-18} F}{\mu m^2} \times \underbrace{(10 \mu m)^2}_{\text{área}} + \frac{104 \times 10^{-18} F}{\mu m} \times \underbrace{40 \mu m}_{\text{perímetro}} = 8 fF$$

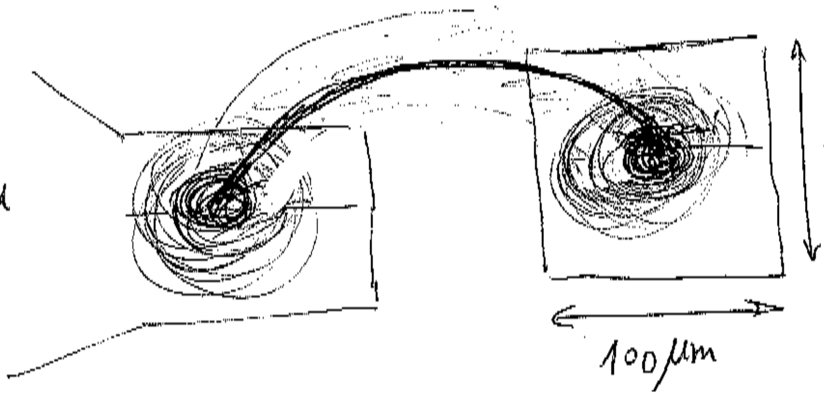
$$C_{1S} = \frac{26 \times 10^{-18} F}{\mu m^2} \times \underbrace{10 \mu m \times 100 \mu m}_{\text{área}} + \frac{82 \times 10^{-18} F}{\mu m} \times \underbrace{220 \mu m}_{\text{perímetro}} = 44 fF$$

$$\Delta V = \frac{8}{8 + 44} \times 5 V = 0.8 V$$

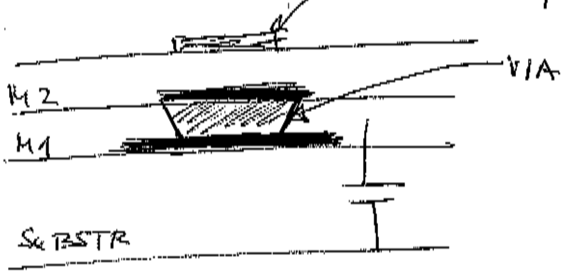
BOND PADS E BOND WIRES



Amplicação



Cálculo da capacidade de 1 bond pad

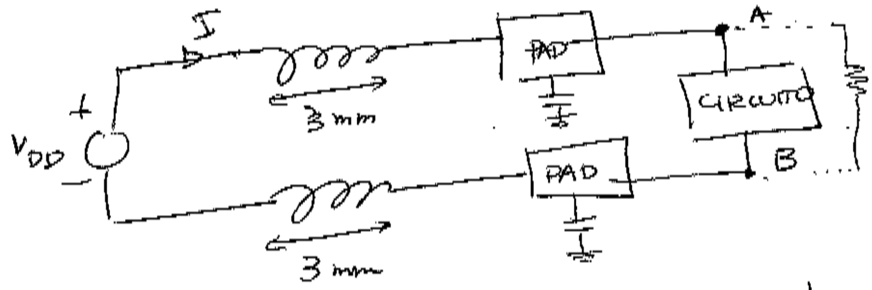


$$C_{1S} = \frac{26 \times 10^{-18}\,F}{\mu m^2} \times \underbrace{(100\,\mu m)^2}_{\text{área}} + \frac{52 \times 10^{-18}\,F}{\mu m} \times \underbrace{400\,\mu m}_{\text{perímetro}} =$$

$$\simeq 0.3\ pF \leftarrow$$

Capacidade não negligível: causa um circuito RC com a impedância de saída

BONDWIRE $L = 1\ nH/mm$

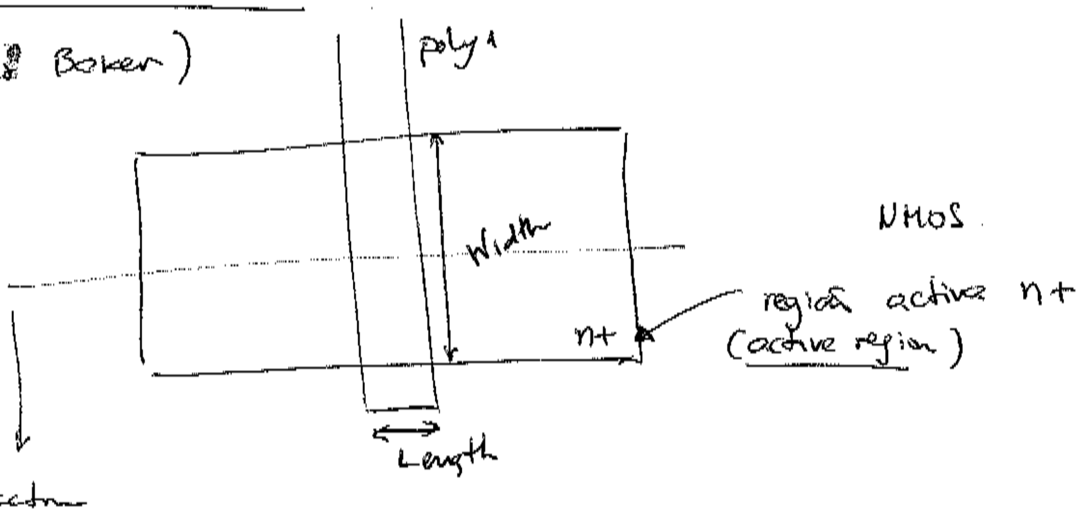


$$V_B = L\frac{dI}{dt} = 3\,nH \cdot \frac{50\,mA}{3\,ns} = 50\,mV$$

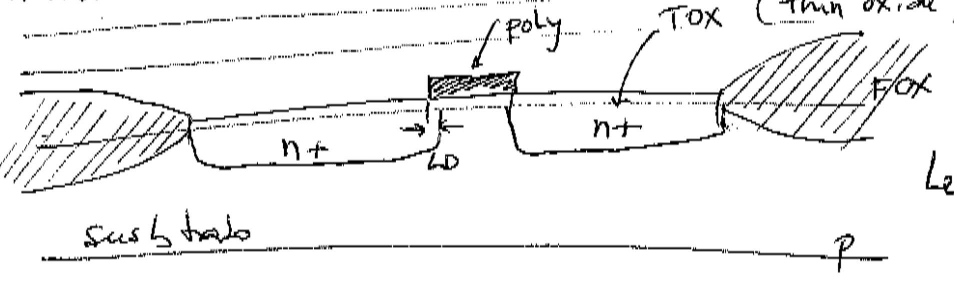
Calcular a variação de tensão no ponto B (A) quando a corrente I varia 50 mA em 3 ns

LAYOUT DO MOSFET

(Figure 4.8 Baker)

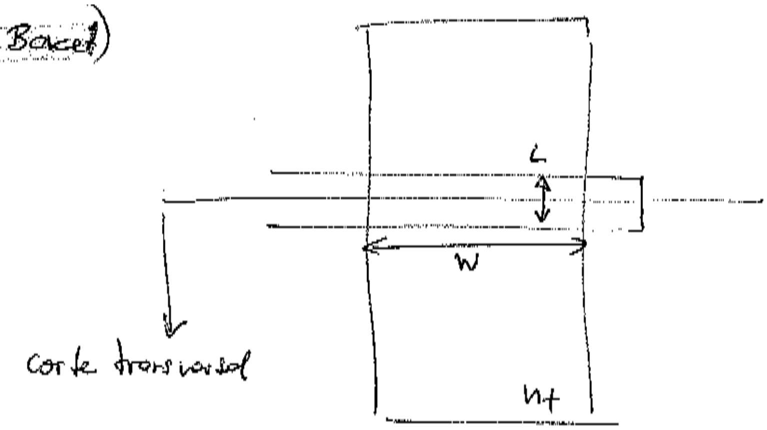


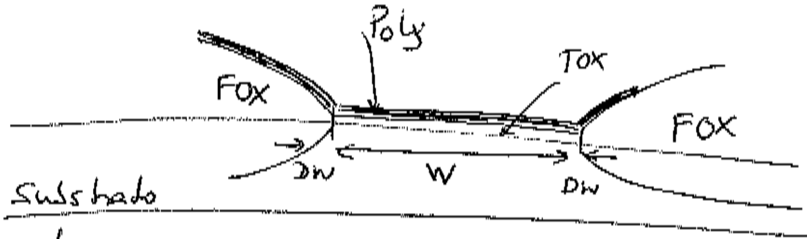
Cross section
Secção transversal



$$L_{eff} = L - 2LD$$

(Figura 4.11 Baker)

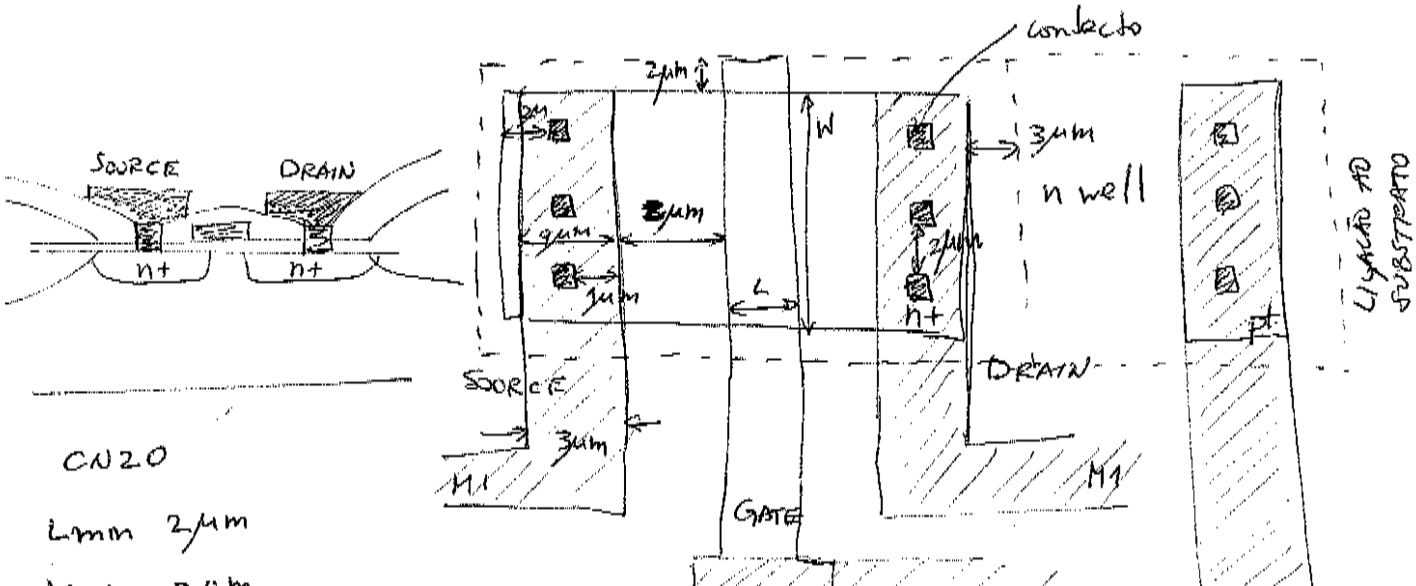




$W_{eff} = W + 2DW$

Este efeito chama-se <u>BIRD'S BEAK</u>

<u>REGRAS DE LAYOUT DO MOSFET</u> (NMOS)



CN20

Lmin 2µm

Wmin 2µm

CONTACTO 2×2 µm²

ACTIVE CONTACT TO GATE 2µm

POLY OVERLAP 2µm

ACTIVE OVRLAP 2µm

VIA 2×2µm²

METAL 2 OVERLAP 2µm

METAL 1 OVERLAP 1µm