CMOS

CIRCUIT DESIGN, LAYOUT, AND SIMULATION

Baker

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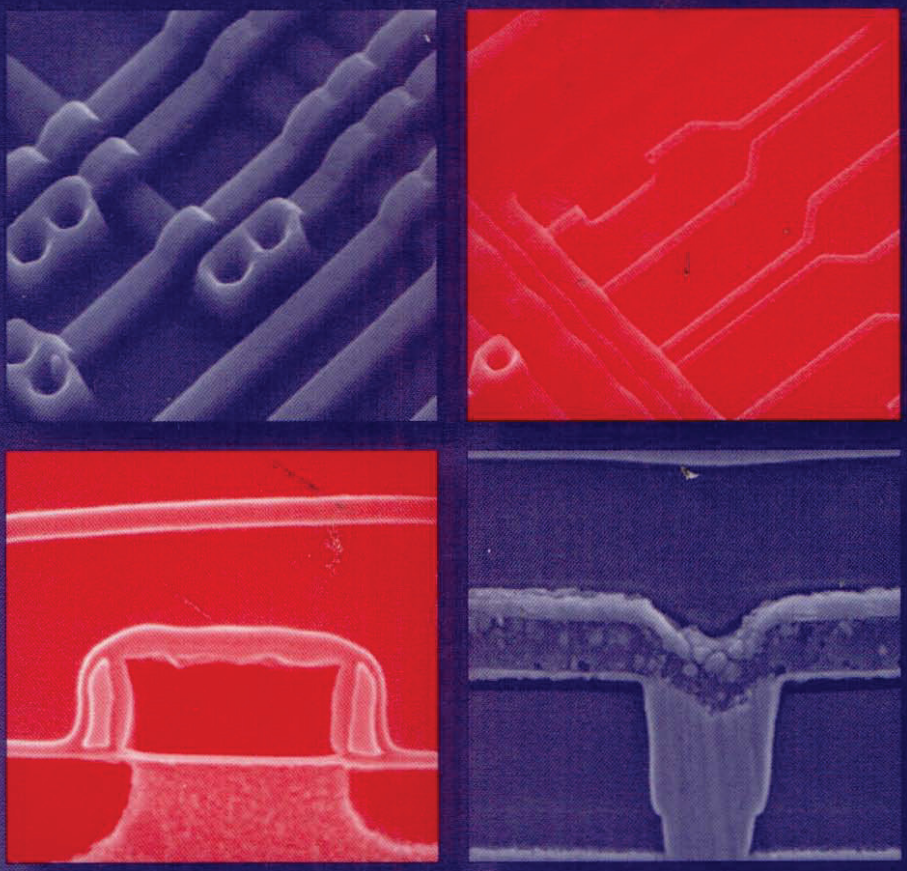

R. Jacob Baker ■ Harry W. Li ■ David E. Boyce

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The LASI Layout Software, as well as other layout software, can be downloaded at http://www.mrc.uidaho.edu/vlsi/cad_free.htm

Process Information for Hand-Calculations

Process	*CN*20 NMOS	*CN*20 PMOS	*CMOS*14 NMOS	*CMOS*14 PMOS
Information	App. A	App. A	App. C	App. C
VDD ($VSS = 0$)	5 V	5 V	3.3 V	3.3 V
minimum L_{drawn}	2.0 µm	2.0 µm	0.6 µm	0.6 µm
$DL = L_{drawn} - L_{eff}$	0.6 µm	0.8 µm	0.06 µm	0.09 µm
minimum W_{drawn}	3.0 µm	3.0 µm	0.9 µm	0.9 µm
$DW = W_{drawn} - W_{eff}$	0.14 µm	0.16 µm	0.35 µm	0.35 µm
V_{THN} or V_{THP}	0.83 V	0.91 V	0.7 V	0.9 V
KP, µA/V^2	50	17	170	50
λ, V^{-1}	0.06 for $L \geq 5$ µm	0.06 for $L \geq 5$ µm		
I_{drive} (µA/µm)			380 (typ.)	190 (typ.)
C'_{ox}	800 aF/µm^2	800 aF/µm^2	3.7 fF/µm^2	3.7 fF/µm^2
R_n or R_p	12 kΩ · (L/W)	36 kΩ · (L/W)	(9 kΩ · µm)/W	(18 kΩ · µm)/W
τ_n or τ_p	38 ps	114 ps	20 ps	40ps

Multipliers

Name	Symbol	Value
terra	T	10^{12}
giga	G	10^{9}
mega	M or (MEG)	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	µ (or u)	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Physical Constants

Name	Symbol	Value/Units
Vacuum dielectric constant	ε_0	8.85 aF/μm
Silicon dielectric constant	ε_{si}	$11.7\varepsilon_0$
SiO_2 dielectric constant	ε_{ox}	$3.97\varepsilon_0$
SiN_3 dielectric constant	ε_{Ni}	$16\varepsilon_0$
Boltzmann's constant	k	1.38×10^{-23} J/K
Electronic charge	q	1.6×10^{-19} C
Temperature	T	K
Thermal voltage	V_T	kT/q = 26 mV @ 300 K

Equations

Parameter	NMOS equations in terms of BSIM1 parameters
	for PMOS use V_{SD}, V_{SG}, V_{BS}, and V_{THP}
V_{THN}	$VFB + PHI + K1 \cdot \sqrt{PHI + V_{SB}} - K2 \cdot (PHI + V_{SB})$
C'_{ox}	ε_{ox}/TOX
KP	$MUZ \cdot C'_{ox}$
β	$KP \cdot (W/L)$
I_D (triode) $V_{DS} \le V_{GS} - V_{THN}$	$\beta\left((V_{GS} - V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right)$ (for Long L)
I_D (saturation) $V_{DS} \ge V_{GS} - V_{THN}$	$\frac{\beta}{2}(V_{GS} - V_{THN})^2[1 + \lambda(V_{DS} - V_{DS,sat})]$ (for Long L)
g_m	$\beta(V_{GS} - V_{THN}) = \sqrt{2\beta I_D}$ or $I_D/(V_T \cdot N0)$
η	$K1 \cdot \left(2\sqrt{PHI + V_{SB}}\right)^{-1} - K2$ and $g_{mb} = g_m \cdot \eta$
r_o	$1/(\lambda I_D)$

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