MOSFETs Part 5: MOS Energy Bands

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The MOS Capacitor

- MOSCAP: Simplified version of the ٠ MOSFET
 - Simplified Analysis
- Analyse the capacitance as a way of ٠ understanding the channel charge:





Metal Energy Borel Diagram

- Sea of free e below Fermi level •
- Fermi Level: •
 - E where there's a 50% chance of finding an e should the state exist
 - No Bandgap --> Always a state @ £_F
- Work Function: Avg. Energy required to remove ٠ e from the material

$$q \phi_{WF} = \Sigma_0 - \Sigma_f$$

- Typical Values:
- Free Space Out of Material E₀ $q\Phi_{\scriptscriptstyle WFM}$ 9 QuF Ef

Aluminium OWF = 4.26 eV Polysilicon $\phi_{w\neq} \simeq 4.15 eV$





Oxide Energy Bond Diagrom

- Wide bandgap
 - No e have energy to jump gap from valence 0 to conduction band
 - Looks like an insulator
- SiO2: An excellent Oxide •
 - Grown w/ steam or heat on the Si surface 0
 - Easy Processing 0
 - Aka sand or glass

5;0z ~ 8eV



Silicon Energy Banel Diagram Free Space – Out of Material Conduction Banel E₀ $E_{ea} = q \chi_{Si}$ W/ available corel. States (free e) **Conduction Band** Energy Bonelejap e must gain EG to Jump from V to C bonel E_c ų $E_G = q\Phi_{GSi}$ $q\Phi_{\scriptscriptstyle WF}$ Ei $E_{FP} = q \Phi_{FPSi}$ $\Sigma = 1.12 eV$ Ef Valence Banel w occupied Atomie States Eν Valence Band - Oxide - Semiconductor Metal Free Space Free Space – Out of Material ⁻ **E**₀ $\int E_{ea} = q \chi_{Si} \qquad \text{Semiconductor}$ Ec Metal Oxide $q\Phi_{\scriptscriptstyle WFM}$ Ec $q\Phi_{WFSi}$ $E_G = q\Phi_{GSi}$ $E_G = q \Phi_{GOx}$ Ei **E**_{fSi} $\mathbf{E}_{\mathbf{fSi}}$ $E_{FP} = q \Phi_{FPSi}$

Free Electrons															- 1																				
	18	18	:20	10	161	120	44	111	:20	20	191		181	10	20		1	28	111	20	161	1.1	21	163	12	20	161		:25	2.5		12	180	111	23
83	82	82	121	1.1			12	22	223	19		83	20	1	28			82	10	28		2.2	199	:20	82	121	283		202	18		91	201	191	- 1
	13	11			: 11	161	11	- 11	191	1	- 1 -	23	18		52	11		15		- 1	11			:25	15		523	1.1			53	1.1	183		-
				- 1	222		22	222		82	223	18	181		82			18		83	22	19		223			823	11		83	222	12			81
	18	14		10			11		: 25	2.5		14	181	1	25			28	11	21	191	1.1	21	191	12	191	151			2.5		121	180	: 45	21
81	82	81	223	1.1		203		191	203			81	- 11		18		1	82	11	28	191	1.1	11	191	- 1	111	181		202			191	823		- 1
25	25			1.1	:25	253		22	263		:45	83	253	1	58	180	22	25	19	28	: 20	10	18	:25	25	194	:80	22	253		: 20	83	253	191	- 1
18	18	18		1.1	828	181	11	818	191	82	818	18	181		81	11		18	191	81	11		81	828	18	191	823		191	81	11	11	181	191	81
	11	11	12	1.5	191	12	1.5	191	1.1	1.1	191	84	12		13			84		11	191		11	191	11	11	183		12		183		12	1.1	1
	22	22	191	12		223	11	22	223	11	: 25		25		58		21	22	19	28	:20	2.5	191	:21	22	191			222				253	111	- 1
23	13	18				151		- 11	193		- 44	43	13		52	12		18	1	53		10	194	121	48	194	121	11	19	-	53	1.1	153	191	- 1
13	18	13	2	11	11	121	22	111	12	20	11	13	18	1	21	11		12	1	21	10		21	111	18	21	10		121	21	11		181	2	23

o Insulator

voltage Vg

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Valence Band

Έv

