2-1 32 種晶體點群對稱

Crystal system	International notation	Schönflies' notation	Remarks[1]	Crystal system	International notation	Schönflies' notation	Remarks[1]
Triclinic	1	C_1	• +	Trigonal	3	C_3	• +
	$\bar{1}$	$C_i(S_2)$	–		$\bar{3}$	$C_{3i}(S_6)$	–
Monoclinic	2	C_2	• +		$3m$	C_{3v}	• +
	$m(\bar{2})$	$C_s(C_{1h})$	• +		32	D_3	•
	$2/m$	C_{2h}	–		$\bar{3}m$	D_{3d}	–
Orthorhombic	$2mm$	C_{2v}	• +	Hexagonal	6	C_6	• +
	222	$D_2(V)$	•		$\bar{6}$	C_{3h}	•
	mmm	$D_{2h}(V_h)$	–		$6mm$	C_{6v}	• +
Tetragonal	4	C_4	• +		$6/m$	C_{6h}	–
	$\bar{4}$	S_4	•		622	D_6	•
	$\bar{4}2m$	$D_{2d}(V_d)$	•		$\bar{6}m2$	D_{6h}	•
	422	D_4	•		$6/mmm$	D_{6h}	–
	$4mm$	C_{4v}	• +	Cubic	23	T	•
	$4/m$	C_{4h}	–		$\bar{4}3m$	T_d	•
	$4/mmm$	D_{4h}	–		$m3$	T_h	–
					43	O	–
					$m3m$	O_h	–

[1] '•' implies that piezoelectric effect may be exhibited and '+' implies that pyroelectric and ferroelectric effects may be exhibited.

表 2-2 一般常用在 DRAM 之材料及介電常數

Material	ε	Growth Process	Capacitance (fF/μm^2)
TiO_2	30-40	MOCVD	9.3
Ta_2O_5	25	MOCVD	13.8(20.4)
ZrO_2	14-28	MOCVD	9.9
Y_2O_3	17	Sputtering	4.7
Si_3N_4	7	MOCVD	7-8.6

表 2-3 絕緣體之漏電流機制

Mechanism	J–$\mathcal{E}$ Characteristics		Experimentally Derivable Material Constants
1. Schottky Emission	$J_S = AT^2\exp - \frac{q\Phi_B}{kT}\exp\left[\frac{1}{kT}\left(\frac{q^3\mathcal{E}}{4\pi\varepsilon_i}\right)^{1/2}\right]$	(10-21)	Φ_B
2. Tunneling	$J_T = \frac{q^2\mathcal{E}^2}{8\pi h\Phi_B}\exp - \left[\frac{8\pi(2m)^{1/2}}{3hq\mathcal{E}}(q\Phi_B)^{3/2}\right]$	(10-22)	Φ_B
3. Space Charge Limited	$J_{SCL} = \frac{9\mu\varepsilon_i}{8}\frac{\mathcal{E}^2}{d}$	(10-23)	—
4. Ionic Conduction	$J_i = \frac{a\mathcal{E}}{kT}\exp - \frac{E_i}{kT}$	(10-24)	E_i
5. Intrinsic Conduction	$J_{in} = bT^{3/2}\exp - \frac{E_g}{2kT}\cdot\mathcal{E}$	(10-25)	E_g
6. Poole-Frenkel Emission	$J_{PF} = c\mathcal{E}\exp - \frac{E_i}{kT}\exp\left[\frac{1}{kT}\left(\frac{q^3\mathcal{E}}{\pi\varepsilon_i}\right)^{1/2}\right]$	(10-26)	E_i

a, b, c = constant.
ε_i = insulator dielectric constant.