Appendix-I

Properties of intrinsic semiconductors at 300 K

Properties	Material						
	Ge	Si	GaAs	GaP	InP	InSb	ZnS
Energy band gap, Eg (eV)	0.67	1.11	1.43	2.76	1.35	0.18	3.6
Electron Mobility, μ_n(cm^2/V.s)	3900	1350	8500	300	4000	10^5	110
Hole mobility, μ_p (cm^2/V-s)	1900	480	400	150	100	1700	-
Intrinsic carrier concentration n_i (cm^{-3}) E∫	2.4 x 10^{13}	1.5 x 10^{10}	1.79 x 10^6		1.2 x 10^8		
Resistivity ρ (Ω cm)	43	2.5 x 10^5	4x 10^8	1	8 x 10^{-3}	0.06	10^{10}
Transition (Type of energy band structure) direct/indirect	i	i	d	i	d	d	d
Lattice constant a (Å)	5.66	5.43	5.65	5.45	5.87	6.48	5.409
Density (g/cm^3)	5.32	2.33	5.31	4.13	4.79	5.78	4.09
Atomic / Molecular weight (g/mole)	72.6	28.09	144.63	100.694	145.794	236.57	97.44
Melting point (^{0}C)	936	1415	1238	1467	1070	525	1650
Dielectric constant Relative permittivity, ∫$_r$	16	11.8	13.2	11.1	12.4	17.7	8.9
Electron affinity, ψ_s(V)	4.0	4.05	4.07		4.38		
Density of states in conduction band, N_C (cm^{-3})	1.04 x 10^{19}	2.8 x 10^{19}	4.7 x 10^{17}				
Density of states in valence band, N_V (cm^{-3})	6 x 10^{18}	1.02 x 10^{19}	7 x 10^{18}				
Critical field or Breakdown field (V/cm)	10^5	3 x10^5	4x 10^5				
Crystal structure Diamond / Zinc blende / Wurtzite	D	D	Z	Z	Z	Z	Z,W

Appendix-II

Properties of SiO_2 and Si_3N_4

Property	**SiO_2**	**Si_3N_4**
Structure	amorphous	amorphous
Density (g/cm^3)	2.2	3.1
Dielectric constant $\int_r$	3.9	7.5
Dielectric strength (V/cm)	10^7	107
Energy gap (eV)	9	5
Resistivity at 25^0C (Ωcm)	~10^{15}	~10^{14}
Refractive index	1.46	3.1

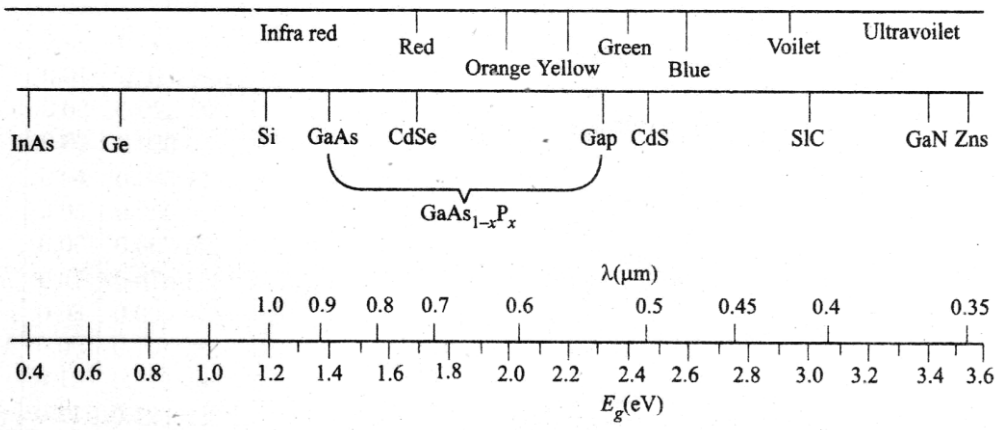
Appendix-III

Work functions and Richardson Constants

Metal	**ϕ_m(V)**	**R^*($A/cm^2/K^2$)**
Al	4.2	-
Au	4.7	-
Pt	5.4	32
Cu	4.4	65
W	4.5	60

Appendix-IV

Band gaps of common semiconductors related to the optical spectrum



Appendix-V

Physical Constants

Name	Symbol	Value
Avogadro number	N	6.023 x $l0^{23}$/mole
Boltzmann constant	k	1.381 x 10^{-23} J/K
Electronic charge	q	1.602 x 10^{-19} C
Electron rest mass	m_0	9.109 x 10^{-34} g
Permittivity of free space	ε_0	8.854 x 10^{-14} F/cm
Planck's constant	h	6.626 x 10^{-34} J-s
Thermal voltage at 300 K	V_T	0.0259 V
Velocity of light in vacuum	c	2.998 x 10^{10} cm/s
Electron volt	eV	1 eV = 1.602 x 10^{-19} J
Amstrong (A^0)		1 A^0 = 10^{-8} cm = 10^{-4} μm

Appendix-VI
Hyperbolic functions

$\sinh x = \frac{e^x - e^{-x}}{2}$

$\cos hx = \frac{e^x + e^{-x}}{2}$

$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$

$$\frac{d}{dx}(\sinh x) = \cosh x$$

$$\frac{d}{dx}(\cosh x) = \sinh x$$

$$\frac{d}{dx}(\tanh x) = \frac{2}{\cosh^2 x}$$

$\tanh x = x - \frac{x^3}{3} + \ldots$

$\cot hx = \frac{1}{x} + \frac{x}{3} - \frac{x^3}{45} + \ldots$

$\sec hx = 1 - \frac{x^2}{2} + \frac{5y^4}{24} - \ldots$

$\operatorname{cosec} hx = \frac{1}{x} - \frac{x}{6} + \frac{7x^3}{360} - \ldots$

Appendix - VII

Unit Prefixes

Multiple	Prefix	Symbol	Multiple	Prefix	Symbol
10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	Kilo	k	10^{-6}	micro	μ
10^{2}	hecto	h	10^{-9}	nano	n
10	deca	da	10^{-12}	pico	P

Appendix-VIII

Table of Error Function erf (u)

u	erf(u)	u	erf(u)	u	erf(u)	u	erf(u)
0.00	0.000 000	0.33	0 359 279	0.65	0.642 029	0.97	0.829 870
0.01	0.011 283	0.34	0.369 365	0.66	0.649 377	0.98	0.834 232
0.02	0.022 565	0.35	0.379 382	0.67	0.656 628	0.99	0.838 508
0.03	0.033 941	0.36	0.389 330	-0.68	0.663 792	1.00	0.842 701.
0.04	0.045 111	0.37	0.399 206	0.69	0.670 840	1.01	0.846 810
0.05	0.056 372	0.38	0.409 009	0.70	0.677 801	1.02	0.850 838
0.06	0.067622	0.39	0.418 739	0.71	0.684666	1.03	0.854 784
0.07	0.078 858	0.40	0.428 392	0.72	0.691 433	1.04	0.858 650
0.08	0.090 078	0.41	0.437 969	0.73	0.698 104	1.05	0.862 436
0.09	0.101 281	0.42	0.447 969	0.74	0.704 678	1.06	0.806 144
0.10	0.112 463	0.43	0.456 887	0.75	0.711 156	1.07	0.869 773
0.11	0.123 623	0.44	0.466 225	0.76	0.717 537	1.08	0.873 326
0.13	0.145 867	0.45	0.475 482	0.77	0.723 822	1.09	0.870 803
0.14	0.156 947	0.46	0.484655	0.78	0.730 010	1.10	0.880 205
0.15	0.167 996	0.47	0.493 745	0.79	0.736 103	1.11	0.883 533
0.16	0.179 012	0.48	0.502 750	0.80	0.742 101	1.12	0.886 788
0.17	0.189 992	0.49	0.511 668	0.81	0.748 003	1.13	0.889 971
0.18	0.200 936	0.50	0.520 500	0.82	0.753 811	1.14	0.893 082
0.19	0.211 840	0.51	0.529 244	0.83	0.759 524	1.15	0.896 124
0.20	0.222 703	0.52	0.537 899	0.84	0.765 143	1.16	0.899 096
0.21	0.233 522	0.53	0.546 464	0.85	0.770 668	1.17	0.902 000
0.22	0.244 296	0.54	0,554 939	0.86	0.776 110	1.18	0.904 837
0.23	0.255 023	0.55	0.563 323	0.87	0.781 440	1.20	0.910 314
0.24	0.265 700	0.56	0.571 616	0.88	0.786 687	1.21	0.912 956
0.25	0.276 326	0.57	0.579 816	0.89	0.791 843	1.22	0.815 534
0.26	0.286 900	0.58	0.597 923	0.90	0.796 908	1.23	0.918 050
0.27	0.297 418	0.59	0.595 936	0.91	0.801 883	1.24	0.920 505
0.28	0.307 880	0.60	0.603 856	0.92	0.806 768	1.25	0.922 900
0.29	0.318 283	0.61.	0.611 681	0.93	0.811 564	1.26	0.925 236
0.30	0.328 627	0.62	0.619 411	0.94	0.816 271	1.27	0,927 514
0.31	0.338 908	0.63	0.627 046	0.95	0.820 991	1.28	0.929 734
0.32	0.349 126	0.64	0.634 586	0.96	0.825 424	1.29	0.931 899

u	erf(u)	u	erf(u)	u	erf(u)	u	erf(u)
1.30	0.934 008	1.71	0.984 407	2.12	0.997 284	2.53	0.999 654
1.31	0.936 063	1.72	0.985 003	2.13	0.997 407	2.54	0.999 672
1.32	0.938 065	1.73	0.985 578	2.14	0.997 525	2.55	0.999 689
1.33	0.940 015	1.74	0.986 135	2.15	0.997 639	2.56	0.999 706
1.34	0.941 914	1.75	0.986 672	2.16	0..997 747	2.57	0.999 722
1.35	0.943 762	1.76	0.987 190	2.17	0.997 851	2.58	0.999 736
1.36	0.945 561	1.77	0.987 691	2.18	0.997.951	2.59	0.999 751
1.37	0 947 312	1.78	0.988 174	2.19	0.998 046	2.60	0.999 764
1.38	0.949 016	1.79	0.988 641	2.20	0.998 137	2.61	0.999 777
1.39	0.950 673	1.80	0.989 091	2.21	0.998 224	2.62	0.999 789
1.40	0.952 285	1.81	0.989 525	2.22	0.998 308	2.63	0.999 800
1.41	0.953 852	1.82	0.989 943	2.23	0.998 388	2.64	0.999 811
1.42	0.955 376	1.83	0.990 347	2.24	0.998 464	2.65	0.999 822
1.43	0.956 857	1.84	0.990 736	2.25	0.998 537	2.66	0.999 831
1.44	0.958 297.	1.85	0.991 111	2.26	0.998 607	2.67	0.999 841
1.45	0.959 695	1.86	0.991 472	2.27	0.998 674	2.68	0.999 849
1.46	0.961 054	1.87	0.991 821	2.28	0.998 738	2.69	0.999 858
1.47	0.962 373	1.88	0.992 156	2.29	0.998 799	2.70	0.999 866
1.48	0.963 654	1.89	0.992 479	2.30	0.998 857	2.71	0.999 873
1.49	0.964 898	1.90	0.992 790	2.31	0.998 912	2.72	0.999 880
1.50	0.966 105	1.91	0.993 090	2.32	0.998 966	2.73	0.999 887
1.51	0.967 277	1.92	0.993 378	2.33	0.999 016	2.74	0.999 893
1.52	0.968 413	1.93	0.993 656	2.34	0.999 065	2.75	0.999 899
1.53	0.969 516	1.94	0.993 923	2.35	0.999 111	2.76	0.999905
1.54	0.970 586	1.95	0.994 179	2.36	0.999 155	2.77	0.999 910
1.55	0.971 623	1.96	0.994 426	2.37	0.999 197	2.78	0.999 916
1.56	0.972 628	1.97	0.994664	2.38	0.999 197	2.79	0.999 920
1.57	0.973 603	1.98	0.994 892	2.39	0.999 275	2.80	0.999 925
1.58	0.974 547	1.99	0.995 111	2.40	0.999 311	2.81	0.999 929
1.59	0.975 462	2.00	0.995 322	2.41	0.999 346	2.82	0.999 933
1.60	0.976 348	2.01	0.995 525	2.42	0.999 379	2.83	0.999 937
1.61	0.977 207	2.02	0.995 719	2.43	0.999 411	2.84	0.999 941
1.62	0.978 308	2.03	0.995906	2.44	0.999 441	2.85	0.999 944
1.63	0.978 843	2.04	0.996 086	2.45	0.999 469	2.86	0.999 948
1.64	0.979 622	2.05	0.996 258	2.46	0.999 497	2.87,	0.999 951
1.65	0.980 376	2.06	0.996 423	2.47	0.999 523	2.88	0.999 954
1.66	0.981 105	2.07	0.996 582	2.48	0.999 547	2.89	0.999 956
1.67	0.981 810	2.08	0.996734	2.49	0.999 571	2.90	0.999 959
1.68	0.982 493	2.09	0.996880	2.50	0.999 593	2.91	0.999 961
1.69	0.983 153	2.10	0.997 021	2.51	0.999 614	2.92	0.999 964
1.70	0.983 790	2.11	0.997 155	2.52	0.999 634	2.93	0.999 966

u	erf(u)	u	erf(u)	u	erf(u)
2.96	0.999 972	3.36	0.999 997 983	3.76	0.999 999 895
2.97	0.999 973	3.37	0.999 998 120	3.77	0.999 999 903
2.98	0.999 975	3.38	0.999 998 247	3.78	0.999 999 910
2.99	0.999 976	3.39	0.999 998 367	3.79	0.999 999 917
3.00	0.999 977 91	3.40	0.999 998 478	3.80	0.999 999 923
3.01	0.999 979 26	3.41	0.999 998 582	3.81	0.999 999 929
3.02	0.999 980 53	3.42	9.999 998 679	3.82	0.999 999 934
3.03	0.999 981 73	3.43	0.999 998 770	3.83	0.999 999 939
3.04	0.999 982 86	3.44	0.999 998 855	3.84	0.999 999 944
3.05	0.999 983 92	3.45	0.999 998 934	3.85	0.999 999 948
3.06	0.999 984 92	3.46	0.999 999 008	3.86	0.999 999 952
3.07	0.999 985 86	3.47	0.999 999 077	3.87	0.999 999 956
3.08	0.999 986 74	3.48	0.999 999 141	3.88	0.999 999 959
3.09	0.999 987 57	3.49	0.999 999 201	3.89	0.999 999 962
3.10	0.999 988 35	3.50	0.999 999 257	3.90	0.999 999 965
3.11	0.999 989 08	3.51	0.999 999 309	3.91	0.999 999 968
3.12	0.999 989 77	3.52	0.999 999 358	3.92	0.999 999 970
3.13	0.999 990 42	3.53	0.999 999 403	3.93	0.999 999 973
3.14	0.999 991 03	3.54	0.999 999 445	3.94	0.999 999 975
3.15	0.999 991 60	3.55	0.999 999 485	3.95	0.999 999 977
3.16	0.999 992 14	3.56	0.999 999 521	3.96	0.999 999 979
3.17	0.999 992 64	3.57	0.999 999 555	3.97	0.999 999 980
3.18	0.999 993 11	3.58	0.999 999 587	3.98	0.999 999 982
3.19	0.999 993 56	3.59	0.999 999 617	3.99	0.999 999 983
3.20	0.999 993 97	3.60	0.999 999 644		
3.21	0.999 994 36	3.61	0.999 999 670		
3.22	0.999 994 73	3.62	0.999 999 694		
3.23	0.999 995 07	3.63	0.999 999 716		
3.24	0.999 995 40	3.64	0.999 999 736		
3.25	0.999 995 70	3.65	0.999 999 756		
3.26	0.999 995 98	3.66	0.999 999 773		
3.27	0.999 996 24	3.67	0.999 999 790		
3.28	0.999 996 49	3.68	0.999 999 805		
3.29	0.999 996 72	3.69	0.999 999 820		
3.30	0.999 996 94	3.70	0.999 999 833		
3.31	0.999 997 15	3.71	0.999 999 845		
3.32	0.999 997 34	3.72	0.999 999 857		
3.33	0.999 997 51	3.73	0.999 999 867		
3.34	0.99999768	3.74	0.999 999 877		

Appendix-IX

List of Symbols

a	-	lattice constant, Half thickness of channel of JFET, MESFET channel thickness
A	-	area
B	-	magnetic flux density
B, E, C	-	base, emitter, collector of BJT
c	-	velocity of light
C	-	capacitance/unit area of MOSFET
C_j	-	depletion layer capacitance of p-n junction
C_s	-	storage (diffusion) capacitance of p-n junction
D	-	diffusion coefficient of impurities
D_n, D_p	-	diffusion coefficient of electrons, holes
D, G, S	-	drain, gate source of FET
E	-	electric field strength
E	-	energy
E_A, E_D	-	acceptor, donor energy levels
E_C, E_V	-	conduction band, valence band edge
E_F	-	equilibrium Fermi level
E_{F_n}, E_{F_p}	-	equilibrium Fermi level in n material, p material
E_r, E_t	-	recombination, trap energy level
E_g	-	Energy band gap
E_i	-	intrinsic energy level
$f(E)$	-	Fermi-Dirac distribution function
F_n, F_p	-	quasi Fermi level for electrons, holes
f_T	-	figure of merit
f_α, f_β	-	alpha, beta cutoff frequency
g, g_{op}	-	EHP generation rate, optical generation rate
g_m	-	transconductance or mutual conductance
G_o	-	channel conductance of JFET, MESFET under equilibrium
hkl	-	Miller indices
h	-	Planck's constant
h	-	Planck's constant divided by 2π
$h\nu$	-	photon energy
I	-	current
I_B, I_C, I_E	-	BJT DC base, collector, emitter current
I_{CBO}	-	magnitude of collector base saturation current with emitter open
I_{CEO}	-	collector emitter saturation current with base open
I_{CS}	-	collector base saturation current with emitter shorted to base
I_{ES}	-	emitter base saturation current with collector shorted to base

I,F (superscript)- inverse, forward mode of BJT

I_S - reverse saturation current in a p-n junction

I_R - recombination current in a p-n junction

J - current density

k - Boltzmann constant

$\boldsymbol{k}$ - wave vector

k_0 - segragation constant

k_p - MOSFET device parameter

L_n - diffusion length for electron

L_p - diffusion length for holes

$\bar{l}$ - mean free path for carriers in random motion

m,m^* - mass, effective mass

m_n^*, m_p^* - effective mass of electrons, holes

m_0 - rest mass of electron

M - avalanche multiplication factor

n - electron concentration

n^+ - heavily doped n-type material

n_i - intrinsic concentration of electrons

n_{n_0}, n_{p_0} - equilibrium concentration of electrons in n-type. p-type material

n_0 - equilibrium concentration of electrons

N_A,N_D - concentration of acceptors, donors

N_C,N_V - effective density of states at the edge of the conduction band, valence band

p - concentration of holes in valence band

p^+ - heavily doped p-type material

p_{n_0}, p_{p_0} - equilibrium concentration of holes in n-type, p-type material

p_0 - equilibrium hole concentration

q - magnitude of electron charge

Q_D - depletion layer charge of p-n junction, depletion region charge per unit area of MOS device

Q_f - oxide fixed charge/area

Q_I - implanted charge per unit area in MOSFET

Q_{ox} - MOS oxide charge per unit area

Q_m - mobile ionic charge/area

Q_s - stored charge in p-n junction

R_p - projected range

r - recombination rate

R - resistance

R_H - Hall coefficient

$\bar{t}$ - mean free time between scattering collisions

t_{sd} - storage delay time

T - temperature

V_{CB}, V_{EB} - voltage from collector to base, emitter to base in a BJT

V_{DS}, V_{GS} - voltage from drain to source, gate to source in an FET

V - Electrostatic Potential

V_o - contact potential

V_p - pinch-off voltage

V_{PT} - punch through voltage

V_{th} - threshold voltage

V_{FB} - flat band voltage

V_d - drift velocity

W - depletion layer width

W_B - base width of BJT

W_p,W_N - width of neutral p-region, n-region

V_A - BJT Early voltage

V_{Br} - breakdown voltage

V_a - applied voltage

V_T - thermal voltage (kT/q)

V_{BrCBO} - BJT breakdown voltage collector to base with emitter open

V_{BrCEO} - BJT breakdown voltage collector to emitter with base open

x_n,x_p - distance in the neutral n-region, p-region of a junction, measured from the edge of the depletion region

X_n, X_p - Penetration of the depletion region into the n-region, p-region measured from the metallurgical junction

Z - dimension in z-direction

α - common base short circuit current gain

$\propto$ - optical absorption coefficient

α_r - recombination coefficient

α_T - transport factor

γ - emitter injection efficiency

Δ_{pC} , Δ_{pE} - excess hole concentration in the base of a BJT, evaluated at the edge of the depletion region of the collector, emitter junction

$\int$,$\int_r$,$\int_0$ - permittivity, relative dielectric constant, permittivity of free space; $\int = \int_0\int_r$

λ - wave length of light

μ - mobility

ν - frequency of light

ρ - resistivity, charge density

σ - conductivity

$\tau_n\tau_p$ - lifetime of electrons holes

τ_t - transit time

τ_{tB} - transit time in the base of BJT

ϕ - flux density, potential

ϕ_F - Fermi potential

ϕ_S - surface potential

ϕ_m	-	work function potential of metal
ϕ_{SC}	-	work function potential of semiconductor
ψ	-	time independent wave function
ψ_s	-	electron affinity- of semiconductor
Ψ	-	time dependent wave function
η	-	ideality factor of p-n junction
δ_n, δ_p	-	excess electron, hole concentration
ω	-	angular frequency
Δ_{pC} , Δ_{pE}	-	excess electron, hole concentration at the edge of depletion region on the p-side, n-side

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