

Physical Constants of IC Package Materials

Table 5-1 through Table 5-9 list typical values for selected properties of materials used in IC packages.

Table 5-1. Case Material Characteristics

Properties	Units	Alumina (92%)	Kovar	Molding Compound	Sealing Glass	Cu-W (90%)	Cu
Density	kg/m ³ (g/cc)	3600-3700 (3.6-3.7)	8400 (8.4)	1790-1850 (1.79-1.85)	4700 (4.7)	17000 (17)	8900 (8.9)
Modulus of Elasticity	GPa	55	138	E ₁ = 11.7 E ₂ = 0.1	5.7	255	125
Tensile Strength	MPa	157	627	19.98			270
Thermal Conductivity (20°C)	W/mK	18	17.5	0.58 - 0.67	0.6	180 - 200	
Coefficient of Thermal Expansion	ppm/ °C	6.8 (25°C - 400°C)	5.3 (40°C - 250°C)	a ₁ ≤ 23 a ₂ ≤ 80 (40°C - 250°C)	6.3 - 7.0 (40°C - 250°C)	6.5 (25°C - 500°C)	16 (25°C - 500°C)
Electrical Resistivity	Ω cm	10 ¹⁴	49 X 10 ⁻⁶	5 X 10 ¹²	>10 ¹¹	<6 X 10 ⁻⁶	<2 X 10 ⁻⁶
Dielectric Constant (1 MHz)		7.9 - 10.0	NA	≤ 5.0	11.5	NA	NA
Flammability Rating *	inches			1/8			

NOTE:

- * UL-94V-0

Table 5-2. Lead/Lead Frame Characteristics

Properties	Units	Copper Alloy MF 202	Alloy 42	Kovar	TAMAC5	CDA 194	OLIN 7025	EFTEC 64T
Density	kg/m ³ (g/cc)	8880 (8.8)	8100 (8.1)	8400 (8.4)	8900 (8.9)	8800 (8.8)	8800 (8.8)	8900 (8.9)
Modulus of Elasticity	GPa	113	145	138	120	121	131	119
Tensile Strength	MPa	490-590	588-735	627	527-562	480-519	527	560
Thermal Conductivity (20°C)	W/mK	160	15.7	17.5	138	263	166	300
Coefficient of Thermal Expansion	ppm/ °C	17.0	4.5	5.3	16.7	16.3	17.1	17.0
Electrical Resistivity	Ω cm	5.7 X 10 ⁻⁶	57 X 10 ⁻⁶	49 X 10 ⁻⁶	4.9 X 10 ⁻⁶	2.6 X 10 ⁻⁶	4.3 X 10 ⁻⁶	2.3 X 10 ⁻⁶

Table 5-3. Solder Material Melting Temperatures

Solder Type	Temperature (°C)
Sn-Pb Plating (85 wt% Sn)	200 - 225
Sn-Pb Eutectic (62 wt% Sn)	183
Tin	232
Lead	327
Gold	1063
Copper	1083
Silver	961
Copper/Silver Braze (28 wt% Cu)	850
Au-Sn Eutectic (80 wt% Au)	280

Table 5-4. Die Attach Material Characteristics

Property	Units	Silver Filled Glass	Silver Filled Adhesive	Silver Filled Epoxy	99.99% Au + 2% Si	99.99% Au
Density	kg/m ³ (g/cc)	4500 (4.5)		2500 (2.5)	14500 (14.5)	19300 (19.3)
Modulus Elasticity	GPa		0.77		69.5 (Data for Au + 3% Si)	62.5
Tensile Strength	MPa	> 10.			500-600	130
Thermal Conductivity	W/mK	270	2.5 @ 121°C	1.6 @ 121°C	50	311
Coefficient of Thermal Expansion	ppm/°C	8	$\alpha_1 = 40$ $\alpha_2 = 150$	$\alpha_1 = 46$ $\alpha_2 = 240$	50 @ 25°C	14.2 @ 25°C
Electrical Resistivity	Ω cm	1×10^{-5}	1×10^{-4}	2×10^{-4}	3.1×10^{-4}	2.21×10^{-6}

Table 5-5. TCP Package Materials Characteristics

Property	Units	Polyimide	Adhesive	Cu-Foil Rolled	Cu-Foil Electro-Deposited	Encapsulant
Density	kg/m ³ (g/cc)	1470 (1.47)	1500 - (1.5)	8931 (8.9)	8931 (8.9)	1330 (1.33 uncured)
Modulus Elasticity	GPa	9 @ 25°C 4 @ 300°C	8 @ 25°C	127.4	127.4	6.55 @ 25°C
Tensile Strength	MPa	400	40 - 100	~450	532	
Thermal Conductivity	W/mK	0.2	0.1 - 0.2	390	390	0.52
Coefficient of Thermal Expansion	ppm/°C	12 - 18 25°C - 300°C	30 - 60 25°C - 300°C	16.7 25°C	16.7	$\alpha_1 = 31$ $\alpha_2 = 118$
Electrical Resistivity	Ω cm	$>1 \times 10^{15}$	$>10^{16}$ (0%RH) $>10^{15}$ (55%RH)	1.7×10^{-6}	1.7×10^{-6}	
Dielectric Constant	relative	3.5 (KHz)	3.0 (1 KHz)	NA	NA	3.8 (1 KHz)

Table 5-6. PPGA Package Materials Characteristics

Property	Units	Silver Filled Epoxy	Encapsulant
Density	kg/m ³ (g/cc)	2500 (2.5)	
Modulus Elasticity	GPa		10.2 @ 25° C
Tensile Strength	MPa		
Thermal Conductivity	W/mK	1.6 @ 121°C	0.52
Coefficient of Thermal Expansion	ppm/°C	$\alpha_1 = 46$ $\alpha_2 = 240$	$\alpha_1 = 19$ $\alpha_2 = 70$
Electrical Resistivity	Ω cm	$>1 \times 10^{-4}$	2.18×10^{16}
Dielectric Constant	relative		@ 1kHz=3.68

Table 5-7. PBGA Material Characteristics

Property	Units	Laminate Substrate	Solder Mask	Die Attach	Molding Compound	Solder Spheres
Density	g/cc		1.4	3.5	1.9	8.4
Modulus of Elasticity	GPa	12-18		0.3-2.0	Flexural Modulus 15 - 20	30
Tensile Strength	MPa	225-300			Flexural strength 95 - 150	35
Thermal Conductivity	W/mK		0.20	2.0	0.7-0.9	50.6
Glass Transition Temp	°C	195 (BT epoxy)	105	25-100	180-225	Eutectic point 183
Coefficient of Thermal Expansion	ppm/°C	12-16 (x, y) 72 - 85 (z)	$\alpha_1 = 60$ $\alpha_2 = 160$	$\alpha_1 = 40-80$ $\alpha_2 = 150-200$	$\alpha_1 = 12-18$ $\alpha_2 = 41-65$	24.7
Volume Resistivity	Ω cm = 25 °C		$10^{13} - 10^{16}$		$> 10^{14}$	

Table 5-8. High-Thermal, Low-Profile HL-BGA Material Characteristics

Property	Units	Copper Slug	Tape Substrate	Die Attach	Encapsulation	Solder Spheres
Density	g/cc	8.96	1.4 (resin)	3.5	1.5-1.8	8.4
Modulus of Elasticity	GPa	110-20		0.3-2.0	5-13	30
Tensile Strength	MPa	220	24kpsi (resin)		70	35
Thermal Conductivity	W/mK	390-400		2.0	0.85-0.90	50.6
Glass Transition Temp	°C	Melting Point 1083	260	25-100	90-170	Eutectic point 183
Coefficient of Thermal Expansion	ppm/°C	16-18	(x, y) 50 (z)	$\alpha_1 = 40-80$ $\alpha_2 = 150-200$	$\alpha_1 = 16-26$ $\alpha_2 = 70-80$	24.7
Volume Resistivity	$\Omega \text{ cm} = 25 \text{ }^\circ\text{C}$		10^6		$> 10^{15}$	

Table 5-9. Flip Chip Style HL-PBGA Material Characteristics

Property	Units	Substrate	Solder Mask	Underfill
Modulus of Elasticity	GPa	3	3	8
Tensile Strength	MPa	70	60	
Glass Transition Temp	°C	200	175	135
Coefficient of Thermal Expansion	ppm/°C	$\alpha_1 \sim 70$	$\alpha_1 \sim 70$	$\alpha_1 \sim 30$
Volume Resistivity	$\Omega \text{ cm} = 25 \text{ }^\circ\text{C}$	$\sim 10^{10}$	$\sim 10^{10}$	