表 2.1 無鉛焊料候合金系與特徵[4]

基本元素	第二元素	添加元素	特徵	問題點
Sn	Bi	Ag Cu	融點較低 強度較強	融溶溫度較低 合金硬 脆 加工性差(錫絲製造困難) 接合強度、耐疲勞強度差
	Ag Cu	Bi In	具有優良的耐疲勞性 強度較強 融溶溫度區域狹窄	融點較高
	Zn	Bi In	比較接近 Sn-Pb 共晶 焊材融點強度較強 融溶溫度區域狹窄 成本較低	迴焊性極端不良 經時變化激烈 資源回收困難
	In	Ag	融點較低	產量極少、成本極高 經時變化激烈 資源回收困難 群組特性不加
Sn 系			無毒性的問題 充分的供給性	Ag、蝕銀機率增加 加工性差 (錫絲製造困難)

表 3.1 熱循環測試建議的溫度範圍 [21,p.5]

Test Condition*	Nominal Ts(min)(°C) with Tolerances	Nominal Ts(max)(°C) with Tolerances
A	-55(+0, -10)	+85(+10, -0)
B	-55(+0, -10)	+125(+15, -0)
C	-65(+0, -10)	+150(+15, -0)
G	-40(+0, -10)	+125(+15, -0)
H	-55(+0, -10)	+150(+15, -0)
I	-40(+0, -10)	+115(+15, -0)
J	-0(+0, -10)	+100(+15, -0)
K	-0(+0, -10)	+125(+15, -0)
L	-55(+0, -10)	+110(+15, -0)
M	-40(+0, -10)	+150(+15, -0)

表 3.2 焊墊表面處理建議 [22,p.20]

Finish	Class 1	Class 2	Class 3
Gold (min) for edge-board connectors and areas not to be soldered	0.8 µm	0.8 µm	1.3 µm
Gold (max) on areas to be soldered	0.8 µm	0.8 µm	0.8 µm
Gold (min) on areas to be wire bonded (ultrasonic)	0.05 µm	0.05 µm	0.15 µm
Gold (min) on areas to be wire bonded (thermosonic)	0.3 µm	0.3 µm	0.8 µm
Nickel (min) for edgeboard connectors	2.0 µm	2.5 µm	2.5 µm
Nickel (min) barrier to prevent formation of copper-tin compounds**	1.0 µm	1.3 µm	1.3 µm
Electroless Nickel	2.5 - 5.0 µm		
Immersion Gold	0.08 - 0.23 µm		
Unfused tin-lead (min)	8.0 µm	8.0 µm	8.0 µm
Fused tin-lead or Solder Coat	Coverage and solderable	Coverage and solderable	Coverage and solderable
Solder Coat over Bare Copper	Coverage and solderable	Coverage and solderable	Coverage and solderable
Organic Solderability Preservative	Solderable	Solderable	Solderable
Bare Copper	None	None	None
Surface and Holes			
Copper* (Avg. minimum)	20 µm	20 µm	25 µm
Min. thin areas***	18 µm	18 µm	20 µm
Blind Vias			
Copper (Avg. minimum)	20 µm	20 µm	25 µm
Min. thin area	18 µm	18 µm	20 µm
Buried Vias			
Copper (Avg. minimum)	13 µm	15 µm	15 µm
Min. thin area	11 µm	13 µm	13 µm

表 5.1 AIM(Sn/Ag3.8-4.0/Cu0.5-0.7)規格

TECHNICAL DATA SHEET

CATEGORY: **LEAD-FREE ALLOY**
NAME: **TSC-4 (Sn/Ag3.8-4.0/Cu0.5-0.7)**

FEATURES

- SN-AG-CU ALLOY
- GOOD WETTING ALLOY
- EXCELLENT SOLDER JOINT RELIABILITY
- LOW MELTING POINT FOR A PB-FREE ALLOY (217°C -218°C)
- COMPATIBLE WITH ALL FLUX TYPES
- EXCELLENT FATIGUE RESISTANCE

DESCRIPTION

TSC-4 is a lead-free alloy that contains tin, 3.8 - 4% silver, and 0.5 - 0.7% copper. This alloy falls under the NEMI recommendation for lead-free soldering. TSC-4 is a near drop-in replacement for 63Sn/37Pb for wave soldering and hand soldering applications. When used in wave soldering, TSC-4 produces less dross than other solder alloys, wets well, and provides superior joint strength. In SMT applications, TSC-4 produces strong solder joints and offers good mechanical fatigue resistance. TSC-4 may be used with many existing types of equipment, processes, coatings, and flux chemistries. The TSC-4 alloy is available in bar, cored wire, solid wire, foil, preforms, powder, and no-clean, water soluble and rosin solder pastes. TSC-4 no-clean solder pastes pass all Bellcore and IPC specifications.

IMPURITY LEVELS TO IPC-JSTD-006 in Percent				
Al: 0.005	Au: 0.05	Cd: 0.002	Fe: 0.02	In: 0.10
As: 0.03	Bi: 0.10	Zn: 0.003	Ni: 0.01	

HANDLING

Refer to the specific Material Safety Data Sheet and the handling section of the individual Technical Data Sheets for the chemistry type of TSC-4 solder paste being used.

FLUX COMPATIBILITY

TSC-4 is compatible with all major electronic grade fluxes on the market today, and is available in paste and wire form in no-clean, water soluble and rosin chemistries.

CLEANING

Refer to the liquid flux manufacturer's data sheet for specific cleaning information, or refer to the cleaning section of the individual AIM solder paste technical data sheets for the recommended cleaning information.

TEMPERATURE REQUIREMENTS

APPLICATION	RECOMMENDED TEMPERATURE
REFLOW SOLDERING (SEE NEXT PAGE)	PEAK TEMPERATURE 235° - 245°C (455° - 473°F)
WAVE SOLDER	POT TEMPERATURE OF 260°C (500°F)
HAND SOLDER - SOLDERING IRON	TIP TEMPERATURE OF 370° - 425°C (700° - 800°F)

06.17.04

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表 5.2 南亞樹酯 BT 印刷電路板板材規格

NAN YA PLASTICS CORPORATION
ELECTRONIC MATERIALS DIVISION.
COPPER CLAD LAMINATE DEPARTMENT

NO.201 TUNG HWA N. ROAD
TAIPEI, TAIWAN. ROC

Glass cloth base BT resin
Flame retardant copper clad laminate

NP-200TL

■FEATURES
- **High Tg 190℃ (TMA)**
- **Excellent dimensional stability and through-hole reliability**
- **Excellent electrical, chemical, and heat resistance properties**
- **IPC-4101 specification is applicable**
- **U.L file number E98983(S)**

■Product Applications
- **BGA substrates.**
- **High layer count PWB**
- **Wireless communication**
- **MCM**
- **Direct Chip Attach**

■PERFORMANCE LIST

Characteristics	Unit	Conditioning		Typical Values	SPEC
Volume resistivity	MΩ-cm	C-96-35/90		1.5×10^{10}	10^{6} ↑
Surface resistivity	MΩ	C-96/35/90		4.5×10^{9}	10^{6} ↑
Permittivity 1MHZ	—	C-24/23/50		4.1~4.7	4.8 ↓
Loss tangent 1MHZ	—	C-24/23/50		0.010~0.016	0.020 ↓
Arc resistance	SEC	D-48/50+D-0.5/23		120 ↑	60 ↑
Dielectric breakdown	KV	D-48/50		45 ↑	40 ↑
Moisture absorption	%	D-24/23	<0.78mm	0.18	0.80 ↓
			≧0.78mm	0.15	0.35 ↓
Flammability	—	C-24/23/50+E-24/125		94V0	94V0
Peel strength 1oz	lb/in	288℃×10" solder floating		9	8 ↑
Heat resistance	SEC	288℃ dipping		600 ↑	10 ↑
Glass transition temp	℃	TMA		190±5	N/A
Dimensional stability X-Y axis	%	E-4/105		0.01~0.03	0.05 ↓
Coefficient of thermal expansion Z-axis before Tg Z-axis after Tg	 in/in℃ in/in℃	 TMA TMA		 5.0×10^{-5} 25.0×10^{-5}	N/A

表 6.1 IMC **的厚度(**μm**)與老化**(aging)**時間的關係**

	ENIG	OSP(Cu side)	OSP(solder side)
120 hour	1.1556	1.1721	2.3829
240 hour	1.327	1.6967	2.401
480 hour	2.2428	2.1497	2.4351
720 hour	2.3586	3.0473	4.1706
1000 hour	2.6254	3.0518	4.2267
EDX **分析**	Cu-Ni-(Au)-Sn	Cu_3Sn	Cu_6Sn_5

表 6.2 **常溫下**(25℃)**老化與高溫**(150℃)**老化的剪力強度測試**

a. **常溫老化**(25°C)**剪力推球強度**(gf)

	ENIG(25°C)	ENIG **標準差**	OSP(25°C)	OSP **標準差**
0hour	370.83	32.12	499.46	42.11
120hour	347.88	23.55	495.21	19.12
240hour	345.02	42.87	487.69	24.56
480hour	321.58	29.76	502.25	35.17
720hour	324.68	33.45	489.27	27.42
960hour	320.07	22.14	497.16	42.13

b.**高溫老化**(150°C)**剪力推球強度**(gf)

	ENIG(25°C)	ENIG **標準差**	OSP(25°C)	OSP **標準差**
0hour	370.83	32.12	499.46	42.11
120hour	382	24.14	460.12	35.12
240hour	357.23	24.56	425.25	33.12
480hour	342.42	28.12	455.98	40.77
720hour	356.42	25.44	445.12	37.34
960hour	300.14	33.1	440.13	37.13
1200hour	306.23	23.42	450.12	23.45

表 6.3 OSP 表面處理下可靠度分析比較

公式試算

	OSP		OSP-IMC		OSP-120℃	
	?	ß	?	ß	?	ß
5mm	4147.56	10.13	3475.9	9.01	2197.6	7.12
6mm	1764.21	7.97	1732.84	6.69	1444.76	7.18
7mm	946.93	3.72	659.9	5.36	700.36	4.31

可靠度軟體試算

	OSP		OSP-IMC		OSP-120℃	
	?	ß	?	ß	?	ß
5mm	4155.3	9.8756	3498	7.434	2222.8	5.18
6mm	1770	7.063	1744.5	6.242	1454.2	5.82
7mm	959	2.96	668.45	4.322	703.8	3.85

表 6.4 ENIG 表面處理下可靠度分析比較

公式試算

	Au		Au-IMC		Au-120℃	
	?	ß	?	ß	?	ß
5mm	2752	4.93	2141.9	6.72	1859	5.22
6mm	1494	4.89	953.1	6.541	1528.1	7.332
7mm	1009.34	6.31	632.67	7.94	730	3.82

可靠度軟體試算

	Au		Au-IMC		Au-120℃	
	?	ß	?	ß	?	ß
5mm	2716.72	6.79	2144.56	8.22	1853.79	5.64
6mm	1475.38	6.68	950.36	7.15	1522.09	8.27
7mm	1008.72	6.61	625.94	8.25	727.32	4.16

表 6.5 兩種不同表面處理在不同熱循環周次時間點的殘餘強度(kgf)比較

	ENIG	OSP
0cycle	1.506	1.96
100cycle	1.11	1.475
200cycle	0.908	0.89
300cycle	0.945	0.9
400cycle	1.051	1.021
500cycle	1.026	1.036

表 6.6 ENIG 表面處理在不同熱循環時間點的電阻值(mohm)

	焊點 1	**焊點 2**	**焊點 3**	**焊點 4**	**焊點 5**	**焊點 6**	**焊點 7**	**焊點 8**
0cycle	3.33	3.46	3.26	0	0	1	4.25	3.33
100cycle	3.45	3.55	3.6	0	0	1.1	4.32	3.35
200cycle	3.55	3.45	3.8	0	0	1.13	4.28	3.42
300cycle	3.56	3.72	3.62	0	0	1.14	4.36	3.45
400cycle	3.58	3.72	3.66	0	0	1.14	5.04	3.55
500cycle	4	3.73	3.65	0	0	1.15	5.08	3.55

表 6.7 OSP 表面處理在不同熱循環時間點的電阻值(mohm)

	焊點 1	**焊點 2**	**焊點 3**	**焊點 4**	**焊點 5**	**焊點 6**	**焊點 7**	**焊點 8**
0cycle	30.12	31.12	30.69	31.11	70.12	70.35	71.37	70.35
100cycle	31.49	31.15	31.58	31.33	70.12	70.42	70.45	70.43
200cycle	32.35	32.33	31.16	31.1	70.69	71.43	69.97	70.04
300cycle	32.38	32.35	31.22	31.33	70.72	71.11	71.23	70.72
400cycle	32.32	31.12	31.73	31.06	70.19	71.12	71.13	70.78
500cycle	32.33	32.32	31.41	31.44	70.12	71.12	71.23	70.45