

Table of Contents

Preface	v
List of Authors	xi
Introduction	1
Chapter 1: Lead Restrictions and Other Regulatory Influences on the Electronics Industry	5
1.1 Introduction	5
1.2 A Regulatory Tour of Europe	6
1.3 A Regulatory Tour of Asia	14
1.4 Regulatory Tour of the Americas	16
1.5 Business Impacts and Conclusions	17
Chapter 2: Fundamental Properties of Pb-Free Solder Alloys	21
2.1 Search for a Pb-Free Alternative to Sn-Pb Eutectic	21
2.2 Primary Alloy Design Criteria	21
2.3 Solder Alloy Solidification and Microstructural Development	25
2.4 Melting Behavior	25
2.5 Solidification Behavior	44
2.6 Wetting and Solderability	58
2.7 Pb-Free Solder Mechanical Behavior and Solder Joint Reliability	62
Chapter 3: Lead-Free Surface Mount Assembly	75
3.1 Introduction	75
3.2 Solder Paste Alloy	75
3.3 Screen Printing Process	76
3.4 Component Placement	77
3.5 Reflow Soldering	78
3.6 Solder Joint Inspection and Acceptance Criteria	82
Chapter 4: Lead-Free Wave Soldering	91
4.1 Introduction	91

4.2 Lead-Free Wave Solder Alloy Alternatives	92
4.3 Wave Solder Equipment Recommendations	94
4.4 Process Recommendations	98
4.5 Solder Joint Characterization	102
4.6 Design Considerations	110
Chapter 5: Lead-Free Rework	117
5.1 Introduction	117
5.2 Lead-Free Hand Soldering SMT Rework	117
5.3 Lead-Free SMT Rework of BGA/CSP Soldered Joints	124
5.4 Lead-Free Pin-Through-Hole (PTH) Hand Solder Rework	135
5.5 Lead-Free Pin-Through-Hole Mini-Pot Rework Soldering	138
Chapter 6: Lead-Free Solder Joint Reliability	145
6.1 Introduction	145
6.2 General Trends	146
6.3 SAC Solder Joint Reliability Case Study	153
Chapter 7: Backward and Forward Compatibility	173
7.1 Introduction	173
7.2 Reliability of BGA/CSP Backward Compatibility	177
7.3 Estimation of Mixed Composition Liquidus Temperature	182
7.4 Chip Component and Lead-Frame-Component Backward Compatibility	187
7.5 Forward Compatibility	190
7.6 Press Fit Connector Interconnections	192
Chapter 8: PCB Laminates	199
8.1 Introduction	199
8.2 Types of Stress in Printed Wiring Boards	200
8.3 Laminate Material Test Methods	202
8.4 Accelerated Thermal Stress Testing	206
8.5 Accelerated Thermal Stress Test Methods	209
8.6 HATS Test Methods – A Case Study	212
Chapter 9: Lead-Free Board Surface Finishes	221
9.1 Introduction	221
9.2 Process Overview	222
Chapter 10: Lead-Free Soldering Standards	271
10.1 Introduction	271
10.2 IPC and JEDEC Standards	271

10.3 IEC Standards	279
10.4 Japan (JEITA) Standards	280
10.5 Other Standards	281
Conclusions	285
Index	291