

Table of Content

Acknowledgement.....	i
Zusammenfassung	iii
Summary	v
Table of Content	vii
List of Figures	xii
List of Tables.....	xvii
List of Symbols.....	xix
Chapter 1 Introduction	1
Chapter 2 Reliability in Electronic Packaging.....	3
2.1 Introduction to Packaging Processes	3
2.2 Reliability Tests of Electronic Packages	6
2.3 Effects of Moisture on the Reliability of Electronic IC Packages.....	9
2.4 Outline of the Dissertation.....	12
Chapter 3 Materials and Instrumentations.....	15
3.1 Introduction	15
3.2 Materials	15
3.2.1 Epoxy Molding Compound.....	15
3.2.2 Leadframe	17
3.3 Transfer Molding Process.....	17
3.4 Testing Equipments	19
3.4.1 Load Frame	19
3.4.2 Shadow Moiré Interferometry.....	20
3.4.3 MicroProf with Chromatic Sensor	21
3.4.4 Dynamic Mechanical Analysis (DMA)	22
3.4.5 Thermo-Mechanical Analysis (TMA)	23
3.4.6 Scanning Electron Microscopy (SEM)	24

3.4.7 Scanning Acoustic Microscopy (SAM)	25
Chapter 4 Process-Induced Stresses in Plastic IC Devices	27
4.1 Introduction	27
4.2 Cure Shrinkage of Epoxy Molding Compounds	29
4.3 Sample Fabrication and Material Characterization	30
4.4 Experimental Warpage Measurements	32
4.5 Viscoelastic FE Analysis Considering Cure Shrinkage	35
4.6 Conclusions	37
Chapter 5 Mechanism of Moisture Diffusion in Epoxy Molding Compounds	39
5.1 Introduction	39
5.2 Moisture Diffusion in Plastic Encapsulated Microcircuits	40
5.2.1 Moisture Diffusion in a Package <i>vs.</i> Bulk EMC	43
5.2.2 Interfacial Moisture Diffusion	44
5.2.3 Moisture Accommodation at Interfaces	44
5.3 Fickian Model of Moisture Diffusion.....	45
5.4 Non-Fickian Dual-Stage Moisture Diffusion	47
5.5 Moisture Desorption	53
5.6 Second Run of Absorption (Re-sorption)	60
5.7 Conclusions	62
Chapter 6 Mechanism of Hygroscopic Swelling in Epoxy Molding Compounds	65
6.1 Introduction	65
6.2 Characterization of CHS by Warpage Measurement of Bimaterial Beams	67
6.3 Characterization of CHS by TMA/TGA	70
6.4 Conclusions	73
Chapter 7 Theory of Fracture Mechanics and Numerical Implementations	75
7.1 Introduction	75
7.2 Brief Introduction to Fracture Mechanics in Isotropic Materials	76
7.3 Theory of Interface Fracture	79
7.3.1 Nature of Interface Cracks	80
7.3.2 Complex Stress Intensity Factor	80
7.4 Methods of Computational Fracture Mechanics	83
7.4.1 The Crack Closure Method Using Two Analysis Steps	83
7.4.2 The Virtual Crack Closure Technique (VCCT).....	84
7.4.3 The Virtual Crack Extension (VCE) Method	87
7.4.4 The J-integral	87
7.5 Verification of Implemented Fracture Methods	88
7.5.1 Compact Tension (CT) Specimen.....	89
7.5.2 Four-Point Bending (4PB) Delamination Problem.....	91

7.5.3	Three-Point End-Notch Flexure (3-ENF) Delamination Problem	92
7.6	Determination of Mode Mixity of Bimaterial Cracks	93
7.7	2D vs. 3D FEA of Interfacial Fracture Problems	95
7.8	Conclusions	97
Chapter 8	Fracture Tests	99
8.1	Introduction	99
8.2	Procedure of Fracture Tests	100
8.3	Delamination Testing Methods	102
8.3.1	Four-Point Bend (4PB) Delamination Test.....	102
8.3.2	Three-Point End Notched Flexure (3-ENF) Delamination Test	110
8.3.3	Four-Point End Notched Flexure (4-ENF) Delamination Test.....	112
8.4	Determination of the Intrinsic Interfacial Fracture Toughness	112
8.5	Experimental and Numerical Fracture Mechanics to Select a Proper EMC	116
8.6	Effect of Mode Angle	119
8.7	Discussion on Fracture Tests	121
8.8	Conclusions	121
Chapter 9	Mechanism of Adhesion Degradation of Epoxy Molding Compounds	123
9.1	Introduction	123
9.2	Theories of Adhesion.....	124
9.3	Test Matrix	125
9.4	Effect of Temperatures on the Interfacial Fracture Toughness	128
9.5	Effect of Thermal Aging on the Interfacial Fracture Toughness.....	130
9.6	Effect of Moisture on the Interfacial Fracture Toughness.....	134
9.6.1	Adhesion Degradation by Interfacial Diffusion.....	136
9.6.2	Intrinsic Effect of Moisture on Interfacial Fracture Toughness.....	139
9.7	Conclusions	143
Chapter 10	Applications and Case Study	145
10.1	Introduction	145
10.2	Evaluation of Critical Moisture Content in a TQFP package	146
10.3	Thermo-mechanical simulation of a TQFP-epad package	148
10.4	Material Selection and Design Change	151
Chapter 11	Concluding Remarks and Outlook	153
11.1	Concluding Remarks	153
11.2	Recommendations and Future Work	156
References	157