

Contents

Preface *xi*

Acknowledgments *xiii*

1	Definition, Function, and Design of Interface in Ceramic-Matrix Composites	1
1.1	Introduction	1
1.2	The Definition of Interface in Ceramic-Matrix Composites	2
1.2.1	Non-oxide CMCs	3
1.2.2	Oxide/Oxide CMCs	13
1.3	The Function of Interface in Ceramic-Matrix Composites	18
1.3.1	Effect of Interphase on Sliding Resistance	19
1.3.2	Effect of Interphase on Thermal Misfit Stress	19
1.4	The Design of Interface in Ceramic-Matrix Composites	20
1.4.1	PyC Interphase	20
1.4.2	BN Interphase	21
1.5	Conclusion	21
	References	22
2	Interface Characterization of Ceramic-Matrix Composites	29
2.1	Introduction	29
2.2	Effect of Interface Properties on Tensile and Fatigue Behavior of Ceramic-Matrix Composites	30
2.2.1	Theoretical Analysis	31
2.2.1.1	First Matrix Cracking Stress	31
2.2.1.2	Matrix Cracking Density	31
2.2.1.3	Fatigue Hysteresis-Based Damage Parameters	32
2.2.2	Results and Discussion	33
2.2.2.1	Effect of the Interface Properties on First Matrix Cracking Stress	33
2.2.2.2	Effect of the Interface Properties on Matrix Cracking Density	36
2.2.2.3	Effect of the Interface Properties on the Fatigue Hysteresis-Based Damage Parameters	39
2.2.3	Experimental Comparisons	41
2.2.3.1	First Matrix Cracking Stress	42
2.2.3.2	Matrix Cracking Density	43

2.2.3.3	Fatigue Hysteresis-Based Damage Parameters	46
2.3	Effect of Pre-exposure on Tensile Damage and Fracture of Ceramic-Matrix Composites	51
2.3.1	Theoretical Analysis	52
2.3.1.1	Stress Analysis Considering Interface Oxidation and Fiber Failure	54
2.3.1.2	Matrix Multicracking Considering Interface Oxidation	56
2.3.1.3	Interface Debonding Considering Interface Oxidation	57
2.3.1.4	Fiber Failure Considering Interface and Fiber Oxidation	58
2.3.1.5	Tensile Stress–Strain Curves Considering Effect of Pre-exposure	59
2.3.2	Results and Discussion	60
2.3.2.1	Effect of Pre-exposure Temperature on Tensile and Damage Process	60
2.3.2.2	Effect of Pre-exposure Time on Tensile and Damage Processes	61
2.3.2.3	Effect of Interface Shear Stress on Tensile and Damage Processes	62
2.3.2.4	Effect of Fiber Strength on Tensile and Damage Processes	64
2.3.2.5	Effect of Fiber Weibull Modulus on Tensile and Damage Processes	65
2.3.3	Experimental Comparisons	66
2.4	Effect of Interface Properties on Lifetime of Ceramic-Matrix Composites	71
2.4.1	Theoretical Analysis	73
2.4.1.1	Life Prediction Model at Room Temperature	74
2.4.1.2	Life Prediction Model at Elevated Temperatures in the Oxidative Environment	77
2.4.2	Experimental Comparisons	79
2.4.2.1	Life Prediction at Room Temperature	79
2.4.2.2	Life Prediction at Elevated Temperature	89
2.5	Conclusion	100
	References	103
3	Interface Assessment of Ceramic-Matrix Composites	109
3.1	Introduction	109
3.2	Relationships Between Interface Slip and Temperature Rising in CMCs	112
3.2.1	Hysteresis Theories	112
3.2.1.1	Case I	113
3.2.1.2	Case II	115
3.2.1.3	Case III	116
3.2.1.4	Case IV	117
3.2.2	Experimental Comparisons	118
3.2.2.1	Unidirectional CMCs	118
3.2.2.2	Cross-Ply CMCs	122
3.2.2.3	2D CMCs	124
3.3	Interface Assessment of CMCs from Hysteresis Loops	127
3.3.1	Results and Discussion	128
3.3.1.1	Unidirectional C/SiC Composite	129
3.3.1.2	Cross-Ply C/SiC Composite	131
3.3.1.3	2.5D C/SiC Composite	135

3.3.2	Experimental Comparisons	138
3.3.2.1	Unidirectional C/SiC Composite	138
3.3.2.2	Unidirectional SiC/CAS Composite	142
3.3.2.3	Unidirectional SiC/CAS-II Composite	144
3.3.2.4	Cross-Ply C/SiC Composite	144
3.3.2.5	2.5D C/SiC Composite	149
3.4	Conclusion	155
	References	156
4	Interface Damage Law of Ceramic-Matrix Composites	161
4.1	Introduction	161
4.2	Interface Damage Law at Room Temperature	163
4.3	Interface Damage Law at Elevated Temperature in Inert Atmosphere	167
4.4	Interface Damage Law at Elevated Temperature in Air Atmosphere	172
4.4.1	1000 °C	172
4.4.2	1200 °C	175
4.4.3	1300 °C	178
4.5	Interface Damage Law at Elevated Temperature in Steam Atmosphere	185
4.5.1	1000 °C	185
4.5.2	1200 °C	187
4.6	Results and Discussion	192
4.6.1	Effect of Temperature, Oxidation, and Fiber Preforms on Interface Damage of CMCs	192
4.6.2	Comparisons of Interface Damage Between C/SiC and SiC/SiC Composites	193
4.7	Conclusion	195
	References	196
	Index	199