

## CONTENTS

	Page
<b>Preface</b>	<b>vii</b>
<b>1. Origins of Carbon and Graphite Fibers</b>	
<b>2. Preparation and Properties of Carbon and Graphite Fibers</b>	<b>41</b>
Properties of Bulk Graphite	42
Properties of High Strength Whiskers	44
Characteristics of C/G Crystals	47
Organic Fiber Precursors for C/G Fibers	49
Pan Fiber Precursors	55
Pitch Precursors for C/G Filaments	61
Hybrids	68
Review of Industry Activity in the Production of C/G Fibers	80
Principal Producers of Carbonized Filaments	81
Prepreg	83
<b>3. Synthetic Resin Matrices for Service to 200° C</b>	<b>88</b>
Epoxy Resin Systems	89
High Heat Resistant Epoxy Resins	90
Curing Agents for Epoxy Resins	94
Processing Measures for Thermosetting Resin Systems	98
Phenolic Resins	111
Polyester Resins	116
Polyurethanes	118
Miscellaneous Thermoset Matrices for Advanced Composites	119
<b>4. Synthetic Resin Matrices for Use Up to 300° C</b>	<b>125</b>
Polyimides	126
Thermoplastic Polyimides	143
Acetylene Terminated Polyimides	149
Polybenzimidazoles	151
Miscellaneous High Temperature Matrices	151
<b>5. Thermoplastic Matrices</b>	<b>156</b>
Characteristics of Thermoplastics	159
C/G Fibers with Engineering Thermoplastics	169
Engineering Thermoplastics	169
Polyesters	172
Miscellaneous Thermoplastic Matrices	173
<b>6. Surface Treatments of Carbon / Graphite Fibers and Their Effect on Composites</b>	<b>177</b>
Chemical Coupling Agents	185
Liquid Oxidizing Agents	187
Gaseous Oxidizing Agents	187
Gaseous Oxidative Treatment	189
Treatment with Chemical Solutions	191
Vapor Phase Depositions and Treatments	192
Electropolymerization on Graphite Fibers	193
<b>7. Mechanical and Physical Properties of Carbon/Graphite Composites</b>	<b>198</b>

Polymer Fracture	199
Toughness of Advanced Composites	225
Fatigue and Creep Phenomena	234
Miscellaneous Environmental Factors	245
<b>8. Electrical Properties and Electrical Applications of Carbon/Graphite Fibers</b>	<b>251</b>
Applications	254
Carbon Fiber Disposal	267
<b>9. Environmental Influences on Carbon/Graphite Fiber Composites</b>	<b>270</b>
Thermal Spikes	281
Marine Exposure	287
Effect of Thermal Cycling	291
Environmental Effects on Fatigue Properties of C/G Composites	293
<b>10. Test Methods for Advanced Fiber Composites</b>	<b>299</b>
Tensile Strength	300
Compressive Strength	311
Shear Strength	313
Flexural Strength	318
Resin Content and Void Content	319
Impact Testing	321
Preperg Testing	324
Chemical Quality Assurance	326
Non-Destructive Tests	327
<b>11. Carbon/Graphite Fiber Composites in Aircraft, Space and Automotive Applications</b>	<b>337</b>
Aerospace	340
Space Applications	350
Miscellaneous Aerospace Applications	355
Automotive Applications	358
<b>12. Industrial and Commercial Applications</b>	<b>370</b>
Sporting and Recreational Uses	370
Marine Applications	372
Pressure Vessels	374
Energy Storing Devices	375
Low Friction	379
Carbon Fiber Reinforced Concrete and Ceramics	382
Miscellaneous Applications	384
<b>13. High Temperature Resistant Matrices for Service Above 300° C (Metal Matrices and Carbon/Carbon Composites)</b>	<b>388</b>
Metal Matrices Composites	388
Carbon Fiber/Carbon Matrix Composites (Carbon/Carbon Composites)	397
Pitch Matrix Blends	399
Resin Matrices for Carbon/Carbon Composites	404
Chemical Vapor Deposition (CVD)	407
Glass Matrices	417
<b>14. Manufacturing and Processing Techniques for Carbon/Graphite Fiber Composites</b>	<b>422</b>
Material Selection	422
Material Handling	426
Curing and Post-curing	429
Pultrusion Process	435
Adhesive Bonding	439
<b>Index</b>	<b>445</b>