## **Advanced Materials for Sports Equipment**

## HOW ADVANCED MATERIALS HELP OPTIMIZE SPORTING PERFORMANCE AND MAKE SPORT SAFER

## K. E. Easterling

School of Engineering University of Exeter

> Fachbereich Mathrialwissenschaft der Techn. Hochschule Darmstadt

Inv.-Nr.: 1212



CHAPMAN & HALL

London · Glasgow · New York · Tokyo · Melbourne · Madras

## Contents

Preface	xi
Acknowledgements	xiii
Chapter 1 Sports equipment and philosophy of design	1
Synopsis	2
Introduction	2
The role of bioengineering in sports equipment	4
Advanced materials in the design of sports equipment	6
The science of biomechanics in sports	10
Concluding remarks	13
Chapter 2 Fundamentals of advanced materials	14
Synopsis	15
Introduction	15
Composite materials	15
Rule of mixtures	17
Cracking and fracture	20
The raw materials in composites: fibres and binders	22
The fibres	22
The binder	23
Cellular composites	26
Comparing and selecting materials	27
Specific property	30

CONTENTS	
Case studies in materials selection	32
Vaulting pole	32
Bicycle construction	35
Appendix	37
Chapter 3 Sports shoes	38
Synopsis	39
Introduction	39
Basis of sports shoe design	41
Athletes' feet	41
Sports shoe anatomy	48
The midsole	48
Encapsulated midsoles	50
The outsole	53
Treads	54
The insole	55
The heel counter	55
The upper	56
Further down the road	57
Chapter 4 Bicycles	59
Synopsis	60
Introduction	60
Cycle mechanics	65
From bamboo to fibre composites	66
Space frame	67
Materials	69

Chapter 5 Tennis and se	quash rackets	79
Synopsis		80
Introduction		80
Biomechanical conside	erations	80
Racket mechanics: the	sweet spot	83

74

76 77

The wheels

Optional extras Future trends

,

CONTENTS	
Making a racket	83
The head	83
Materials in racket construction	87
Specific designs and tests on rackets	89
Racket strings	90
Ball construction	. 91
Tennis balls	92
Squash balls	92
Chapter 6 Boats and boards	94
Synopsis	95
Introduction	95
Materials for racing hulls	98
Canoes and Kayaks	102
Oars and Paddles	102
The shaft	104
The blade	105
The sleeve	105
The handle	105
Surfboards	106
Chapter 7 Skis	108
Synopsis	109
Introduction and design philosophy	109
Developments in ski design	113
Advanced materials in skis	114
Core materials	115
Testing ski properties	117
Safety equipment in skiing	117
Materials in boots and bindings	119
Bindings	119
Ski-boots	119
Ski-sticks	120
Further reading	121
Index	122

ix