

---

## Contents

---

<b>Introduction . . . . .</b>	ix
<b>Chapter 1. Acoustic Emission: Definition and Overview . . . . .</b>	1
1.1. Overview . . . . .	1
1.2. Acoustic waves. . . . .	8
1.2.1. Infinite medium: volume waves . . . . .	8
1.2.2. Semi-infinite medium: surface waves . . . . .	9
1.2.3. Guided waves . . . . .	9
1.2.4. Anisotropic medium and wave attenuation . . . . .	10
1.3. The sensors and acquisition system. . . . .	12
1.4. Location of sources . . . . .	16
1.5. The extracted descriptors from the AE signal. . . . .	21
1.5.1. Time domain descriptors . . . . .	22
1.5.2. Frequency domain descriptors . . . . .	26
1.5.3. Time–frequency analysis . . . . .	30
1.6. The different analyses of AE data. . . . .	32
1.6.1. Conventional analysis: qualitative analysis. . . . .	32
1.6.2. Multivariable statistical analysis: application of pattern recognition techniques . . . . .	42
1.7. Added value of quantitative acoustic emission . . . . .	55
<b>Chapter 2. Identification of the Acoustic Signature of Damage Mechanisms. . . . .</b>	59
2.1. Selection of signals for analysis. . . . .	59
2.2. Acoustic signature of fiber rupture: model materials . . . . .	63
2.2.1. Characterization of the fiber at the scale of the bundle . . . . .	64

---

2.2.2. At the microcomposite scale . . . . .	69
2.2.3. At the minicomposite scale . . . . .	72
2.3. Discrimination using temporal descriptors of damage mechanisms in composites: single-descriptor analysis . . . . .	75
2.4. Identification of the acoustic signature of composite damage mechanisms from a frequency descriptor . . . . .	79
2.5. Identification of the acoustic signature of composite damage mechanisms using a time/frequency analysis . . . . .	81
2.6. Modal acoustic emission . . . . .	82
2.7. Unsupervised multivariable statistical analysis . . . . .	84
2.7.1. Damage identification for organic matrix composites . . . . .	85
2.7.2. Static fatigue damage sequence identification for a ceramic matrix composite . . . . .	89
2.7.3. Identification of the cyclic fatigue damage sequence for a ceramic matrix composite . . . . .	92
2.7.4. Validation of cluster labeling . . . . .	96
2.8. Supervised multivariable statistical analysis . . . . .	100
2.8.1. Library created from data based on model materials . . . . .	100
2.8.2. Library created from structured data by unsupervised classification . . . . .	103
2.9. The limits of multivariable statistical analysis based on pattern recognition techniques . . . . .	104
2.9.1. Performance of algorithms . . . . .	105
2.9.2. Influence of the acquisition conditions and the geometry of the samples . . . . .	113
2.10. Contribution of modeling: towards quantitative acoustic emission . . . . .	120
<b>Chapter 3. Lifetime Estimation . . . . .</b>	123
3.1. Prognostic models: physical or data-oriented models . . . . .	125
3.2. Generalities on power laws: link with seismology . . . . .	128
3.3. Acoustic energy . . . . .	133
3.3.1. Definition of acoustic energy . . . . .	133
3.3.2. Taking into account coupling and definition of equivalent energy . . . . .	134
3.4. Identification of critical times or characteristic times in long-term tests: towards lifetime prediction . . . . .	136
3.4.1. The $R_{AE}$ emission coefficient . . . . .	137

3.4.2. Optimal circle contribution: highlighting the critical region . . . . .	139
3.4.3. The attenuation coefficient B . . . . .	140
3.4.4. The $R_{LU}$ coefficient for cyclic fatigue tests . . . . .	142
3.4.5. The coupling between acoustic energy and mechanical energy: the Sentry function . . . . .	144
3.5. Simulation of the release of energy using a power law: prediction of the rupture time . . . . .	146
<b>Conclusion</b> . . . . .	151
<b>Bibliography</b> . . . . .	153
<b>Index</b> . . . . .	181