



**SEM:**  
**A USER'S**  
**MANUAL**  
**FOR**  
**MATERIALS**  
**SCIENCE**

B.L. Gabriel



American Society for Metals

---

---

# Contents

---

---

## Part 1: Instrumentation

<b>1</b>	<b>The Scanning Electron Microscope</b>	<b>3</b>
	SEM Instrumentation	4
	Illuminating/Imaging System	4
	Electron Gun	4
	Imaging System	10
	Information System	13
	Electron Signals	15
	X-ray and Cathodoluminescence Signals	21
	Display System	25
	Vacuum System	25
	Rotary Pumps	26
	Diffusion Pumps	27
	Turbomolecular Pumps	27
	Summary: Operation and Maintenance of the SEM	28
	SEM Operation	28
	SEM Maintenance	30
	References	31
<b>2</b>	<b>Photography</b>	<b>33</b>
	Film Types	33

## Contents

Practical SEM Photography	35
Image Enhancement	36
Signal Processing	36
Image Processing	41
Stereo SEM	44
Recording and Viewing Stereo Images	45
Quantitative Stereoscopy	48
References	49
<b>3 Energy-Dispersive Spectroscopy</b>	<b>53</b>
Origin of the X-ray Signal	54
Absorption Effects	58
Detection and Processing of the X-ray Signal	61
Instrumentation	61
Spectrometer Resolution	63
Qualitative Energy-Dispersive Spectroscopy	66
Spatial Resolution	66
Geometrical Considerations	68
Data Display	70
Quantitative Energy-Dispersive Spectroscopy	71
Spectrum Manipulation	72
Matrix Corrections	73
Sample Preparation	74
References	76
<b>Part 2: Specimen Preparation</b>	
<b>4 Introduction to Sample Preparation</b>	<b>81</b>
Sample Size	81
Sample Cleaning	82
Sample Mounting	83
Conductive Coatings	84
Particle Analysis	84
References	85

<b>5</b>	<b>Polished Samples</b> _____	<b>87</b>
	Sample Preparation	89
	SEM of Polished Samples	90
	References	92
<b>6</b>	<b>Fracture Surfaces</b> _____	<b>95</b>
	Introduction to Fractography	95
	Methods of Fractography	99
	Preliminary Examination	99
	Cleaning of Fracture Surfaces	100
	Macroscopic and Microscopic Examinations	103
	Ductile Fracture Modes	109
	Brittle Fracture Modes	114
	Intergranular Fracture Modes	114
	Transgranular Fracture Modes	122
	References	131
	Bibliography: Ceramics and Plastics	134
<b>7</b>	<b>Replicas</b> _____	<b>137</b>
	Materials and Methods	138
	Cellulose Acetate	139
	Dental Impression Media	141
	Comparison of Casting Media	144
	References	146
<b>8</b>	<b>Thin Films</b> _____	<b>149</b>
	Thermal Evaporation	150
	Vacuum Bell Jar	150
	Theory of Evaporation	152
	Method of Evaporation	155
	Carbon Thin Films	158
	Film Thickness	159
	Artifacts of Thermal Evaporation	160
	Sputter Coating	161
	Sputter Coaters	162
	Theory and Method of Sputter Coating	163
	Artifacts of Sputter Coating	169

Comparison of Coating Methods 169

References 170

**Appendixes** \_\_\_\_\_ **175**

Appendix A: Glossary of SEM Terminology 175

Appendix B: Characteristic X-ray Energies and Absorption Edge  
Energies in keV 186

Appendix C: Manufacturers and Suppliers 188

**Index** \_\_\_\_\_ **191**