
Contents

1 Measurement of Structure of High Temperature and Undercooled Melts by using X-Ray Diffraction Methods Combined with Levitation Techniques	
Tadahiko Masaki, Akitoshi Mizuno, and Masahito Watanabe	1
1.1 Introduction	1
1.2 Electrostatic Levitator for the Structural Analysis by X-Ray Diffraction Technique	5
1.3 Experimental	7
1.4 Results and Discussion	10
References	14
2 Viscosity and Density Measurements of High Temperature Melts	
Yuzuru Sato	17
2.1 Introduction	17
2.2 Viscosity Measurement	17
2.2.1 Capillary Method	18
2.2.2 Oscillating Method	21
2.2.3 Rotating Method	26
2.3 Density Measurements	28
2.3.1 Archimedean Method	29
2.3.2 Pycnometric Method	31
2.3.3 Manometric Method	32
2.3.4 Maximum Bubble Pressure Method	33
2.3.5 Sessile Drop Method and Levitation Method	34
2.4 Summary	36
References	36

3 Marangoni Flow and Surface Tension of High Temperature Melts

Taketoshi Hibiya and Shumpei Ozawa	39
3.1 Introduction	39
3.2 Marangoni Effect on High-Temperature Melts	39
3.2.1 Definition of Marangoni Flow	39
3.2.2 Crystal Growth	41
3.3 Welding	44
3.4 Electron Beam Melting	46
3.5 Methods for Measuring Surface Tension: Oscillating Drop Method Using Electromagnetic Levitation	47
3.6 Surface Tension of Molten Silicon: Influence of Oxygen on Surface Tension	49
3.7 Surface Tension of Molten Iron and Iron-based Alloy	54
3.8 Thermodynamic Approach for Adsorption of Oxygen at Melt Surface	56
3.9 Perspective	56
References	57

4 Diffusion Coefficients of Metallic Melts Measured by Shear Cell Technique Under Microgravity and on the Ground

Shinsuke Suzuki	61
4.1 Introduction	61
4.2 Design of Shear Cell	62
4.2.1 Principle of Shear Cell Technique	62
4.2.2 Minimization of Shear Convection	64
4.2.3 Minimization of Free Surfaces	65
4.2.4 Structure of the Shear Cell	66
4.3 Experimental Procedure	66
4.3.1 Diffusion Experiments	66
4.3.2 Evaluation of Mean Square Diffusion Depth	67
4.4 Quantitative Measurement of Shear Convection and Correction Method	68
4.4.1 Short-Time Diffusion Experiments	68
4.4.2 Time Dependence of Mean Square Diffusion Depth	70
4.4.3 Influence of Shear Convection	71
4.5 Correction Method for the Determination of Diffusion Coefficients	71
4.6 $1g$ -Diffusion Measurements with Stable Density Layering	72
4.6.1 Experimental	72
4.6.2 Data Analysis	73
4.6.3 Effect of Density Layering	76

4.7	Microgravity Experiments	77
4.7.1	Utilization of Microgravity Environment	77
4.7.2	Microgravity Diffusion Experiments in Foton-M2	77
4.8	Temperature Dependence of the Diffusion Coefficients	79
4.9	Perspectives	80
4.10	Summary	82
	References	83
5 Thermal Diffusivity Measurements of Oxide and Metallic Melts at High Temperature by the Laser Flash Method		
	Hiroyuki Shibata, Hiromichi Ohta, and Yoshio Waseda	85
5.1	Introduction	85
5.2	A Brief Background of the Present Requirement for the Thermal Property Measurements of High Temperature Materials	86
5.3	Experimental Procedures and Theoretical Basis for the Laser Flash Method	88
5.4	Selected Examples of Thermal Diffusivities of Oxide Melts	94
5.5	Selected Examples of Thermal Diffusivities of Metallic Melts	100
5.6	Summary	107
	References	108
6 Emissivities of High Temperature Metallic Melts		
	Masahiro Susa and Rie K Endo	111
6.1	Introduction	111
6.2	Definition of Emissivity	111
6.3	Measurement Techniques for Emissivities	112
6.3.1	Method Based on Wien's Formula	112
6.3.2	Method Based on Optical Constants	113
6.3.3	Method Based on Direct Measurements of Radiation Intensities	116
6.3.4	Other Methods	118
6.4	Emissivity Data	120
6.4.1	Noble Metals	120
6.4.2	Transition Metals	122
6.4.3	Semiconducting Materials	124
6.4.4	Alloys	124
	References	127
7 Noncontact Thermophysical Property Measurements of Metallic Melts under Microgravity		
	Ivan Egry	131
7.1	Introduction	131
7.2	Microgravity	132

XII Contents

7.3	Containerless Methods	134
7.4	Thermophysical Properties	137
7.4.1	Electrical Conductivity	137
7.4.2	Density and Thermal Expansion	139
7.4.3	Specific Heat	139
7.4.4	Viscosity and Surface Tension	141
7.5	Summary and Outlook	145
	References	146

8 Noncontact Laser Calorimetry of High Temperature Melts in a Static Magnetic Field

Hiroyuki Fukuyama, Hidekazu Kobatake, Takao Tsukada, and Satoshi Awaji 149

8.1	Introduction	149
8.2	Theory of Modulation Calorimetry	150
8.2.1	Heat Capacity	150
8.2.2	Thermal Conductivity and Emissivity	153
8.2.3	Verification of the Assumptions of Conduction-Dominated Heat Transfer	157
8.2.4	Verification of the Model and Sensitivity Analysis	159
8.2.5	Emissivity Determination from Cooling Curve	163
8.3	Experimental	163
8.4	Experimental Results	164
8.4.1	Motion of the Silicon Droplet	164
8.4.2	Temperature Response and Phase Difference	164
8.4.3	Isobaric Molar Heat Capacity	166
8.4.4	Hemispherical Total Emissivity	167
8.4.5	Thermal Conductivity	168
8.5	Summary	169
	References	171

9 Noncontact Thermophysical Property Measurements of Refractory Metals Using an Electrostatic Levitator

Takehiko Ishikawa, Paul-François Paradis 173

9.1	Introduction	173
9.2	Electrostatic Levitation System	174
9.3	Thermophysical Property Measurements	177
9.3.1	Density	177
9.3.2	Surface Tension and Viscosity	178
9.3.3	Experimental Uncertainties	181
9.4	Results of Thermophysical Property Measurements of Refractory Metals	181
9.4.1	Density	181

9.4.2	Surface Tension	185
9.4.3	Viscosity	190
9.5	Summary	192
	References	192
Index	197