

# Contents

<b>1</b>	<b>General Introduction</b>	<b>1</b>
1.1	Laser Surface Treatment and Laser Shock Processing	1
1.2	Recent Development of Laser Shock Processing on Alloys and Metallic Materials	3
1.3	Typical Applications of Laser Shock Processing	6
1.4	Scope of the Book	9
	References	11
<b>2</b>	<b>Surface Integrity of LY2 Al Alloy Subjected to Laser Shock Processing</b>	<b>15</b>
2.1	Introduction	15
2.2	Laser Systems for Laser Shock Processing	16
2.3	Generation of Laser Shock Wave	17
2.4	Laser Shock Processing Equipment in this Book	19
2.5	Nano-Hardness, Micro-Hardness and Residual Stress	21
2.5.1	Experimental Material and Parameters	23
2.5.2	Measurement of Elastic Modulus and Hardness	24
2.5.3	Effects of LSP on Nano-Hardness and Elastic Modulus	26
2.5.4	Enhancement Mechanism of LSP on Hardness and Elastic Modulus	29
2.6	Surface Roughness and Surface Profile	30
2.6.1	Sample Preparation and Surface Topography Measurements	31
2.6.2	Surface Topography	32
2.6.3	Residual Stress	36
2.6.4	Micro-Hardness	36

2.7	Simulation and Validation of the Residual Stresses Using Laser Elliptical Spot . . . . .	37
2.7.1	Sample Preparation and Measurements of Residual Stress . . . . .	38
2.7.2	Numerical Simulation Procedures . . . . .	39
2.7.3	The Simulation and Verification of Surface Residual Stress Distribution . . . . .	40
2.7.4	The Simulation and Verification of Residual Stress Distribution in Depth Direction. . . . .	45
2.8	Summary . . . . .	47
	References . . . . .	48
<b>3</b>	<b>Tensile Properties and Fatigue Lives of LY2 Al Alloy Subjected to Laser Shock Processing . . . . .</b>	<b>53</b>
3.1	Introduction . . . . .	53
3.2	Tensile Properties Under Different Stain-Rates . . . . .	53
3.2.1	Experimental Material and Parameters. . . . .	54
3.2.2	Tensile Properties of Strain Rate on LY2 Al Alloy During LSP . . . . .	56
3.3	Fractural Morphologies Under Different Stain-Rates . . . . .	61
3.3.1	Experimental Material and Parameters. . . . .	61
3.3.2	Effects of Strain Rate on the Fractural Morphologies of LY2 Al Alloy by Laser Shock Processing . . . . .	62
3.4	Fatigue Life of LY2 Al Alloy by Laser Shock Processing Under Different Treatment Parameters . . . . .	65
3.4.1	Experimental Material and Parameters. . . . .	65
3.4.2	Residual Stress Distribution Near the Edge of the Blade . . . . .	67
3.4.3	Micro-Hardness Distribution Near the Edge of the Blade . . . . .	69
3.4.4	Effect of LSP Processing Parameters on the Fracture Morphology . . . . .	70
3.4.5	Effect of LSP Processing Parameters on the Fatigue Performance . . . . .	74
3.5	Influence Mechanisms . . . . .	76
3.5.1	Effect of LSP with Different Processing Parameters on the Residual Stress Distribution Along the Depth Direction. . . . .	76
3.5.2	Effect Mechanism of LSP with Different Processing Parameters on the Fatigue Property of LY2 Al Alloy . . .	77
3.6	Summary . . . . .	79
	References . . . . .	82

<b>4 Grain Refinement of LY2 Al Alloys Induced by Multiple Laser Shock Processing Impacts . . . . .</b>	<b>85</b>
4.1 Introduction . . . . .	85
4.2 Micro-Structural Characterization . . . . .	86
4.3 Residual Stress Distribution of the Hardening Layer . . . . .	87
4.4 Plastic Deformation and Microstructural Feature . . . . .	89
4.4.1 SEM Observations . . . . .	90
4.4.2 OM Observations . . . . .	90
4.4.3 TEM Observations . . . . .	93
4.5 Micro-Structural Strengthening Mechanism . . . . .	95
4.5.1 Enhancement Mechanism of Multiple LSP Impacts. . . . .	95
4.5.2 Schematic Illustration of Grain Refinement Induced by Multiple LSP Impacts . . . . .	96
4.6 Summary . . . . .	99
References . . . . .	99
 <b>5 Visual Inspection and Control Methods of Laser Sock Processing Effectiveness . . . . .</b>	 <b>103</b>
5.1 Introduction . . . . .	103
5.2 Experiment Details . . . . .	104
5.2.1 Selection of Laser Parameters. . . . .	104
5.2.2 Samples and Treatments . . . . .	104
5.3 Surface Quality and Fatigue Life. . . . .	105
5.3.1 Grade A Surface Quality and Fatigue Life . . . . .	105
5.3.2 Grade B Surface Quality and Fatigue Life . . . . .	105
5.3.3 Grade C Surface Quality and Fatigue Life . . . . .	107
5.3.4 Grade D Surface Quality and Fatigue Life . . . . .	108
5.4 Analysis and Discussion. . . . .	109
5.4.1 Fatigue Life . . . . .	109
5.4.2 Surface Qualities. . . . .	110
5.4.3 How to Obtain Grade A Surface Quality . . . . .	110
5.5 Summary . . . . .	111
References . . . . .	111
 <b>6 Mechanical Properties of AISI 304 SS and its Welded Joint Subjected to Laser Shock Processing . . . . .</b>	 <b>113</b>
6.1 Introduction . . . . .	113
6.2 Measurement and Characteristics of Mechanical Properties and Micro-Structures . . . . .	115
6.2.1 Experimental Material . . . . .	115
6.2.2 Laser Welding Parameters . . . . .	116
6.2.3 LSP Parameters . . . . .	117
6.2.4 Measurements of Nano-Hardness, Elastic Modulus and Residual Stress . . . . .	117

6.2.5	Measurements of Tensile Properties . . . . .	118
6.2.6	Micro-Structural Observations . . . . .	118
6.3	Nano-Hardness, Elastic Modulus and Residual Stress of AISI 304 SS . . . . .	119
6.3.1	Effects of LSP on Nano-Hardness, Elastic Modulus and Residual Stress . . . . .	119
6.3.2	Results of XRD Analysis . . . . .	122
6.3.3	Effects of LSP on Micro-Structure in the Shocked Region. . . . .	123
6.3.4	Enhancement Mechanism of LSP on Mechanical Properties of AISI 304 SS . . . . .	124
6.4	Mechanical Properties and Fracture Morphology of Laser Welded Joint. . . . .	126
6.4.1	Mechanical Properties of Laser Welded Joint . . . . .	126
6.4.2	Fracture Morphology of Laser Welded Joint . . . . .	129
6.5	Summary . . . . .	133
	References . . . . .	133
<b>7</b>	<b>Stress Corrosion Cracking Resistance of AISI 304 SS Subjected to Laser Shock Processing . . . . .</b>	<b>137</b>
7.1	Introduction . . . . .	137
7.2	Experimental Procedures . . . . .	138
7.2.1	Sample Preparation . . . . .	138
7.2.2	Experimental Parameters . . . . .	139
7.2.3	Measurement of Residual Stress and Micro-Structural Observations . . . . .	141
7.3	Results and Discussion. . . . .	141
7.3.1	High-Temperature SCC Resistance . . . . .	141
7.3.2	Residual Stress Distributions of Different U-Bend Samples. . . . .	142
7.3.3	OM Morphologies of the Cross-Section and TEM Observations of the Top Surface . . . . .	145
7.3.4	Improvement Mechanism of Massive LSP Impacts on SCC. . . . .	148
7.4	Summary . . . . .	150
	References . . . . .	151
<b>8</b>	<b>Grain Refinement of AISI 304 SS Induced by Multiple Laser Shock Processing Impacts. . . . .</b>	<b>153</b>
8.1	Introduction . . . . .	153
8.2	Experimental Procedures . . . . .	155
8.2.1	Principle and Experimental Procedure of LSP . . . . .	155
8.2.2	Experimental Material and Processing Parameters. . . . .	155
8.2.3	Micro-Structural Observations . . . . .	156

8.3	Grain Size Variation Along Depth Direction. . . . .	156
8.4	Micro-Structural Evolvement Along Depth Direction. . . . .	157
8.5	TEM Observation of the Top Surface . . . . .	160
8.6	Micro-Structural Evolution Process of the Top Surface . . . . .	161
8.7	Micro-Structural Evolution Along Depth Direction . . . . .	163
8.8	Summary . . . . .	165
	References . . . . .	165
<b>9</b>	<b>Electrochemical Corrosion Resistance of AISI 304 SS</b>	
	<b>Weldment Treated by Laser Shock Processing . . . . .</b>	<b>169</b>
9.1	Introduction . . . . .	169
9.2	Experimental Procedures . . . . .	170
9.2.1	Experimental Material and Sample Preparation. . . . .	170
9.2.2	Experimental Procedure of Laser Welding and LSP . . . .	170
9.2.3	Cavitation Erosion Testing and Residual Stress Measurements. . . . .	171
9.2.4	Morphology Observation and Surface Roughness Measurements. . . . .	172
9.2.5	Electrochemical Testing and Surface Morphology Observation . . . . .	172
9.3	Results and Discussion. . . . .	174
9.3.1	Residual Stress Depth Profile of Weldments Without and with LSP Impacts . . . . .	174
9.3.2	Morphology Observation of Cross Sections of Weldments Without and with LSP Impacts After Cavitation Erosion . . . . .	175
9.3.3	Comparisons Between Surface Roughness of Weldments Without and with LSP Impacts After Cavitation Erosion . . . . .	177
9.3.4	Analysis of Potentiodynamic Polarization Curves for Laser Weldments Without and with LSP Impacts After Cavitation Erosion . . . . .	178
9.3.5	OM Micrographs on the Surface in the WZ and HAZ of Laser Weldments Without and with LSP Impacts After Cavitation Erosion in 3.5 wt % NaCl Solution . . . .	180
9.4	Summary . . . . .	183
	References . . . . .	184
	<b>About the Authors. . . . .</b>	<b>189</b>
	<b>Index . . . . .</b>	<b>191</b>

Laser Shock Processing of FCC Metals  
Mechanical Properties and Micro-structural  
Strengthening Mechanism

Zhang, Y.; Lu, J.; Luo, K.

2013, XI, 194 p., Hardcover

ISBN: 978-3-642-35673-5