



# Table of Contents

<b>1</b>	<b>Introduction to Plating of the Rarer Precious Metals .....</b>	<b>1</b>
1.1	The Rarer Precious Metals .....	1
1.2	Deposition from Molten (fused) Salt and Non-Aqueous Media. ....	3
1.3	Physical Processes .....	5
1.4	Using Insoluble Anodes in PM Electrodeposition .....	7
	References .....	8
<b>2</b>	<b>Rhodium Plating .....</b>	<b>9</b>
2.1	Introduction .....	9
2.2	Some Physical and Chemical Properties of Rhodium .....	11
2.3	Chemistry of Rhodium and Rhodium Electrolytes .....	11
2.3.1	Rhodium sulphate .....	12
2.3.2	Rhodium phosphate .....	13
2.3.3	Electrolyte types .....	13
2.3.4	Preparation of rhodium electrolytes .....	16
2.3.5	Some aspects of operating rhodium plating processes .....	16
2.3.6	Additives and brighteners .....	19
2.4	Orthodox Rhodium Plating Processes .....	20
2.4.1	Technical applications .....	20
2.4.2	Decorative applications .....	22
2.5	Black Rhodium .....	23
2.6	“Whiter than White” – The Colour of Rhodium Deposits .....	25
2.6.1	Reflectance data .....	26
2.6.2	Rhodium deposit colour comparisons. ....	27
2.6.3	“White Gold” and the use of rhodium .....	32
2.7	Electroless Rhodium .....	33
2.8	Less Commonly Used Deposition Methods .....	34
2.8.1	Rhodium from molten salts .....	34
2.8.2	Non-aqueous solvent plating .....	35



2.9	Properties of Rhodium Deposits .....	35
2.9.1	General comments .....	35
2.9.2	Hardness: .....	36
2.9.3	Stress .....	38
2.9.4	Electrical applications .....	40
2.9.5	Porosity .....	42
2.9.6	Rhodium as a barrier layer .....	42
2.10	Bath Contaminants and Treatments .....	43
2.10.1	A general faultfinding chart .....	44
2.10.2	Ion exchange resin applications. ....	45
2.10.3	Excessive free acid .....	47
2.11	Analysis and Control .....	47
2.11.1	Rhodium and other metals .....	47
2.11.2	Acid content .....	48
2.11.3	Plating tests .....	49
2.12	Miscellaneous Topics .....	50
2.12.1	Stripping of rhodium .....	50
2.12.2	Pen-plating (brush or tampon) with rhodium .....	50
2.12.3	Pulse plating of rhodium and use of ultrasonic and laser radiation .....	51
2.12.4	Electrodeposition with ultrasonic or laser irradiation .....	57
2.12.5	Rhodium alloy deposition .....	57
	References .....	62
	Further Reading .....	65
	Patents .....	65
	Publications .....	66
	Analysis Methods .....	66
	Appendix Rhodium Sulphate Species .....	67
<b>3</b>	<b>Deposition of Ruthenium .....</b>	<b>69</b>
3.1	Introduction .....	69
3.2	Properties – Data for Ruthenium .....	70
3.3	Applications for Electrodeposited Ruthenium .....	70
3.4	Ruthenium Plating Processes .....	71
3.4.1	Aqueous processes .....	71
3.4.2	Fused salt baths .....	72
3.4.3	Non-Aqueous electrolytes .....	72
3.4.4	PM coatings applied by non-electrochemical methods .....	73
3.5	Chemistry and Electrochemistry of Ruthenium Plating Processes .....	73
3.5.1	Inorganic chemistry of ruthenium .....	73
3.5.2	Key studies .....	74



3.5.2.1 Nitrosyl complexes. (1) .....	74
3.5.2.2 Nitrosyl complexes of ruthenium (2) .....	77
3.6 Ruthenium Plating – Practical Aspects .....	83
3.6.1 Electrochemical relationships .....	83
3.6.2 Typical ruthenium plating electrolytes .....	83
3.7 Electroless Ruthenium .....	85
3.8 Ruthenium Deposit Properties .....	88
3.9 Pretreatments for Ruthenium Plating .....	91
3.10 Analytical Control .....	93
References .....	96
Further Reading .....	97
Patents .....	97
Publications .....	98
<b>4 Iridium Plating .....</b>	<b>99</b>
4.1 Introduction .....	99
4.2 Electrolytes for Plating Iridium and their Underlying Chemistry .....	100
4.2.1 Plating processes – parameters and peculiarities .....	102
4.3 Electrodeposition of Pt-Ir Alloy – Aqueous Processes .....	113
4.4 Fused Salt Electrolyte Plating of Ir and Pt-ir Alloy Deposits .....	117
4.5 Non – Aqueous Processes, Iridium Coating of Graphite, and “Electro-less” .....	119
4.6 Physical Properties of Ir and Pt-ir Alloy Deposits .....	120
4.7 Analysis for Ir .....	121
4.8 Ir Recovery from Waste Water .....	122
4.9 Preparatory Treatments Prior to Iridium Plating .....	122
References .....	123
Further Reading .....	124
Patents .....	124
Publications .....	124
<b>5 Rhenium Plating .....</b>	<b>125</b>
5.1 Introducing Rhenium .....	125
5.2 Chemistry of Rhenium and Electroplating Electrolytes: .....	127
5.2.1 Chemistry .....	127
5.2.2 Electrolytes for rhenium deposition .....	127
5.2.3 Rhenium as a barrier layer .....	131
5.3 Deposit Properties and Applications .....	134
5.4 Rhenium alloy electrodeposition .....	136
5.4.1 Patents .....	140



5.5	Electroless Deposition of Rhenium and Rhenium Alloys .....	140
5.6	Pulse Plating of Rhenium .....	142
5.7	Concluding Comments .....	144
	References .....	144
<b>6</b>	<b>Osmium Plating .....</b>	<b>147</b>
6.1	Introductory Comments .....	147
6.2	Electrolytes used for Osmium Deposition and their Chemistry .....	148
6.3	Physical Properties of Osmium Deposits .....	157
6.4	Analysis and Health & Safety .....	159
	References .....	160
<b>7</b>	<b>Electropolishing of Precious Metals .....</b>	<b>161</b>
7.1	Introduction .....	161
7.2	Electropolishing of gold & gold alloys .....	164
7.3	Electropolishing of platinum group metals .....	169
7.4	Fabrication of microprobes .....	172
7.5	Miscellaneous aspects of electropolishing PM's .....	175
7.6	Conclusion .....	175
	References .....	176
<b>8</b>	<b>Stripping of Precious Metal Coatings .....</b>	<b>179</b>
8.1	Introduction .....	179
8.2	Chemical & electrolytic methods .....	181
8.3	Rhodium .....	182
8.4	Platinum .....	183
8.5	Gold & palladium .....	184
8.6	Ruthenium .....	185
8.7	Iridium .....	187
8.8	Osmium .....	187
	References .....	188
<b>9</b>	<b>Electroless Platinum Plating .....</b>	<b>189</b>
9.1	Introduction .....	189
9.2	Immersion or displacement plating .....	190
9.3	Electroless (chemical reduction) plating .....	193



x

"ELECTRODEPOSITION OF THE PRECIOUS METALS"

9.4 Electroless deposition of Pt alloys .....	206
9.5 Additional patents .....	207
9.6 Concluding comments .....	208
Appendix - Standards .....	211
Index .....	217

