

TABLE OF CONTENTS

Chapter 1. INTRODUCTION	1
Chapter 2. HIGH VACUUM REQUIREMENTS FOR WAFER PROCESSING	8
2.1. PVD and the like	8
2.1.1. <i>Gases to be pumped in sputtering</i>	9
2.1.2. <i>Pumping arrangement for sputtering</i>	10
2.2. CVD and the like	12
2.2.1. <i>Eliminating particulate materials</i>	17
2.2.2. <i>Explosions hazards</i>	18
2.2.3. <i>Clogging of pipes</i>	21
2.2.4. <i>Oil damage</i>	21
2.3. Plasma etching	22
2.3.1. <i>Gases to be pumped</i>	25
2.3.2. <i>Time-life of the species</i>	30
2.3.3. <i>Corrosion induced by water vapor</i>	30
2.3.4. <i>Ion milling</i>	32
2.4. Ion implantation	32
Chapter 3. SAFETY	35
3.1. Tightness means safety	36
3.2. Oxygen pumping	36
3.3. Servicing	37
3.4. Handling gases	39
3.4.1. <i>Flammable gases</i>	39
3.4.2. <i>Selection of appropriate materials</i>	39
3.4.3. <i>Avoidance of sources of continuous contamination</i>	40
3.4.4. <i>Storing cylinders</i>	41
3.4.5. <i>Cylinders handling</i>	42

3.5. Risks with the pump exhaust lines	42
3.6. Monitoring	43
3.7. Toxicity of process gases	43
Chapter 4. SELECTING A VACUUM PUMP	47
4.1. Vacuum pumps classification	47
4.2. Ultimate vacuum	48
4.3. Pumping speed	50
4.4. Maximum compression ratio	52
4.5. Hydrocarbon emission	54
4.6. Crossover pressure	55
4.7. Vacuum pump selectivity	56
4.8. Linking up of vacuum pumps	57
Chapter 5. USE OF OIL-SEALED MECHANICAL PUMPS	59
5.1. Corrosion resistance	61
5.1.1. <i>Evacuation of the gases</i>	63
5.1.2. <i>Prevention of condensation</i>	63
5.1.3. <i>Selection of appropriate materials</i>	63
5.2. Oils for mechanical vacuum pumps	64
5.2.1. <i>Utilization of synthetic fluids</i>	66
5.2.2. <i>Neutralizing systems</i>	69
5.2.3. <i>Changing from one type of oil to another</i>	73
5.2.4. <i>Inert fluid reclamation</i>	74
5.2.5. <i>When to change the oil</i>	75
5.3. Exhaust connection	77
5.4. Bubbler	79
5.4.1. <i>Using the bubbler with inert PFPE fluids</i>	79
5.5. Use of the gas ballast	81
5.6. Effluents handling	83
5.6.1. <i>Wet gas scrubbers</i>	85
5.6.2. <i>High temperature scrubbers</i>	87
5.6.3. <i>Adsorption scrubbers</i>	88
5.6.4. <i>Chemical scrubbers</i>	89
Chapter 6. USE OF TRAPS	91
6.1. Cold traps	92

	XI
6.1.1. <i>Cooling the traps</i>	94
6.1.2. <i>Trap regeneration</i>	95
6.2. Sorption traps	97
6.2.1. <i>Zeolites</i>	97
6.2.2. <i>Activated charcoal</i>	98
6.2.3. <i>Regeneration of adsorbents</i>	98
6.3. Ionic traps	99
6.4. Catalyser traps	99
Chapter 7. HIGH VACUUM PUMPS	101
7.1. Roots pumps	101
7.1.1. <i>Thermal behavior of the Roots</i>	103
7.1.2. <i>Maximum compression ratio: K_0</i>	104
7.1.3. <i>Pumping speed of Roots blowers</i>	106
7.1.4. <i>Use of Roots pumps</i>	108
7.1.5. <i>Monitoring Roots blower speed</i>	109
7.1.6. <i>Selection of the backing pump</i>	110
7.1.7. <i>Multistage Roots blower combination</i>	111
7.2. Turbomolecular pumps	113
7.2.1. <i>Turbomolecular pumps versus Roots blowers</i>	117
7.3. Cryopumps	118
7.3.1. <i>Safety concerns</i>	120
7.3.2. <i>Cryopumps operation</i>	121
7.3.3. <i>Cryopumps regeneration</i>	122
7.4. Diffusion pumps	123
Chapter 8. REDUCING WAFER CONTAMINATION	126
8.1. Hydrocarbon pollution	126
8.1.1. <i>Use of a Roots blower or turbomolecular pump to reduce oil back-streaming</i>	131
8.2. Dust pollution	132
8.2.1. <i>Movement of dust in a gaseous atmosphere</i>	134
8.2.2. <i>Effects of static electricity</i>	136
8.2.3. <i>Dust contamination during pumpdown</i>	137
8.2.4. <i>No-turbulence pumping systems</i>	139
Chapter 9. VACUUM MEASUREMENT AND PUMP MONITORING	142
9.1. Vacuum measurement	142
9.1.1. <i>Dust protection</i>	142
9.1.2. <i>Corrosion</i>	143
9.1.3. <i>RF radiation</i>	143

9.2. Pressure gauges used in microelectronics	144
9.2.1. <i>Thermal pressure gauge</i>	145
9.2.2. <i>Membrane gauges</i>	146
9.2.3. <i>Ion gauges</i>	147
9.3 Vacuum system monitoring	151
9.4. Partial pressure measurements	153
9.4.1. <i>The gas analyser</i>	154
9.4.2. <i>Interpreting the mass spectrum</i>	156
9.4.3. <i>Use of RGAs in the semiconductor industry</i>	157
9.4.4. <i>Operating pressure of an RGA</i>	159
9.5. Flowmeters	160
9.5.1. <i>Thermal flowmeters</i>	160
9.5.2. <i>Massflow controllers</i>	162
REFERENCES	163
APPENDICES	
Appendix 1. GASES COMMONLY USED IN ELECTRONICS	168
Appendix 2. HIGH VACUUM CALCULATION (BASIC)	187
A.2.1. Definitions	187
A.2.2. Pumping a vacuum system	190
2.1. <i>Pumping down of the vacuum system</i>	190
A.2.3. Vacuum manifolding	192
3.1. <i>Conductance</i>	192
3.2. <i>Effect of pipes on pump efficiency</i>	193
3.3. <i>Effect of connecting pipes on pump down times</i>	194
A.2.4. Flow of gases in pipes	195
4.1. <i>Calculation of the viscous flow</i>	195
4.2. <i>Calculation of the molecular flow</i>	196
4.3. <i>Fast conductance calculation</i>	199
4.4. <i>Simplified formulas for American readers</i>	200
A.2.5. Outgassing	201
Appendix 3. GLOSSARY OF COMMON TERMS USED IN WAFER PROCESSING	204
Appendix 4. FRONTIER EQUIPMENT – THE DRY PUMPS	210

	XIII
A.4.1. Why dry pumps?	210
A.4.2. The screw vacuum pump	211
A.4.3. The molecular drag pump	212
A.4.4. The multistage Roots pumps	213
A.4.5. Other dry pumps	216
A.4.6. Are the dry pumps dry?	217
SUBJECT INDEX	218