

Index

- Acceptor impurity, 5
- Acetone, 16
- Additive process, 146
- Alignment marks, 18
- Alignment tolerance, 181, 188
- Aluminum, 2
 - bulk resistivity, 135
 - solubility in silicon, 136
 - spiking, 136
- Aluminum-copper-silicon metallization, 115, 140
- Aluminum-silicon eutectic point, 135
- Ammonia, 119
- Angle-lap method, 65
- Anisotropic etching, 20, 21, 191, 218, 219
- Antimony, 11
- Antimony pentachloride, 82
- Argon, 113
- Arrhenius relation, 33, 54, 122
- Arsenic, 82
- Arsenic trioxide, 82
- Arsine, 81, 82
- Autodoping, 125
- Avalanche breakdown voltage, 208
- Bacteria, 16
- Ball bond, 155
- Barrel reactor, 123
- Barrier layer, 13, 16
- Barrier metal, 137, 145, 162
- Base diffusion, 11
- Base width, 203–205
- Binomial distribution, 166
- Bipolar process flow, 11
- Bipolar process integration, 201
- Bipolar transistor, 2, 10, 201
 - base punch-through, 208
 - base region, 201
 - base transit time, 205
 - base width, 203, 205
 - capacitances, 205
 - collector resistance, 205, 214
 - collector-base breakdown voltage, 208–209
 - cross section, 202
 - current gain, 202
 - design rules, 211
 - dielectric isolation, 219
 - diffusion lengths, 204
 - emitter region, 201
 - emitter-base breakdown voltage, 207–208
 - Gummel numbers, 203
 - junction-isolated, 201
 - layout, 212
 - n^+ buried layer, 11, 201, 214
 - oxide-isolated, 215
 - parasitic, 191
 - SBC process, 10, 201
 - subcollector, 11
 - transit time, 204
 - trench isolation, 217
 - V-groove isolation, 218
- Bird's beak, 43, 189

- Blockout masks, 216
- Bonding tool, 157
- Bonding wire, 155
- Boron, 6, 11, 79
- Boron depletion, 38, 181
- Boron diffusivity, hydrogen dependence, 40
- Boron nitride, 80
- Boron tribromide, 80
- Boron trioxide, 79
- Borosilicate glass, 20
- Buffered hydrofluoric acid (BHF), 20
- Buffered oxide etch (BOE), 20
- Built-in potential, 141
- Bulk resistivity, 60
- Buried contacts, 142
- Buried layer, 11, 125
 - autodoping, 125
 - out-diffusion, 125
- Burn box, 78
- Butted contacts, 142

- Capillary, 155
- Channel length and width bias, 188
- Channeling, 99
- Chemical vapor deposition (CVD), 4, 107, 115
 - plasma-enhanced (PECVD), 116
- Chip carriers, 160
- Chrome master masks, 23
- Clean room, 13, 15
 - classification, 16
- CMOS, 8-9, 190
- Coevaporation, 136, 145
- Collector-diffusion isolation (CDI), 216
- Collector resistance, 11
- Complementary error function, 51, 54
- Computer graphics, 21
- Constant-source diffusion, 51
- Contact printing, 18
- Contact resistance, 138
- Contact windows, 142, 185
- Cosputtering, 145
- Cost, 153
- Crystallographic etch, 192
- CVD metal deposition, 120
- CVD reactors:
 - atmospheric pressure, 116
 - low-pressure (LPCVD), 116
 - plasma, 116
- Defect density, 167
- Defects, 13
- Deionized (DI) water, 14
- Depletion-layer width, one-sided step junction, 176, 178
- Design rules, MOS, 181
- Diborane, 80, 81
- Dichlorosilane, 81, 118, 119, 123
- Die attachment, 153
 - epoxy, 154
 - eutectic, 155
- Die separation, 154
- Dielectric isolation, 219
- Diffusion, 4, 49
 - antimony, 82
 - arsenic, 82
 - boron, 79-80
 - complementary error function, 51
 - concentration dependence, 74
 - constant-source, 51
 - Dt product, 53
 - gaseous sources, 79
 - Gaussian, 52
 - high-concentration equations, 75
 - interstitial, 49
 - interstitialcy, 49
 - junction formation, 58
 - limited-source, 51, 52
 - liquid sources, 79
 - mathematical model, 51
 - phosphorus, 81-82
 - phosphorus kink effect, 75, 77
 - solid-solubility limited, 57
 - solid sources, 79
 - spin-on sources, 79
 - substitutional, 49
 - successive, 57
 - two-step, 53
- Diffusion coefficient, 53-56
 - Arrhenius behavior, 54
- Diffusion systems, 77-78
- Donor impurity, 5
- Dopant redistribution, 38
- Dose, 51, 91
- Drain region, 6, 7, 173

- DRAM, 1
- Drive-in, 53
- Dry-wet-dry oxidation, 41
- Dual-in-line package, 160
- Electromigration, 138
- Electron-beam system, 25
- Ellipsometer, 45
- Emulsion masks, 23
- Epitaxial layer, 125
- Epitaxy, 4, 11, 121
 - liquid-phase, 121, 127
 - molecular-beam, 121, 128
 - solid-phase, 102
 - vapor-phase, 121
 - vapor-phase etching, 121, 123
- Error function, 51
- Etch bias, 21
- Etch rate, doping dependence, 20
- Etching, 4
 - anisotropic, 20
 - dry, 21
 - isotropic, 20
 - plasma, 21
 - reactive-ion, 21
 - sputter, 21
 - wet chemical, 20
- Eutectic temperature, 136, 145
- Evaporation, 4, 107
 - electron-beam, 111
 - filament, 110
 - flash, 112
 - growth rate, 111
 - shadowing, 113
 - step coverage, 113
- Fick's first law, 30, 51
- Fick's second law, 51
- Film deposition, 107
- Flip-chip bonding, 161
- Four-point probe, 71
 - correction factors, 74
- Furnace, 41, 77
- Gallium arsenide (GaAs), 1
- Gamma distribution, 168
- Gas toxicity, 81
- Gaussian distribution, 52, 54, 91
- Germanium, 1
- Gold bumps, 163
- Gold-silicon eutectic, 155
- Groove-and-stain method, 64
- Guard rings, 191
- High-voltage accelerator, 89
- Hydrofluoric acid (HF), 20
- Impingement rate, 109
- Impurity redistribution, 38
- Inked die, 12, 153
- Insulator, 1
- Interconnections, 133
 - diffused, 140
 - metal, 134
 - polysilicon, 142
- Interlevel dielectric, 148
- Ion implantation, 4, 89
 - annealing, 99, 101
 - channeling, 99
 - cost, 91
 - dose, 91
 - junction depth, 98
 - lattice damage, 99, 101
 - mask thicknesses, 96–97
 - masking, 95
 - mass spectrometer, 89–90
 - mathematical model, 91
 - nonideal, 102
 - selective, 94
 - sheet resistance, 98
 - technology, 89
- Ion source, 89
- Ionic contamination, 14
- Irvin's curves, 69–72
- Isolation region, 10
- Junction depth, 58–60
 - ion implantation, 98
- Junction-depth measurement, 64
 - angle-lap method, 65
 - groove-and-stain method, 64
- Junction formation, 58

- Junction isolation, 201
- Junction penetration, 136
- Kinetic gas theory, 108
- Kink effect, 75, 77
- Kovar, 158
- Laminar flow hoods, 13
- Latchup, 9, 121, 191
- Lateral diffusion, 62, 188
- Layout rules, MOS, 181
- Liftoff, 133, 146
- Limited-source diffusion, 51
- Lindhard, Scharff, and Schiott (LSS) theory, 92
- Mask alignment, 17, 182
- Mask fabrication, 23
- Masking material, 6
- Masking properties of oxides, 39
- Mass spectrometer, 89
- Mass-transfer coefficient, 122
- Mead and Conway, 182
- Mean free path, 109
- Mean time to failure (MTF), 140
- Metallurgical base width, 203, 205
- Metallurgical junction depth, 59
- Mil, 2
- Minimum feature size, 181
- Molybdenum, 120
- Monolayer formation, 109
- MOS transistor, 2, 7, 173
 - body effect, 178
 - breakdown voltage, 173
 - channel-length control, 173
 - complementary (CMOS), 190
 - depletion-mode, 180
 - design rules, 173
 - drain current expression, 173
 - field region, 180
 - gate-oxide thickness, 174
 - ion implantation, 179
 - mask alignment sequence, 173
 - oxide breakdown voltage, 174
 - oxide charge, 175
 - parasitic, 174, 180
 - punch-through voltage, 173, 176
 - source/drain junction breakdown voltage, 177
 - substrate doping, 175
 - substrate sensitivity, 178
 - threshold voltage, 175
 - threshold voltage adjustment, 178
 - VMOS, 192
- Multilayer contacts, 145
- Multilevel metallization, 147
- Mvlar, 21, 154
- n*-channel MOSFET, 2, 6, 173
- n*-well, 8, 9, 192
- Nail head bond, 155
- Native oxide, 29
- Negative binomial distribution, 168
- Neutral beam, 90
- NMOS process flow, 6, 8
- Ohmic contacts, 135
- Organic contamination, 14
- Out-diffusion, 125
- Oxidation, 4
 - diffusion coefficient, 31
 - linear rate constant, 32
 - parabolic rate constant, 33
- Oxidation model, 30
- Oxidation process, 29
- Oxidation rate, 33–38
 - crystal orientation dependence, 37
 - doping dependence, 38
 - pressure dependence, 37
- Oxide:
 - fully recessed, 43
 - semirecessed or semirox, 43
- Oxide breakdown voltage, 42
- Oxide color chart, 44
- Oxide mask thickness, 40
- Oxide quality, 41
- Oxide windows, 6
- Oxygen, 29
- p*-channel MOSFET, 8, 190
- p*-well, 191
- Packages:
 - ceramic DIP, 160
 - dual-in-line (DIP), 158

- leadless chip carriers (LCC), 160
- pin-grid array (PGA), 160
- postmolded DIP, 160
- premolded DIP, 160
- surface mount, 161
- TO-style, 158
- Packaging, 153, 158
- Palladium, 138
- Pascal (unit), 107
- Passivation layer, 6
- Pattern generator, 22
- Pattern shift, 127
- Phosphine, 81, 82
- Phosphorus, 81
- Phosphorus oxychloride (POCl_3), 81
- Phosphorus pileup, 38, 181
- Phosphosilicate glass, 6
- Photolithography, 4, 6, 13
- Photomask, 18
- Photomask fabrication, 21
- Photoresist, 13, 16
 - application, 17
 - ashing, 21
 - etching, 20
 - exposure and development, 18
 - hard baking, 20
 - negative, 18
 - positive, 18
 - removal, 21
 - soft baking, 16
 - spinning, 17
- Plasma-enhanced CVD, 116
- Plasma nitride, 119
- Platinum, 138
- pn* junction breakdown voltage, 177
- Poisson's distribution, 166
- Polycide, 145
- Polyimide, 148
- Polysilicon, 5, 138, 185
- Polysilicon deposition, 116
- Predeposition, 53
- Probe station, 153
- Process integration, MOS, 173
- Process simulation, 76
- Projected range, 91, 93
- Projection printing, 23
- Proximity printing, 23
- Purple plague, 155
- Pyrolytic decomposition, 124
- RAM, 1
- Reactive-ion etching, 21
- Recessed oxide, 43
- Rectifying contact, 135
- Resistivity, four-point probe, 71
- Resistor ends, 68
- Resistors, 66
 - number of squares, 67
- Reticle, 22
- Rubylith, 21
- Salicides, 145
- Schottky barrier diode, 135
- SCR, 191
- Scribe borders, 154
- Scribing, 154
- Scrubber, 78
- Segregation coefficient, 38
- Selective oxidation, 42
- Self-aligned contacts, 214
- Self-aligned gate, 188
- Semirecessed oxide, 7, 43
- Sheet resistance, 66
 - Irvin's curves, 69–72
 - van der Pauw's method, 73
- Silane, 81, 118, 119, 123
- Silicide, self-aligned, 145
- Silicides, 142–145
- Silicon, 1
- Silicon dioxide, 5, 16
- Silicon dioxide deposition, 118
- Silicon lattice atomic sheet density, 92
- Silicon nitride, 5, 16
- Silicon nitride deposition, 119
- Silicon tetrachloride, 123
- Sodium-ion contamination, 42
 - chlorine gettering, 42
 - threshold voltage shift, 42
- Solder balls, 162
- Solid-phase epitaxy, 102
- Solid-solubility limits, 57, 58
- Source region, 6, 7, 173
- Specific contact resistivity, 138

- Sputter etching, 115
- Sputtering, 4, 107, 113
- Sputtering threshold, 114
- Squares, 66
- Stabine, 82
- Standard buried collector (SBC) process, 201
- Step-and-repeat, 21, 23
- Step-on-wafer, 25
- Straggle, 91, 94
 - lateral, 95
- Subcollector, 11
- Subtractive process, 146
- SUPREM, 76
- Surface profilometer, 45
- Surface reaction rate constant, 122

- Tantalum, 120
- Tape-automated bonding (TAB), 163
- Testing, 153
- Tetraethylorthosilicate (TEOS), 119
- Thermal oxidation, 29
- Threshold adjustment implantation, 6, 179, 191
- Threshold voltage, 175
- Titanium, 120, 138, 145
- Torr, 107
- Toxic gases, 81
- Transistor layout:
 - bipolar, 212
 - MOS metal-gate, 181
 - MOS polysilicon-gate, 185, 188
- Transverse straggle, 95
- Trench isolation, 217

- Trichloroethylene, 16
- Trichlorosilane, 123
- Trimethylborate (TMB), 80
- Tungsten, 120, 138, 145
- Twin-well, 9, 192

- Ultraviolet light, 18
- Undercutting, 20
- Unity gain frequency, 204

- V-groove isolation, 218
- Vacuum system, 107
- van der Pauw's method, 73
- Via filling, 148
- Vias, 148
- VMOS technology, 192

- Wafer cleaning process, 16
- Wafer probing, 153
- Wafer sawing, 154
- Wafer yield, 163
- Water vapor, 29
- Wedge bond, 155
- Wire bonding, 153, 155
 - thermocompression, 155
 - thermosonic, 157
 - ultrasonic, 156

- Yield, 153, 163, 167
- Yield curves, 169

- Zener breakdown voltage, 208