Index

1/f noise 160
2DEG 191
3D device, structure 40, 42–5, 63, 102, 148, 177, 180, 182, 243, 247, 278
3D IC, technology 42–5, 151, 152, 153, 181, 182
3D MEMS 247
3D packaging 131
Σ − Δ (sigma-delta) converter 162
ABS, automatic braking systems 205, 207
AC adapter 204, 209
AC to DC converter 204–5, 209
airbag 205
automotive electronics 204–5, 207
avalanche (breakdown, multiplication) 78, 207
avalanche clamp (1-of-n) 208
avalanche energy 207
Active matrix flat panel imagers (AMFPI) 229–33
Active matrix liquid crystal displays (AMLCD) 79–81
(see Liquid crystal display (LCD))
Active matrix organic light emitting diode display
(AMOLED) 79, 81 (see Organic light emitting diode (OLED))
Active pixel sensor (APS) 167
advanced dielectric gap-filling materials 125
advanced equipment control (AEC) 129
Advanced process control (APC) 129
Al gate 27–8
AlGaAs 191
AlGaAs/GaAs HBT 193
AlGaN/GaN HEMT 197
aluminum (Al) 72, 73, 77–8, 112, 127
aluminum oxide (Al2O3) 73–4, 77, 79
aluminum-copper (AlCu) 112
AM1.5G 216
amorphous silicon (a-Si, a-Si:H) 74, 81, 183, 185, 214, 218, 227, 228
amplifier 4–5, 12, 15–16
amplitron (see crossed-field amplifier)
analog 157–62, 167
Analog-digital converter (ADC) 158, 161–3, 165, 167
ASIC 159, 161
aspect ratio 124, 40–42
assembly 116, 121, 127, 129, 130, 247, 248
atomic-layer deposition 125, 127
back-end processing 54, 125, 129
ballasts (lamp) 204
ball bonding 129
ball-grid-array (BGA) 130
band diagram 6, 8, 12, 17–18
bandgap 12, 17–19, 71, 77–8, 205, 210–211, 215, 218–21, 266–8
band-to-band tunneling 26
bandwidth 45, 52, 55, 151, 159, 186, 251–8, 261, 268–9, 270, 271
batch processing 124–6
Bayer pattern 166
BCD, bipolar-CMOS-DMOS 205–9
Built in self-test (BIST) 131
Bennet clocking 61
BiCMOS 19, 51, 52, 54, 162
BioMEMS, Micro Total Analysis Systems, Microfluidics 246, 248
bipolar technology 27, 51, 124, 162
bipolar circuit 53
bipolar memory 170–174, 176, 185
bipolar junction SiC 197
bipolar junction transistor (BJT) 1, 4, 8, 10, 12, 14–17, 19, 27, 71–2, 74, 77, 89, 97, 107, 159, 160, 184, 189, 192, 193, 203, 205–9, 211, 270
bipolar power devices 204–6
bipolar transistor model 87
Boltzmann statistics 26

© 2013 John Wiley & Sons, Ltd. Published 2013 by John Wiley & Sons, Ltd.
Boltzmann-transport-equation (BTE) 98, 100, 101
boron penetration 29
Borophosphosilicate glass (BPSG) 72
breakdown voltage 17, 160, 191, 196, 197, 208, 269
bright field optical inspection 129
BSIM 89
built-in potential 22,
Built-in realiability (BIR) 108
Built-in voltage 8
Bulk acoustic wave (BAW) devices 160
bulk conduction 205, 208
bulk transistor 140
bumps 130
Buried oxide (BOX) 143
cache memory 38–9
cadmium selenide (CdS) 78

cadmium Telluride (CdTe) 78, 227–8
calcogenides 228
capacitance 4, 8, 16, 73–5
capacitor 49, 51–2, 54, 92
car, automotive 203, 205
Carbon nano tube (CNT) 152, 282
placement 283
purity 283
Cathode ray tube (CRT) 79
CdTe 218
CEA (see constant efficiency amplifier)
cell (DMOS) 205, 208
cell phone (smartphone, mobile phone) 203–5, 209
Central processor unit (CPU) 135, 150
charge
charge gate (QG) 207–8
neutralitly 206–7
trap 42
trapping 208
Charge-coupled device (CCD) 166–7, 174, 207–8, 230, 270
chemically-amplified resists 122
Chemical–mechanical planarization (CMP) 124–6
chip manufacturing 121
Chip-package interaction (CPI) 109, 116
CIGS (solar cell) 218
clock frequency 277
CMOS
analog CMOS (ACMOS), 204
circuit 29, 38, 72, 131, 194, 244, 271
cutoff frequency ($f_T$) 15–17, 19, 189, 191, 197
cyclotron resonance maser 260
Czochralski (CZ) 216–17
data throughput rate 38
DC to DC converter 207
deep P 207–8
deep space network 257
Deep trench isolation (DTI) 209
defect density 122, 123
delta FET 26
Dennard, Robert 25
density modulation 255
deployment capacitance 86
deployment mode (MOSFET) 207
depth of focus 124
Design for manufacturing (DFM) 131
Design for reability (DFR) 108
Design for test (DFT) 131
design for “X” 131
detector 268–71
device 49–50, 53
architecture 278–9
simulation 104
Device under test (DUT) 130–131
DG-FET 26
diamond 197
diamond-based RF power electronics 199
dielectric constant 30, 41, 73, 139, 146, 180, 210
diffused base 203
diffused body 207
diffusion (carrier) 6–8, 12, 86, 90, 91, 98, 193, 205
diffusion (impurity) 16, 28, 31, 72, 73, 76, 103, 104, 109, 112, 113, 127, 209, 216
digital 268, 270–271
Digital micromirror device (DMD) 244
Digital signal processing (DSP) 159
Digital-analog converter (DAC) 158, 161–2, 165
dimensional control 124
diode 3–5, 8–10, 49, 52, 64, 86, 101, 102, 144, 165–8, 173, 183, 185, 194, 205, 211, 227, 229, 232, 233, 265–70
dipole 7, 8
direct-tunneling 29–30
discrete device 206
disk drive 205
dislocation 268
display 71, 79–82
distributed passive components 52
DMOS, double diffused MOSFET 204–5, 207, 209
dopant 71, 76–9, 81
doping 3, 5–6, 8, 10, 12, 16
Double data rate (DDR) 177, 181
Double HBT (DHBT) 193
double-gate MOSFET 26, 30
double-patternning 122–3
down-conversion 221
down-sizer 21, 23–6, 30–31
DPAK (power package) 203
drain 22, 24–31
Dynamic random access memory (DRAM) 22, 37–43, 51, 54, 73–4, 81, 113, 114, 136
drift current 6, 8, 86, 90, 97, 98, 108
drift length, LD 208
drift region 208
Drift-diffusion model (DD) 86, 97, 98
DTI, deep trench isolation 209
dual damascene 147
Dual-in-line package (DIP) 114
dynamic nuclear polarization 261
Effective number of bits (ENOB) 162–3
electric field 6–8
Electrically erasable PROM (EEPROM) 177
electro-discharge machining 127
electroluminescence 265
electromagnetic 267–8
electromigration 109, 112–13
electron-cyclotron resonance heating 261
electron-hole pair 268
electronic counter measures 254
ignition 205
paper display 235
electrons 6–8, 10–12, 15–16
Electrophoretic ink (E-Ink) 79, 81
emission 265–7
Emitter-base (EB) junction 12, 14
Emitter-coupled logic (ECL) 53, 173
energy 265, 268
enhancement mode (MOSFET) 207
epitaxy 75–7, 125, 190, 191, 203, 207, 266–8
equipment simulation 104
Electrically erasable PROM (EEPROM) 39, 41, 42, 177
Equivalent oxide thickness (EOT) 125, 139
Erasable programmable read-only memory (EPROM) 41, 176
Error code correction (ECC) 114
Esaki diode 4
Etch technology 123
etching 122
ETSOI, extremely thin SOI 278
extended interaction klystron 257
extension 25, 29
Extreme ultra-violet (EUV) lithography 104, 122, 131

Ferro electric FET 284
negative capacitance 284
Ferroelectric random access memory (Fe-RAM) 148
fast-wave devices (see gyro-devices)
Field effect transistor (FET) 4, 10, 75, 77, 81, 98, 111
field-plated HEMT 198
Figure-of-merit (FOM) 15–16, 162–3
filter 162, 165–6
final test 130
FinFET (fin Field Effect Transistor) 26, 40, 42–3, 104, 115, 140, 143, 139, 277–9
Finite-element method (FEM) 116
First Micromachined Structures 240
Fixed pattern noise (FPN) 168, 232
FLASH 159, 162
memory 42–3, 148, 177, 179–82
Flat panel display (FPD) 233–5
Flat panel imagers (FPI) (see Active matrix flat panel imagers (AMFPI))
flip-chip 130
Float zone (FZ) 216
Floating gate (FG) 182
Fourier harmonics 101
Fowler-Nordheim (FN) tunneling 41
Frequency division multiplexing (FDM) 161
front-end processing 124
fuel gauge (battery) 209
Fully-depleted devices (FDD) 139
Fully-depleted silicon-on-insulator (FD-SOI) 143
functionality 121

gain 4–5, 9–10, 12, 14–17, 160, 268–9, 271, 276
Gallium arsenide (GaAs) 3, 6, 17, 75, 77–8, 160, 219
Gallium nitride (GaN) 77–8, 160, 189–93, 210–211, 219, 267–8, 271
MESFET 197
gate 22, 25–31
charge, QG 207–8
control, drive 203, 205–7
dielectric 125
instability 28
insulated, MOS, DMOS, IGBT 205–9
pitch, contacted 277
stack 30–31
trench, planar 205, 207–9
width (MOSFET) 206
gate-dielectric reliability 110
Germanium (Ge) 31, 71, 74, 266–8
Giant magneto resistance (GMR) 183
Gold (Au) 74
graphene 44–5, 65, 284
BisFET 285
pn junction devices 286
ground word-line (GWL) 39
GTO, gate turn off thyristor 203, 206
guard rings 210
Gummel, H.K. (Hermann) 98
Gummel-Poon model 87
gyro-devices 260–261
gyro-klystron 261
gyrotron 260, 261

Hafnium oxide (HfO₂) 73
half pitch 122
halo 29
heat sink 130
HEMT 191
heterojunction 3–4, 6, 17
Heterojunction bipolar transistor (HBT) 3, 4, 17–19, 73, 76–8, 160, 193–7
heterostructure 266–7
HEV 204
HFET 100
HfO₂, hafnium dioxide 30
high current 203, 205, 210
high density 209
high dielectric constant 30
### Index

<table>
<thead>
<tr>
<th>Term</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>High electron mobility transistor (HEMT)</td>
<td>77–8, 160</td>
</tr>
<tr>
<td>High energy implantation</td>
<td>207, 209</td>
</tr>
<tr>
<td>High frequency</td>
<td>205–6</td>
</tr>
<tr>
<td>High impedance</td>
<td>206</td>
</tr>
<tr>
<td>High voltage, breakdown</td>
<td>205–6, 208</td>
</tr>
<tr>
<td>High-k dielectric</td>
<td>30, 41–3, 73–4, 124–5</td>
</tr>
<tr>
<td>Insulator</td>
<td>139</td>
</tr>
<tr>
<td>High mobility materials</td>
<td>279</td>
</tr>
<tr>
<td>High power</td>
<td>205, 210</td>
</tr>
<tr>
<td>High throughput</td>
<td>125</td>
</tr>
<tr>
<td>High voltage device</td>
<td>205–6, 208</td>
</tr>
<tr>
<td>High-definition television (HDTV)</td>
<td>164, 203</td>
</tr>
<tr>
<td>Highest occupied molecular orbital (HOMO)</td>
<td>64</td>
</tr>
<tr>
<td>Highly accelerated stress test (HAST)</td>
<td>115</td>
</tr>
<tr>
<td>Holes</td>
<td>6–8, 10–12, 16, 17</td>
</tr>
<tr>
<td>Homojunction</td>
<td>3, 5</td>
</tr>
<tr>
<td>HVDC (high voltage DC)</td>
<td>205</td>
</tr>
<tr>
<td>HVIC (high voltage IC)</td>
<td>209–10</td>
</tr>
<tr>
<td>ICECREM</td>
<td>103</td>
</tr>
<tr>
<td>IGBT, insulated gate bipolar transistor</td>
<td>204–6, 209</td>
</tr>
<tr>
<td>Image</td>
<td>267, 270</td>
</tr>
<tr>
<td>Impurity</td>
<td>7, 16, 28, 72, 77, 100, 110, 113, 114, 125, 130, 136, 197, 198, 215, 221</td>
</tr>
<tr>
<td>Indium Gallium Arsenide (InGaAs)</td>
<td>131, 192, 193, 219, 285</td>
</tr>
<tr>
<td>Indium phosphide (InP)</td>
<td>75, 77–8, 160</td>
</tr>
<tr>
<td>Indium tin oxide (ITO)</td>
<td>74, 79–81</td>
</tr>
<tr>
<td>Inductive output tube</td>
<td>258</td>
</tr>
<tr>
<td>Inductor</td>
<td>49, 51, 54–6</td>
</tr>
<tr>
<td>InP</td>
<td>270</td>
</tr>
<tr>
<td>InP-based HEMT</td>
<td>192</td>
</tr>
<tr>
<td>Input/output (I/O)</td>
<td>160</td>
</tr>
<tr>
<td>In-situ</td>
<td>128</td>
</tr>
<tr>
<td>Insulated gate bipolar transistor (IGBT)</td>
<td>74, 205, 206, 209</td>
</tr>
<tr>
<td>Insulator</td>
<td>71–3, 75, 81</td>
</tr>
<tr>
<td>Integrated optic</td>
<td>268, 270</td>
</tr>
<tr>
<td>Integration</td>
<td>268–70</td>
</tr>
<tr>
<td>Integration density</td>
<td>121</td>
</tr>
<tr>
<td>Interconnect</td>
<td>72–4, 111, 271</td>
</tr>
<tr>
<td>Delay</td>
<td>145</td>
</tr>
<tr>
<td>Repeater</td>
<td>145</td>
</tr>
<tr>
<td>Inter-level dielectric (ILD)</td>
<td>113</td>
</tr>
<tr>
<td>Intermetallic compound (IMC)</td>
<td>109</td>
</tr>
<tr>
<td>Inversion layer</td>
<td>101</td>
</tr>
<tr>
<td>Inverter, DC to AC</td>
<td>205</td>
</tr>
<tr>
<td>IOT (see inductive output tube)</td>
<td></td>
</tr>
<tr>
<td>IPM, intelligent power module</td>
<td>203</td>
</tr>
<tr>
<td>Isolation</td>
<td>160, 168</td>
</tr>
<tr>
<td>Junction</td>
<td>208–9</td>
</tr>
<tr>
<td>Trench</td>
<td>209</td>
</tr>
<tr>
<td>ITRS 147 roadmap</td>
<td>104, 137, 160</td>
</tr>
<tr>
<td>Kilby, Jack</td>
<td>135, 210</td>
</tr>
<tr>
<td>JFET</td>
<td>4</td>
</tr>
<tr>
<td>Joule heating</td>
<td>146</td>
</tr>
<tr>
<td>Junction (diode, PN)</td>
<td>205, 210</td>
</tr>
<tr>
<td>Klystrode (see inductive output tube)</td>
<td></td>
</tr>
<tr>
<td>Klystron</td>
<td>251, 255–7</td>
</tr>
<tr>
<td>Landauer theory</td>
<td>64</td>
</tr>
<tr>
<td>Large area imaging</td>
<td>229, 233</td>
</tr>
<tr>
<td>Large area scanner</td>
<td>230</td>
</tr>
<tr>
<td>Large-scale integration (LSI)</td>
<td>107</td>
</tr>
<tr>
<td>Laser</td>
<td>265–7, 269, 271</td>
</tr>
<tr>
<td>Annealing</td>
<td>125</td>
</tr>
<tr>
<td>Latching (operation)</td>
<td>203, 208</td>
</tr>
<tr>
<td>Lateral IGBT</td>
<td>209</td>
</tr>
<tr>
<td>Lattice</td>
<td>266–8</td>
</tr>
<tr>
<td>Layout modification to reduce charge collection (LEAP)</td>
<td>114</td>
</tr>
<tr>
<td>LDD, lightly doped drain</td>
<td>28–9, 204–5, 208</td>
</tr>
<tr>
<td>LDMOS, lateral DMOS</td>
<td>4, 160, 195, 205–9, 211</td>
</tr>
<tr>
<td>Lead-frames</td>
<td>130</td>
</tr>
<tr>
<td>Leakage current</td>
<td>38–40, 125, 210</td>
</tr>
<tr>
<td>Light</td>
<td>265–70</td>
</tr>
<tr>
<td>Light emitting diode (LED)</td>
<td>71, 81, 165, 204–5, 265–6</td>
</tr>
<tr>
<td>Linear accelerator</td>
<td>255</td>
</tr>
<tr>
<td>Linearity</td>
<td>259</td>
</tr>
<tr>
<td>Liquid crystal display (LCD)</td>
<td>164, 165, 229, 234–5</td>
</tr>
<tr>
<td>Liquid Encapsulated Czochralski (LEC)</td>
<td>190</td>
</tr>
<tr>
<td>Lithium ion, LiIon</td>
<td>204–5, 209</td>
</tr>
</tbody>
</table>
lithography 17, 45, 64, 103–5, 122, 123, 124, 127, 131, 181, 192
low-k dielectric 127
low-k materials 113
low noise 192
low power 131
Lowest occupied molecular orbital (LUMO) 64
Low-pressure-chemical-vapor-deposition (LPCVD) 125
magnetic materials 124
Magnetoresistive random access memory (MRAM) 74, 148, 183, 185
magnetron 259–60
majority carrier 6, 12, 17, 205–7
mask 28, 71, 122, 208
mass production 44
material 265–9, 271
Maximum oscillation frequency \( f_{\text{max}} \) 16, 19, 191
Maxwell equations 49
MBK (see multiple-beam klystron)
mechanical stress 115
Medium-scale integration (MSI) 107
memory 37–45
memory stack 43
MESFET 4, 76–7, 100, 189–90
metal, metallization 71–4, 76, 78, 81
metal gate 30, 125
Metal insulator semiconductor field effect transistor (MISFET) 59
Metal organic chemical vapor deposition (MOCVD) 191,
266, 267
Metal-insulator-metal (MIM) capacitor 54
Metal-oxide semiconductor (MOS) 173–6, 184
MeV (million-eV) implant 207, 209
micromachining silicon 227–8
Micro-electromechanical system (MEMS) 52, 160, 127
Inertial Sensors 244
micromachining 240–41, 246–7
Microprocessor (μP) 157, 136
microwave/millimeter-wave power module 254–5
Microwave monolithic integrated circuit (MMIC) 190
microwave oven 251, 259–60
minimum noise figure 191
mini-tube 254
minority carrier 205–7, 6, 8–12, 16–17
  recombination 207
mixed-signal 157, 159–61, 165
mobility 28, 30, 31
MODFET 76–7, 191
modulator 269, 271
molding 127
Molecular beam epitaxy (MBE) 191, 195, 266
moletronics 63
monolithic 269–71
Monte Carlo (MC) simulation approach 100, 102
Moore’s law 23, 38, 43, 136
MOS 52, 57
  transistor model 89, 94
  performance 275
motor (control, drive) 203–5, 209
MPM/MMPM (see microwave/millimeter-wave power module)
Multi-chip package (MCP) 44
multiferroic 60
multijunction solar cell 219
Multi-level cell (MLC) 42, 181–2
multi-patterning 104, 124
multiple-beam klystron 257–8
multiple-gate MOSFET 26
multiprobe 130
multi-RESURF 209
multi-stage depressed collector (see collector depression)
NAND Flash 178–82
nanocrystalline silicon 227–8
Nanomagnetic logic (NML) 61
Nanoscale mechanical relays (NEMFETs) 65
nanowire 101, 143
nanowire FET 26, 30–31
N-channel MOSFET 22, 28, 29, 31, 140, 207
Negative bias temperature instability (NBTI) 109–11, 117
Negative word-line (NW) 39–40
Network-on-chips (NoC) 145
networks 204
Nickel (Ni) 73
Nickel silicide (NiSi) 29
III-nitrides (III-N) 197
NMOS 50, 54, 135
Index

noise 158, 160–162, 164, 167–8
Non equilibrium Green’s function (NEGF) 102
non-latching (operation) 206
nonvolatile memory 41
notebook computer 204–5, 209
Noyce, Robert 135
nuclear magnetic resonance 261
numerical aperture 122, 124
NVSM (non-volatile semiconductor memory) 21

off-current, \( I_{\text{off}} \) 277
offline 204–5, 209
on-current, \( I_{\text{on}} \) 277
On-screen display (OSD) 164
optical communication 270–271
optical fibre 269–71
optical MEMS 244–5
Organic light emitting diode (OLED) 81, 233, 234, 235
organics and polymers 229, 266
organic semiconductors 80–81
overlay tolerance 124
oxynitride 29

package reliability testing 115
packaging 129
parasitic 51–2, 54, 57, 160
   bipolar 207–9
   conduction 207, 209
   device 209–10
   MOSFET 209
   suppression 209
   thyristor 209
parasitic NPN 206–7
passive component 49–53, 57
Passive pixel sensor (PPS) 167
p-channel 28–9, 31
   MOSFET 207
personal computer 205
perveance 257
PFC, power factor correction 204–5
Phase-change random access memory (PC-RAM) 150, 183–4
phase-shift masks 122
Phosphosilicate glass (PSG) 72, 115
photodetector 268–71
photodiode 166–8, 227, 229, 232, 268, 269

photoresist 122
photovoltaic 213, 268
   PV inverters 205
Picture-in-picture (PIP) 164
PIN diode 52, 205
Pioneer 6 (NASA) 253
pixel 166–8
planar (device) 207–9
planar processing 121
plasma nitridation 125
platinotron (see crossed-field amplifier)
PMOS 50, 53, 135
PN junction 86, 205, 210, 266–8
PNP 206, 209
Poisson equation 100
polarization doping 197
polycide 29
polycrystalline silicon 74, 83, 187, 215, 216, 241
polymer 80, 81
polysilicon (poly-Si) gate 16, 28, 53–4, 92, 125, 182, 208, 209, 216, 230, 242
Positive bias temperature instability (PBTI) 109, 111
power 266, 268, 271
   active 277
   bipolar 205
   device 71, 74, 203–7, 209–10
   dissipation 205
   distribution 203
   electronics 206
   IC, PIC 204–5, 209–10
   losses 205
   management IC, PMIC 209
   MOSFET 205–7, 210
   package 203
   power amplifier (PA) 160, 192
   power semiconductor 203, 205, 209
   power supply 205
precision manufacturability 124
process
   clustering 125
   control 128
   simulation 104
   variability 131
programmable metallization cell 184
Programmable read-only memory (PROM) 174
Pseudomorphic HEMT (PHEMT) 192
pseudo spin 65
PSOC, power system-on-chip 209
Pulse code modulation (PCM) 161
Pulse width modulation (PWM) 165
punchthrough 24
purple plague 108
Quality factor (Q) 54–5
quantum 267, 269
quantum capacitance 64
quantum well 266, 269
quasi-vertical DMOS, QV-DMOS 207, 209
radarange 260
radiative 266
radio 49
Radio frequency (RF) 51–2, 57, 101, 157–8, 160
Random access memory (RAM) 37–8, 171, 173–4, 181, 183
Random telegraph noise (RTN) 182, 109, 111, 117
Rayleigh Criterion 124
RC delay 146
Reaction-diffusion (R-D) model 110
Reactive ion etching (RIE) 127
Read-only memory (ROM) 39, 173
Recess channel array transistor (RCAT) 40
recombination 8, 266
rectification, AC to DC 205
rectifier 4, 9, 205
reflectometer 128
registration accuracy 122
regulator (voltage, linear, LDO, switching) 204–5, 207
reliability 121
resistive devices 185
Resistive random access memory (RRAM) 65, 150
resistivity 53, 55
resistor 92, 49–53
resolution pitch 122
Resonant frequency (fsR) 54–5
resonator 49, 55
RESURF 204–5, 208–9
reverse recovery time 205
RF circuit 57
RF MEMS 245
RF MOSFET 194
Ru 128
salicide 73
SAMPLE 103
scaling 139
method 25, 28
classical 277
Scanning electron microscopy (SEM) 129
Scharfetter, D.L. (Don) 98
Schottky barrier diode 4
Schottky diode 211
Schottky-barrier FET 189
Schrödinger equation 100
SCR 203
selective epitaxy 125
self-aligned 16–17, 19
etches 124
semiconductor 3–7, 15, 17, 71, 74–8, 81, 266–70
manufacturing 121
semi-insulating SiC substrate 198
sensor 239–43, 247
shallow junctions 125
Shallow trench isolation (STI) 168, 209
Shannon theorem 158
Shockley 27
diode equation 86
short channel 208
short-channel effects 28–9
Si dangling bonds 110
Si/SiO2 interface 28
SiC-based FET 197
sidewall spacer 208
SiGe HBT 3, 18, 19, 195
Signal-to-noise (S/N) ratio 158
Signal-to-noise distortion ratio (SNDR) 162, 163
silicide 29, 31, 73, 76
silicon 71–8, 81, 215–16, 203–6, 208, 210–211, 222, 268, 271
carbidc, SiC 205, 210–211
limit 205, 208, 210
Silicon carbide (SiC) 197, 246
Silicon dioxide (SiO2) 74, 76, 125, 128
Silicon germanium (SiGe) 3, 17, 18, 19, 73, 143, 160
Silicon monolithic millimeter wave integrated circuits (SIMMWIC) 194
Silicon nitride (Si3N4) 76, 125, 128
Silicon oxinitride (SiON) 72
silicon-on-insulator (SOI) 30, 122, 208–9
SIMS 104
<table>
<thead>
<tr>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single event upset (SEU) 114</td>
</tr>
<tr>
<td>Single heterostructure bipolar transistor (SHBT) 193</td>
</tr>
<tr>
<td>Single spin logic (SSL) 60–61</td>
</tr>
<tr>
<td>single wafer processing 121</td>
</tr>
<tr>
<td>SiO$_2$ 110, 139</td>
</tr>
<tr>
<td>SiO$_2$/Si interface 110</td>
</tr>
<tr>
<td>Si-SiGe heterostructure 195</td>
</tr>
<tr>
<td>Small-scale integration (SSI) 107</td>
</tr>
<tr>
<td>snapback, second breakdown 206–7</td>
</tr>
<tr>
<td>Soft error rate (SER) 114</td>
</tr>
<tr>
<td>soft errors 114</td>
</tr>
<tr>
<td>SOI, silicon on insulator 30, 122, 208–9</td>
</tr>
<tr>
<td>solar cell 71, 74, 213</td>
</tr>
<tr>
<td>solar spectrum 215</td>
</tr>
<tr>
<td>source 22, 24–6, 29–31, 269</td>
</tr>
<tr>
<td>specific on-resistance, m$\Omega$-cm$^2$ 208, 210</td>
</tr>
<tr>
<td>spherical harmonics expansion 101</td>
</tr>
<tr>
<td>SPICE 85, 88, 89, 145</td>
</tr>
<tr>
<td>spin devices 283</td>
</tr>
<tr>
<td>Spin field effect transistor (SPINFET) 60, 62, 285</td>
</tr>
<tr>
<td>spin orbit coupling 60, 63</td>
</tr>
<tr>
<td>Spin-transfer torque random access memory (STT-RAM) 148</td>
</tr>
<tr>
<td>spintronics 63</td>
</tr>
<tr>
<td>stacked packaging 121</td>
</tr>
<tr>
<td>Static random access memory (SRAM) 22, 38–9, 53–4, 111, 143, 148, 171–6</td>
</tr>
<tr>
<td>Statistical process control (SPC) 129</td>
</tr>
<tr>
<td>step-and-repeat exposure 122</td>
</tr>
<tr>
<td>straintronics 62</td>
</tr>
<tr>
<td>stress 30</td>
</tr>
<tr>
<td>stress-induced voiding 113</td>
</tr>
<tr>
<td>submicron (devices, facilities) 205, 207, 209</td>
</tr>
<tr>
<td>substrate 22, 26–7, 266–70</td>
</tr>
<tr>
<td>subthreshold 25–6, 30</td>
</tr>
<tr>
<td>leakage 25–6, 30</td>
</tr>
<tr>
<td>slope, S 277–8, 280</td>
</tr>
<tr>
<td>subtractive etch 124</td>
</tr>
<tr>
<td>superjunction 204–5, 207–9</td>
</tr>
<tr>
<td>supply voltage 277, 281, 284</td>
</tr>
<tr>
<td>SUPREM 103</td>
</tr>
<tr>
<td>surface micromachining 242–3</td>
</tr>
<tr>
<td>Surface modulated field effect transistor (SurFET) 65</td>
</tr>
<tr>
<td>surface states 72</td>
</tr>
<tr>
<td>switching regulator 205</td>
</tr>
<tr>
<td>symmetric linearization 90, 91</td>
</tr>
<tr>
<td>System-in-package (SiP) 130, 151</td>
</tr>
<tr>
<td>System-on-chip (SoC) 136</td>
</tr>
<tr>
<td>Tantalum (Ta) 128</td>
</tr>
<tr>
<td>tablet computer 209</td>
</tr>
<tr>
<td>Tantalum Nitride (TaN) 30, 128</td>
</tr>
<tr>
<td>Technology computer aided design (TCAD) 97</td>
</tr>
<tr>
<td>Television (TV) 164</td>
</tr>
<tr>
<td>temperature 266, 268</td>
</tr>
<tr>
<td>temperature coefficient 53</td>
</tr>
<tr>
<td>Temperature-humidity-bias (THB) 108, 111, 115</td>
</tr>
<tr>
<td>terminal 10, 15, 49</td>
</tr>
<tr>
<td>test 129</td>
</tr>
<tr>
<td>thermal</td>
</tr>
<tr>
<td>conductivity 210</td>
</tr>
<tr>
<td>furnace processes 124</td>
</tr>
<tr>
<td>oxidation 125</td>
</tr>
<tr>
<td>runaway 207</td>
</tr>
<tr>
<td>thermal furnace processes 124</td>
</tr>
<tr>
<td>thermal oxidation 125</td>
</tr>
<tr>
<td>Thermo compression (TC) 109</td>
</tr>
<tr>
<td>thermophotovoltaics 221</td>
</tr>
<tr>
<td>thick metal 210</td>
</tr>
<tr>
<td>thin film photovoltaics 218</td>
</tr>
<tr>
<td>Thin-film solar cells (TFSC) 225–9</td>
</tr>
<tr>
<td>Thin film transistor (TFT) 80–81, 227, 229, 232–5</td>
</tr>
<tr>
<td>Three-dimensional (3D) 40, 42–5</td>
</tr>
<tr>
<td>three-dimensional structures 124</td>
</tr>
<tr>
<td>threshold 266, 271</td>
</tr>
<tr>
<td>threshold voltage 39, 40, 110, 207, 277, 278</td>
</tr>
<tr>
<td>Through-silicon via (TSV) 43–5, 130, 151, 181</td>
</tr>
<tr>
<td>thyristor, PNPN 203–6, 209</td>
</tr>
<tr>
<td>Time division multiplexing (TDM) 161</td>
</tr>
<tr>
<td>Time-dependent dielectric breakdown (TDDDB) 109</td>
</tr>
<tr>
<td>Timing controller (TCON) 165</td>
</tr>
<tr>
<td>Titanium Nitride (TiN) 30, 128</td>
</tr>
<tr>
<td>Titanium silicide (TiSi$_2$) 29</td>
</tr>
<tr>
<td>Titanium oxide (TiO$_2$) 78, 81</td>
</tr>
<tr>
<td>TO220 (power package) 203</td>
</tr>
<tr>
<td>traction 204–5</td>
</tr>
<tr>
<td>transconductance 15, 276</td>
</tr>
<tr>
<td>transistor 3–5, 9–10, 15, 17, 19</td>
</tr>
<tr>
<td>Transistor-transistor logic (TTL) 172–4, 176</td>
</tr>
<tr>
<td>transit time 4, 15</td>
</tr>
<tr>
<td>transmission 157, 158</td>
</tr>
</tbody>
</table>
traveling-wave tube 251–3
trench DMOS 204–5, 207–8
trench gate 205, 207–9
trench Isolation 121
TRIAC, AC thyristor 203, 206
Triple modular redundancy (TMR) 114
troposcatter 257
tunnel FET 102, 280
design parameters 281
Miller capacitance 282
Tunnel magnetoresistance (TMR) 183
Tunneling field effect transistor (TFET) 144
two-carrier (devices, conduction) 205–6, 209
Two-dimensional (2D) 41, 43
Two-dimensional electron gas (2DEG) 77
TWT (see traveling-wave tube)

unipolar (conduction) 205
upconversion 221
UPS, uninterrupted power supply 205
USB charger 209
III-V
compound solar cell 219
semiconductors 31, 75, 215, 219

vacuum electronics 251
vacuum tube 37–8
vacuum tube/electronics 49–50
varactor 4, 52, 57, 92
Variable retention time (VRT) 180

VDMOS, vertical DMOS 204–9
velocity modulation 255
velocity tapering 252
Verilog-A 94
vertical power MOSFET 204, 207
Very-large scale integration (VLSI) 135, 138
via 146
VMOS, V-groove MOSFET 205
voltage 269

W 30
wafer fab 205, 209
wafer scanning 122
wafers 105, 122, 124, 129, 131, 190, 211, 216, 218, 248, 283
wavelength 265, 267, 269–70
Weibull modeling 115
whispering gallery mode 261
wide bandgap, WBG 205, 210–211
wide bandgap devices 197
wire bond 107
wire FET 280
wire pitch 277
without magnetism 63
WSi$_2$ 29

X-ray imaging 230

Yield 12 2, 129, 130

Zener diode 4