

INDEX

- “bird’s beak” 348
1-phenyl-1H-tetrazole-5-thiol
(PTT) 249, 260
3D chips, heterogeneous integration 433
3D electroplating 423
3D fabrication 671–672
3D integration 401, 403, 417, 431–457,
565, 671
3D interconnect 434, 442
3D-integration 425
5-aminotetrazole monohydrate
(ATA) 249, 260
5-phenyl-1H-tetrazole (PTA) 249, 259,
260
- Abrasive agglomerate 676
Abrasive Settling 564–565, 577–584,
591, 602
Abrasive-Free System 209, 213, 235, 239
acoustic emission 82, 84, 86, 107, 109,
113, 117, 118
activated carbon 633
adhesion force 483, 491–499, 502, 505
- Advance process control 61
advanced process control (APC) 329
advantages of CMP 20, 21
AE 84, 85, 105–17
air operated diaphragm (AOD)
pump 591, 619–620
Alumina 206, 212–213, 221–235,
412, 415, 424, 426, 474, 484–485,
493–499, 564, 576–587, 594–607,
618, 687–688
aluminum metallization 652, 660
amino acid effect on STI selectivity 382
Amino Acid, Chelating Agent 216–217
Ammonia, Chelating Agent 214–216,
230, 283, 290, 293
angular rate sensor 402, 403, 417–421
Anodic Dissolution 302–303, 326
Anodic Polarization Curve 300–301, 309
Anodic potential versus current
density 324
antenna impedance matching 424
APC 61, 62, 75, 329, 330, 593, 679, 680
APM (SC1) 477

- approaches to wafer-level 3D
 integration 441–442
 aspect-ratio 526
 Asperity Filtering Regime 191, 195
 atomic force microscopy (AFM) 553

 Back end of the line (BEOL) 27–28,
 41, 346, 363, 431–457, 469, 476,
 652, 675
 Bellows pump 573–579, 604, 621
 benzotriazole 48, 249, 252, 259,
 533, 695
 Boundary layer thickness 472, 502–503
 BPSG (boron phosphorus doped silicon
 glass) 512
 brush lifetime 474
 BTA 19, 48, 49, 204, 205, 211, 213, 222,
 223, 232, 235, 249–271, 410, 486–92,
 533, 570, 594, 696
 buffered HF 478
 bulk micromachining 402, 411, 416–417
 Bulk Particle Density, Abrasive
 Particle 227
 buried oxide (BOX) 437

 cap 550
 capacitive RF switches 424
 Carbon Pad 337–338
 carriers 62, 65, 66, 67, 68, 71, 299, 668
 cavitation 471, 502–503, 505
 Centrifugal pump 603–606
 Chatter mark/Chatter shatter mark
 675–676
 Chelating Agent 201, 214–217
 chip stacking 401, 403, 407, 411, 417,
 425
 chlorinated PVC (CPVC) 630
 clarifiers 636
 CMOS 280, 374, 404–424, 444, 480,
 659, 669
 CMP
 application 29, 249, 513, 674, 688
 equipment 26, 29, 404, 411, 592
 equipment market 654
 industry revenue 654
 market size 25
 system 51, 60, 75, 78, 337, 412
 waste 628
 required planarity 409
 coefficient of friction 43, 81–118, 139,
 174, 190, 474, 594
 Coefficient of Friction (COF) 43, 81,
 118, 139, 174, 190, 474, 594
 COF 43, 84–91, 97–115, 139, 163, 174,
 175, 185–195, 594
 collection system 631
 collection tank 632
 Colloidal Silica 185, 228, 234, 413, 416,
 423, 484–485, 513–517, 524
 color variation 516
 Competitive Surface Adsorption 239,
 266–267, 269
 Composite Particle 233–234
 computer hard drives 8, 9
 conditioner design 102, 103
 Conductive Pad 314, 337–339
 Conductive Polymer 338
 Conductivity 11, 179, 319, 335–341, 442,
 540, 567–579, 586, 591
 CoNiFe 426
 copper annealing 331
 copper CMP 16, 19, 25, 48, 90, 108,
 115, 132, 139, 159, 163, 165, 201–229,
 235, 249, 258, 271, 278, 290, 293,
 486–496, 511, 531–550, 556, 557, 565,
 576, 579, 583, 594, 595, 599, 633,
 642, 643, 680
 copper corrosion 533
 copper electromigration 542
 copper metallization 652, 660
 copper pitting 535
 copper pullout 331, 341
 copper recess 539
 copper-copper bonding 438
 Copper–Phosphoric Acid Solution 303
 copper-to-copper bonding 440, 445,
 455
 copper-to-copper bonding structures in
 3D chips 445
 coring in W CMP 284
 corrosion 524, 534
 Corrosion Density (Icorr) 264
 Corrosion Potential (Ecorr) 264
 Corrosion, PCMP Clean 11, 19, 32,
 35, 45, 59, 61, 145, 201–292, 316,
 325, 410, 467, 468, 486–493,
 505–557, 594, 628, 630,
 692–702

- Cost of CMP 683
- Cost of Ownership (COO) 20, 163, 364, 379, 468, 564–569, 572, 595, 602–603, 623, 644–646
- crystal formation 519
- Cu barrier 533
- Cu CMP 15, 19, 28, 30, 73, 141, 202, 203, 210, 213, 216, 219, 222, 223, 225, 235, 249–272, 410, 423, 424, 474, 484–498, 505, 511, 543, 594, 624, 652, 672, 673
- Cu puddle 532
- Cu residue 547
- Cu-Glycine Complex 206
- Cumulative LPC 564, 569, 595–607, 613, 615
- Current Density 264, 295, 300, 304–305, 323–325, 335–336
- damascene 11–16, 21, 28, 30, 46, 125, 224, 280, 281, 286, 346, 364, 401, 404, 416, 423–426, 431, 438, 440, 447, 451–456, 487, 488, 512–533, 652
- Damping Factor 193
- deep UV (DUV) 551
- defect classification 555
- defect count and LPC 393–395
- Defect reduction 675–677
- Defect-causing large particle 577
- defectivity 7, 33, 49–51, 78, 129–138, 222, 332, 337, 371, 385, 388, 456–458, 468, 532, 555, 564–569, 574, 592, 594, 603, 605, 623
- degrees of planarization 4, 5
- delamination 531
- DELIF 32, 43, 44, 45
- Density scaling 656, 659
- depth of focus 1–4, 21, 28, 277, 320, 347, 408, 665
- depth-of-focus 277, 320
- Development cycle 661–664, 674, 676–677
- DHF (dilute HF) 468, 475–481, 514–519
- Diaphragm pump 591
- Dichromate, Oxidizers 212, 225
- dielectric cap 533
- dielectric erosion 532
- dielectric thinning 532
- diffusion coefficient 47, 300, 303, 324, 325
- Diffusion Layer 303, 309, 325
- Diffusion Leveling 304–308
- digital micromirror 422, 423
- digital micromirror device 422
- disadvantages of CMP 20, 21
- discoloration 523, 529, 540
- Dishing 16, 60, 84, 129–161, 195–424, 451, 456, 481, 484, 521–565, 594, 666
- dishing 532
- disk centrifuge 568
- Dispersion of Particle 221
- DLVO 221–223
- DMA 32, 33, 34, 36, 38, 39, 40, 42
- DNMR 32, 45
- double-sided roller 473
- dressers 65, 67, 69, 70, 71, 72
- dry-in/dry-out 29, 61, 62, 64, 75
- dual damascene 12–14, 28, 30, 125, 280, 281, 286, 319, 404, 533
- dual emission laser induced fluorescence 32, 43
- Dynamic light scattering (DLS) 568
- dynamic mechanical analysis 32, 274
- dynamic nuclear magnetic resonance 32, 45
- dynamic rheometry 32, 36
- ECMP 223, 253, 295–316
- ECMP pad 315
- ECMP planarization efficiency 309, 315, 326, 332
- eddy current sensor 327
- edge exclusion 377, 405, 408, 594
- Edge Overerosion 529
- edge trenching 538
- effect of temperature 87, 100, 271, 503
- elastic deformation 514
- Elastohydrodynamic Lubrication (EHL) 84, 147, 181
- Electric Current 297, 338–340
- electroacoustics 568
- Electrocells for ECMP 338
- Electrochemical Cell 264, 295–299, 312, 313, 316, 323

- Electrochemical Dissolution 295–305, 315, 326
- Electrochemical Impedance Spectroscopy 310
- electrochemical planarization (ECP) 244, 253, 295–307, 340
- Electrochemical polishing in DI (ECP-DI) 335
- Electrochemical Reaction 278, 297–304, 315, 319, 321, 327, 335
- electrocoagulation (EC) 643
- Electrode/Electrolyte Interface 297–298
- electrodeionization (EDI) 642
- Electrolysis of Water 339
- electromigration 543
- Electron dispersive spectra (EDS) 592
- Electropolishing 295, 322–326, 330, 339–340
- Ellipsometry 254, 311–312, 257
- E-manufacturing 61, 62, 75, 77
- Encapsulating Metal Ion 209
- end point 29, 75, 84, 92, 98, 114, 115, 119, 154, 166, 206, 284, 288, 291, 325–330, 340, 353, 357, 364, 407, 412, 427, 544, 670, 679, 680
- end-point detection (EPD) 29, 92, 114, 154, 284, 288, 291, 325–329, 357, 407, 544, 679–680
- energy dispersive X-Ray spectroscopy (EDX) 552
- EPD in W CMP 288
- epitaxy deposition process (EPI poly) 420
- Erosion 60, 84, 129–130, 145–161, 195, 201, 224–289, 332–362, 405, 409, 451, 456, 481, 484, 526–594, 663
- evolution of CMP 28, 61
- extended trench isolation gate (EXTIGATE) 361
- feature topography 431
- Ferric Nitrate, Oxidizers 206, 210–212, 254, 293, 691
- Fick's second law 305
- Filter 564–569, 586–623
- Filter Design 588–590, 602, 623
- Filter lifetime 564, 586–591, 598, 602–604, 621
- FINFET 434, 482, 565, 660, 664–667, 672, 674
- Finfet transistor 565, 664–665, 674
- Flash Heating 172, 178, 185, 197, 198
- flow rate 94, 208, 473, 564, 580, 586, 596–606, 611–615, 621
- flow rate, slurry 34, 87, 129, 139, 173, 211, 237, 290, 355, 372, 499, 683
- focus ion beam (FIB) 331
- Friction Force 82, 91, 123, 136, 141, 388, 492–499
- Front end of the line (FEOL) 41, 346, 436, 444, 449, 651–652, 675
- full-sequence ECMP (FS-ECMP) 321, 334, 341
- Fully silicided (FUSI) metallization 668
- Fumed Silica 228–230, 234, 293
- future trends 27, 29, 31
- glass polishing 6, 174, 345, 373, 412
- global planarization 4, 5, 6, 13, 20, 347
- Glycine 203–218, 235, 251–266, 382–384, 705
- Grain Boundary/Grain Boundaries 296, 302–303
- granulated activated carbon (GAC) 633
- hard mask 533
- Hardness, Abrasive Particle 225, 227, 239
- hardness, pad 123–147, 162, 190
- HF etch 515
- high selective STI slurry 375
- high-aspect-ratio (HAR) 437
- high-density plasma (HDP) 350
- High-k Gate Oxide 660, 667–668
- High-k oxide 660, 667–668
- historic perspective 27, 29, 31
- HPM (SC2) 477
- hybrid-ECMP 331, 334–335, 337–338
- hydrodynamic fractionation 568
- Hydrogen Peroxide 141, 174, 185–187, 202–216, 235–293, 503, 570–578, 586, 633–643, 690–692, 720
- Hydrogen Peroxide, Oxidizers 141, 174, 185, 187, 202, 216, 235, 250–293, 503, 570–578, 586, 633–692, 720
- Hydroxyl Radical 206–207, 216–217, 558

- IC CMP and MEMS CMP
 comparison 404
- IC manufacturing 16, 25, 27, 277, 321,
 345, 401, 404, 563, 655–660, 677, 683
- Impedance Measurement 203, 309–311
- Impedance spectrum 311
- infrared digital micromirror array 422
- integrated pressure sensor 402, 416–417
- Interconnect process trends 30
- interlayer dielectrics (ILD) CMP 7, 27,
 72, 73, 87, 125, 139, 206, 373, 388,
 391, 512, 513, 520, 531, 651, 652, 673,
 678, 683
- International Technical Roadmap for
 Semiconductors (ITRS) 551
- Iodate, Oxidizers 202, 212–213
- ion-exchange 638
- ionic strength 49, 91, 231, 502
- IR Gun 179, 193
- Langmuir-Hinshelwood 172
- large particle counting, abrasive
 particle 228
- large particle counts 49, 246, 390, 563,
 595, 619, 620
- Large Particle Index (LPI) 569
- Large particle retention 564, 591–615,
 622
- Laser Diffraction 568
- linear sweep voltammetry (LSV) 301
- local oxidation of silicon 346, 366, 370
- local oxidation of silicon (LOCOS),
 processing steps 370
- local planarization 4, 5, 6, 340, 512
- LOCOS isolation 347–347, 369, 652–653
- Logic IC 655
- low-k 550
- low-k materials 7, 30, 113, 114, 321, 489,
 548, 551
- LPC 49, 393, 563–569, 575–579,
 591–622
- LPC retention 601
- lubricant film 83, 85
- lubrication, boundary 84, 89, 90
- lubrication, hydrodynamic 44, 84
- lubrication, partial 89
- macroscratch 283–284
- macrowaviness 4
- magnetically levitated centrifugal (MLC)
 pump 591, 603, 619–620
- Marangoni-type IPA 469
- Mass Transport 203, 215, 297–315
- Material Removal Model 168,
 172, 173
- materials of compatibility 629
- MDSC 32, 33, 38, 40
- Mean shear rate 603
- mean time between failures (MTBF) 78
- Megasonic clean/Megasonic Post-CMP
 Cleaning 469–472, 499–505
- membrane-mediated ECP 313–314
- Memory IC 655
- MEMS CMP requirement 405
- Metal gate 346, 364, 565, 660,
 668–672
- Metal Impurity/Metal Impurities 207,
 209, 567
- metals removal 645
- metrology, ex situ 72, 75, 77
- metrology, in situ 72, 75, 77
- microelectromechanical system
 (MEMS) 401, 512, 559
- microfabrication processes 402
- microfabrication products 403
- microfabrication, examples 412
- microfiltration 636
- micromolding 402–403
- microscratch 532
- migration Leveling 304, 307–308
- MIPS (Million instructions
 per second) 655, 657
- Modulated differential scanning
 calorimetry 32
- Moore's Law 345, 365, 404, 408,
 556, 655–660
- MOSFET 356–35, 369, 665
- multichip module (MCM) 432
- multilevel MEMS technology 417
- multilevel metallization 2, 3, 13, 346,
 651, 652
- nano- and microscale planarization 451
- nanoimprint lithography (NIL) 443
- nanotopography 4, 61, 352, 355, 454
- NCP pad 126, 131, 132, 133,
 135, 136
- need for planarization 2

- Nernst Layer 303
NiFe 404, 415, 426
NiP CMP 206
Nitric Acid, Oxidizers 202–203,
254–255, 323
NMOS 280, 668–670
nonporous pad 125, 127, 128, 131,
132, 135, 136, 165
Non-Preston region 322
novel pads 124, 159–164
- Ohmic Leveling 304–305
optical scan 554
orbital (polisher) 29, 57, 59, 64, 92,
337, 374
Organic Acid, Chelating Agent 217
Organic acid, PCMP clean 479
Organic Particles as Abrasive/Organic
Particle 233–239
Organic Residue 467–468, 482–491,
505, 518
organics removal 632
overpolishing 546
Overpolishing Window 239, 293, 392,
396
oversized particles 37, 229, 390, 392,
395, 513
Oxidation-reduction potential
(ORP) 567
oxide thickness variation 516
oxide thinning 532
oxide: nitride selectivity 382
oxide-oxide bonding 436–442
oxide-to-oxide bonding 437, 444, 445,
453
oxidizer removal 632
Oxidizers 32, 35, 45, 59, 123, 202–205,
213, 215, 250, 254, 278, 293, 412, 424,
570, 598–645, 690, 691
- pad compressibility 33, 53, 125, 130,
353, 354, 355
pad conditioning 32, 69, 84, 92–101,
104, 119, 124, 130, 132, 142–144,
159–162, 281, 412
pad conditioning, ex situ 94, 109, 142,
143, 144, 145, 412
pad conditioning, in situ 96, 109, 142,
143, 145, 185, 407, 412
- Pad Density 175–182
pad groove 42, 88, 89, 129, 130,
138, 139, 520
pad groove effects 42, 138
pad groove patterns 89
Pad Heat Capacity 179
Pad Heat Partition Factor 181–182
pad in W CMP 288
pad life 42, 92, 94, 129, 130, 132,
139, 162
pad macrostructure 125, 127, 129,
136
pad material 92, 102, 155,
180, 487
pad microstructure 125, 127, 130
pad modeling 124, 143, 145–158
Pad Planarization Length 190
pad SEM images 125, 126
pad structure 125, 541
pad surface 33, 34, 65, 83, 92–96,
124, 125, 129–152, 159, 164–177,
191, 192, 209
Pad Surface Contact Modeling 175,
177
pad surface roughness 83, 94, 102,
103, 129–131, 141–147, 175
Pad Surface Shape 192
pad surface temperature 34, 136,
137
pad temperature 33, 135, 180,
193, 594
Pad Thermal Conductivity 179
pad thickness 94, 102, 128, 129,
132, 138, 144, 158, 190, 191
pad type 32, 89, 124, 135,
136, 139
pad viscoelasticity 145, 146, 147
pad wear 92–104, 109, 110, 118,
132, 135, 144, 238
PadProbe 92, 93, 95, 96, 98
pads and abrasives 150
pads and dishing 129, 130, 138,
145, 147, 154–158
pads and erosion 129, 130, 138,
145, 147, 154–158
pads and pressure 148
pad-wafer contact 33, 43, 45,
136, 141, 178
particle containing pads 159

- particle crystallinity and shape, abrasive particle 227
- particle removal mechanism 477–478
- particle size distribution (PSD) 33, 49–50, 147, 181, 228–229, 235, 388, 563, 602, 622
- Particle size, abrasive particle 228
- Particle Surface Modification 233
- Passivating Agent 19, 202–205, 211, 223, 235, 249–262, 278, 288, 293, 525
- Passivating Film 211–215, 251–253, 255–257, 259–260, 262, 265–267, 278
- Passivation Film 212, 253–271, 309, 311, 324–325, 337
- pattern width 405, 408
- PCMP Clean for Low-k Materials 489
- perfluorosulfonyl (PFA) 630
- pH adjustment 632
- pH shock 568, 573–574, 579
- photoresist 3, 4, 25, 590
- pitting 523, 524
- planarization efficiency 517
- planarization technologies (CMP, ECP, and ECMP) 321
- plastic deformation 514
- platen temperature control 291
- PMMA 426
- PMOS 280, 668–670
- Point of dispense 594
- point-of-use (POU) filtration 563
- Polarization resistance 302, 315, 316
- polishing debris 548
- polyethylene (PE) 630
- polymer adhesive bonding 454
- polymer adhesive wafer bonding 446
- polypropylene (PP) 630
- Poly-Si polishing (PSP) 652
- poly-Si surface micromachining 402, 417
- polysilicon 520, 521, 522, 523, 524
- Polyurethane pad 38, 69, 70, 92, 101, 111, 124–128, 140, 141, 165, 375
- polyvinyl chloride (PVC) 630
- polyvinylidene fluoride (PVDF) 630
- porosity, pad 38, 125, 127, 128, 130, 131, 144
- porous ultra-low-k (low dielectric constant) materials 320
- post-CMP cleaning 19, 28, 29, 31, 32, 60, 63, 78, 130, 222–225, 269–272, 286, 293, 345, 346, 350, 364, 388, 392, 396, 410, 412, 467–508, 513, 518, 519, 524, 531, 540, 541, 547, 548, 622, 690, 692, 706
- Post-Cu/Low-k CMP Surface Cleaning 484
- Post-Oxide CMP Cleaning 480
- Post-Poly-Si CMP Cleaning 482
- Post-STI CMP Cleaning 481–482
- post-W CMP cleaning 290, 293, 481, 531
- Post-W Deposition 279
- Potassium Permanganate, Oxidizers 207, 212
- POU blending 578, 586
- Pourbaix Diagram 202–203, 210–211, 218, 250–252, 258, 278–279, 699–703
- preexisting defects 531
- premetal dielectric (PMD) CMP 7, 512, 513, 520, 530, 531
- Pressure drop 564, 587–604, 611, 621, 622
- Preston region 322
- Preston's Equation 59, 145
- Preston's Law 59, 65, 174, 188, 321–322
- Probability Density Function (PDF) 175–176, 196
- publicly owned treatment works (POTW) 627
- Pulsed field gradient NMR 47
- pump 295, 564–586, 591–623, 632
- pump (pressure)-pressure-dispense system (PPDS) 577
- radioactive contamination 519
- RC delay 9–11, 346, 359, 434
- Reaction Temperature 172–189
- reactive pad 124, 159, 164, 165, 209
- Real-Time NIR 569
- Recirculated slurry 597–598, 606, 616, 620
- Recirculation 566, 573–579, 585, 596–611, 619–621
- redistribution bonding 456
- redistribution layer bonding 436, 440, 441, 456–457

- Refractive index 320, 407, 568–577, 591, 688
 removal of trace metals 632
 Required minimum flow velocity (RMFV) 566, 580–581, 584
 residue particles 410, 482
 retaining ring 110, 111, 112, 408
 reverse osmosis (RO) 642
 RIE (reactive ion etch) 5, 11, 13, 15, 30, 348–351, 360, 416, 420, 450, 472–478, 482
 rotary polisher 66, 196, 236, 352
 rotating disk electrode (RDE) 210, 301
 Rotating Electrode 300
 rotational coriolis force sensor 419
 rough copper 539

 SC1 468, 472–481, 499–505
 scanning auger microscope (SAM) 553
 scanning electron microscope (SEM) 552
 scratches 513, 514, 515, 516, 528
 SEM local charging 541
 Settling Rate (SR) 580–585, 591, 601
 shallow trench isolation 16, 27, 30, 35, 71, 72, 279, 345–363, 369–404, 464, 467, 512, 652
 shatter marks 544
 Shear rate amplitude 603
 Shear stress 574, 603–604
 Shear-sensitive liquid 603–605
 Shear-sensitive slurry 607, 611, 623
 silica-ceria particle interaction 387
 silicon direct bonding (SDB) 444
 single particle optical sensing 49, 568
 Single-pass filtration 564, 595, 598–600, 612, 615
 singulated die 3D Ics 435
 SKW floor plan 286
 slit density index (SDI) 642
 Slurry blending 577–585, 592, 622–623
 Slurry Characterization 36, 105, 108, 567, 573–574, 591, 622
 slurry conditioner 393–395
 Slurry Delivery 21, 37, 139, 284, 564–605, 620–623, 683
 Slurry distribution 577
 Slurry Filtration 566–567, 573, 586–598
 slurry market 31
 slurry residues 518, 531
 slurry rheology 35
 slurry stability 33, 49, 50, 221, 385, 567
 Slurry Stability Ratio (SSR) 567
 slurry transport 32, 43, 45, 92, 127, 129
 Slurry Turnover 564, 604, 622
 slurry-pad interactions 38
 Soft Particle 234
 solids treatment 645
 Sommerfeld number 83
 spin-lattice relaxation (T1) 46
 spin-spin relaxation (T2) 46
 SPM (sulfuric-peroxide mixture) 468, 477–478
 SPOS 49, 50, 568, 569, 606, 620
 SRAM cell 658
 stacked chip-scale-package 435
 stacked pad 127, 129, 18, 139
 Step Height Reduction Efficiency 123, 132–135, 164, 201, 203, 212, 239, 253, 336
 STI
 defect, scratch count 391
 defectivity, LPC effect 388
 Dishing & Erosion 355
 fabrication steps 349
 slurry 352
 slurry selectivity 352
 slurry, glycine 383
 slurry, oxide: nitride selectivity 383
 slurry, particle size effect 388
 slurry, pH effect 384
 slurry, polymer additive 381
 slurry, removal mechanism 387
 slurry, self-stopping 381
 slurry, surfactant effect 379
 abrasives 373
 directing polishing 376
 dummy active area insertion 359
 end point detection 357
 nitride overcoat 360
 optimization techniques 358
 pattern density dependence 354
 patterned oxide etch back 359

- planarization requirement 353
- polysilicon-filled trenches 363
- post CMP topography 357
- selective oxide deposition 363
- silica based 375
- slurry 373
- slurry, CeO₂ based 374
- testing wafers 371
- stiffness, pad 127–147, 162, 352, 353
- Storage Container 566
- stress migration 332
- stress-induced void 331, 333
- striebeck curves 83, 87, 89, 90
- subpad 127, 192
- substrate thickness 406, 411, 417
- subwavelength structures 547
- Supercritical CO₂ 592
- surface contamination 406, 410
- surface frictional force 91
- surface micromachining 402, 416–416, 423–425
- Surface Quality 92, 225–227, 238, 285, 388, 496, 498–499
- surface roughness 3, 4, 9, 82, 83, 92, 94, 102, 103, 129–147, 175, 238, 254, 255, 304, 305, 431–451, 491, 497, 539–556
- surface smoothing 5
- surface treated pads 124, 162, 163
- Surfactant 201, 219–225, 233–257, 266–267
- surfactant in barrier slurry 224
- surfactant in Cu slurry 222
- surfactant in STI slurry 224
- Surfactant Physical Property 219
- Surfactant Structure 219
- Surfactant, PCMP clean 479–487
- suspended solids 635
- system-in-package (SiP) 432
- system-on-chip (SoC) 432
- Tangential flow filtration (TFF) 590
- TEOS (tetraethyl orthosilicate) 512
- Testing wafer 239, 281, 286
- tetraethylorthosilicate-ozone (TEOS:O₃) 350
- TGA 32, 33
- thermal coefficient of expansion (TCE) 443
- thermal effects 33, 182
- thermal gravimetric analysis 32
- thermal mechanical analysis 32
- thermal oxidation 347, 369, 652
- thinning of the oxide 348
- through-silicon vias 435, 449
- through-silicon vias (TSV) 435
- through-vias etching 425
- Ti/TiN Barrier 279
- TMA 32, 33, 35, 40
- Topography Planarization 4, 189, 191, 193, 195
- total dissolved solids (TDS) 567, 577
- trace elements 519, 522
- Transition Metal 207, 212
- treatment system 632
- Trench Depth 190
- trench oxide recess 356
- Trench Width 190, 191, 196
- trenching 537
- tribology 81, 84, 85, 87, 88, 89, 90, 91, 118, 119, 474
- tribometry 81–120
- Tungsten CMP 7, 15, 19, 125, 141, 149, 151, 153, 159, 201, 204, 206, 211, 277–294, 346, 424, 524–531, 540
- tungsten recess 525, 527
- Two-Step Chemical-Mechanical Model/Two-step Model/Two-step theory 171–173, 184, 193, 198
- Type of Passivating Film 252–253, 255
- types of polishers 62, 63
- Ultra pure water (UPW) 590
- ultrafiltration 636
- ultraviolet radiation 633
- underpolishing 530
- vacuum-pressure-dispense system (VPDS) 566
- via-first 3D 456
- via-first approach to 3D 455

- via-last approach to 3D 440, 453–454
- voids 523, 524
- VPDS 566, 574–585, 606
- W CMP**
 - barrier polishing 289
 - defect 282–283
 - oxide buffing 289
 - process 16, 278–293, 525, 526, 530, 531
 - slurry selectivity 292
 - Slurry/W CMP Slurries 211, 213, 278, 289, 525, 531
- wafer drying 475, 484
- wafer processing 6, 58, 282, 365, 628, 643, 678
- wafer processing flow 58
- Wafer Temperature 178
- wafer thickness profile 329
- wafer thinning for 3D 447
- wafer topography 175, 193, 374, 523, 553
- wafer topography map 334
- wafer-level 3D 432–439, 441, 442–449, 457
- wafer-level 3D using adhesive bonding 439
- wafer-level package (WLP) 434
- wafer-scale planarity 431, 451
- wafer-to-wafer alignment 437, 439, 442, 446
- wafer-scale packaging 419
- Water Solubility 48, 257–258, 262, 269, 691
- Wet batch cleaning 468
- wharf 4
- Wide Trench 190
- within-wafer nonuniformity 110, 123, 143, 201, 239, 284, 285, 289, 291, 358, 453, 523
- WIWNU 94, 95, 123, 131, 132, 144, 146, 159–62, 201, 228, 241, 284, 291, 372, 396, 523, 530, 544–546
- Young's modulus 127–150, 155, 158, 162, 177, 280, 551