

Index

a

- AC electroosmosis (ACEO) 46, 120
- AC manipulation 3
- ACEO, *see* alternating current AC electroosmosis (ACEO)
 - optically induced 49
- acoustic cell separation 18
- acoustic wave driven motion 225
- active probing 537
- actuation
 - magnetic microrobot, *see* magnetic microrobot actuation
- actuators
 - SDA 217
 - silicon nanotweezer 179
 - SNT 171
- adherent cell injection 342
- adhesion
 - definition 260
 - micro-manipulation physics 260
 - van der Waals forces 262
- adhesion force measurement protocol 462–464
- adhesion pocket 525
- adhesive cell injection 341
- AE components, MTB 314
- AFM *see* atomic force microscope (AFM) 480
- AFM-based flexible robotic system 444
- AFM-based flexible robotic system, micro/nanomanipulation 444
- AgNWs synthesis, HF 105
- alkanethiol chemisorption 421
- alternating current electroosmosis (ACEO) 120
- alternating current electroosmosis flow (ACEOF) 120, 123
 - schematic illustration 124
- amplitude-modulation atomic force microscope (AM-AFM) 247
- angioplasty 210
- anti-CD20 mAbs 419
- antibody-dependent cellular cytotoxicity (ADCC) 418
- artesunate (ART) 5
- artificial molecular machines 227
- Aspect Ratio Dependent Etching 180
- assembly after growth techniques 98
- assembly during growth techniques 98
- asymmetric hydrodynamic focusing 104
 - multiple AgNW 112, 113
 - NWs assembly 108, 111
- atomic force microscope (AFM) 169, 190, 236, 284, 419, 442, 480
- atomic force microscopy (AFM)-based cell characterization 359
- automated cell injection system 341, 342
- automated cell selection
 - and positioning 292
- automated cell transportation
 - and deposition 408, 410
- automation
 - micro- and nanoscale 509–511
- axial pulling
 - helical nanostructures 483

b

- B cells 423
 - force spectroscopy molecular interactions 423
- B-cell lymphoma 417
- B-cell NHL 423
- bioadhesive patch releasing capsule 208
- bioconjugation 311
- biofuel cells 209, 210

- biological cells manipulation 539
 - dead cells colonies 543
 - dual nanoprobe 541
 - electrical measurement setup 545
 - experimental results and discussions 546
 - fabrication of dual nanoprobe 544
 - microfluidics 549
- biological entities, OEK 60
- biological tissue powered 219
- biophysical method, SNT 169
- biopsy
 - microscale untethered surgical devices 213
- Bosch process 180
- Brownian motion 47
- building blocks assembly 521
- buoyancy effects 47, 51
- Burkitt's lymphoma cell 422
- bushing 218
- c**
- C. elegans*, robotic cell injection 350
- C2C12 cells 461, 469
- CAD 210
- cancer 417
- Canny edge detector 344
- cantilever 239
- capacitive sensor
 - SNT 173
- capillary electrophoresis (CE) 119
- capillary forces 260
- carbodiimide cross-linking 312
- carbon nanotubes (CNTs) 519
- carcinogenesis 417
- CCD camera 396
- CD20 417
 - *in vitro* experiments 417
 - membrane proteins distribution 430
 - ROR1-labeled cells 425
- CD20-rituximab interactions
 - cancer cell 432
- CD20 – rituximab interactions 418, 422
 - binding force 428, 429
 - on tumor cells 423
- CDC 418
- cell adhesion 442
- cell adhesion forces:in situ quantification of living 459
- cell adhesion:quantitative analysis 443
- cell alignment
 - for flow cytometry 28, 30
- cell assembly
 - by multiple optical traps 408
- cell-cell adhesion force measurement 469–470
- cell characterization
 - silicon nanotweezer 194
- cell cultivation and sample preparation 461
- cell deformability 5
- cell differentiation
 - silicon nanotweezer 193
- cell electroporation, ODEP 131
- cell expansion 283
- cell immobilization methods 343, 344
- cell injection 339
- cell levitation
 - from microwell 407, 408
- cell lysis, ODEP 131
- cell manipulation
 - biological, *see* biological cells manipulation
 - definition 537
 - ESEM, *see* environmental scanning electron microscope (ESEM)
 - and microorganisms 162
 - multichannel sorting 162
 - oocyte enucleation 160, 161
 - with optical tweezers and microfluidic chip 395
- cell manipulation, in microfluidic devices 1
 - direct cell manipulation 2, 3, 10
 - high-speed process 1
 - indirect cell manipulation 2, 9
- cell manipulation, ODEP 129
- cell morphology 6
- cell release 466
- cell separation
 - hydrodynamic cell separation 9
 - non-hydrodynamic particle separation 9
- cell separation, ODEP 130
- cell solution exchange 29
- cell sorting and manipulation 393
- cell sorting strategy 397
 - cell transportation 398
 - experimental results 400
 - microfluidic chip design 397, 398
 - operation principle 396
- cell suction, TPA probe 556
- cell-substrate adhesion force measurement 466–469
- cell transportation
 - by optical tweezers 398
- cell trapping
 - SNT 186
- cell wall apparent stiffness 295
- cell – wall interaction 7
- cells in suspension
 - silicon nanotweezer 190

- cellular force microscope (CFM) 286
 - force sensing technology 286
 - imaging system and interface 289
 - positioning system 288
 - CFD *see* computational fluid dynamic (CFD) 103
 - CFM 286
 - real-time CFM 290
 - charge-coupled device (CCD) 126
 - chemical energy
 - macroscale untethered surgical devices 207
 - chemical fixation, single cell 470
 - CHRONOGRIP 381, 382
 - circulating tumor cell (CTC) 130
 - detection 7
 - purification 15
 - clamping detection, cell grasping 464–465
 - CM factor 22, 45, 46
 - CMOS-MEMS process 238
 - material properties in 242
 - CMOS – MEMS process
 - to sc-SPMs 240
 - colloidal nanoparticles 524–526
 - comb-drive actuator
 - design 171
 - compatibility 507
 - complement-dependent cytotoxicity (CDC) 418
 - complete mechanism, stiffness modeling 327–329
 - complexity 507
 - compliant 4S module 322
 - compliant 4S module, stiffness modeling 325–326
 - compliant P joint deformation 330
 - compliant P module 321
 - compliant P module, stiffness modeling 324–325
 - compliant P(4S) chain, stiffness modeling 327
 - compressed springs 208
 - computer vision techniques, robotic cell injection 344
 - computational fluid dynamic (CFD) 103
 - constriction-based cell interrogation 5
 - constriction-based cell separation 7
 - contact micromanipulation
 - direct pushing 271, 272
 - grasping manipulation 274, 276
 - microrobots 273
 - noncontact manipulation 275
 - controlled assembly 307
 - coronary balloon angioplasties 210
 - Coulomb friction 154
 - covalent coupling method 421
 - critical load 486
 - critical stress 486
 - crystallographic alignment structures, SNT 178
 - CW laser beam 395
- d**
- DAC 245
 - data acquisition 291
 - DCHNB, *see* dual-chirality helical nanobelt (DCHNB)
 - dead cell colonies
 - preparation 543
 - Dean flow 15, 28
 - Debye forces 262
 - deep reactive ion etching (DRIE) 179
 - deformability based cell separation 16, 17
 - degrees of freedom (DOF) 240, 539
 - Derjaguin–Muller–Toporov (DMT) 260, 263
 - deterministic assembly approach 98
 - deterministic lateral displacement (DLD) 13
 - Dielectrophoresis 22, 45
 - forces 42, 120
 - diffusion pump (DP) oil 180
 - diffusion-tensor-based algorithm 342
 - direct cell manipulation 2, 10
 - cell morphology 6
 - electrical cell manipulation 3
 - magnetic cell manipulation 4
 - mechanical cell manipulation 5
 - optical cell manipulation 4
 - direct-current (DC) 345
 - displacement conversion, motion converter 495
 - DNA
 - binary confinement scheme 82
 - center of mass diffusivity 81
 - complex slitlike devices design 86
 - confining structures for 77
 - differential slitlike confinement of 82
 - diffusivity 87
 - electrostatic effects 78
 - energy barrier 82, 83
 - fabrication of complex slitlike devices 88
 - fluctuation 80
 - hydrodynamic interactions 79
 - ionic strength of solvent 81
 - nanofluidic geometries 85
 - nanofluidic structures 84
 - nanofluidic technology 75–77
 - nanoslit 75, 76, 83

- DNA (*contd.*)
 - non-nanofluidic slitlike confinement 85
 - physical behavior 75, 77
 - physical extent of 86
 - relaxation behavior 81
 - scanned probe measurement methods 89, 90
 - silanol protonation 91
 - silicon nanotweezer 185
 - size R 79
 - slitlike confinement of 78
 - SNT 183
 - stress relaxation time 81
 - surface interactions 79
 - transport 86, 87
 - transport and conformation 87
- drag analysis, micromanipulation 265
- DRIE, *see* deep reactive ion etching (DRIE)
 - SNT 180, 182
- drive unit
 - friction reduction by 144
- droplet manipulation method, ODEP 135, 136
- dual nanoprobe
 - cell viability detection 541
 - fabrication 544
- dual stage configuration 291
- dual-chirality helical nanobelt (DCHNB) 494, 498
 - free end of 496
 - force-to-elongation characterization 496
 - motion converter 493, 494
 - 3D microscopy application 498
- e**
 - edge detection algorithms 344
 - elasticity
 - definition 260
 - nanocoils 483
 - electrical cell manipulation 3
 - electrical cell separation 22
 - electrical double layer (EDL) 119
 - OACEOF 123
 - electrical probing
 - ESEM 547
 - single cells 548
 - electro-thermo-mechanical model 248, 249
 - electrokinetic forces 41, 119
 - ACEO 120
 - classification 119
 - DEP force 120
 - EWOD 120
 - ODEP 121
 - electromechanical motion 217
 - electromechanical sensors 492
 - electroosmotic flow (EOF) 119
 - electrowetting on dielectric (EWOD) 120, 135
 - electron beam-induced deposition (EBID) 489
 - electron microscopes 537
 - electroporation 340
 - electrostatic actuation
 - SNT 171
 - electrostatic effects 78
 - electrothermal effects 47
 - electrothermal flow 47
 - electrothermal microgrippers 353
 - electrothermal model
 - self-heated resistors 245, 246
 - vertical actuator 247
 - electrothermal vortex 43
 - end-effector 441, 525
 - energy sources
 - macroscale untethered surgical devices 209
 - environment and tools assembly 521
 - environmental scanning electron microscope (ESEM) 351, 538
 - biological cells manipulation 541
 - electrical measurement 548
 - electrical probing 547
 - nanomanipulation system 538
 - TPA probe 549
 - enzymatic reaction on DNA, SNT 183
 - EOF, *see* electroosmotic flow (EOF)
 - ACEO 120
 - definition 119
 - EWOD 120
 - microchannel-based platforms 119
 - equivalent dynamic model
 - silicon nanotweezer 176
 - ET force 121, 125
 - OACEOF 132
 - etching
 - Aspect Ratio Dependent Etching 180
 - chemical/physical 180
 - directional 179
 - DRIE, *see* deep reactive ion etching (DRIE)
 - focused ion beam 544
 - wet 178, 182
 - Euler – Bernoulli beam equation 248
 - EWOD 120, 135
- f**
 - fabrication
 - dual nanoprobe 544
 - silicon nanotweezer 179

- SNT 181
 - TPA probe 550, 551
 - FACS 25
 - Fåhræus–Lindqvist effect 16
 - FcR 418
 - FcR – rituximab 434, 435
 - FEM 145
 - FemtoTools 372
 - fibrous micro-nanoscale materials, mechanical testing 372
 - field emission scanning electron microscope (FESEM) 483, 487, 496
 - Si/Cr nanobelt 489, 490
 - Field Programmable Gate Array (FPGA) unit 291
 - Finite Element Analysis (FEA) software 249
 - finite element method (FEM) 145
 - finite element method (FEM)-based model 297
 - flexible MOEMS extreme assembly 384
 - flexible robotic setup 444
 - flexure element, stiffness matrix 323–324
 - Flory distribution 80
 - flow cell 28
 - flow cytometry
 - cell alignment for 28, 30
 - fluid conductivity 52
 - fluid drag force 153
 - fluid dynamics effects 264
 - fluid friction reduction
 - for on-chip robot 150
 - fluid-based microsystem technologies 119
 - fluidic thin films manipulation, OEK 63
 - fluorescence-activated cell sorter (FACS) 25
 - focused ion beam (FIB) etching 544
 - follicular lymphoma 417, 426, 428
 - force curve 420
 - blocking 426
 - CD20 distribution 430
 - normal B cells 428
 - Raji cells 422
 - force sensing during pick-and-place 444–446
 - force sensing technology 286
 - force sensors 379
 - force-controlled cell injection 347
 - frequency modulation atomic force microscope (FM-AFM) 247
 - friction reduction
 - by drive unit 144
 - MMT experimental evaluations 146
 - by ultrasonic vibrations 146
 - friction, micro-manipulation 263
 - fuel driven motion 222
- g**
- goat-anti-human-ROR1 antibody 424
 - grasping manipulation, contact
 - micromanipulation 274, 276
 - grayscale photolithography 88, 89
 - green fluorescent protein (GFP) 398
 - gripping 522
- h**
- Hamaker constant 262
 - hardware abstraction layer (HAL) 515
 - HeLa cell interrogation 6
 - HeLa cells 130
 - helical nanobelts characterization 482
 - rolled-up helical nanostructures 483
 - Si/Cr nanobelt 488
 - SiGe/Si microtubes 483
 - helical nanostructures
 - axial pulling 483
 - Helmholtz – Smoluchowski velocity 46
 - hESC 399
 - isolation 402
 - isolation and deposition 410
 - high-resolution vision system 380
 - high-speed microscopy 9
 - high-speed object tracking inside SEM 519–521
 - high-vacuum (HV) mode
 - electrical measurement 547
 - highly oriented pyrolytic graphite (HOPG) 238
 - Hind-III restriction enzyme 185
 - Hodgkin's lymphoma 417
 - horizontal polar drive (HPD) 145
 - Hooke's law 490
 - Hough transform algorithm 345
 - human embryonic stem cell (hESC)
 - assembly process 409
 - fluorescence-based cell isolation and deposition 411
 - isolation 399, 403
 - isolation and deposition 412
 - viability test 414
 - HV mode 539
 - ESEM mode and 540
 - hybrid cell purification systems 25
 - hydrodynamic cell separation 19
 - deformability based cell separation 16, 17
 - shape-based cell purification 17
 - size based cell separation 13
 - size-based cell separation 14

- hydrodynamic focusing (HF) 100
 - AgNWs synthesis 105
 - categories 101
 - schematic of 100
 - concept and mechanism 100
 - NW assembly 104
 - schematic of 101
 - silicon substrate 107
 - symmetrical and asymmetrical behavior 103
 - 2D and 3D hierarchy 101
 - types of 104
- hydrogenated amorphous silicon (a-Si:H) layer 44
 - absorption coefficient of 53
 - and OEK chip 52
 - incident photons in 49
 - laser illumination on 62
 - low conductivity in 52
 - photoconductivity 53
 - Teflon coated 63
- i**
- image processing 394, 404
- image processing, robotic cell injection 344
- imaging system and interface 289
- impedance-based cytometer 3
- indirect cell manipulation 2
 - cell alignment for flow cytometry 9, 30
 - cell solution exchange 9
 - hydrodynamic cell separation 9, 19
 - non-hydrodynamic particle separation 9, 23
 - nonhydrodynamic particle separation 26
- Inductively Coupled Plasma Reactive Ion Etching (ICP-RIE) 179, 180
- inertial cell stretcher 8, 9
- InP NWs 99, 100
- integrated assembly platform 381
- integrated circuit (ICs) 239, 505
- interdigital transducers (IDTs) 226
- intracytoplasmic sperm injection (ICSI) 339
- invasiveness 507
- isothermal scanning method 252
- j**
- Johnson–Kendall–Roberts (JKR) 260, 261
- Joule heating 245
- Jurkat cells 130
- k**
- Kahn – Richardson model 265
- Kalman filters 345
- Kanade-Lucas-Tomasi (KLT) algorithm 293
- Keesom forces 262
- kinematic analysis
 - nanorobotic manipulation 479
- kinematics modeling, micromanipulator 333–336
- Kirchhoff's Voltage law 247
- l**
- λ -phage DNA 62
- laser capture microdissection (LCM) 394
- laser trapping-based cell characterization 358
- laser trapping-based cell transfer 355, 356
- laser-induced photo damage 413
- lateral bending
 - SiGe/Si microtubes 483
- light driven motion 226
- light source, ODEP 126
- lily pollen tube
 - apparent stiffness 297
- lithographic fabrication processes 88
- living cells biomechanical and morphological characterization of 294
 - cell wall apparent stiffness 295
- load conversion, motion converter 497
- local buckling
 - SiGe/Si microtubes 483
- local oxidation of silicon (LOCOS) 178
 - nitride patterning 179
- localization, miniaturization 204, 220
- locomotion method, miniaturization 206, 214, 217
- London dispersion forces 262
- lymphoma
 - clinical information 433
 - follicular 417, 426, 428
- m**
- macroscale untethered surgical devices 204
 - chemical energy 207
 - design parameters 203
 - external magnetic field 208
 - localization 204
 - locomotion 206
 - mechanical energy 208
 - sources of energy 209
 - tasks 203
- Mag-Mite system 267
- magnetic-activated cell sorter (MACS) 24
- magnetic cell manipulation 4
- magnetic cell separation 24
- magnetic field
 - macroscale untethered surgical devices 208

- magnetic field driven motion 223
- magnetic force 215
- magnetic microrobot actuation 216, 266
 - coil arrangements 269
 - locomotion techniques 266
 - magnetic actuation systems 268
- magnetically driven microtool (MMT) 142
 - drive force 144
 - fabrication process for 157, 158
 - positioning accuracy evaluation 146
 - with riblet surface 153
 - and Si–Ni composite structure 156
 - static force on 143
 - total magnetic force 144
 - with ultrasonic vibration 147
- magnetosomes 308
- magnetostriction 267
- magnetotactic bacteria (MTB) 308
- magnetotaxis directional control efficacy 310
- magnetotaxis position control 313
- magnetotaxis system 313
- manipulation 506
- manipulation and automation overview 517
- matrix displacement method 322
- MC-1 bacterial cell 308, 311
 - magnetosomes 309, 313
 - rounded 308
 - strain 308
 - swimming velocity 308, 310
- mechanical cell manipulation 5
 - constriction-based cell interrogation 5
 - constriction-based cell separation 7
 - shear-induced cell manipulation 7
- mechanical energy
 - macroscale untethered surgical devices 208
- mechanical interfacing 512
- mechanical structure
 - SNT 171
- MEMS fabrication 170
 - silicon nanotewwzer 177
- MEMS *see* MEMS 119
- MEMS-based cell characterization 357
- miBase 375
- miBots 376
- micro- and nanoscale automation 509–511
- micro-assembly in MEMS and MOEMS industries 382
- micro-assembly, micromechanisms 377
- micro-electro-mechanical system (MEMS)-based force feedback 286
- micro-electro-mechanical systems (MEMS) 119, 339, 371, 483
 - SPM in 239
 - mechanical testing 371
 - microgrippers 353
- micro-grippers 379
- micro-manipulation
 - adhesion 260
 - physical forces 260
 - remote environments 259
- micromanipulator design 320–322
 - kinematics modeling 333–336
 - stiffness modeling 322
- micro-/nanocompression approaches 284
- microbeads
 - TPA probe 554, 555
- microcantilever 453
- microfabrication 210
- microfluidic assembly
 - HF, *see* hydrodynamic focusing (HF)
 - of 1D nanomaterial 105
 - magnetic technique 99
 - SEM image of NWs 100
- microfluidic cell sorters 393
- microfluidic chip 141
 - cell micromanipulation system with 395
 - design 397, 398, 405
- microfluidic devices 41
- microfluidic drifting 102, 103
- microfluidic flow cytometry 394
- microfluidic microwell array 395
- microfluidics 537
 - biological cells manipulation 549
- microgripper/microhand-based cell transfer 352
- microheater fabrication
 - TPA probe 551, 552
- microinjection 340
- micromanipulation
 - contact-based manipulation 271
 - fluid dynamics effects 264
 - mobile microrobotics competition 279
 - sliding friction 263
 - pick-and-place 447
- micromechanical manipulators 141
- microneedle array 350
- microorganisms
 - cell manipulations and 162
- micropipette aspiration 359, 360
- microrobot
 - permanent magnet 142
- microrobot-based cell transfer 354
- microrobotic fibre 374

- microrobotic platforms, plant mechanics 285
 - cellular force microscope 286
 - computer simulation techniques 285
 - micro-electro-mechanical system 286
 - robotic systems 285
 - visual automation methods 286
- microrobotics for micro-assembly 376
- microrobotics, scientific instrumentation 371
 - MEMS mechanical testing 371
- microrobots 378
 - contact micromanipulation 273
 - fluid dynamics effects 264
 - magnetic actuation 266
 - noncontact manipulation 275
- microscale untethered surgical devices 210
 - angioplasty 210
 - biological tissue 219
 - biopsy 213
 - electromechanical motion 217
 - locomotion 214
 - magnetic force 215
 - micro-manipulation 214
 - optical tweezers 218
 - surgical applications 211
 - wound closure 212
- microscopic vision 345
- Microsystem manufacturing 369
- microtubes
 - SiGe/Si 483
- microwell array-based microfluidic chip design 405
- miniature force sensors 287
- miniaturization 201
 - macroscale untethered surgical devices 203
 - microscale surgical tools 210
 - nanoscale surgical tools, *see* nanoscale surgical tools
- ML components, MTB 314
- mobile microrobots for testing 375
- model validation base, FEA 329–333
- molecules manipulation, ODEP 134
- monochromatic light 90
- Moore's law 235
- motion converter 492
 - 3D microscopy 493, 498
 - DCHNB 493, 494
 - displacement conversion 495
 - load conversion 497
 - STM 493
- MS components, MTB 311
- MTB
 - AE components 314
 - aggregate loaded-MTB 314
 - aggregation 313
 - axial/polar 309
 - control loaded-MTB 314
 - iron oxide nanocrystals 309
 - magnetotaxis directional control 309
 - ML components 314
 - MS components 311
 - nonattached manipulation approach 311
 - self-reproducing capability 310
- μ TAS 394
- multi-walled carbon nanotubes (MWCNT) 442
- multi-trap parallel sorting strategy 402
- n**
 - nano-bio hybrid systems 227
 - nano-electro-mechanical system (NEMS) 477
 - nanorobotic manipulation process 480
 - typical configurations 492
 - nano-objects 506
 - NanoBits 521
 - nanocavities 76
 - nanocoil
 - stiffness characterization 482
 - nanocoils
 - elasticity 483
 - nanofluidic staircase 84
 - nanoforks 518
 - nanoglassblowing 85, 88
 - nanoliters discharge/suction, TPA probe 549
 - nanomanipulation robotic system, 3-D 449–452
 - nanomanipulation system
 - ESEM 538
 - nanomanipulation:pick and place 441
 - nanomaterials 506
 - nanorobotic manipulation 477
 - characterization 477
 - motion converter, *see* motion converter
 - NEMS 480
 - rolled-up helical nanostructures 483
 - Si/Cr nanobelt 488
 - SiGe/Si microtubes 483
 - 3D helical structures 481
 - nanoscale peeling methods 442
 - nanoscale surgical tools 220, 219
 - acoustic wave driven motion 225
 - artificial molecular machines 227
 - fuel driven motion 222
 - light driven motion 226
 - magnetic field driven motion 223
 - nano-bio hybrid systems 227

- nanotubes (NTs) 97
 - assembly approaches 97
 - microfluidic assembly 99
- nanotweezer 453, 460
- nanowire (NW) 97
 - assembly approaches 97, 99
 - complex structures 99
 - fuel-free cargo-towing study 224
 - microfluidic assembly 99
- nanowire handling 518
- nickel nanowires 224
- nitride deposition
 - SNT 178
- Non-Hodgkin lymphoma (NHL) 417
- non-hydrodynamic particle separation 23
 - acoustic cell separation 18
 - magnetic cell separation 24
- noncontact fluid-based manipulation 275, 277
 - noncontact manipulation 275
 - examples 278
 - parallel manipulation 279
 - RodBot 278
 - rotation 277
 - translation 276
 - nonhydrodynamic particle separation 26
 - electrical cell separation 22
 - hybrid cell purification systems 25
 - optical cell separation 25
- novel cell manipulation tool
 - chip preparation and fluid operation 406
 - microwell array-based microfluidic chip design 405
 - operation principle 404
- NP 480
- nylon microspheres 448

- o**
- OctoMag system 268, 270
- ODEP, 44, *see also* optically induced dielectrophoresis (ODEP)
 - chip structure 44
 - spectrum-dependent 53
 - for spherical particle 49
 - trap stiffness 44
 - waveform-dependent 54
- OFFIS automation framework 514–519
- on-chip microrobot 142
- on-chip robots 141
 - multiple-channel mechanical sorting 163
- one dimensional (1D) nanomaterials 97
- one-dimensional (1D) nanomaterials 97
- oocyte enucleation 160, 161
- optical cell manipulation 4
- optical cell separation 25
- optical interferometry 90
- optical profilometry 89
- optical testing 371
- optical tweezers 4, 42, 218, 393
 - cell micromanipulation system with 395
 - cell transportation by 398
- optically induced alternating current electroosmosis (OACEO) 121
- optically induced alternating current electroosmosis flow (OACEOF) 123
- optically induced dielectrophoresis (ODEP) 121
- optically induced electrohydrodynamic instability (OEHI) 63, 64, 65, 66
- optically induced electrokinetics (OEK) 42, 45
 - ACEO 46
 - biological entities 60
 - Brownian motion 47
 - buoyancy effects 47, 51
 - dielectrophoresis 45
 - electrothermal effects 47
 - energy conversion 51
 - fluidic thin films manipulation 63
 - nonbiological materials, manipulation and assembly 55
 - operational principle and design 48
- optically induced OACEOF
 - and ET force 132
- optimal edge detector, *see* Canny edge detector
- optoelectronic tweezer (OET) 44, 121

- p**
- P. laevis* 165
- P. yoelii* 5
- pantograph-shaped microrobot (PSMR) 217, 219
- parallel cell injection 350
- partial cell aspiration 352
- parallel manipulator 323
- parylene coating 545
- PBS 406, 422, 423
- PCD 418
- PECVD *see* PECVD
- peeling force measurement 442
- peeling tests, silicon nanowire (SiNW) 457
- perfluorohexane (PFH) 226
- permanent magnet
 - microrobot and 142
- PFH 226
- phase-locked loop (PLL) 189
- photo-and dark-conductivity 52

- photoconductive layer
 - ODEP 127
 - photolithography
 - silicon nanotweezer 182
 - SNT 179
 - pick-and-place:force sensing during 444–446
 - piezoelectricity 210
 - pipette-based cell transfer 351
 - plant growth mechanism 283
 - plasma-enhanced chemical vapor deposition (PECVD) process 127
 - Plasmodium falciparum 5
 - Pleurosira laevis 164
 - PNIPAAm 549, 550
 - poly(lactic-co-glycolic acid) (PLGA) 218
 - polydimethylsiloxane (PDMS) 161, 348, 349
 - fluidic channel 405, 406
 - polyvinylidene fluoride (PVDF), 348
 - positioning system 288, 290
 - probe-based testing instruments 371
 - proportional-integral-derivative (PID) controller 293, 346
 - protein physisorption 421
 - PVDF 348
 - Python programming language 516
- q**
- quasi-static operation 247
- r**
- radial stretching
 - Si/Cr nanobelts 489
 - Raji cell 422
 - AFM deflection image 425
 - Burkitt's lymphoma 424
 - ROR1 fluorescence labeling 423, 424
 - Rayleigh number 47
 - RBC
 - deformability separation 16
 - Real-time CFM (RT-CFM) 290
 - Real-time intracellular imaging, mechanical stimulation 301
 - resolution 507
 - restenosis 212
 - retraction process 463
 - reverse-transcription polymerase chain reaction (RT-qPCR) 130
 - Reynolds equation 150
 - Reynolds number (Re) 8, 15, 28, 215, 265
 - riblet surface
 - fluid friction reduction by 150
 - fluid friction reduction principle using 150
 - MMT with 153
 - optimal design 152
 - and pressure distribution 151
 - using Si-Ni composite structure 156
 - RInSE 29
 - rituximab 418
 - *in vivo* mechanisms 419
 - ADCC mechanism 418
 - commercial stock 422
 - Fc domains 434
 - FcR 434
 - mechanisms 434
 - problem 419
 - SATP 422
 - RoboCup Nanogram Demonstration Competition 279
 - robot-assisted mechanical characterization
 - AFM based cell characterization 359
 - laser trapping-based cell characterization 358
 - MEMS-based cell characterization 357
 - micropipette aspiration 359
 - robotic biosample transfer 339
 - microgripper/microhand-based cell transfer 352
 - microrobot-based cell transfer 354
 - pipette-based cell transfer 351
 - laser trapping-based cell transfer 355
 - robotic cell injection
 - *C. elegans* 350
 - cell immobilization methods 343
 - electroporation 341
 - force sensing and control 347
 - parallel cell injection 350
 - virus vectors and lipofection 340
 - robotic micromanipulation 339
 - robotic platforms: integration 508
 - robotic system, 3-D micromanipulation 446
 - ROR1 423
 - fluorescence labeling 423
 - rotating microrobot, noncontact manipulation 277
- s**
- sc-AFM
 - layout capture of 244
 - sc-SPMs 237
 - design constraints 244
 - electro-thermo-mechanical model 248
 - lumped element models 243
 - self-heated resistors 245
 - thermal capacitor 243
 - vertical actuator 247
 - Scallop theorem 265
 - scanned probe measurement methods 89, 90

- scanning electron microscopes (SEM) 89, 157, 359, 441, 506
 - dual nanoprobe fabrication 544, 545
 - fundamental tool 508
 - scanning microwave microscopy (SMM) 239
 - scanning probe microscope (SPM) 235, 236
 - chip-scaled instruments 241
 - cylindrical coordinate scanner 251
 - scanning tunneling microscope (STM) 235, 238
 - motion converters 493
 - Scratch drive actuator (SDA) 217
 - self-assembly 307
 - self-heated resistors 245
 - electrothermal model 246
 - self-phoretic motion 223
 - SEM, *see* scanning electron microscope (SEM)
 - dual nanoprobe fabrication 545
 - nanorobotic manipulation 479
 - SEM based manipulation 506–507
 - semi-closed microchip, TPA probe 553, 556
 - semiquantitative methods, cell adhesion 442
 - sensors
 - electromechanical 492
 - SNT 173, 179
 - shape-based cell purification 17
 - shear force 154
 - shear-induced cell manipulation 7
 - shape memory polymer (SMP) 210, 212
 - Si/Cr nanobelts 490
 - Poisson ratios 491
 - radial stretching 489
 - tangential unrolling 488
 - SiGe/Si microtubes
 - axial buckling 485
 - bending tests 484
 - lateral bending/local buckling 483
 - Silicon Crystal Reactive Etching And Metallization (SCREAM) process 240
 - silicon nanotweezer (SNT) 179
 - capacitive sensor 173
 - cell trapping and characterization 186, 188
 - DNA trapping 183
 - DRIE 180, 182
 - electrostatic actuation 171
 - enzymatic reaction on DNA 183
 - sharp tip fabrication 178, 179, 181
 - silicon nanowires (SiNWs) 451
 - peeling tests 457
 - silicon on insulator process (SOI) 240
 - single-cell force spectroscopy (SCFS) testing 471
 - single-walled carbon nanotube (SWNT) 494
 - single cells
 - electrical characterization 546
 - electrical measurement 541
 - electrical probing 548
 - ESEM observation 540
 - probing techniques 537
 - single-trap serial sorting strategy 402
 - single-molecule force spectroscopy (SMFS) 420
 - size-based cell separation 14
 - sliding friction
 - micromanipulation 263
 - slip velocity 46
 - SNT, *see* silicon nanotweezer (SNT)
 - solution discharge, TPA probe 552
 - spectrum dependent ODEP 53
 - sperm motility 352
 - spread cells
 - silicon nanotweezer 192
 - SNT 190
 - spring balance 483
 - SSD 345
 - Standing surface acoustic wave (SSAW)- 29
 - stepper motors 346
 - stiffness modeling, micromanipulator 322
 - compliant 4S module 325–326, 327
 - compliant P module 324–325
 - flexure element 323–324
 - matrix displacement method 322
 - model validation base, FEA 329–333
 - stochastic assembly approach 98
 - stokeslet 265
 - suspended microchannel resonator (SMR) 6
 - substrate exchange 525
 - successful transfer rate 411
 - surface-enhanced Raman scattering (SERS) 132
 - suspended cell injection 341–343
 - cell immobilization 343
 - SVM 345
 - symmetrical hydrodynamic focusing
 - NWs assembly 107, 108
 - synthetic ribosome 228
 - SYTOX Orange nucleic acid stain 413
- t**
- teleoperated robotic cell injection systems 341
 - template matching 345
 - tensile tests 284
 - thermal transmission line model 248
 - thermoreponsive polymer actuated (TPA) probe 538
 - thin die packaging 383

- 3D stiffness and topography maps 299
 - three-dimensional (3D) hydrodynamic focusing 103
 - 3-DOF micromanipulator 342
 - 3-D micromanipulation robotic system 446–449
 - 3-D nanomanipulation robotic system 449–452
 - tip functionalization 421
 - translating microrobot, non-contact manipulation 277, 278
 - transmission electron microscopes (TEM) 441, 493
 - transverse fiber compression measurement 526–529
 - TSV 236
 - tumor progression 417
 - turgor pressure 283
 - two-dimensional (2D) hydrodynamic focusing 102
- u**
- ultrasonic vibrations
- v**
- vacuum environment 508
 - van der Waals forces 262
 - vapor HF process
 - SNT 182
 - vapor-liquid-solid method (VLS) 376
 - vertical actuator 247
 - electrothermal model 244, 247
 - vision-based technique 343
 - visual automation methods 286
 - visual servo system 346
 - visual servoing 293
 - visual-based force measurement 348
- w**
- waveform-dependent ODEP 54, 56
 - wet etching 178, 182
 - whole cell aspiration 351
 - wild type yeast cells (W303) 540
 - worm immobilization mechanism 350
 - wound closure 212
- x**
- X. laevis 343
- y**
- yeast cells 540
 - isolation 399–401
 - isolation and deposition 410
 - multi-trap parallel sorting 401
 - size-based cell isolation and deposition 412
 - yeast cells, 540 *see also* wild type yeast cells (W303)
 - Young's modulus 284
 - YOYO-1 90
- z**
- zeta potential 124