Polymer based হলে mass production easy

Scaling Laws

→ ① Surface force (ST grad & shear force) $\propto L^2$

→ ② volm force (eg - gravity, inertia) $\propto L^3$

③ Their ratio tends to infinity as ~~their~~ the Length scale is reduced

④ volm forces become unimportant
surface forces " important in mf scale

Continuum

① A liq cube of 10 nm side contains ~~4E04~~ 4E4 molecules and exhibits 0.5% fluctuation in numbers.
→ For, gas ~~its~~ the size is 10 times

② For, probe volm Larger than 10 μm, variation in physical prop appear due to ~~exter~~ Feat.

Eulerian Formulation

→ measurement of velo using microparticle image velocitmetry

→ microparticle with diameters of the order of 1 μm are suspended in the flow

→ 2 pics are obtained by sending 2 light pulses in ms apart.

→ use of cross-correlation funⁿ to determine avg velo at pnt r.

Lab-on a-chip

① shorter time
→ close to real time measurements (Blood, food, effluent sample)

→ small req of chemicals, reduced the chemical footprint.

→ Digital o/p and interfacing with soft-,

→ it'll req small vol^m of expensive reagents, parallel operation, high throughput screening, reduced human error

→ High surface to volm ratio → increa catalytic activity & better heat dissipation for highly exothermic rxn → reduced coking, thermal run-away, sintering

→ Robustness of the reactor

→ Hazardous rxn at the pnt of use.

→ Difficult rxn the rq precise cntrl, and otherwise attainable in a randomly packed bed (e.g. → propellant from CO_2 in space-ship)

Component on a Lab-on-a-chip -

① Pumping
- centrifugal force
→ surface "
→ electrokinetic "
- mechanical

② Valve
- hydrogel
- Hydrophobic layer
- Mechanical

③ Mechanical
- Field-flow fractionation (electr, thermal flow)
- Electrophoresis
- Dielectrophoresis DEP + FFF
- Diffusion based separation

④ Mixing
→ passive using grooves, Lamination
- active

⑤ Diffusion b/w layers
- T sensor

⑥ Heating
- cyclic heating for PCR rxn - DNA hybridization

⑦ Detection
- optical interrogation
- Amperometric sensing

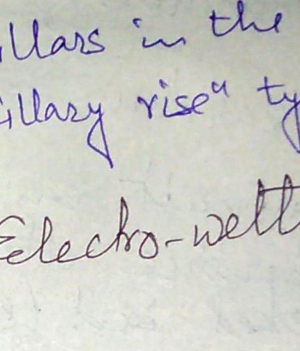
Pumping

↳ centrifugal force to drive ~~flow~~ fluid through channels in radial dire

→ use of coating of favourable contact angle, and ~~pitter~~ pillars in the channel to enhance a "capillary rise" type flow.

Electro-osmosis | Electro-wetting

T-sensor | H-filter



smaller components of the sample stream will diffuse into the acceptor stream

Detection

① Laser induced fluroescence system

→ flurophores are conjugated with migrating analytes

→ Laser beam ~~ex~~ excites the flurophores

→ This resultss, ~~fluroscen~~ fluorescence signal is filtered to block background illumination from the ~~exitation~~ excitation source,

~~→ fluroe fluze~~

→ Fluorescence signal is recorded using CCD ~~cam~~ camera, PMT, APD.

② Electrochemical

Electrophoresis → (grain → neglected)

① → Analytes are suspended in an ionic buffer env at a specific pH,

→ each spc migr with diff mobility, allowing them to be resolved as distinct zones, and seperated on the basis of size and charge.

→ Biological macromolecules are analytes like protein

→ Drag & Electrophoretic mobility are counteracting forces.

→ Polymer gel acts as sieving matrix material in the separation channel. The gel matrix re-introduces a size-dependance to the electrophoretic migration

Dielectrophoresis

$n = \frac{\rho N_A}{M_{at}}$

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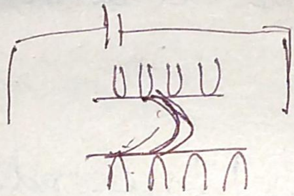

Field Flow fractionation

Thermal FFF

→ diffusivity is a funcⁿ of temp & particle size.

Valve made of Hydrogel

→ Hydrogel in it's expanded state block the channel.

→ Contraction hg allows the flow of fluid down the channel.

→ Response time is critical. fractional change in diameter shd reach 1.0 within secs.

Valve made of hydrophobic Layer

→ If interface is curved, theres press grad accross the if.
interface

The press^n on the concave side

The pre incre is balanced by ST for

→ For, flow to take place,

Applied Pre grad > capillary pr

→ An, abrupt change in the width of the channel causes pre dr at the pnt of restriction

Microfabrication

- Traditional mechanical machining (1mm - 50 cm)
  object size
- precision of the order of 10 μm

Special MM - Special Micro Machining

- Displacement precision ~ 1 nm
- Angular " ~ $(10^{-5})^0$
- only for metal not for plastic, glass or teflon.
- High price

Etching / Lithography Deposition

- Range (0.2 – 500) μm
- use glass or silicon

Plastic MEMS

→ Range → (0.5–500) μm
→ elastomers such as → PDMS or PMMA
- By wt plastic is 100 times less expensive than Si, and is disposable.
→ Rapid prototyping
→ Surface effects, transparency, diversity of material can be introduced easily

Clean Room

→ Temp 20°C
→ No of particles of size < 4 μm per cubic inch is defined as clean room.
per cubic inch
→ for, microprocessor fabrication no is ≤ 10
→ for, MEMS → ≤ 10000
→ Humidity regulated and traversed by flux of filtered air.

PL mask (300-450 nm)

→ ~~plo~~ → plates of quartz on whc deposits of chrome forms a pattern

→ Deposition is made using electron beam.
↳ by e^- beam

Spin Coating

3 stages → ① Distribution
~~② Spreading~~
② Evaporation
③ Solidification

→ use of ~~vacuum~~ vacuum to hold the wafer

70°C

→ Heating of resist @ 70°C for few mins. to evaporate 15% of solvent remaining to avoid formation of cracks.

(+ve) photoresist → PMMA
↓
after exposure the Polymer becomes soluble in a solvent ↳ the exposed part is eliminated as the light weakens the internal bonds

(-ve) photoresist → KTFR from Kodak
SU8 from IBM
↓
the light induces covalent bond b/w chains

For, shear-thinning Fluid
Radial velo ↓, visco ↑

Half Light Effect during exposure

→ Opaque obj produces shadows as well as ~~penumbra~~ penumbra

→ Diffraction ⊥ f ~~fraction~~

These shd be as small as pos

(−ve) PR → adhere better to the substrate
→ more chemically resistant

(+ve) PR → show better contrast in photosolubility

Protocol (31)

→ PDMS is hydrophobic

→ But become philic after oxidation of methyl grp at the surface by O_2-plasma.

Bonding → 59
↳ 61

$$2XeF_2 + Si \rightarrow Xe + SiF_4$$

sublimated (XeF_2)
volatile (SiF_4)

Rate of Etching follow Arhenius Expression

→ a strong funcⁿ of temp
→ unlike solubilisation of resist.

Diff kind of Etching → (33-41)

Protocol

① Immerse the wafer in Acetone in ultrasonic bath → Then Drying

② Immerse in Alchol → Then Drying

③ Dehydrate on Hot plate @ 120°C, 5 mins

→ These are to remove contaminant

④ Wafer is coated in Spin Coater

⑤ System is heated to 65°C, 1 min then 95°C for 3 mins, ~~to~~ for Hardening of photoresist.

⑥ Exposure.

⑦ Again, 65°C, 1 min & 95°C for 2 mins
For, progressive rearrangements of material during thermal deformation

(8) Dipped in Developer solⁿ for 3 min

(9) Rinsed in Alcohol → Dried with N_2

(10) Heating the system to 200°C, 2 hrs.

Silicon (33)

→ Delivered in the form of wafer that constitute a Monocrystal

→ Slices are cut from a cylinder, then atomic polishing

→ Typical thickness of Wafer → ≃ 500 μm
other dimensions ≃ 4 inc

→ 2 inter penetrating FCC network.

→ Side of cubic face ~ 5.43 Å

→ ~~Hig~~ Highest density plane <1 1 1>
form an angle ~~54.7°~~ 54.74° to <1 0 0> plane

Anisotropic etching

→ <1 1 1> are highly packed with atoms

→ Etching velo is slow along this <1 1 1>

→ " " " Fast " <1 0 0> or <1 1 0>

→ Etching speed with KOH along <1 1 1> is 13 μm/hr

→ Anisotropic etching isn't for → amorphous solid e.g → glass

→ etching happens along crystallographic planes

Isotropic

→ Equally in 3-spatial direction

→ ~~eamp~~ → of glass by HF

Dry Etch

→ attack of a substrate by an ionic species, contained in gaseous or plasma phase

Physical Etch

→ Elect Fiel → 10-5000eV

→ ions are bombarded on the substr

→ ~~mtt~~ Press → ~mTorr to make the ion ballistic

→ CF_4 gas → this is Anisotrop

→ Poor selectivity

→ Rate 0.6 - 18 μm/hr

Chemical Etch (Mostly Isotropic)

→ By diffusion

→ Chem rxn happens on target surface

$$2\underset{\text{sublimated}}{XeF_2} + Si \rightarrow 2Xe + \underset{\text{volatile}}{SiF_4}$$

→ Both the pdts ~~des~~ desorb & diffuse back.

→ Chem species are not accelarated by app of voltage

→ Volatile pdts aren't reflected

→ Rate ~ (µm/min)

→ surface is Rough

→ Press → 0.1-1 Torr

diffusive | not ballistic

Physicochemical Dry Etching

Reactive ion etching → RIE (Anisotropic)

→ used for microfab

→ Target is on Cathode

→ Rate = (10X physical etch)

→ Good for SiO_2 from surface of Si wafer

→ Cold plasma breaks, $CF_4 \rightarrow CF_3^+ + F^+$

Ballistic @ low press

Now or Never

Deep reactive ion Etch → DRIE

Physico-Chemical etc with inhibitor.

→ This is for non-volatile ~~non~~ pdts

→ Gas CCl_4

→ Ballistic, Anisotropy

→ Can obtain → very deep struc

~500 μm

aspect ratio → 30:1

PVD → ① Thermal evaperation

② Sputtering

① Thermal → Target is in a container

→ High Temp ensure sublimation of material

→ Press → 10^{-8} Torr

→ Rate ~ A°/s

→ Good for metal deposition

→ Simple

② Sputt

→ Target on Anode

→ material on ⊝ Cathode

→ use Cold Plasma so that various material can be deposited.

→ Ionic KE → 0.3 – 2 keV

peritration by 1 or 2 molecular layers of the substr

→ Good Adhesion

CVD

Homogen Rxn → in Gas phase

→ pdt absorbed on Target surface

$SiH_4 \rightarrow Si + 2H_2$ → nucleation & growth of Si-Crys
desorption of $2H_2$

Hetero → at the surface of Substrate

$Si + O_2 \rightarrow SiO_2$

→ 2 nm layer of SiO_2 when Si-waf exposed ~~on~~ to ambient air

→ 1 μm layer when expo to air @ 650°C

→ Gas phase ensure low defect density in crystal

CVD → 3 types
① Low Press CVD (LPCVD) ~1 Torr
② Atmosphe Press CVD → ~~AP~~ APCVD
③ PECVD → plasma enhanced Low Press

Rate ⇝ μm/hr

→ Low Press → mean free path high → easy diffusion of spc.

Electrolytic Depo (Metal depo)

→ Substrate is Anode

→ soln is $CuSO_4$ → metallic salt

→ Cu^{2+} migrate → anode

→ Metal ion capture e^- at electrode & form molecule that Adsorb onto the electrode

Sealing in Si & Glass

→ Anodic bonding refers to Glass-Si sealing by EF of 1 kV & 400°C

electric field

→ EF induces migra of Na^+ glass → interface & interpenetration of atoms at the Glass-Si interface

→ For avoiding crack → Thermal expansion co-eff of Glass Lid shd be same

∴

≈ → Pyrex Corning 7740

→ Glass layer → 0.5–4 μm

→ water-tight upto 100 atm

→ Fusion bonding → only by high temp 600 – 1100°C

Fabri of Plastic mf device

① Moulding ② Casting

③ Microinjection

① Mould (PDMS) → (-ve) master

is made by Photolithography

→ made of Si

→ electro deposited metal or reticulated polymer

→ In high Temp & Press

→ metallic mould is used

→ Temp → 70°C

② Casting/Hot embossing (PMMA, PE, PVC, PEEK)

→ Temp → 170°C

→ 10-100 Bar

– Mould is pressed into a heated deformable mat

③ Micro injec

→ For, serial production on Indus lev

→ Temp → > glass transition temp

(-ve) mould → ①, ②, ③ ✓

Adv of Plastic MF del

→ Precision ↑↑

Dadv

Di

(PDMS)

→ transparent

→ hydrophobic naturally

→ can turned into philic by oxidation of methyl grp @ the surface by O_2-plasma

→ permeable to gas

→ Weak surface energy