Paper 8 – Discussion

ME-426 – Micro/Nanomechanical Devices

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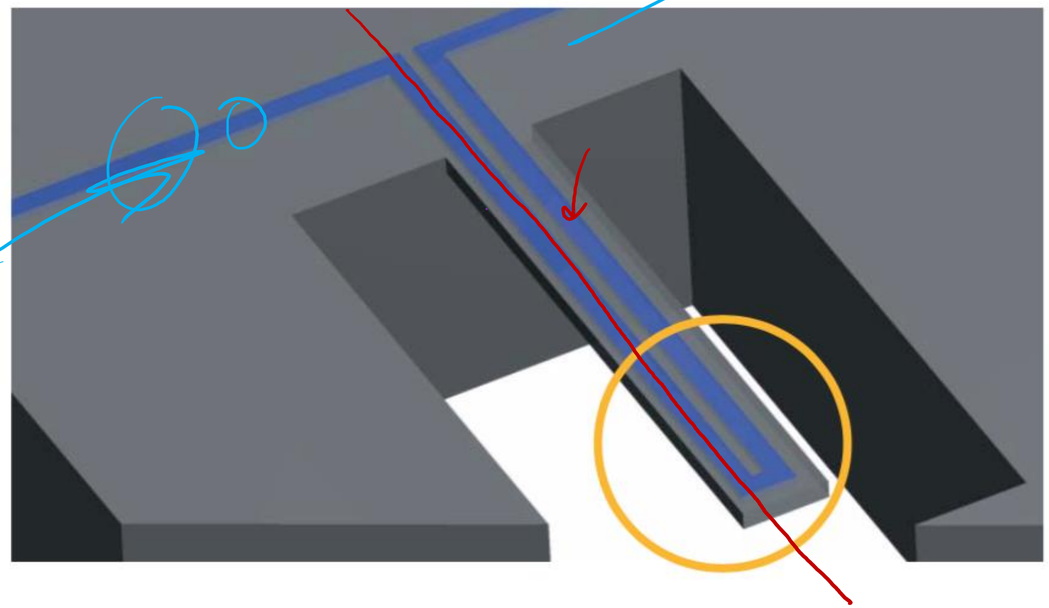
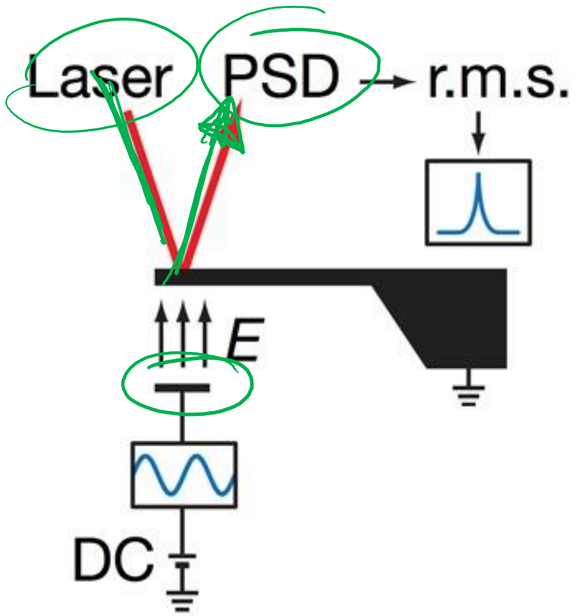
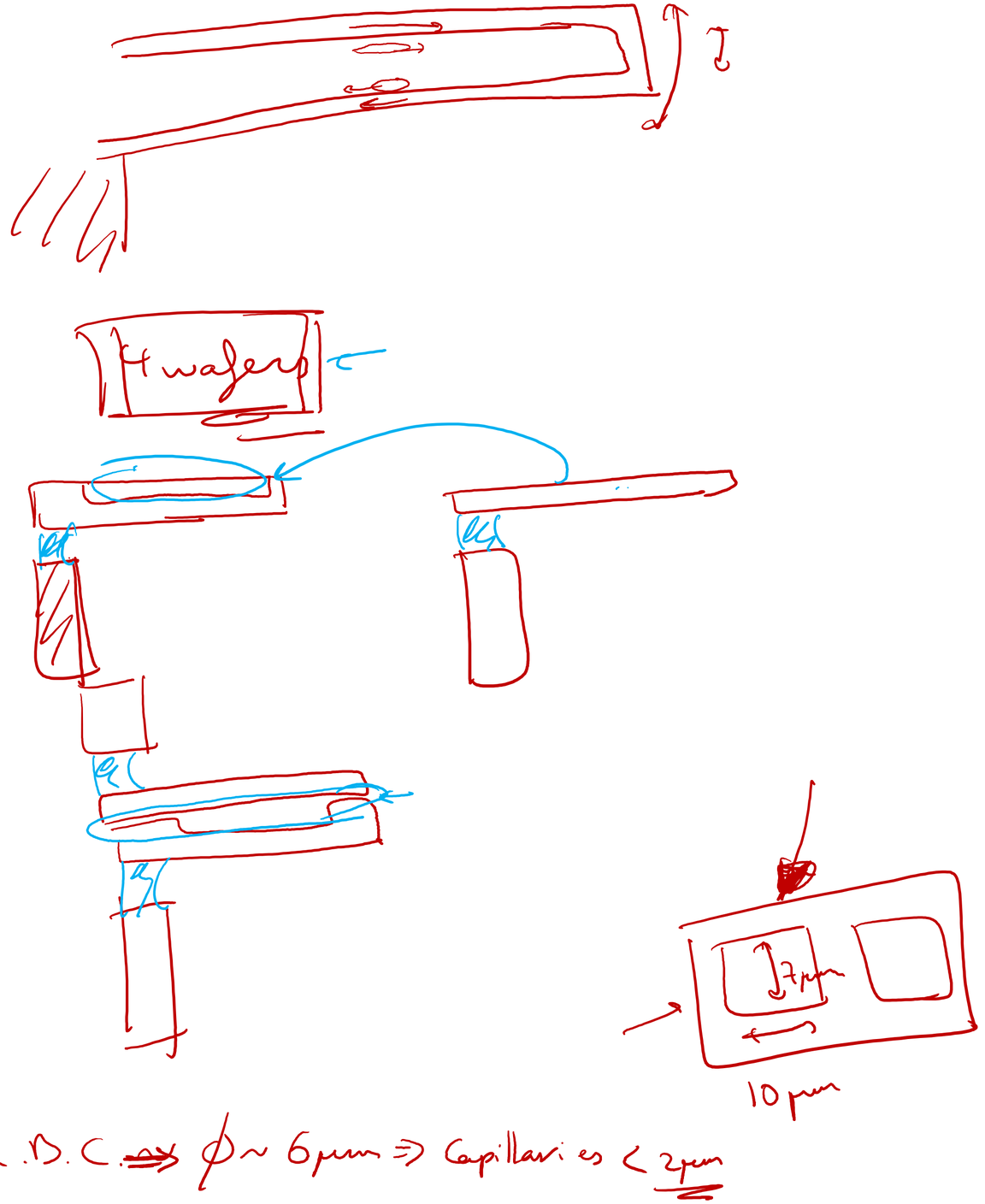
Questions

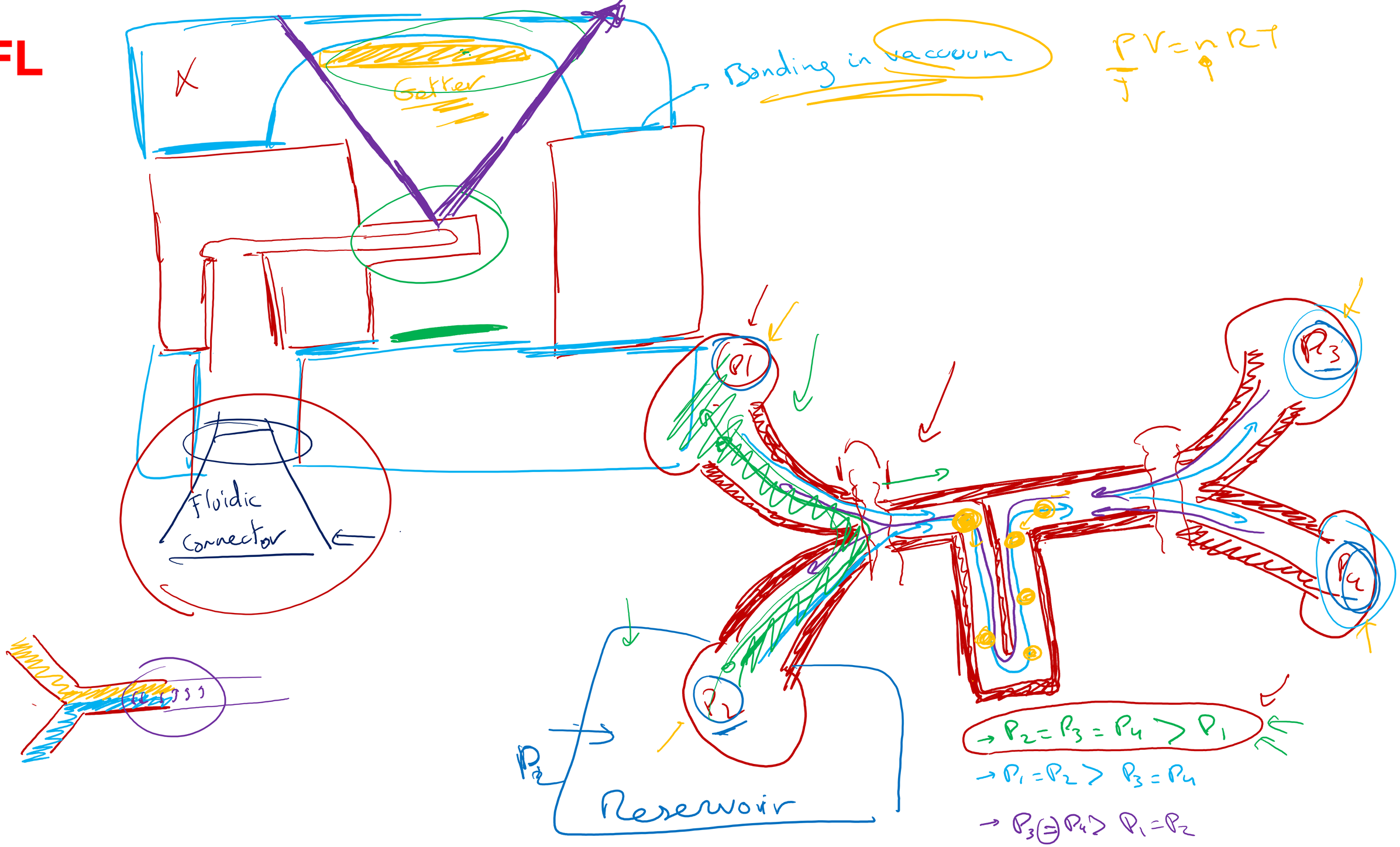
- What is the main characteristic of these devices?
- How are the devices made? Isn't it very expensive? What is a getter?
- How are the devices actuated and detected?
- How fast is the liquid flowing?
- Is there a problem with viscous fluids, with capillary forces, with turbulence?
- What is that "alpha" parameter in the mass responsivity?
- Why is there an 8% dispersion due to the position? How to avoid it?
- Differences between in-flow and attachment solutions
- Can we use this as a Coriolis-force sensor?

Discussion

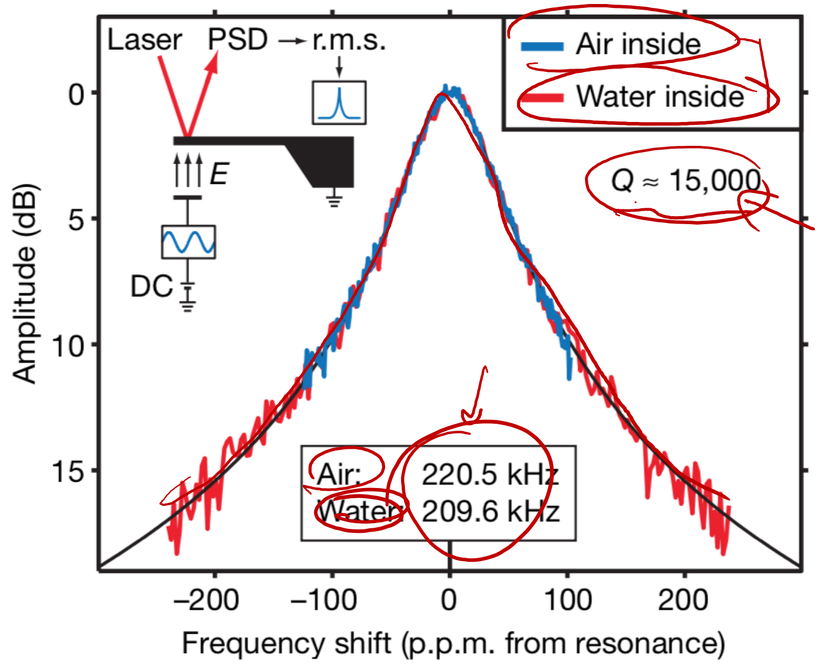




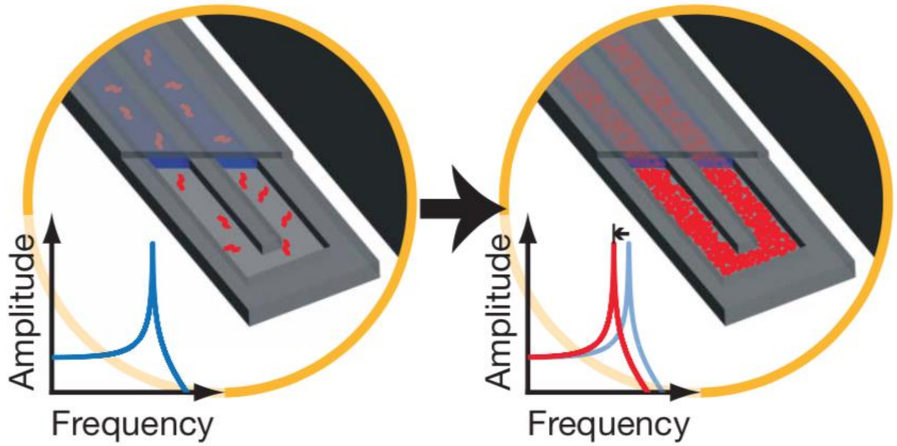


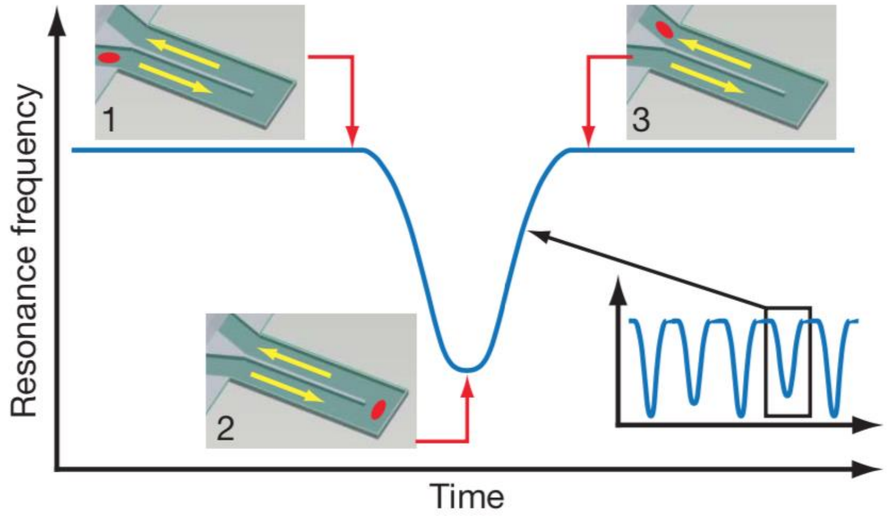

Getter
Bonding in vacuum
PV=nRT
Fluidic Connector
P1
P3
P4
P2
Reservoir
→ P2 = P3 = P4 > P1
→ P1 = P2 > P3 = P4
→ P3 (=) P4 > P1 = P2

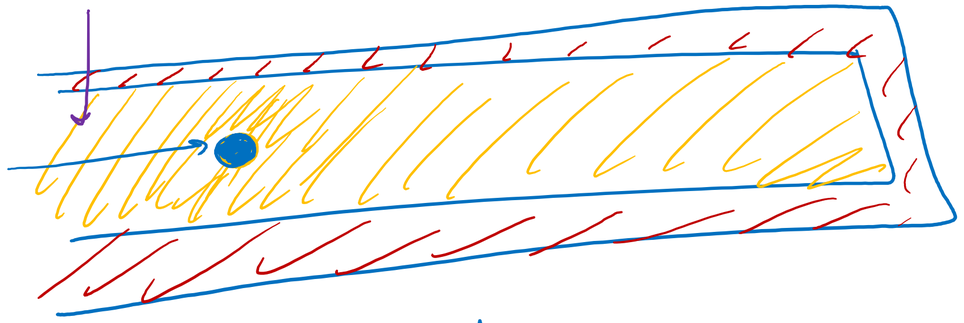
Discussion

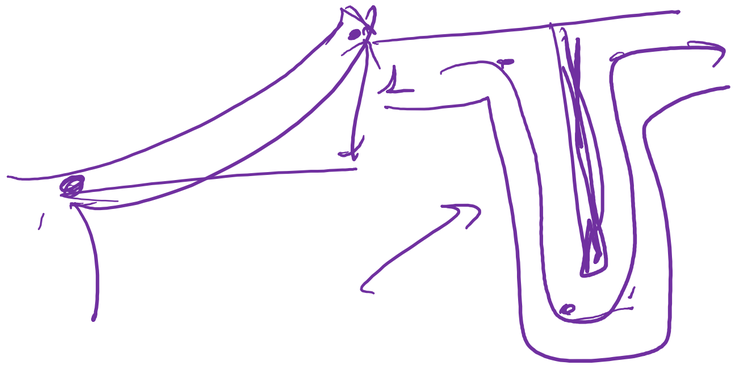

Laser
PSD
r.m.s.
E
DC
Air inside
Water inside
Q ≈ 15,000
Air: 220.5 kHz
Water: 209.6 kHz
Amplitude (dB)
0
5
10
15
–200
–100
0
100
200
Frequency shift (p.p.m. from resonance)

Discussion


Amplitude
Frequency
Amplitude
Frequency


Resonance frequency
Time
1
2
3



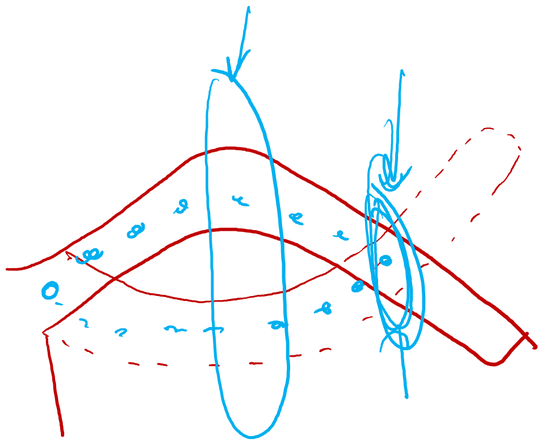


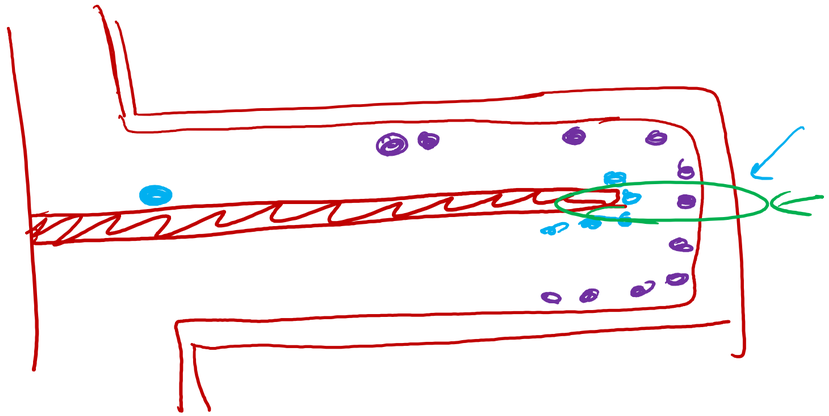
$$m_{eff} = \int_{n.} \phi_n^2 \cdot dm$$

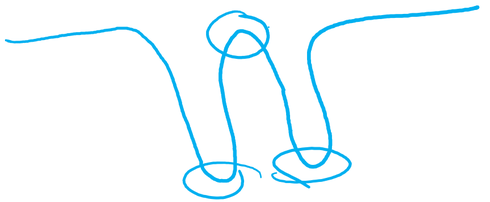
$$m_{eff} = \int_{Si} \rho_{Si}\, \phi_n^2 \cdot dV + \int_{WATER} \rho_{WATER} \cdot \phi_n^2 \cdot dV + \int_{V_{part.}} (\rho_{part.} - \rho_{WATER})\, \phi_n^2 \cdot \delta(x) \cdot dV$$

$m_{eff,\,no\,particle}$

$$(\rho_{part} - \rho_{water})\, \phi_n^2(x_{part.}) \cdot V_{part.}$$







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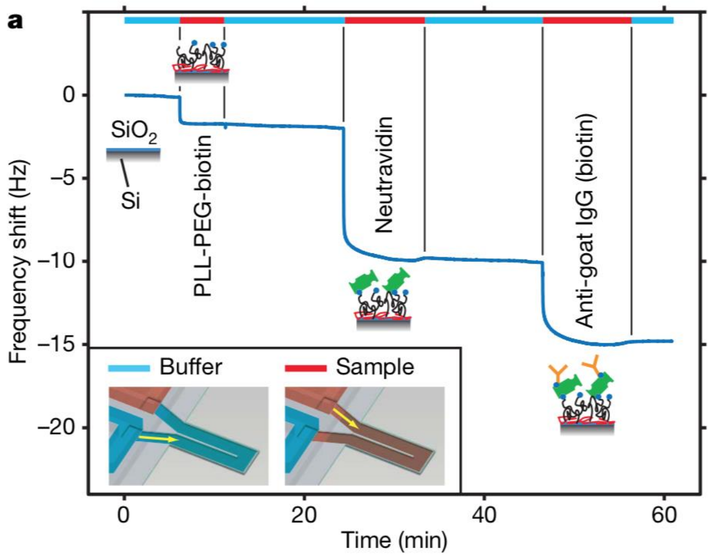
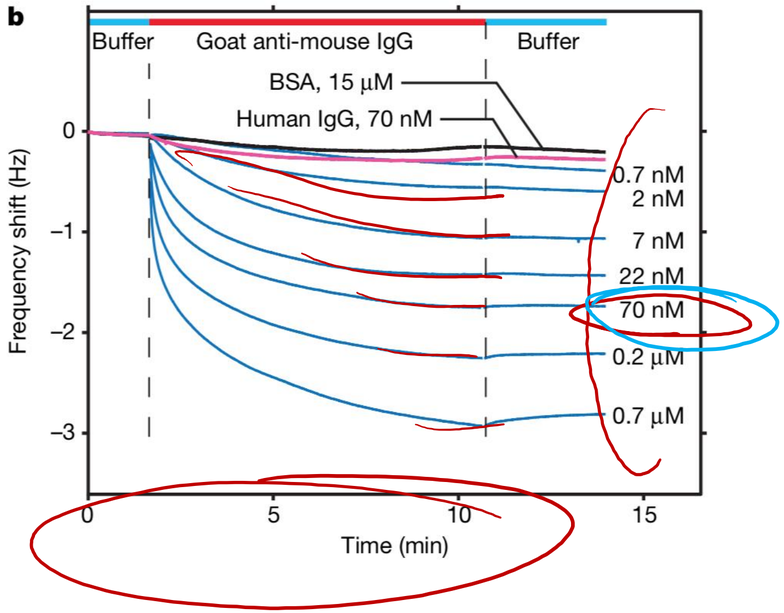
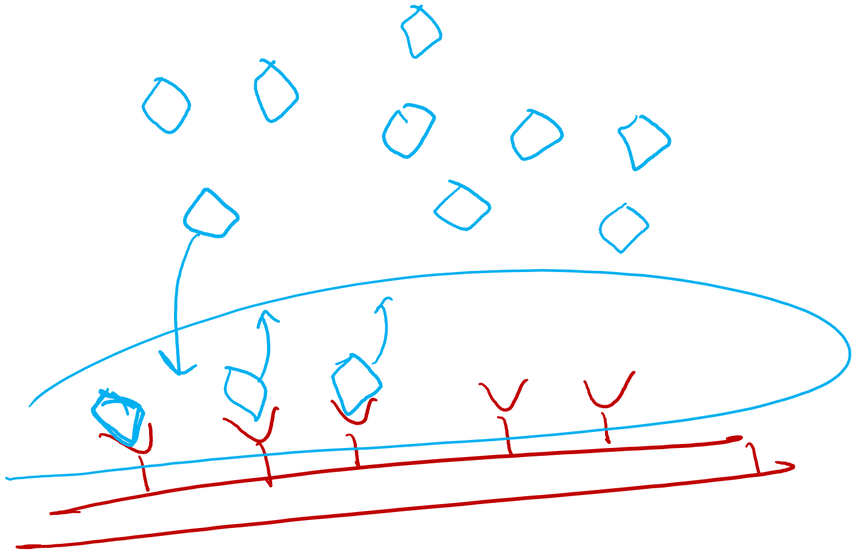

a
0
−5
−10
−15
−20
Frequency shift (Hz)
SiO2
Si
PLL-PEG-biotin
Neutravidin
Anti-goat IgG (biotin)
Buffer
Sample
0
20
40
60
Time (min)


b
Buffer
Goat anti-mouse IgG
Buffer
BSA, 15 µM
Human IgG, 70 nM
0.7 nM
2 nM
7 nM
22 nM
70 nM
0.2 µM
0.7 µM
0
−1
−2
−3
Frequency shift (Hz)
0
5
10
15
Time (min)



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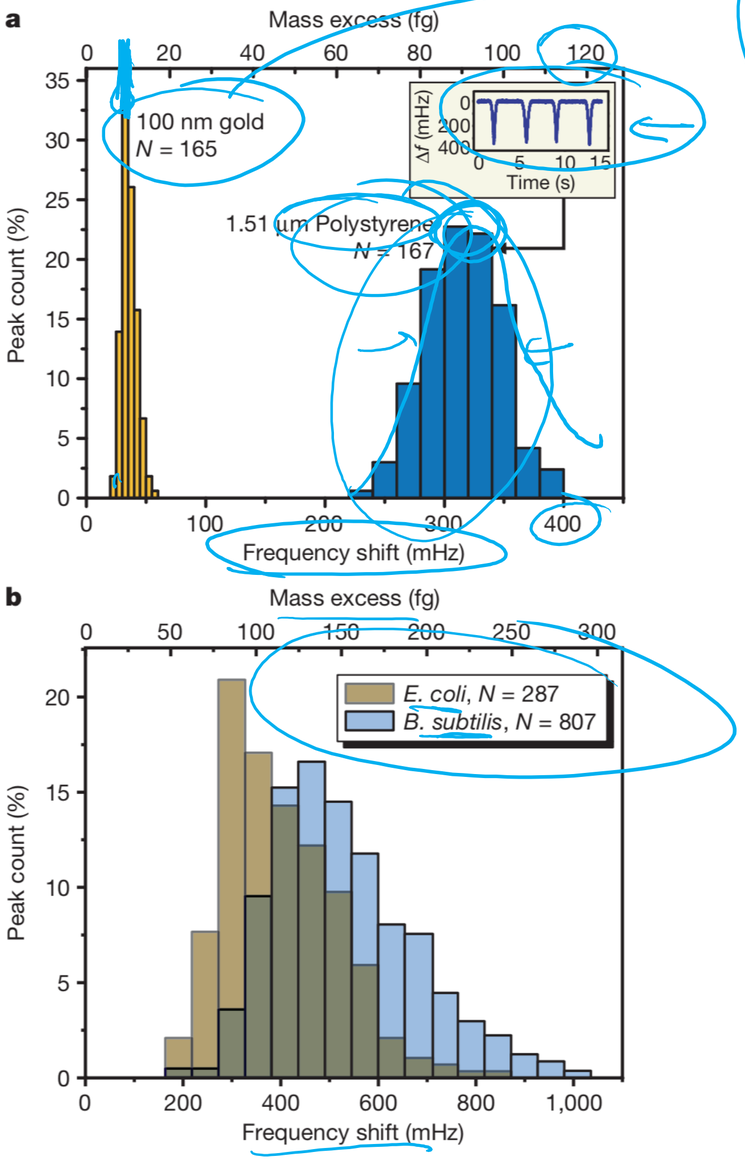
a
Mass excess (fg)
0
20
40
60
80
100
120
35
30
25
20
15
10
5
0
Peak count (%)
100 nm gold
N = 165
1.51 μm Polystyrene
N = 167
Δf (mHz)
0
200
400
0
5
10
15
Time (s)
0
100
200
300
400
Frequency shift (mHz)
b
Mass excess (fg)
0
50
100
150
200
250
300
20
15
10
5
0
Peak count (%)
E. coli, N = 287
B. subtilis, N = 807
0
200
400
600
800
1,000
Frequency shift (mHz)