Paper 7 – Discussion

ME-426 – Micro/Nanomechanical Devices

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Questions

- What devices are studied? How are they made?
- How are the devices actuated and detected?
- What techniques could be used to extract Q?
- Why is Q lower for high stress than for low stress?
- Why do we see a limit for very thin devices?

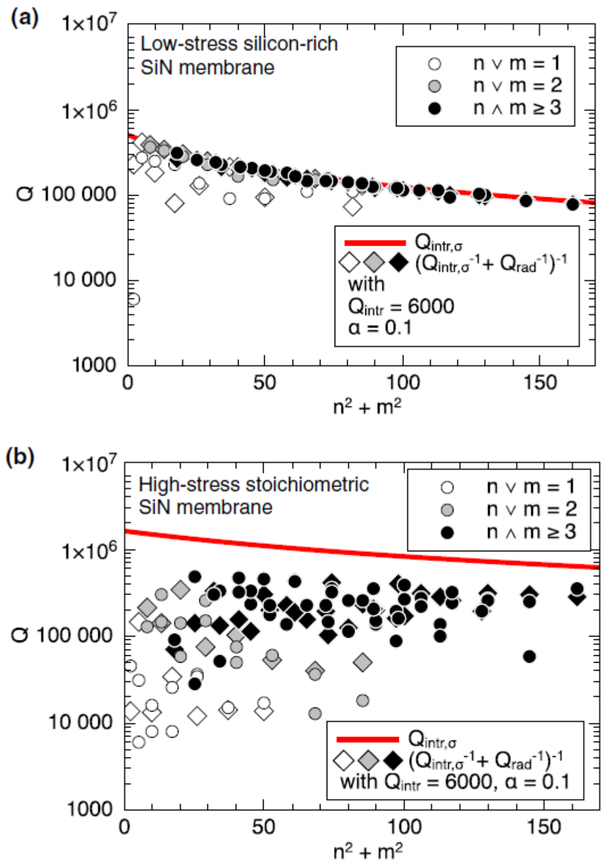
Discussion

Discussion

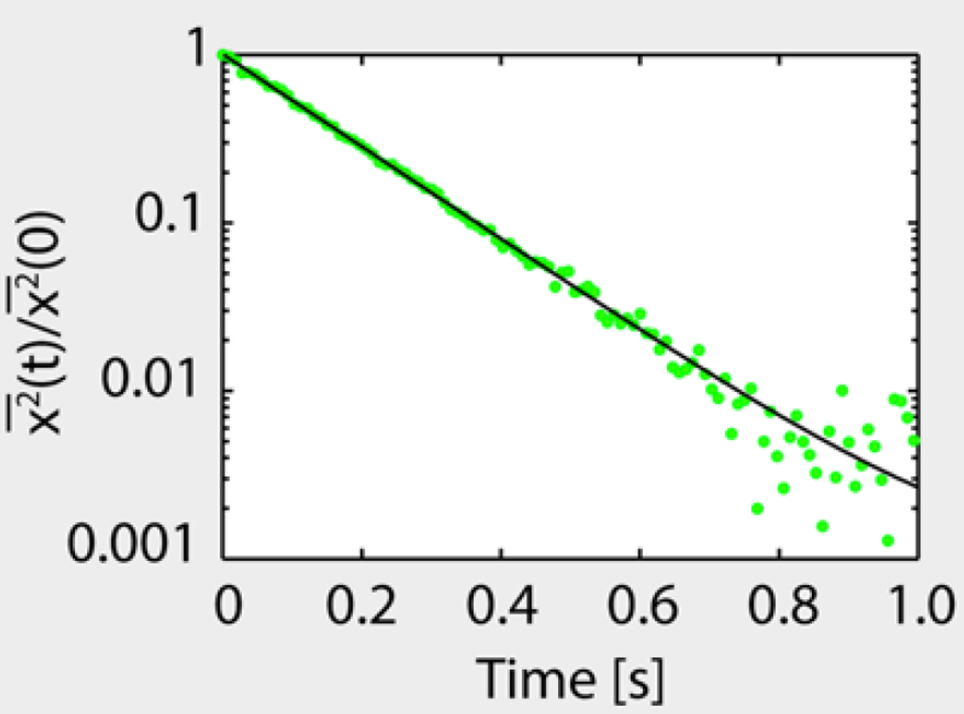
$$Q_{\text{intr},\sigma} \approx Q_{\text{intr}}\left[2\lambda + (n^2 + m^2)\pi^2\lambda^2\right]^{-1}$$

$$Q_{\text{rad}} \approx 1.5\alpha\frac{\rho_s}{\rho_r}\eta^3\frac{n^2m^2}{(n^2+m^2)^{3/2}}\frac{L}{h} \qquad \eta \approx \sqrt{(E_s/\sigma)(\rho_r/\rho_s)}$$

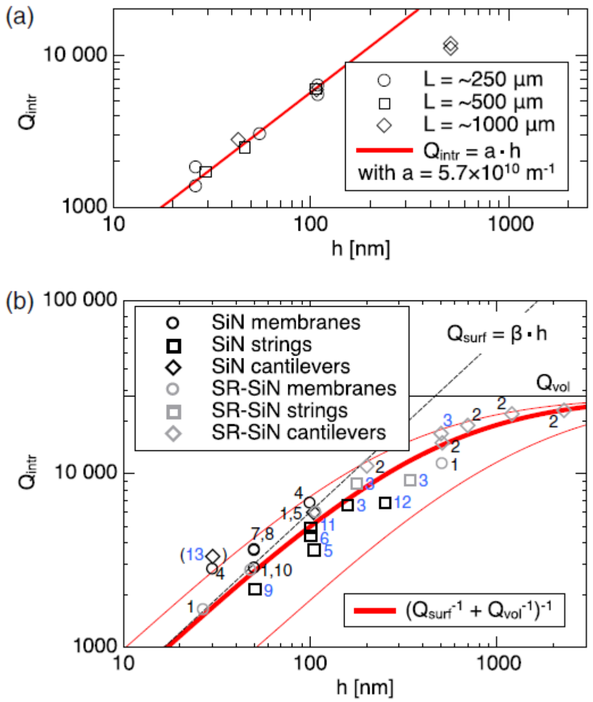
Discussion


(a)
Low-stress silicon-rich
SiN membrane
n ∨ m = 1
n ∨ m = 2
n ∧ m ≥ 3
Q_intr,σ
(Q_intr,σ^-1 + Q_rad^-1)^-1
with
Q_intr = 6000
α = 0.1
Q
1×10^7
1×10^6
100 000
10 000
1000
0
50
100
150
n^2 + m^2
(b)
High-stress stoichiometric
SiN membrane
n ∨ m = 1
n ∨ m = 2
n ∧ m ≥ 3
Q_intr,σ
(Q_intr,σ^-1 + Q_rad^-1)^-1
with Q_intr = 6000, α = 0.1
Q
1×10^7
1×10^6
100 000
10 000
1000
0
50
100
150
n^2 + m^2

Discussion



Discussion


(a)
10 000
1000
Q_{intr}
10
100
1000
h [nm]
L = ~250 µm
L = ~500 µm
L = ~1000 µm
$Q_{intr} = a \cdot h$
with $a = 5.7 \times 10^{10}$ m^{-1}
(b) 100 000
10 000
1000
Q_{intr}
10
100
1000
h [nm]
SiN membranes
SiN strings
SiN cantilevers
SR-SiN membranes
SR-SiN strings
SR-SiN cantilevers
$Q_{surf} = \beta \cdot h$
Q_{vol}
$(Q_{surf}^{-1} + Q_{vol}^{-1})^{-1}$

Discussion