

Mirrors for optical levitation and my future plan

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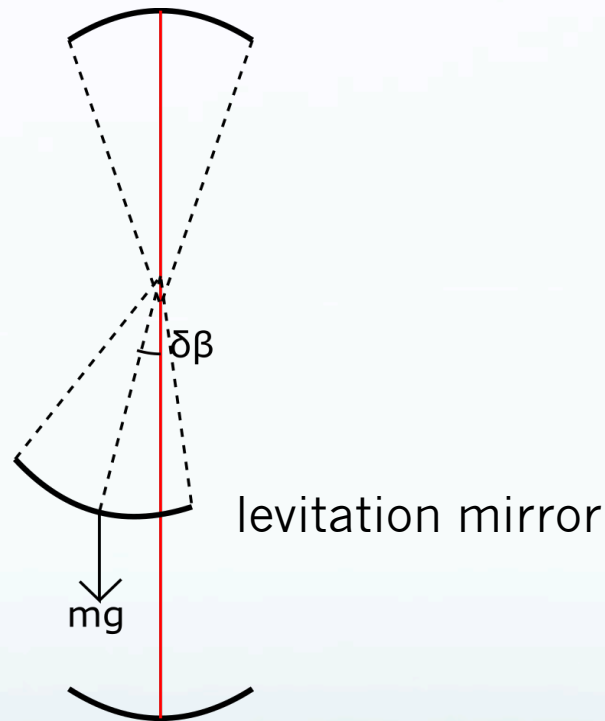
The objective and the background

- The objective of my study
 - To make mirrors for optical levitation and evaluate them
- The background of the study
 - To explore macroscopic quantum mechanics on the mg scale
 - Optical levitation will make it possible

Requirements

- Requirements on mirrors for optical levitation
 - diameter: $d \sim 3\text{mm}$
 - mass: $m \sim 1.6\text{mg}$
 - reflectance: $r > 99.95\%$ (@ $\lambda = 1064\text{nm}$)
 - radius of curvature: $R \sim -30\text{mm}$

Requirements on RoC



$$\delta N_{\beta} = mgR\delta\beta \Rightarrow R < 0$$

Requirements on reflectance

- Balance between gravity and the radiation pressure

$$mg = \frac{2P_{circ}}{c} = \frac{2P_{in}}{c\mathcal{T}}$$

- When $P_{in} = 1W$

$$\mathcal{T} = 0.043\% \quad \therefore r > 99.95\%$$

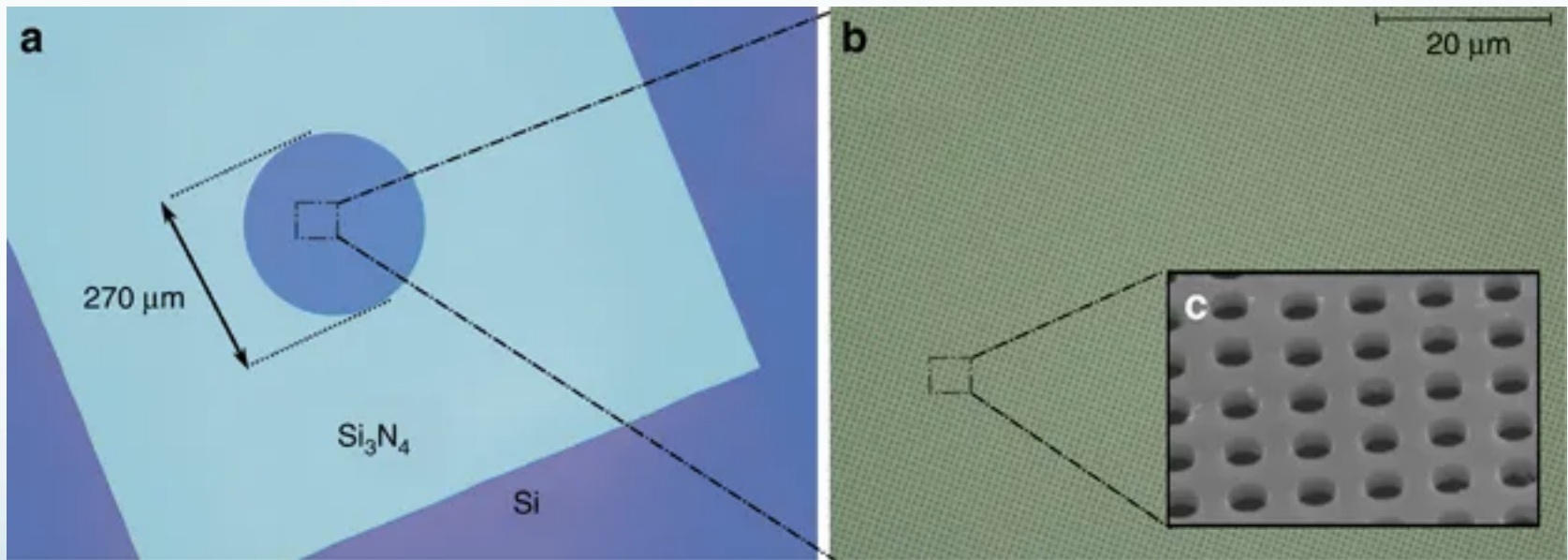


Candidates of such mirror

1. Photonic crystal
and
2. high reflectance coating

Photonic crystal

- High reflectance and effective RoC by making holes in Si_3N_4 membrane



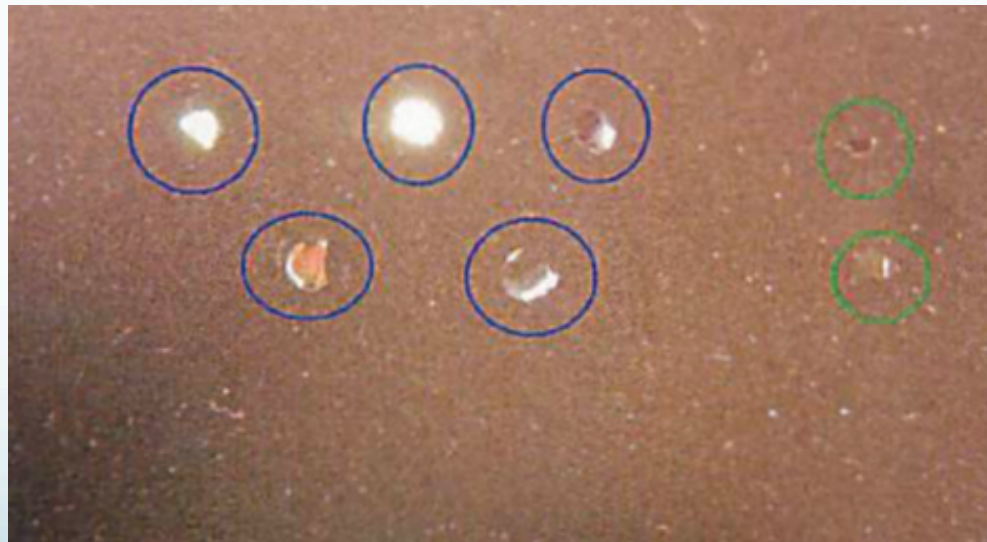
X. Chen+ Light: Science & Applications 6, e16190 (2017)

Values of r and RoC

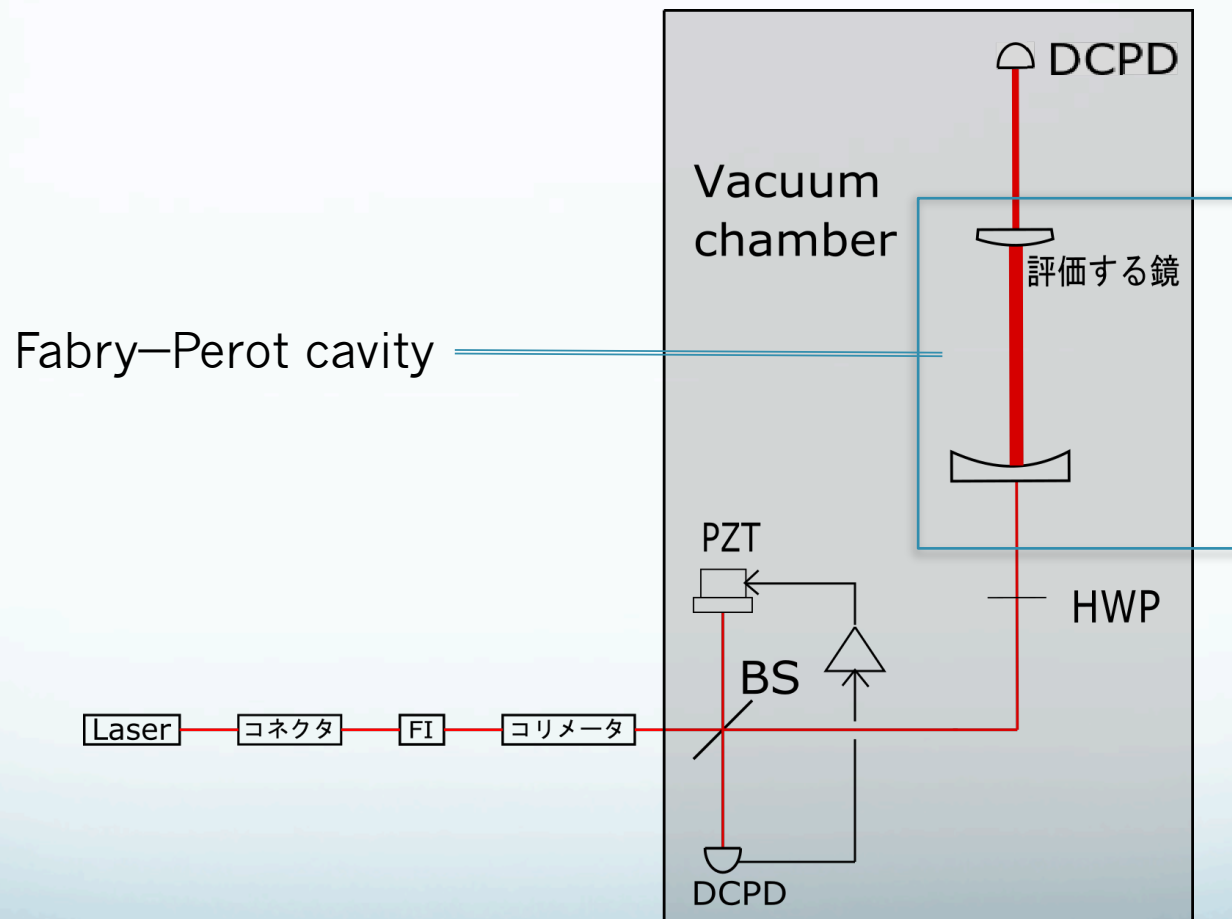
thesis	r	RoC
D. Friedrich+ Optics Express 19, 14955	99.2% ($\lambda = 1064$ nm)	
X. Chen+ Light: Science & Applications 6, e16190 (2017)	99.9470 \pm 0.0025% ($\lambda = 1$ μ m)	
D. Fattal+, Nature Photonics 4, 466 (2010)	80~90%	20 \pm 3 mm
M. S. Seghilani+, Optics Express 22, 5962 (2014)	>99%	20 mm

High reflectance coating

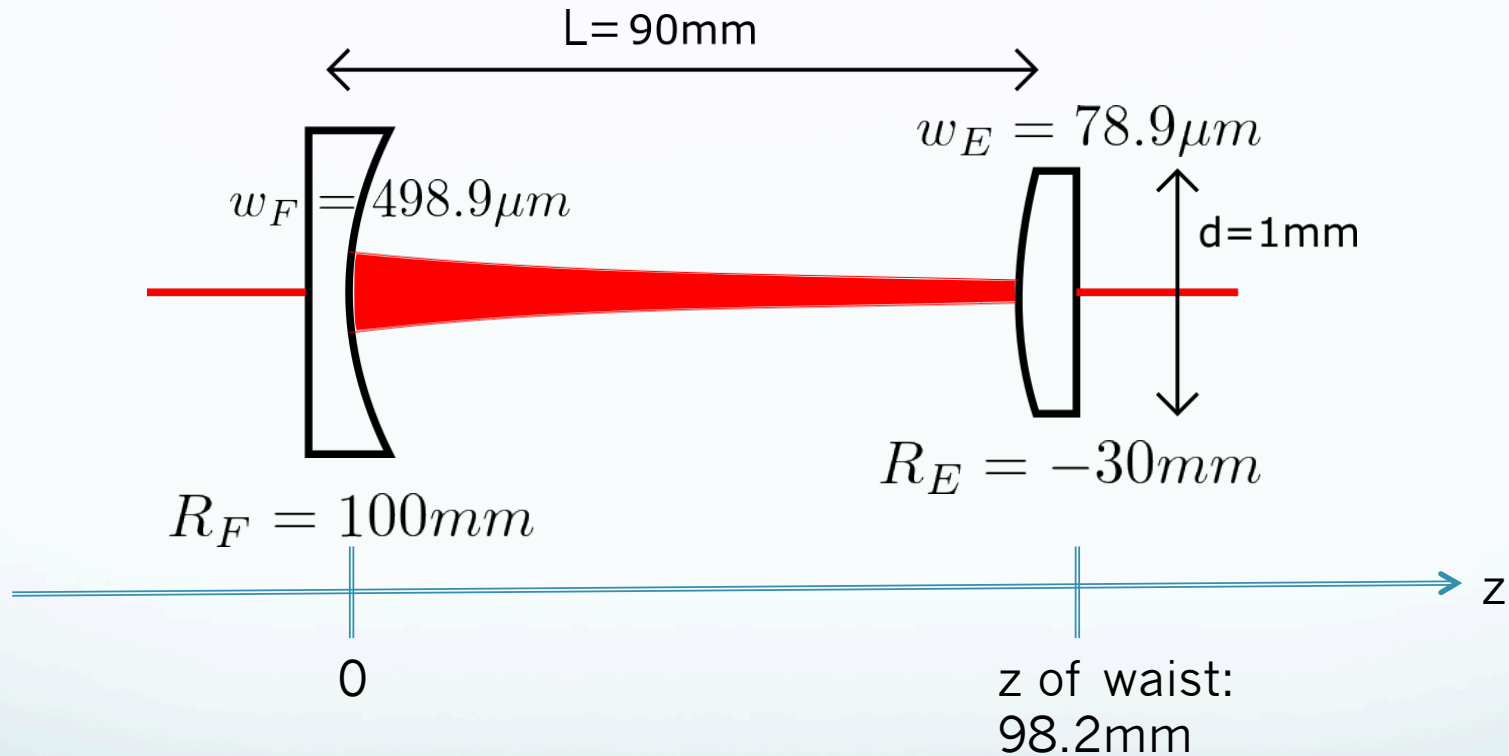
- So far, mirror cracks because of coating stress
- Proposal: coating on **flat** mirrors and making RoC by controlling the stress of coating



Setup for evaluation



Design parameters of cavity



w: beam radius

R: radius of curvature of the mirror

Requirements on cavity

- The stability of the cavity

$$g_F = 0.1, g_E = 4.0 \quad \therefore 0 < g_F g_E < 1$$

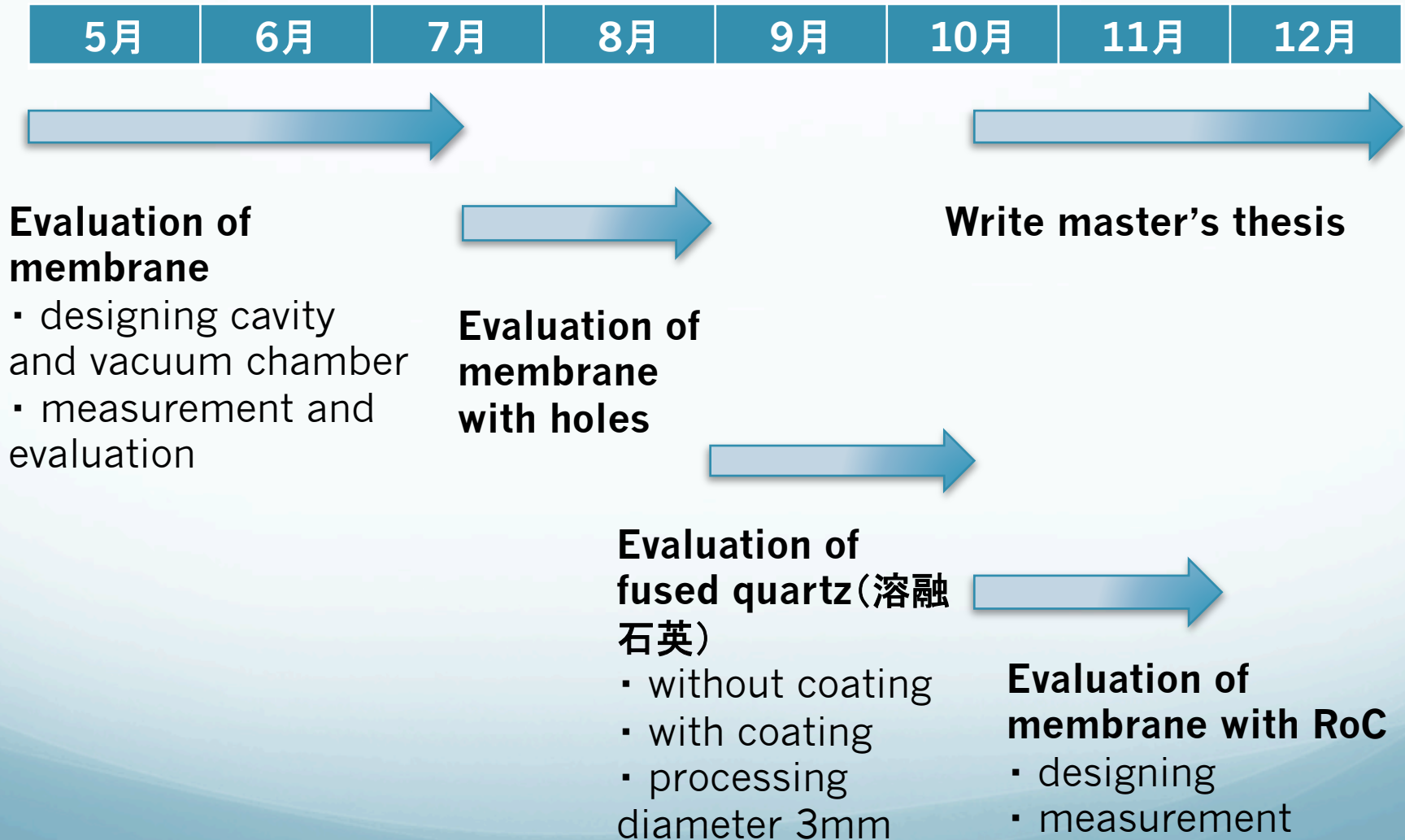
- To prevent higher modes resonating

$$\frac{FSR}{TMS} = 3.54$$

- Loss of the end mirror $\ll 0.05\%$

$$L = \exp\left[-2\left(\frac{d/2}{w_E}\right)^2\right] = 1.26 \times 10^{-35}$$

Schedule





Thank you for watching