[CK-P.7]

Demonstration of wavelength tuning of silica toroid microcavity via additional laser reflow

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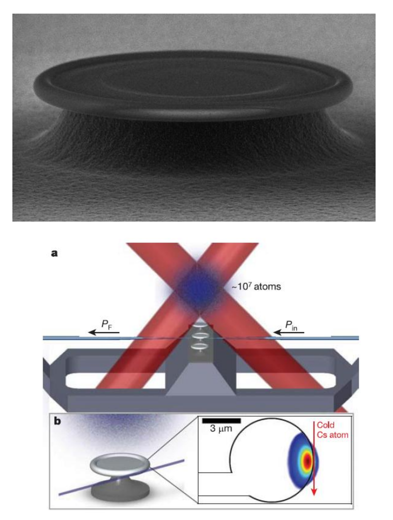
Abstract

We demonstrate resonant wavelength tuning of silica toroid microcavity by performing additional laser reflow. Resonant wavelength shift of 160 pm was observed in our experiment.

Background: *Silica toroid microcavity*



T. Aoki *et al.*, Nature **443**, 671 (2006).

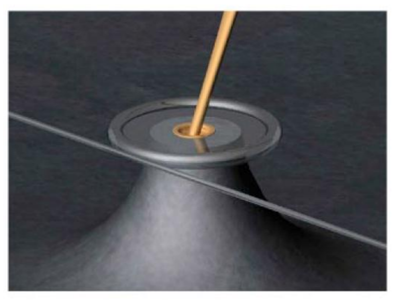
Silica toroid microcavity

- Ultra high quality factor ($Q > 10^8$).
- Possible to fabricate on a chip.
- **Prominent candidate for nonlinear optics and single photon devices.**

Application: *Cavity Quantum Electrodynamics*

- Requires accurate matching of cavity resonance and resonance of single atom.
- **Cavity resonance tuning method is required.**

Background: *Wavelength tuning*



Wavelength tuning by TO effect

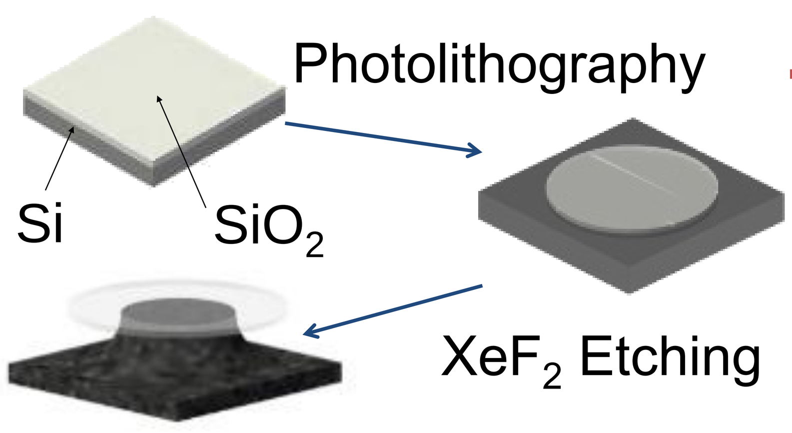
- Metal heater induces refractive index change.
- Repeatable wavelength tuning is possible.
- **However, it is not a permanent uning.**

D. Almani *et al*., Appl. Phys. Lett. **85**, 5439 (2004).

Objective of this study:

Developing a method of permanent resonance tuning of silica toroid microcavity based on additional laser reflow.

Principle: *Fabrication of disk cavity*



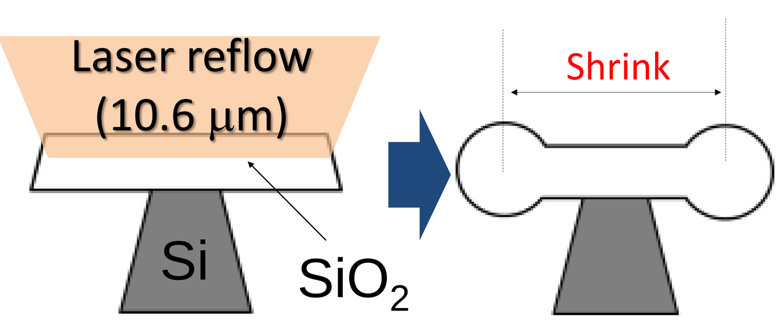
Photolithography

By performing photolithography on SOI substrate, SiO_2 pad is fabricated on a Si chip

XeF_2 etching

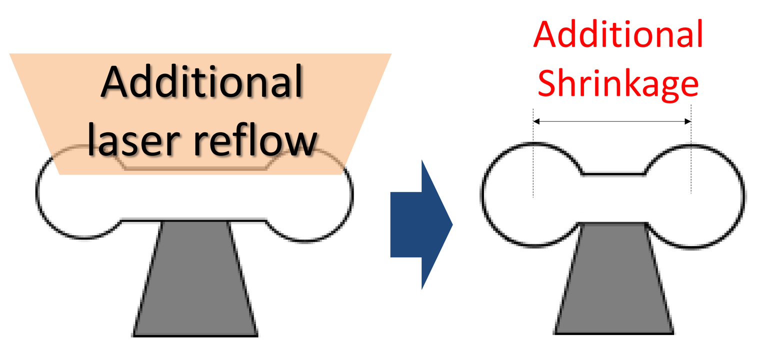
By performing isotropic XeF_2 Etching, Si is undercutted and SiO_2 disk cavity is formed.

Principle: *Laser reflow & Wavelength tuning*



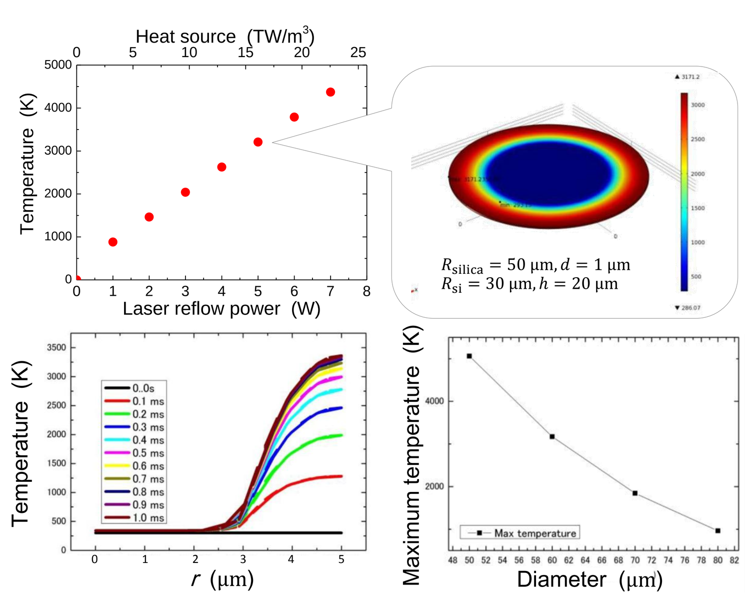
Laser reflow process

- Absorption in 10.6 μm: SiO_2 >> Si.
- Thermal conductivity: SiO_2 << Si.
- **Only silica disk is heated and toroid shape is formed.**



Additional laser reflow

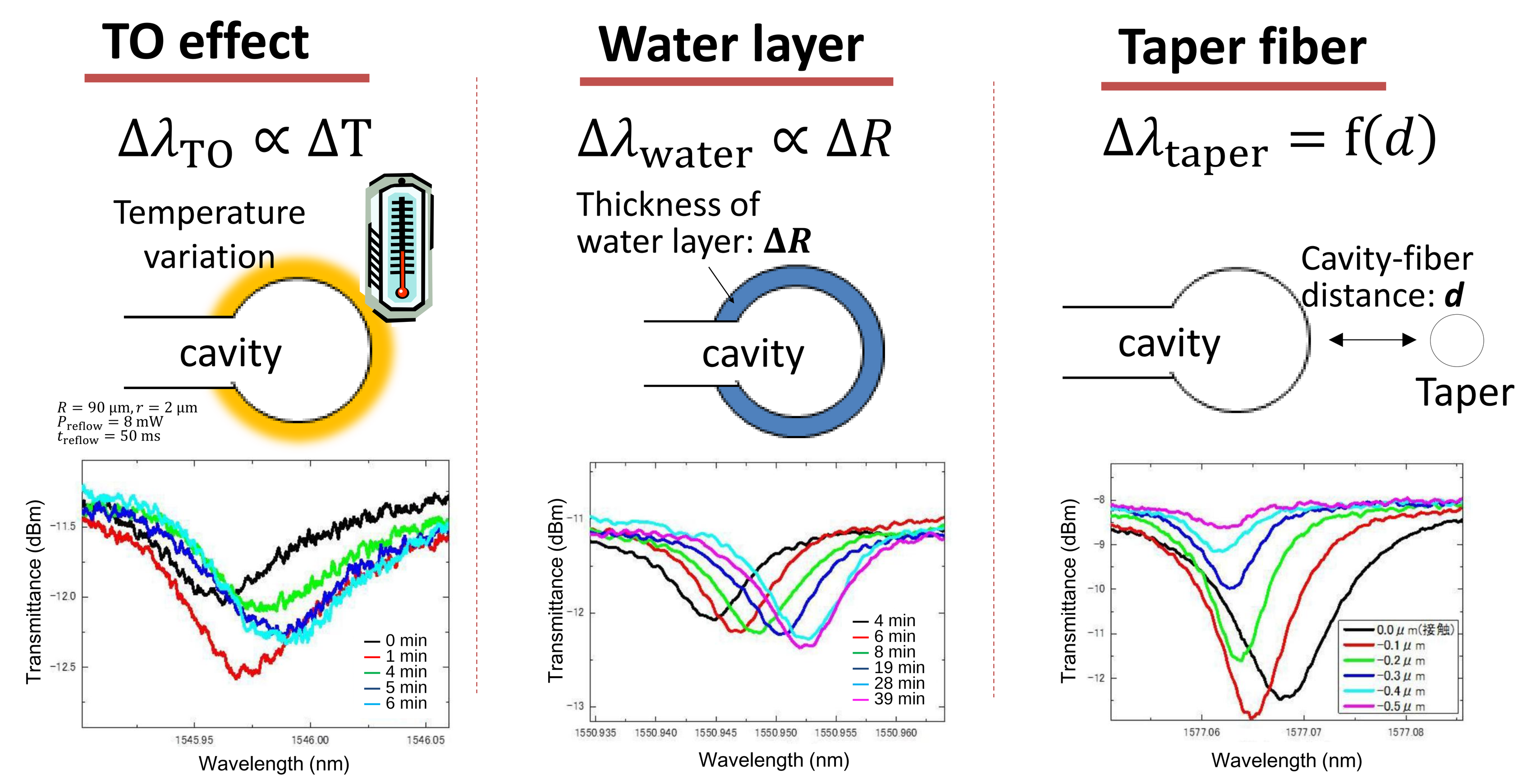
- Additional laser reflow induce additional shrinkage.
- **Shrinkage results resonant wavelength shift.** $\lambda_m = 2\pi n R / m$



Laser reflow condition

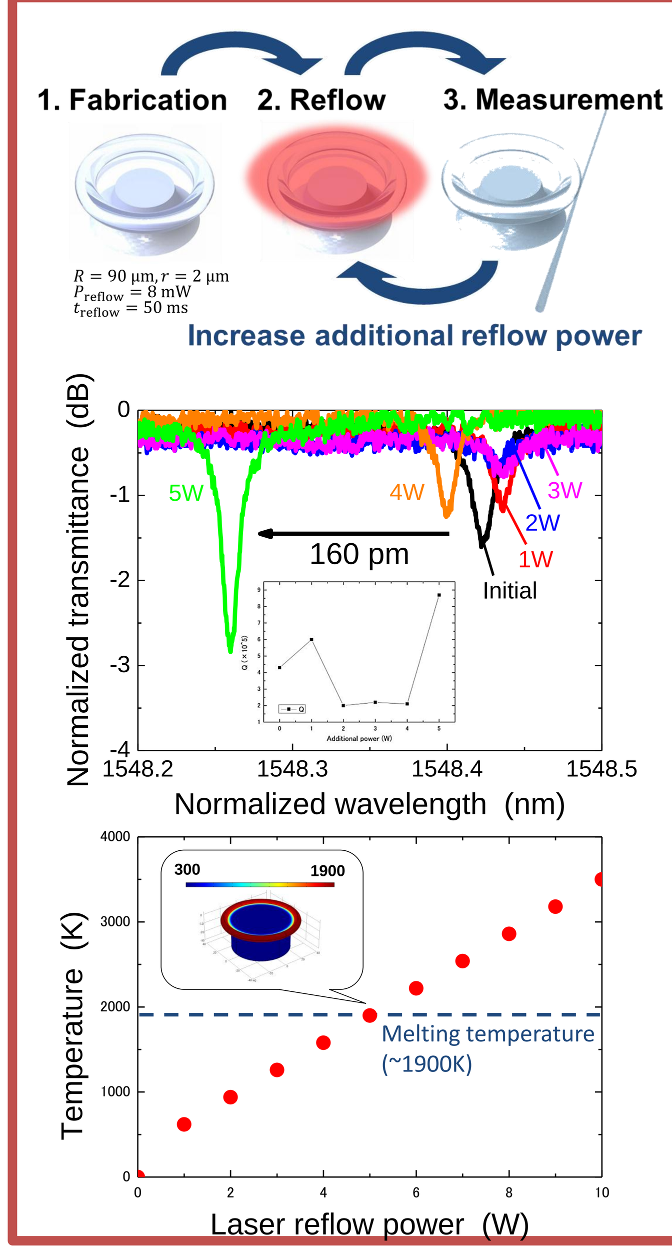
- Calculated maximum temperature by using FEM (COMSOL multiphysics).
- Maximum temperature greatly depends on reflowpower.
- **"Reflow power" is the key for post-processing.**

Result: *Influences of noises*



Maximum wavelength shift from other sources are less than 30 pm.

Result: *Wavelength tuning*



Experimental procedure

1. Fabricating silica toroid microcavity.
2. Performing additional laser reflow.
3. Measuring wavelength shift.
4. Back to 2. with increased reflow power.

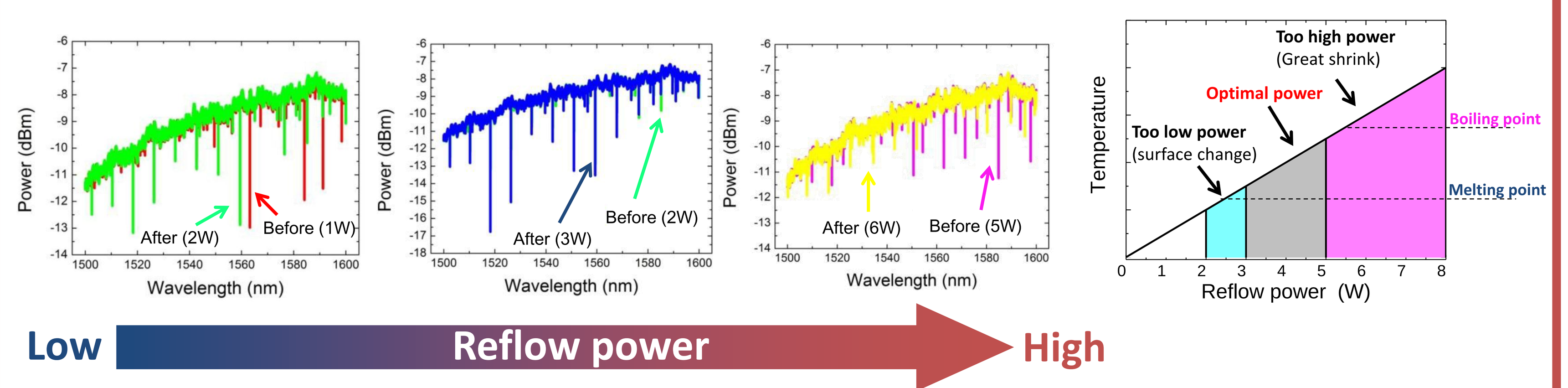
Observation of blue shift

- When additional reflow with 5W power is performed, wavelength shifts **~160 pm**.
- **Resonant wavelength tuning based on additional laser reflow is achieved.**

Numerical analysis

- Result of FEM simulation shows that temperature during laser reflow of 5W is on melting point.
- **Good agreement with experimental result.**

Discussion: *Controllability*



- **Too low power** : No shift and surface condition change
- **Too high power** : Too large structural change

Conclusion & Future works

Resonant wavelength blue shift of 160 pm was observed in silica toroid microcavity. Further optimization on additional reflow condition and suppression of noises are desired.

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