

The 12th Conference on Lasers and Electro-Optics Pacific Rim  
(CLEO-PR 2017)

2-1L-4 9:30 pm - 9:45 pm Aug. 2. 2017

# Demonstration of direct coupling between a toroid microcavity and a photonic crystal waveguide

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Keio Univ



# Background: Coupled optical cavity system

## Optical nano-microcavities

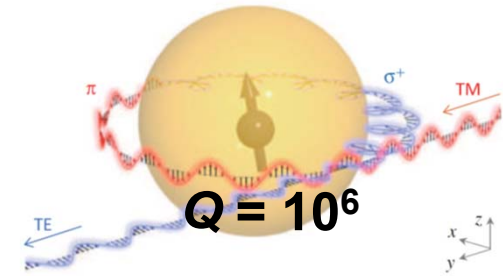
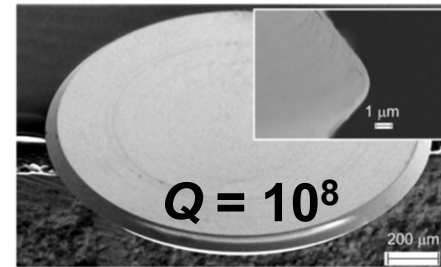
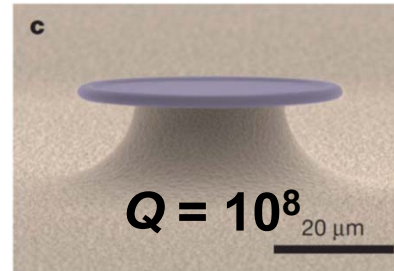
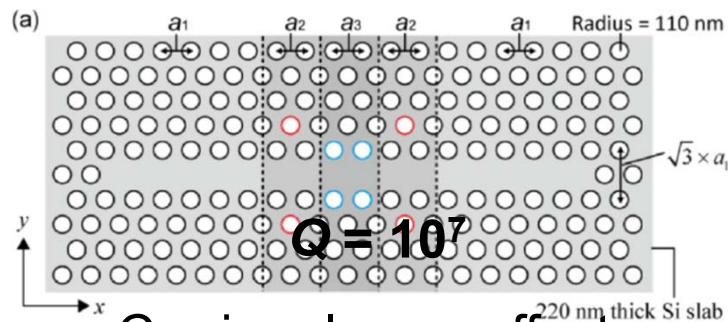
[1] Opt. Express **25**, 1769-77 (2017) [2] Nature **450**, 1214-7 (2007)  
 [3] PR B **74**, 245119 (2006) [4] PRL **117**, 123605 (2016)

Si PhC nanocavity [1]

Silica toroid microcavity [2]

LN WGM cavity [3]

YIG micro sphere cavity [4]



Carrier plasma effect  
(EO effect)

Kerr effect

Piezo-electric effect

MO effect

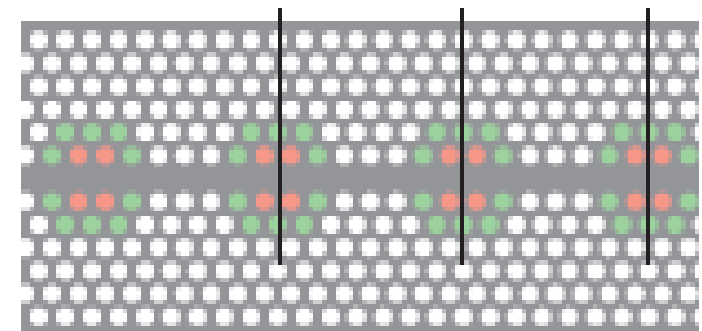
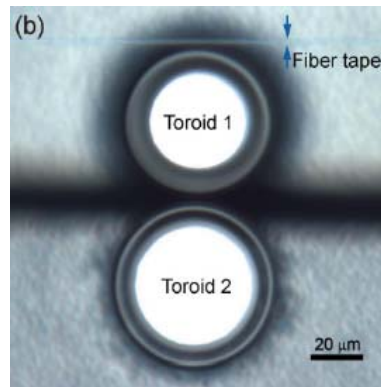
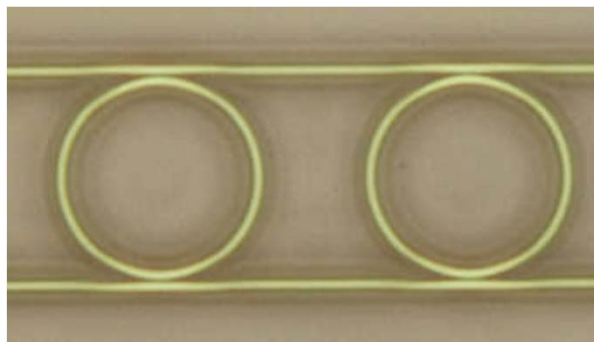
## Coupled optical cavities

[5] Nat. Phys. **3**, 406 - 410 (2007) [6] Opt. Express **20**, 18319-18325 (2012)  
 [7] Nat. Photon. **2**, 1741 - 747 (2008)

Si rings [5]

Silica toroids [6]

Si PhCs [7]



Bandwidth tuning

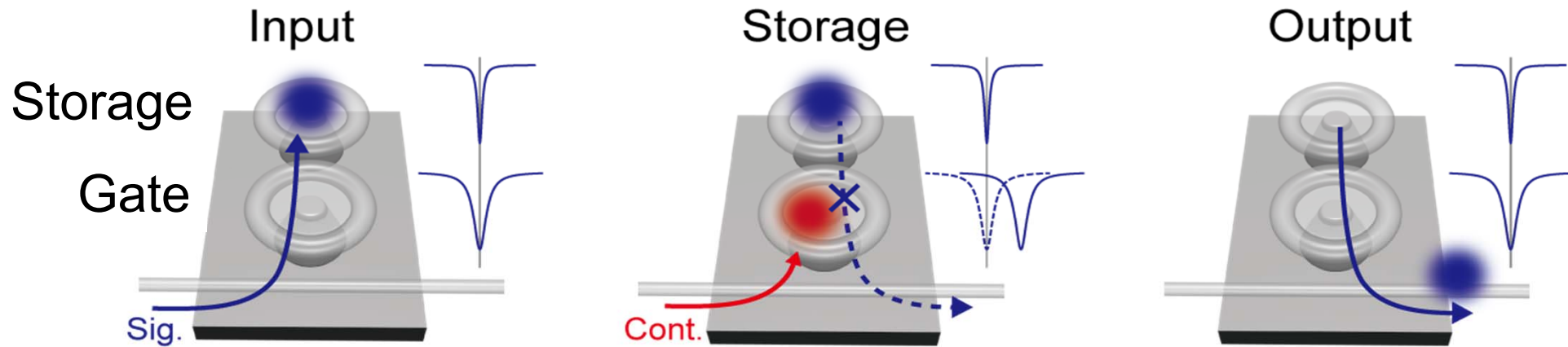
Optical isolation

Optical buffering



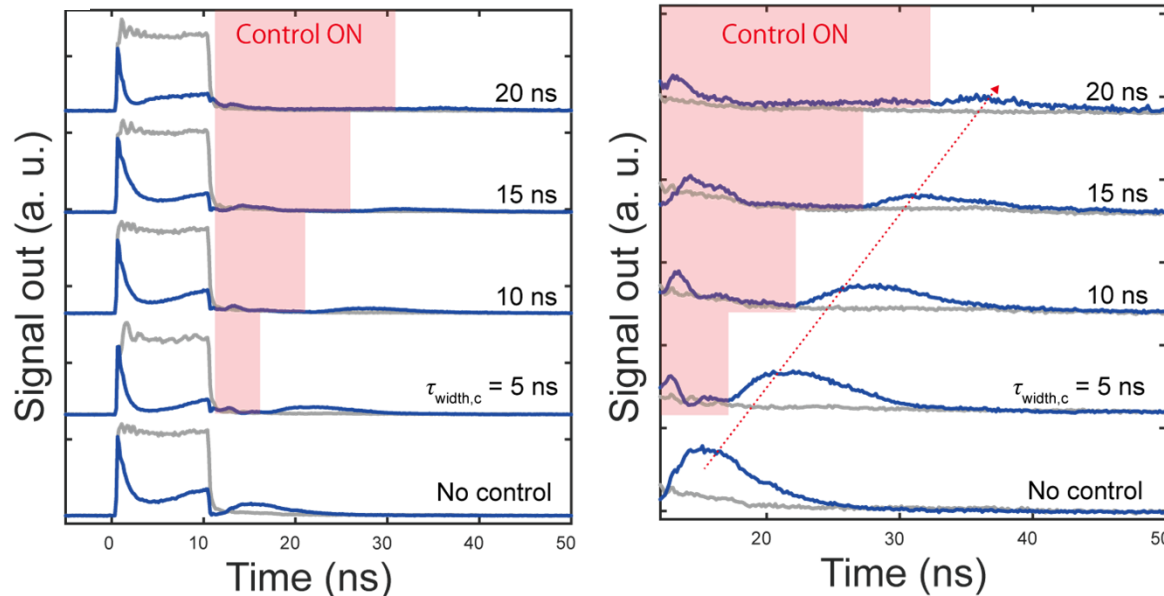
# Tunable optical buffer with coupled cavity system

## Schematic of operation



## Experimental result

### Expanded view



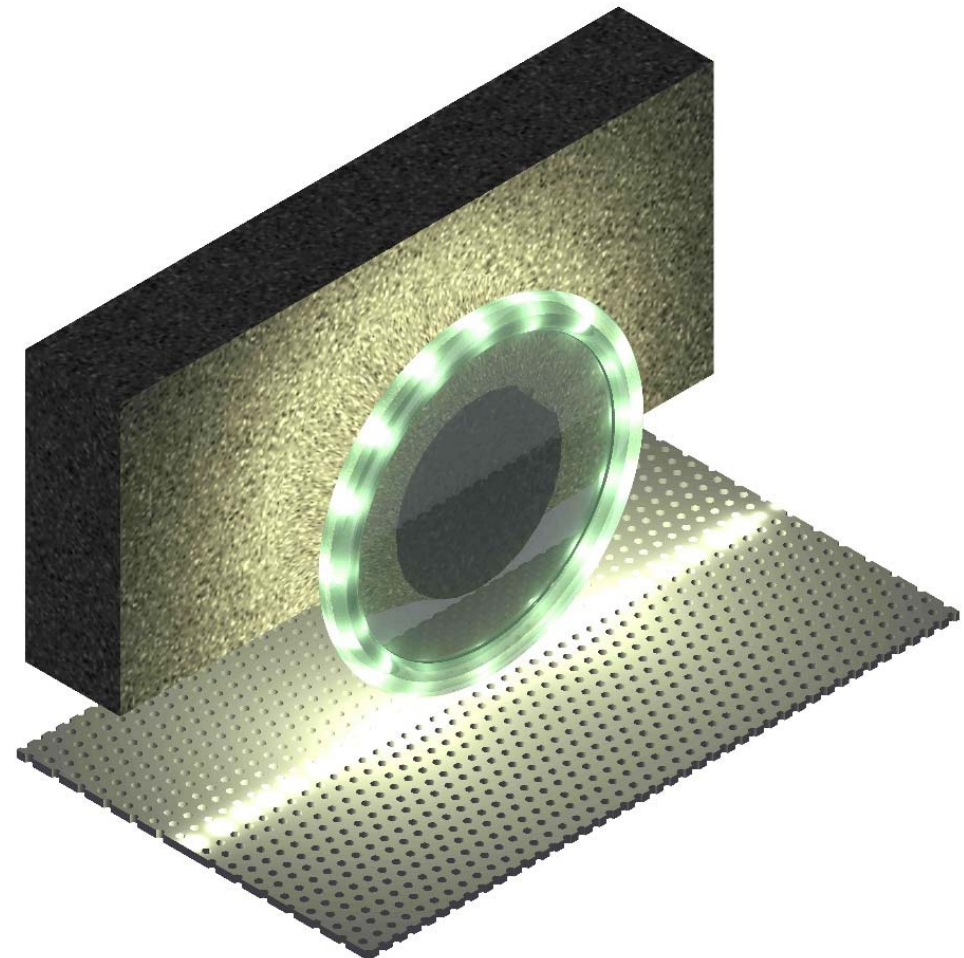
- ✓ Achieved **long buffering time of 20 ns**
- ✓ Can tune buffering time
- ✓ **Slow switching speed**



# Motivation

## Toward a hybrid system of silicon & silica microcavities

- ✓ Demonstrate direct coupling between a toroid microcavity & a PhC waveguide experimentally
- ✓ Quantify a possible coupling quality factor





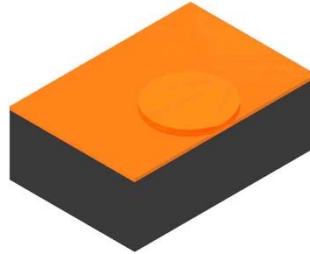
# Sample preparation

## Fabrication procedure

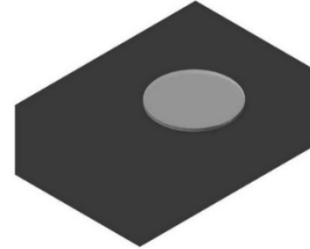
1. Resist application



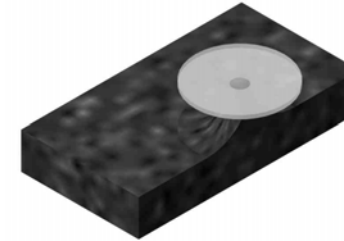
2. Dicing



3. Resist removal



4. XeF<sub>2</sub> etching



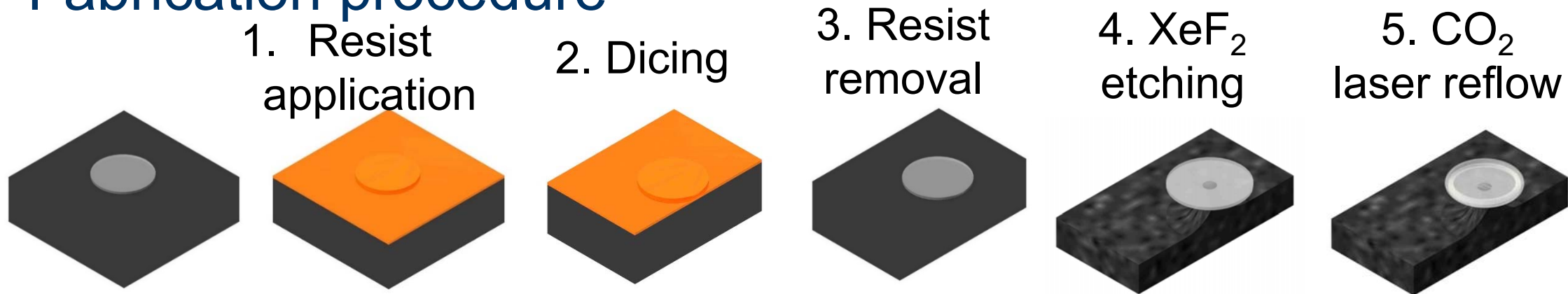
5. CO<sub>2</sub> laser reflow



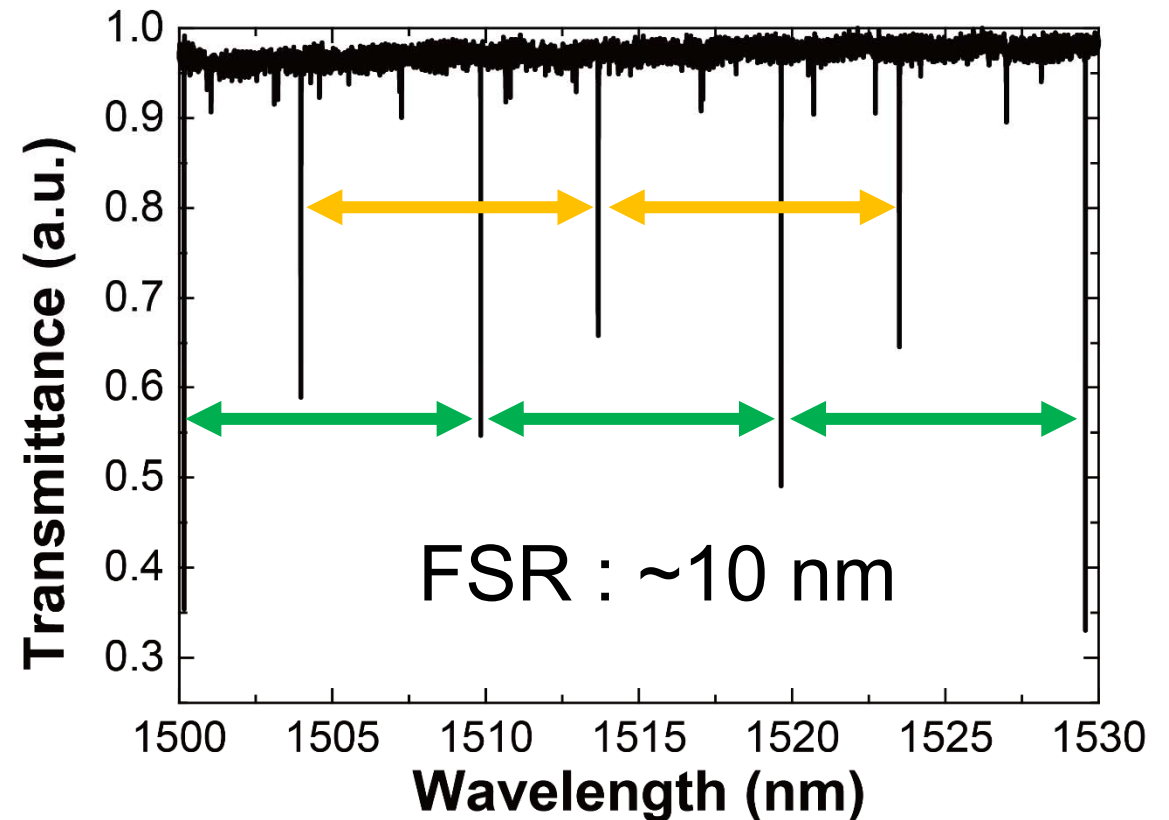
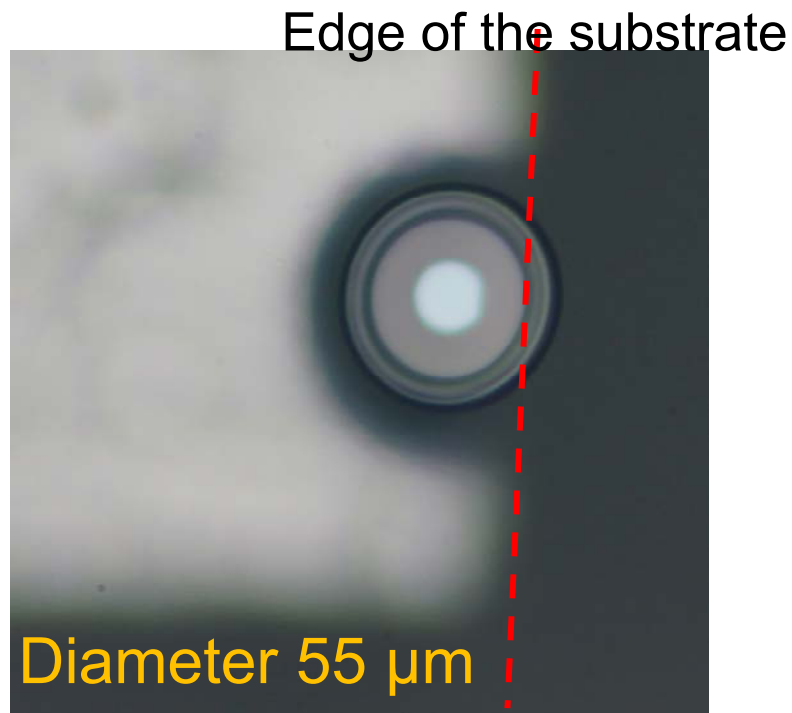


# Sample preparation

## Fabrication procedure



## Fabricated structure





# Sample preparation

## Fabrication procedure

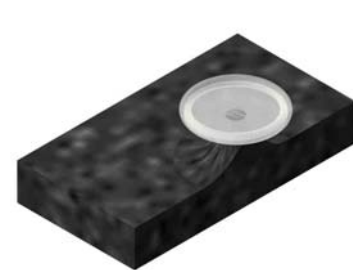
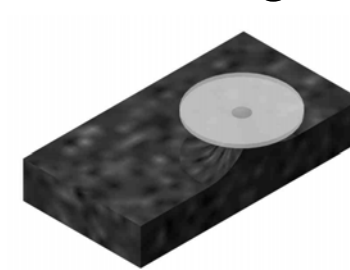
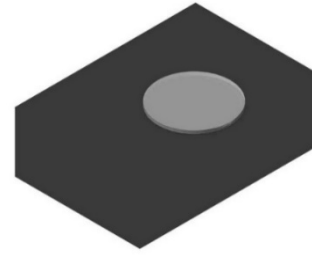
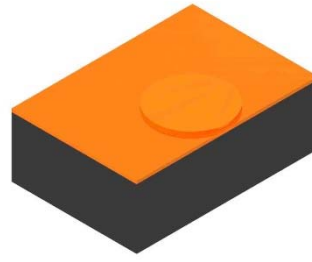
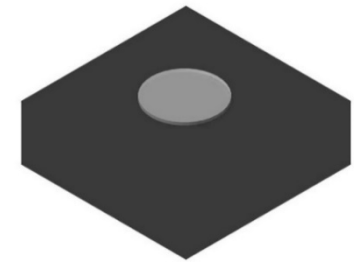
1. Resist application

2. Dicing

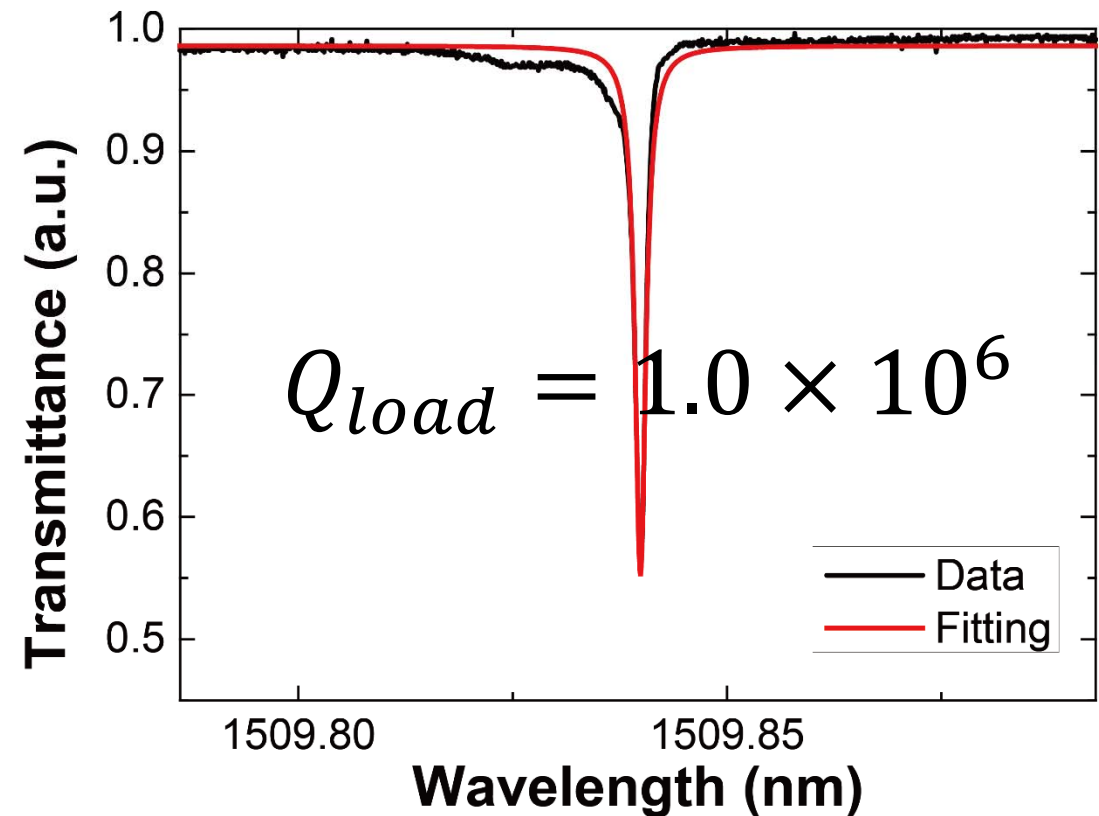
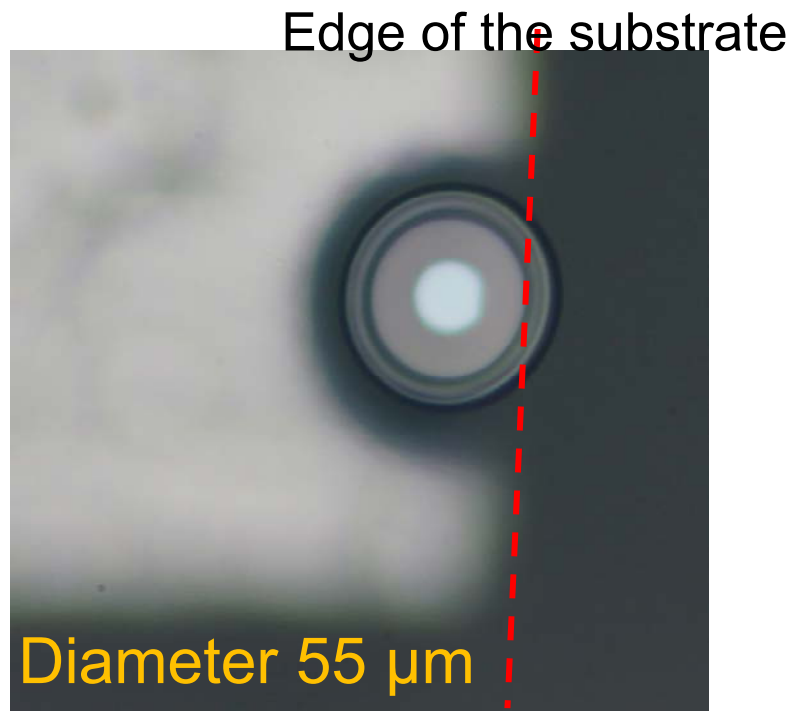
3. Resist removal

4. XeF<sub>2</sub> etching

5. CO<sub>2</sub> laser reflow

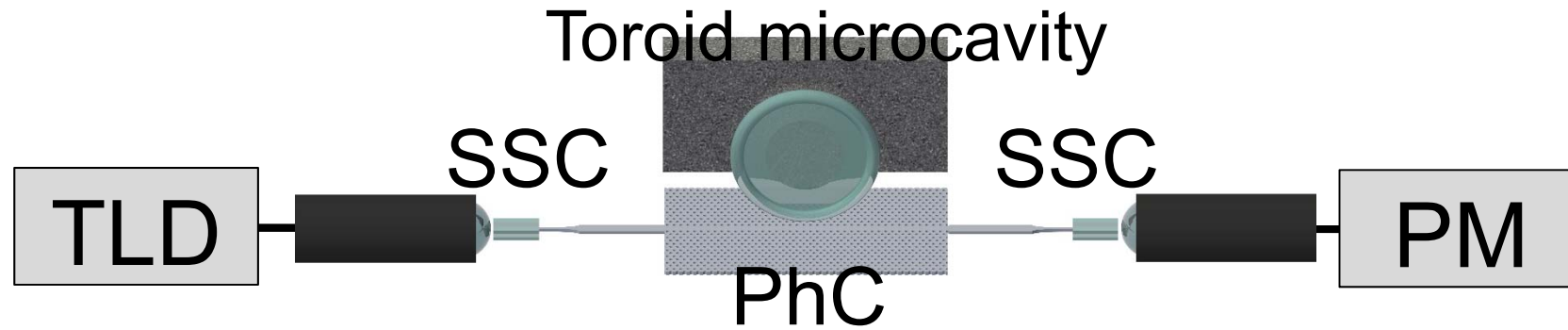


## Fabricated structure

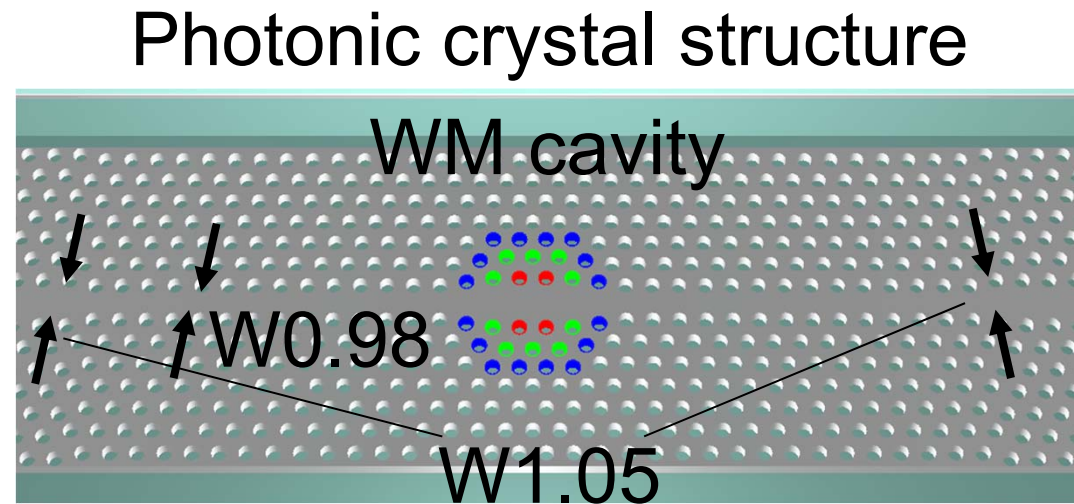
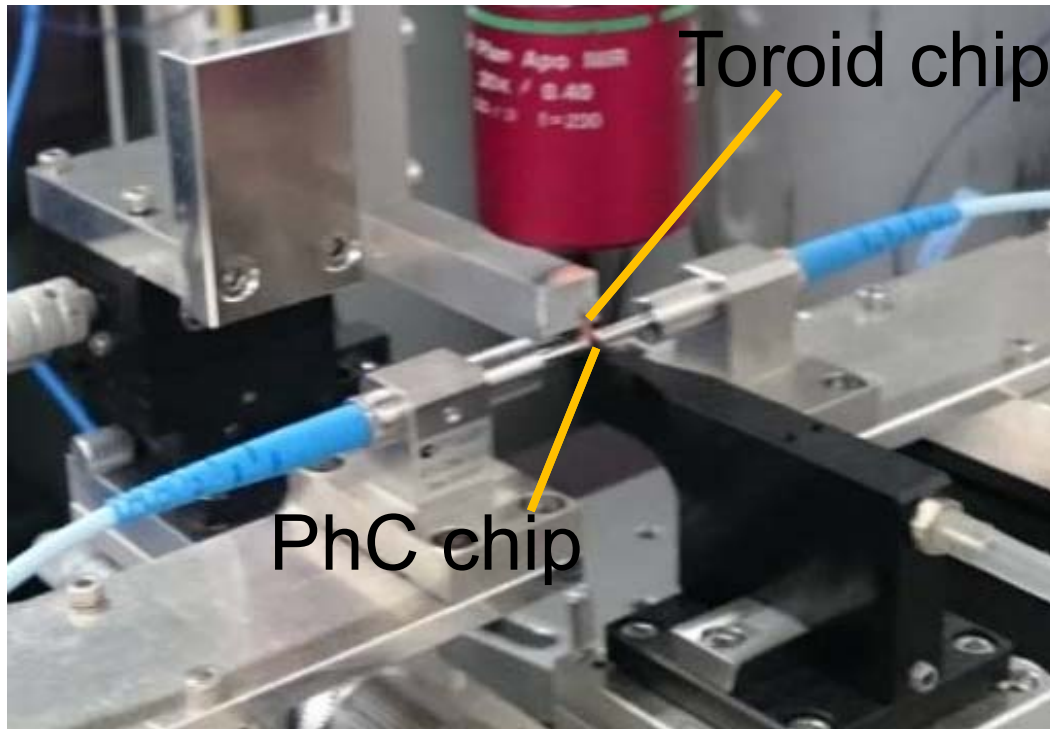




# Experimental setup



TLD: Tunable laser diode. SSC; Spot size converter. PM: Power monitor

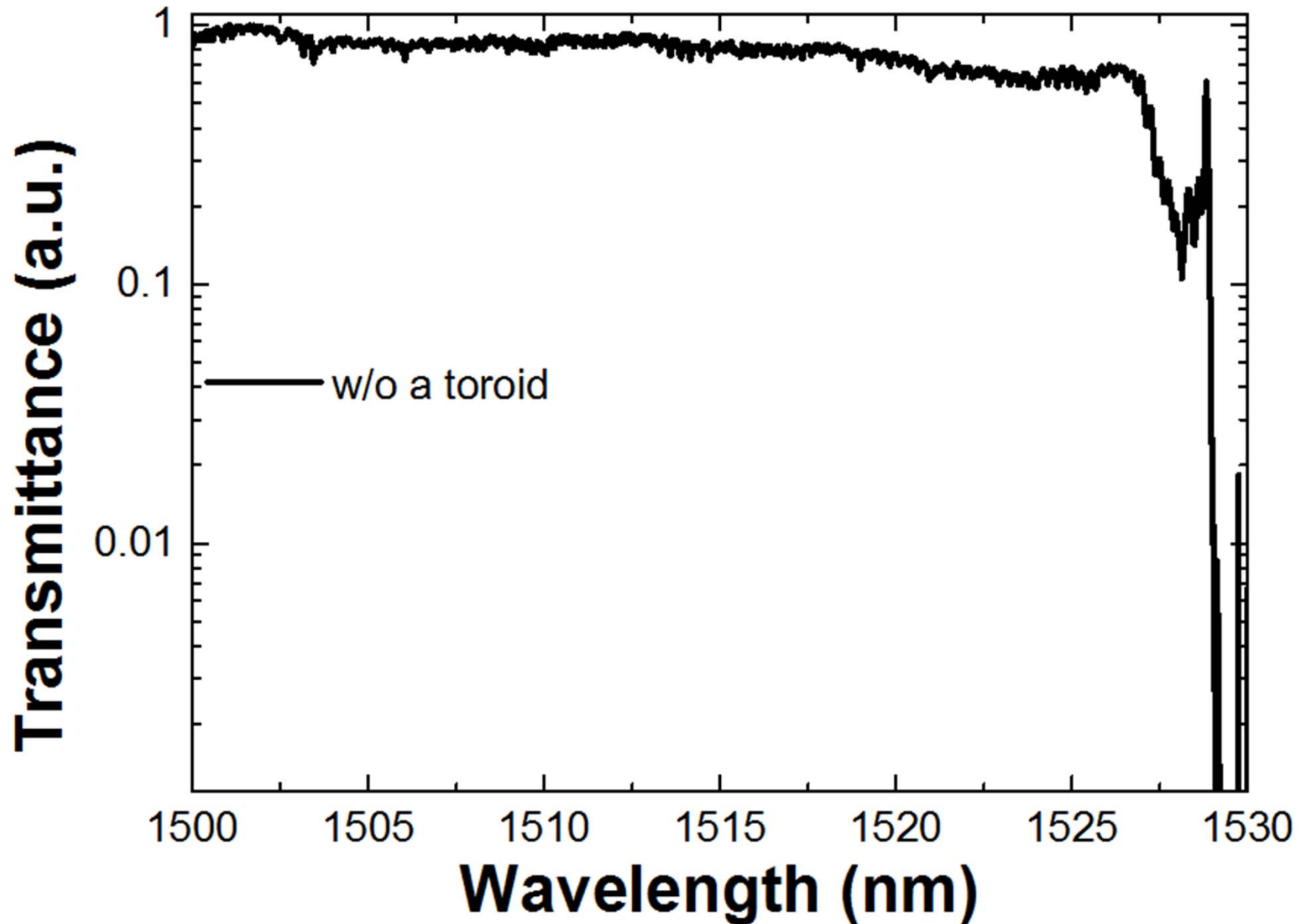


Lattice constant 420 nm Radius 123 nm,  
Thickness 210 nm )



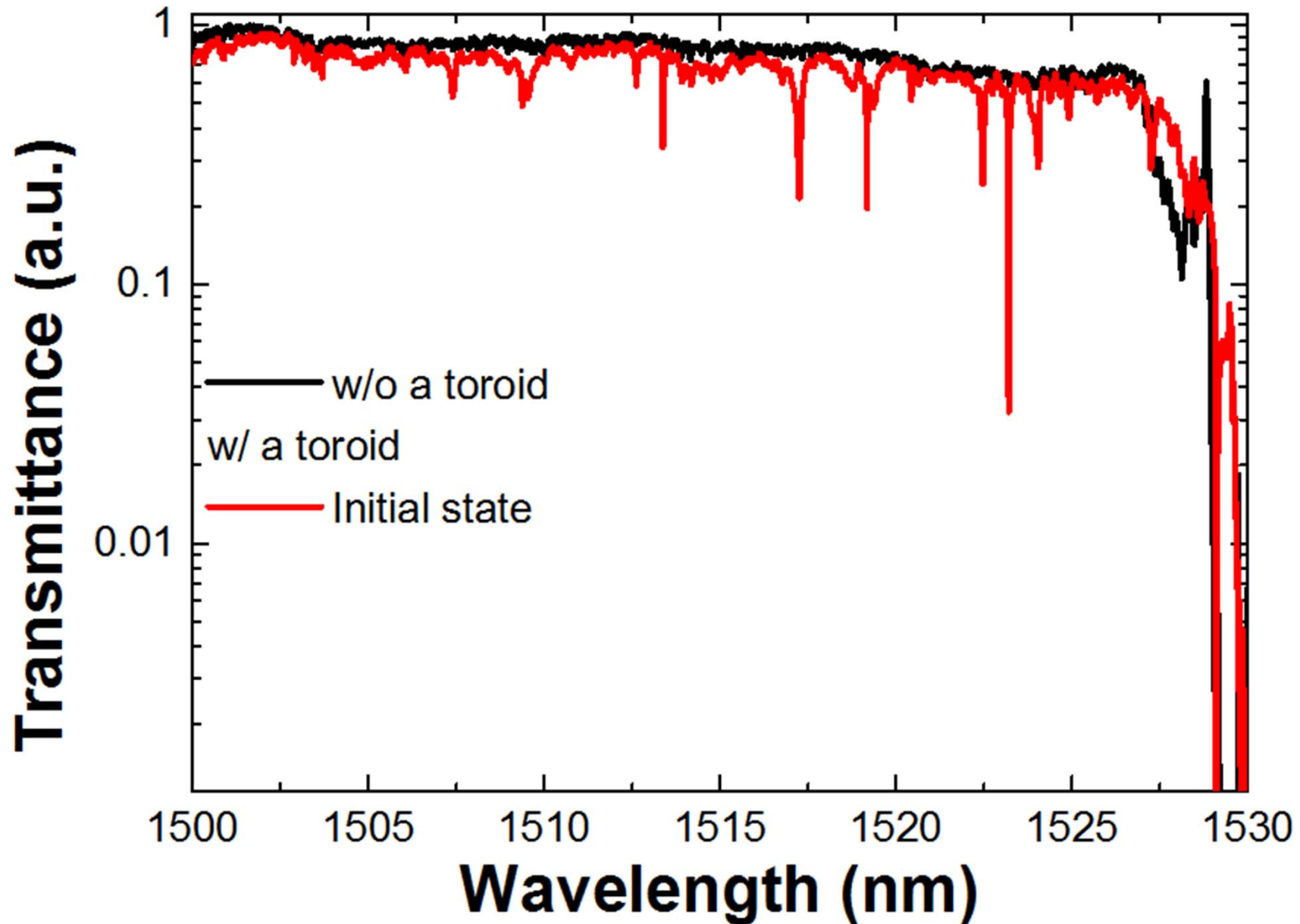


# Result: Transmission spectrum



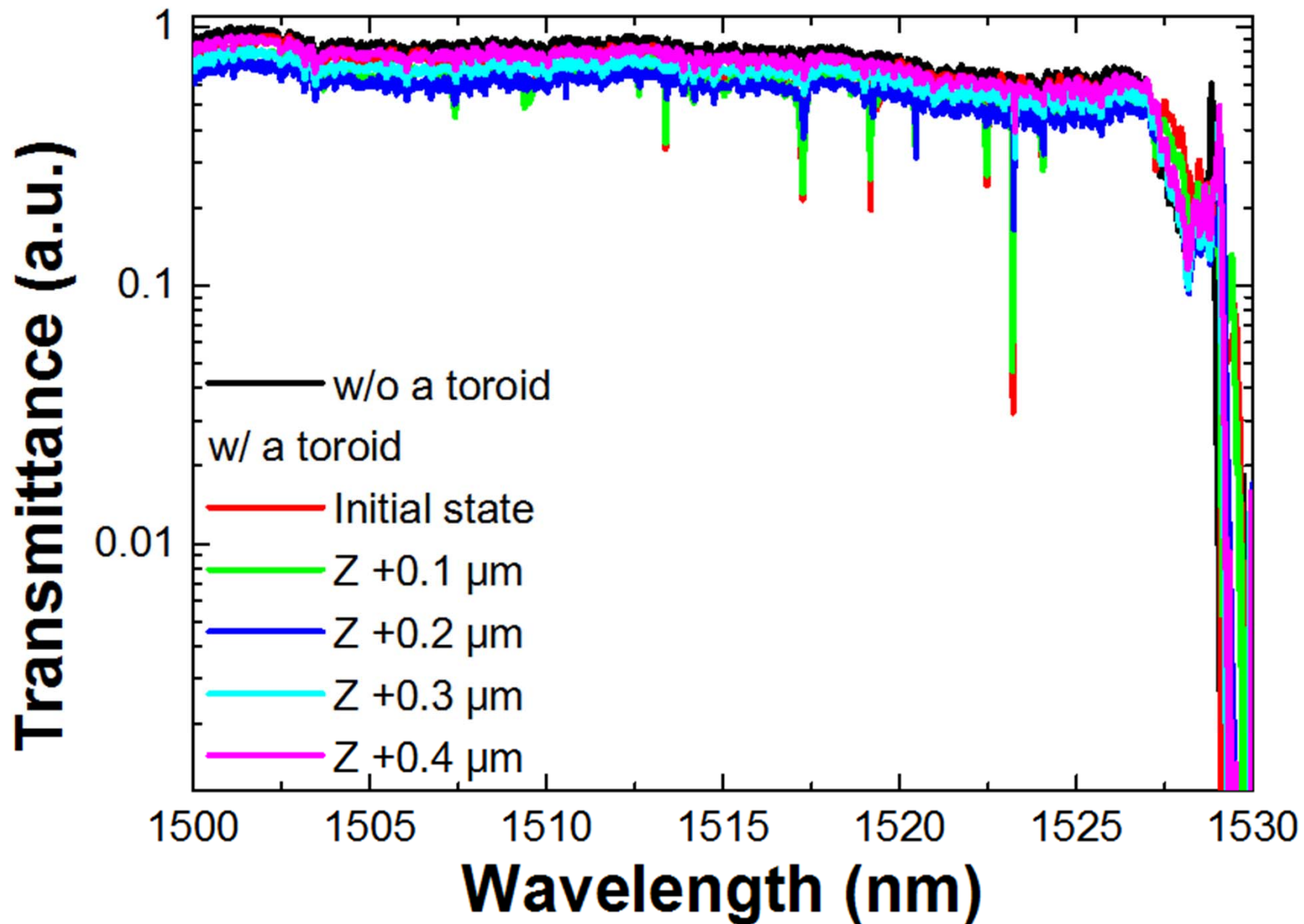


# Result: Transmission spectrum



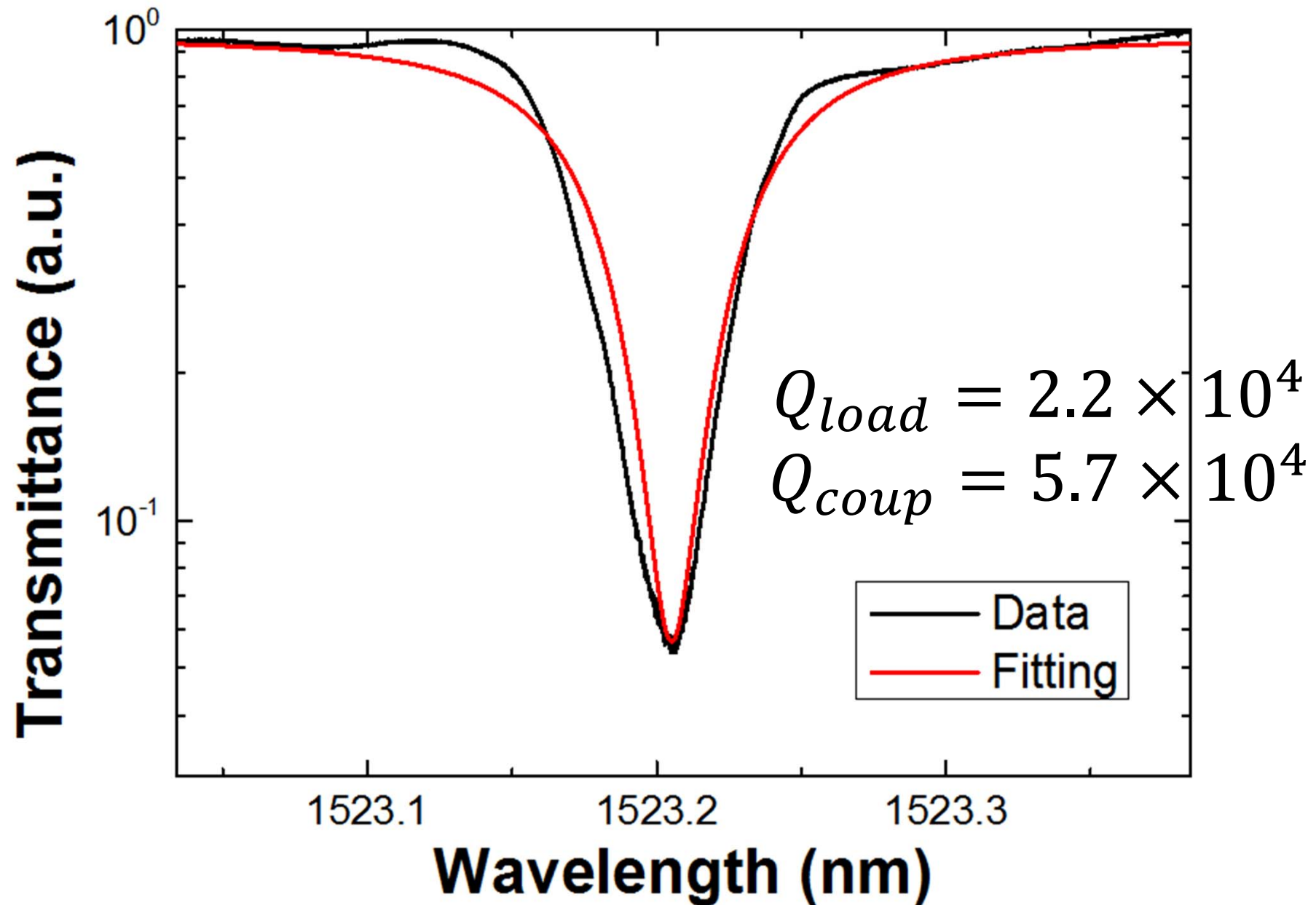


# Result: Transmission spectrum





# Result: Smallest coupling $Q$





# Summary

## Achievements

- ✓ Demonstrated direct coupling between a toroid microcavity & a PhC waveguide
- ✓ Obtained a coupling Q of  $5.7 \times 10^4$

## Acknowledgements

This work is supported by

- ✓ Strategic Information and Communications R&D Promotion Programme (SCOPE) (#152103015)
- ✓ JSPS KAKENHI Grant Number 16J05171