Analysis of Various Whispering Gallery Modes in an Octagonal Silica Toroidal Microcavity

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Abstract
Controlled coupling is demonstrated with a whispering-gallery-mode octagonal silica toroidal microcavity. We found two different modes, one of which exhibits a theoretical Q of $8.8 \times 10^6$ and an experimental Q of $2.2 \times 10^6$. The coupling coefficient is controlled by changing the contacting point of the cavity.

Background: High-Q optical cavity
Silica toroid, Silicon microring, Crystalline, Photonic crystal

Q-factor

<table>
<thead>
<tr>
<th>size [μm]</th>
<th>Q &gt; $10^6$</th>
<th>Q &gt; $10^5$</th>
<th>Q &gt; $10^4$</th>
<th>Q &gt; $10^3$</th>
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Application of High-Q cavity
- Optical frequency comb
- Sensing etc.

Background: Optical coupling of WG modes
Whispering gallery mode is excited through an evanescent field

Using tapered fiber

The problem of using tapered fiber
- Very fragile for disturbance
- Need sensitive control

Fiber touches the cavity
- Highest stability
- Low coupling due to over coupling

Motivation & proposal
Need for an ultrahigh-Q cavity that is robust for practical applications
- By changing the shape of a cavity, design the coupling with waveguide like microring
- Proposal of "Polygonal silica toroidal microcavity"

Simulation
Calculating resonance modes in a silica toroid microcavity by using 2D-FDTD method

Experiment: Fabrication process

Experiment: Optical measurement
Transmittance spectrum (gap is 0 nm)

We obtained a higher Q at the side because of lower coupling loss.

Gap distance vs. Transmittance

Potential application: Optical frequency comb
preliminary FWM experiment by using circular toroid

By performing similar experiment with polygonal cavity, we may enable the demonstration of the robust micro-sized frequency comb generator.

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