Analysis and Experimental Measurement of the $Q$ Factor of Hexagonal Microcavities Fabricated with Crystal Growth

Hiroshi Kudo$^1$, Ryo Suzuki$^1$, Atsushi Yokoo$^{2,3}$, and *Takasumi Tanabe$^1$

$^1$ Electronics and Electrical Engineering, Keio University
$^2$ NTT Nanophotonics Center, NTT Corporation
$^3$ NTT Basic Research Laboratories, NTT Corporation

*takasumi@elec.keio.ac.jp
Progress of Polygonal microcavities

Merit
✓ Sizeable light source on the substrate
✓ Robust system using coupling coefficient

ZnO


InGaAs/ GaAs


Al₂O₃


CLEO-PR & OECC/PS 2013 TuPM-12, T. Kato et al., “Analysis of Various Whispering Gallery Modes in an Octagonal Silica Toroidal Microcavity.”
Laser-heated pedestal growth (LHPG)

**Original LHPG:**
- Fabrication of uniform crystal rods possible
- Fabrication of rods with diameter $< 100 \mu m$ possible
- Fabrication of rods with smooth surface possible

**Modified LHPG:**
- Form bulge by changing growth rate (it allows WGM excitation)

**Experimental setup**

Mathematical expression:

$$D_{grown} = D_{feed} \times \sqrt{\frac{v_{feed}}{v_{seed}}}$$

**Fabricated cavity**

WGM cavity fabricated
Optical measurement

The Q is dependent on the cross-sectional shape.

Q factor vs. corner radius

What kind shape is the best to obtain high $Q$?
Mode mixing between different modes in hexagonal cavities

Strong coupling occurs between perturbed & quasi modes
A number of perturbed modes couple with the quasi mode.
In Detailed: Quasi-mode

Corner radius (μm)

Wavelength (μm)

13 14 15 16 17 18 19 20

1.545 1.550 1.555 1.560 1.565 1.570 1.575 1.580

Circular Hexagonal

Copyright © Keio University
In Detailed: Perturbed mode

![Graph showing wavelength versus corner radius with different symbol colors representing different corner shapes: hexagonal and circular.](image-url)
In Detailed: High-order (multi) perturbed mode

Corner radius ($\mu$m) vs. Wavelength ($\mu$m) graph showing the transition from Hexagonal to Circular geometry.
Q factors for different WGM modes

- **Low Q** = quasi-WGM (due to strong mode mixing)
- **High Q** = perturbed-WGM (but only with round corner)

![Graph showing Q factors vs. corner radius](image)

- **perturbed-WGM**
- **quasi-WGM**
Optimal size of hexagonal cavity for high-\(Q\).

In perturbed mode, the optimal radius is 30 \(\mu\text{m}\).
Summary

① Perturbed mode and Quasi mode is strongly coupled.
   ✓ Coupling coefficient $\kappa = 29.9$ GHz
   ✓ Large number of perturbed mode coupled with quasi-mode.

② Studied the effect of circle & hexagonal shape for these $Q$ factor.
   ✓ Both perturbed and quasi mode exhibit low $Q$ when the cavity is hexagonal.
   ✓ There are a optimal radius when the cavity is polygonal.
Acknowledgements

Financially supported by:

Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology, Japan

the Strategic Information and Communications R&D Promotion Programme (SCOPE)