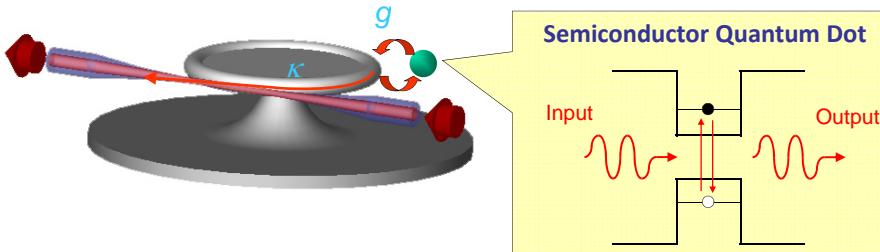




京都大学 大学院理学研究科
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青木 隆朗

Quantum dot coupled to a microtoroidal resonator



NATURE | VOL. 424 | 14 AUGUST 2008 | www.nature.com/nature **insight review articles**

Optical microcavities

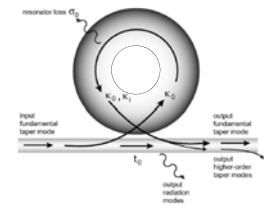
Kerry J. Vahala

	Fabry-Perot	Whispering gallery	Photonic crystal
High Q	Q ~ 10 ⁵	Q ~ 10 ⁶	Q ~ 10 ⁷
Scalability	Yes	No	No
Efficient coupling to fibers	Yes	No	No

Why Toroids?

- Scalability
- High quality factor
- Efficient coupling to fibers

Efficient coupling to fibers



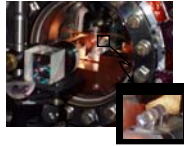
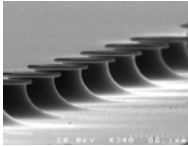
Ideality (\approx mode matching efficiency) $\geq 99.97\%$

S. M. Spillane, T. J. Kippenberg, O. J. Painter, and K. J. Vahala, PRL 91, 043902(2003)

Scalability

Toroid

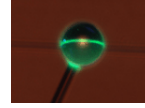
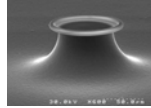
Fabry-Perot



High quality factor

Toroid

Sphere



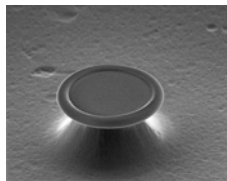
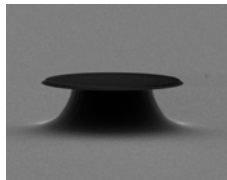
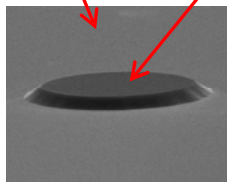
$$Q_{\text{measured}} \approx 8 \times 10^9 \rightarrow Q_{\text{projected}} \geq 10^{10}$$

D. W. Vernooy, V. S. Ilchenko, H. Mabuchi, E. W. Streed, and H. J. Kimble, Opt. Lett. 23, 247 (1998)

Current status of our research

Fabrication of microtoroidal resonators

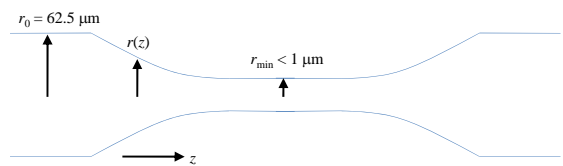
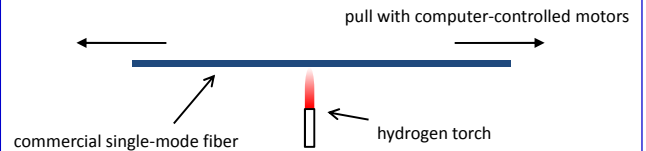
Si substrate SiO₂ disk



Photolithography & etching

reflow with CO₂ laser

Fabrication of tapered optical fibers



$$\text{Adiabatic condition: } \left| \frac{dr}{dz} \right| \ll \frac{r(\beta_1 - \beta_2)}{2\pi}$$

(longer taper has lower coupling to higher-order modes, thus shows higher transmission)

With tapering length of ~ 4 cm, we fabricate tapered fibers with transmission $> 99\%$.

Future plan

- Couple a tapered fiber to a toroid
- Construct a quantum-dot cavity QED system

Acknowledgements

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