

Silica toroid microcavity coupled to silicon photonic chip

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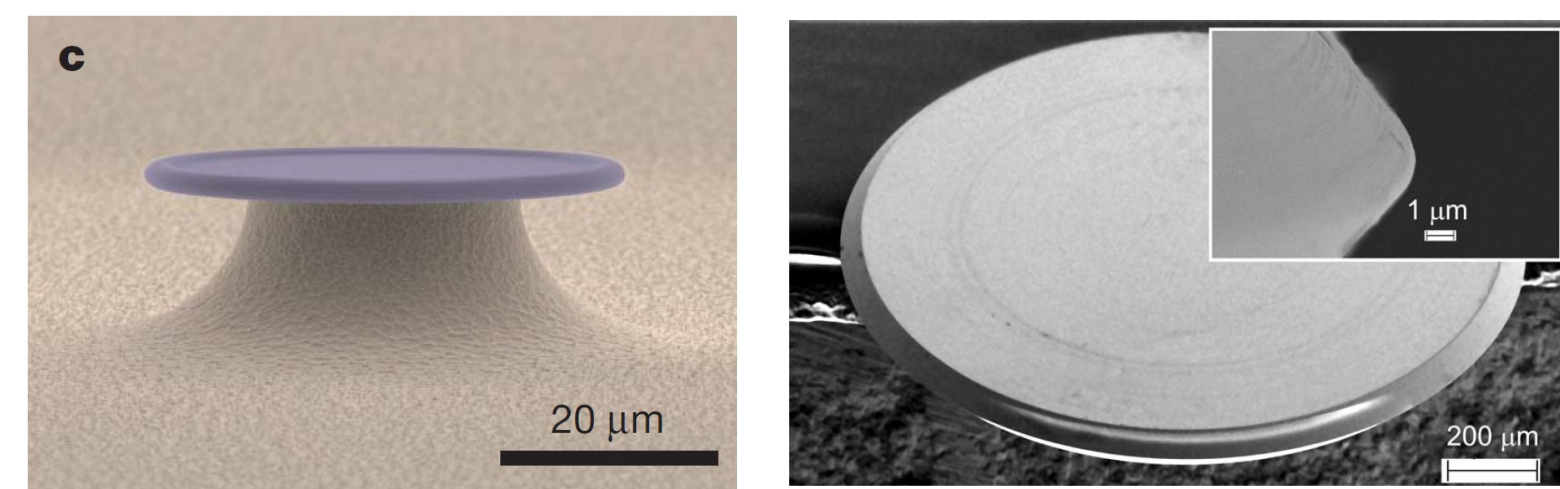
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Abstract

Efficient optical coupling to whispering gallery mode (WGM) microresonators is important for a wide range of applications. We experimentally demonstrated efficient optical coupling between low-index silica whispering gallery mode microresonator with high-index silicon chip. We can minimize the phase index mismatch by using photonic crystal waveguide (PhC-WG) as a coupler.

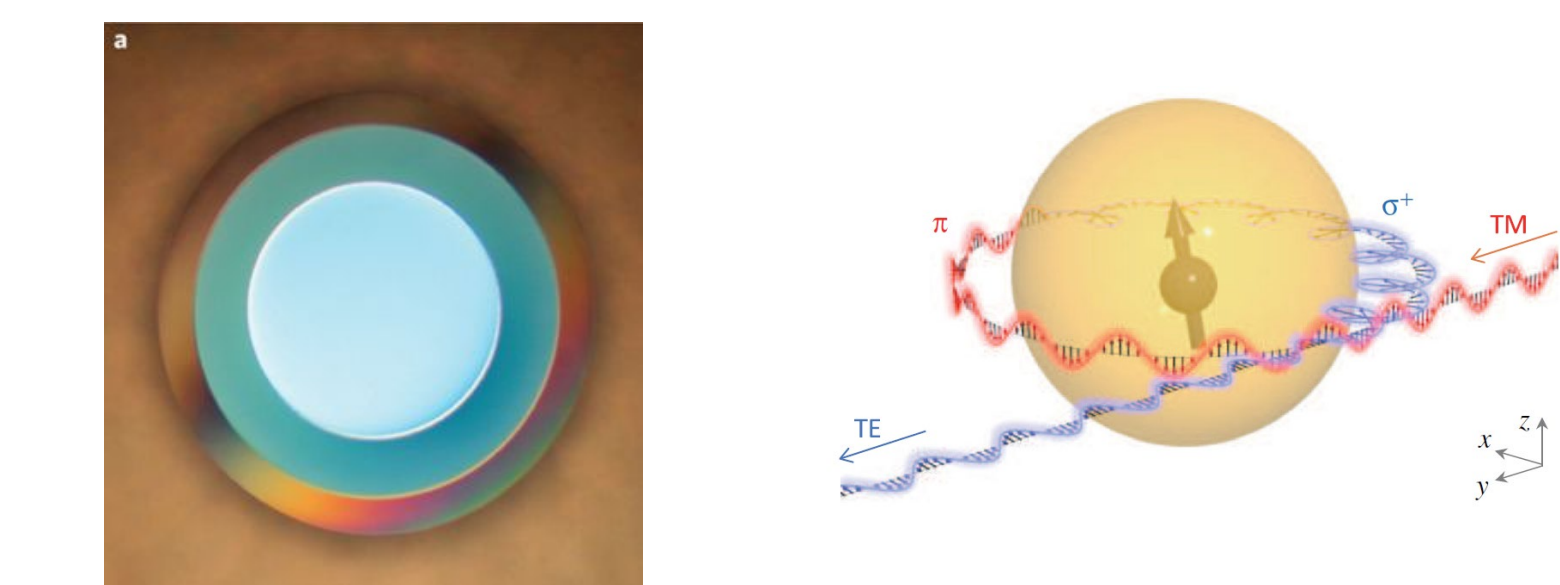
Background

WGM resonator



Nature 450, 1214–7 (2007)

Phys. Rev. B 74, 245119 (2006)

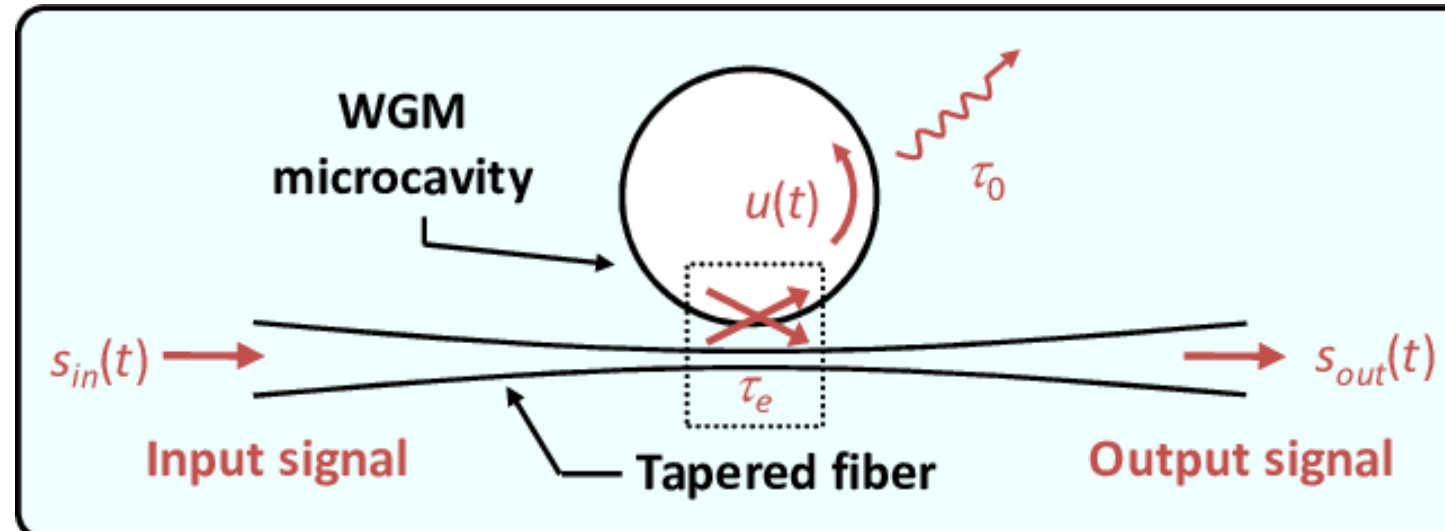


Nat. Photo, 6, 369–373 (2012)

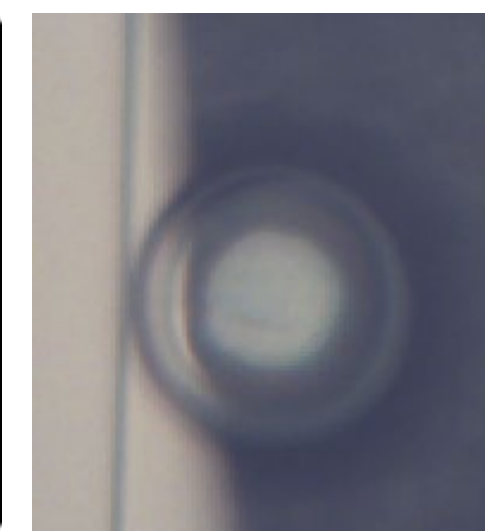
Phys. Rev. Lett. 117, 123605 (2016)

- Compact
- High Q-factor
- Small mode volume

Tapered fiber

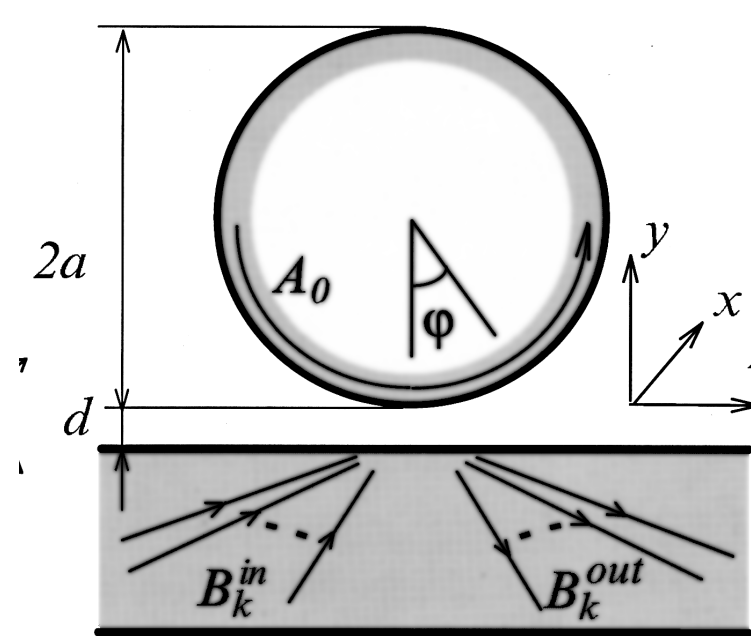
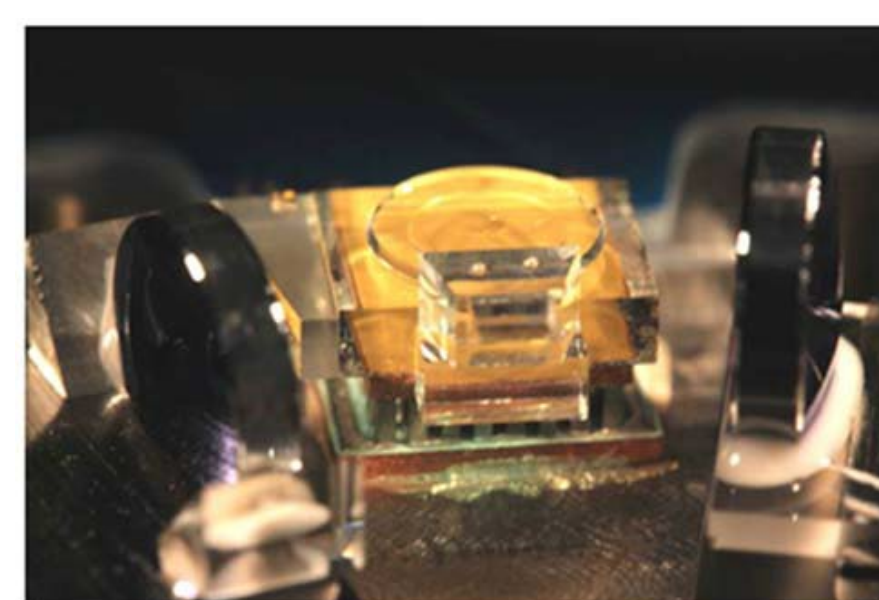


Alphonse Rasoloniaina et al. J. Opt. Soc. Am. B, 32, 370-378 (2015)



- Ultra-high coupling efficiency (~99.97%)
- Sensitive to environmental noise

Prism coupler

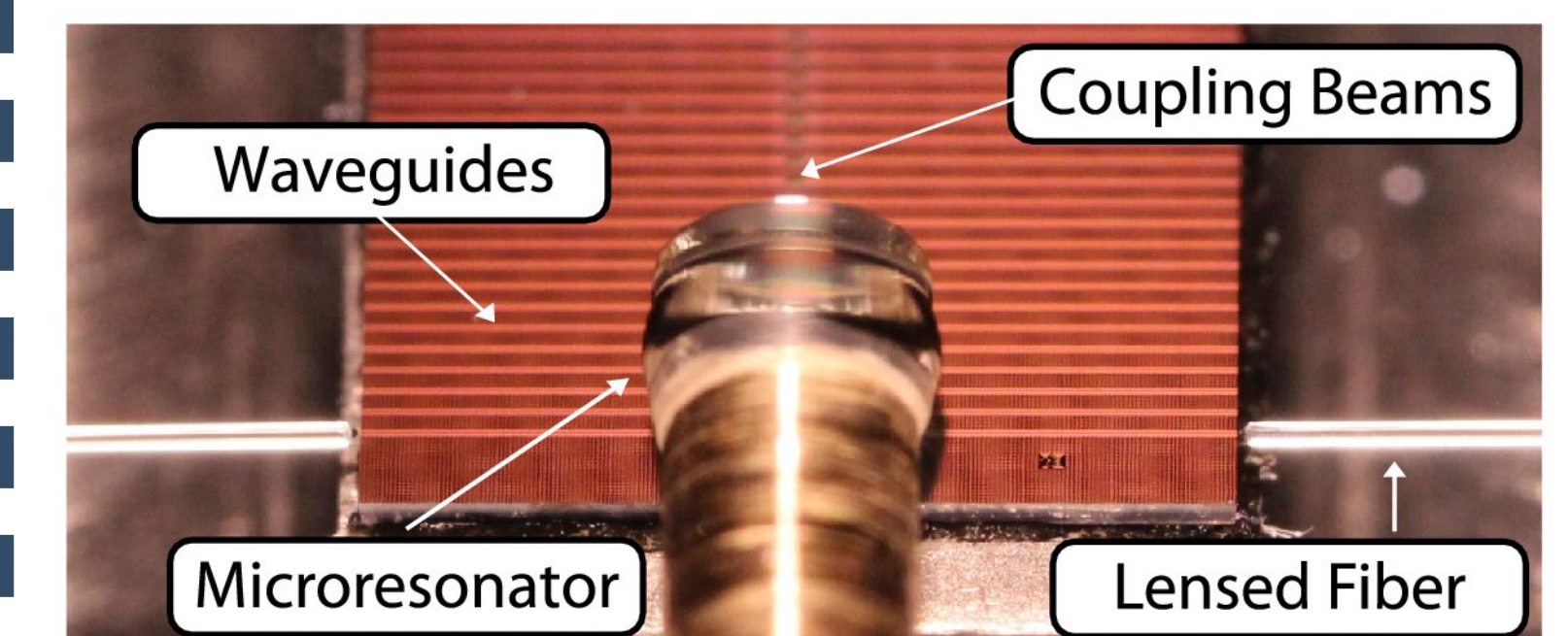


A. A. Savchenkov et al. Opt. Lett. 40, 3468 (2015)

M. L. Gorodetsky et al., J. Opt. Soc. Am. B, 16, 147 (1999)

- More robust than tapered fibers
- The coupling efficiency is limited less than 80%

Planar waveguide coupler

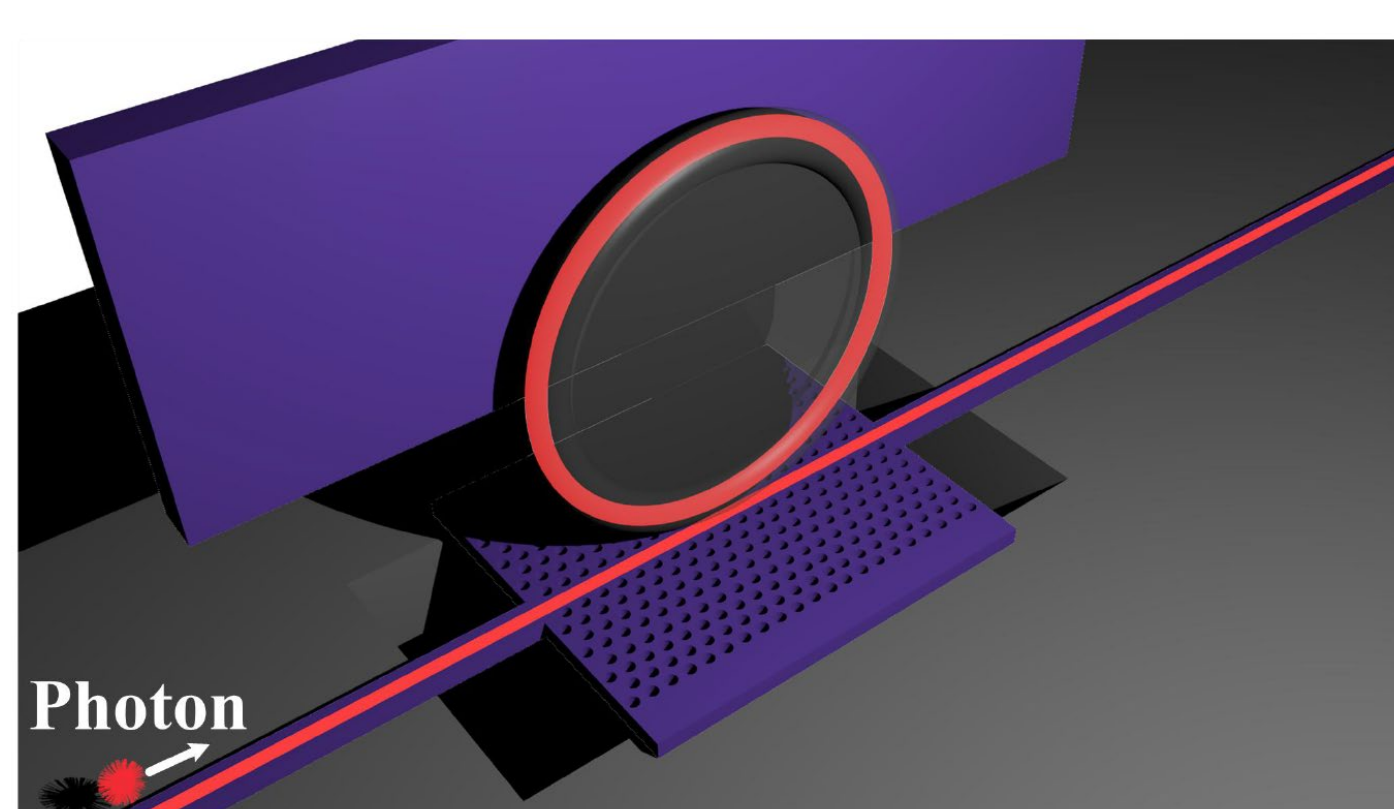


A. A. Savchenkov et al. IEEE Photon. Technol. Lett. 29, 667 (2017)

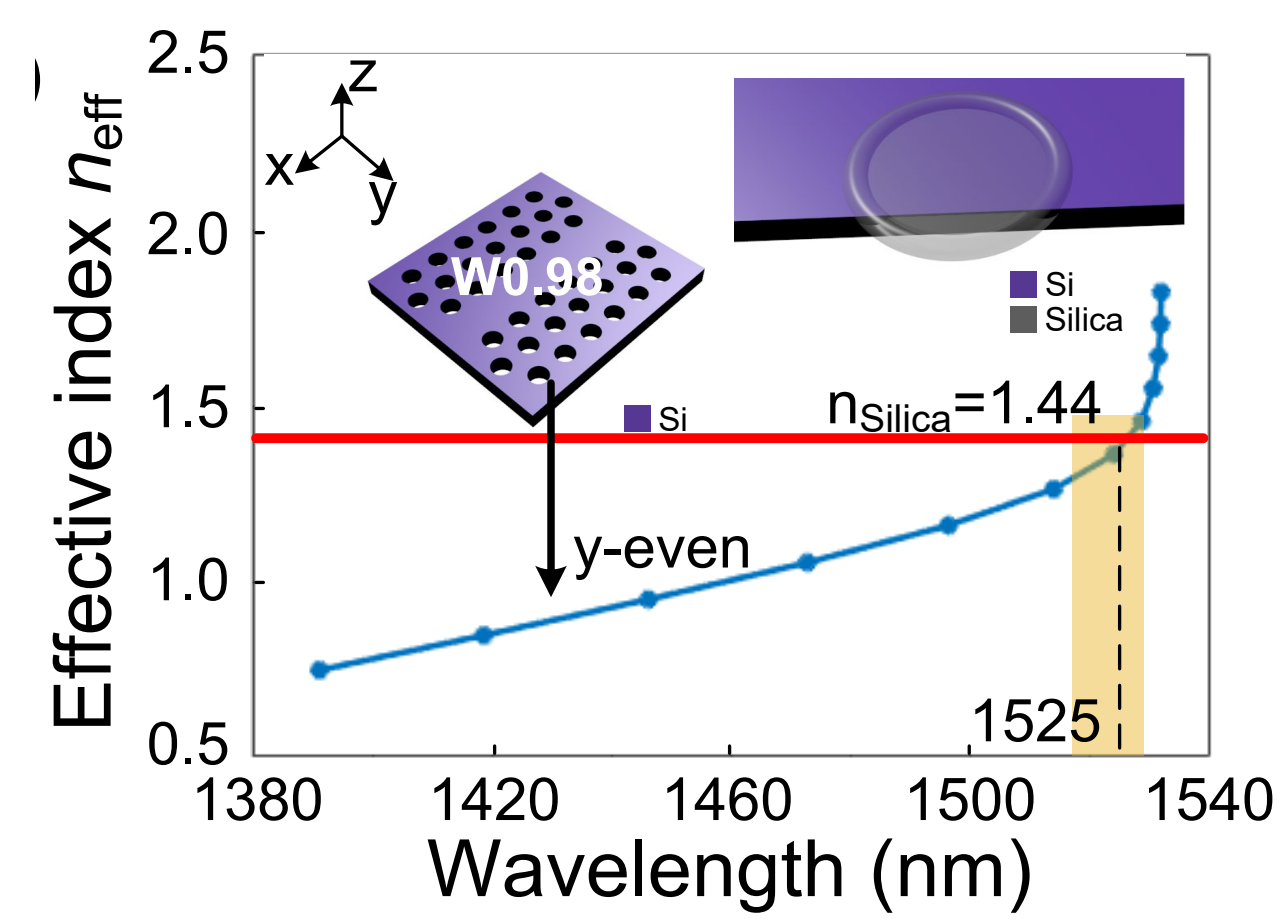
- Robust (almost same as prism)
- Practical approach to integrate with WGM resonators
- Necessary to make index matching

Motivation

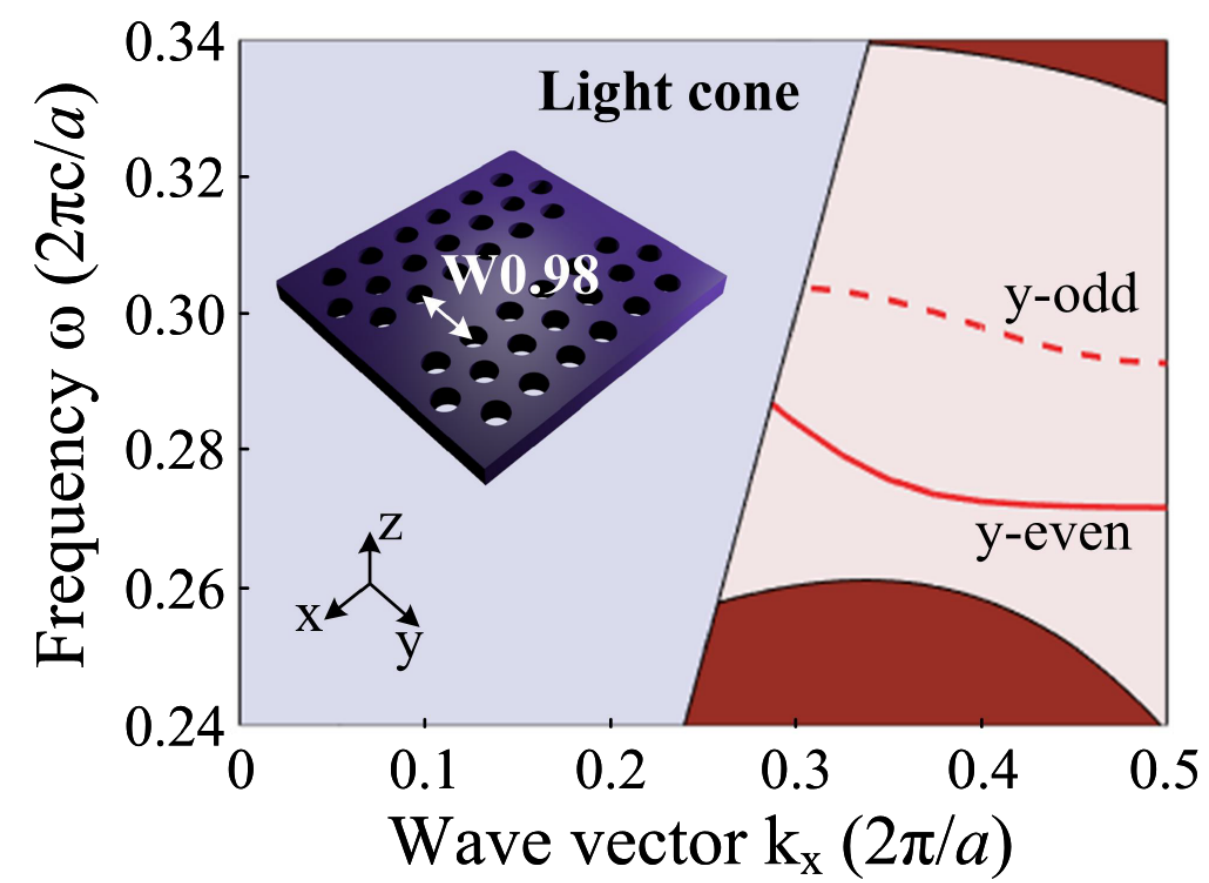
Structure



The n_{eff} of an air-bridged PhC-WG is close to that of a silica microtoroid, when the wavelength is close at the mode edge of the PhC-WG.

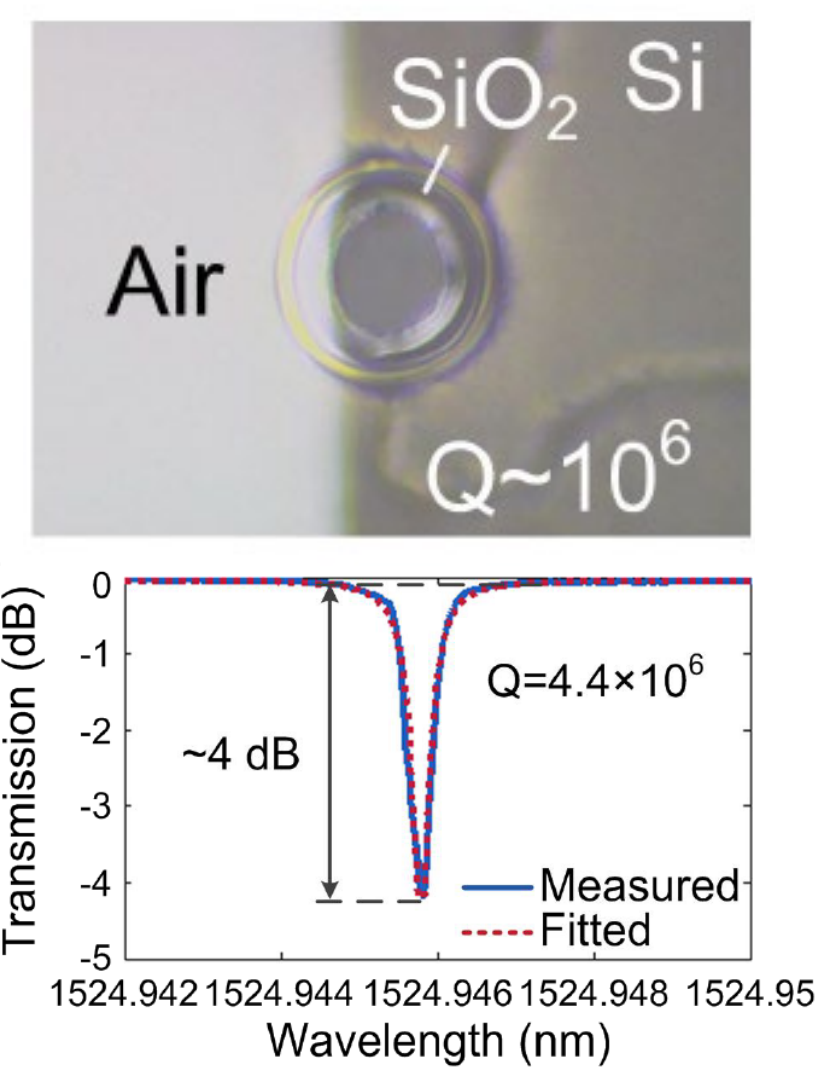
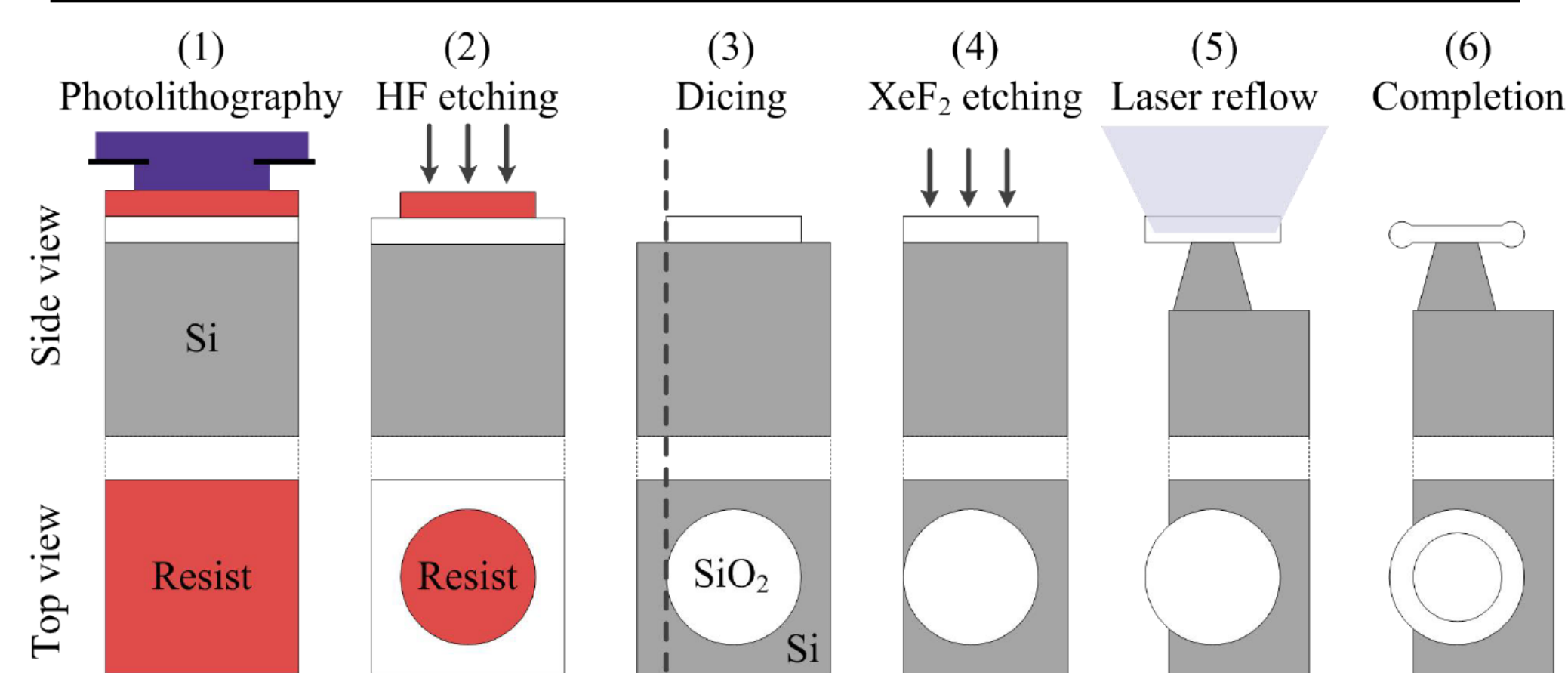


Efficient coupling is achieved

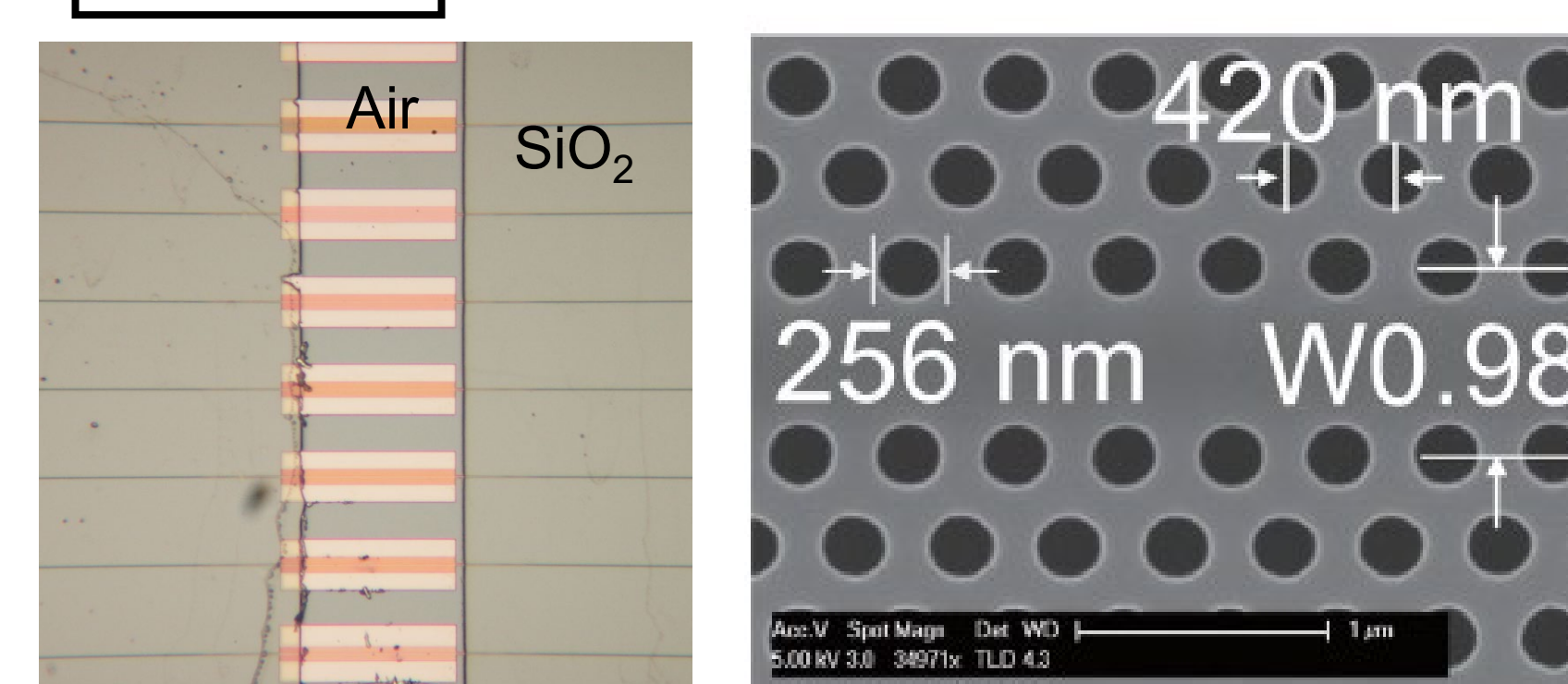


Devices

Fabrication process of edge toroid microresonator



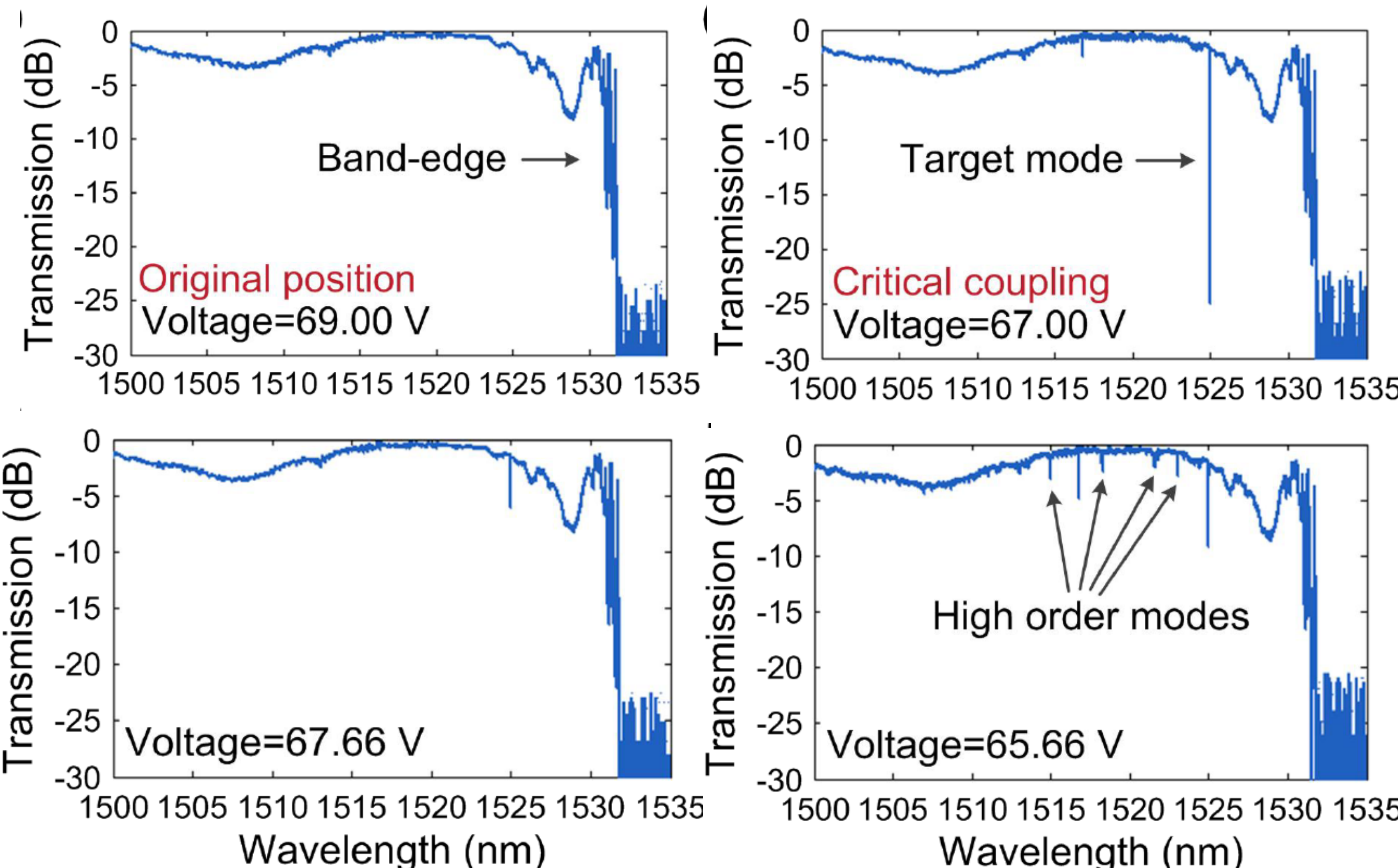
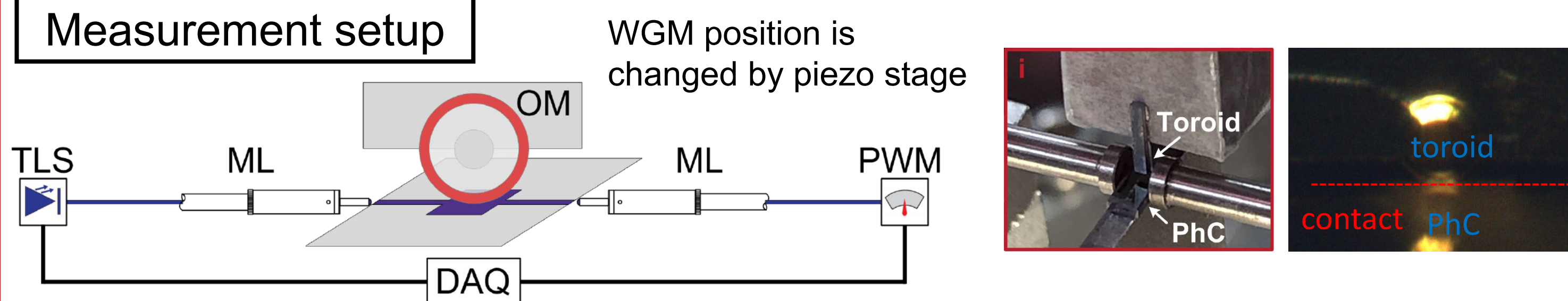
PhC-WG



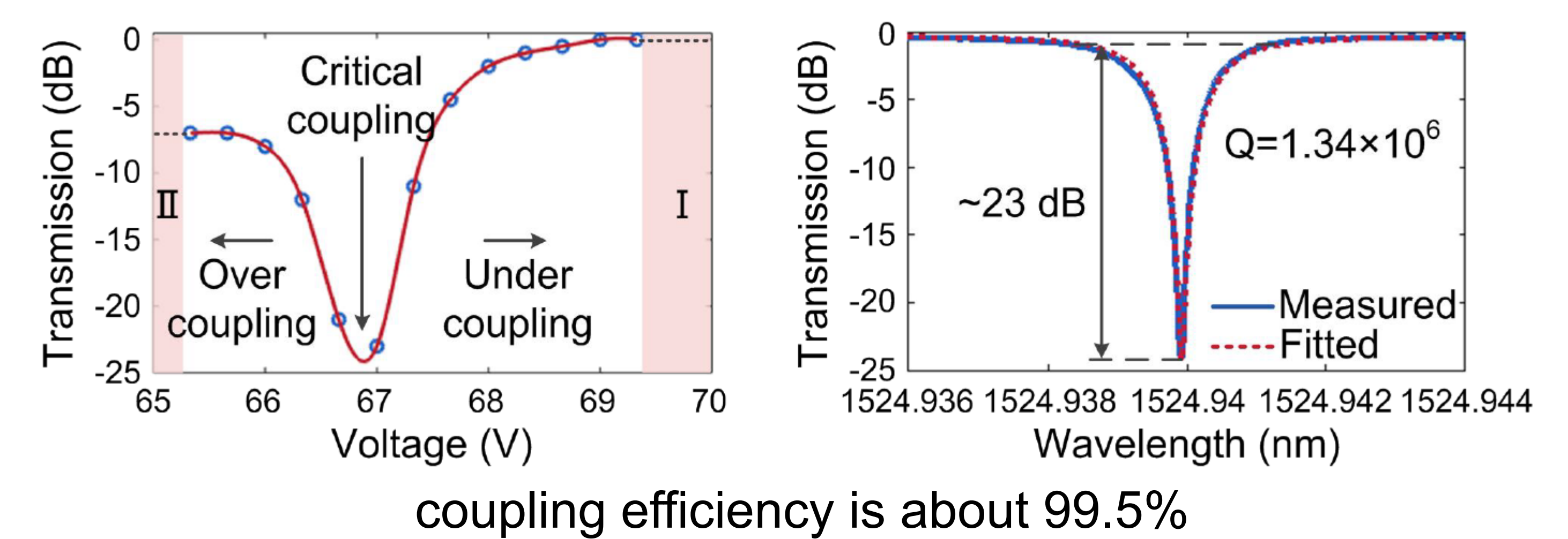
- PhC is made by CMOS process with silica clad
- Partially etching to silica clad to allow to contact with PhC-WG and edge toroid microresonator

Experimental Results

Measurement setup



Experimental Results – Coupling efficiency



coupling efficiency is about 99.5%

Conclusion

In this work, we report optical coupling between silica WGM microresonator and CMOS-compatible PhC-WG and demonstrate extremely high coupling efficiency of higher than 99%. The phase-matching is achieved by the use of W0.98 PhC-WG. This result provides a robust method of ultrahigh-Q WGMs to be coupled with a high-index silicon photonics integrated platform.