COMSOL CONFERENCE 2016 SHANGHAI

Leibniz Institute for Solid State and Materials Research Dresden

Simulations of rolled-up optical microcavities using COMSOL

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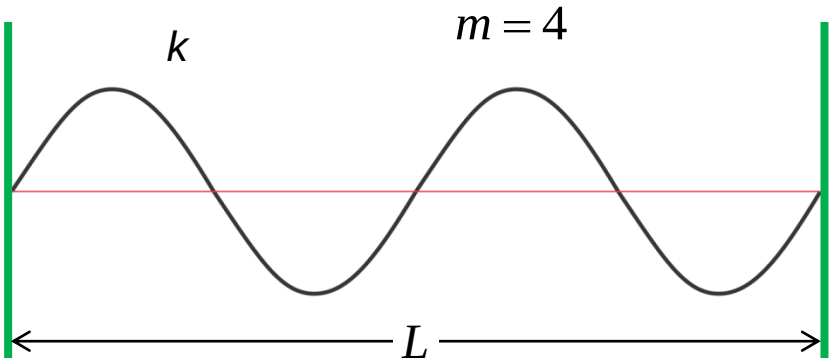
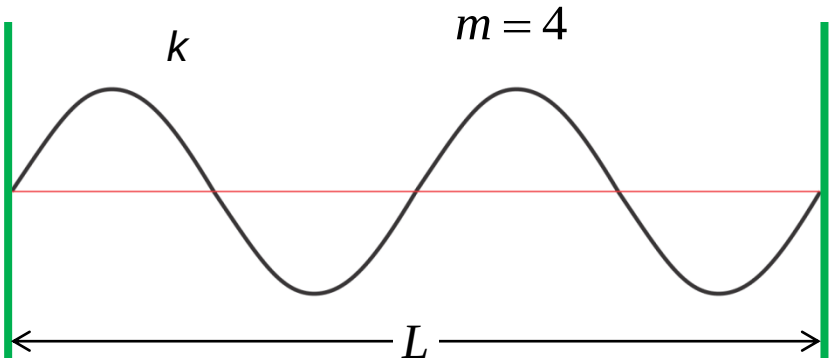
Optical resonances



→ resonant modes:

$$k \cdot 2L = m \cdot 2\pi, \quad m = 1,2,...$$

Optical resonances



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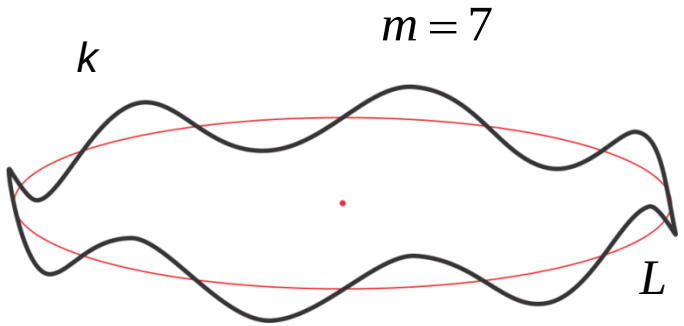
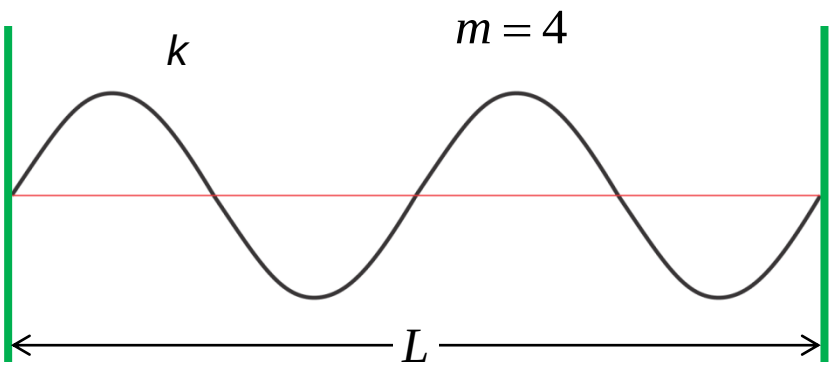


→ whispering gallery modes (WGMs):

$$k \cdot L = m \cdot 2\pi, \quad m = 1,2,...$$

Optical resonances



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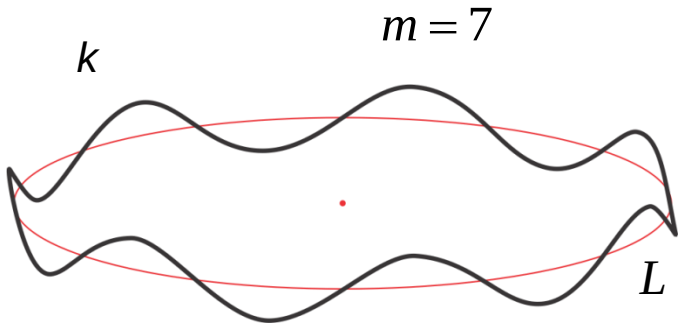

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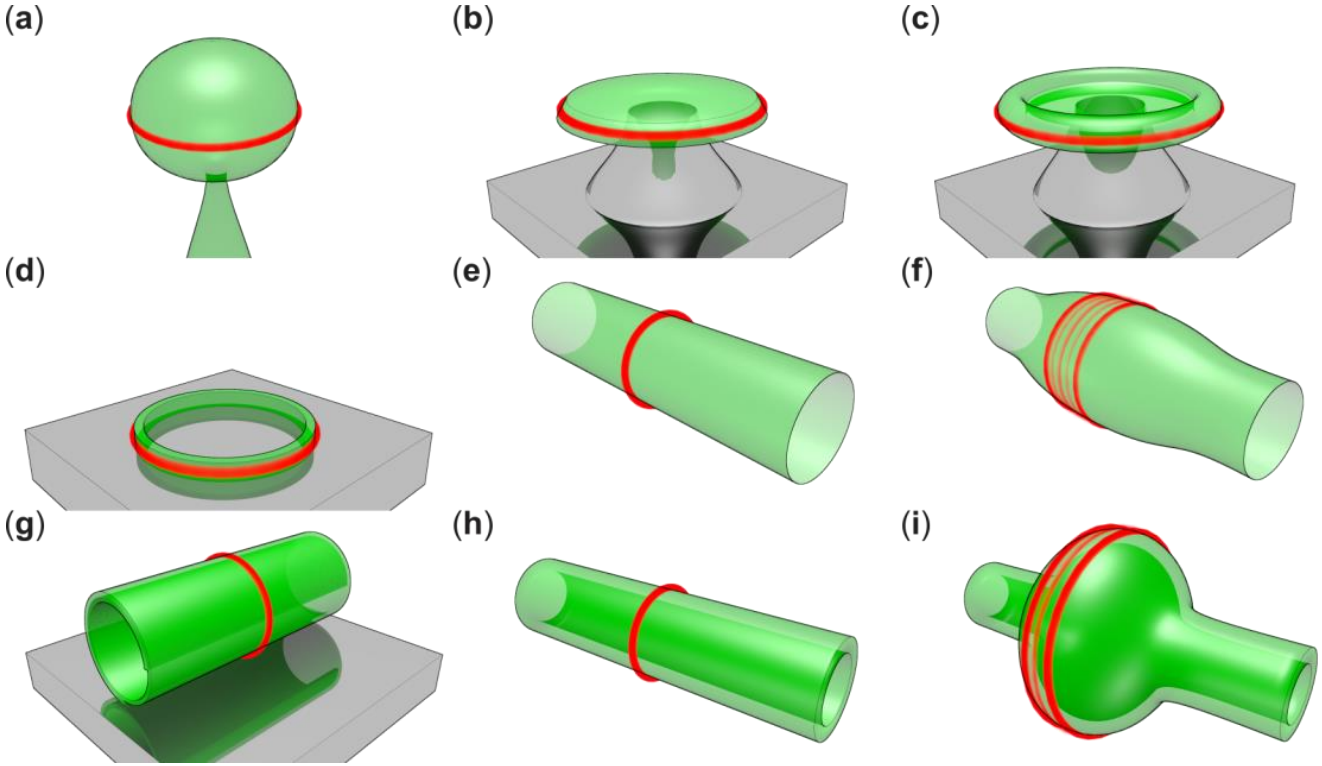
$$k \cdot L = m \cdot 2\pi, \quad m = 1,2,...$$

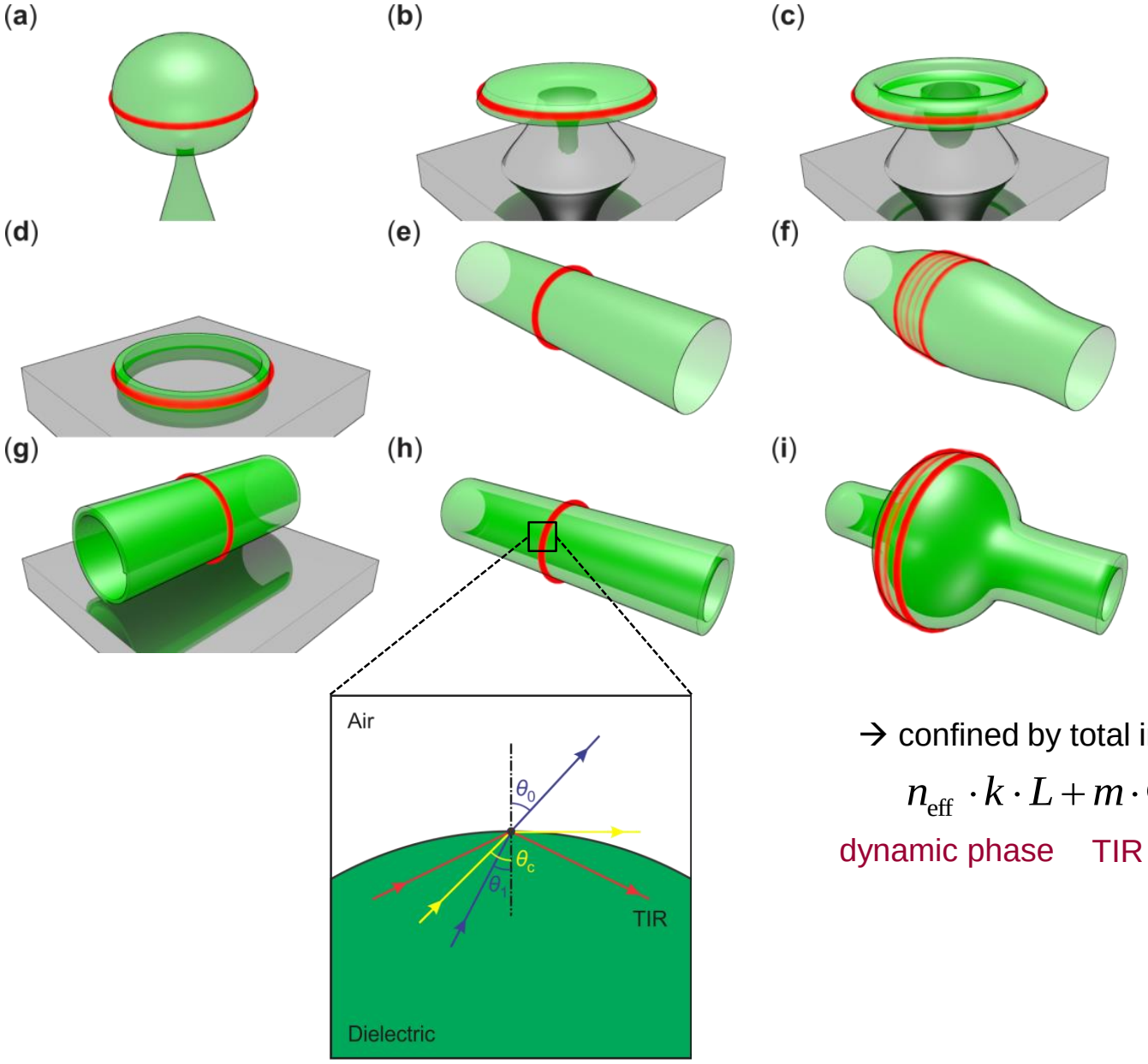
→ WGM optical microcavities (WGM OMs)

WGM optical microcavities



K. J. Vahala, Nature **424**, 839 (2003).

WGM optical microcavities



→ confined by total internal reflection (TIR):

$$n_{\text{eff}} \cdot k \cdot L + m \cdot \Theta_A = m \cdot 2\pi, \quad m = 1,2,...$$

dynamic phase TIR phase

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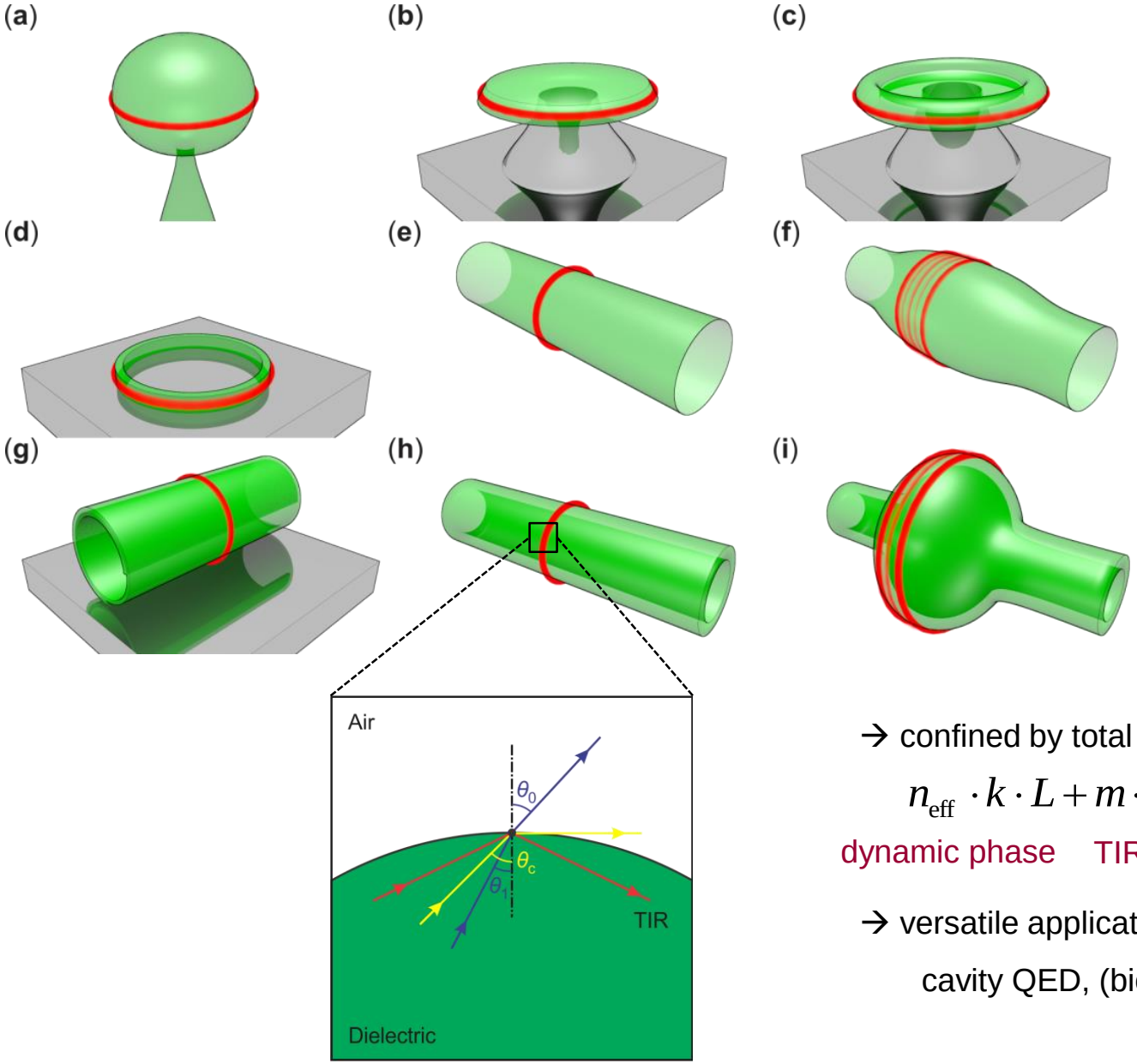
WGM optical microcavities



→ confined by total internal reflection (TIR):

$$n_{\text{eff}} \cdot k \cdot L + m \cdot \Theta_A = m \cdot 2\pi, \quad m = 1,2,...$$

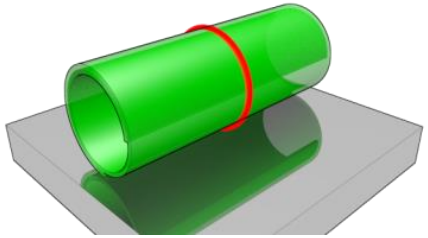
dynamic phase TIR phase

→ versatile applications:

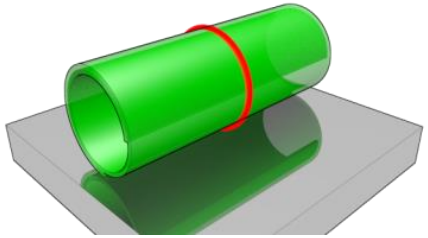
cavity QED, (bio)sensors, photonic devices

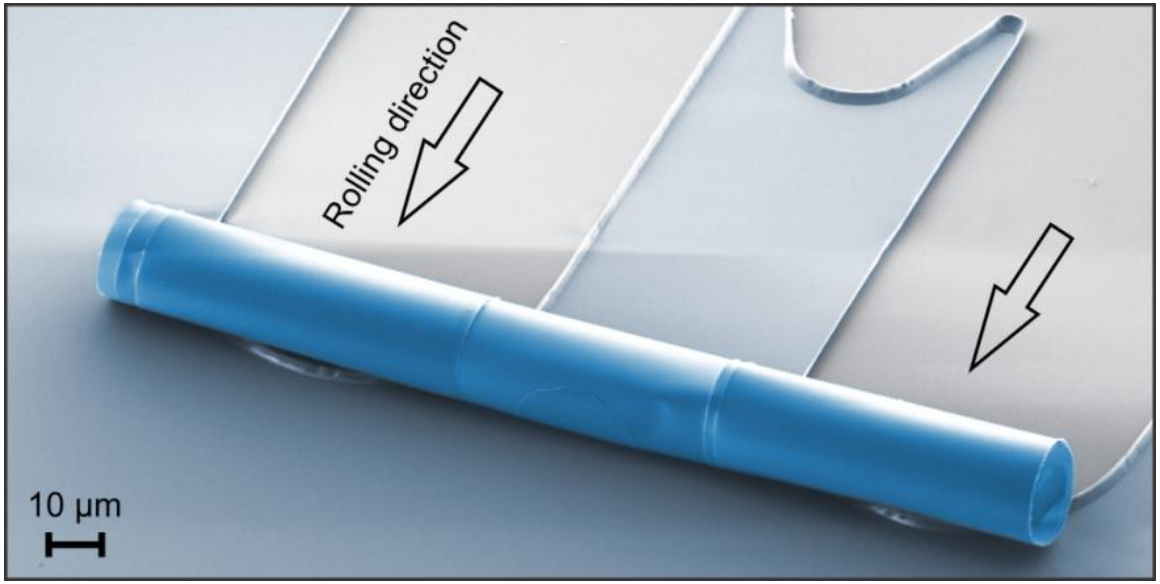
K. J. Vahala, Nature **424**, 839 (2003).

Rolled-up optical microcavities



Rolled-up optical microcavities





→ advantages using rolled-up WGM OMs:

on-chip [1]

arbitrary material [2-5]

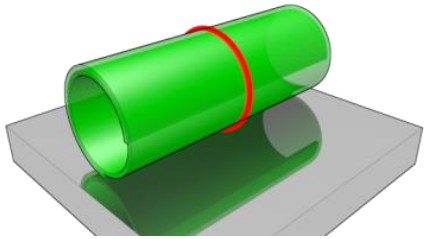
hollow tubular geometry [1]

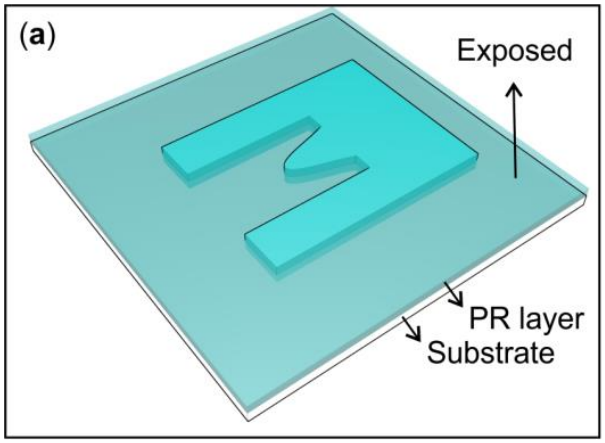
subwavelength wall thickness [6]

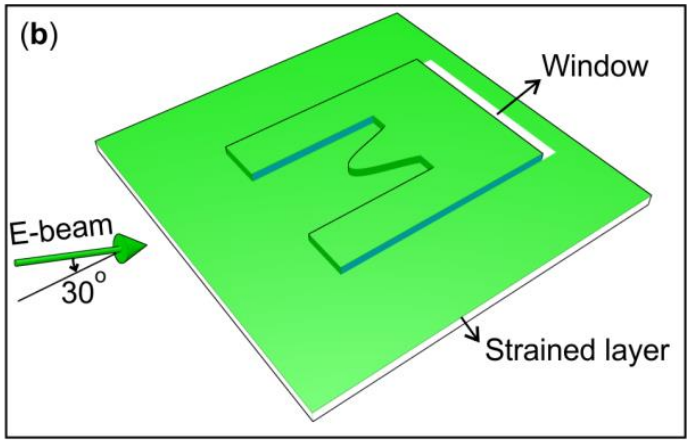
diverse structure

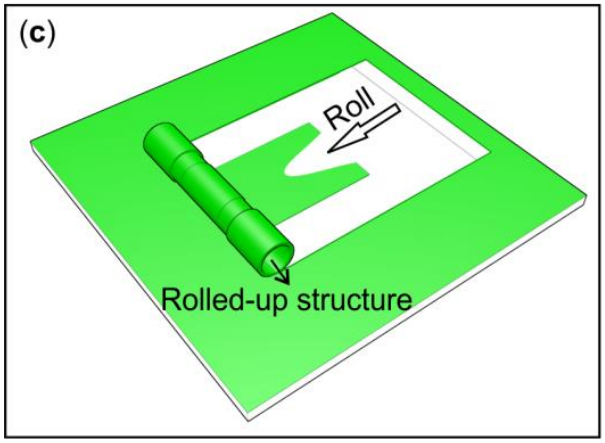
[1] Y. F. Mei *et al.*, Adv. Mater. **20**, 4085 (2008).
[2] S. Böttner *et al.*, Opt. Lett. **37**, 5136 (2012).
[3] T. Kipp *et al.*, Phys. Rev. Lett. **96**, 077403 (2006).
[4] R. Songmuang *et al.*, Appl. Phys. Lett. **90**, 091905 (2007).
[5] J. Wang *et al.*, Opt. Express **20**, 18555 (2012).
[6] S. M. Harazim *et al.*, Lab Chip **12**, 2649 (2012).

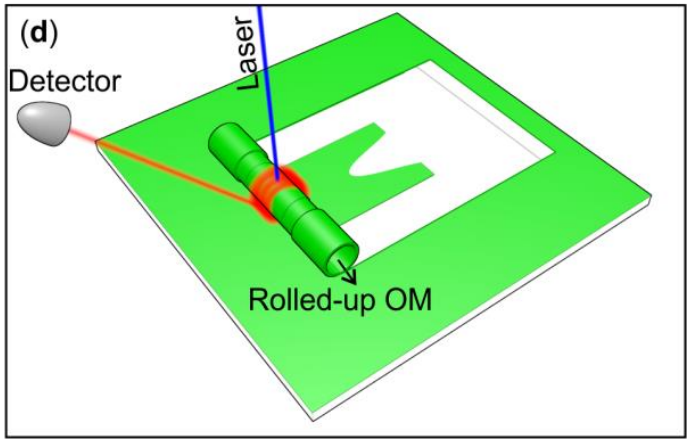
Rolled-up optical microcavities









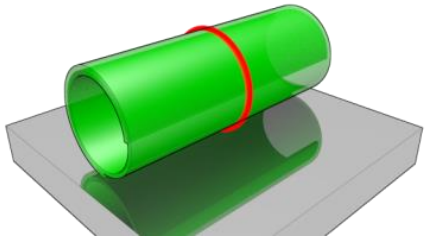


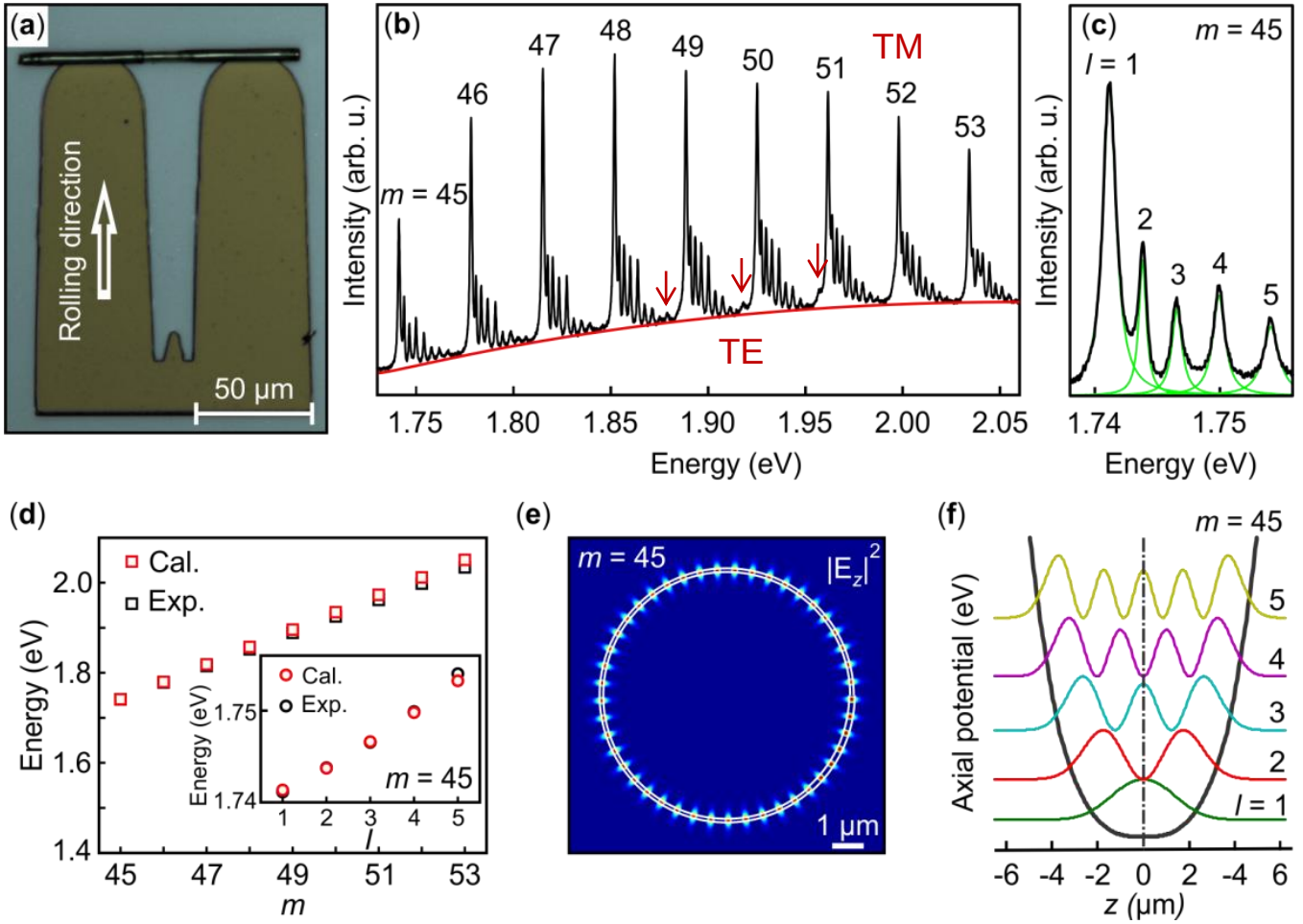
→ U-shaped pattern:

free-standing in the middle

axial confinement

Rolled-up optical microcavities

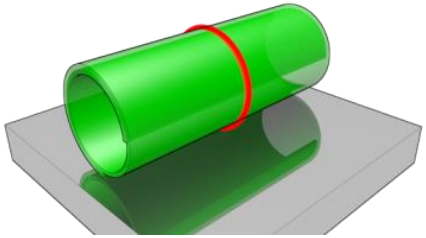


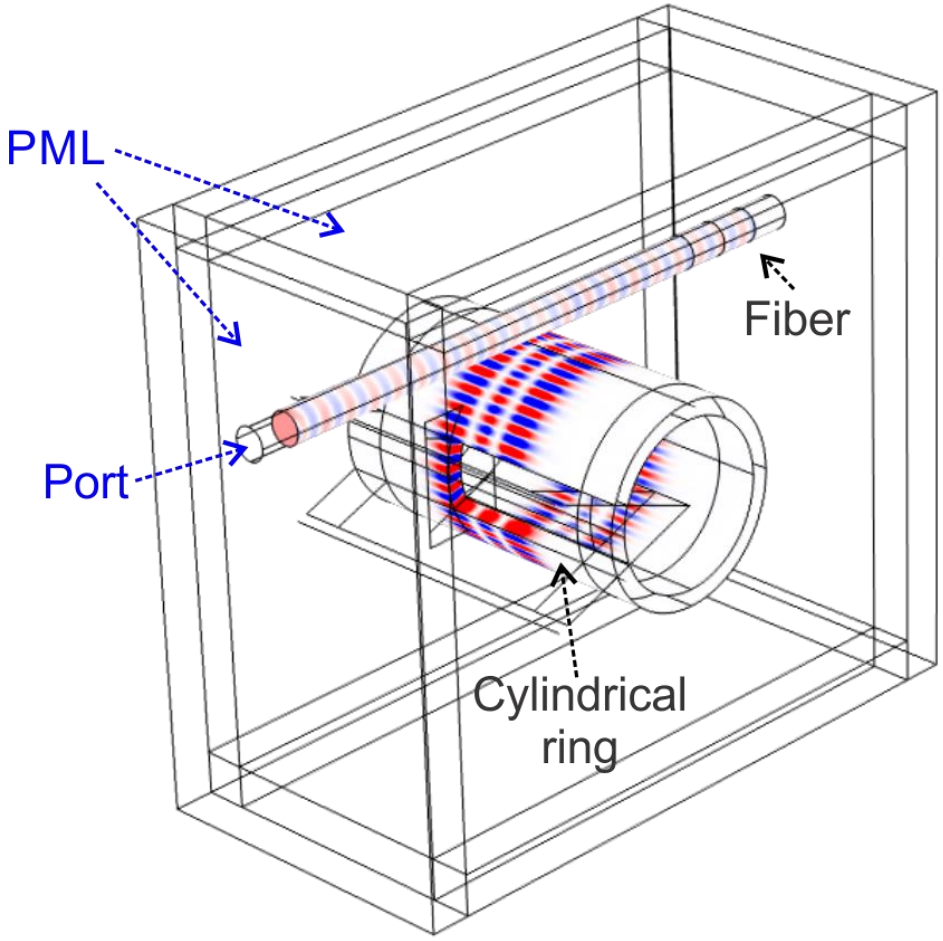


→ bilayer: 7 nm SiO_x and 28 nm SiO_2

S. Li *et al.*, Appl. Phys. Lett. **101**, 231106 (2012).

Simulations for rolled-up optical microcavities

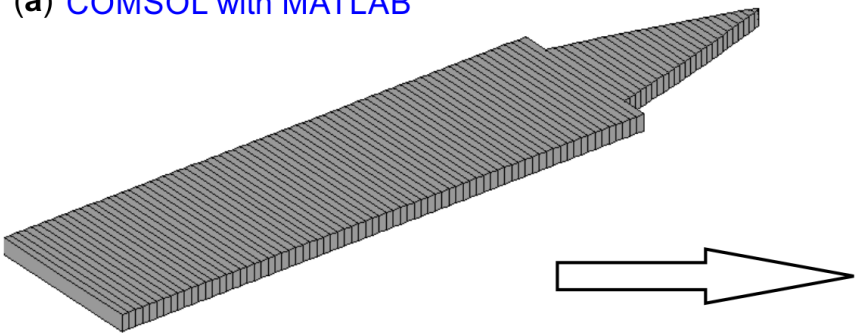




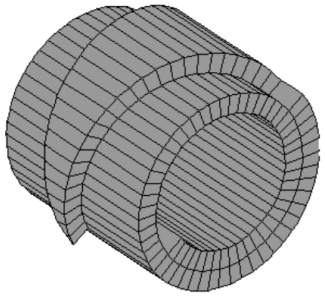
→ cylindrical ring approximation

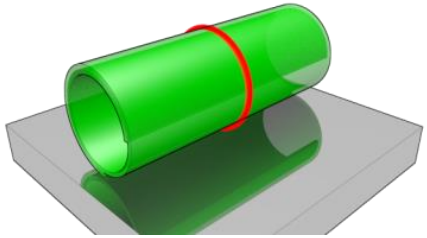
Simulations for rolled-up optical microcavities

(a) COMSOL with MATLAB



Rolled-up spiral

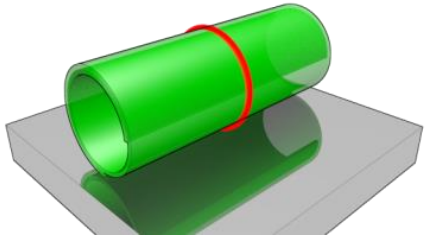




→ rolled-up tubular structure

→ ***hexahedron3***

Simulations for rolled-up optical microcavities



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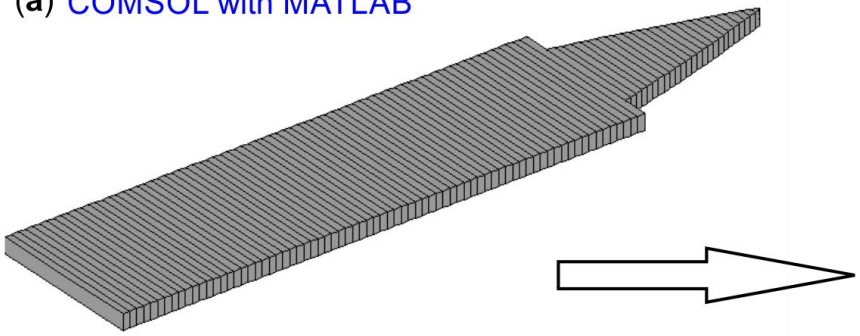

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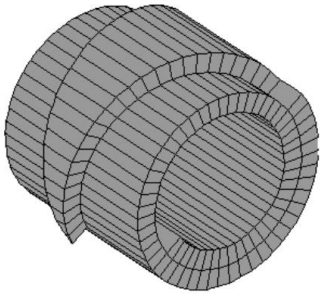
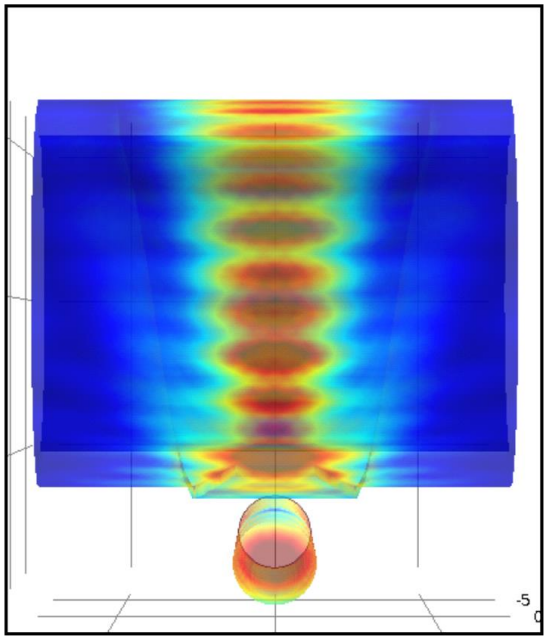
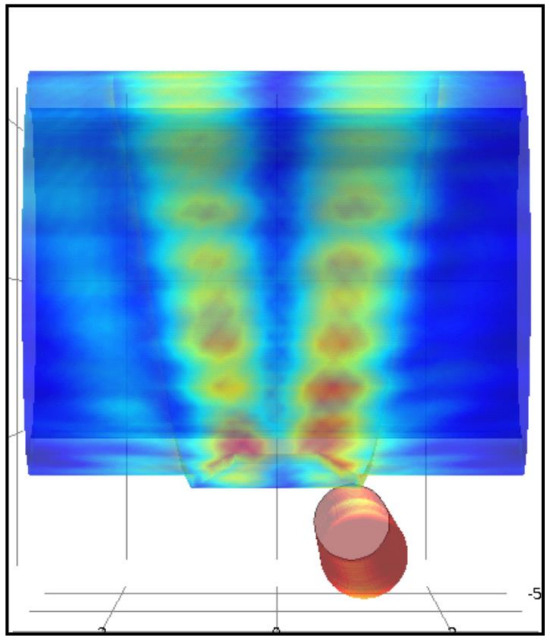


(b)





Acknowledgements

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- Prof. Vladimir Fomin
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Thank you very much for your attention!