Recent Progress in Photonic Crystal Devices

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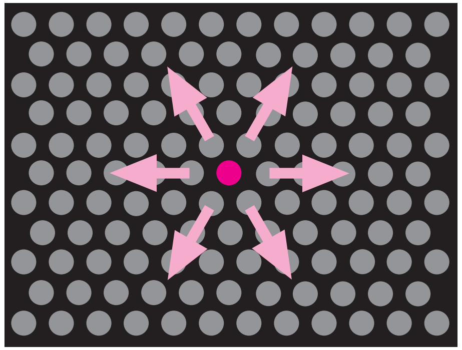
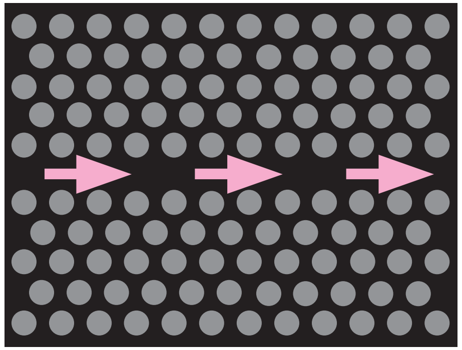
CREST, JST
http://www.jst.go.jp/kisoken/crest/

Topics



PC Nanolaser

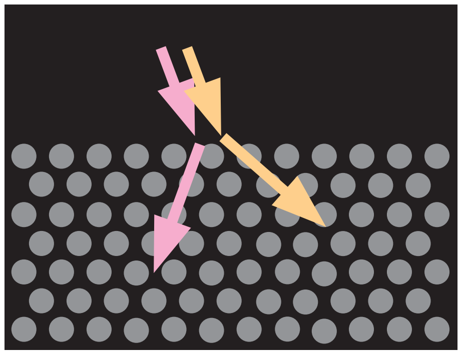
RT CW lasing in ultrasmall nanocavity
Purcell effect and thresholdless behavior
Active and passive integration
Application to refractive index sensing



PC Slowlight waveguide

Dispersion-compensated slowlight

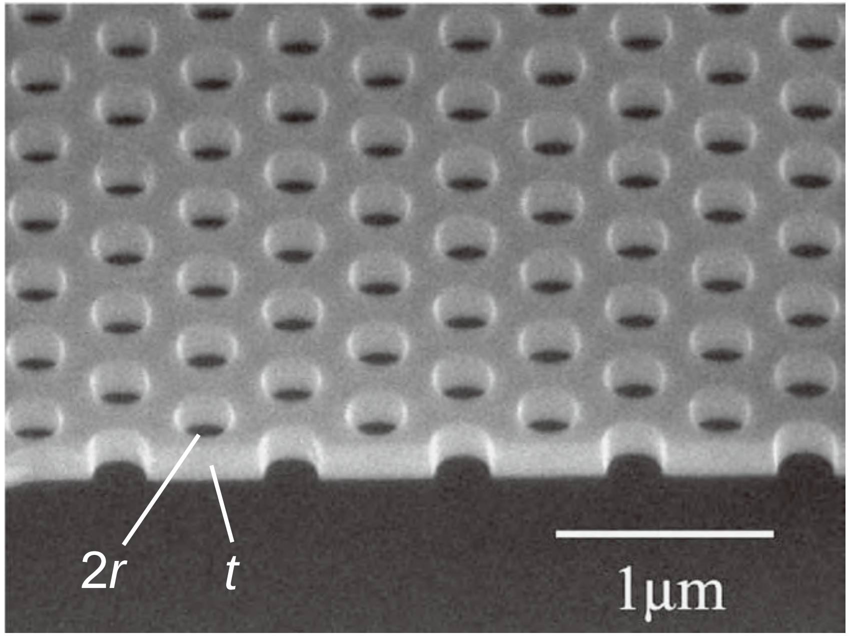
Zero-dispersion slowlight

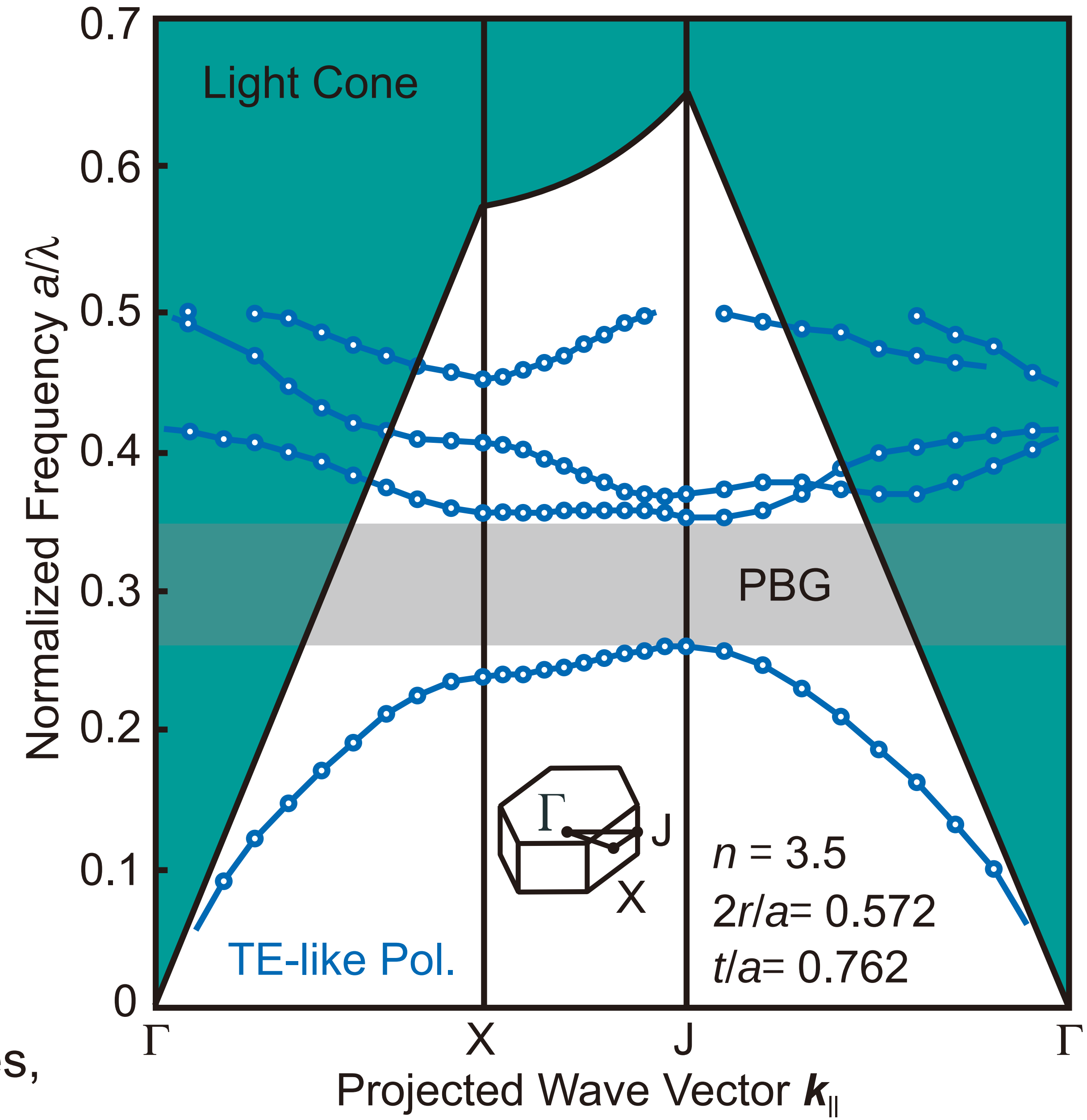


PC Negative refractive optics

Lens and prism effects
Application to compact demultiplexer

PC Slab





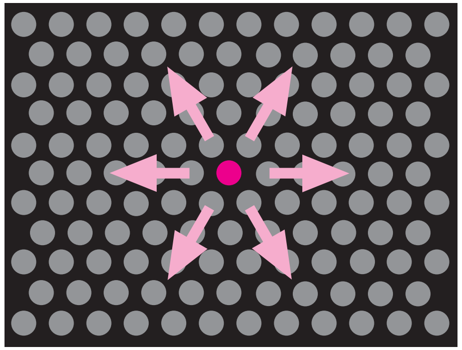
A thin membrane with airholes

Light is confined by TIR and PBG effect occurs in the plane

Easily fabricated into SOI, III-V with < 5nm roughness

Widely applied for lasers, waveguides, dense photonic integration, etc.

Topics



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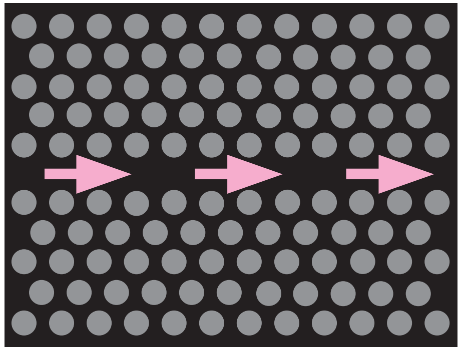

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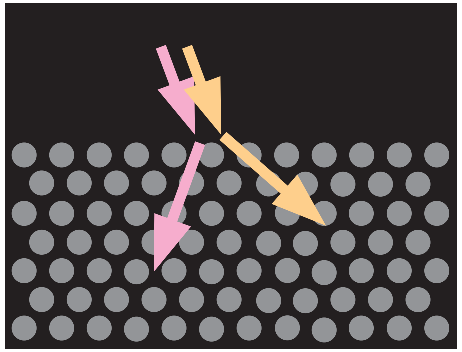

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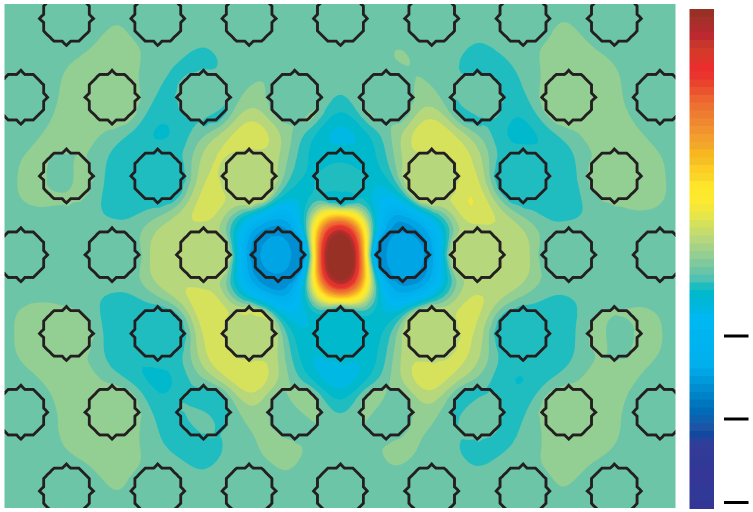
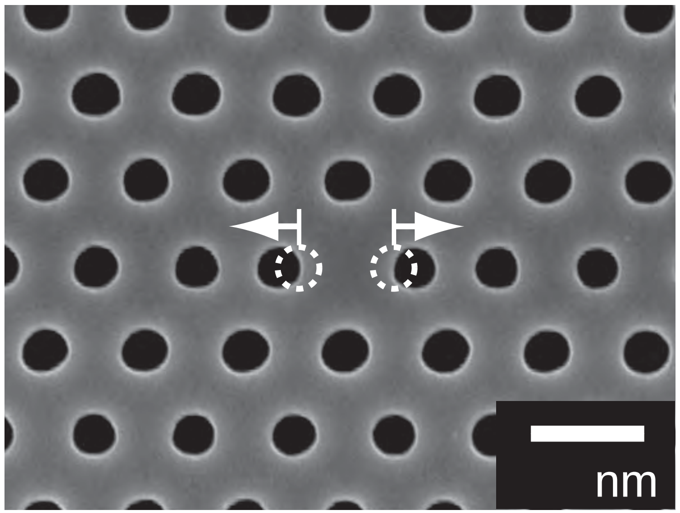
Application to compact demultiplexer

Point hift PC anolaser

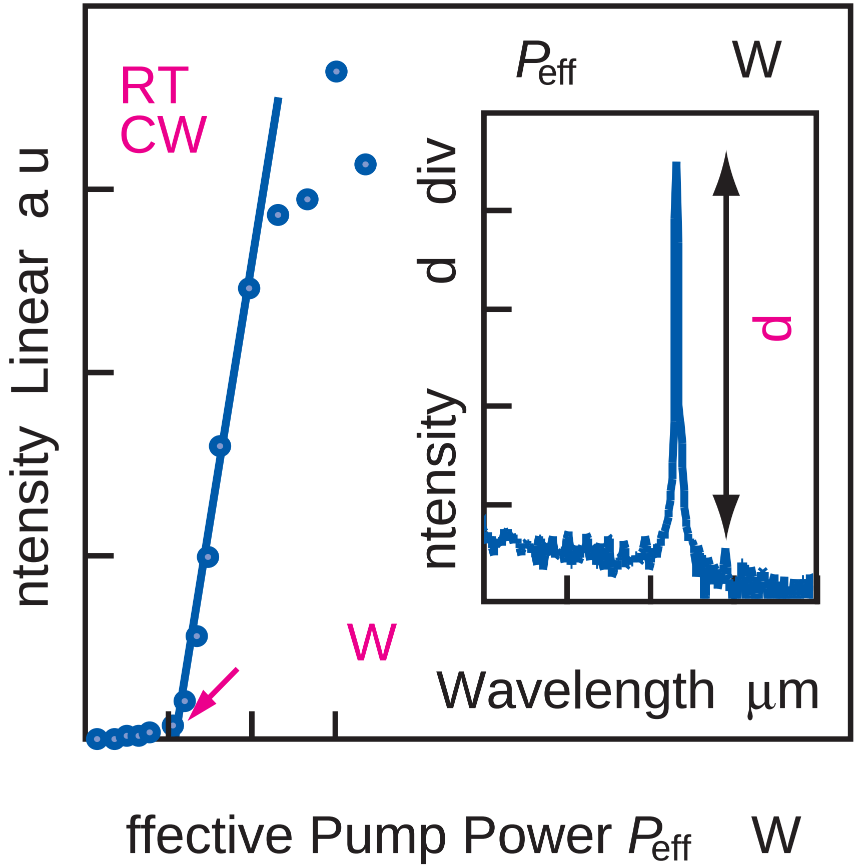
- anolaser consisting of only two point shift o a i et al *EL* **41**





- abricated by CP
de et al *JJAP* **45** L

- RT CW lasing first achieved in nanolaser
o a i et al *OE* **15**



- World s smallest V_m λ *n* evaluated
o a i et al *APL* **88**

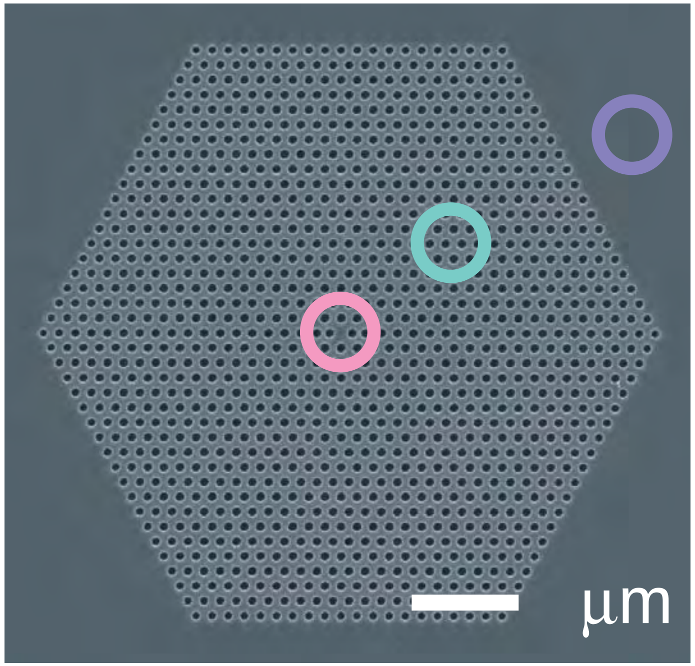
Purcell ffect in PC anocavity

aba et al *APL* **85**

rate enhanced by factor

$$\frac{\Gamma_r \lambda}{\pi \; n \; V_m \Delta\lambda}$$

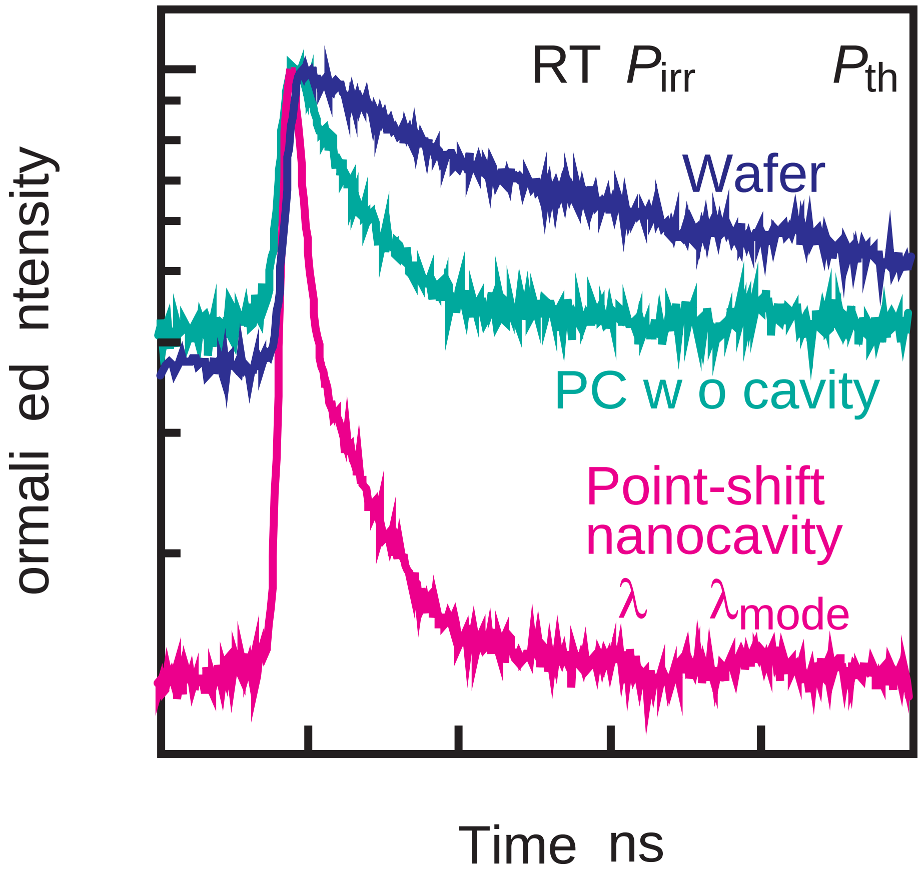
$\Delta\lambda$ Cavity linewidth – or
homog broadening RT



o a i et al *OE* **15**

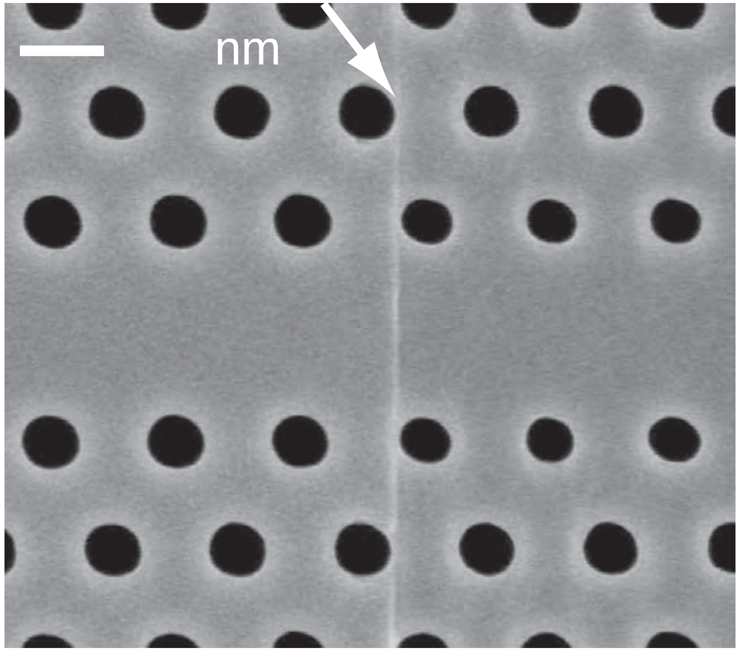
x – enhancement expected for various materials including i etc

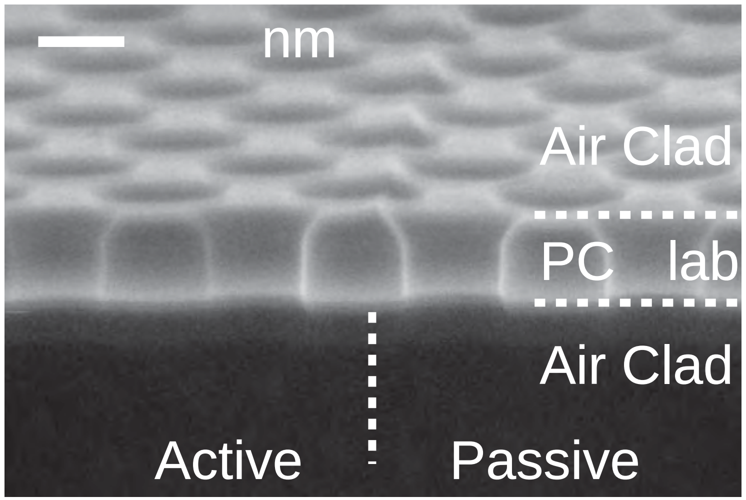
Thresholdless lasing expected



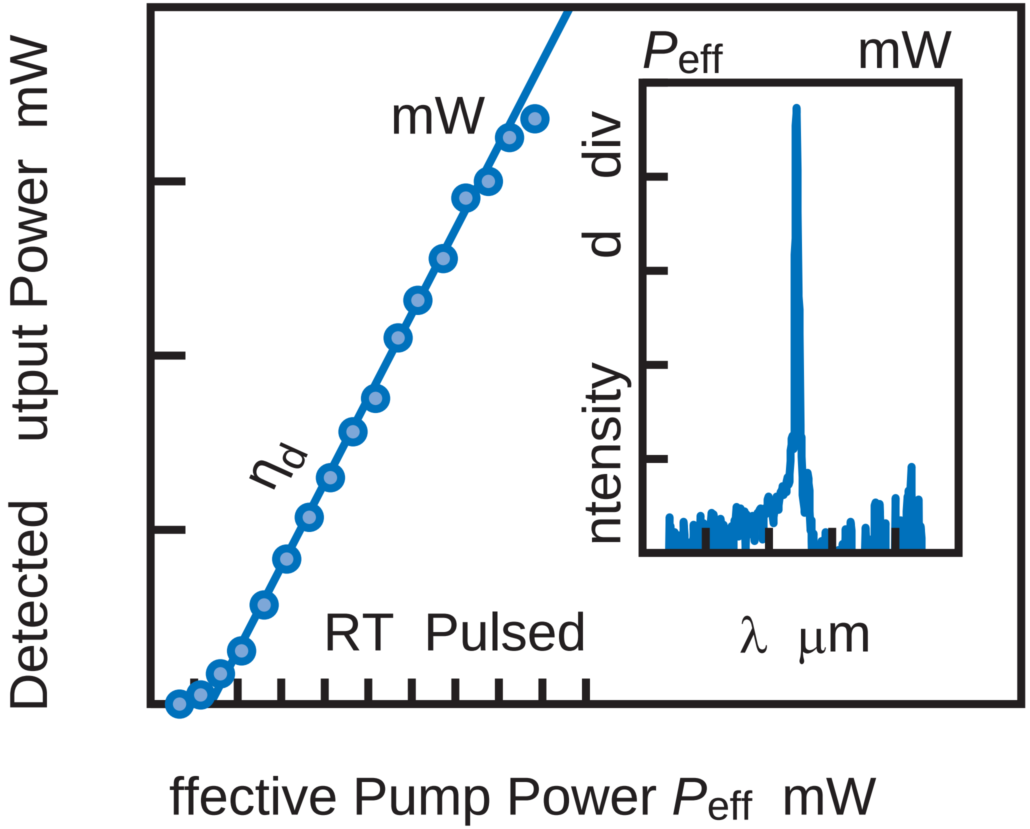
Active Passive- ntegrated PC lab

Watanabe and aba *EL* 42 *OE* 16



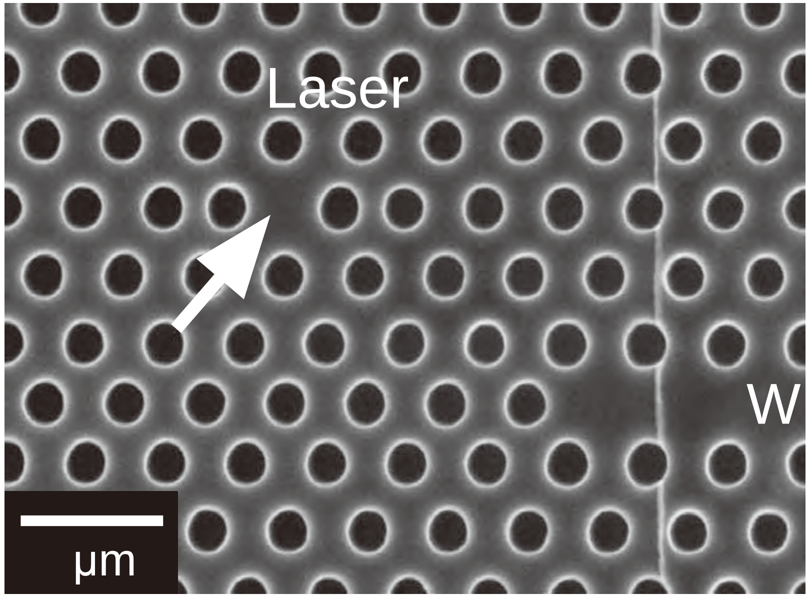


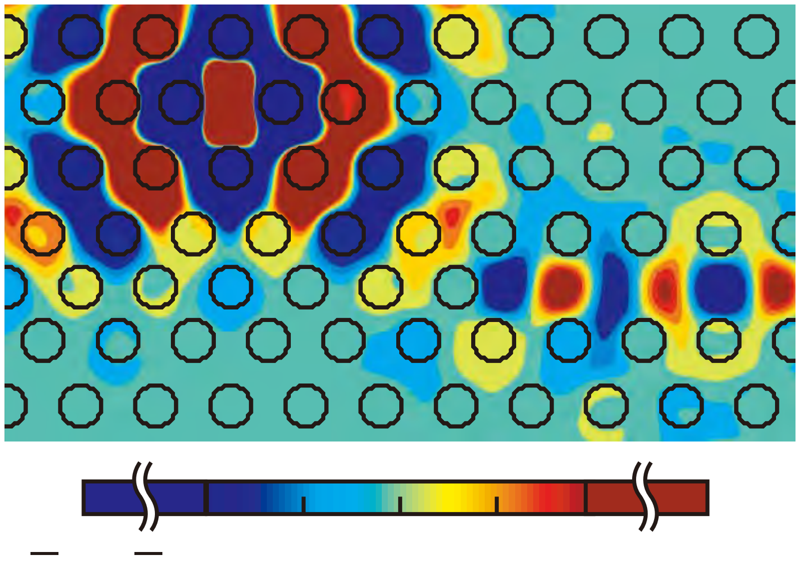
PC laser and waveguide integrated by butt oint C D regrowth process



η_d estimated for total output

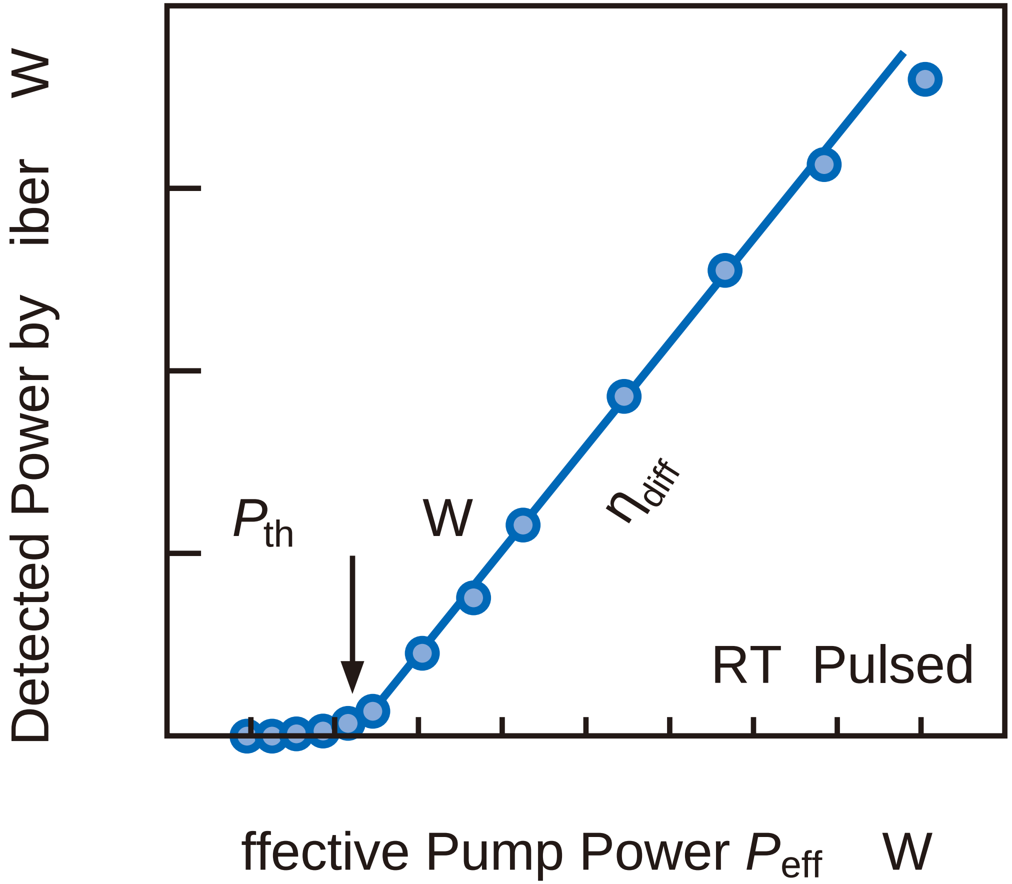
ntegration of PC anolaser with Waveguide





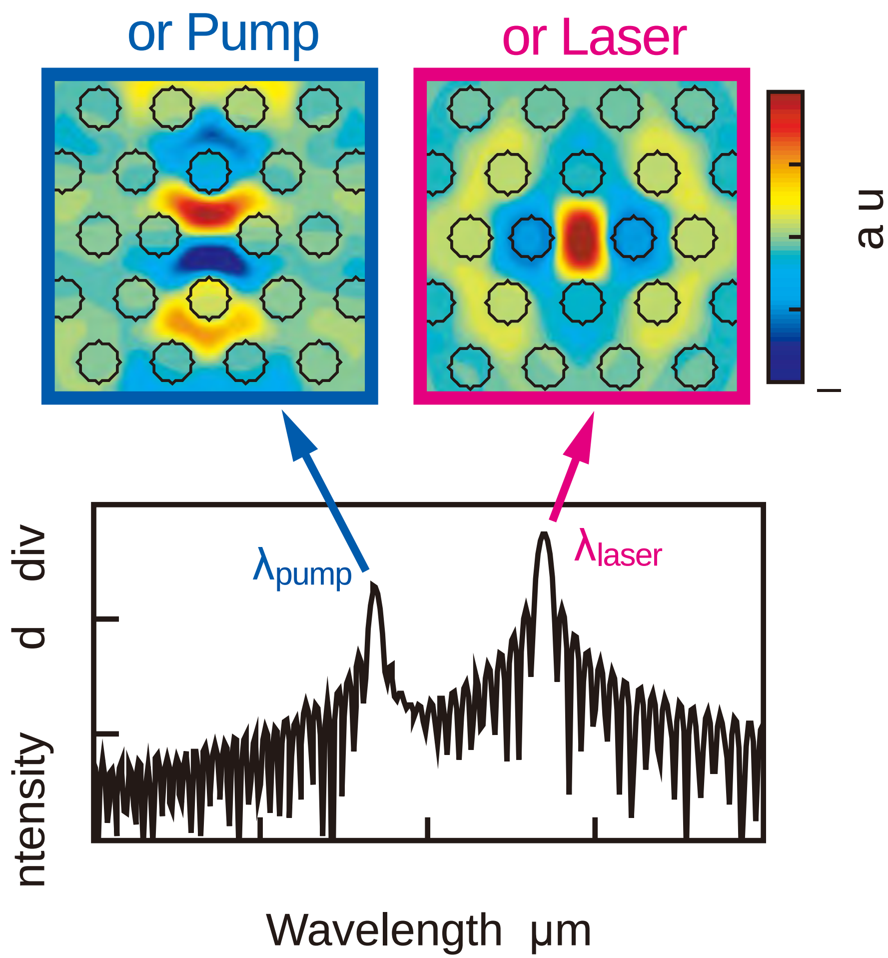
o a i et al *APL* 2

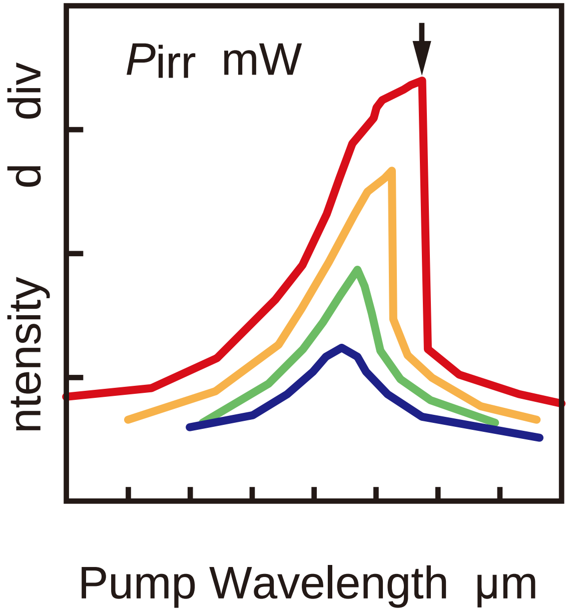
Coupling of laser and waveguide enhanced by optimi ing distance and direction

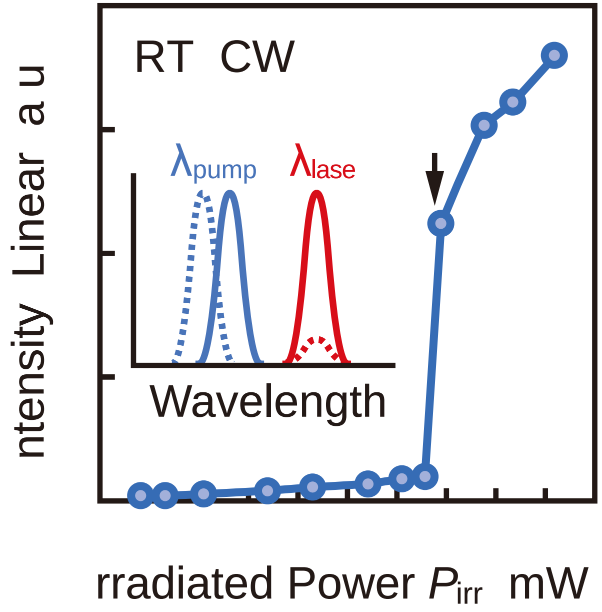


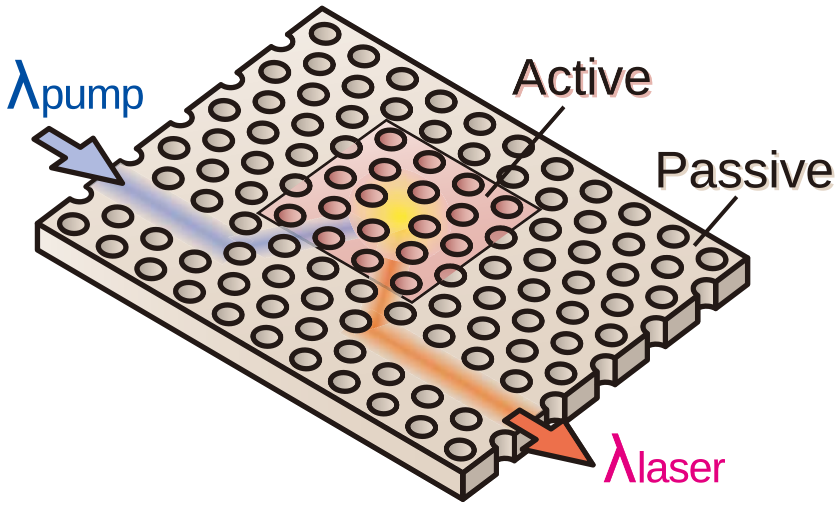
witching ehavior by Resonant Pumping

o a i et al *APL* 2



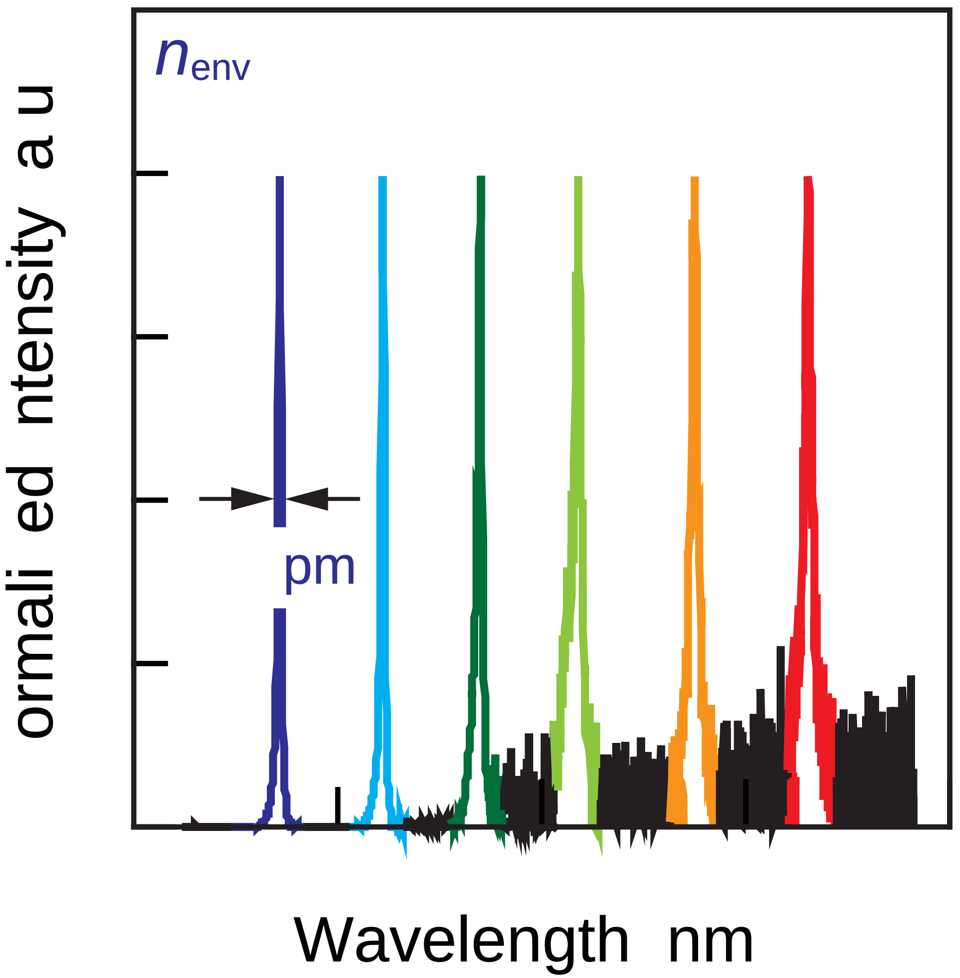


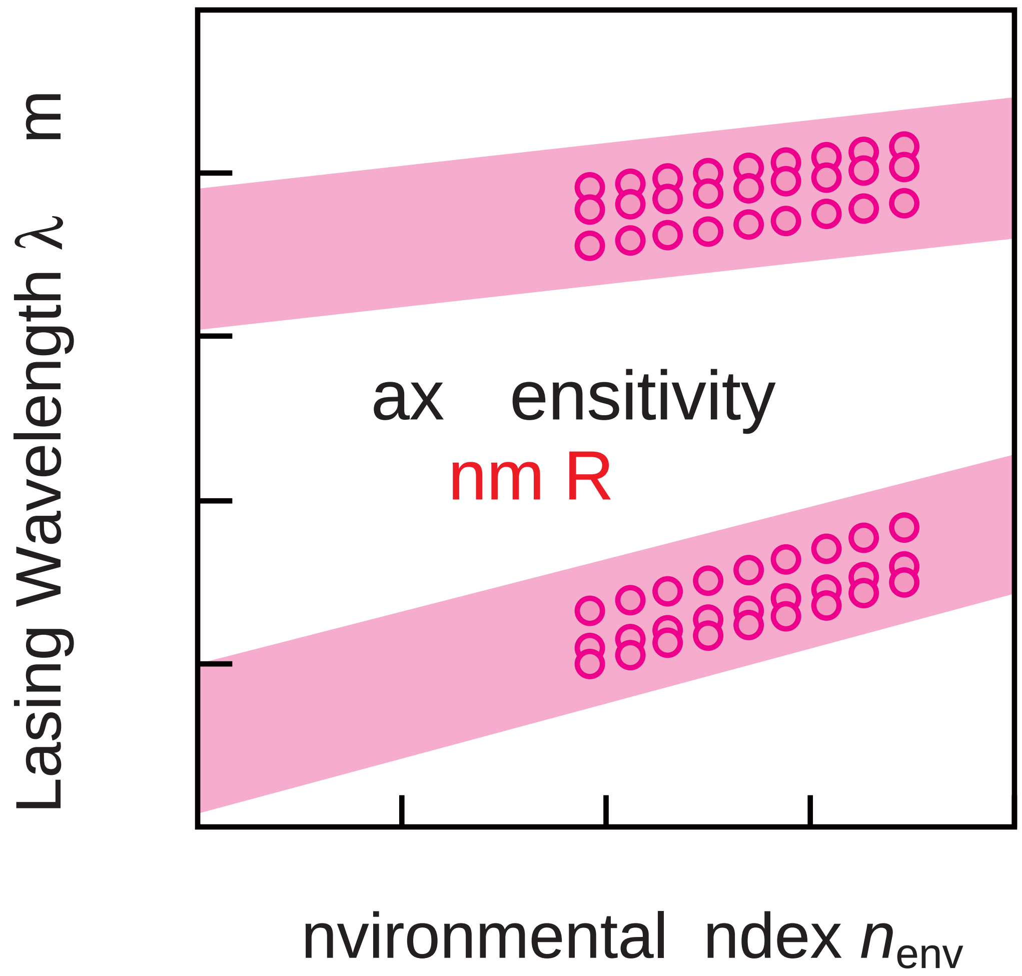




- fficient selective excitation of nanocavity
- Applicable to wavelength converter bistable device etc

ndex ensitivity in PC anolaser

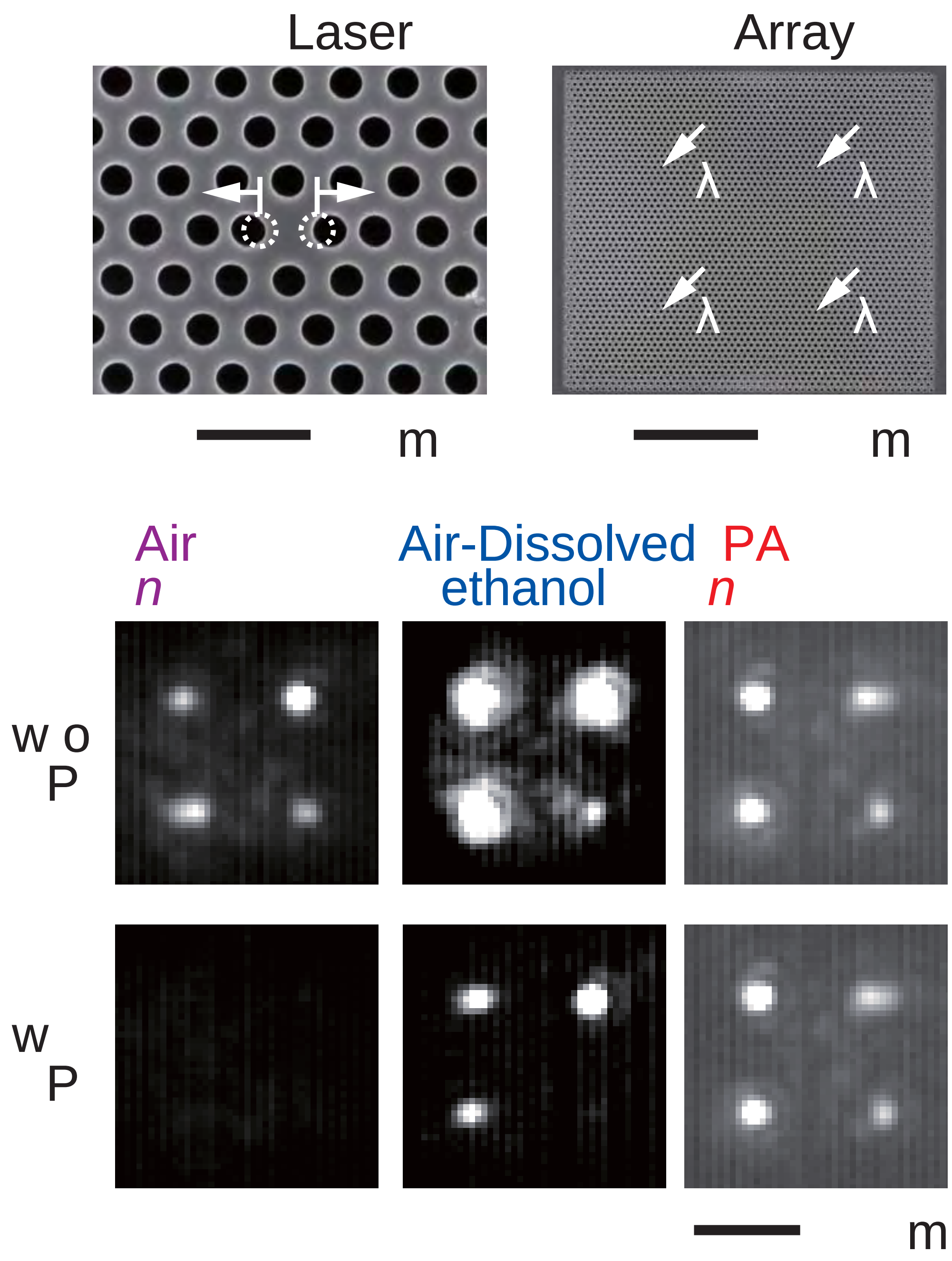




pectral W pm Resolition limit ensitivity of nm R

→ Potential detection limit of - R

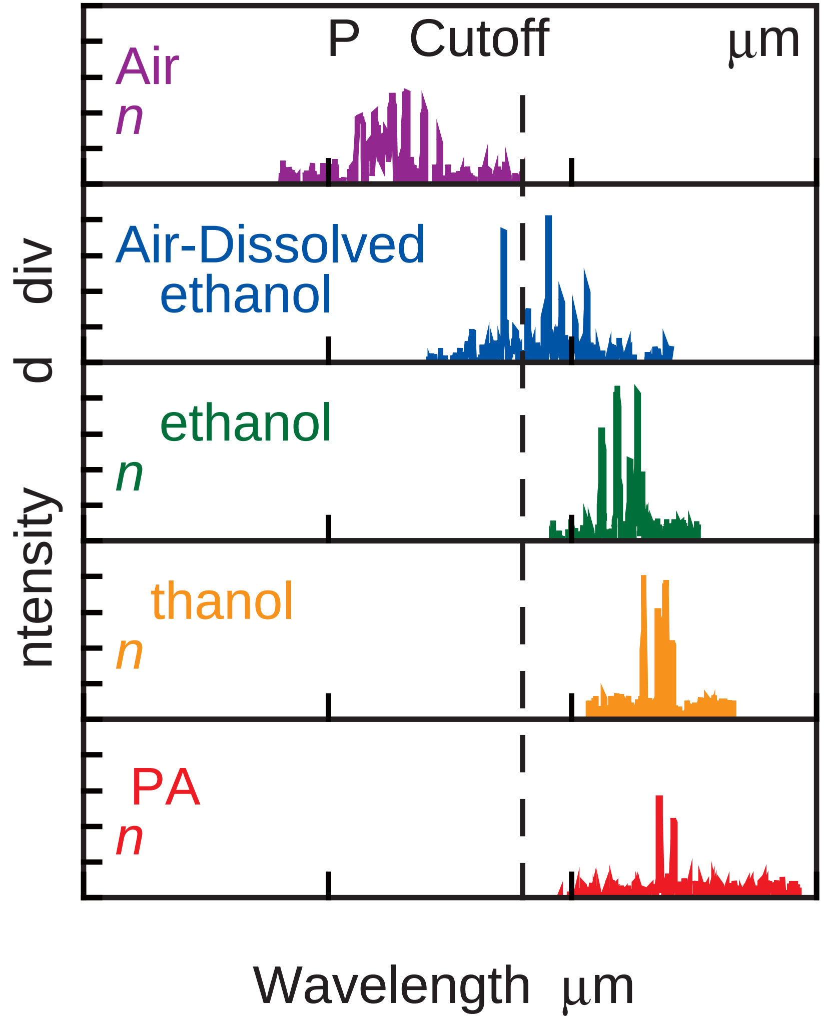
ndex ensing using anolaser Array



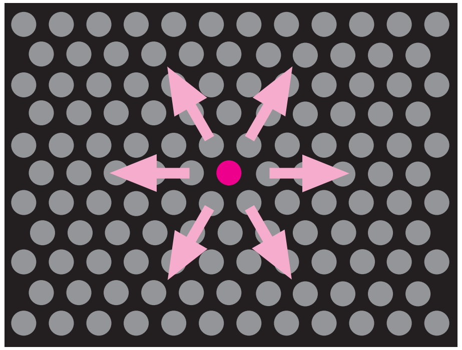
ita et al TuC P-

Large ndex sensitivity of nm Δn

pectrometer-less sensing from P
using laser array and P



Topics



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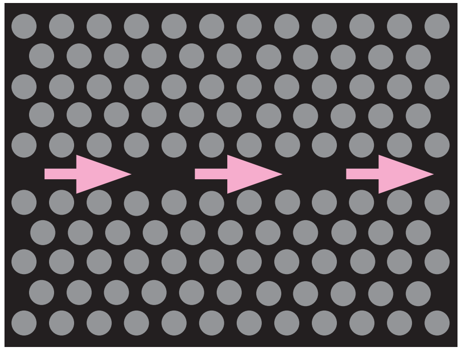
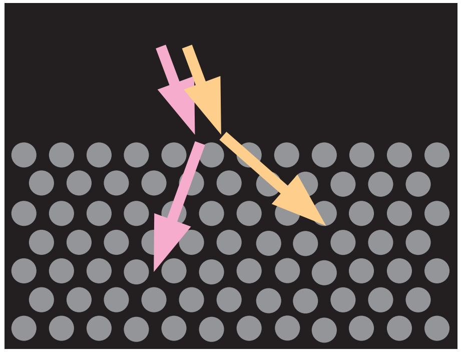


PC Slowlight waveguide

Dispersion-compensated slowlight
Zero-dispersion slowlight



PC Negative refractive optics

Lens and prism effects
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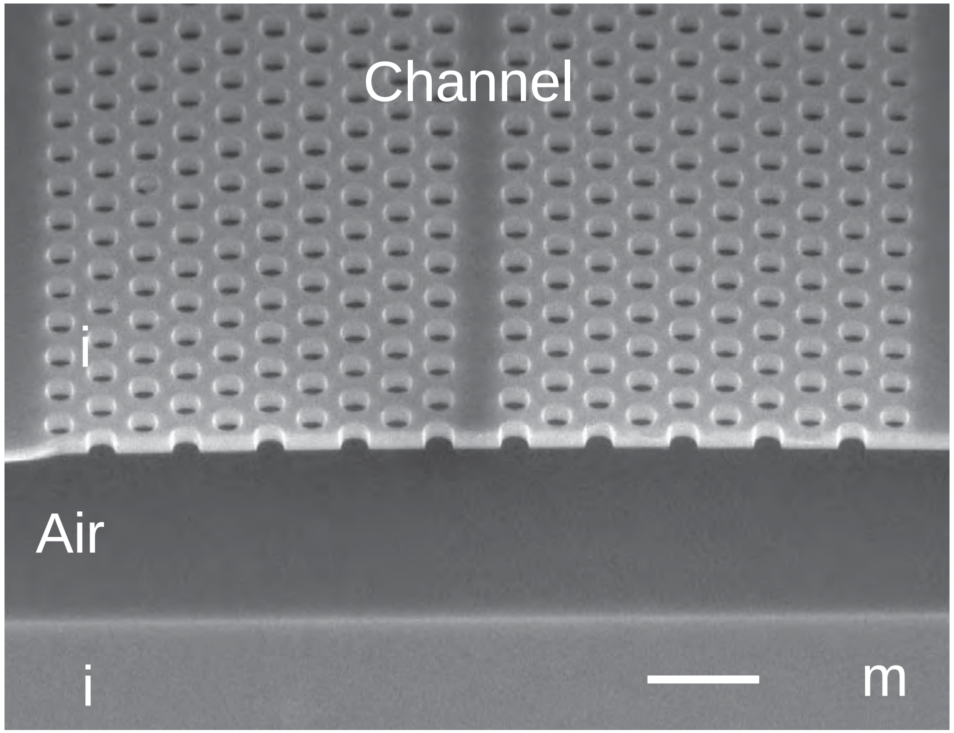
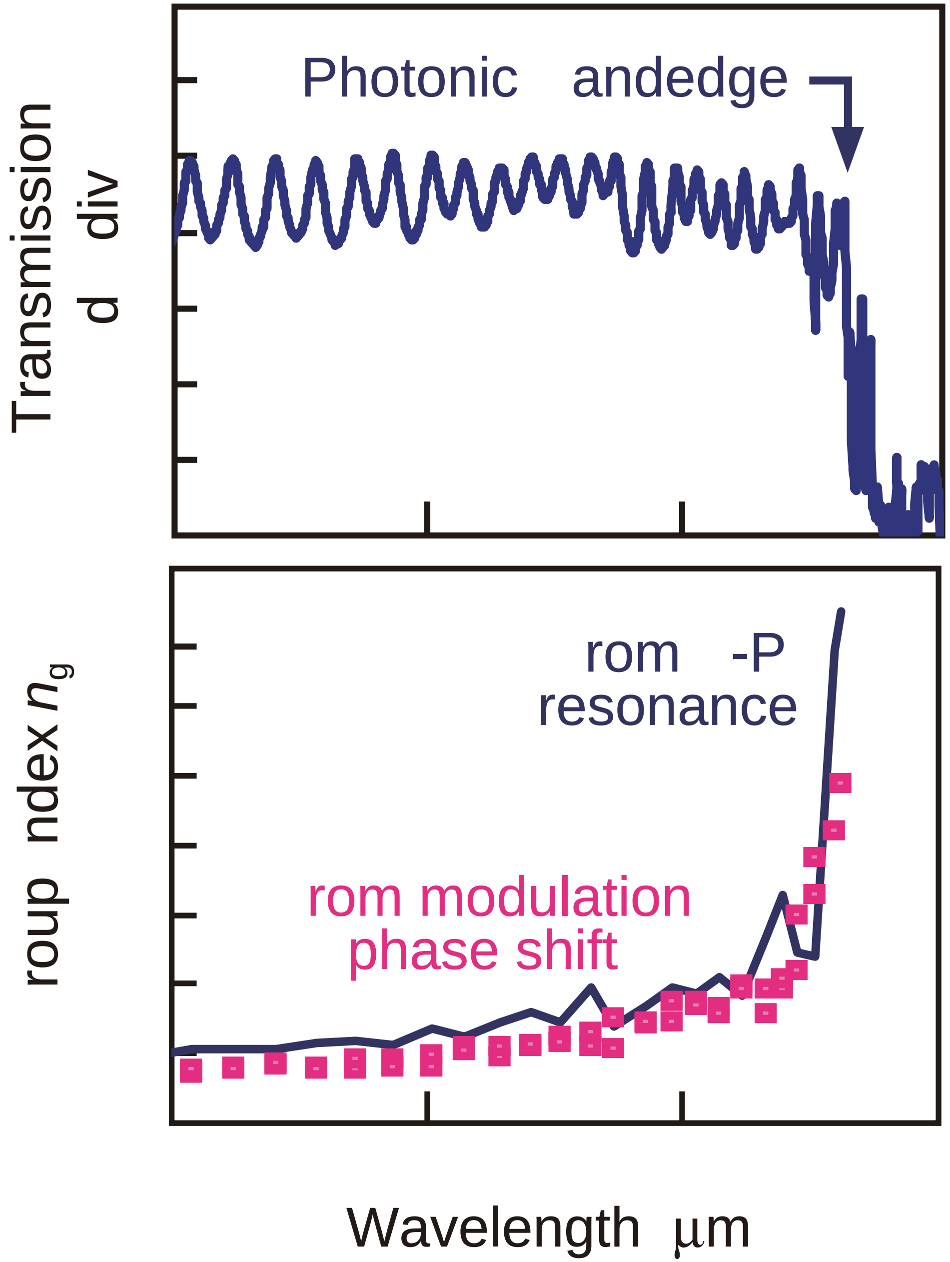
PC　low Light Waveguide

after　aba et al　*EL*　**5**

- asy fabrication on　　wafer　etc
- Lossless guided mode exhibiting slow light at bandedge with narrow bandwidth and large　D



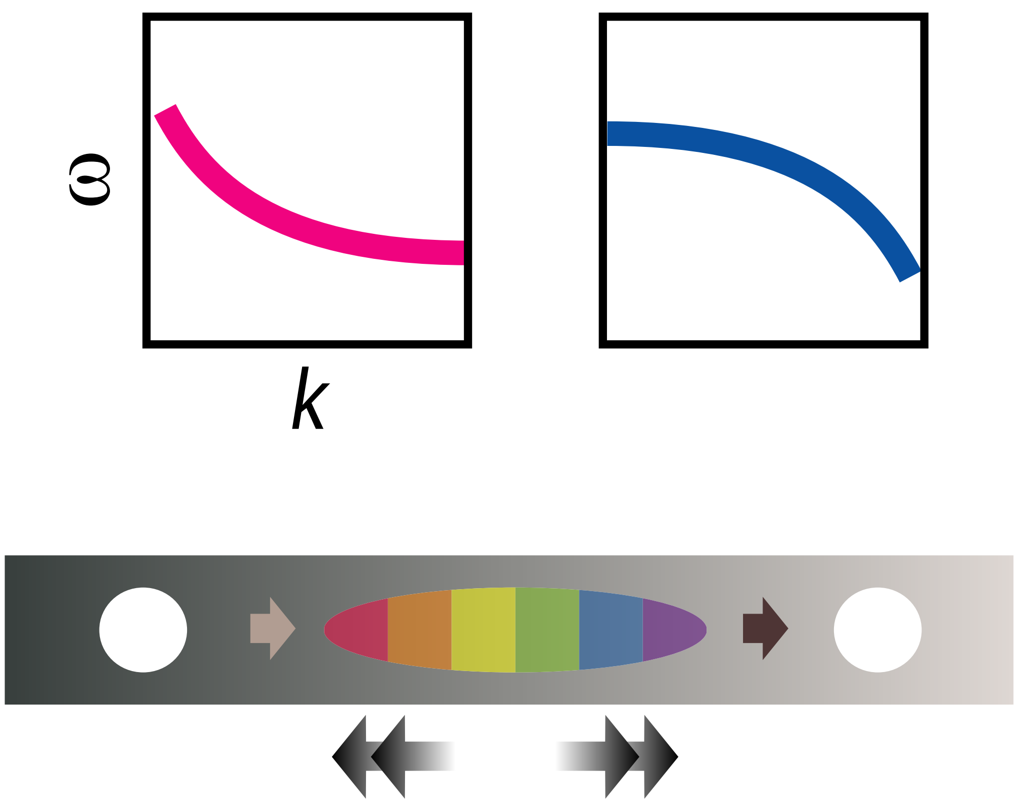


Dispersion- ree Widband low Light

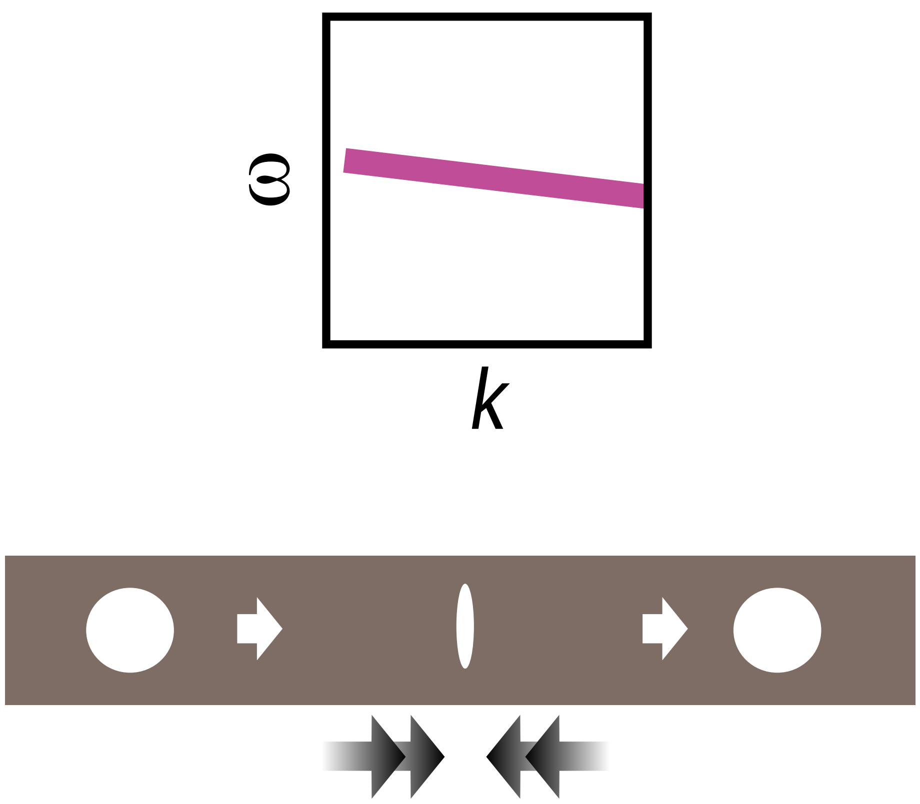
Dispersion-Compensated low Light

Zero-Dispersion low Light

L LD Low elocity Low Dispersion



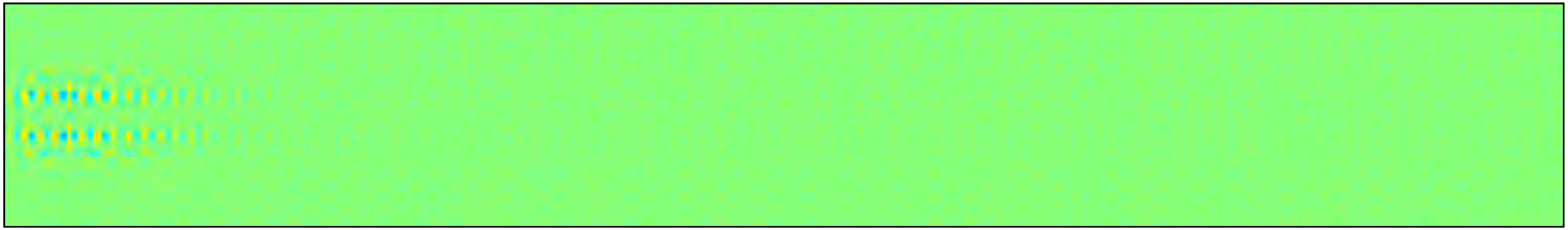
patially dispersed

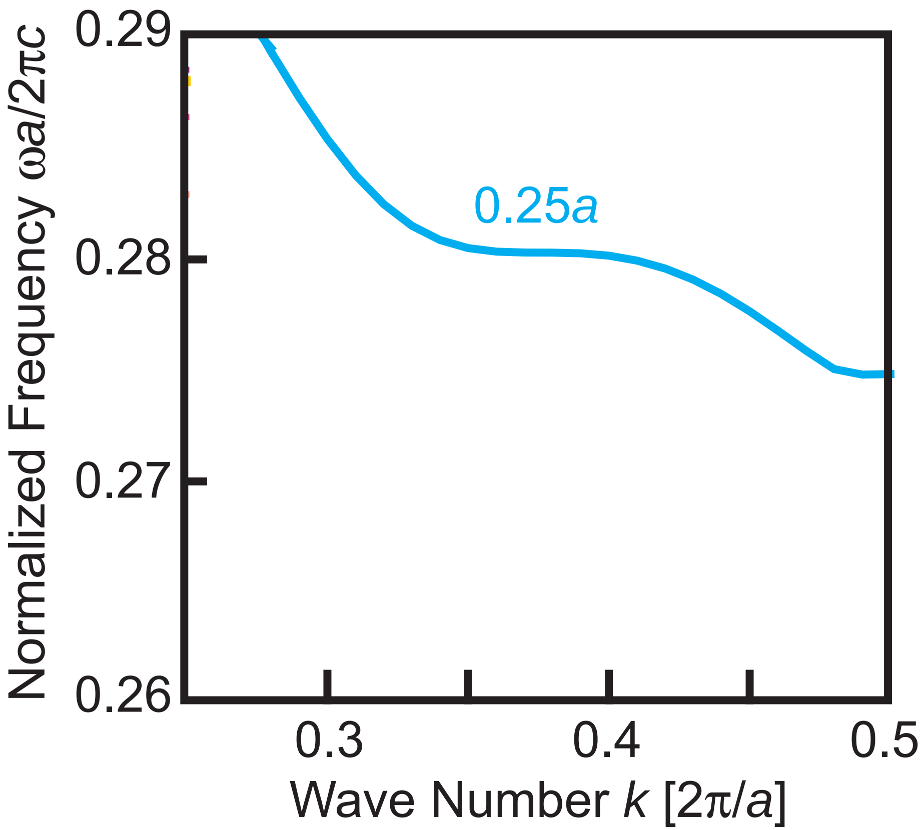


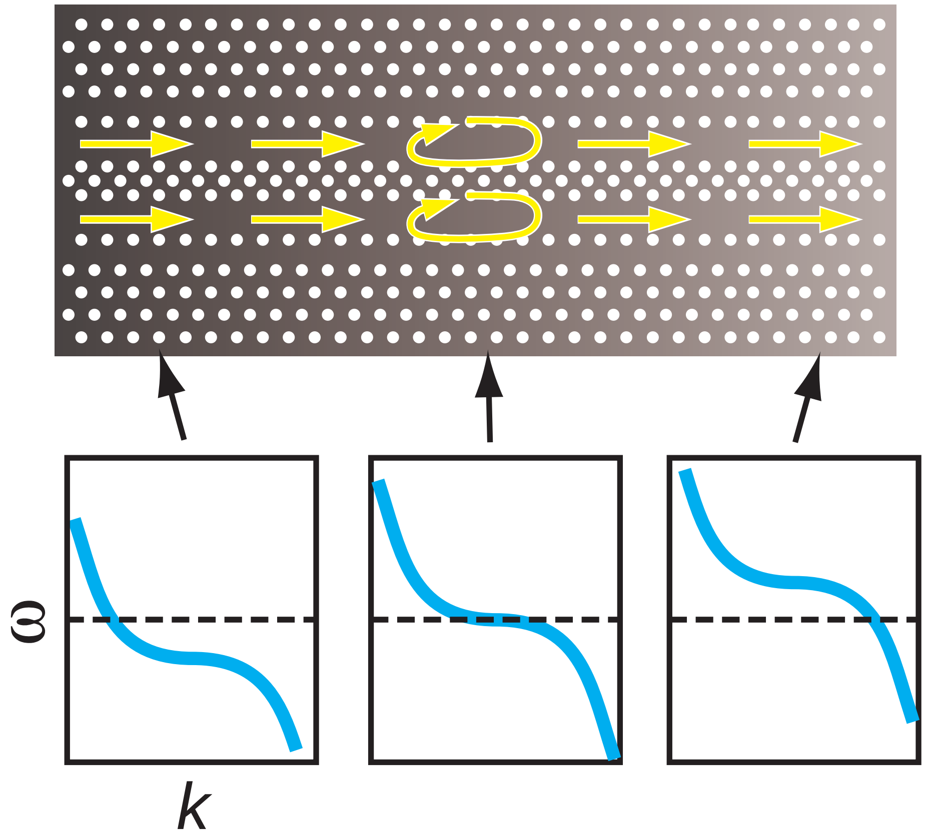
patially compressed

Smooth Delay by Coupled Waveguides

(Mori and Baba, *Opt. Express* **13**, 9398 (2005))

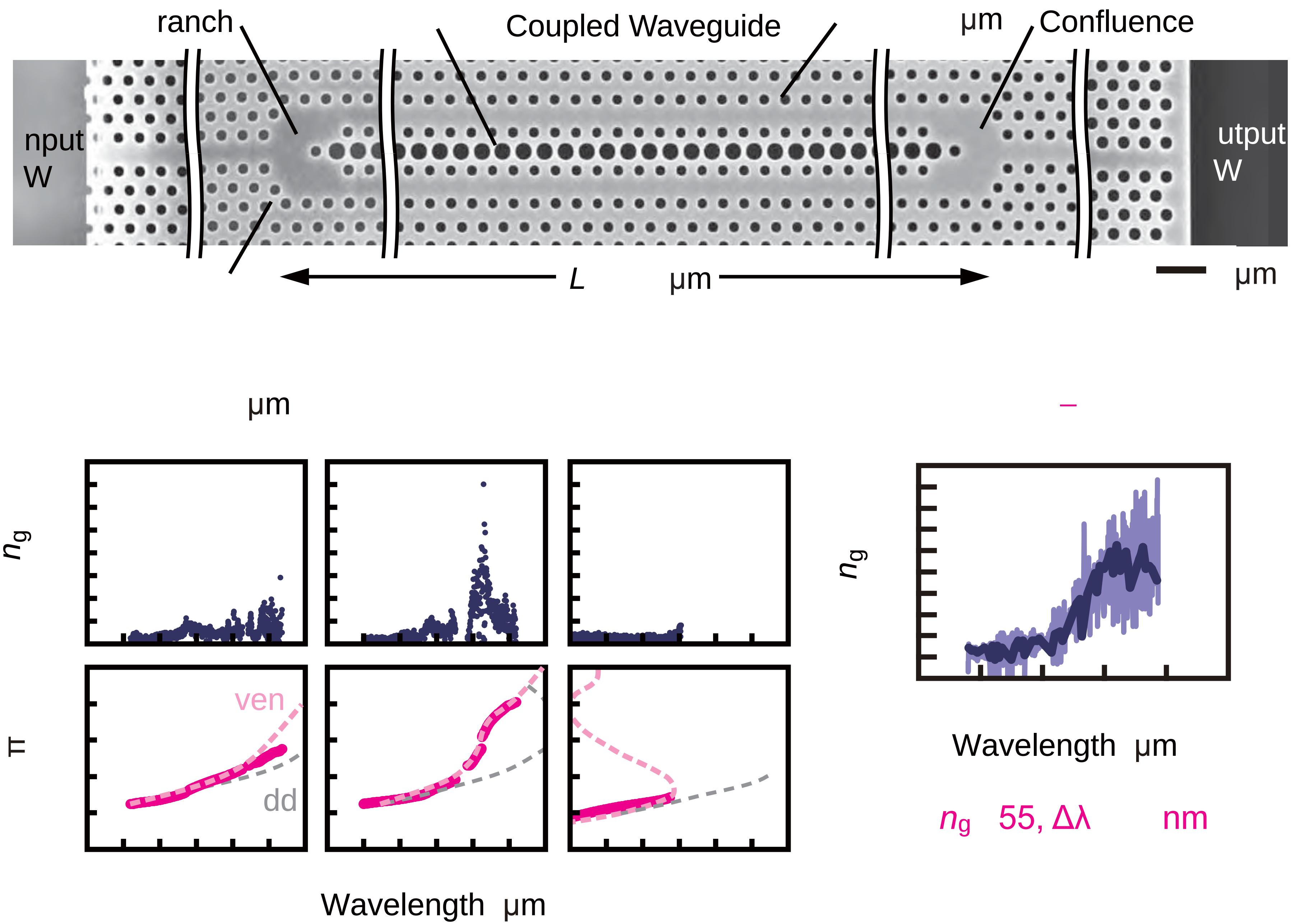




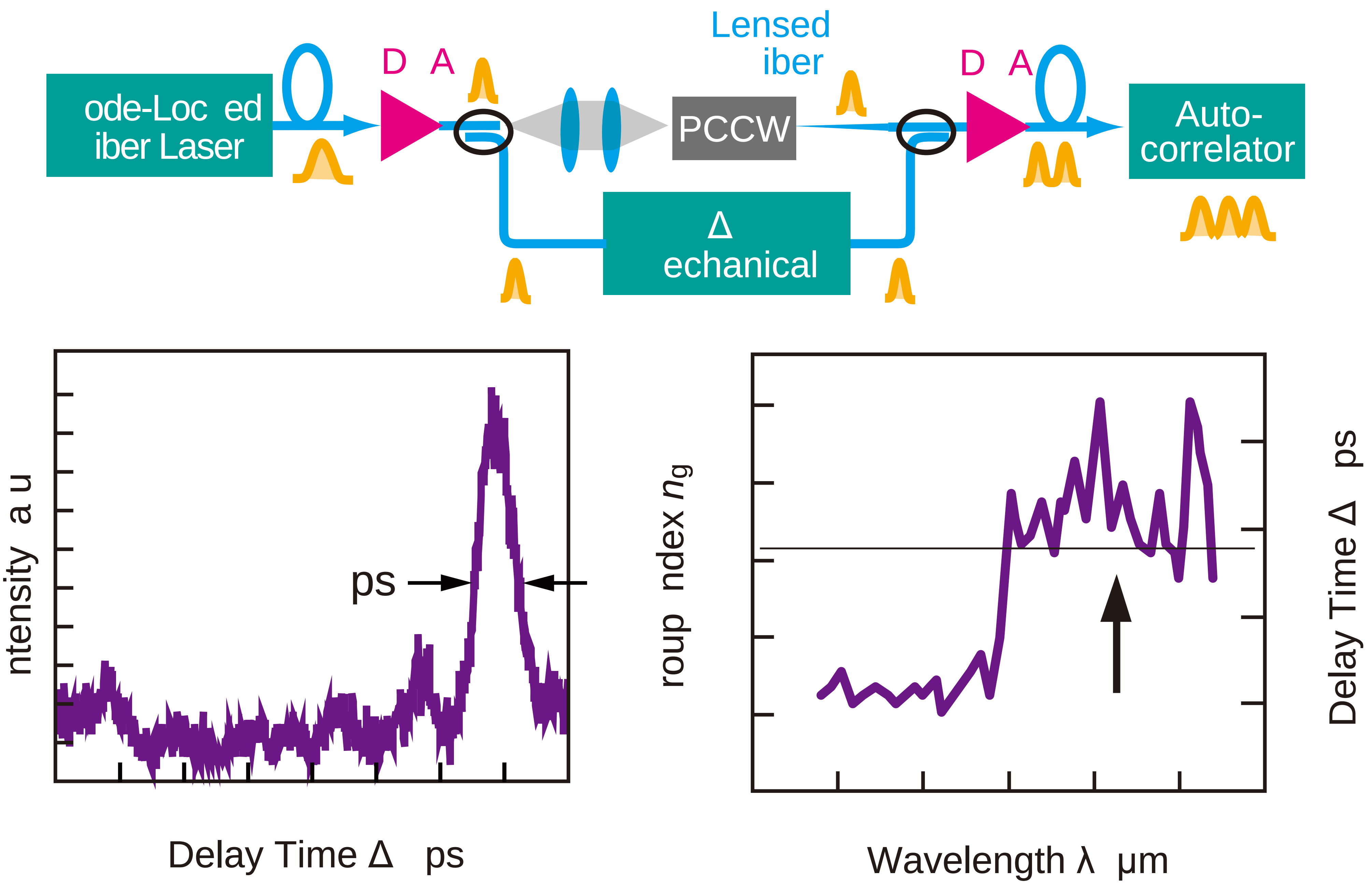


Dispersion-Compensated low Light in PCCW

awasa i ori and aba *OE* **15**

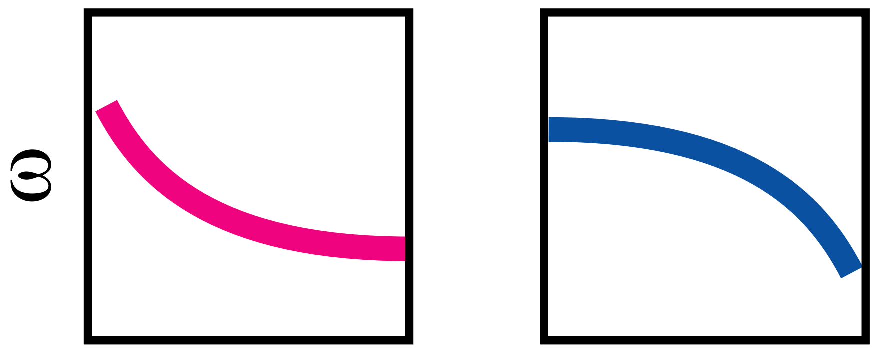


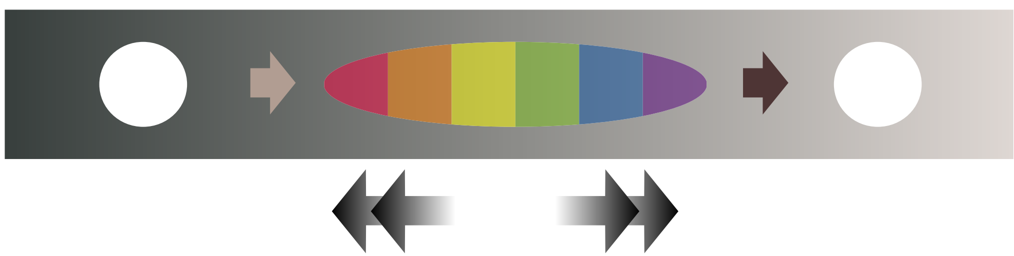
ffective Delay in low Light Pulse



Dispersion- ree Widband   low Light

Dispersion-Compensated low Light

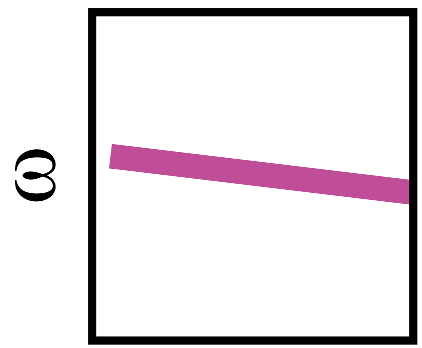


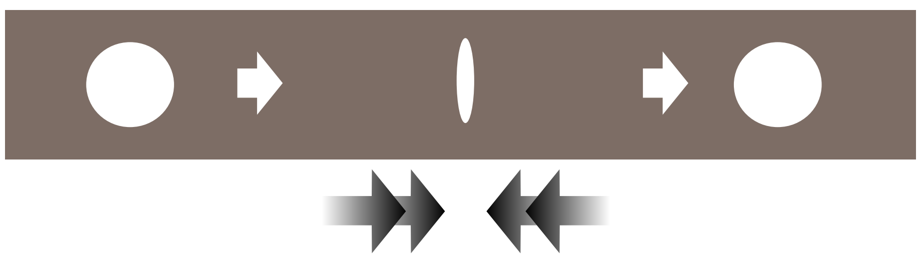


patially dispersed

Zero-Dispersion   low Light

L LD Low   elocity Low Dispersion

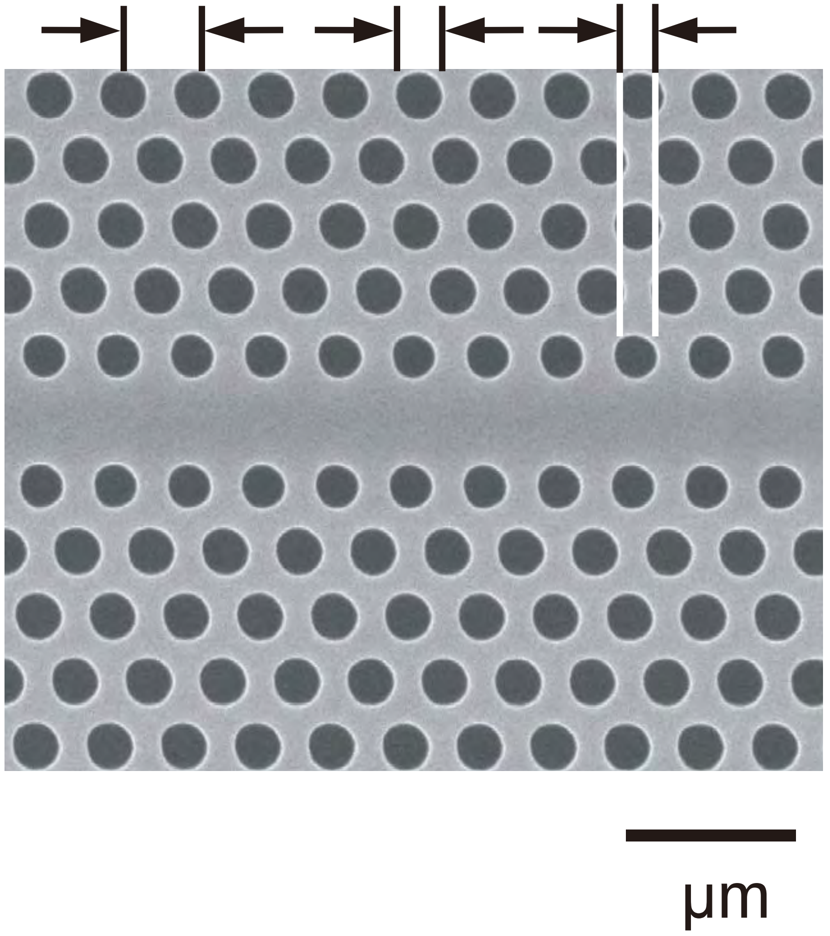


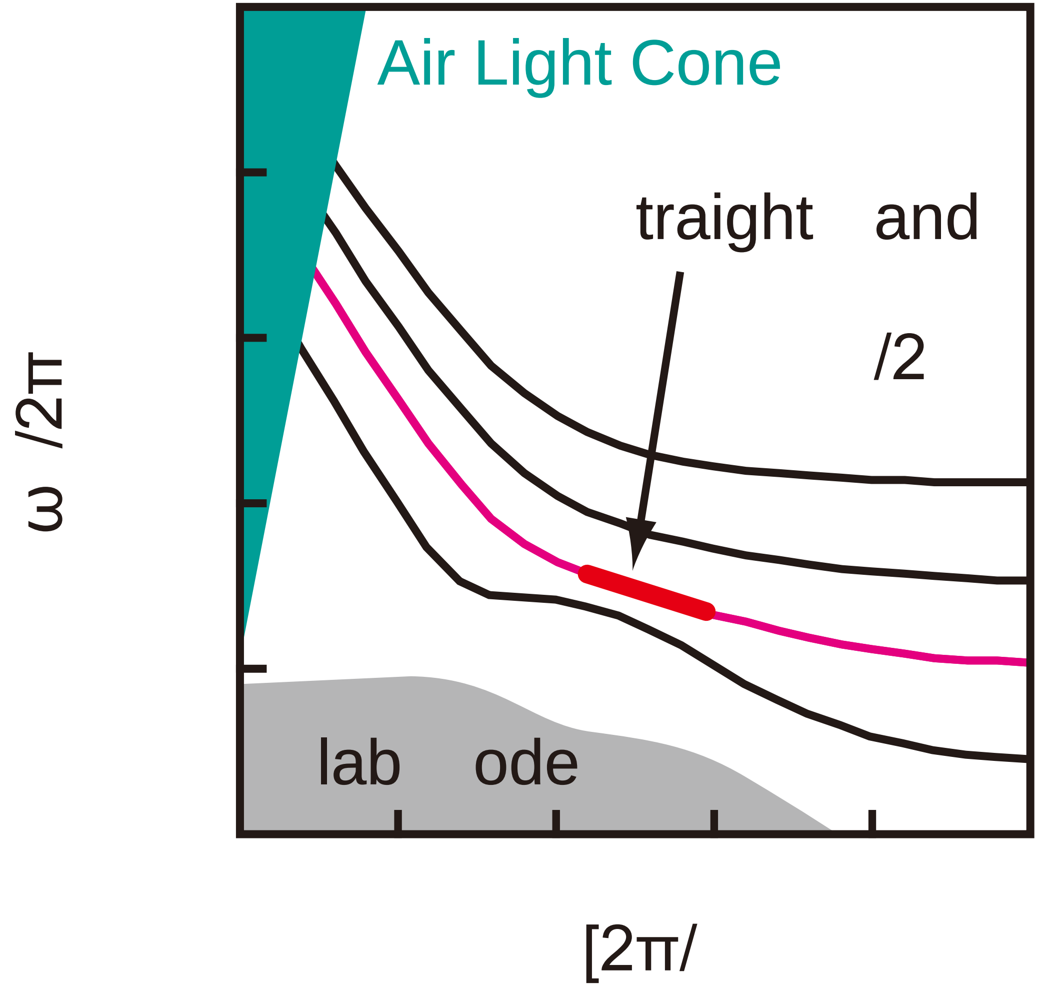


patially compressed

L LD Characteristics in PC Waveguides

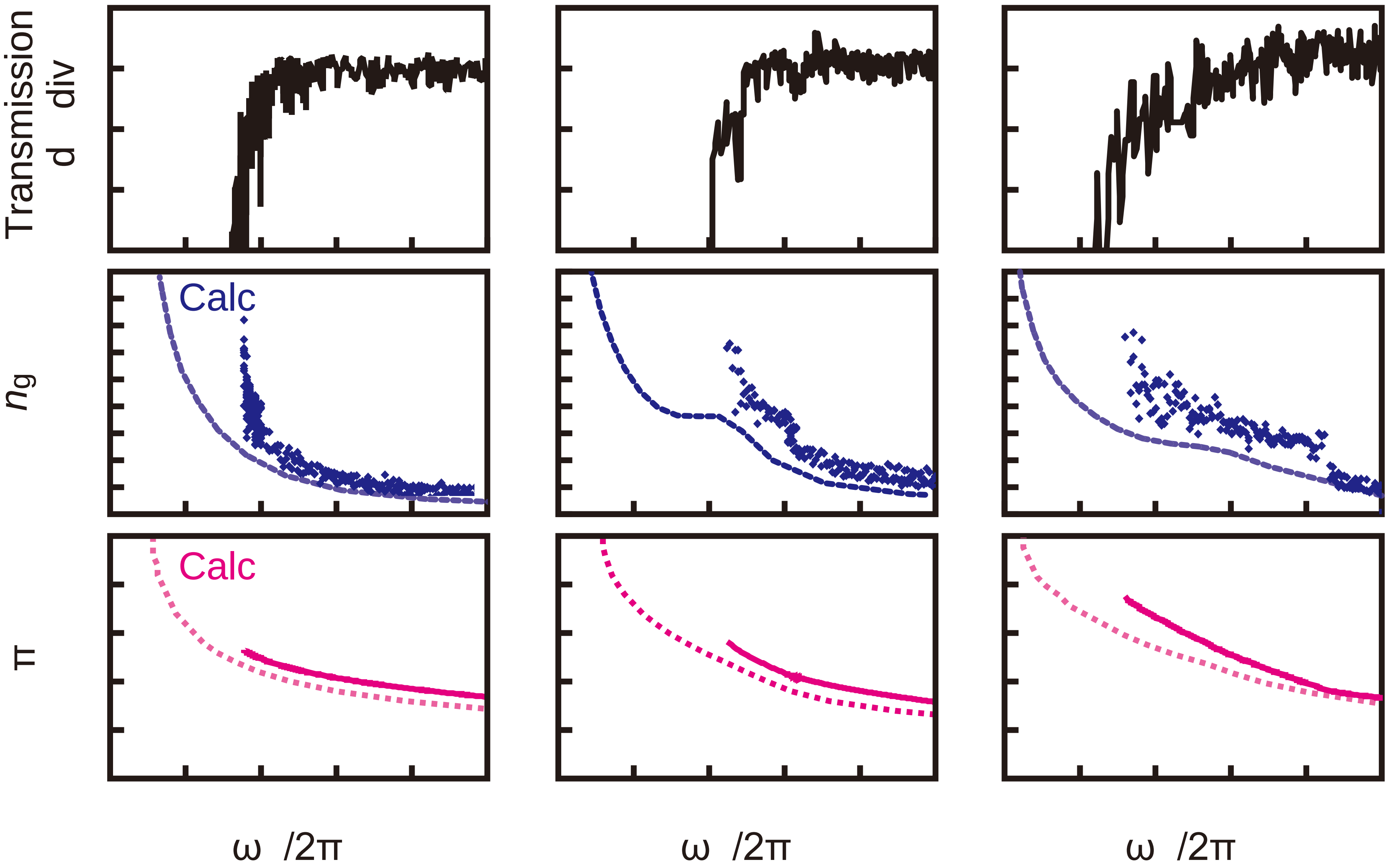
a ai aba et al *EEE LEO Ann* Th -
\- patented in



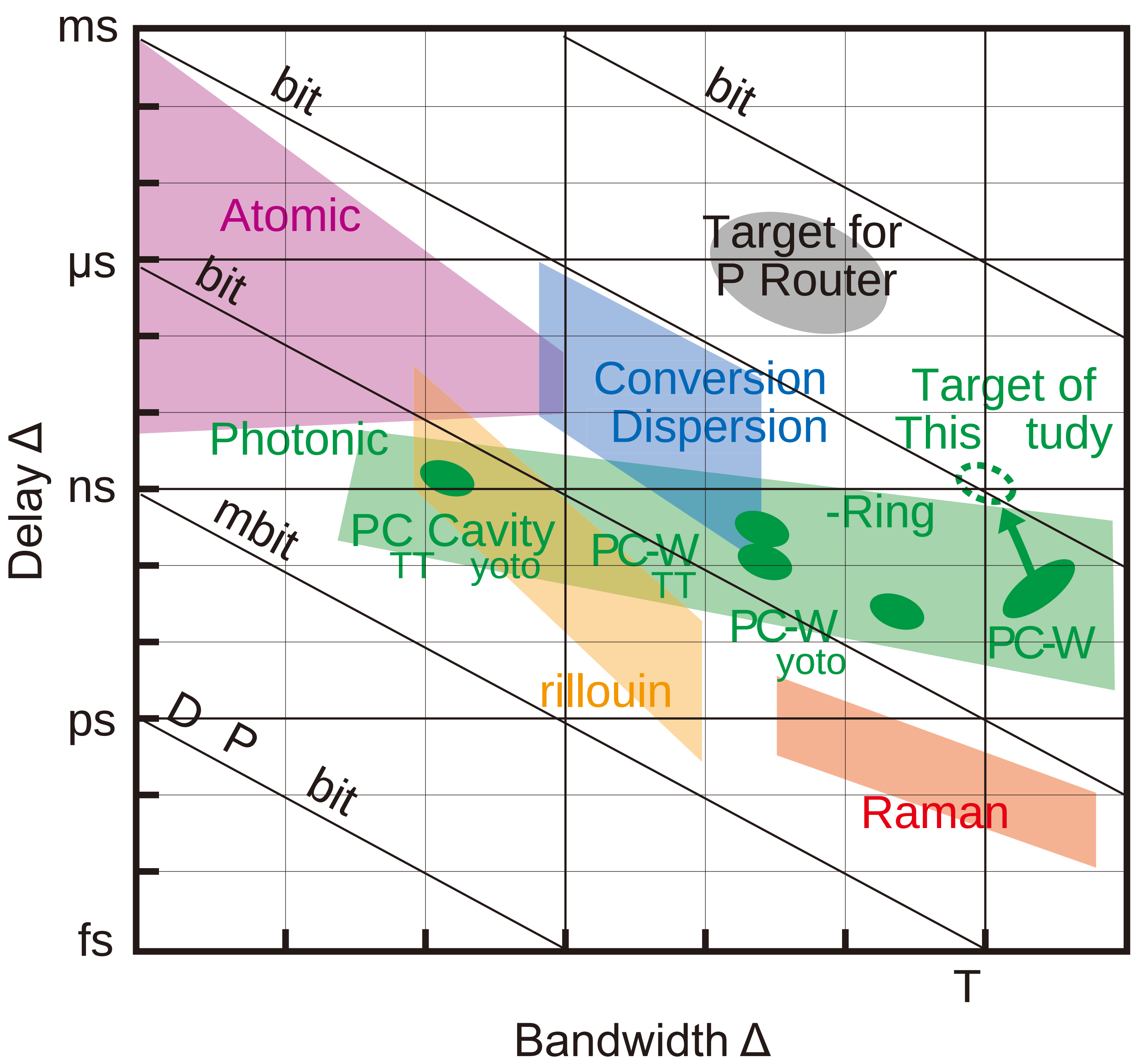


bservation of L LD Characteristics

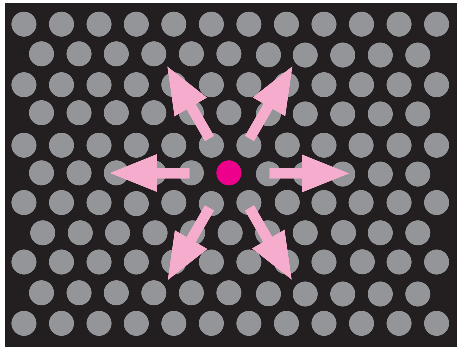
ubo   ori and   aba *OL*



Delay- andwidth Relation of lowlight



Topics



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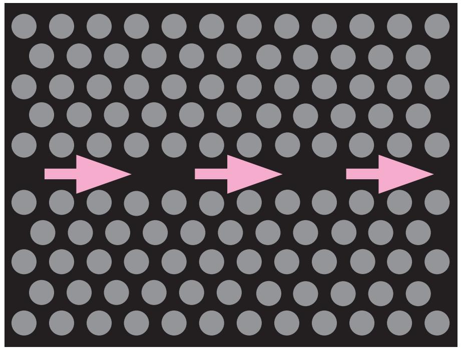

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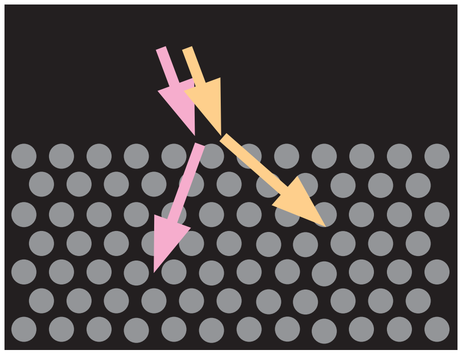

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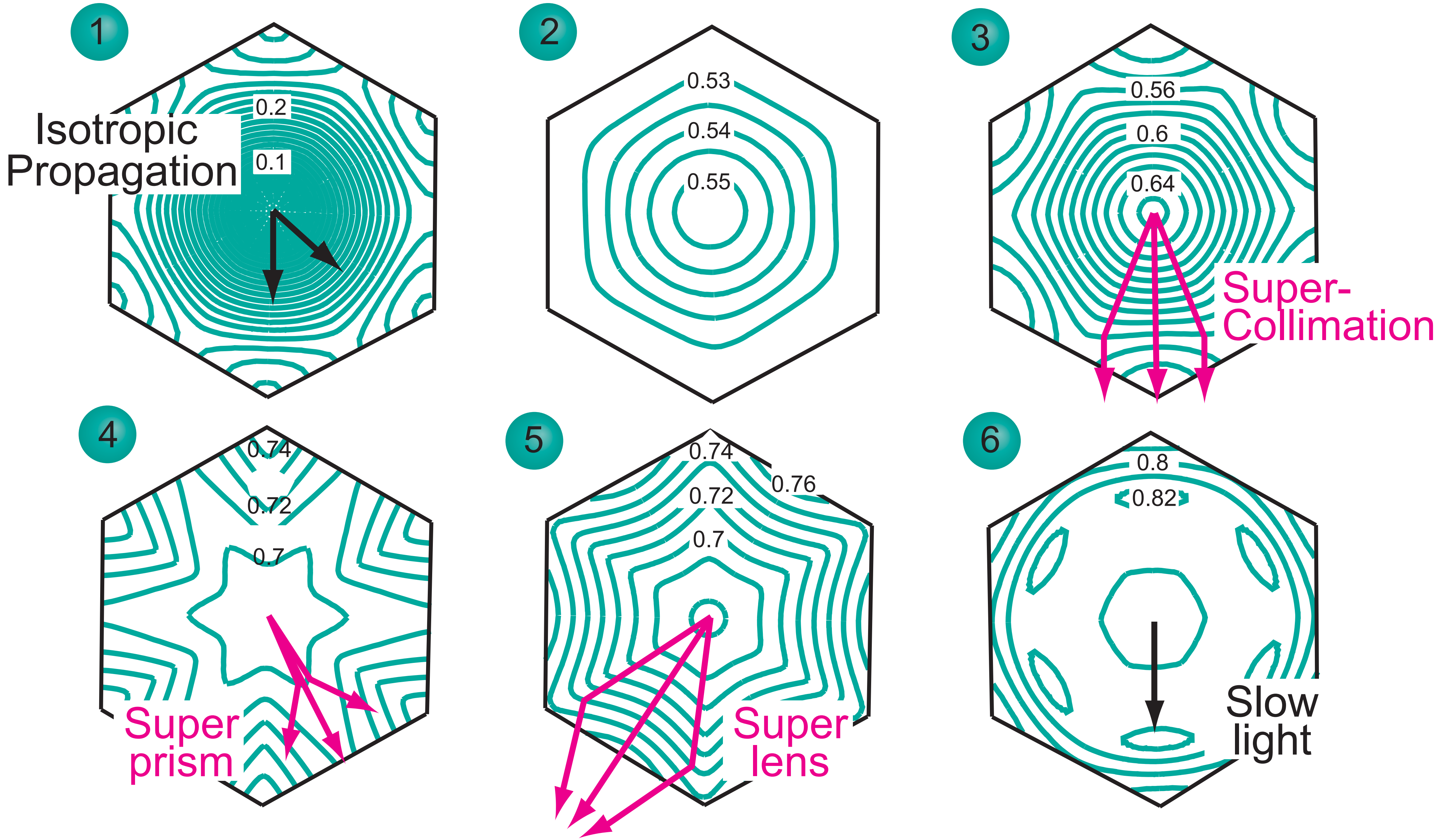
Application to compact demultiplexer

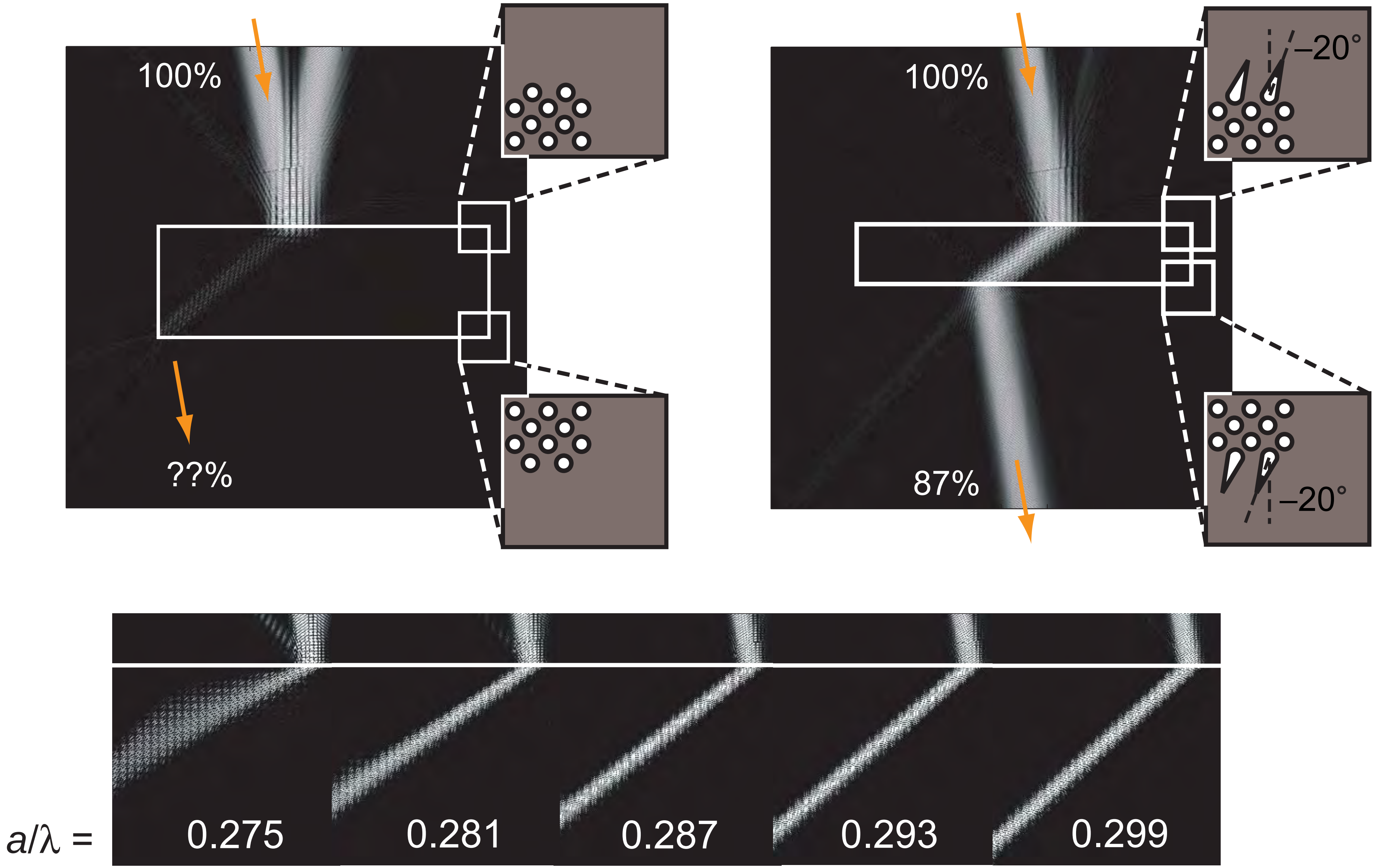
Functions Predicted from Dispersion Surfaces

(after Kosaka et al., *PRB* **58**, 10096 (1998))



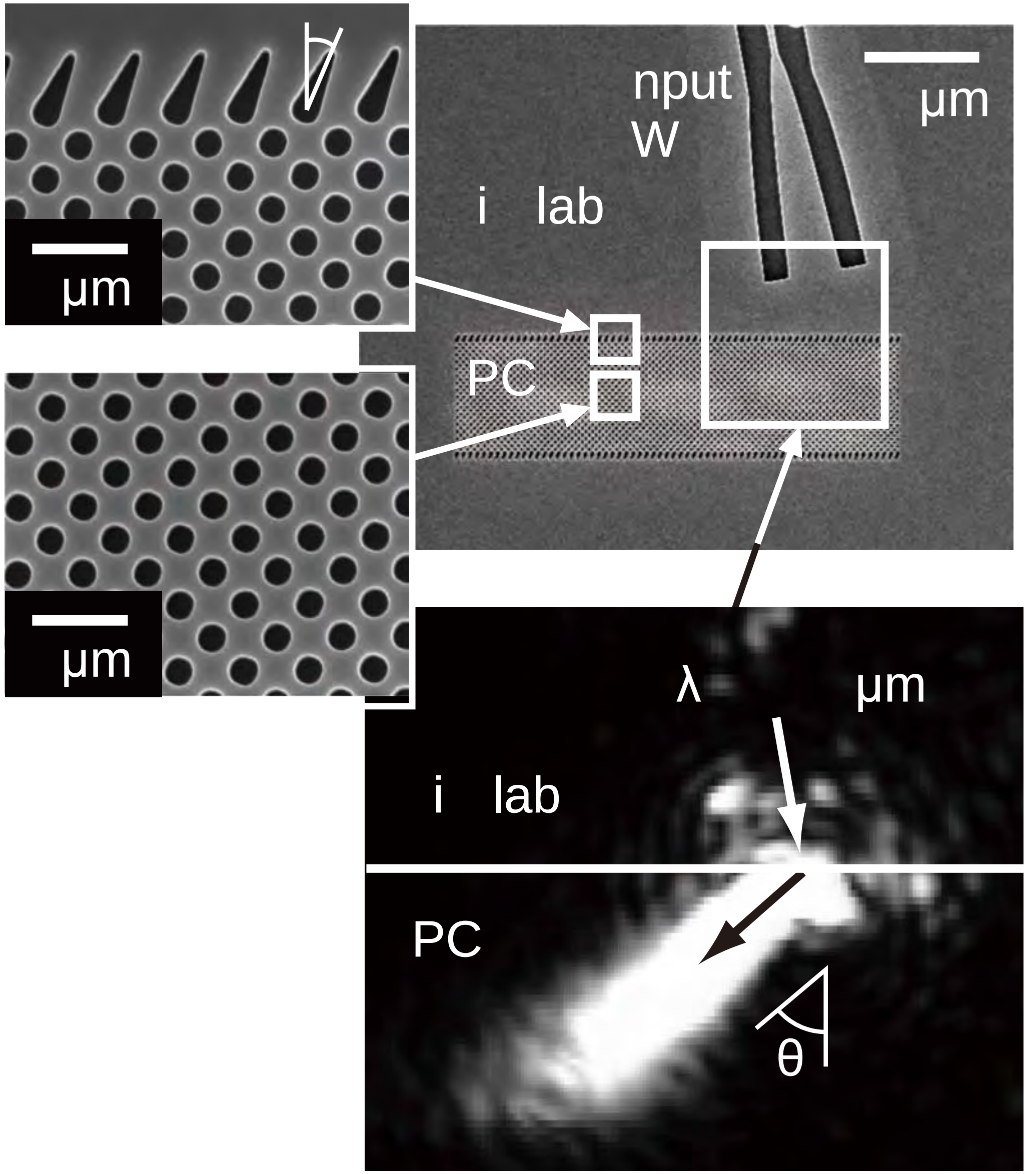
Negative Refraction by Optimized Interfaces

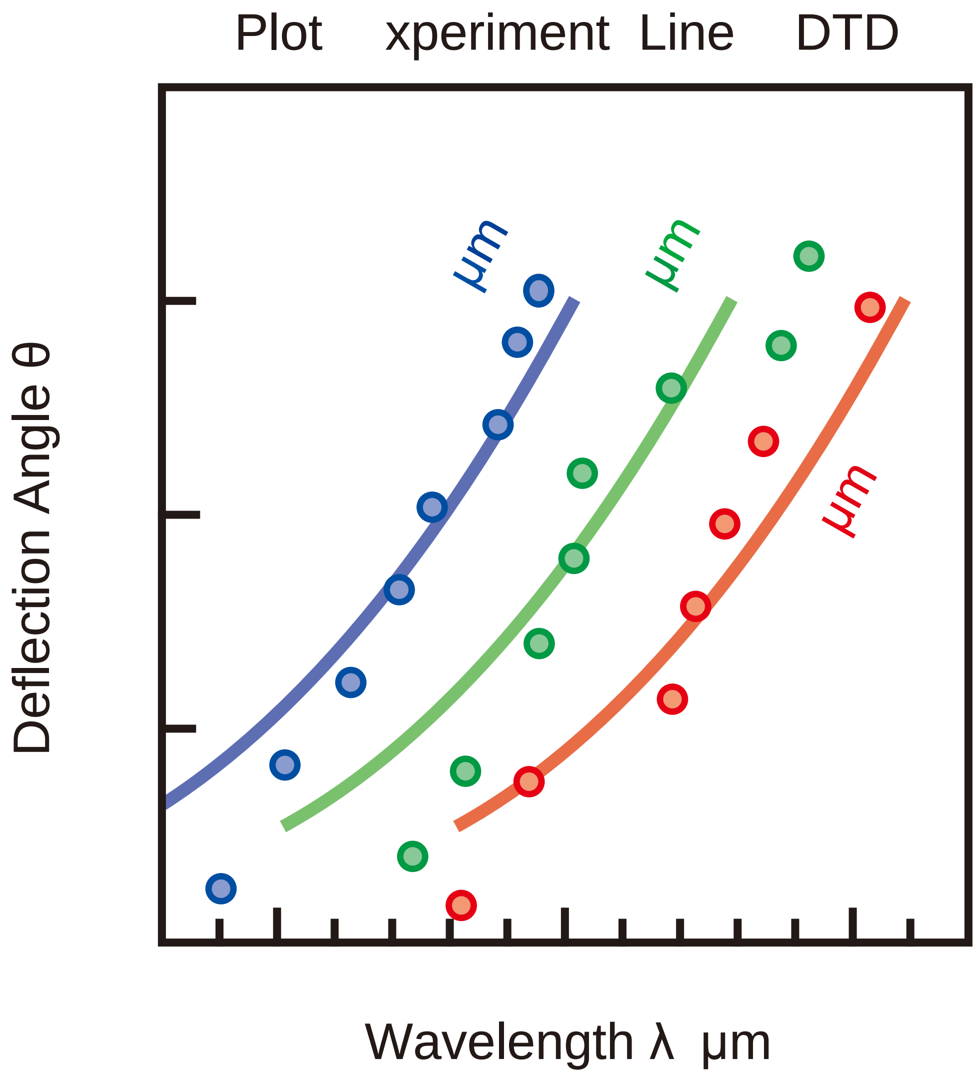
(Baba et al., *Opt. Express* **12** (2004) 4608)



bservation of egative Refraction

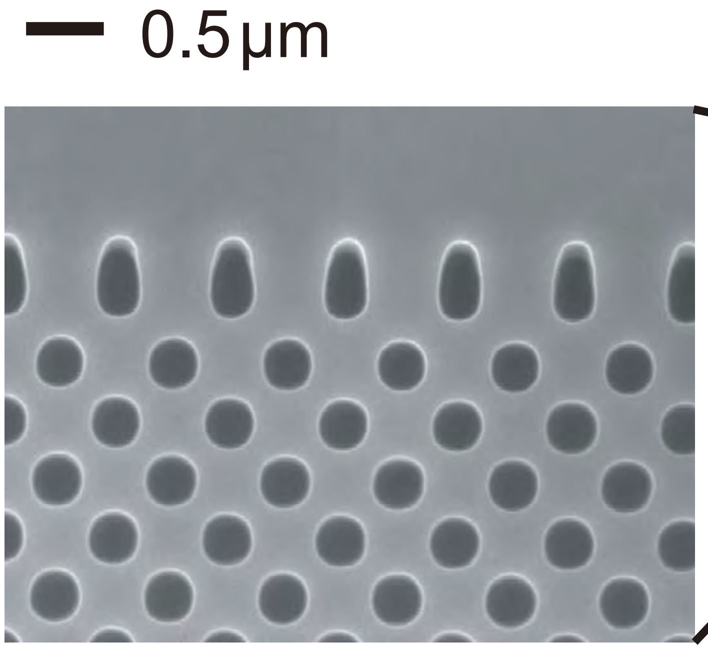
atsumoto et al *APL* **1**



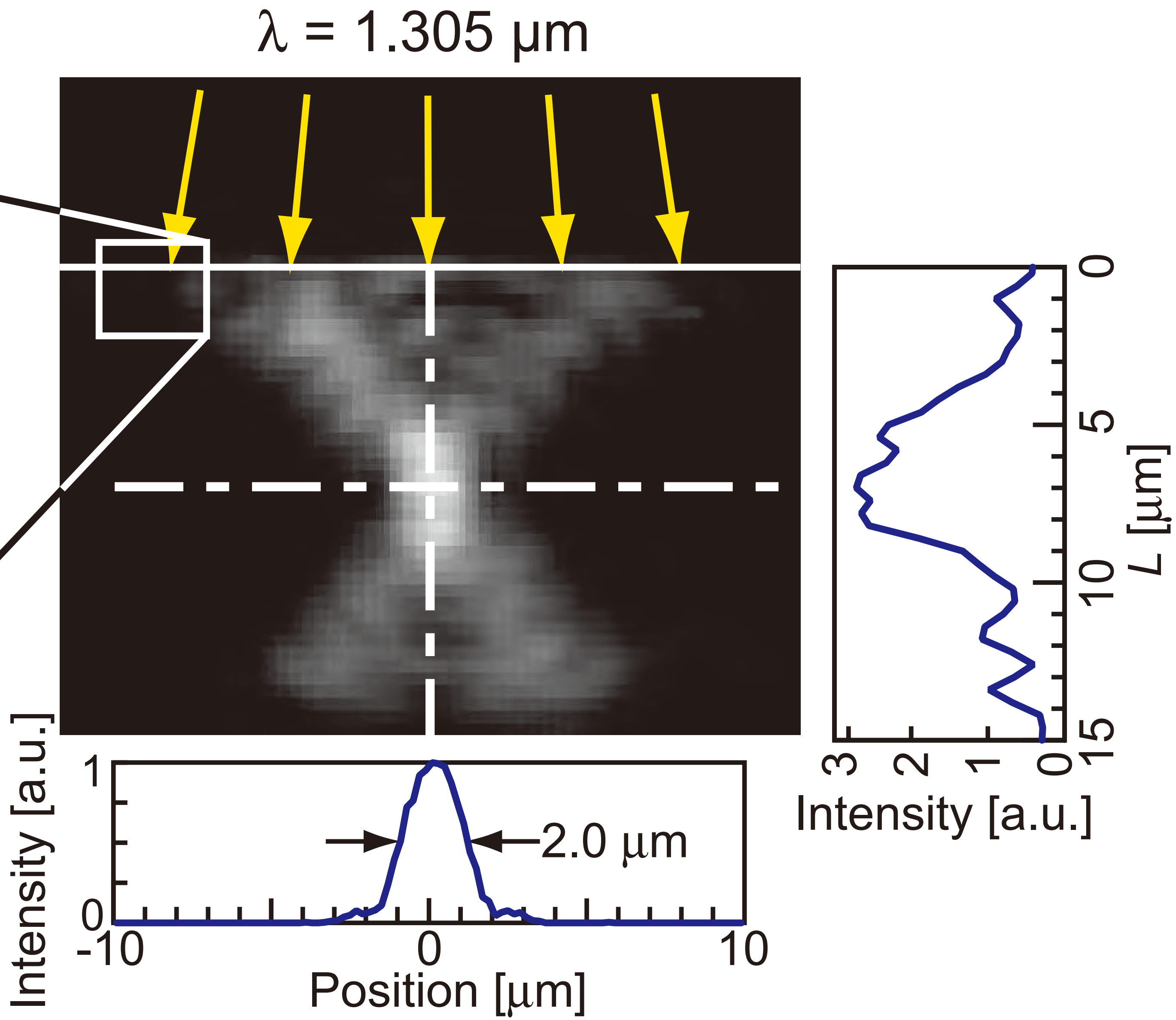


Light Focusing in PC Superlens

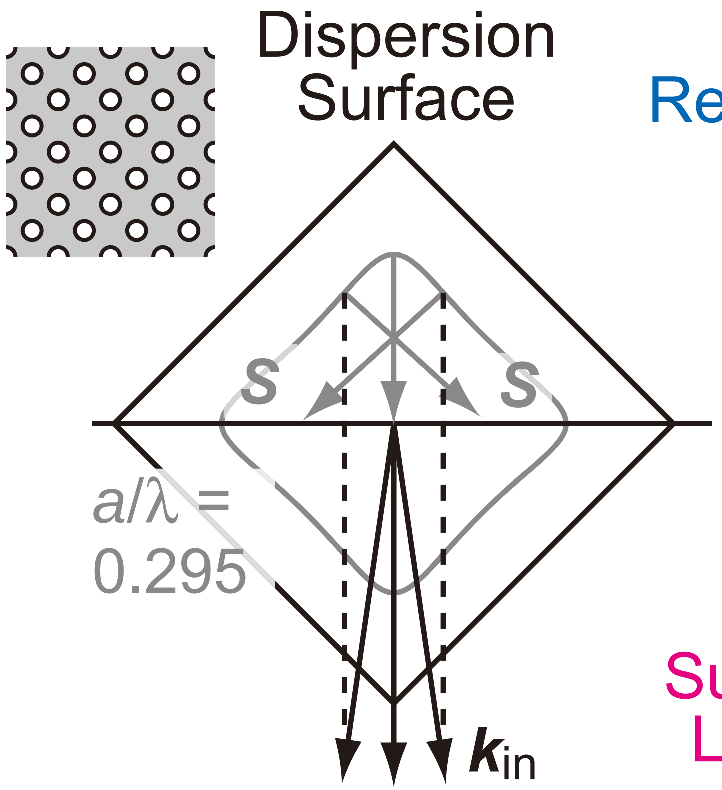
(Matsumoto, et al. *OL* 31, 2776 (2006))

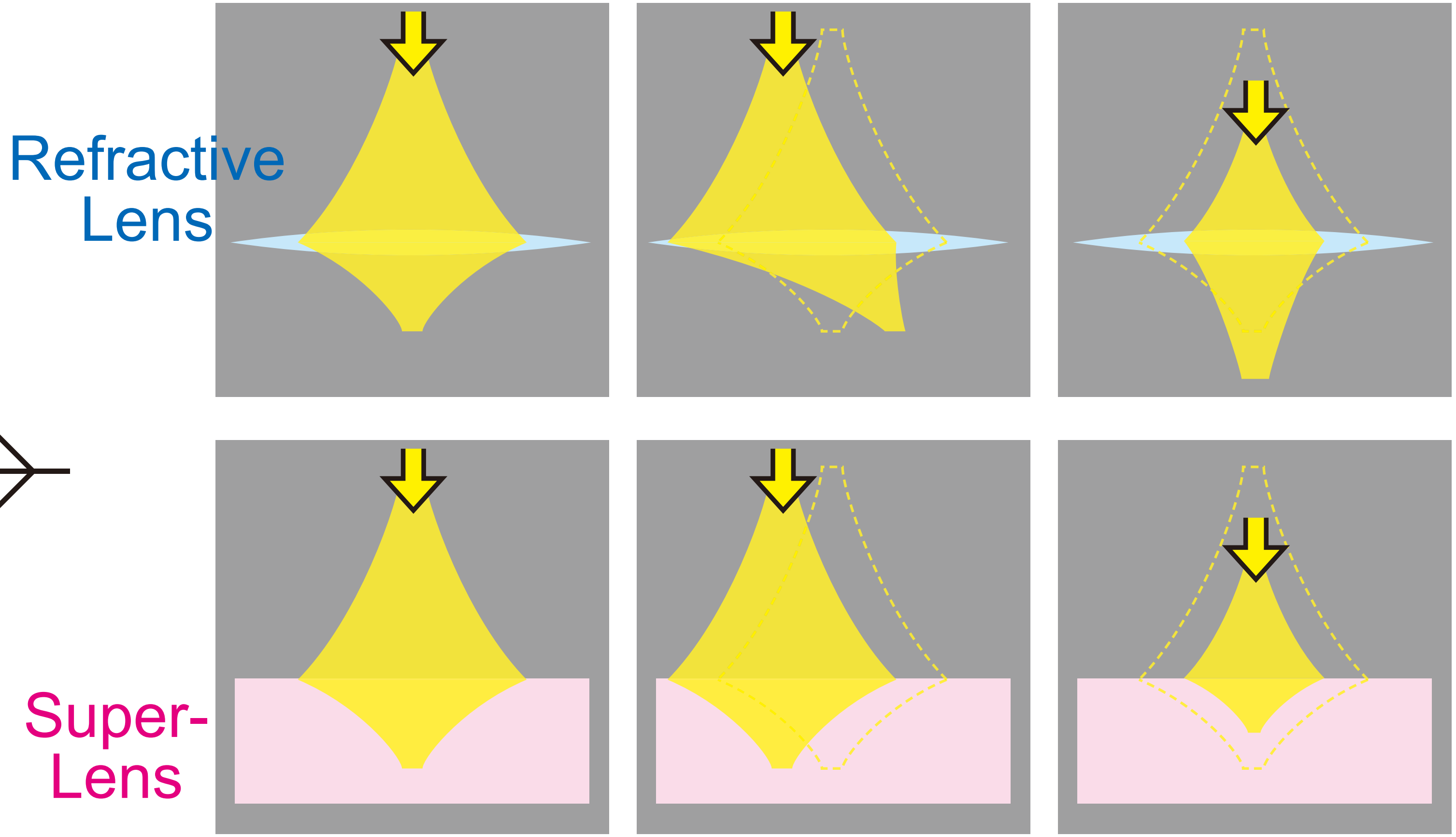


PC slab superlens



Unique Focusing of PC Superlens



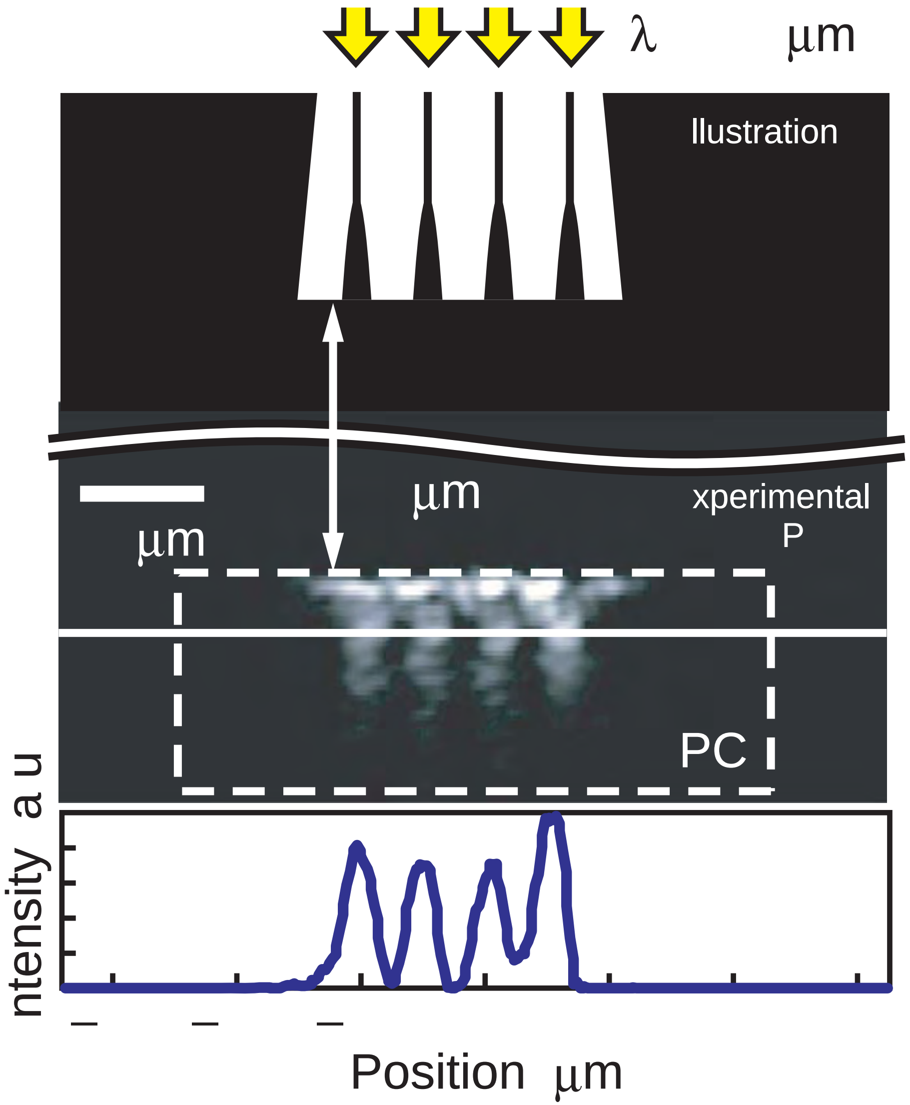


- Real image formation by flat lens (virtual image by curved lens)
- Compact total system due to very short focal length
- Applications to compact parallel optical coupler, demultiplexer, image system, etc.

Applications of uperlens

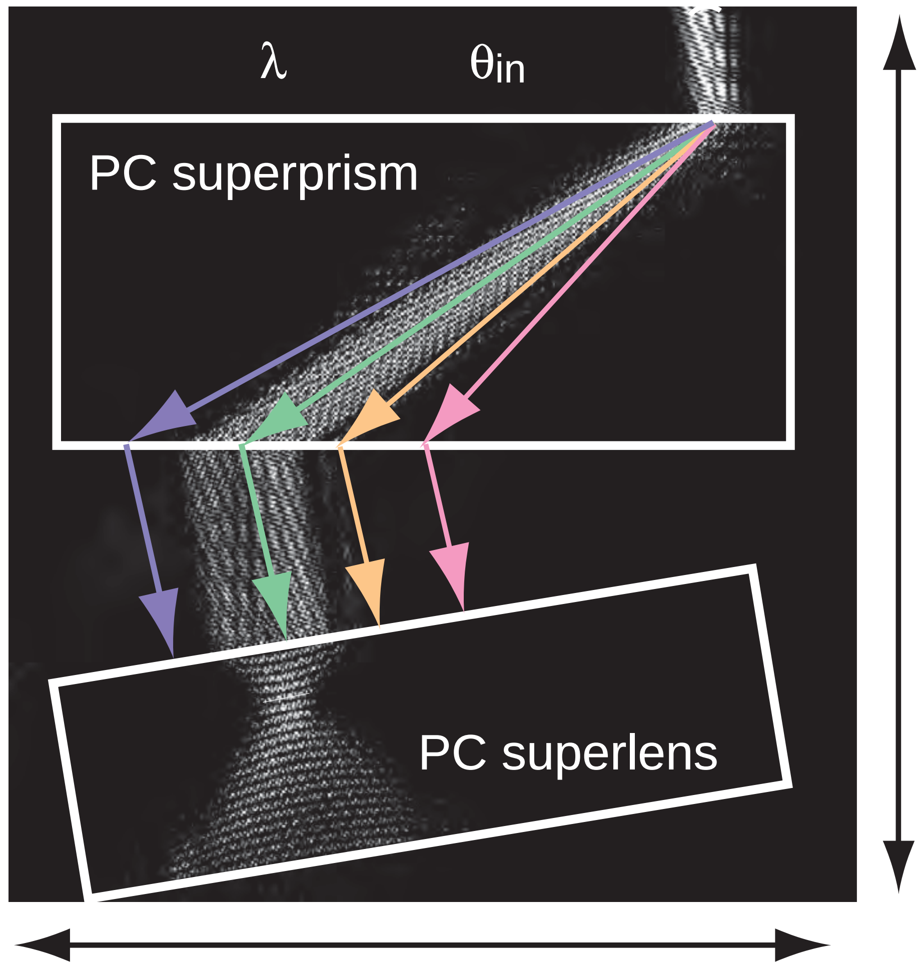
Parallel optical coupler

atsumoto et al *EL* W



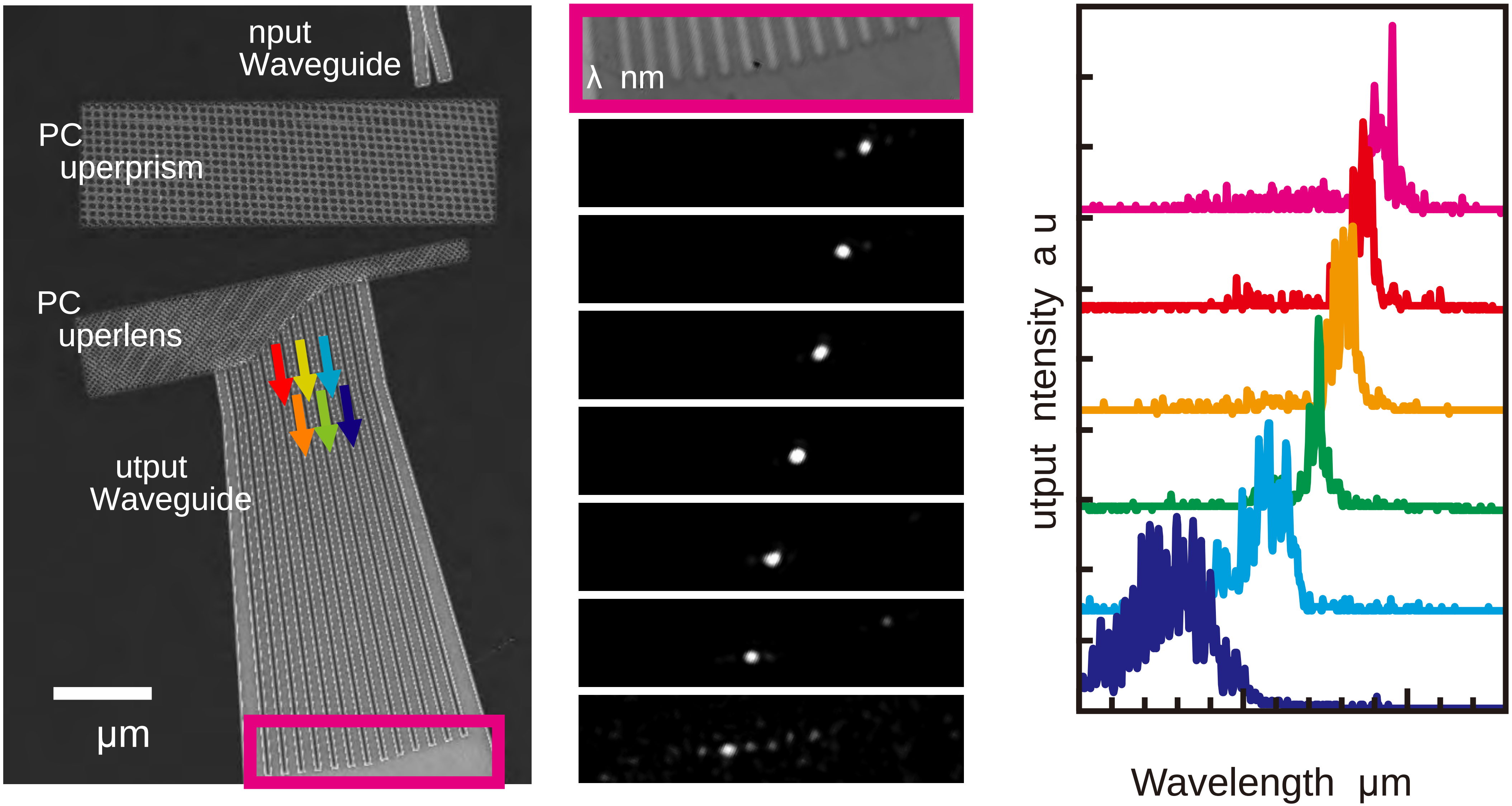
Compact demultiplexer

atsumoto et al *OE* 1



uperprism and uperlens Demultiplexer

atsumoto et al *APL* 1



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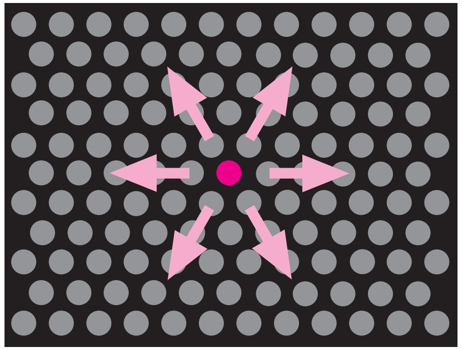

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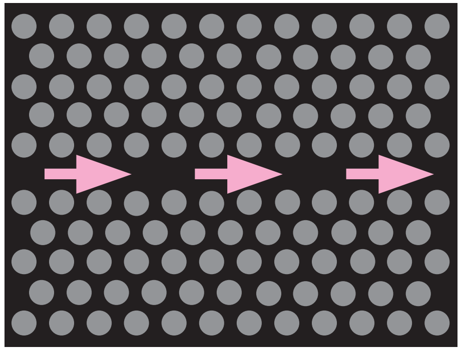

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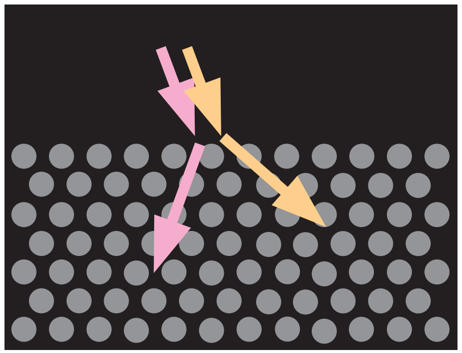
Dispersion-compensated slowlight
Zero-dispersion slowlight



PC Negative refractive optics

Lens and prism effects
Application to compact demultiplexer