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F-7-1 (Invited)

3D Photonic Crystal as a Novel Dielectric Material

Shojiro Kawakami[1], Takayuki Kawashima[2], Takashi Sato[1,2], Tsutomu Aoyama[2], Wataru Ishikawa[2], Yasuo Ohtera[1], Hiroyuki Ohkubo[1], Kenta Miura1, and You Honma[2]

[1]Tohoku Univ., New Industry Creation Hatchery Center (NICHe),
10, Aoba, Aramaki, Aoba-ku, Sendai, Miyagi 980-8579, Japan
Phone: +81-22-217-4018 E-mail: kawakami@niche.tohoku.ac.jp
[2]Photonic Lattice Inc.,
c/o New Industry Creation Hatchery Center (NICHe), Tohoku University
10, Aoba, Aramaki, Aoba-ku, Sendai 980-8579, Japan

Photonic crystals are 3D periodically patterned structures which behave as artificial materials exhibiting unique dielectric properties at optical frequencies. The authors have developed a fabrication process, the "Autocloning" technology of photonic crystals.

This paper reviews

(1) Unique dielectric properties of photonic crystals
(2) Straightforward application of the bulk property to display/optcomm
(3) One-Batch Integration of multiple patterns: in-plane and plane-normal
(4) Integration of sophisticated, "fantastic" guided wave devices onto a chip: Heterostructured photonic crystals.

Table I
Features of photonic crystals by autocloning

- Reliability
- Mass-productivity
- Multi-pattern
- Lattice modulation

Table II Comparison of several candidates of the "next generation PLC": pros and cons

	Silica PLC	Developing. Example of the current technologies: Si channel	Sub-µm PhC	Heterostructure
Spot size	5〜10mm	〜0.5mm	〜0.5mm	〜5mm
Dielectric characteristics of the material	Ordinary		Wide DBR stopband Superprism Strong l-dependence of group delay	
Propagation loss	0.1dB/cm	〜5dB/mm	〜10dB/mm Other structure for wiring	〜0.1dB/mm Good match with functional parts
Radius of bends	2〜5mm	〜2mm <1dB	〜2mm 〜1dB	〜500mm 〜0.2dB Corner reflector
Coupling with fibers	Excellent	Lens required?		Good
Productivity	Excellent			Very good

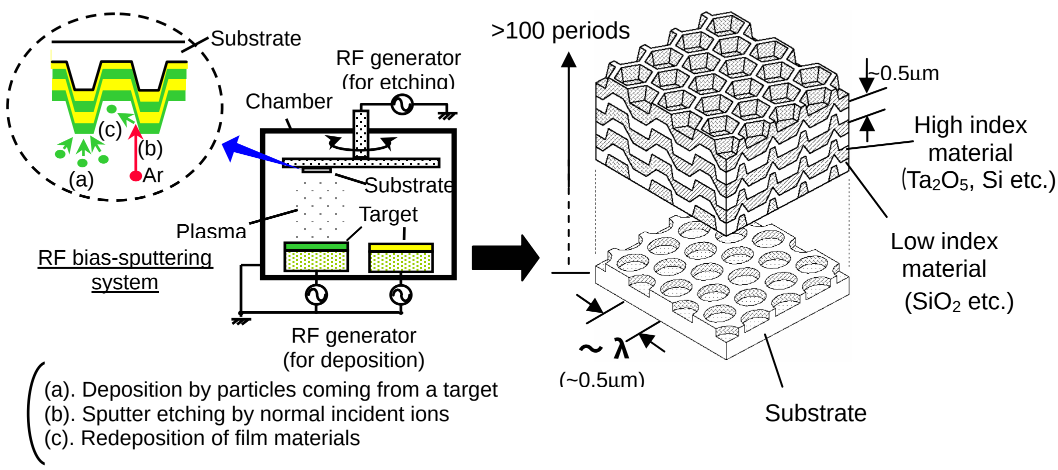


Fig. 1 Schematic of autocloning. It is based on combination of sputter deposition and sputter etching. The surface corrugation which reflects the substrate pattern is preserved automatically while stacking multilayers.

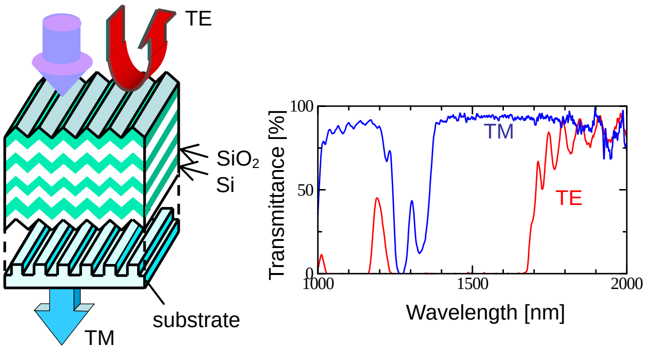


Fig.2 Autocloned photonic crystal polarization beam splitter. The right is a transmission spectra. Insertion loss is typically 0.1dB, and extinction ratio is more than 40 dB for λ=1550nm.

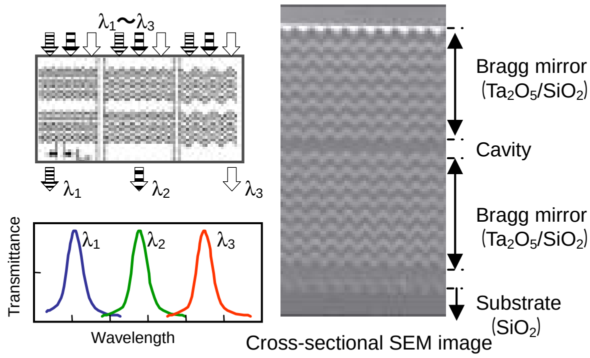


Fig. 3 Integrated multi-channel wavelength filter fabricated on a substrate having several patterns whose periods are different from each other.

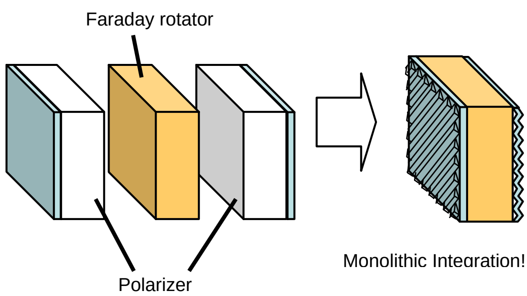


Fig. 4 Free space isolator: smallest and simplest. Photonic crystal polarizers can be fabricated on a Faraday rotator directly.

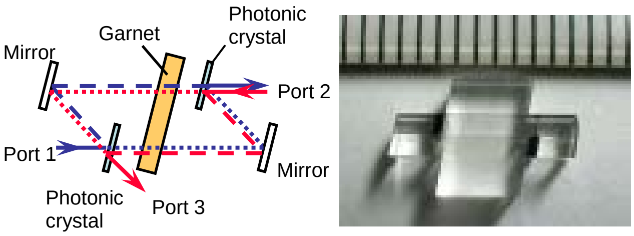


Fig. 5 Novel configuration of optical circulator.

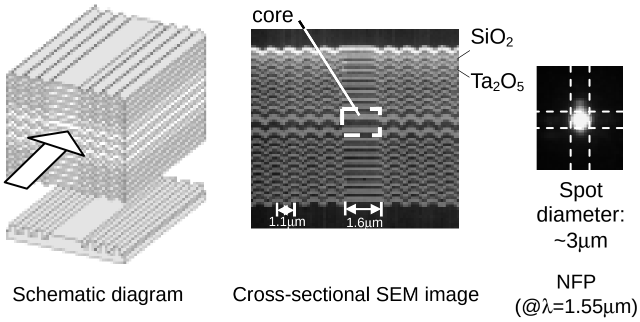


Fig. 6 Hetero-structured photonic crystal waveguide. Light is confined with difference of effective refractive indices caused by modulation of periods.

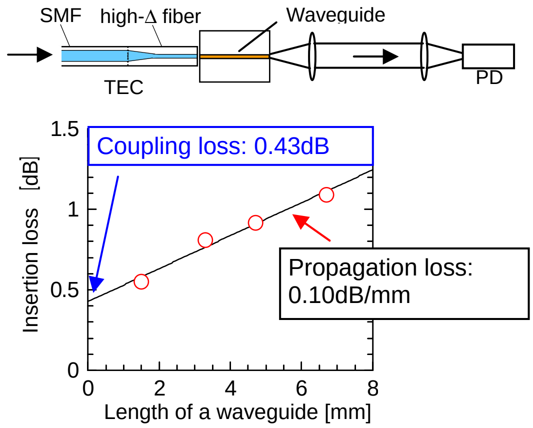
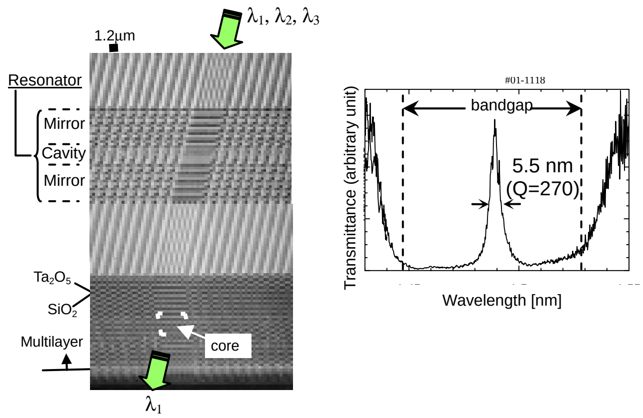


Fig. 7 Low-loss characteristics of a hetero waveguide. The upper is a measurement system.



SEM image (bird's-eye view)

Fig. 8 Hetero-structured Bragg-reflection resonator.