History of photonic crystals

- Prehistory and pioneers
- Official birth 1987
- Setting up of the main concepts 1987 - 2000
- Current trends
Prehistory

Lord Rayleigh (1842-1919), Philos. Mag. 34, 481-502 (1892) and many other papers

**LVI. On the Influence of Obstacles arranged in Rectangular Order upon the Properties of a Medium. By Lord Rayleigh,**

Sec. R.S.*

G. Lippmann (1845-1921), color photography

Probable the first to fabricate "photonic crystal" structures

c. 1891-1899
Prehistory

G. Floquet (1847-1920), Annales Scientiques de l'Ecole Normale Supérieure, 12, 48-88 (1883)

SUR LES

ÉQUATIONS DIFFÉRENTIELLES LINÉAIRES

A COEFFICIENTS PÉRIODIQUES,

PAR M. G. FLOQUET,

F. Bloch (1905-1983), Zeitschrift für Physik, 52, 555-600 (1928)

Über die Quantenmechanik der Elektronen in Kristallgittern.

Von Felix Bloch in Leipzig.

\[ \psi_{k\ell m}(xyz) = e^{\frac{2\pi i}{aG_1} \frac{kx}{bG_2} \frac{ly}{cG_3}} \cdot \psi_{k\ell m}(xyz), \]
Control of spontaneous emission, E.M. Purcell (1912-1997), 1946


The spontaneous emission probability is thereby increased, and the relaxation time reduced, by a factor $f = 3Q\lambda^3/4\pi^2 V$, the Purcell factor.

Propagation in periodic medium, F. Abelès (1922-2005), 1946 and latter

SUR LA PROPAGATION DES ONDES ÉLECTROMAGNÉTIQUES DANS LES MILIEUX STRATIFIÉS

Par Florin Abelès

Ann. de Phys., 12e Série, t. 3 (Juillet-Août 1948), pp. 504-520

Considers the case of a periodic stack
Spontaneous Emission in a Periodic Structure

V. P. Bykov

Submitted May 31, 1971

electromagnetic field which cannot propagate in a periodic structure.

Propagation in a stratified medium, P. Yeh, A. Yariv, 1976

Electromagnetic propagation in periodic stratified media. I. General theory*

Pochi Yeh, Amnon Yariv, and Chi-Shain Hong
California Institute of Technology, Pasadena, California 91125
(Received 8 November 1976)

Bloch waves, the dispersion relations, and the band structure

**Light propagation in singly and doubly periodic planar waveguides**

**R. Zengerle**
Forschungsinstitut der Deutschen Bundespost,
P.O. Box 5000, D-610 Darmstadt, F.R. Germany

*(Received 7 September 1987)*

**Abstract.** Light propagation in singly and doubly periodic planar waveguides is investigated with respect to future applications in integrated optics. The

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Propagation in a stratified medium, **P.St. Russell**, 1986

**Interference of integrated Floquet-Bloch waves**

**P. St. J. Russell**
IBM Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, New York 10598

*(Received 16 September 1985)*

Interference, producing, respectively, real and virtual spatial fringes. In the paper considerable use is made of a reciprocal-space representation of the Floquet-Bloch waves (the wave-vector diagram),

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Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
Optical devices and waveguides using a thin film optical waveguide having a two dimensional array of perturbations associated therewith or with adjacent optically coupled layers. The array is regular and forms
Thin-film laser based on a Bragg waveguide

V. A. Sychugov, A. V. Tishchenko, and A. A. Khakimov

P. N. Lebedev Physics Institute, Academy of Sciences of the USSR, Moscow
(Submitted April 3, 1980)
Kvantovaya Elektron. (Moscow) 7, 2254–2256 (October 1980)

FIG. 2. Bragg-waveguide laser (a) and a photograph of track of laser beams (b).

Some scientific interests in semiconductor optics by the late 1980 and early 1990


**Physics and Device Applications of Optical Microcavities**

H. Yokoyama

---

Control of spontaneous mission, emission pattern and radiative lifetime

---

Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
Some scientific interests in semiconductor optics by the late 1980 and early 1990:

Observation of the Coupled Exciton-Photon Mode Splitting in a Semiconductor Quantum Microcavity

C. Weisbuch, (a) M. Nishioka, (b) A. Ishikawa, and Y. Arakawa
Research Center for Advanced Science and Technology, University of Tokyo, 4-6-1 Meguro-ku, Tokyo 153, Japan
(Received 12 May 1992)

FIG. 2. 5-K reflectivity curves on a seven-QW microcavity structure. Various detuning conditions between cavity and QW exciton frequencies are obtained by choosing various points on the wafer, typically 0.5 mm apart. Note the line narrowing approaching and at resonance, the resonance mode splitting, and the indication of a light-hole exciton mode splitting around 1.605 eV for the lowest trace.

FIG. 3. Reflectivity peak positions as a function of cavity detuning for a five-quantum-well sample at T = 5 K. The theoretical fit is obtained through a standard multiple-interference analysis of the DBR–Fabry-Pérot–quantum-well structure.

Implement in solid state physics concepts developed in atomic physics.
The official birth ...

Control of spontaneous emission, E. Yablonovitch, 1987

Inhibited Spontaneous Emission in Solid-State Physics and Electronics

Eli Yablonovitch
Bell Communications Research, Navesink Research Center, Red Bank, New Jersey 07701
(Received 23 December 1986)

junction bipolar transistors, and solar cells. If a three-dimensionally periodic dielectric structure has an electromagnetic band gap which overlaps the electronic band edge, then spontaneous emission can be rigorously forbidden.

dex can result in a forbidden gap in the electromagnetic spectrum near the wavelength \( \lambda \), irrespective of propagation direction, just as the electronic spectrum has a band

Omnidirectionality

With a sufficiently large difference in refractive index between \( n_1 \) and \( n_2 \), a gap will open up in the electromagnetic density of states. The idea here is for the gap or

Minimum index contrast

Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
The official birth ...

Control of spontaneous emission, E. Yablonovitch, 1987

Inhibited Spontaneous Emission in Solid-State Physics and Electronics

Eli Yablonovitch
Bell Communications Research, Navesink Research Center, Red Bank, New Jersey 07701
(Received 23 December 1986)

junction bipolar transistors, and solar cells. If a three-dimensionally periodic dielectric structure has an electromagnetic band gap which overlaps the electronic band edge, then spontaneous emission can be rigorously forbidden.

Opals

Proposal of 3D structure fabricated by epitaxy
The official birth ...

Light Anderson localization, S. John, 1987

Strong Localization of Photons in Certain Disordered Dielectric Superlattices

Sajeev John
Department of Physics, Princeton University, Princeton, New Jersey 08544
(Received 5 March 1987)

FIG. 2. Photon density of states in a disordered superlattice exhibiting low-frequency Rayleigh scattering and high-frequency geometric-optics extended states separated by a pseudogap of strongly localized photons.

\[ \frac{\sqrt{2}\varepsilon_1 G_c}{\varepsilon_0 + \varepsilon_1} \]
Photonic Band Structure: The Face-Centered-Cubic Case

E. Yablonovitch and T. J. Gmitter
Bell Communications Research, Navesink Research Center, Red Bank, New Jersey 07701-7040
(Received 25 July 1989)

Dimensionally periodic face-centered-cubic (fcc) dielectric structures. This can produce a “photonic band gap” in which optical modes, spontaneous emission, and zero-point fluctuations are all absent. In the


Fabrication


Measurements
First troubles: computation performed with a vectorial model of the electromagnetic field do not predict a bandgap

except that we do not find a true gap for this configuration.

at best, a deep in the density of states
Photonic band-gaps bite the dust

Hopes that dielectric materials in which the transmission of certain frequencies would be forbidden seem to have been disappointed by the difficulty of realizing expectation and, now, by calculation.
New structures, new calculations

Existence of a Photonic Gap in Periodic Dielectric Structures

K. M. Ho, C. T. Chan, and C. M. Soukoulis

Ames Laboratory and Department of Physics, Iowa State University, Ames, Iowa 50011
(Received 4 September 1990)

Stack of dielectric spheres in vacuum or spherical holes in a dielectric medium

fcc structure fcc previously investigated, no bandgap

Diamond structure, bandgap

Yes, but fabrication ????
Hope for photonic bandgaps

Sir — The search for photonic bandgaps has not bitten the dust, John Maddox suggests.¹

The method of constructing an f.c.c. lattice of nonspherical atoms. A slab of material is covered by a mask consisting of a triangular array of holes. Each hole is drilled through three times, at an angle 35.26° away from normal, and spread out 120° on the azimuth. The resulting criss-cross of holes below the surface of the slab, suggested by the cross-hatching shown here, produces a fully three-dimensionally periodic f.c.c. structure. The drilling can be done by a real drill bit for microwave work, or by reactive ion-etching to create an f.c.c. structure at optical wavelengths.

additional drilling directions in addition to those shown in the figure, all in the plane of the slab.

E. YABLOWOVIATCH
First modelling of bi-dimensional structures, 1991

Two-dimensional photonic band structures

M. Plihal, A. Shambrook, A.A. Maradudin
Department of Physics, University of California, Irvine, CA 92717, USA

and

Ping Sheng
Exxon Research and Engineering Co., Route 22 East Clinton Township, Annandale, NJ 08801, USA

square, triangular, honeycomb lattices of holes or pillars etc...

Photonic band structure of two-dimensional systems: The triangular lattice

M. Plihal and A. A. Maradudin
Department of Physics, University of California, Irvine, California 92717
(Received 8 February 1991)
First measurements of 2D structures (microwaves), 1991-1992

Microwave Propagation in Two-Dimensional Dielectric Lattices
S. L. McCall and P. M. Platzman
AT&T Bell Laboratories, 600 Mountain Avenue, Murray Hill, New Jersey 07974
R. Dalichaouch, David Smith, and S. Schultz
Department of Physics, University of California, San Diego, 9500 Gilman Drive, La Jolla, California 92093-0319
(Received 15 February 1991)

Measurement of Photonic Band Structure in a Two-Dimensional Periodic Dielectric Array
W. M. Robertson and G. Arjavalingam
IBM Research Division, Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, New York 10598
R. D. Meade, K. D. Brommer, A. M. Rappe, and J. D. Joannopoulos
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 10 January 1992)
Photonic Band Structure: The Face-Centered-Cubic Case Employing Nonspherical Atoms

E. Yablonovitch and T. J. Gmitter
Bell Communications Research, Navesink Research Center, Red Bank, New Jersey 07701-7040

K. M. Leung
Department of Physics, Polytechnic University, Brooklyn, New York 11201
(Received 26 December 1990)

We introduce a practical, new, face-centered-cubic dielectric structure which simultaneously solves two of the outstanding problems in photonic band structure. In this new “photonic crystal” the atoms are nonspherical, lifting the degeneracy at the W point of the Brillouin zone, and permitting a full photonic band gap rather than a pseudogap. Furthermore, this fully three-dimensional fcc structure lends itself readily to microfabrication on the scale of optical wavelengths. It is created by simply drilling three sets of holes 35.26° off vertical into the top surface of a solid slab or wafer, as can be done, for example, by chemical-beam-assisted ion etching.

Fig. 2. The method of constructing an fcc lattice of the Wigner-Seitz cells as shown in Fig. 1(b). A slab of material is covered by a mask consisting of a triangular array of holes. Each hole is drilled through 3 times, at an angle 35.26° away from normal, and spread out 120° on the azimuth. The resulting crisscross of holes below the surface of the slab, suggested by the cross hatching shown here, produces a fully three-dimensionally periodic fcc structure, with unit cells as given by Fig. 1(b). The drilling can be done by a real drill bit for microwave work, or by reactive ion etching to create an fcc structure at optical wavelengths.

3-cylinder structure

G. Feiertag et al.

Inverse 3-cylinder structure
or Yablonovite

C. C. Cheng et al.

Microwaves
Near IR
Donor and Acceptor Modes in Photonic Band Structure

E. Yablonovitch and T. J. Gmitter
Navesink Research Center, Bell Communications Research, Red Bank, New Jersey 07701-7040

R. D. Meade, A. M. Rappe, K. D. Brommer, and J. D. Joannopoulos
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
(Received 11 March 1991)

Three-dimensionally periodic dielectric structures, photonic crystals, possessing a forbidden gap for electromagnetic wave propagation, a photonic band gap, are now known. If the perfect 3D periodicity is broken by a local defect, local electromagnetic modes can occur within the forbidden band gap. Addition of extra dielectric material locally, inside the photonic crystal, produces “donor” modes. Conversely, removal of dielectric material from the crystal produces “acceptor” modes. It is now possible to make high-Q electromagnetic cavities of ~1 cubic wavelength, for short wavelengths at which metallic cavities are useless. These new dielectric cavities can cover the range from mm waves to uv wavelengths.

FIG. 1. A (110) cross-sectional view of our face-centered-cubic photonic crystal [2] consisting of nonspherical “air atoms” centered on the large dots. Dielectric material is represented by the shaded area. The rectangular dashed line is a face-diagonal cross section of the unit cube. Donor defects consisted of a dielectric sphere centered in an atom. We selected an acceptor defect as shown, centered in the unit cube. It consists of a missing horizontal slice in a single vertical rib.

FIG. 3. (a) Transmission attenuation through a defect-free photonic crystal, as a function of microwave frequency. The forbidden gap falls between 13 and 16 GHz. (b) Attenuation through a photonic crystal with a single acceptor in the center. The large acceptor volume moved its frequency near midgap. The electromagnetic resonator Q was ~1000, limited only by the loss tangent of the dielectric material. (c) Attenuation through a photonic crystal with a single donor defect, an uncentered dielectric sphere, leading to two shallow donor modes.

FIG. 4. Donor and acceptor mode frequencies as a function of normalized donor and acceptor defect volume. The points are experimental and the corresponding lines are calculated. Defect volume is normalized to $\lambda/2\pi n^3$, where $\lambda$ is the midgap vacuum wavelength and $n$ is the refractive index. A finite defect volume is required to bind a mode in the forbidden gap.

Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
First conference dedicated to photonic crystals, 1992


Followed by:
www.public.iastate.edu/~cmphy/ASI/photonics

Proceedings:

PECS: Photonic and Electromagnetic Crystal Structures www.pecsconference.org
— PECS-III (St. Andrews, UK, 2001) www.pecsconference.org/PECSIII/
— PECS-IV (Los Angeles, USA, 2002) www.ipam.ucla.edu/programs/pecs-iv/
— PECS-V (Kyoto, Japon, 2003) www.pecsconference.org/PECSV/
— PECS-VI (Aghia Pelagia, Crète, Grèce, 2005) www.pecsconference.org/PECSVI/
— PECS-VII (Monterey, USA, 2007) www.pecsconference.org/PECSVII/
— PECS-VIII (Sydney, Australie, 2009) pecs8.mtci.com.au
— PECS-IX (Granada, Spain, 2010) www.pecs-ix.org
— PECS-X (Santa Fe, USA, 2012) pecs-x.pecsconference.org
— PECS-XI (Shanghai, China, 2014)
1987 - 2000

Setting up of new concepts

Blooming of numerous technological approaches
First fabrication of a 2D photonic crystal operating in the near infra-red, 1992-1993

**Nanofabrication of photonic lattice structures in GaAs/AlGaAs**
Sandia National Laboratories, Albuquerque, New Mexico 87183

pp. 2637-2640

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**Fabrication of 2-D photonic bandgap structures in GaAs/AlGaAs**

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**Etching in bulk GaAs, no waveguide**
No optical measurement

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**ELECTRONICS LETTERS** 18th August 1994 Vol. 30 No. 17
pp. 1444-1445

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**PHOTONIC BANDGAP OF TWO-DIMENSIONAL DIELECTRIC CRYSTALS**

J. M. Gerard¹, A. Izaël¹, J. Y. Marzin¹, R. Padjen¹ and F. R. Ladan²
¹France Telecom/CNET/PAB, 196 av Henri Rava, F-92220 Bagneux and ²Laboratoire de Microstructures et Microélectronique, CNRS, 196 av Henri Rava, F-92220 Bagneux, France

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Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
Woodpile structure, 1994

PHOTONIC BAND GAPS IN THREE DIMENSIONS: NEW LAYER-BY-LAYER PERIODIC STRUCTURES

K. M. Ho, C. T. Chan, C. M. Soukoulis, R. Biswas* and M. Sigalas

Metallic structures, 1993-1994

Photonic band structures of two- and three-dimensional periodic metal or semiconductor arrays

Arthur R. McGurn
Department of Physics, Western Michigan University, Kalamazoo, Michigan 49008

Alexei A. Maradudin
Department of Physics, University of California, Irvine, California 92717


Experimental and theoretical results for a two-dimensional metal photonic band-gap cavity

D. R. Smith, S. Schultz, and N. Kroll
Department of Physics, University of California, San Diego, 9500 Gilman Drive, LaJolla,
California 92093-0319

M. Sigalas, K. M. Ho, and C. M. Soukoulis
Ames Laboratory and Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011

Appl. Phys. Lett. 65 (6), 1 August 1994 pp. 645-647

Forbidden gap between 0 and fc
Slow light, 1994

The photonic band edge laser: A new approach to gain enhancement
Jonathan P. Dowling, Michael Scalora, Mark J. Bloemer, and Charles M. Bowden

Bends and cavities, 1994

Novel applications of photonic band gap materials: Low-loss bends and high Q cavities
Robert D. Meade, A. Devenyi, and J. D. Joannopoulos
Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02143
O. L. Alerhand, D. A. Smith, and K. Kash
Bell Communications Research, 331 Newman Springs Road, Red Bank, New Jersey 07701-7040

First mention in a rather obscure paper
Fabrication, 1995

First opals

Interferometric technique for the measurement of photonic band structure in colloidal crystals

İ. İnanç Tarhan, Martin P. Zinkin, and George H. Watson

First anodization of micro-porous Si

Possibility of InP-Based 2-Dimensional Photonic Crystal: An Approach by the Anodization Method
Toshikiko Baba and Miyuki Koma

Two-dimensional infrared photonic band gap structure based on porous silicon

U. Grünig and V. Lehmann
Siemens AG, Dept. ZPE T HE, Otto-Hahn-Ring 6, 81730 München, Germany

C. M. Engelhardt
Walter-Schottky-Institut, Am Coulombwall, 85748 Garching, Germany

and first not very successful attempts of modification of the spontaneous emission lifetime

Optical Spectroscopy of Opal Matrices with CdS Embedded in its Pores: Quantum Confinement and Photonic Band Gap Effects(*).

V. N. Astratov(1), V. N. Bogomolov(1), A. A. Kaplyanskii(1), A. V. Prokofiev(1)
L. A. Samoilovich(1), S. M. Samoilovich(1) and Yu. A. Vlasov(1)

Il Nuovo Cimento, 17, 1349-1354, 1995

First holographic fabrication

Three-dimensional ordered patterns by light interference

Dongbin Mei, Bingying Cheng, Wei Hu, Zhaolin Li, and Dazhong Zhang

March 1, 1995 / Vol. 20, No. 5 / OPTICS LETTERS
First membrane structures, 1995

Air-bridge microcavities

Pierre R. Villeneuve, Shanhui Fan, and J. D. Joannopoulos  
Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

Kuo-Yi Lim, G. S. Petrich, L. A. Kolodziejski, and Rafael Reif  
Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology,  
Cambridge, Massachusetts 02139


First investigation on the impact of fabrication defects, 1995

Theoretical investigation of fabrication-related disorder on the properties of photonic crystals

Shanhui Fan, Pierre R. Villeneuve, and J. D. Joannopoulos

J. Appl. Phys. 78 (3), 1 August 1995  pp. 1415-1418

Conclusion very/too naïve/optimistic  
Will be revisited later

Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
Very high transmission (>95%) over wide frequency ranges. High transmission is observed even for 90° bends with zero radius of curvature, with a maximum transmission of 98% as opposed to 30% for analogous conventional dielectric waveguides. We propose a simple one-dimensional...
First fabrication with optical measurements of a 2D photonic crystal inoperating in the near infra-red, 1996

Two-dimensional photonic-bandgap structures operating at near-infrared wavelengths

Thomas F. Krauss*, Richard M. De La Rue* & Stuart Brand†

* Optoelectronics Research Group, Department of Electronics and Electrical Engineering, University of Glasgow, Glasgow G12 8LT, UK
† Department of Physics, University of Durham, Durham DH1 3LE, UK

NATURE · VOL 383 · 24 OCTOBER 1996 · pp. 699-702
From the forbidden bandgap to Bloch modes, 1996 - 2000
(or 25 years after R. Zengerle)
Highly dispersive photonic band-gap prism

Shawn-Yu Lin, V. M. Hietala, Li Wang, and E. D. Jones
November 1, 1996 / Vol. 21, No. 21 / OPTICS LETTERS 1771


Self-collimating phenomena in photonic crystals
Hideo Kosaka(4), Takayuki Kawashima(5), Akhisa Tomita, Masaya Notomi(6), Toshiaki Tamamura(7), Takashi Sato(8), and Shojiro Kawakami(9)

Photonic crystals for micro lightwave circuits using wavelength-dependent angular beam steering
Hideo Kosaka(4), Takayuki Kawashima(5), Akhisa Tomita, Masaya Notomi(6), Toshiaki Tamamura(7), Takashi Sato(8), and Shojiro Kawakami(9)

- Equi-frequency surfaces
- Superprism
- Negative fraction
- Super lens
- Selfcollimation
First photonic crystal laser, 1996

Lasers incorporating 2D photonic bandgap mirrors


ELECTRONICS LETTERS 21st November 1996 Vol. 32 No. 24 pp. 2243-2244

but especially, 1999

Two-Dimensional Photonic Band-Gap Defect Mode Laser

O. Painter,¹ R. K. Lee,¹ A. Scherer,¹* A. Yariv,¹ J. D. O’Brien,² P. D. Dapkus,² I. Kim²

SCIENCE VOL 284 11 JUNE 1999 pp. 1819-1821

- Laser
- Design
  + high-Q cavities
  + small modal volume
- Membrane structure

Fig. 5. L-L curve showing the power at the laser wavelength versus the incident pump power. The sample was cooled to 143 K and pumped with 10-ns pulses (4% duty cycle). The actual absorbed pump power is difficult to estimate for a structure with this geometry.
Fabrication of 3D structures in the near infra-red, 1996 - 2005


Nanofabricated Three Dimensional Photonic Crystals Operating at Optical Wavelengths

C. C. Cheng, V. Arbet-Engels, A. Scherer and E. Yablonovitch

1996

Microassembly of semiconductor three-dimensional photonic crystals

KANNA AOKI†, HIDEKI T. MIYAZAKI, HIDEKI HIRAYAMA, KYOJI INOSHITA, TOSHIHIKO BABA, KAZUAKI SAKODA, NORIO SHINYA and YOSHINOBU AOGI

nature materials | VOL 2 | FEBRUARY 2003 | pp. 117-121

Figure 3. Optical properties of the fabricated 3D photonic crystals. a. Reflection spectra. b. Transmission spectra. The peaks appearing at 4.2 μm in all spectra are derived from absorption of carbon dioxide in air.
Endlessly single-mode photonic crystal fiber

T. A. Birks, J. C. Knight, and P. St. J. Russell

July 1, 1997 / Vol. 22, No. 13 / OPTICS LETTERS

Photonic Band Gap Guidance in Optical Fibers

J. C. Knight, J. Broeng,* T. A. Birks, P. St. J. Russell


Single-Mode Photonic Band Gap Guidance of Light in Air

R. F. Cregan,¹ B. J. Mangan,¹ J. C. Knight,¹ T. A. Birks,¹ P. St. J. Russell,¹* P. J. Roberts,² D. C. Allan³

3 SEPTEMBER 1999 VOL 285 SCIENCE pp. 1537-1539

hollow-core fiber
Quantitative Measurement of Transmission, Reflection, and Diffraction of Two-Dimensional Photonic Band Gap Structures at Near-Infrared Wavelengths


pp. 4147-4150
On-chip natural assembly of silicon photonic bandgap crystals

Yurii A. Vlasov*,†, Xiang-Zheng Bo‡, James C. Sturm‡ & David J. Norris*

NATURE | VOL 414 | 15 NOVEMBER 2001 | pp. 289-293
Finally, "true" quantum effects

Controlling the Spontaneous Emission Rate of Single Quantum Dots in a Two-Dimensional Photonic Crystal

Dirk Englund, David Fattal, Edo Waks, Glenn Solomon, Bingyang Zhang, Toshihiro Nakaoka, Yasuhiko Arakawa, Yoshihisa Yamamoto, and Jelena Vučković

Efficient Single-Photon Sources Based on Low-Density Quantum Dots in Photonic-Crystal Nanocavities

Wen-Hao Chang, Wen-Yen Chen, Hsiang-Szu Chang, Tung-Po Hsieh, Jen-Inn Chyi, and Tzu-Min Hsu

Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
Back to initial motivation II, 2004

Vacuum Rabi splitting with a single quantum dot in a photonic crystal nanocavity

T. Yoshie¹, A. Scherer¹, J. Hendrickson², G. Khitrova², H. M. Gibbs², G. Rupper, C. Ell¹, O. B. Shchekin¹ & D. G. Deppe³

Nature | Vol 432 | 11 November 2004 | pp. 200-203

Also in micro-pillars

Strong coupling in a single quantum dot–semiconductor microcavity system

J. P. Reithmaier¹, G. Sökk¹, A. Löffler¹, C. Hofmann¹, S. Kuhn¹, S. Reitzenstein¹, L. V. Keldysh¹, V. D. Kulakovskii¹, T. L. Reinecke¹ & A. Forchel¹

Nature | Vol 432 | 11 November 2004 | pp. 197-200

And

Deterministic Coupling of Single Quantum Dots to Single Nanocavity Modes

Antonio Badolato¹, Kevin Hennessy¹, Mete Atature³, Jan Dreiser³, Evelyn Hu¹,², Pierre M. Petroff¹,² Atac Imamoglu¹

Science | Vol 308 | 20 May 2005 | pp. 1158-1161

Ecole doctorale photonique, Photonic crystals, PHYS-605, Romuald Houdré, Summer semester 2013
Why do we need slow light?

THOMAS F. KRAUSS
High-Q cavities

Analysis of the experimental $Q$ factors
( ~ 1 million) of photonic crystal nanocavities

Takashi Asano, Bong-Shik Song, Susumu Noda
6 March 2006 / Vol. 14, No. 5 / OPTICS EXPRESS 1996

$Q_{th} = 16 \cdot 10^6$, $Q_{exp} \approx 1 \cdot 10^6$

\begin{figure}
\centering
\includegraphics[width=\textwidth]{image.png}
\caption{Emission intensity and transmission spectrum of a photonic crystal nanocavity.}
\end{figure}