

Prof. Dr. C. von Borczyskowski

Aspekte der modernen Optik

Vorlesung vom 15.07.2010

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Wahlpflicht SS 2010

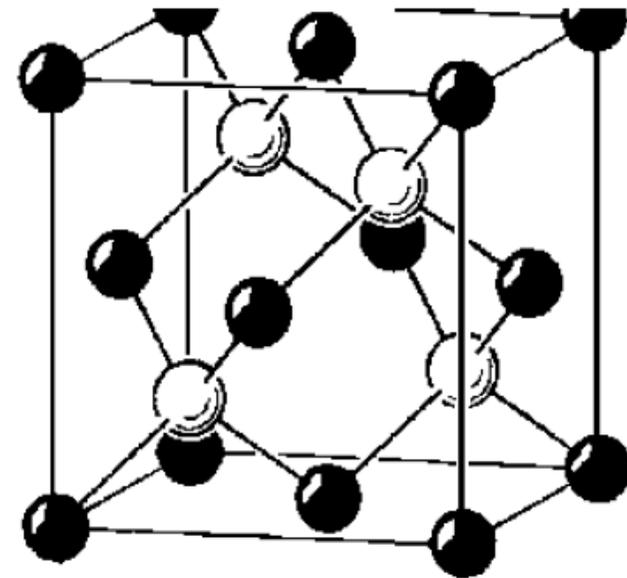
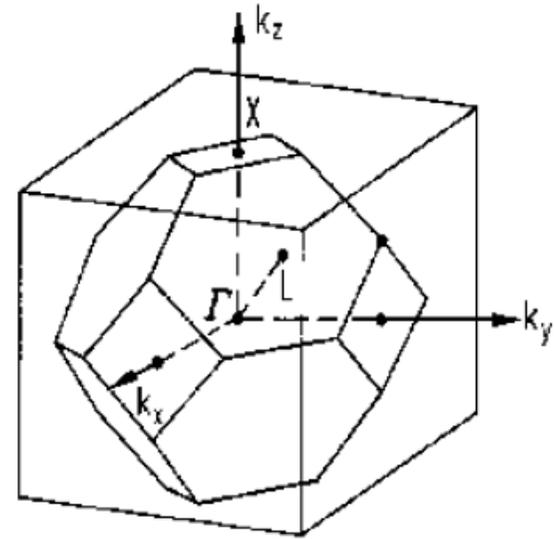
Literatur

Dieter Meschede Optik, Licht, Laser Teubner

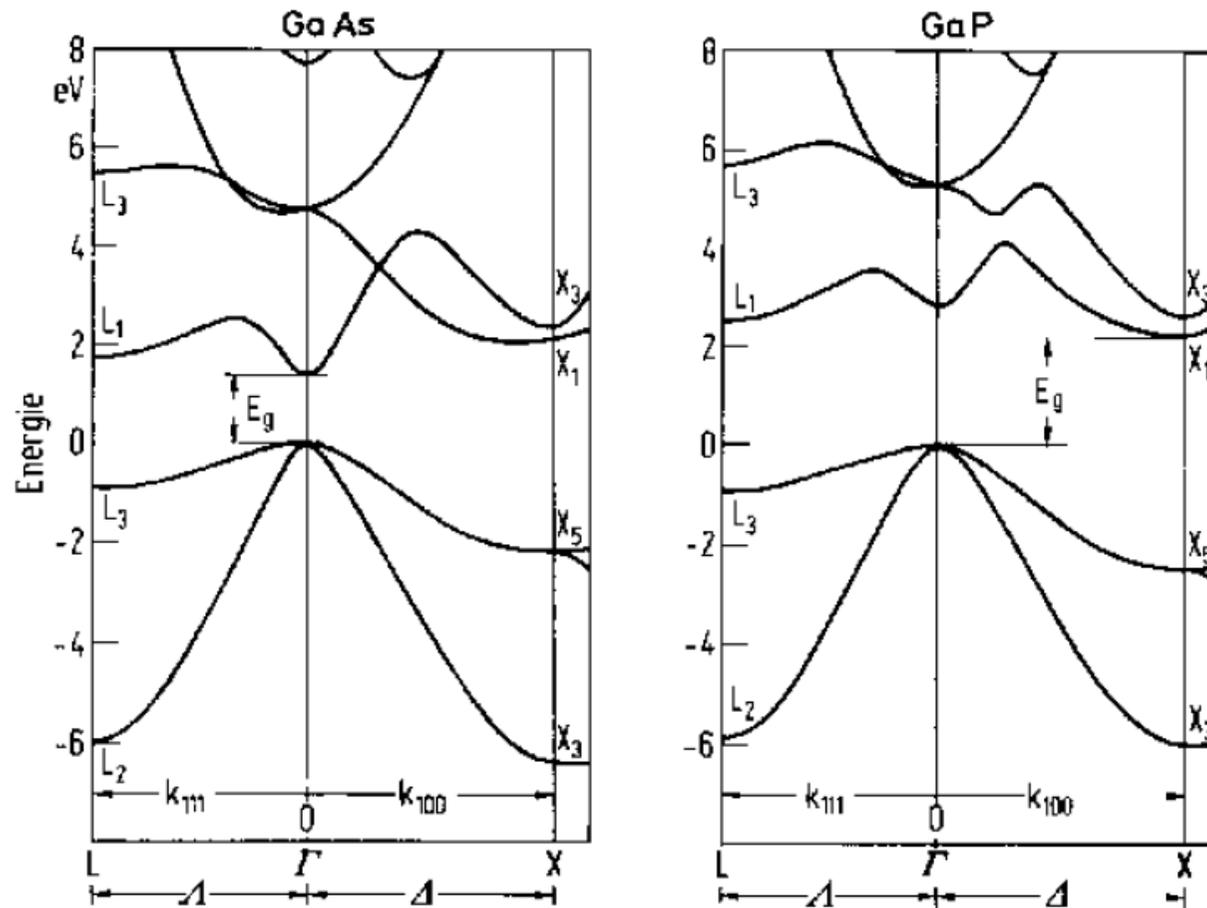
Ralf Menzel Photonics Springer

H. Rigneault et al. Nanophotonics ISTE

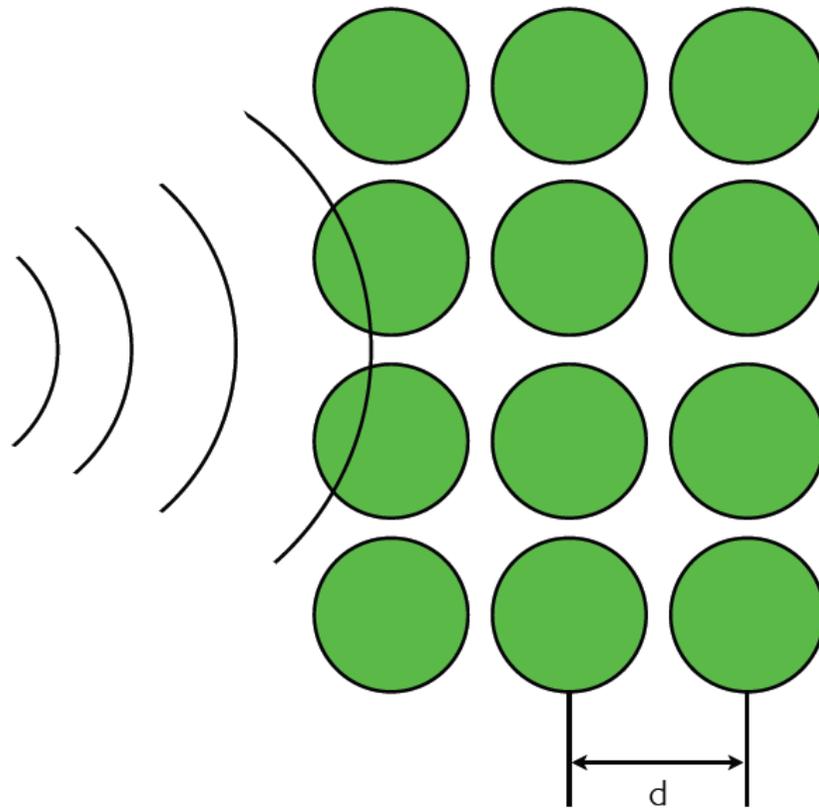
Kristalle



Bandstruktur



periodic arrangements of dielectric units

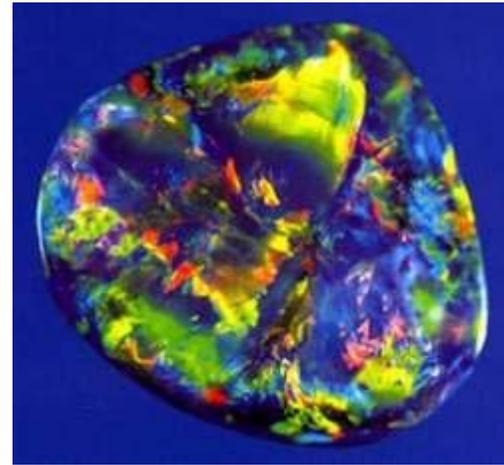


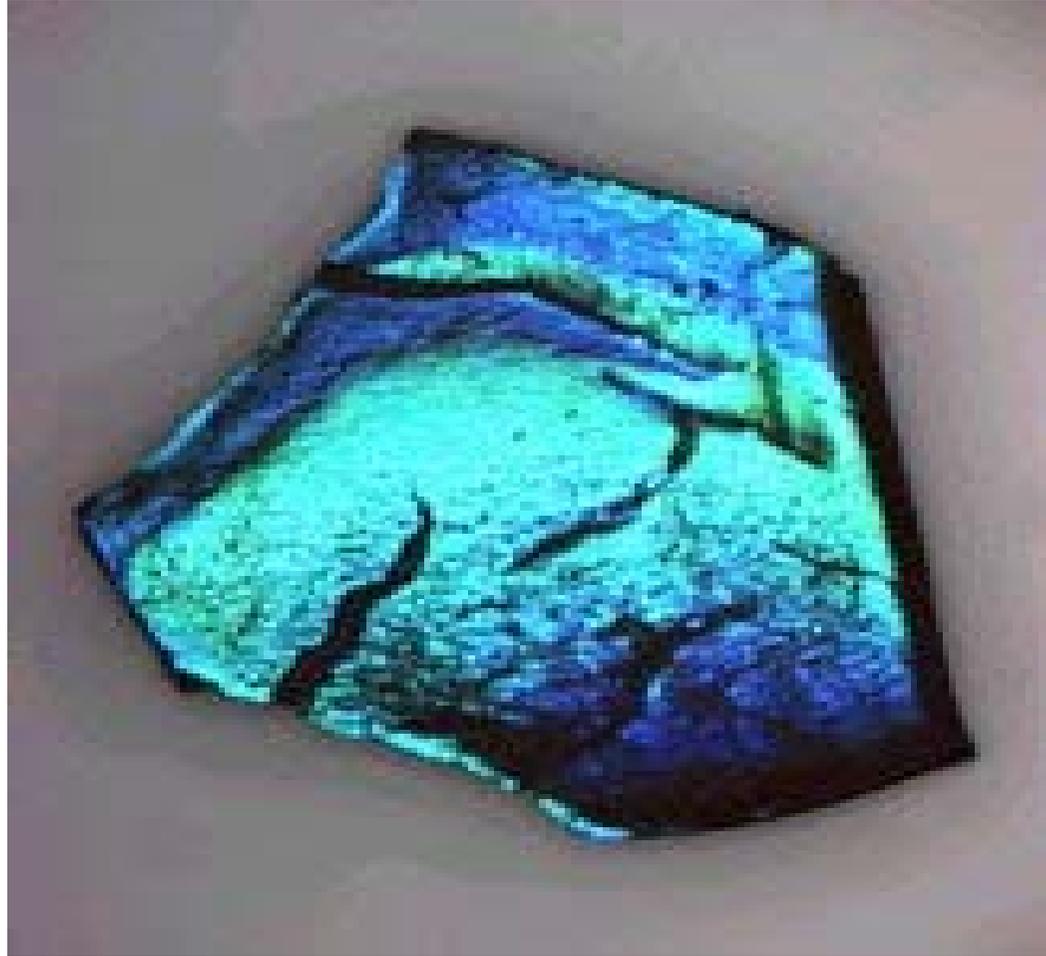
refractive index is the potential for photons

$d \sim$ optical wavelength

Photonische Kristalle

- Farbe
 - Reflexion
 - Transmission
- Parallelität
- Verlangsamung Lichtgeschwindigkeit
 - Verstärkung
- Mikroresonatoren
- Wellenleitung
 - Lineare Wellenleitung
 - Ecken
- Dotierung
- Elektronische Steuerung

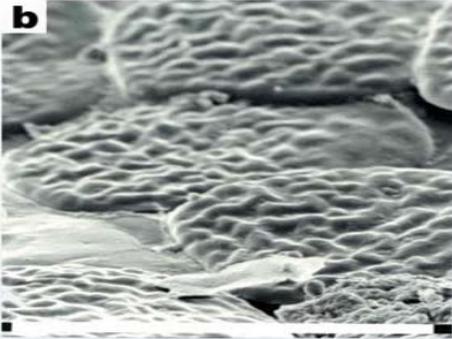




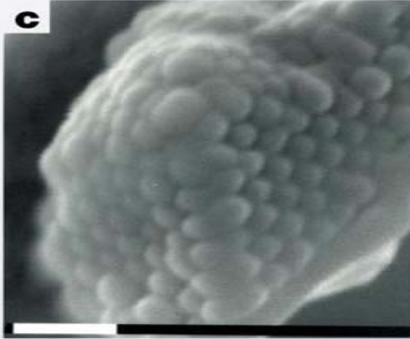
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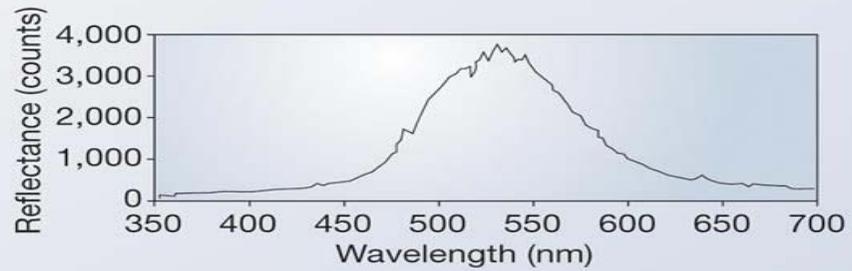
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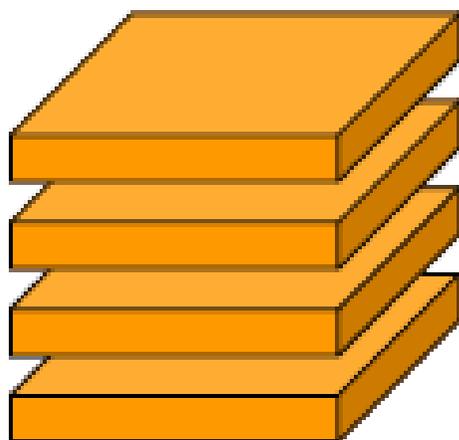
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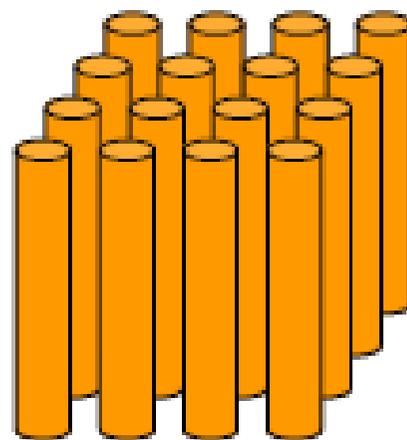
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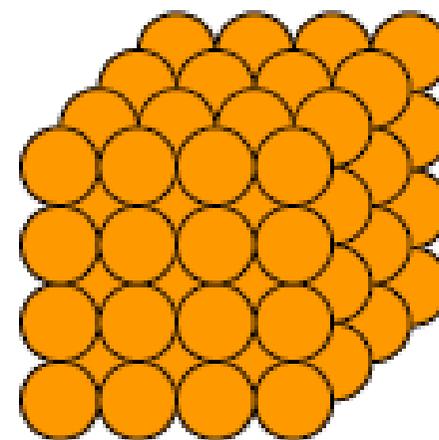
1D

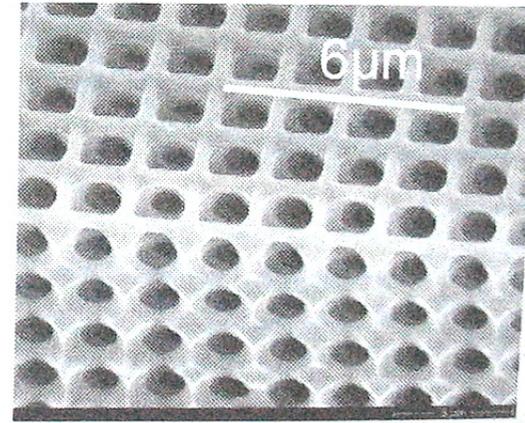
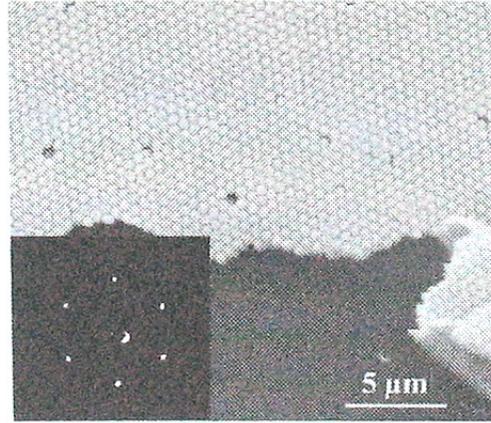
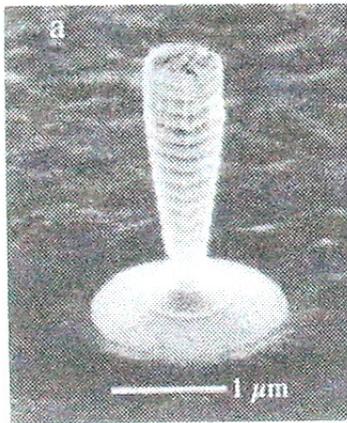
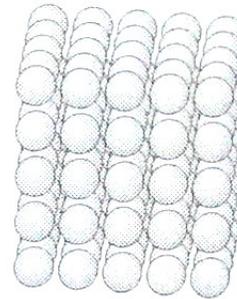


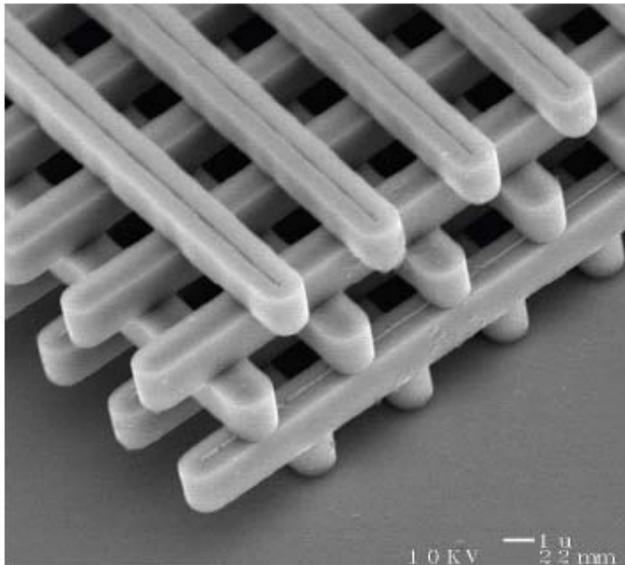
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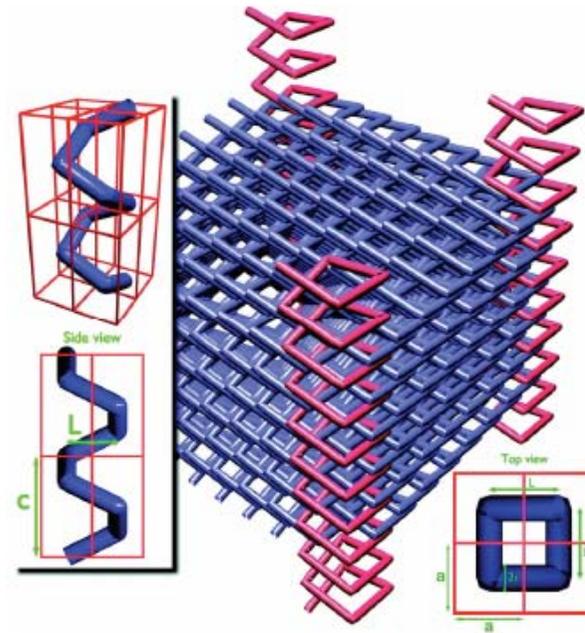
3D



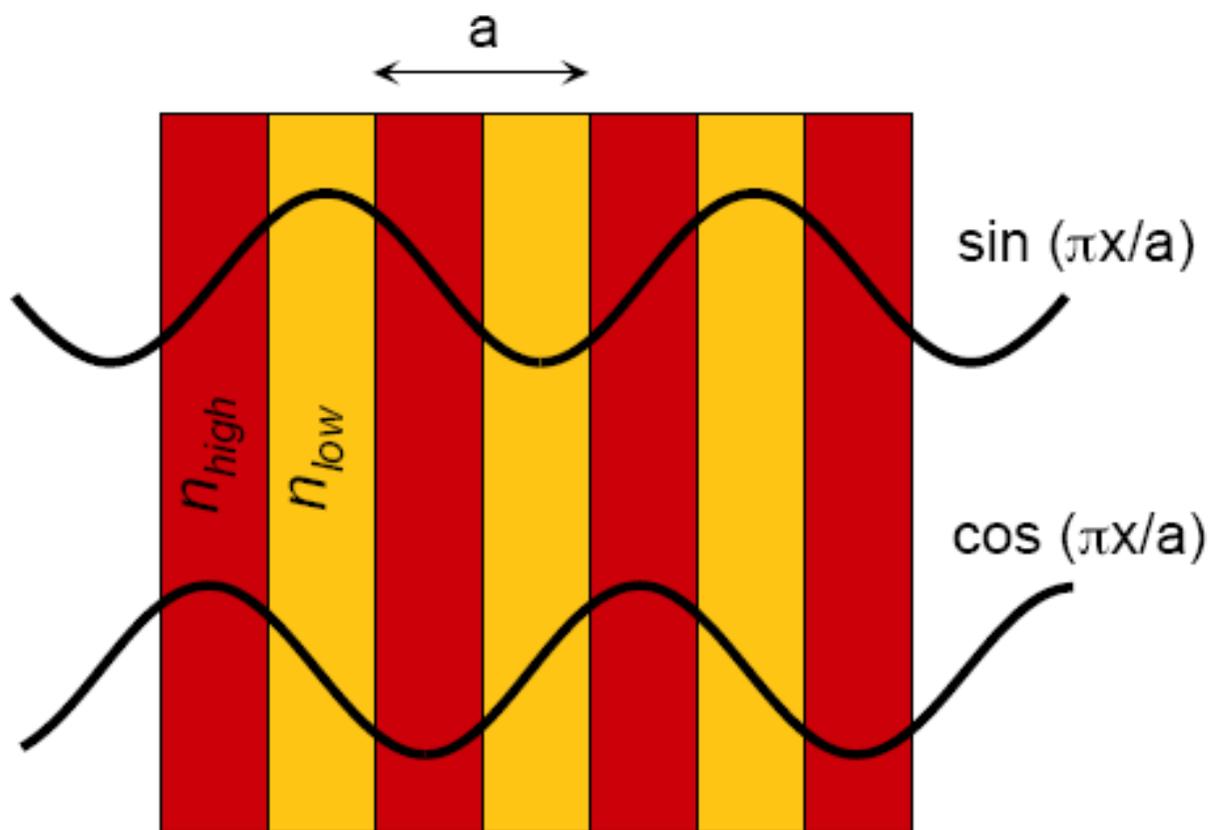


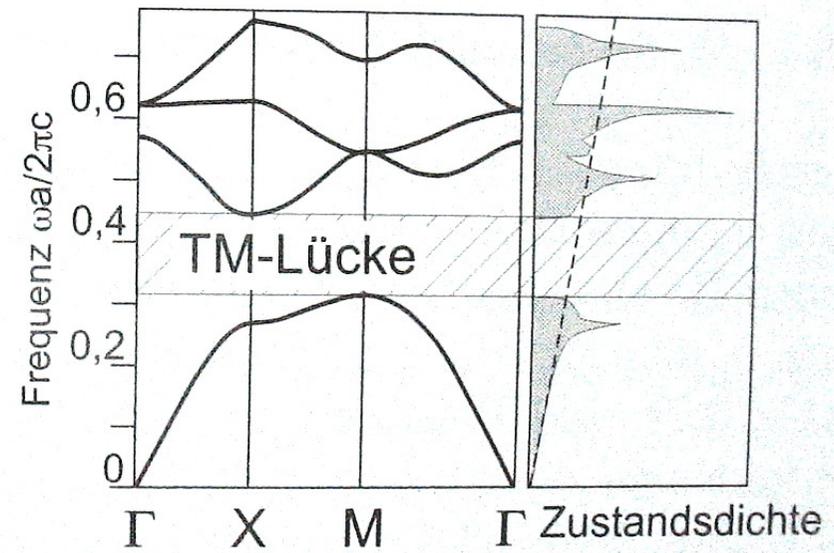
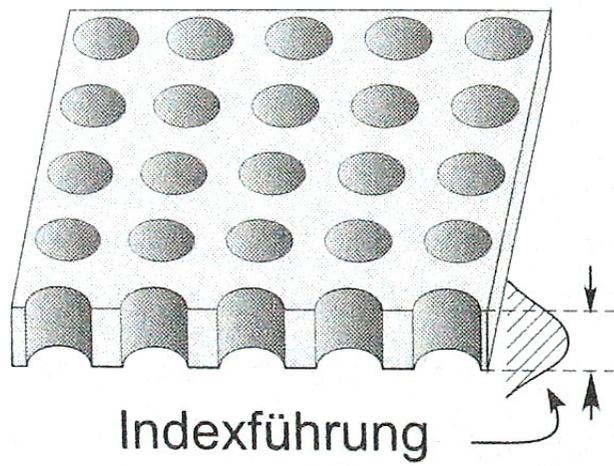


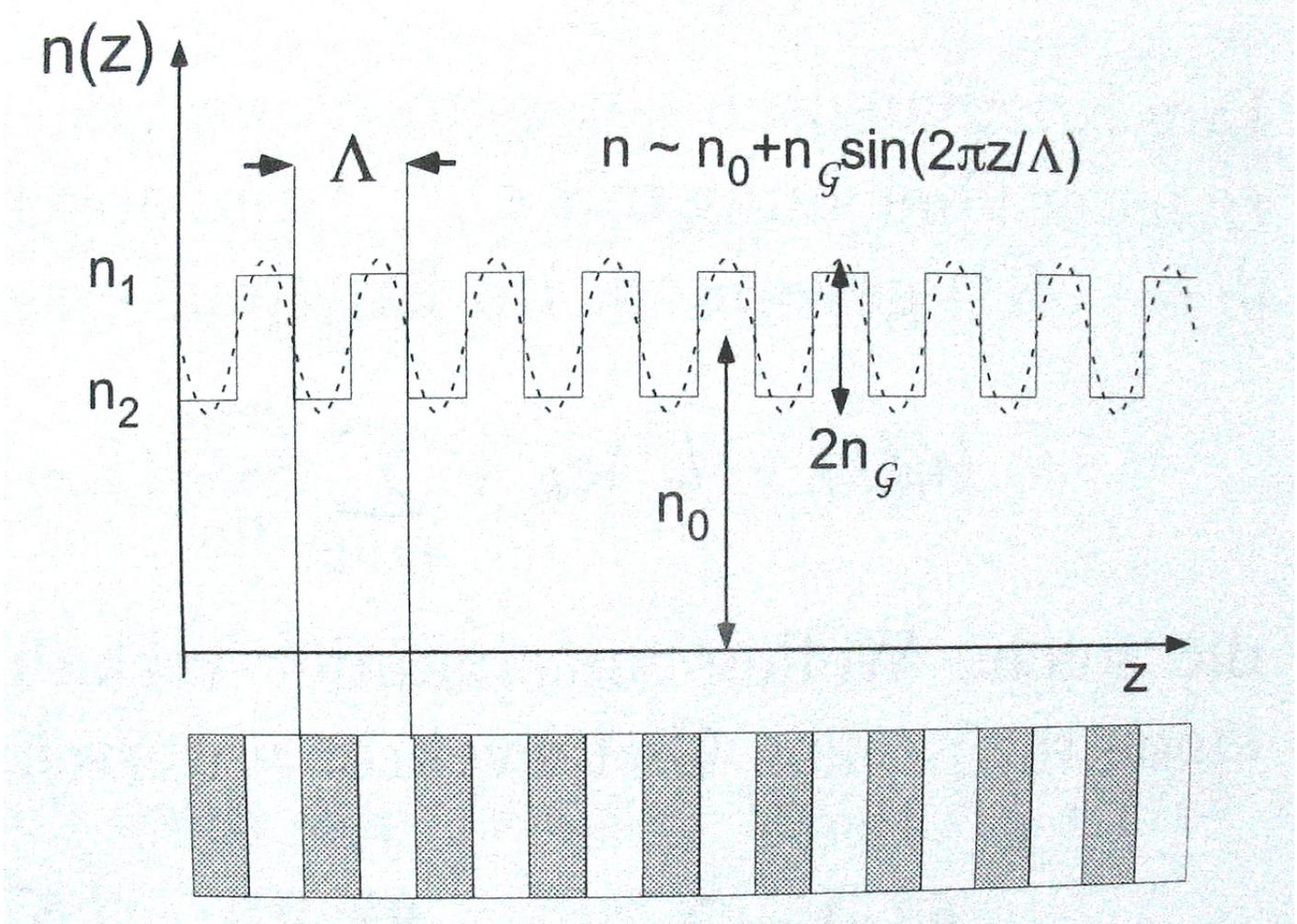
S.Y. Lin et al., Nature 394, 251 (1998)

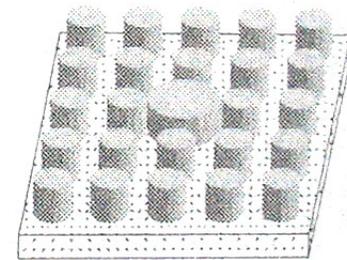
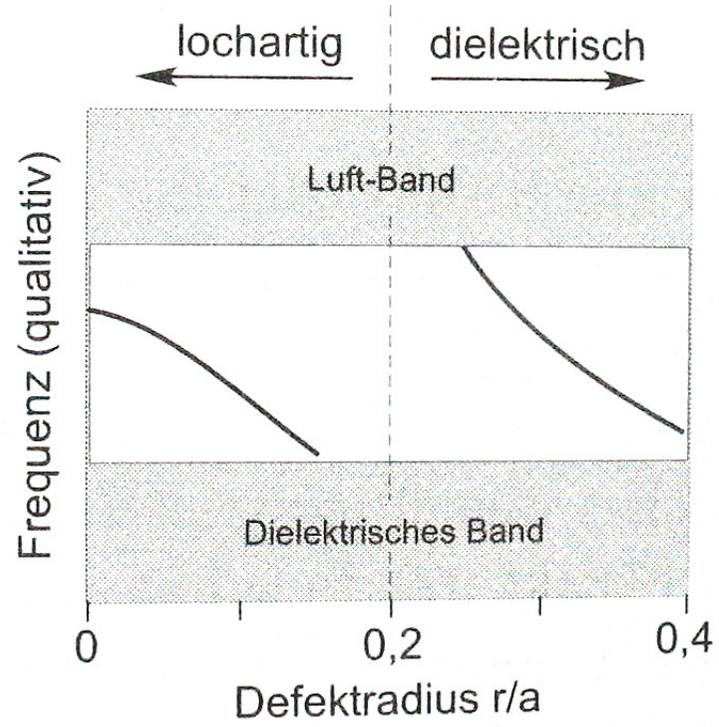
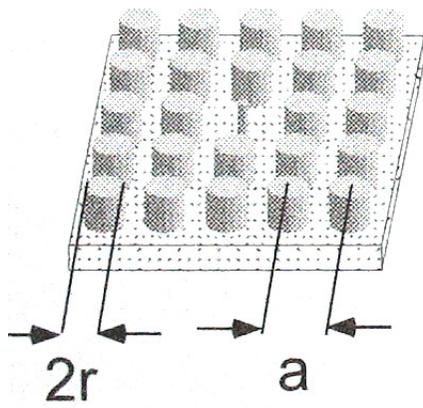


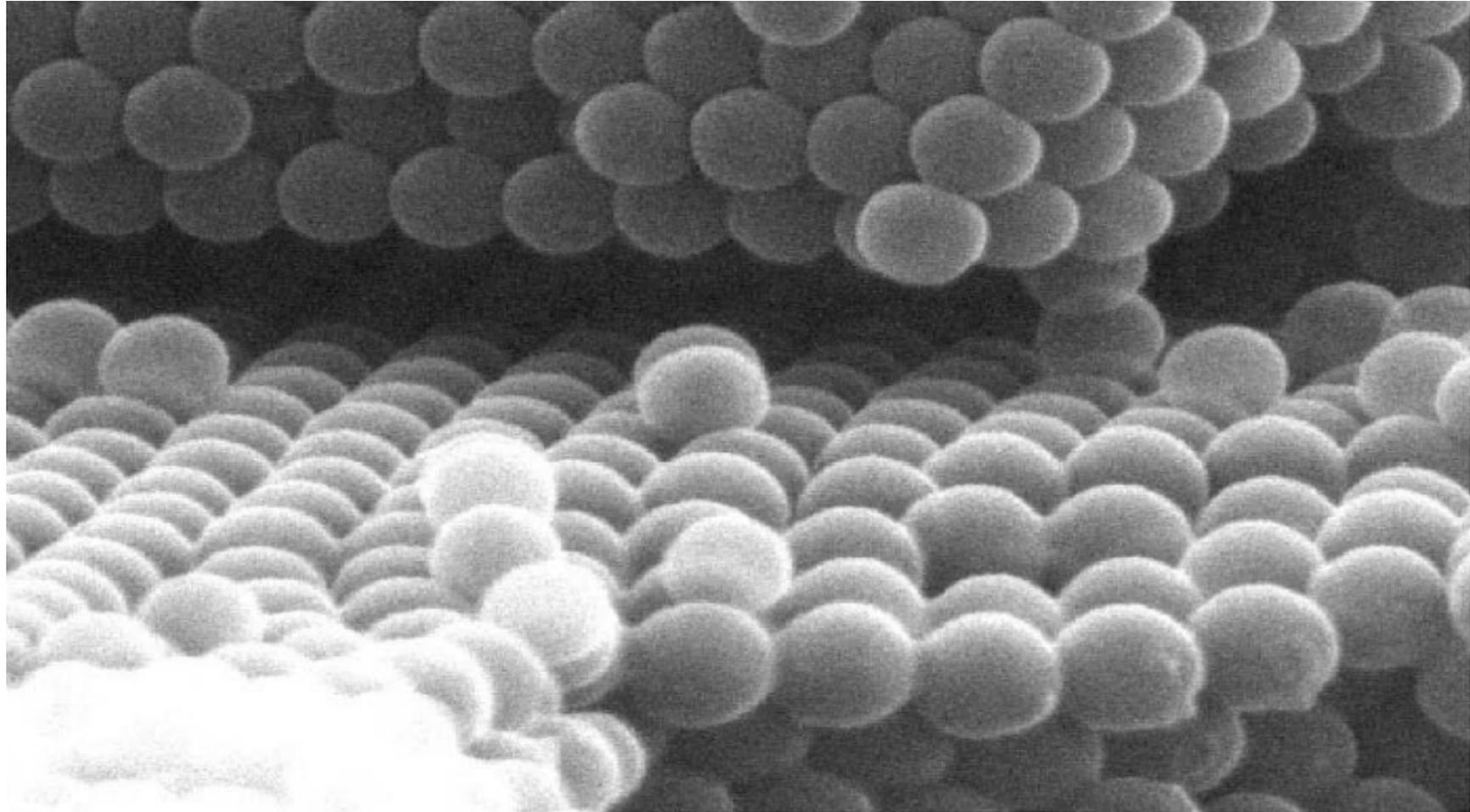
O. Toader and S. John, Science 292, 1133 (2001)











Maxwell Gleichungen

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{E} + \frac{1}{c} \frac{\partial \vec{B}}{\partial t} = 0$$

$$\nabla \cdot \vec{D} = 4\pi \rho$$

$$\nabla \times \vec{H} - \frac{1}{c} \frac{\partial \vec{D}}{\partial t} = \frac{4\pi}{c} \vec{j}$$

- E** : elektrisches Feld
- H** : magnetisches Feld
- D** : dielektrische Verschiebung
- B** : magnetische Erregung
- ρ** : freie Ladungen
- J** : Ströme

Dielektrische Verschiebung

$$D_i = \sum_j \epsilon_{ij} E_j$$

$$\epsilon(\vec{r}, \omega) = \epsilon_\omega(\vec{r}) = \epsilon(\vec{r})$$

Bandlücke

Lineares Medium:

$$\omega(k) = ck / \sqrt{\epsilon}$$

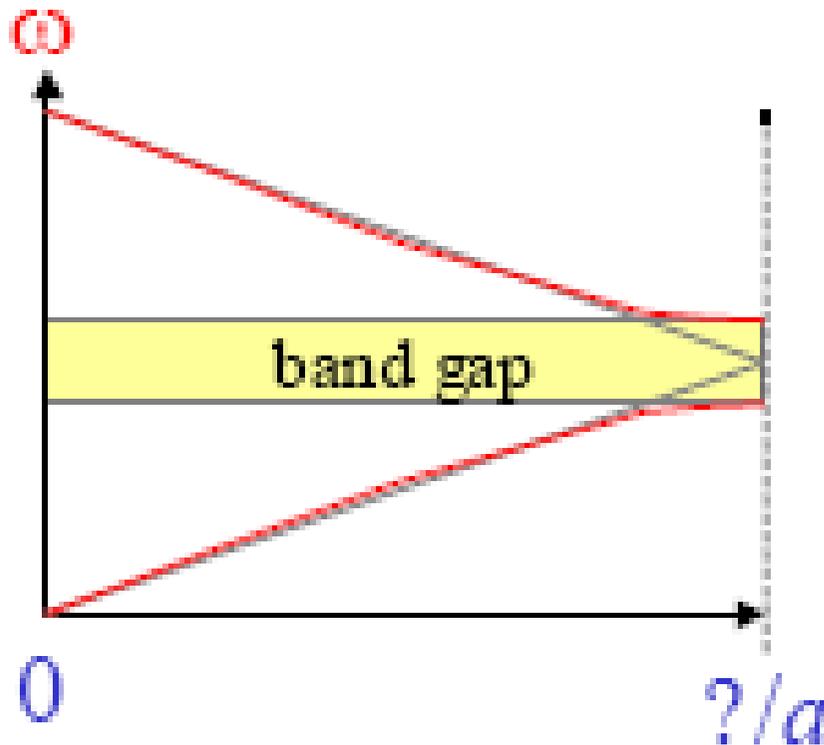
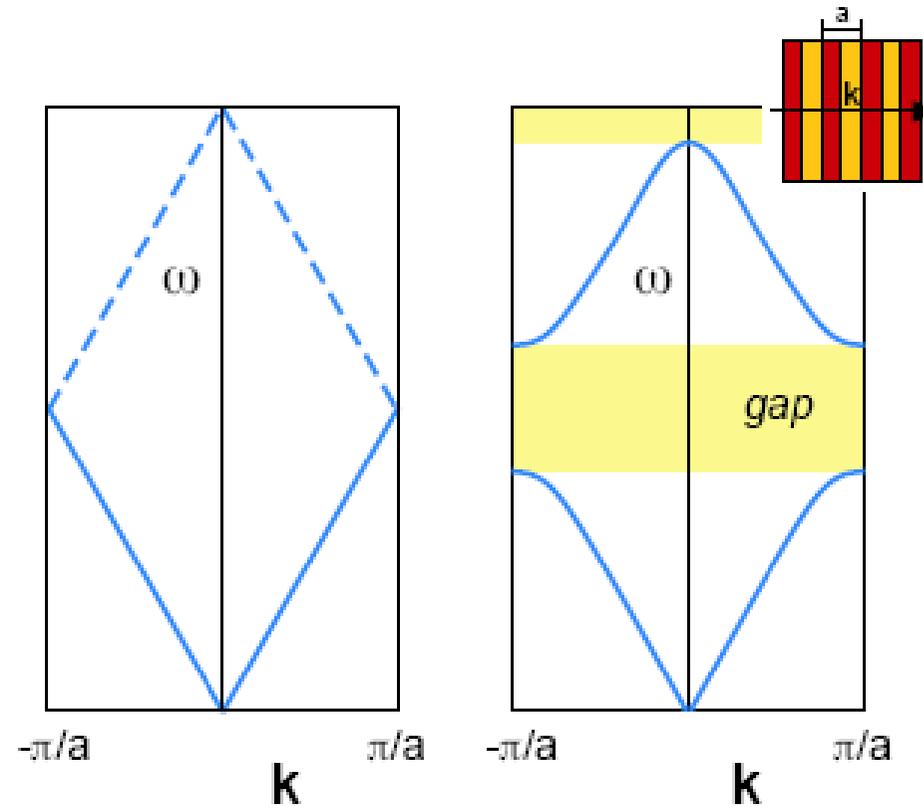
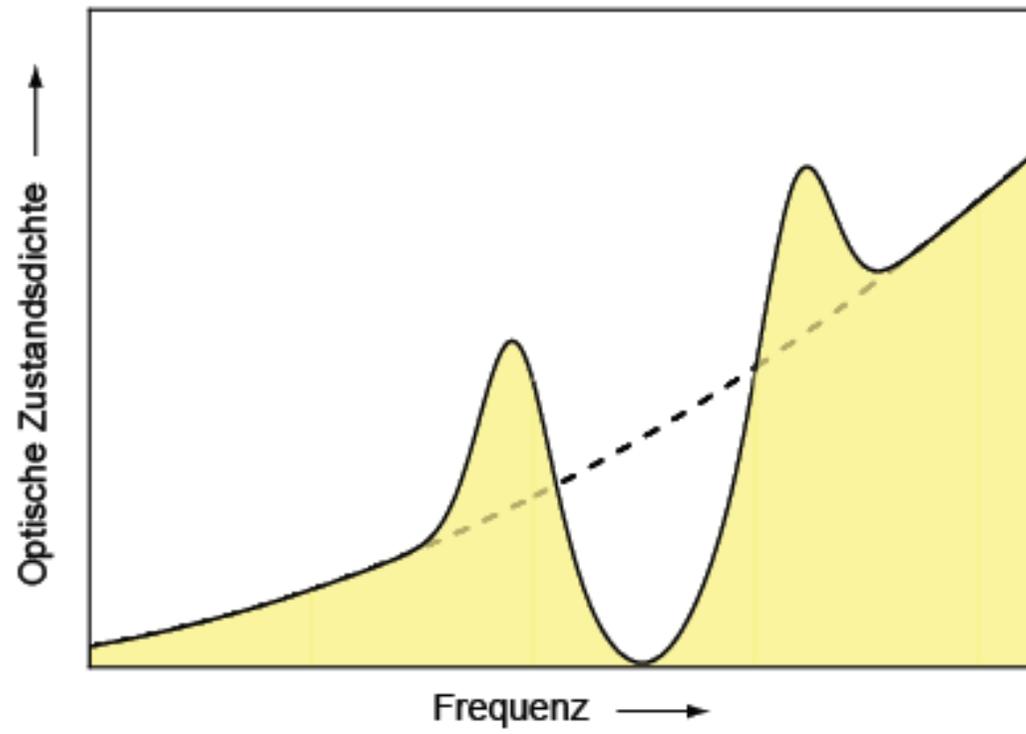
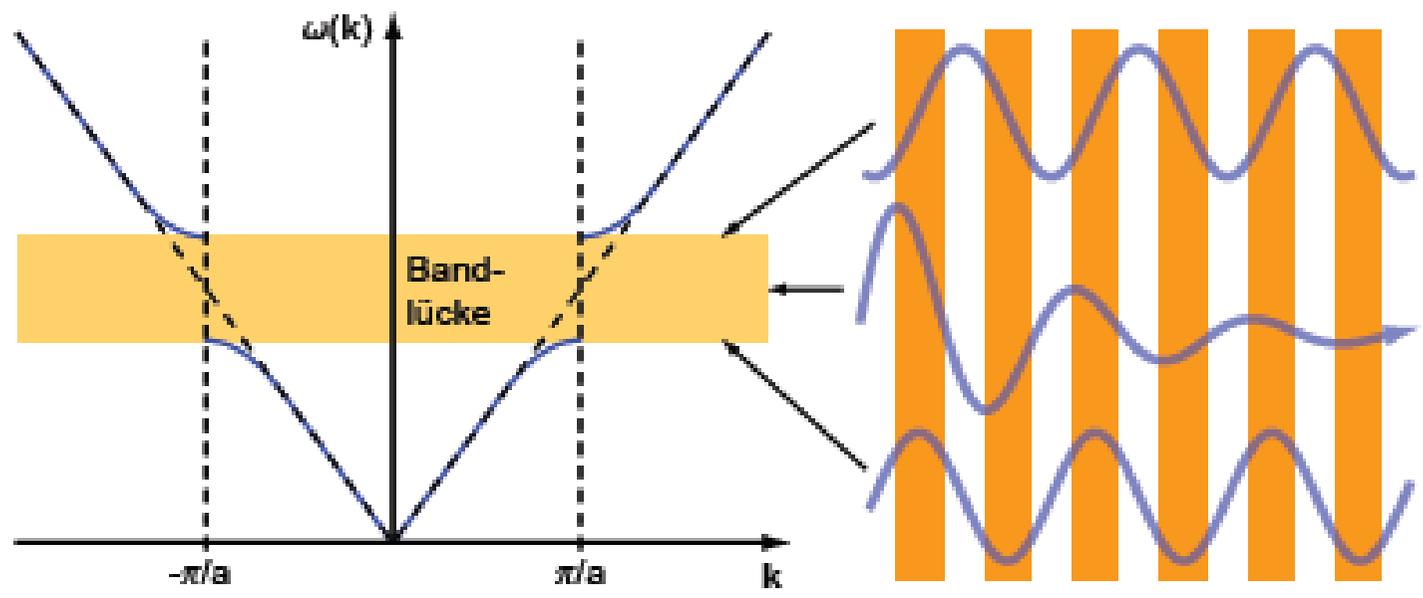


Abb.3: Dispersionsrelation für einen Multilayerfilm

1-dim Bandlücke







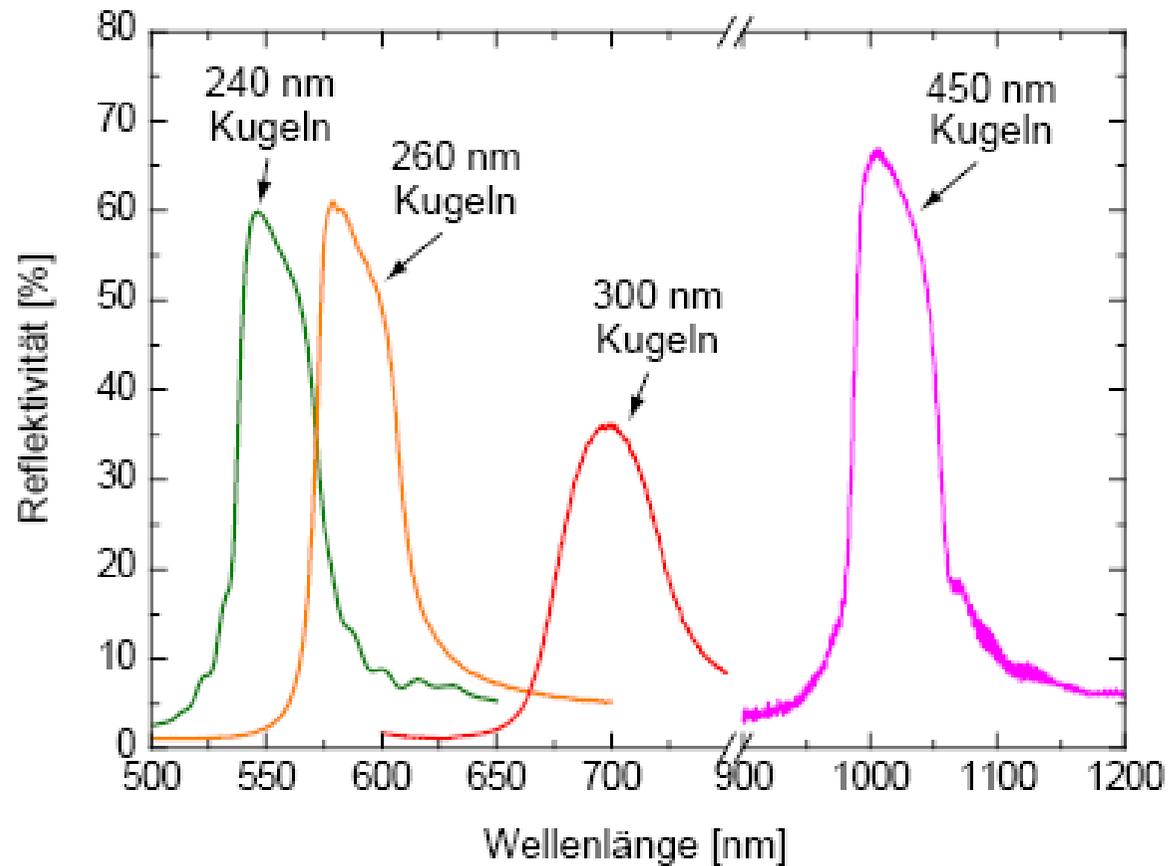
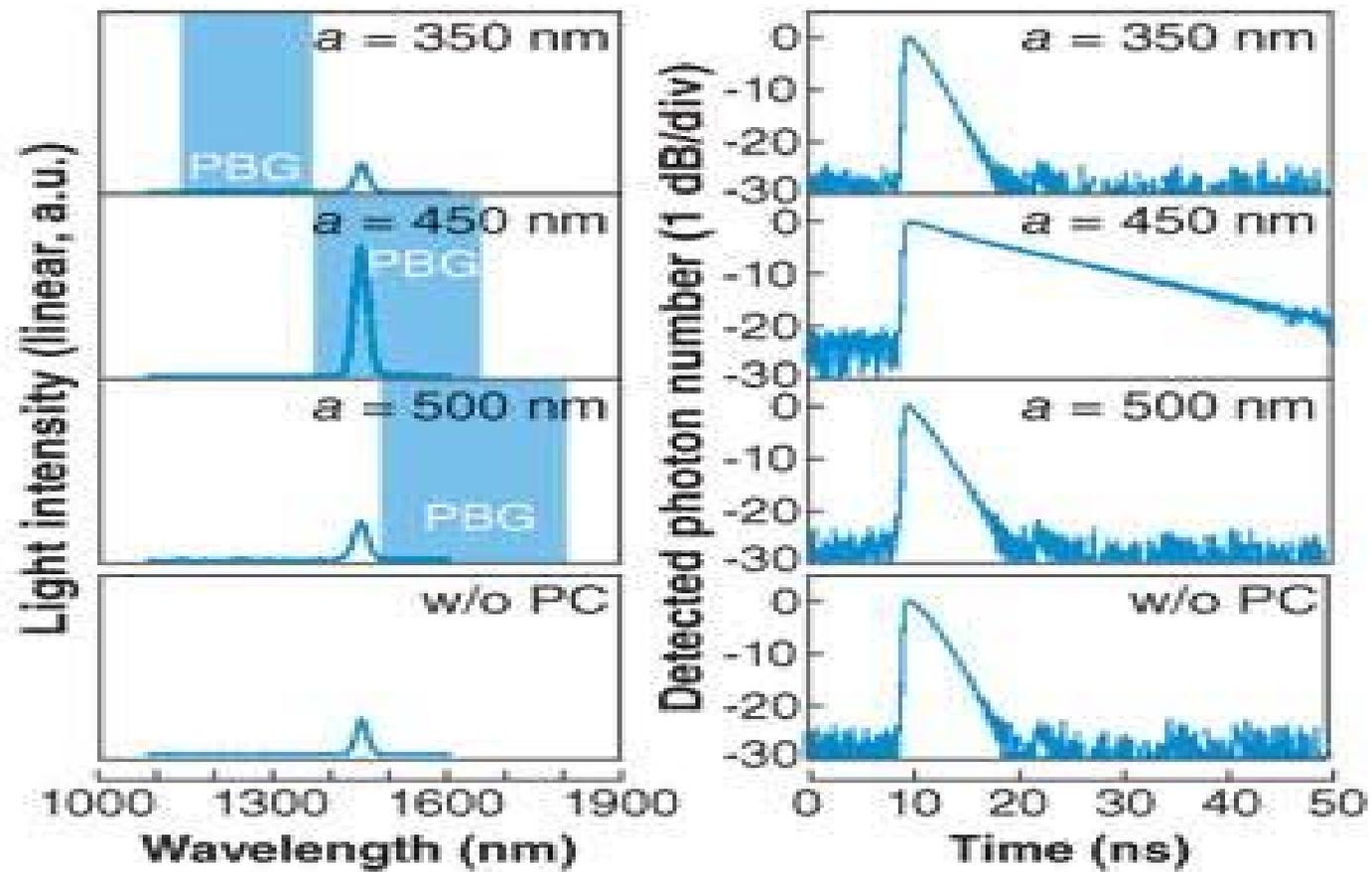
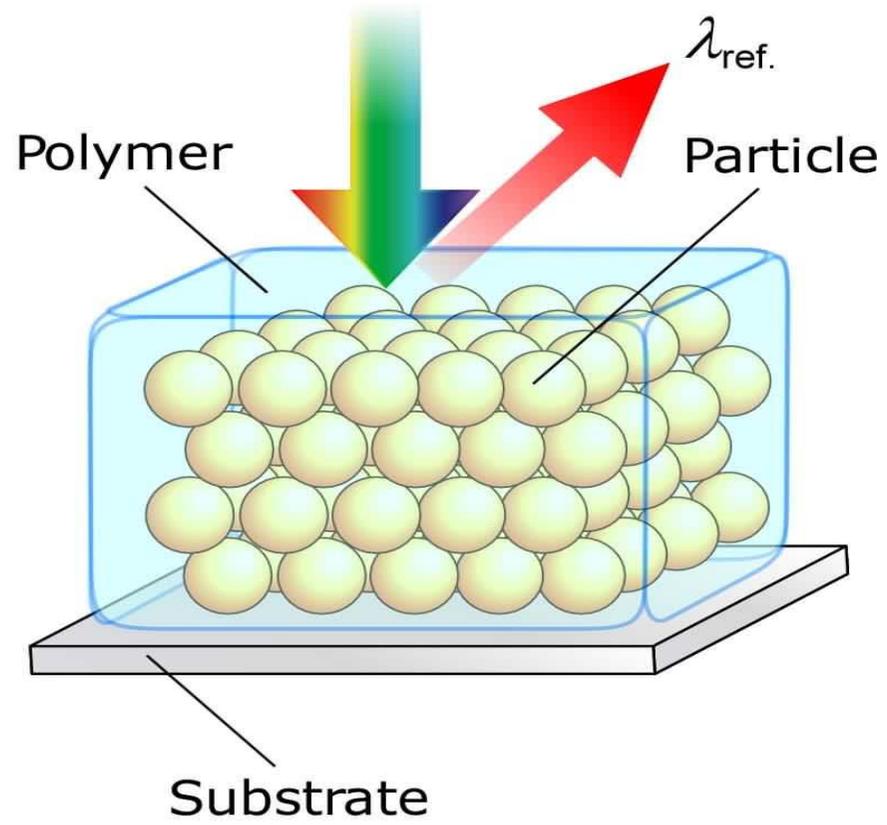
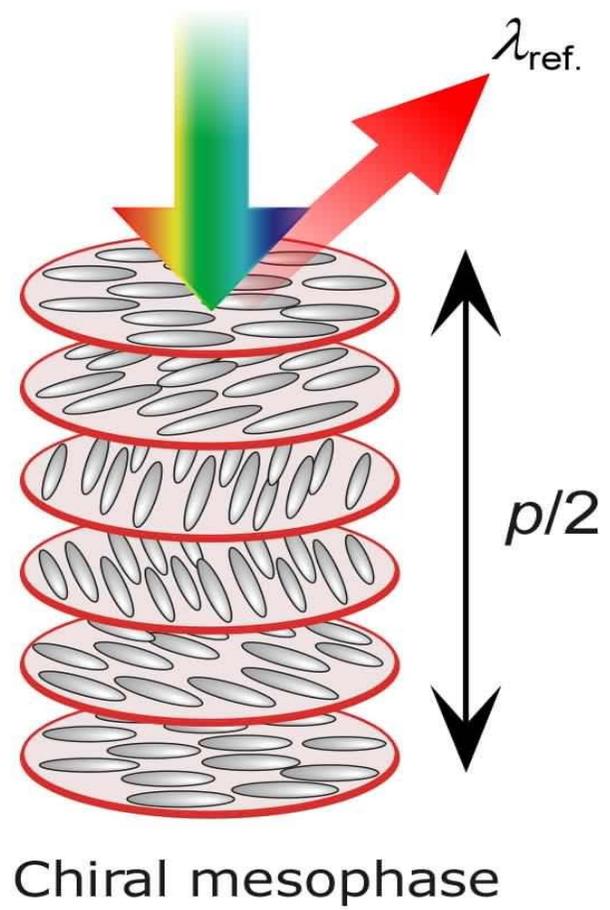
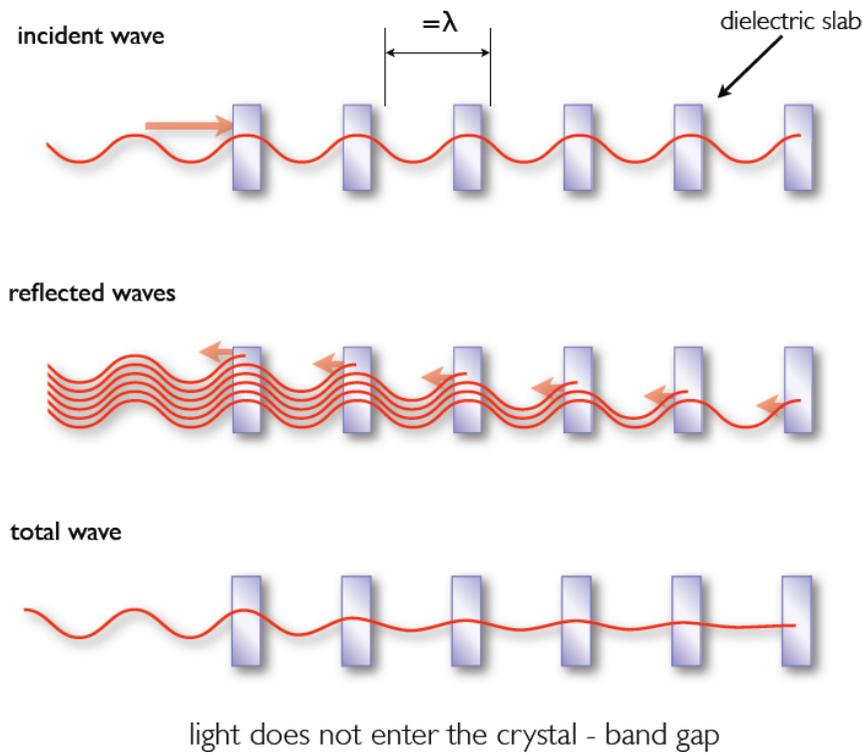


Abbildung 6.5: Reflexionsspektren photonischer Kristalle aus Polystyrol-Kugeln verschiedener Durchmesser, aufgenommen senkrecht zur Probenoberfläche.

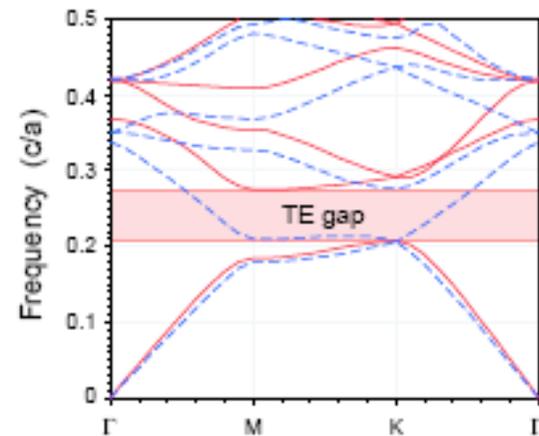
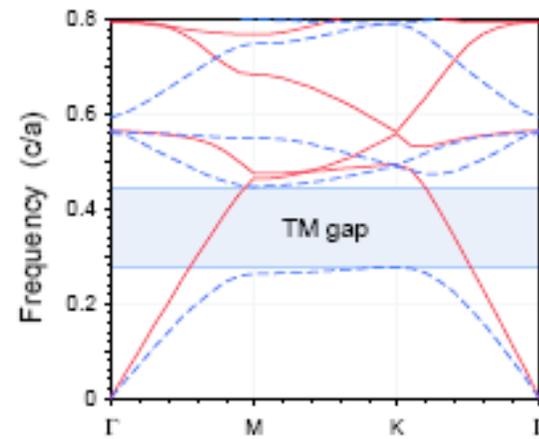
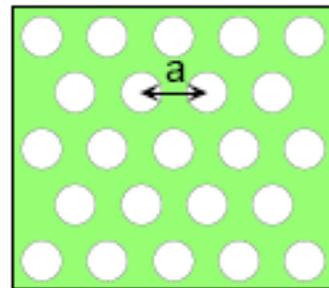
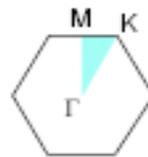
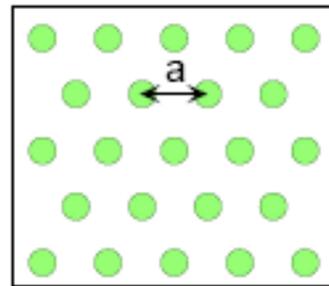




semiconductor for 1 dimension

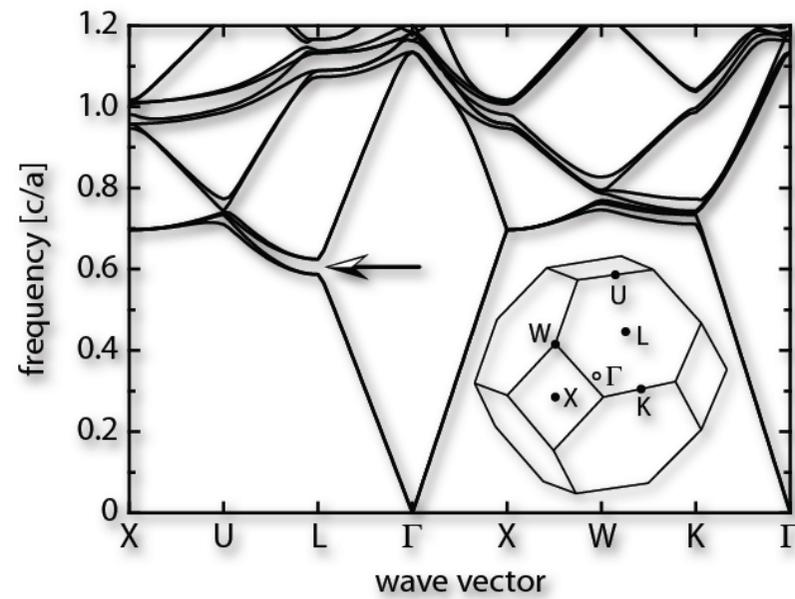


2- Dimensionen

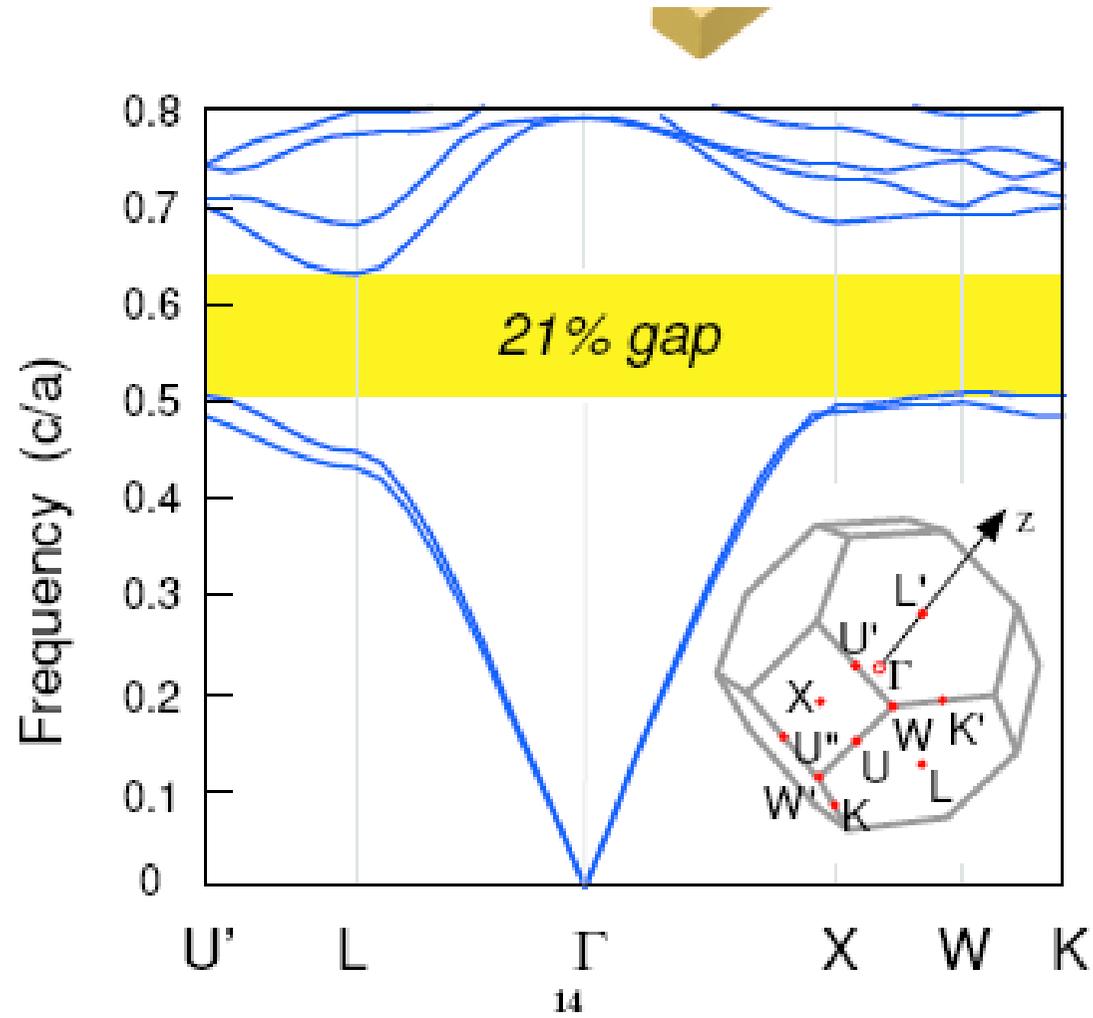


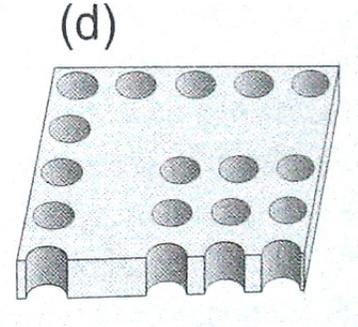
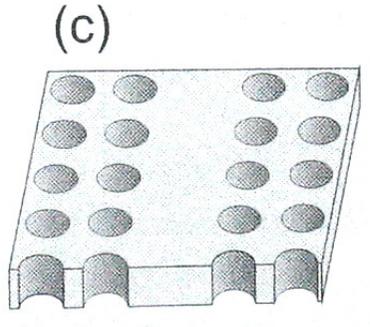
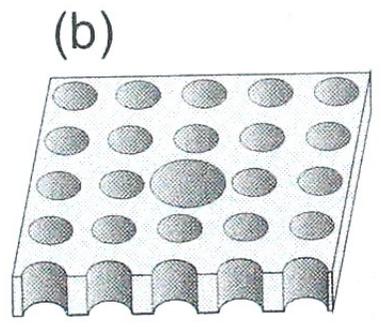
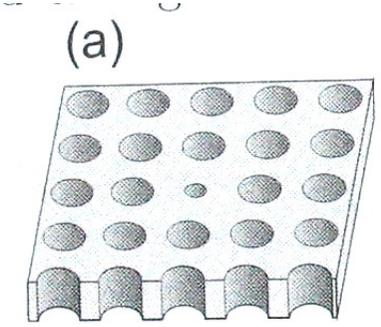
bandstructure of a real system

fcc-photonic crystal made of 260 nm polystyrene beads



3-Dimensionen

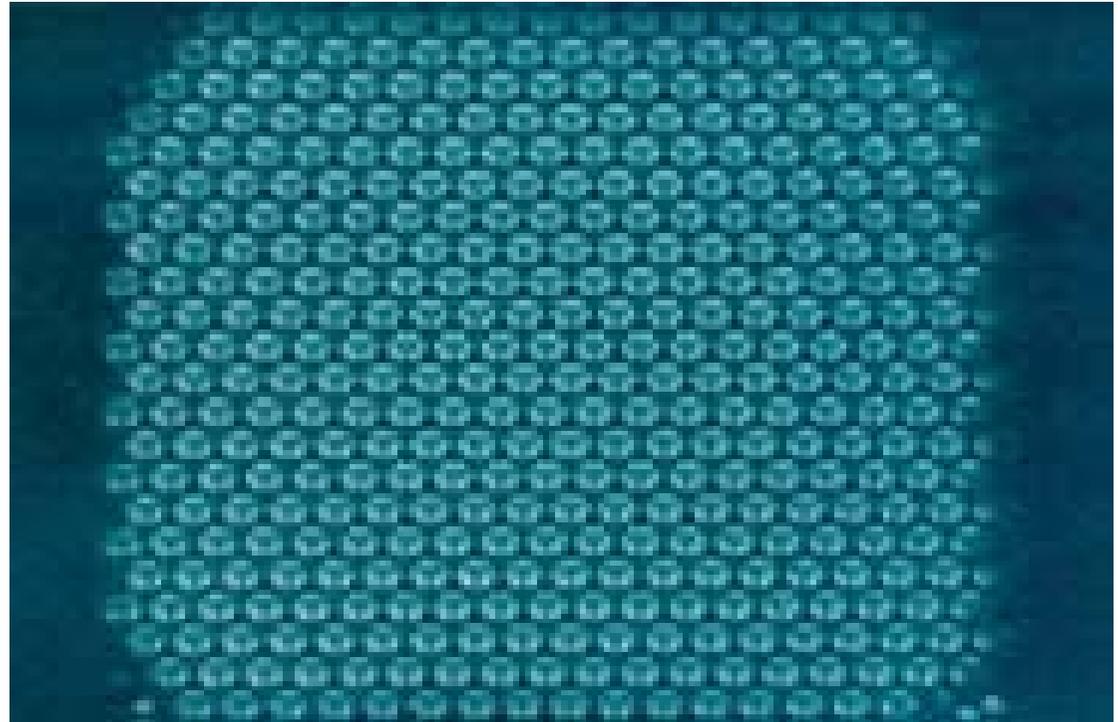




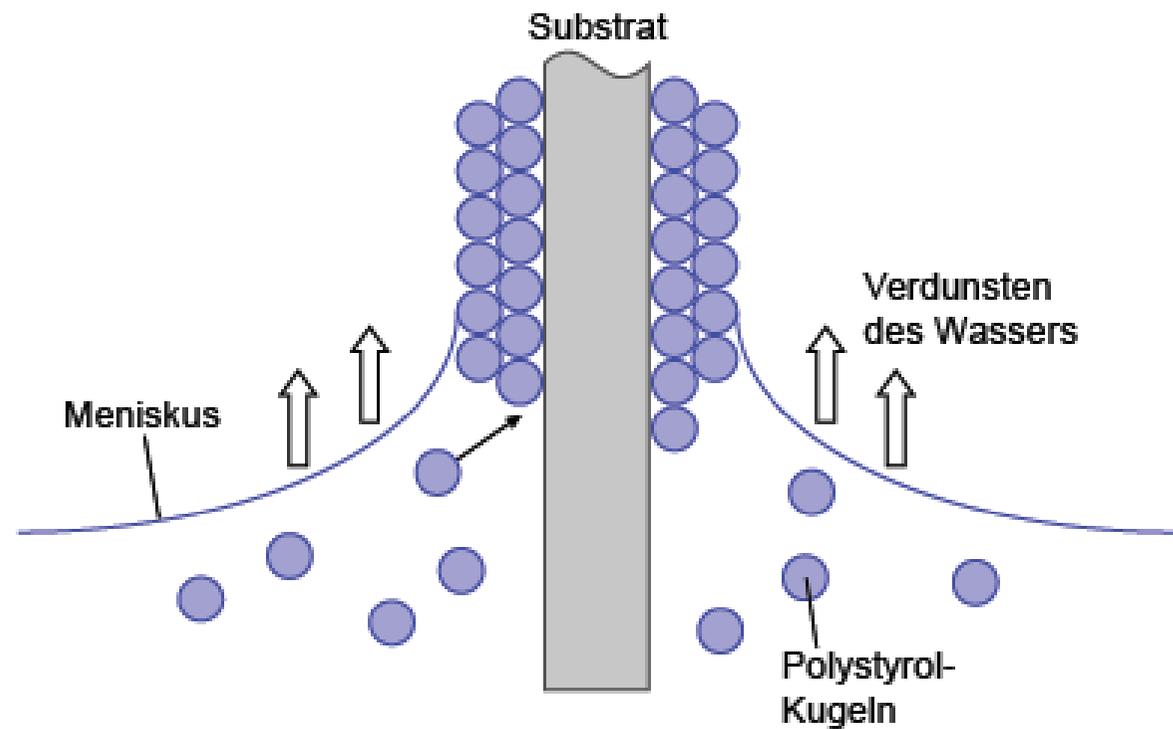
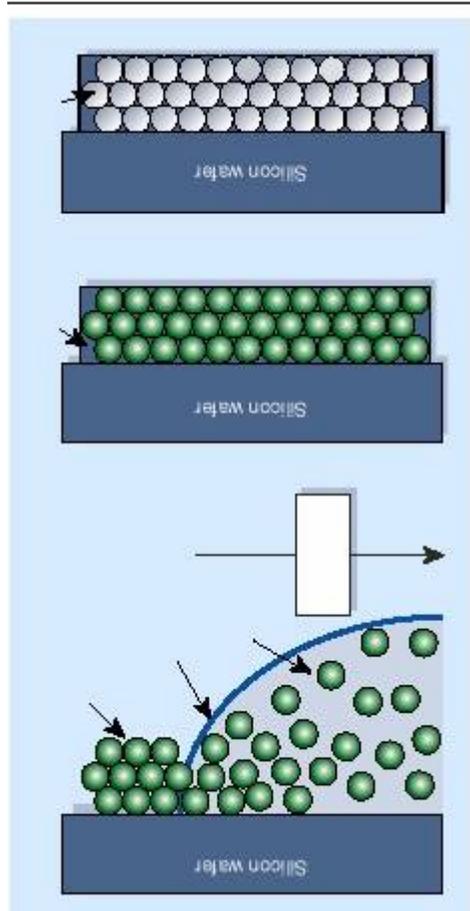
Herstellung

- Mechanisch
- Selbstorganisation
- Laserstrukturierung

Herstellung



Selbstorganisation



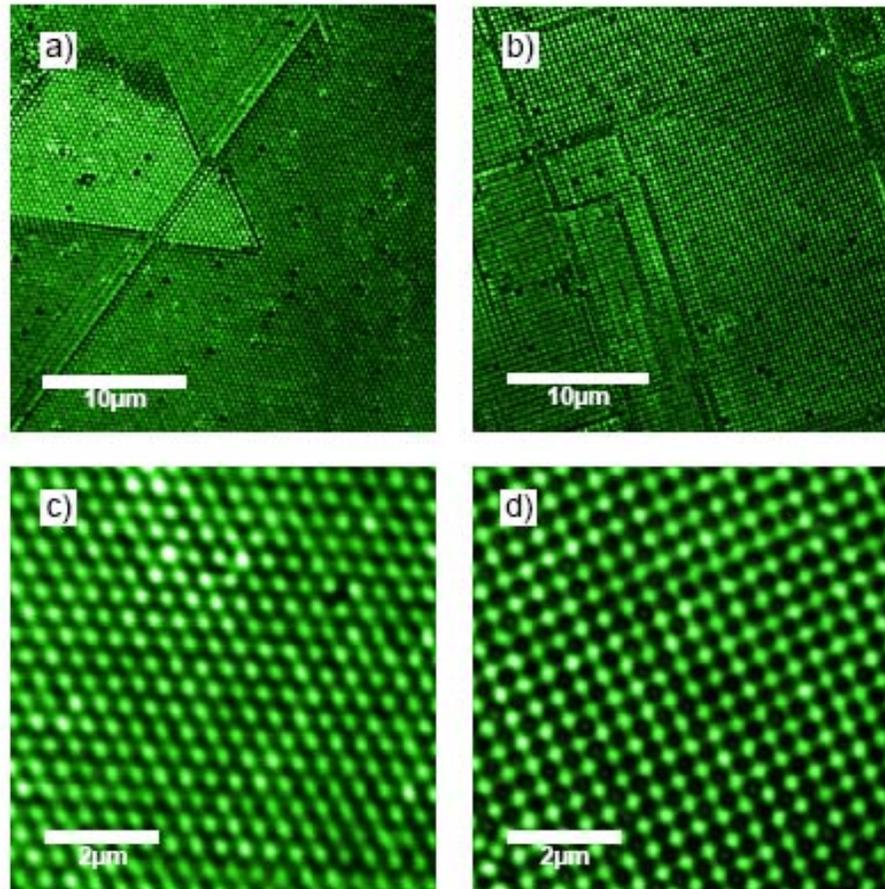
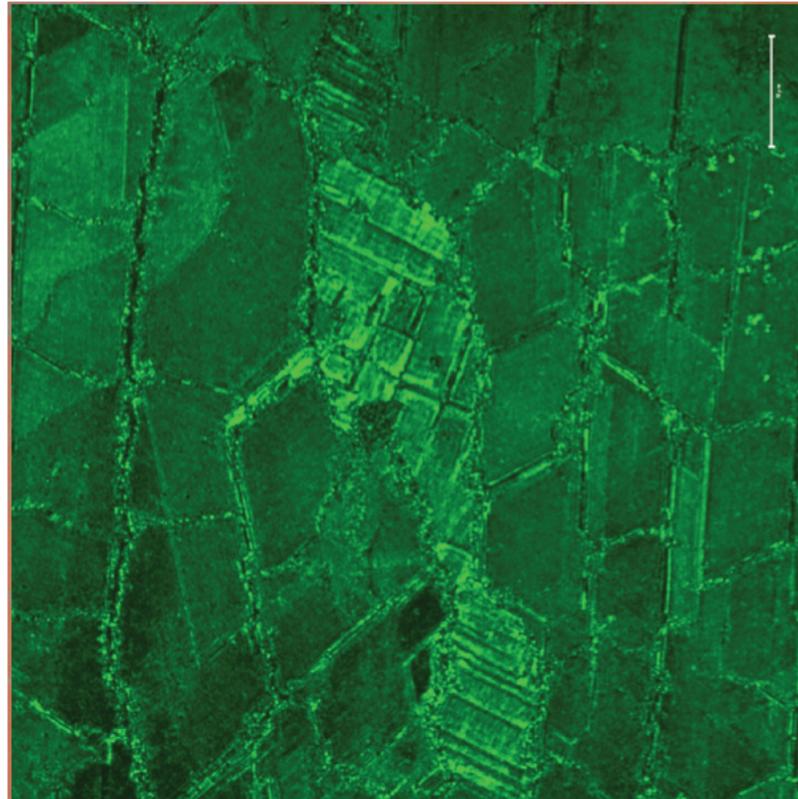
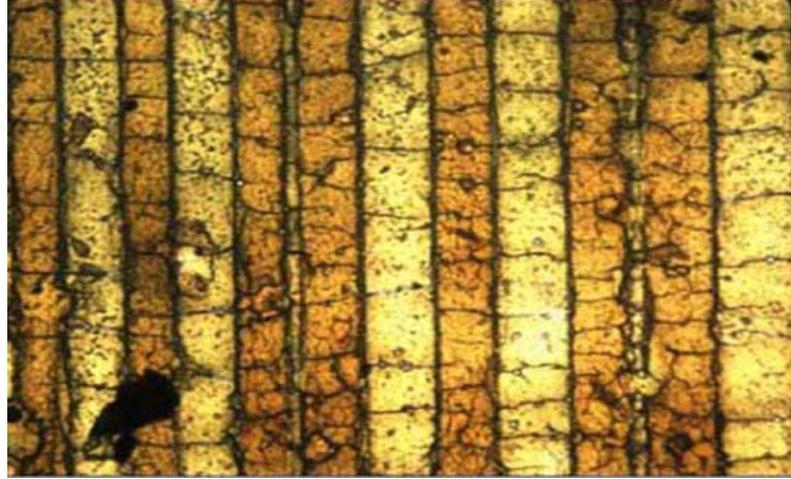


Abbildung 6.2: Aufnahmen eines photonischen Kristalls aus 450 nm Polystyrol-Kugeln mittels konfokaler Mikroskopie. Es zeigen sich Domänen mit hexagonaler (a) und quadratischer (b) Struktur. In (c) und (d) sind jeweils vergrößerte Ausschnitte solcher Bereiche dargestellt.

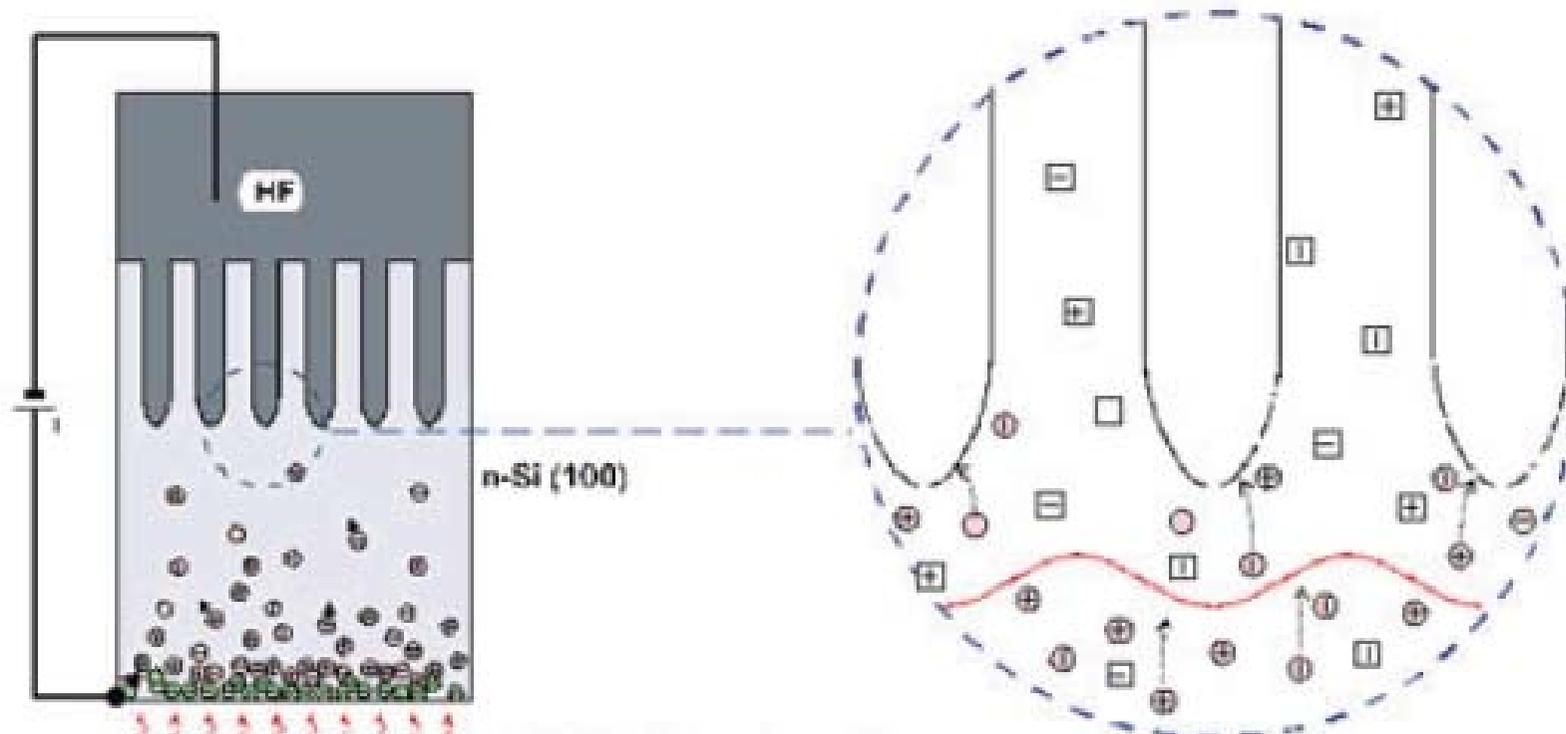
300 nm plastic beads

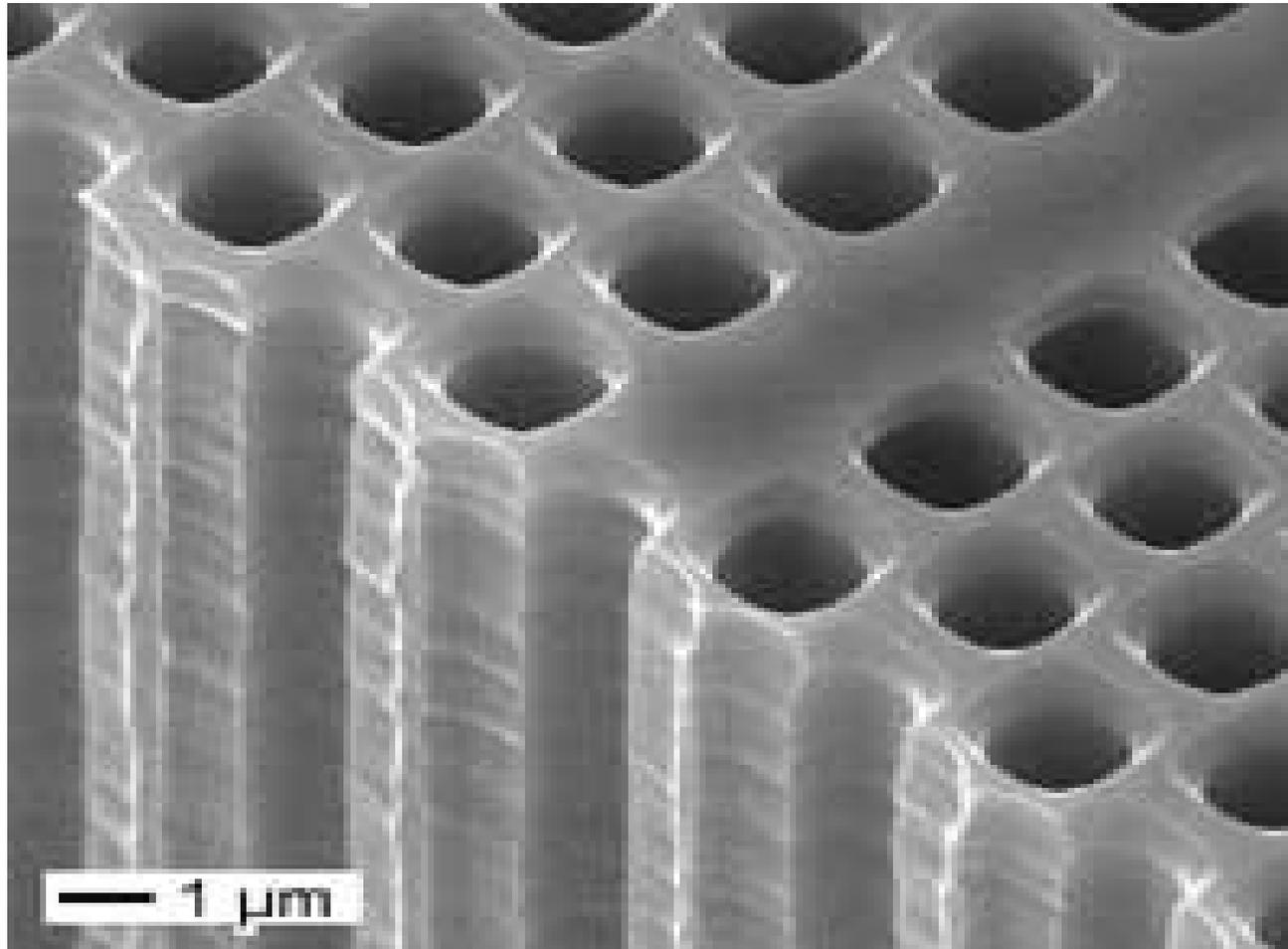


M. Barth, POM Lab

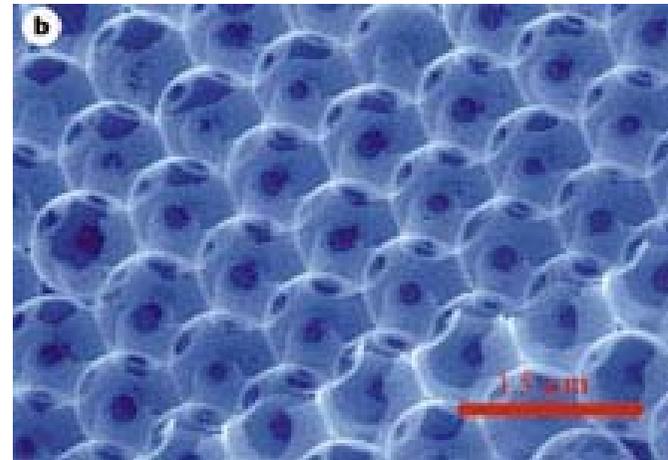


Influence of the space charge region (SCR)

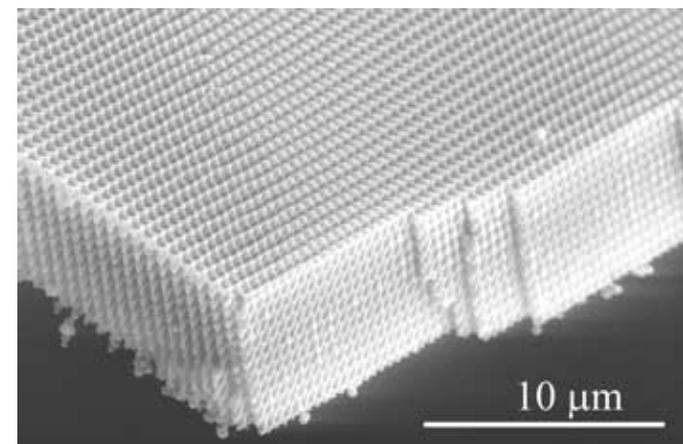




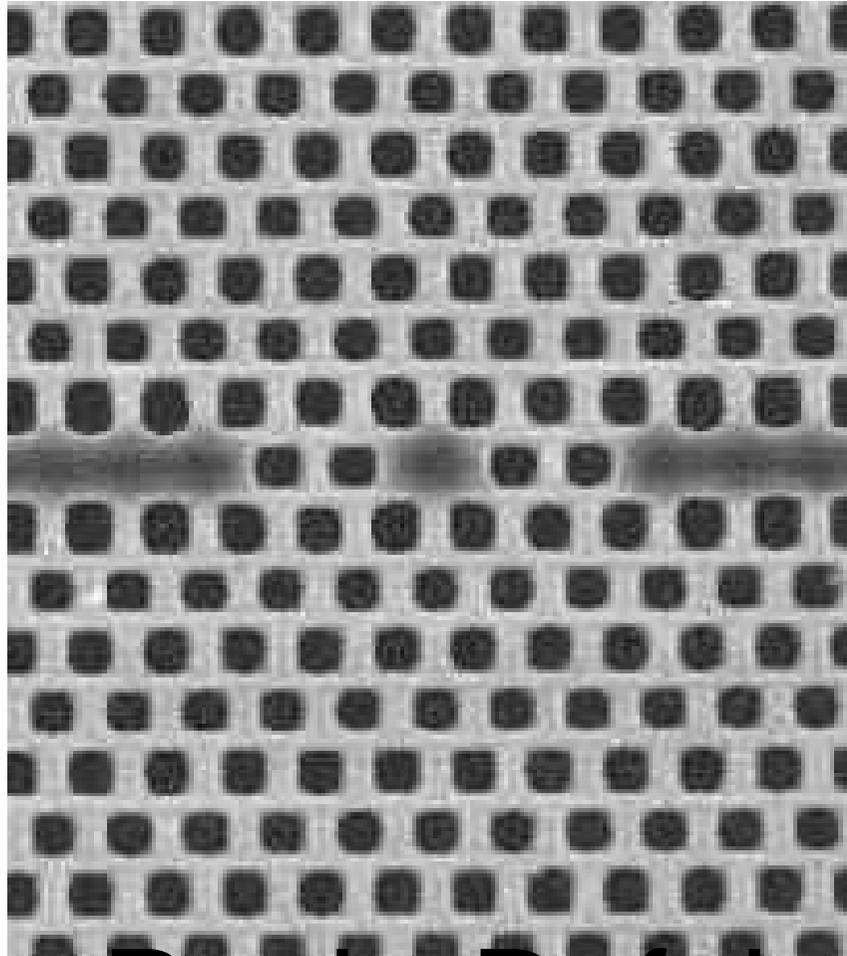
- Opal
- Inverted Opal



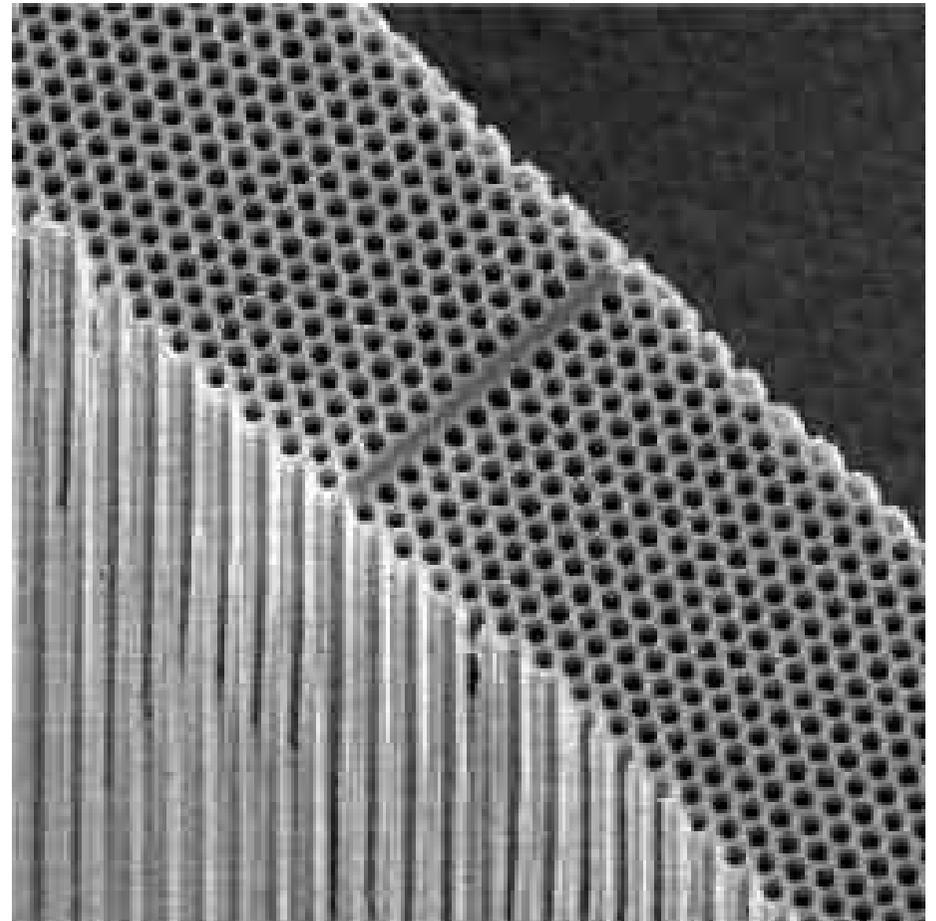
- Holografische Herstellung



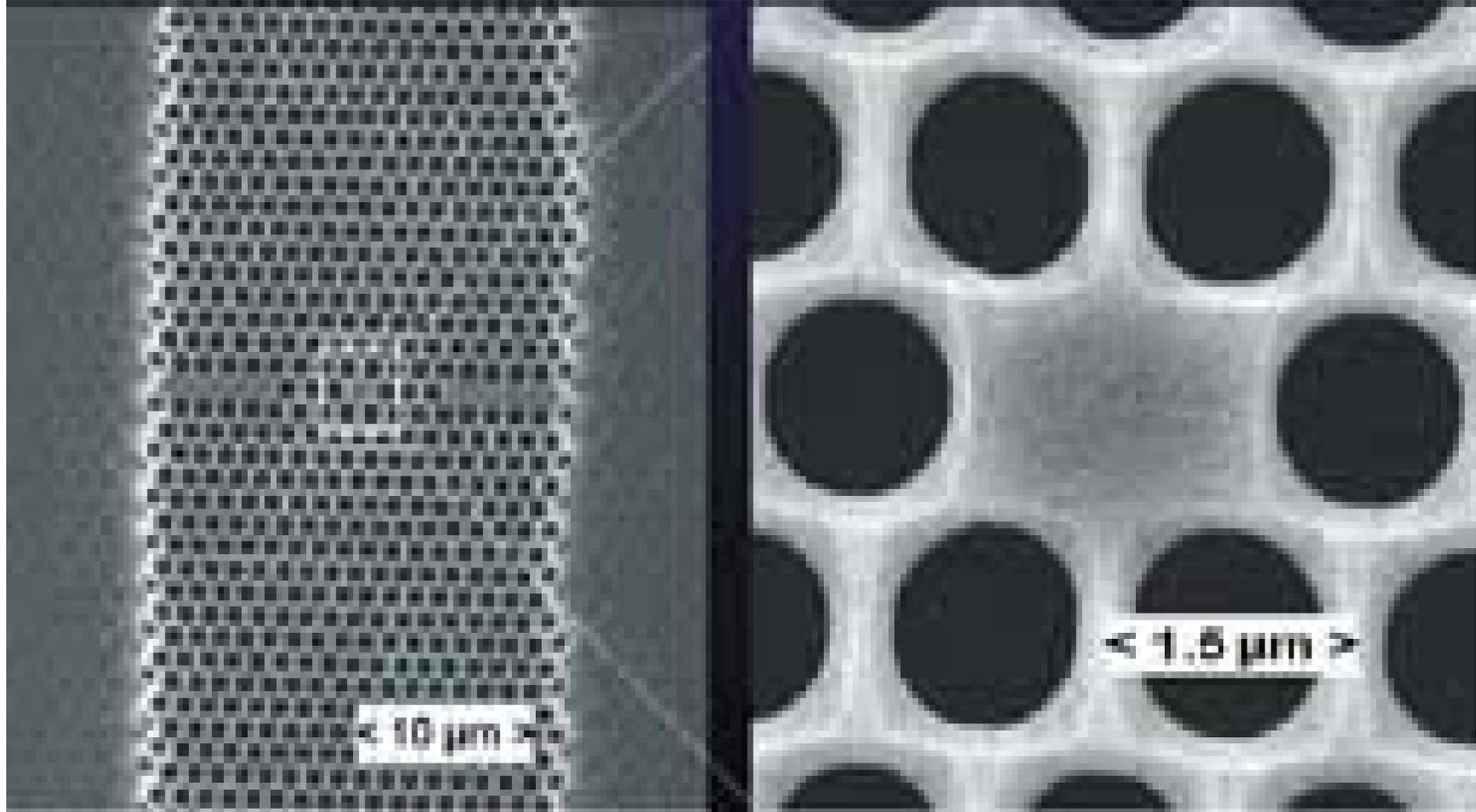
Makroporöses Silizium



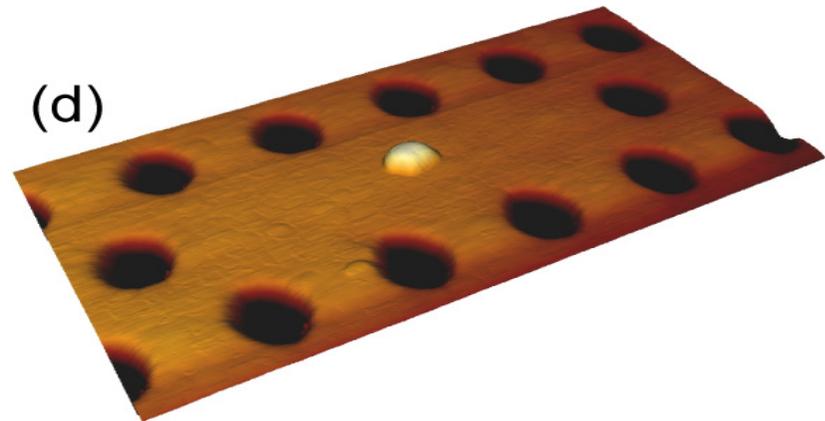
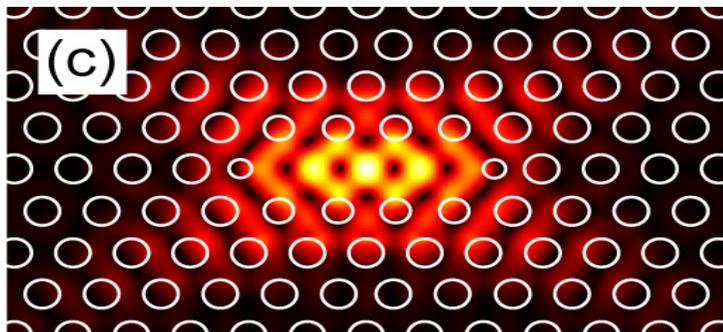
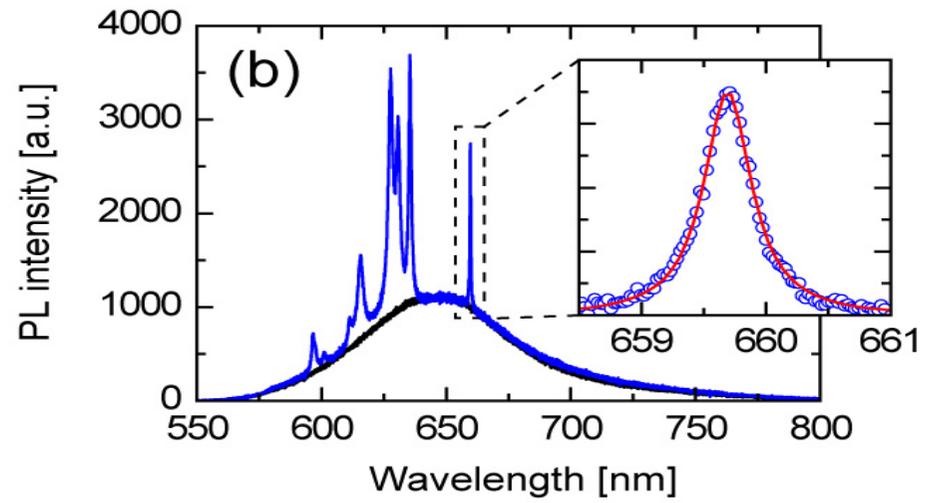
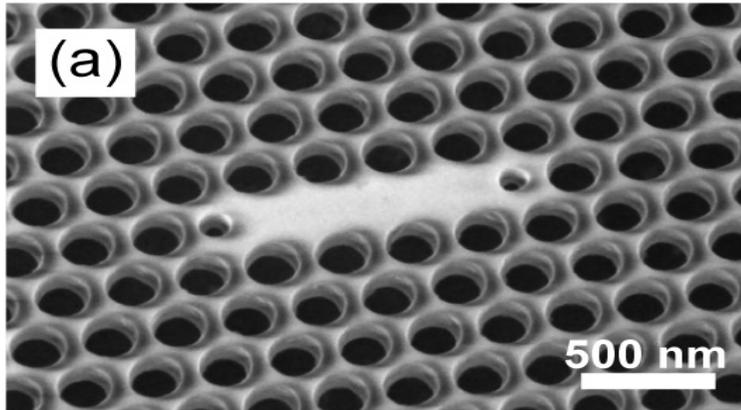
Punkt-Defekt

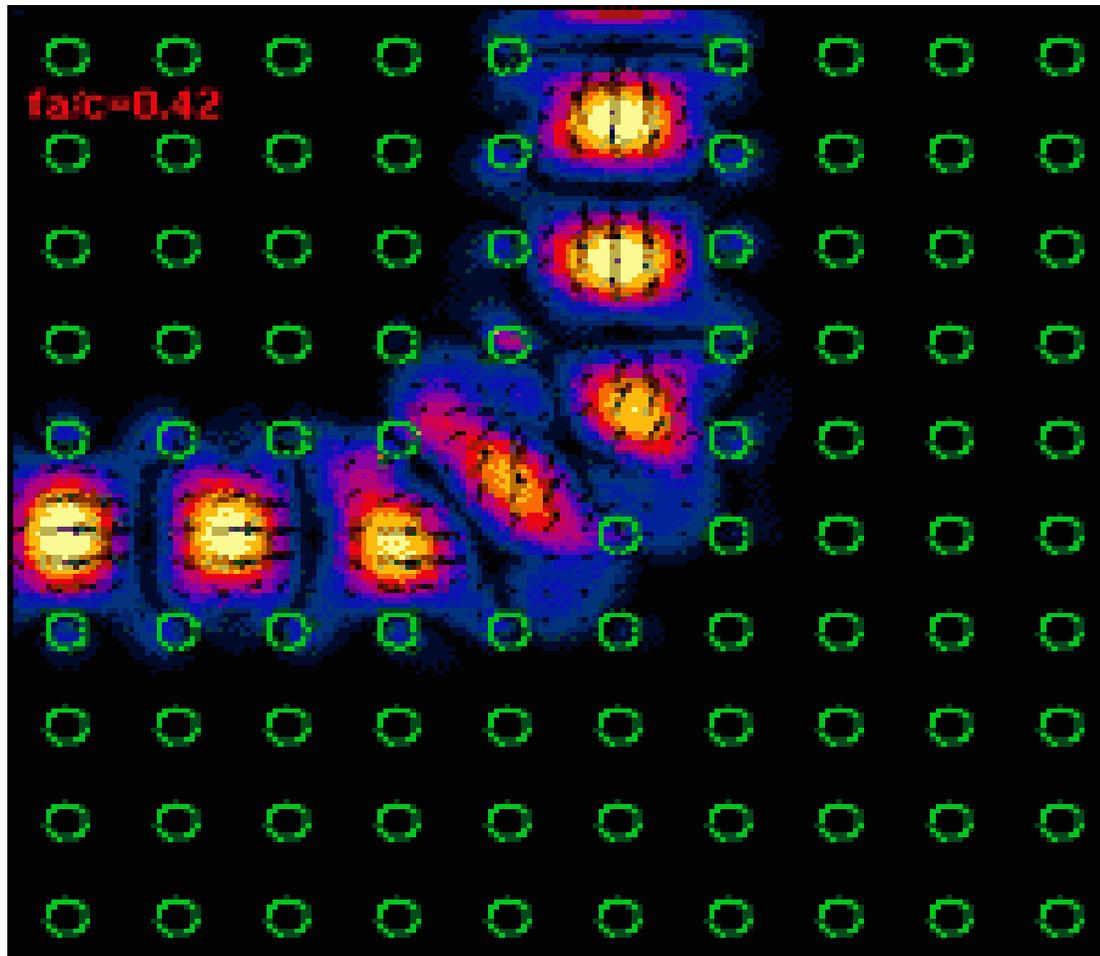


Linien-Defekt

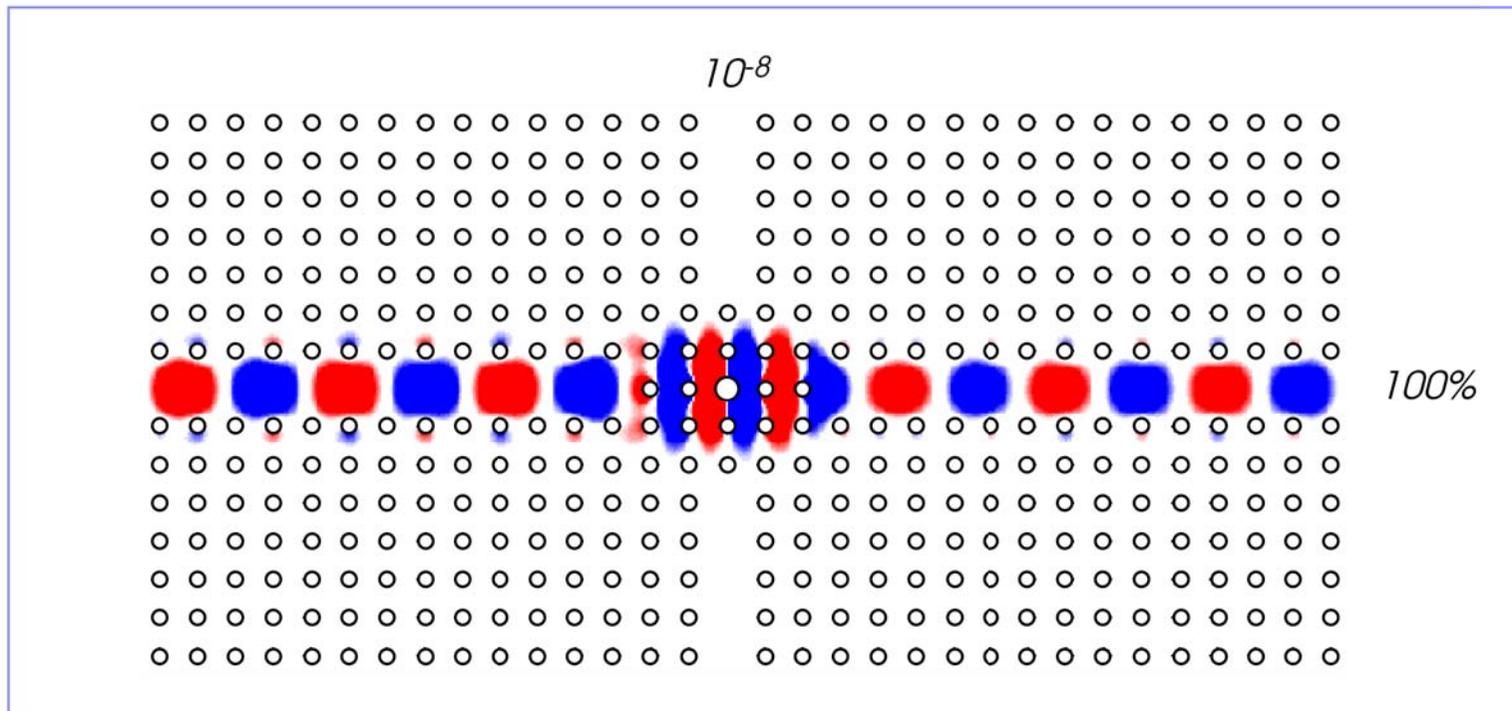
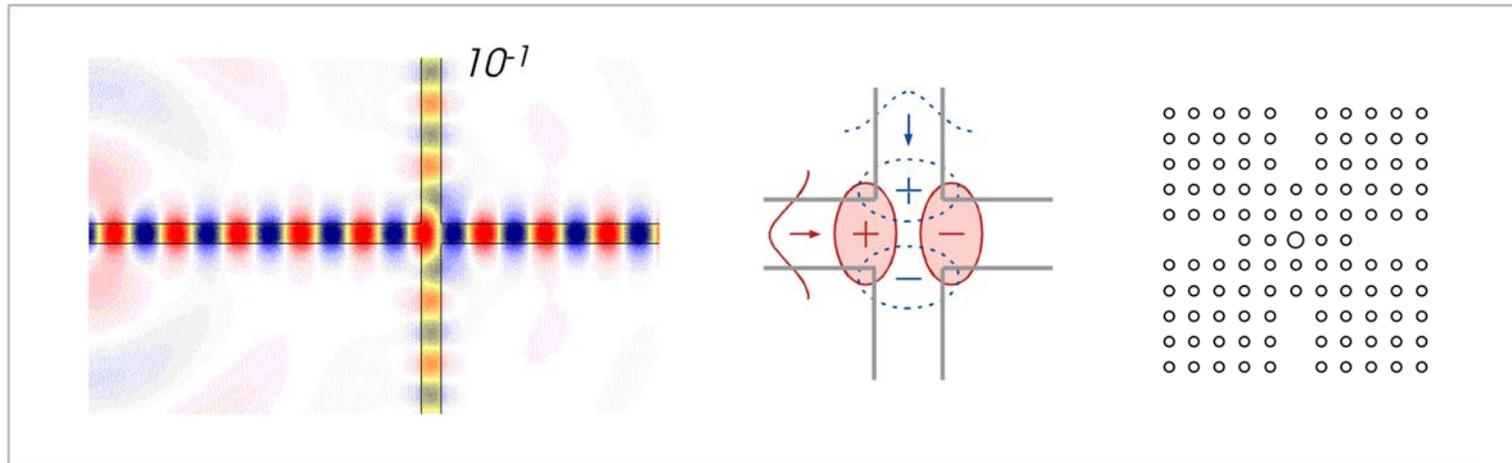


Cavities



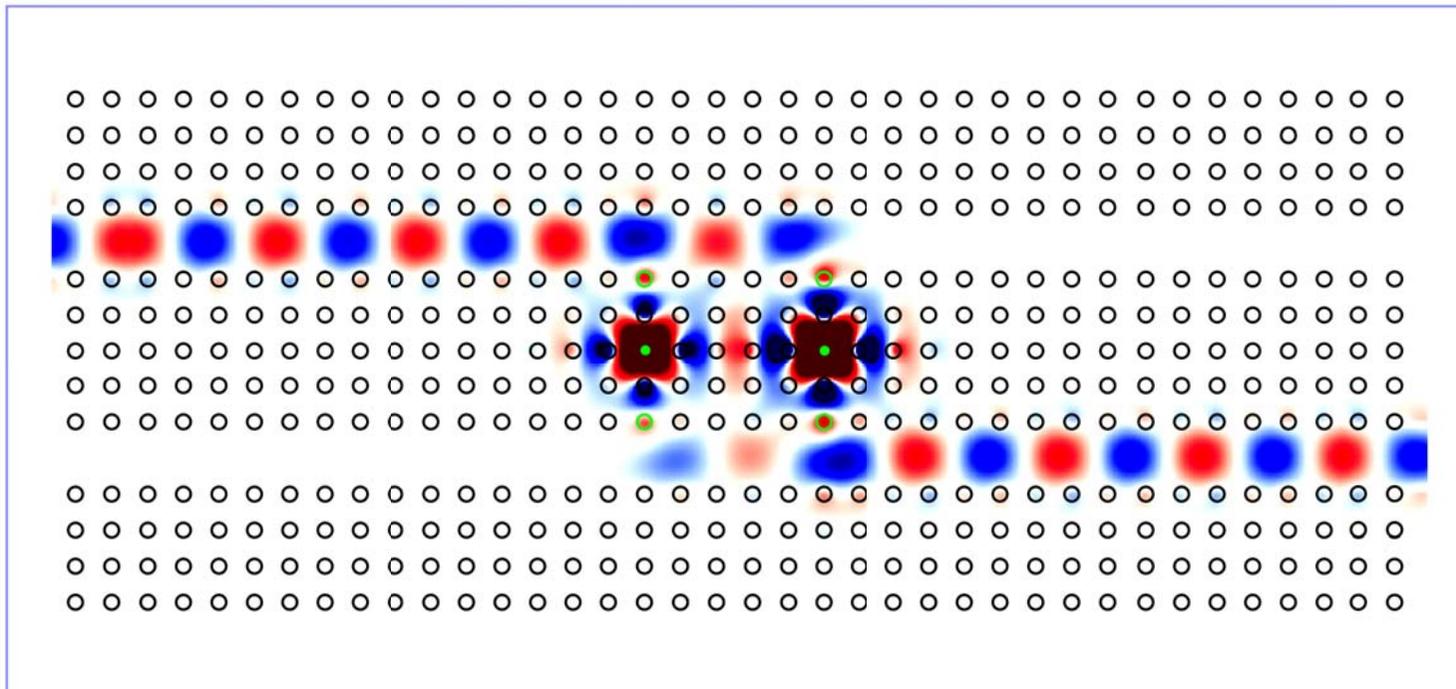
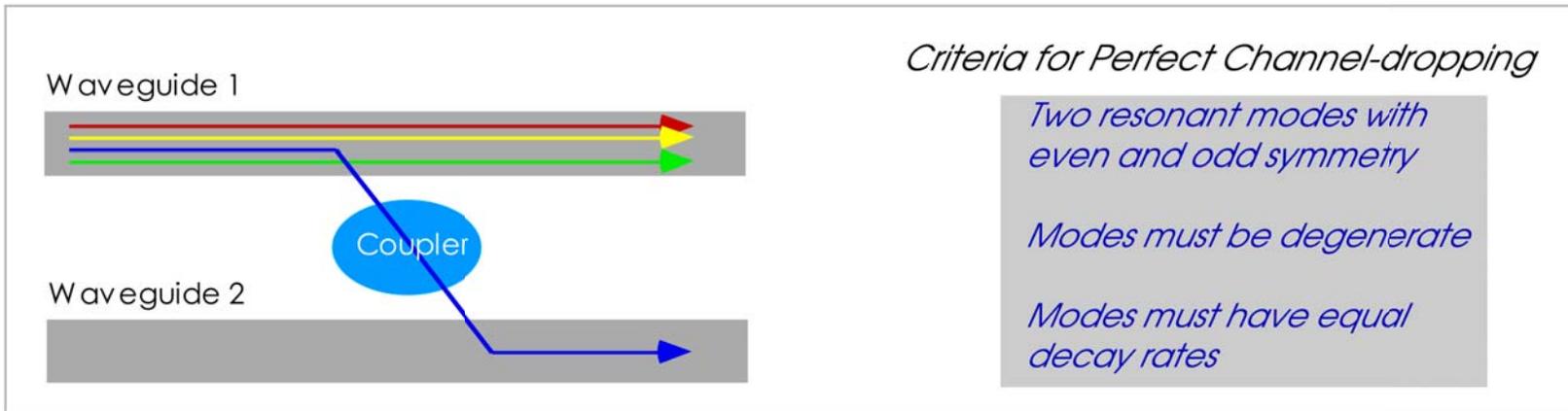


Waveguide Crossings



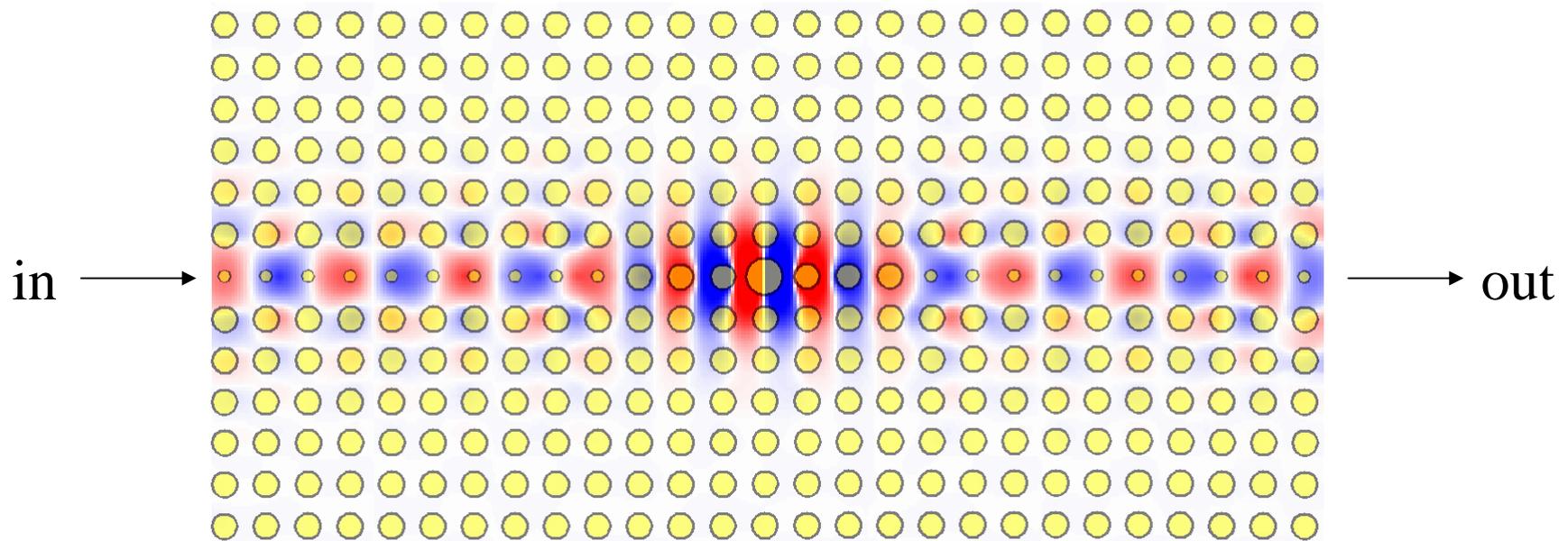
[S. G. Johnson *et al.*, *Opt. Lett.* **23**, 1855 (1998)]

Channel-Drop Filters



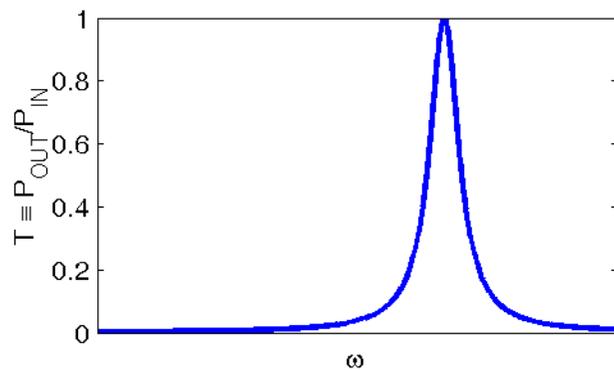
[S. Fan *et al.*, *Phys. Rev. Lett.* **80**, 960 (1998)]

A ~~Linear~~ *Nonlinear* Filter



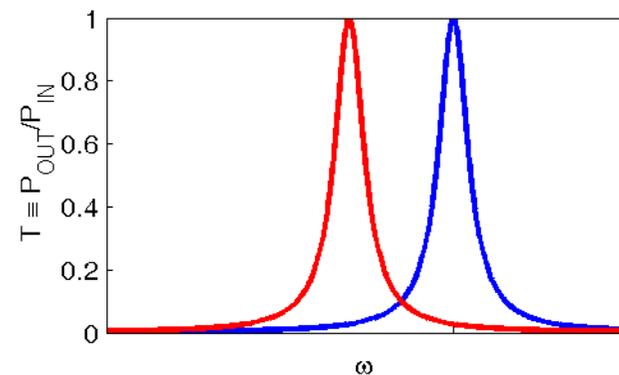
Linear response:

Lorentzian Transmisson

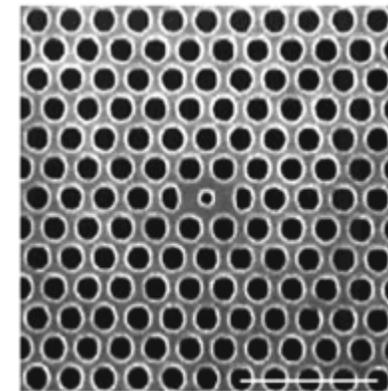
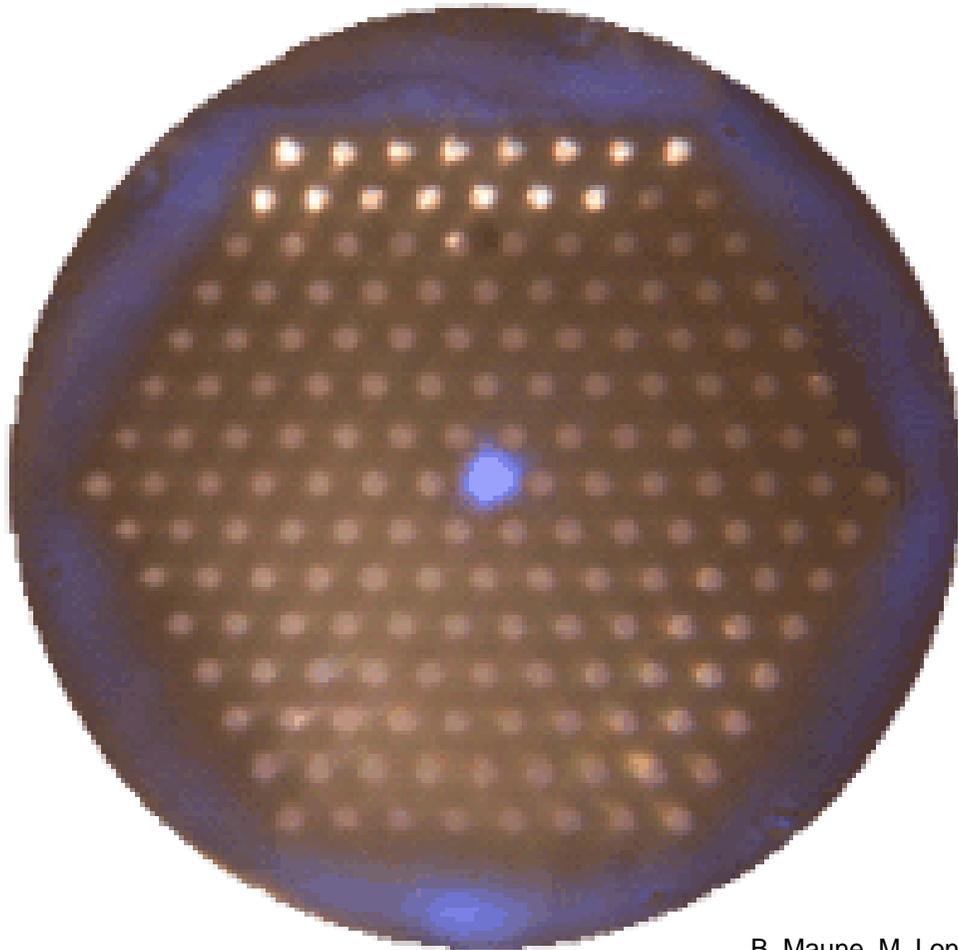


+ nonlinear
index shift

shifted peak



Liquid-crystal electric tuning of a photonic crystal laser



B. Maune, M. Loncar, J. Witzens, M. Hochberg, T. Baehr-Jones, D. Psaltis, A. Scherer

Applied Physics Letters **85**, 360-362 (2004)