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Fabrication of Photonic Crystals with high refractive index

Yongan Xu
University of Pennsylvania

Jun Hyuk Moon
University of Pennsylvania

Shu Yang
University of Pennsylvania, shuyang@seas.upenn.edu

Yaping Dan
University of Pennsylvania

Alan T. Johnson
University of Pennsylvania, cjohnson@physics.upenn.edu

See next page for additional authors

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Fabrication of Photonic Crystals with high refractive index

Abstract
• Complete photonic bandgap • High contrast of refractive index (RI) • Polymer material with a low RI • Inorganic material with a higher RI, such as silicon, titania. • Fabrication of diamond-like PCs by MBIL, • Fabrication of high RI inorganic PCs via double templating, • Core-shell morphology of replica • Pinch-off problem • Development of combined level-surface to address pinch-off problem • Electrodeposition of titania 3D structure • Electrophoretic deposition of surface charged nanoparticles

Comments
Poster presented at *The Search for a Sustainable Energy Future: Challenges for Basic Research*, A Mini-Symposium sponsored by the Energy Working Group at Penn, March 9, 2007.

Author(s)
Yongan Xu, Jun Hyuk Moon, Shu Yang, Yaping Dan, Alan T. Johnson, Joseph W. Perry, Ali Adibi, Peter Hotchkiss, and Seth Marder

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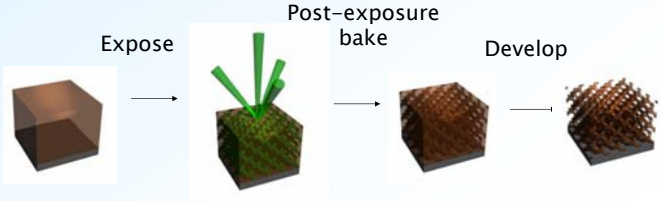
Yongan Xu, Jun Hyuk Moon and Shu Yang, Department of Materials Science and Engineering, University of Pennsylvania
Yaping Dan, Alan. T. Johnson, Department of Physics and Astronomy, University of Pennsylvania
Joseph W. Perry, and Ali Adibi, School of Chemistry and Biochemistry and School of Electrical and Computer Engineering, Georgia Institute of Technology
Peter Hotchkiss, Seth Marder, Department of Chemistry and Biochemistry, Georgia Institute of Technology

Introduction

- Complete photonic bandgap
  - High contrast of refractive index (RI)
  - Polymer material with a low RI
  - Inorganic material with a higher RI, such as silicon, titania.
- Fabrication of diamond-like PCs by MBIL,
- Fabrication of high RI inorganic PCs via double templating,
  - Core-shell morphology of replica
  - Pinch-off problem
  - Development of combined level-surface to address pinch-off problem
- Electrodeposition of titania 3D structure
- Electrophoretic deposition of surface charged nanoparticles

Holographic lithography



Diamond like FCC structure

Umbrella-like beam assembly

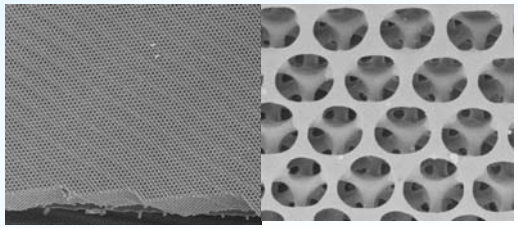
$\boldsymbol{k}_0=\pi/a[333]$	Circular polarization
$\boldsymbol{k}_1=\pi/a[511]$	$\boldsymbol{e}_1=[0.680\ 0.680\ -0.272]$
$\boldsymbol{k}_2=\pi/a[151]$	$\boldsymbol{e}_2=[0.680\ -0.272\ 0.680]$
$\boldsymbol{k}_3=\pi/a[115]$	$\boldsymbol{e}_3=[-0.272\ 0.680\ 0.680]$

Superposed interference terms:
$I \sim \sin(x+y-z)+\sin(x-y+z)+\sin(-x+y+z)$

Materials

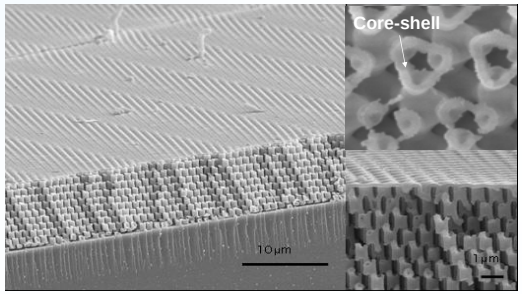
- SU-8 photoresist
- Photoacid generator: Irgacure 261

3D Polymer templates



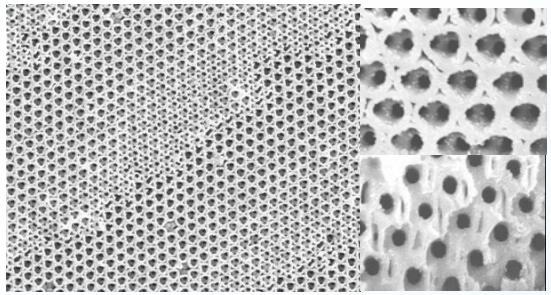
$SiCl_4$, CVD
Sintered at 500°C

Inversed silica replica



SiH_4, LPCVD, 550°C,
Remove silica

Silicon photonic crystals



Core-shell morphology in replica due to incomplete filling

Pinch-off problem in backfilling

a: The pores into the internal voids are closed during the deposition before filling the voids completely

Simulation of the conformal coating layer on template using combined level surfaces

Simple cubic

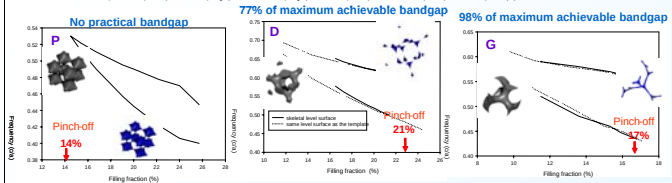
$G_P(x,y,z)=\sin(x)+\sin(y)+\sin(z)-c(\sin(x)\sin(y)+\sin(y)\sin(z)+\sin(z)\sin(x))$

- Diamond D

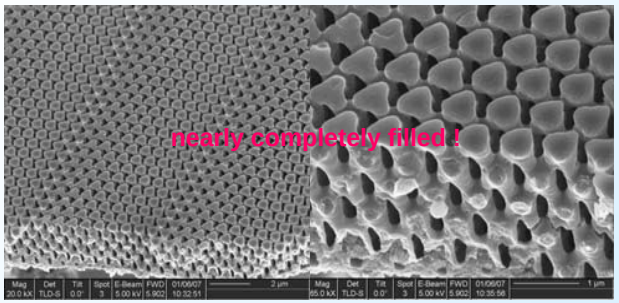
$G_D=\sin(x+y+z)+\sin(-x+y+z)+\sin(x-y+z)+\sin(x+y-z)-c(\cos(2x)+\cos(2y)+\cos(2z))$

- Gyroid G

$G_G=\sin(x+y)+\sin(x-y)+\sin(y+z)+\sin(y-z)+\sin(z+x)+\sin(z-x)-c(\cos(2x)\cos(2y)+\cos(2y)\cos(2z)+\cos(2z)\cos(2x))$



Diamond-like titania by electrodeposition



Infiltration of nanoparticles by electrophoretic Deposition