ARRADIANCE *Sneak Preview*

Sequential infiltration of two-photon polymerized 3D photonic crystals for mid-IR spectroscopic applications

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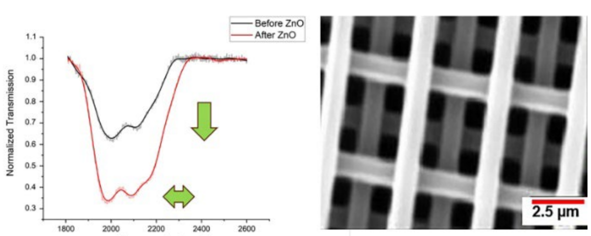
Photonic crystals, also known as PhCs, are spatially organized structures with optical lattice parameters equivalent to the wavelength of light. Ever since their discovery, PhCs have found applications in the telecommunications industry including mid-IR spectroscopic applications, electronic gates and polarizing filters for optical computing and ICs, and in stress force sensing. PhCs also enable device miniaturization (including in microfluidics), biosensing, and chemical sensing.

The unique geometric properties and refractive index of the PhCs enable either permitting or restricting the propagation of electromagnetic waves within a specific frequency range. The restricted range of frequencies is called the photonic bandgap (PBG), and its presence allows the structure to slow and mold the light. When applied to sensors in gas spectrometry applications, slower light increases the interaction time between light and the target gas, which in turn enhances sensitivity. The PBG is highly dependent on the refractive index (RI) contrast between the PhC and background material, usually air. When poor RI contrast conditions exist, the application of PhCs is limited.

In this new report, scientists from the University of Illinois in Chicago and Argonne National Lab improved the poor RI of advanced three-dimensional (3D) PhCs by coating the internal optical surfaces with ALD-deposited high refractive index ZnO, enabling future improvements to sensitivity, accuracy, and detection limit of PhC-based sensors. Complete PBG region of forbidden light propagation frequencies in the band structure regardless of polarization make three-dimensional (3D) PhCs preferred over 2D and 1D PhCs for spectroscopic applications but prove more difficult to manufacture.

Uniquely designed to support sequential infiltration synthesis (SIS) processes, Arradiance's GEMStar™ ALD system enables lower reaction temperatures, higher reaction pressures, and longer reaction times than a conventional ALD. This enables precursor gases to infiltrate and react deep within the 3D polymer matrix, ensuring no degradation, material loss or degassing from PhC.



Anuj Singhal, Ralu Divan, Anandvinod Dalmiya, Liliana Stan, Arian Ghiacy, Patrick T. Lynch, and Igor Paprotny, J. Vac. Sci. Technol. A 42, 012404 (2024); doi: 10.1116/6.0003271

The FTIR transmission spectra and SEM/EDX confirms the presence of ZnO in 3D polymer and wider PBG (blocking light transmission); and the feasibility of sequential infiltration of 3D PhCs for mid-IR spectroscopic applications.

Arradiance technology enables ALD films in optical, solar cell, sensor, and electronic applications. For more information on GEMStar™ Technology, ALD systems or Foundry services, please contact Arradiance.