LARGE AREA 3D PHOTONIC CRYSTALS WITH EMBEDDED WAVEGUIDES

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ABSTRACT

Three-dimensional photonic crystals are attractive for very compact waveguide devices. A novel interferometric lithography technique for fabricating three-dimensional photonic crystals is presented, which allows for independent dimensional control of each axis of the crystal. Previous interferometric approaches using 3, 4, 5 or more beams have inherent constraints between the lattice constants and the exposure wavelength. It is possible with this new technique to control each individual crystal lattice constant independent of exposure wavelength. Both mathematical models and experimentally realized three-dimensional photonic crystals, over one square centimeter in size and up 12 microns thick using this interferometric lithography technique are presented.

Simulations of three-dimensional photonic crystals are presented, modeling both the band-gap of the photonic crystal and the transmission and reflection characteristics of the crystals. Transmission and reflection measurements of fabricated photonic crystals are compared to the models.

Photonic crystals with integrated waveguides are of particular significance. A novel new approach to fabricating waveguides embedded in three-dimensional photonic crystal is also presented. This approach uses multiple exposure wavelengths, with one longer wavelength propagating throughout the photoresist for the photonic crystal fabrication and other shorter highly absorptive wavelength for the waveguide fabrication. This new approach to waveguide fabrication leads itself to easy mass manufacturing using standard semiconductor lithography equipment; significant because all previously reported techniques do not scale well to volume manufacturing.

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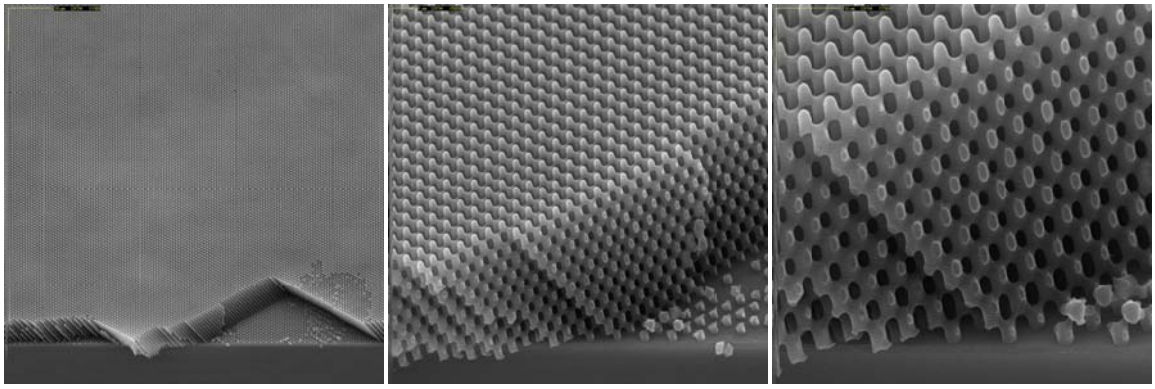
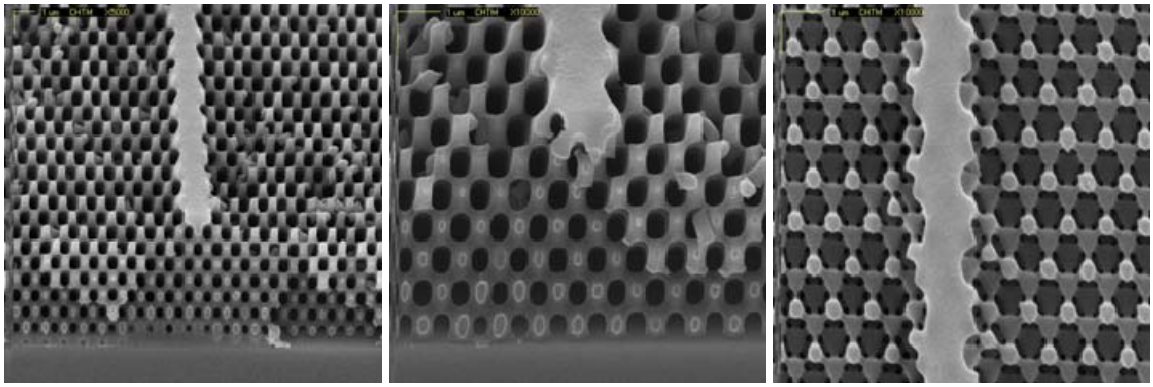


1,000 X Magnification 5,000 X Magnification 10,000 X Magnification

Cross-section SEM images of a 3D photonic crystal, with a periodic size of x = y = 640 nm, z = 1375 nm, made using 3-exposure interferometric lithography at 355 nm in 12 μm of photoresist.



5,000 X Magnification 10,000 X Magnification 10,000 X Magnification Top-Down

Cross-section SEM images of 355 nm 3-exposure 3D photonic crystal, with a 244 nm exposed surface waveguides in 6 μm of negative photoresist.