

Near-field characterization of three-dimensional woodpile photonic crystals fabricated with two-photon polymerization

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Abstract: A scanning near-field optical microscope (SNOM) is used to observe high-resolution optical intensity distributions of three-dimensional woodpile photonic crystals fabricated with two-photon-polymerization technique. Near-field signals reveal different mode distributions inside and outside the partial bandgap.

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1. Introduction

Photonic crystals (PCs) as a promising candidate for integrated optical device have been intensively studied. The fabrication materials of such crystals vary from high index semiconductors to comparatively low index polymers. Recently the direct experimental evidence of superprism effect in polymer PCs demonstrates the great potential of low-index three-dimensional (3D) crystals to directly serve as functional micro-optical devices in the near-infrared (NIR) wavelength regime [1]. The characterization of such novel low-index 3D photonic crystal structures becomes important and urgent in order to understand the operation of the device and improve the performance. As a powerful tool capable of detecting near-field signals, SNOM has recently been applied to study the detailed local intensity distributions in photonic crystal structures because it provides significant additional information about the optical properties of the devices, which was previously inaccessible [2].

2. Experiment

In this paper, a SNOM is utilized to observe the optical intensity distributions from 3D woodpile photonic crystals fabricated using the two-photon polymerization (2PP) technique with an organic/inorganic hybrid polymer (Ormocers). The fabricated crystal, shown in Fig. 1(a) and (b), has a lattice spacing of 700 nm, which enables a partial photonic band gap in the r - x direction at NIR (1.19 -1.23 μm) region. A SNOM operating in the collection mode is placed right above the crystals to collect the diffracted light in the r - x direction. The topological and the optical signals of the PCs are obtained simultaneously with sub-wavelength resolution, as shown in Fig. 1(c) and (d). Illumination light with a wavelength spanning from below to above the fundamental partial band gap is utilized. The optical signals from the SNOM, particularly the near-field part, reveal the variations of the mode confinement and light propagation in the PCs at different wavelength.

3. References

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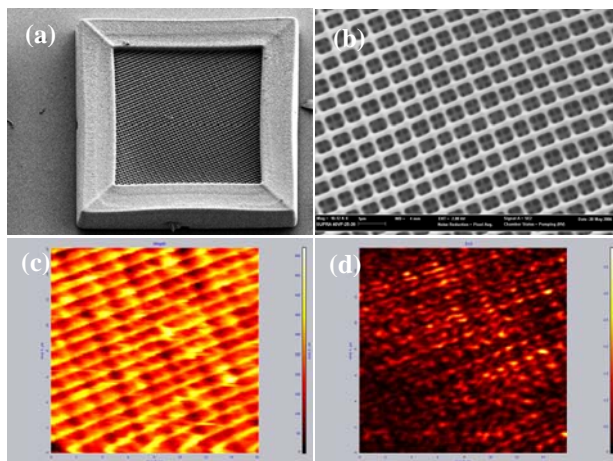


Fig. 1 (a) SEM image of a 3D woodpile photonic crystal fabricated with 2PP. (b) Details of the woodpile. (c) A topological image of the structure taken by SNOM. (d) Intensity distribution of the structure at an illumination wavelength of 632.8 nm taken simultaneously with (c).