

Near-field Scanning Optical Microscopy of Photonic Crystal Laser

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Near-field scanning optical microscopy (NSOM) is a powerful alternative method to observe the optical intensity distributions in fabricated nanophotonic structures. Several groups have obtained NSOM images of photonic crystal (PC) [1-2]. Quite recently, we have reported the optical mode images obtained by NSOM on compact PC cavities based on fractional edge dislocations [3]. Here we report higher spatially resolved near-field images of modes from the PC lasers.

The metal-coated fiber tip with small aperture size (150nm) was used to distinguish between localized cavity modes and radiating modes, and to obtain more precise mode profiles. A He-Ne laser (633nm) and a diode laser (780nm) were used as cw excitation laser sources. Photoluminescence (PL) signals were filtered out to suppress pumping laser signals, and were detected with a high-sensitivity (fW) InGaAs photo-detector.

The PC nanocavities fabricated in active InGaAsP material used in this work are very similar to those used to realize low-threshold lasers described in our previous publication [4-6]. We confirmed that the PC nanocavities have only high- Q localized modes in the QW emission range by micro-photoluminescence. We measured Q factors of $Q=2,000$ and realized laser action with low threshold of 220 μ W in the design with $r'/a=0.18$ (r' : defect air hole size, a : periodicity of the lattice). On the other hand, Q factors, for the designs of no central defect hole ($r'/a=0$), are limited to about 1000, according to our theoretical predictions.

Obtained NSOM-PL images of localized defect modes in PC nanocavities with $r'/a=0.18$ was shown in Fig. 1. The bright spot was found in this images located at the center of the PC structures, matching the positions of the defect cavities. The small spots indicate that, indeed, the modes have small mode volumes as expected from our modeling. The size of the bright spot, probed from the nanocavity with $r'/a=0$, was roughly four by three lattice spacing [3]. On the other hand, the spot area in nanocavity with $r'/a=0.18$ was as small as center hole size and exhibited the high spatially resolved optical mode profile around the center hole (Fig. 1). The NSOM images were very similar with mode profiles obtained by our three-dimensional finite difference time domain (FDTD) modeling [4-6].

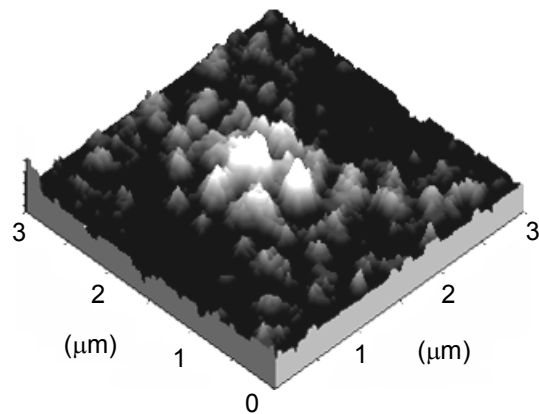


Fig. 1 NSOM Image of photonic crystal laser

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