

## Local lattice imperfections of planar photonic crystals

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A high precision metrological atomic force microscope (AFM) is used to measure hole positions in a planar photonic crystal. The triangular photonic crystal structure ( $a=270\text{nm}$ ,  $r/a=0.33$ , hole depth= $150\text{nm}$ ) was fabricated in GaAs using a state-of-the-art JEOL-JBX9300FS electron-beam facility and reactive ion etching.

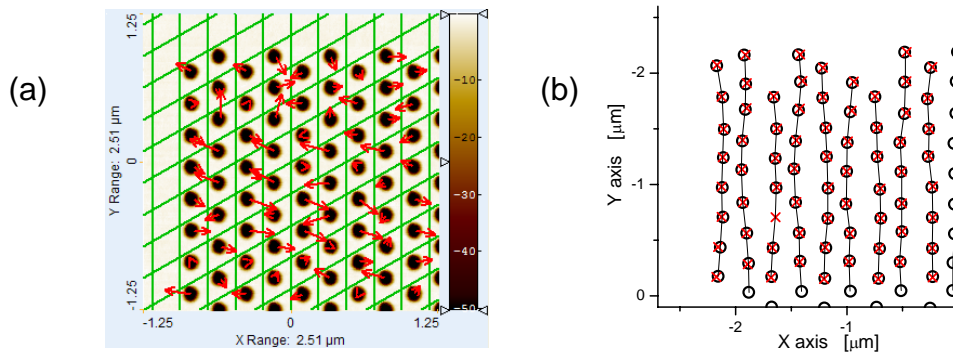


Fig. 1: (a) Typical AFM image of the photonic crystal lattice. The measured global lattice is shown by lines while arrows illustrate individual hole position deviations. (b) Hole pattern with position errors amplified by a factor of 10 for clarity. Two measurement sets (one with a  $2.5\mu\text{m}$  field-of-view (crosses), another with a  $5.0\mu\text{m}$  field-of-view (circles)) are superimposed to illustrate the measurement reproducibility.

After correction for image distortions the center-of-mass positions of individual holes and the global lattice parameters are determined (fig. 1a). Fig. 1b shows measured hole positions where deviations from the global lattice have been amplified by a factor of 10 for clarity. The obtained resolution for the hole position map is at least one order of magnitude better than what is obtainable using conventional scanning electron microscopy and systematic lattice imperfections are clearly visible. The maximum hole position error is typically  $\sim 4\text{nm}$  for each highlighted plane.

The AFM measurements presented here represent, to the best of our knowledge, the most precise assessment of hole position errors to date. The observed positional deviations are comparable in size to the local changes in lattice constant required for ultra-high-Q double heterostructure nanocavities [1] and therefore represent a significant factor limiting the ability to fabricate such devices.

[1] Song et al., Nature Materials, **4**, 207-210 (2005).