Photonic Band Gap Microcavity Laser Embedded in a Strip Waveguide

Personnel

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A One-Dimensional (1-D) photonic crystal is fabricated within a strip waveguide to provide strong optical confinement with a small modal volume on the order of a half-cubic wavelength. The microcavity is formed by a defect in the one-dimensional periodic photonic crystal. Optical confinement is achieved in the lateral and vertical directions by high refractive index contrast. A high-efficiency, low-threshold, microcavity laser results with the light output coupling to the strip waveguide. The structure is designed to be integratable with other opto-electronic devices.

output will occur on the side of the defect with the least number of holes.

The device structure is grown using gas-source molecular beam epitaxy. The separation layer is initially grown as $Al_{0.9}Ga_{0.1}As$. The AlGaAs composition is graded at the AlGaAs/InGaP interface in order to stabilize the interface during the oxidation of the separation layer. The holes and strip waveguide are defined in PMMA by direct-write electron-beam lithography. The pattern is then reversed using a Ni liftoff process. The Ni mask

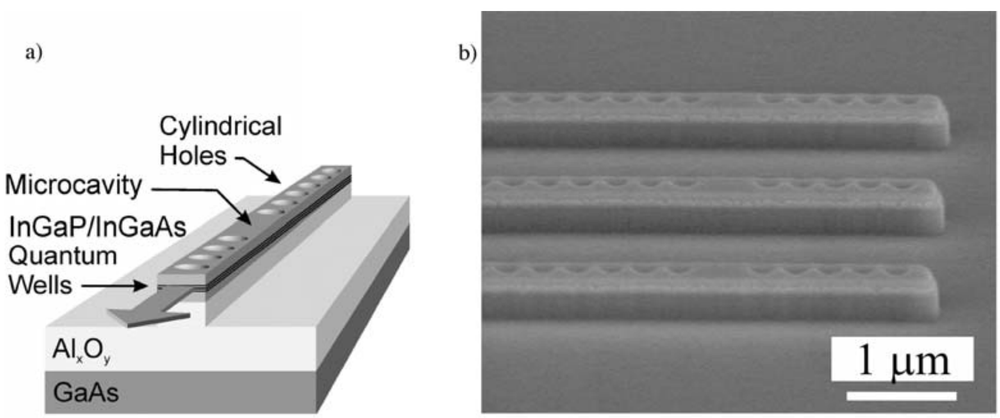

Figure 7. a) Schematic of 1-D PBG microcavity laser structure. The line of cylindrical holes forming the photonic crystal provides strong optical confinement along the waveguide. b) A SEM micrograph showing several completed microlaser structures.

The 1-D photonic band gap microcavity laser consists of an InGaP/InGaAs multiple quantum well active region emitting at λ=980 nm, on top of a low refractive index Al_xO_y spacer layer. Figure 7(a) shows a schematic of the structure. The 1-D photonic crystal consists of a periodic line of holes etched within the active region with a hole-to-hole spacing of 256 nm and a hole diameter of 113 nm. The strip waveguide width and depth are 320 nm and 112 nm, respectively. The length of the defect region is 426 nm. The active quantum well region lies on top of a low index spacer layer to separate the waveguide mode from the high index substrate. The laser

is used to transfer the microlaser pattern into the InGaP/InGaAs active region using reactive ion etching (RIE) in the NanoStructures Laboratory (NSL) with a $CH_4/H_2/O_2$ plasma with an 8:8:1 gas flow ratio. The $CH_4/H_2/O_2$ plasma etching slows at the $Al_{0.9}Ga_{0.1}As$ separation layer. Further RIE of the spacer layer is accomplished using a BCl_3 plasma. The Ni mask is then removed using a wet etchant. The final step in the fabrication is the wet thermal oxidation of the $Al_{0.9}Ga_{0.1}As$ separation layer. Figure 1(b) shows several completed microlaser structures. Optical testing of the microlasers is currently underway.