AlGaInAs/InP hexagonal resonator microlasers with a center hole

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Introduction:

In this poster, mode characteristics are investigated numerically and experimentally for AlGaInAs/InP hexagonal resonator microlasers with a center hole. Optimized structural lasers are proposed and fabricated in the experiment.

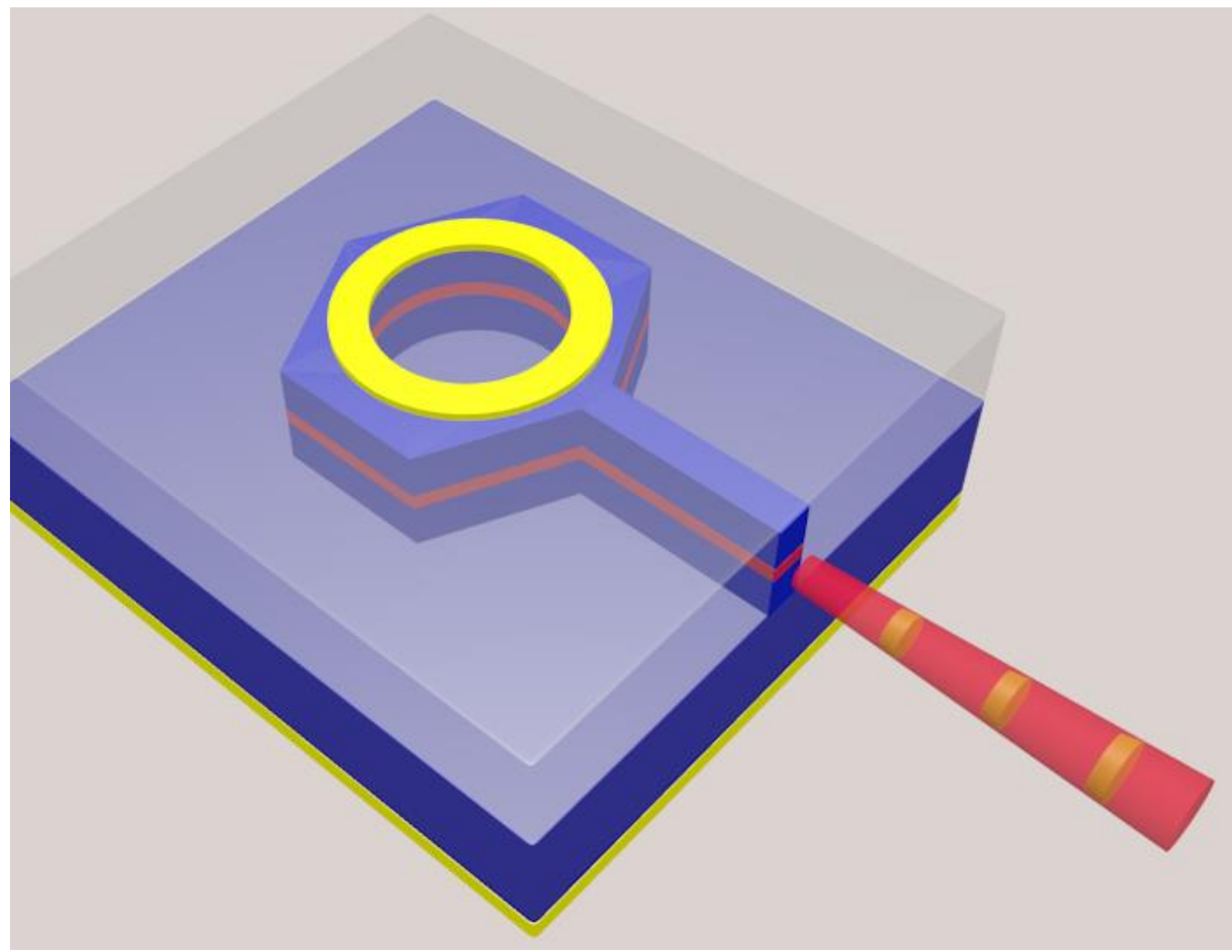


Fig. 1. Schematic diagram of hexagonal microcavity laser with a center hole.

2D-FEM simulation:

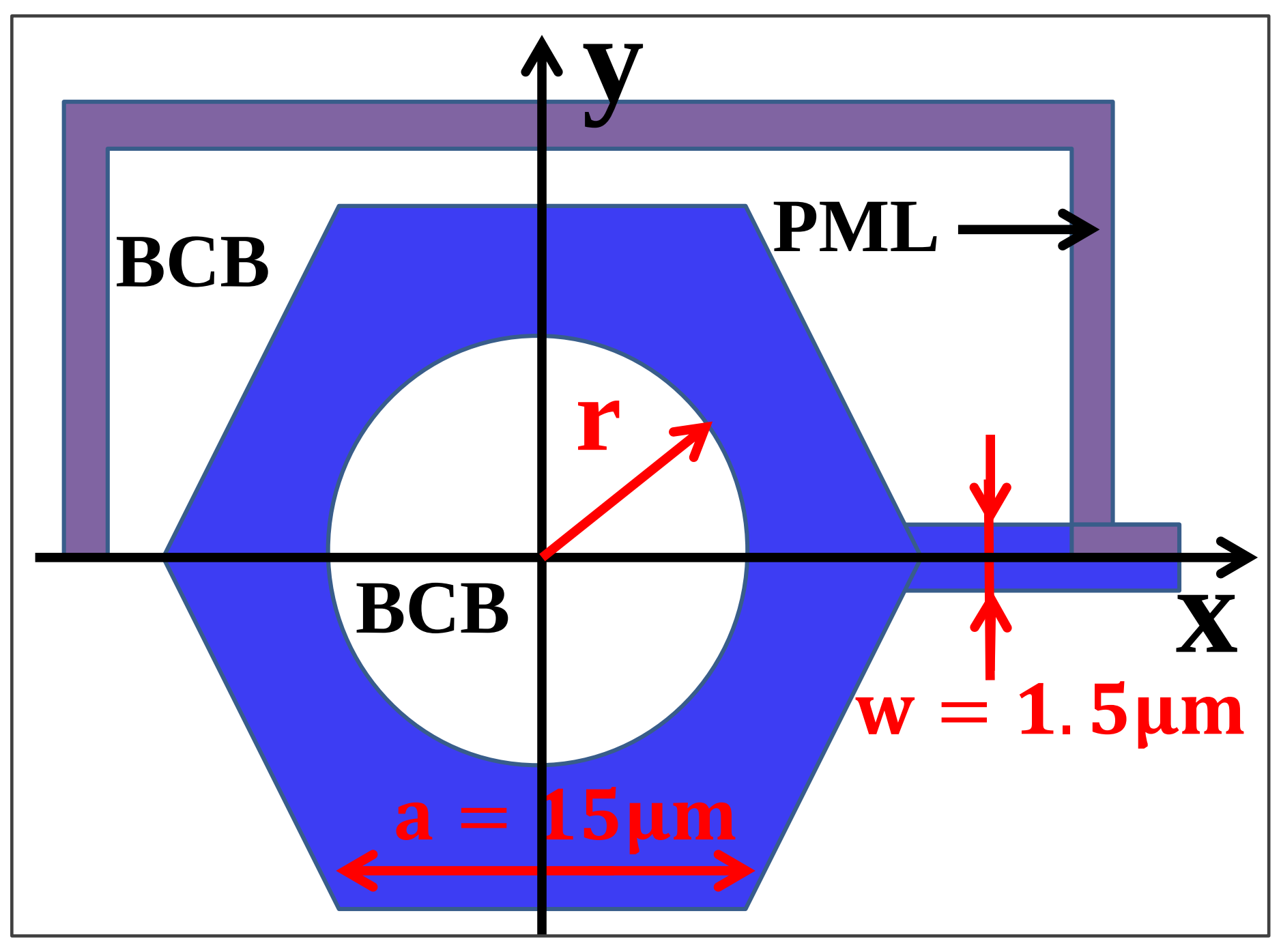


Fig. 2. Schematic diagram of 2D hexagonal resonator with a center hole and an output waveguide at a vertex. The radius of the center hole changes from r = 0 to 9μm. The resonator has a constant effective index of 3.2 and is surrounded by a bisbenzo cyclobutene (BCB) layer with a index of 1.54.

The FEM (finite element method, a commercial software: COMSOL Multiphysics® 5.0) computational domain under the symmetry or anti-symmetry conditions relative to the x

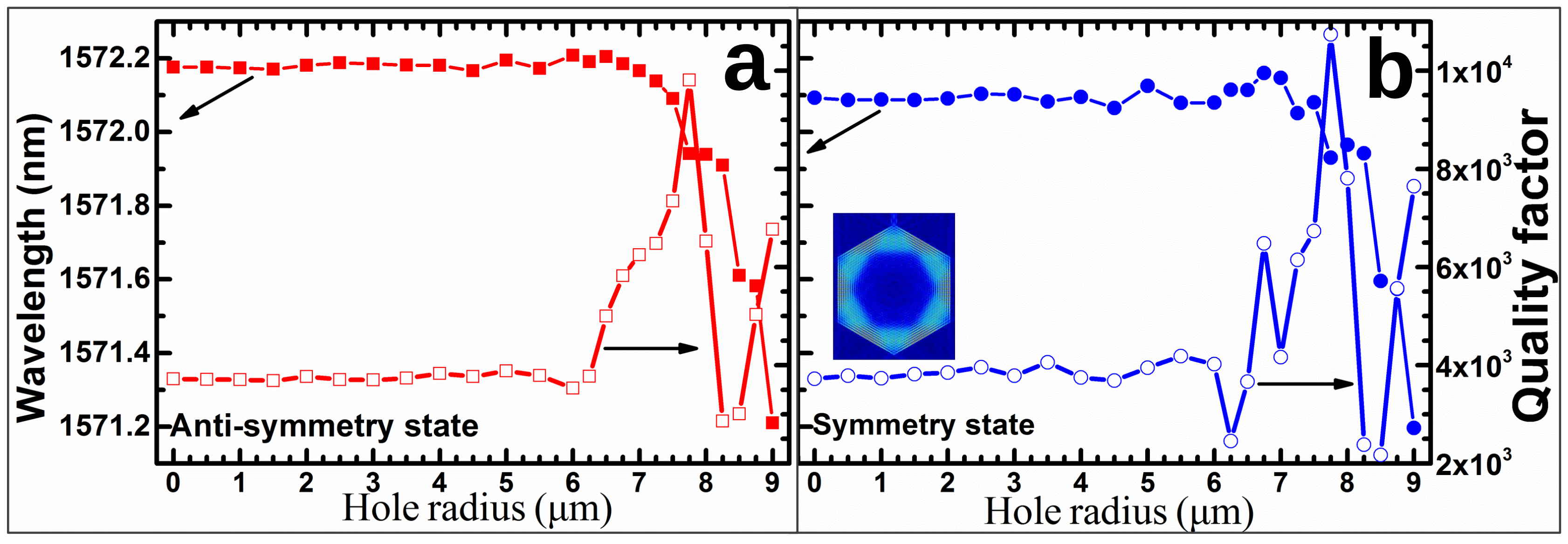
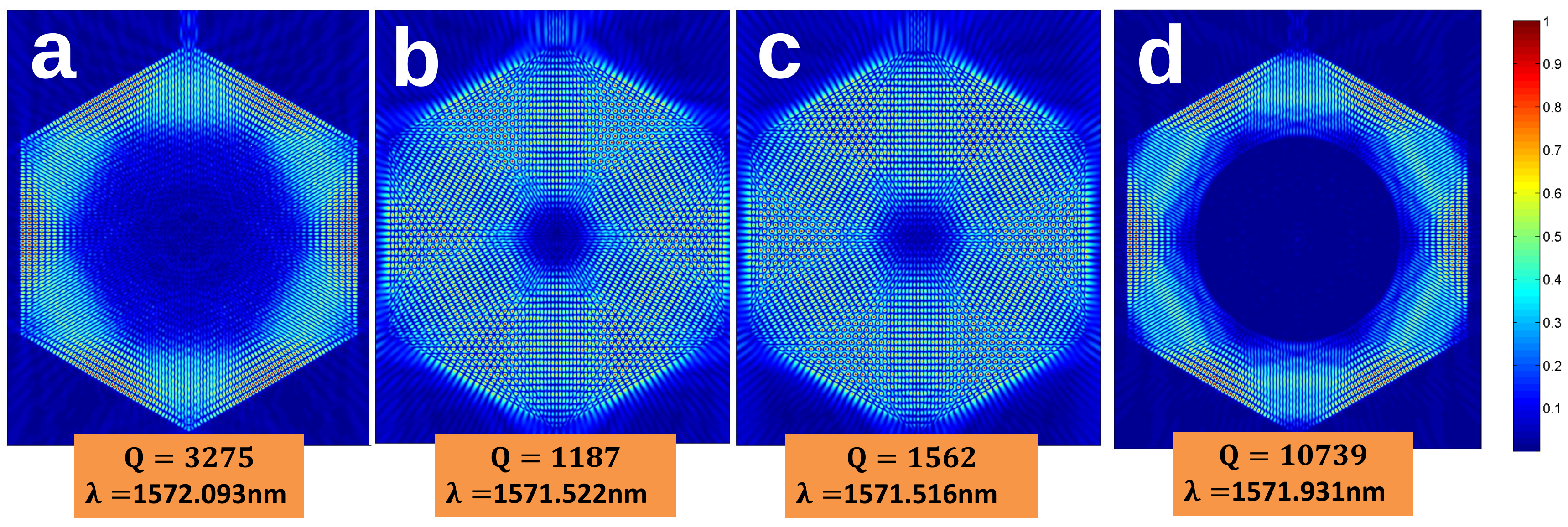


Fig. 3. Wavelengths (solid symbols) and Q factors (open symbols) of the fundamental mode versus the hole radius of anti-symmetry modes (a) and symmetry modes (b). The inset of (b) gives the intensity pattern of $|H_z|^2$ for symmetry fundamental TE mode when r = 0μm.

For both symmetry conditions, the mode wavelengths decrease very little as the hole radius increases from 0 to 6μm and blue shift drastically later. For symmetry state, Q factors of the fundamental mode reach to a peak of 10739 when r = 7.75μm , which is enhanced thrice compared to r = 0μm. The Q factors decrease from 7.75μm to 8.25μm because the hole reaches the strong field region of the fundamental mode. So, the enhancement of the Q factor can be obtained with a center hole of suitable size, due to the change of propagation mode and the enhancement of total reflection .



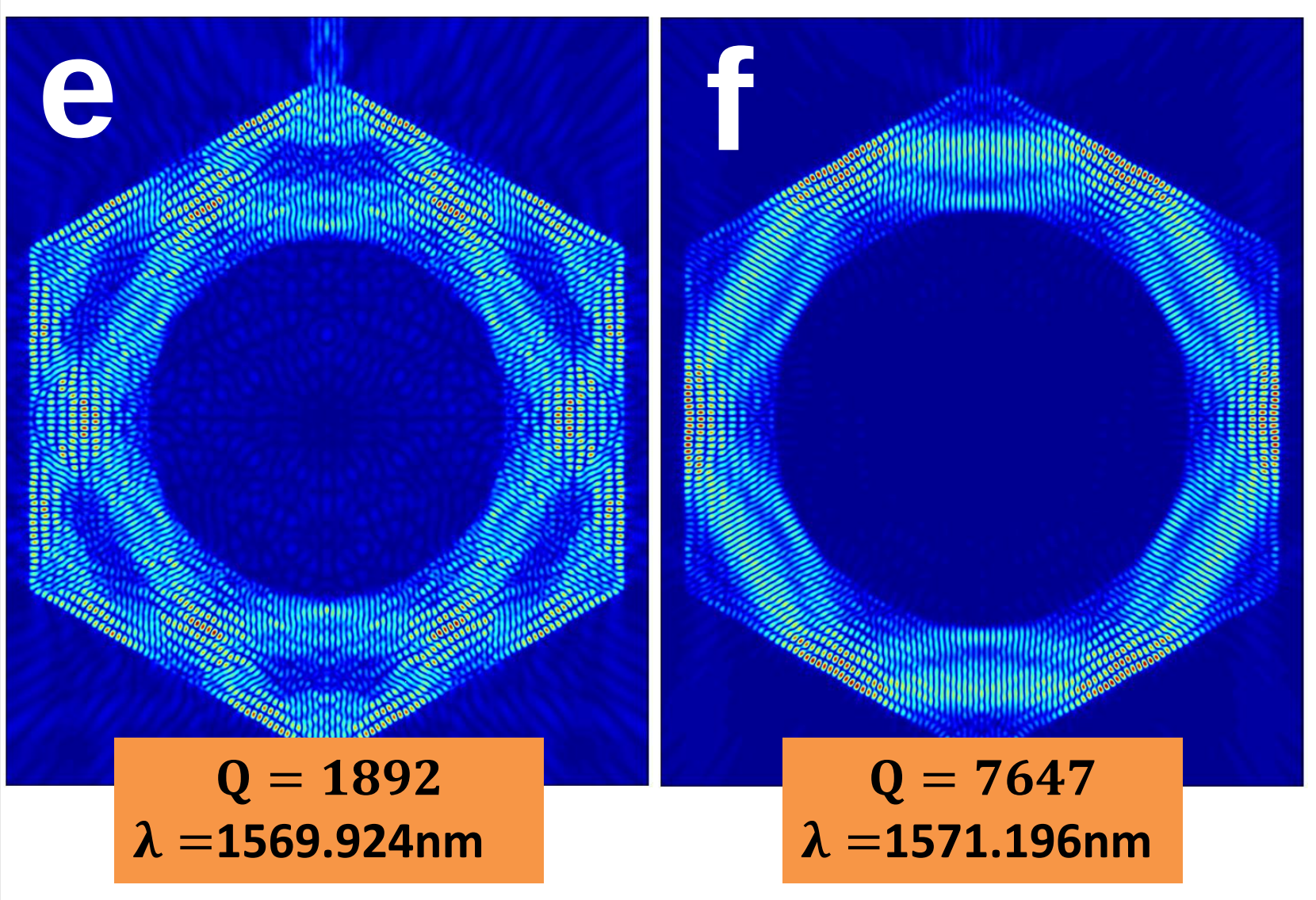


Fig. 4. Intensity patterns of $|H_z|^2$ for symmetry TE modes near the wavelength of 1570nm for r = 0μm in (a), (b) and (c), for r = 7.75μm in (d) and (e), for r = 9μm in (f). Corresponding Q factors and resonant wavelengths of these modes are shown in the bottom of the figures.

The field distribution changed a lot because of the mode coupling when r = 9μm , which can explain the increase of Q factor when r changes from 8.25 μm to 9 μm in Fig.3.

Experiment results:

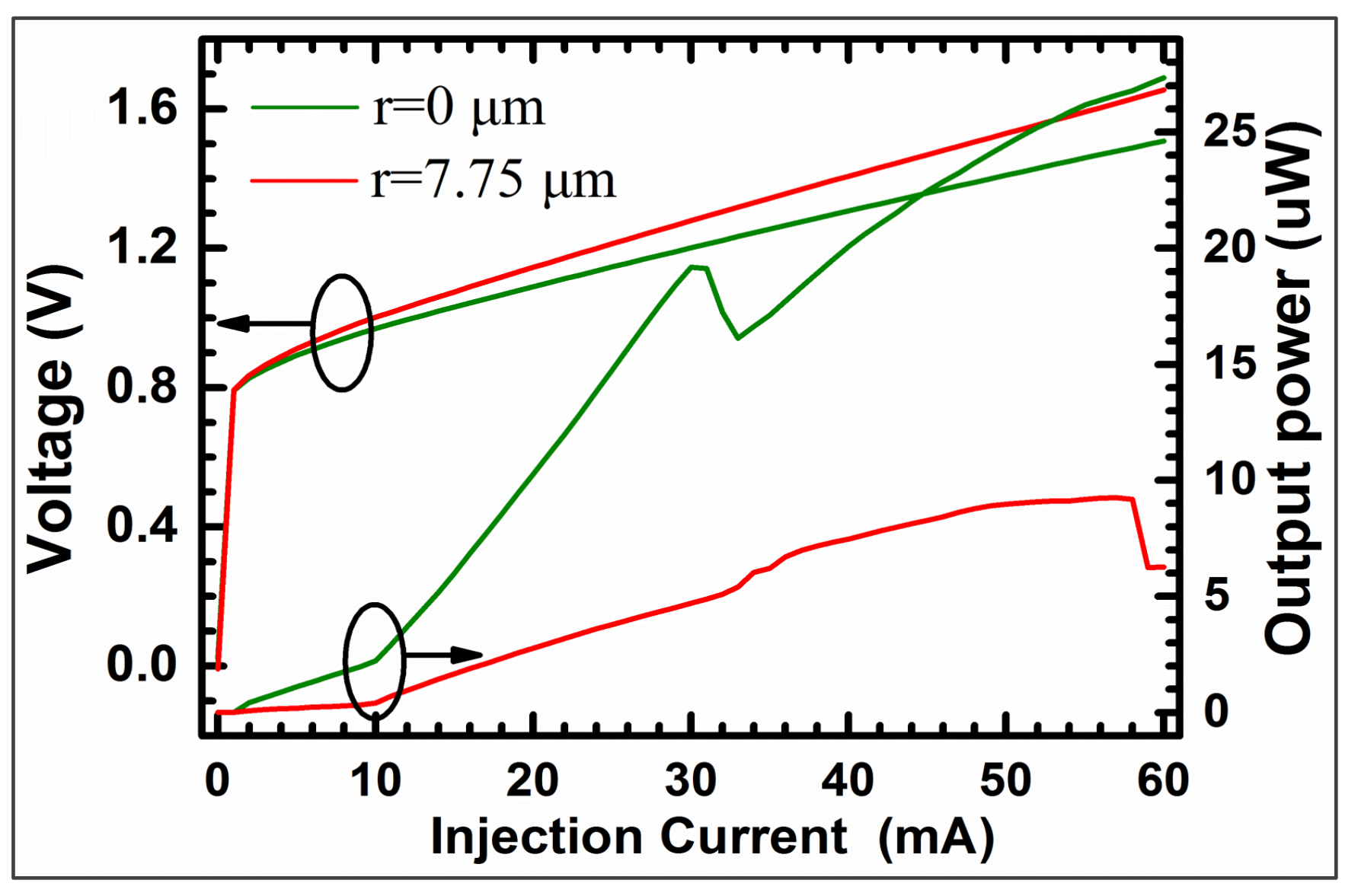


Fig. 5. Applied voltage and output power versus continuous wave injection current at the temperature of 288K for the two lasers.

For the hexagonal microcavity laser without hole, the resistor is 11.7Ω and the threshold current is 11mA. When the radius of the hole is 7.75μm , these values are 14.9Ω and 10mA. In case of the tested devices, the laser without hole has a higher maximum power of 28μW， the other one is 10μW .

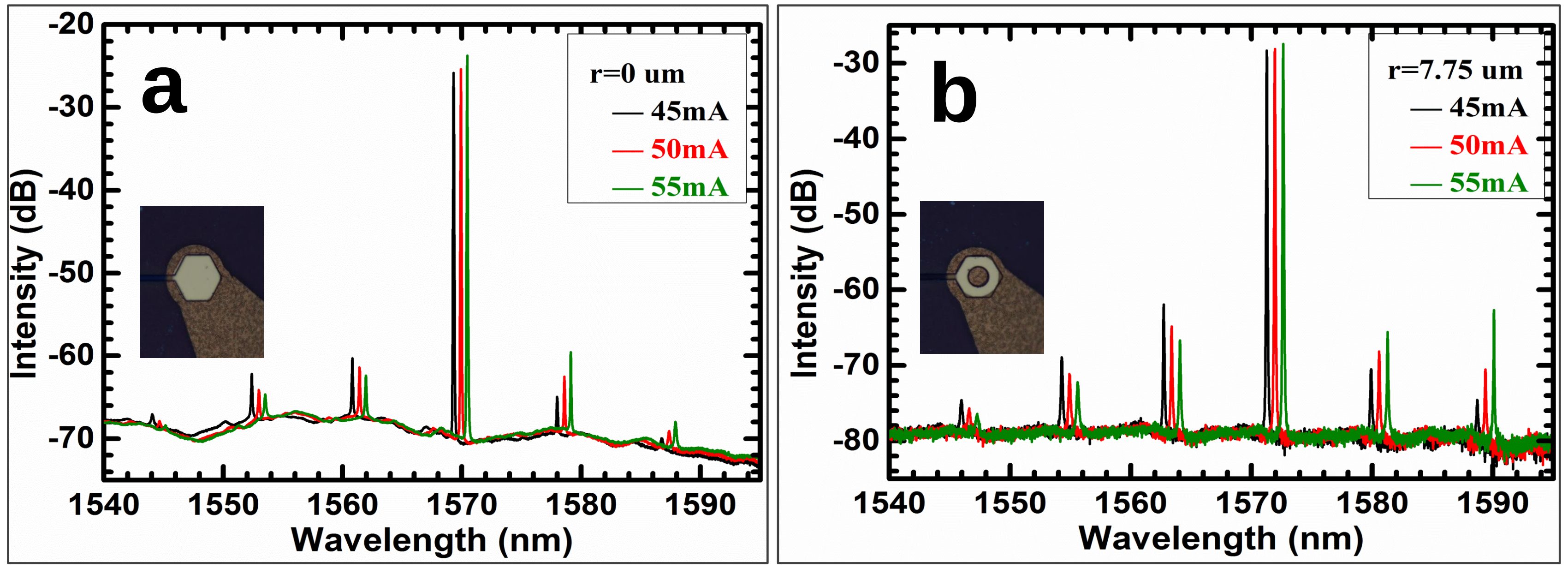


Fig. 6. Lasing spectra of the microlasers with r = 0μm (a) and r = 7.75μm (b) in different injection currents at 288K. The insets give the corresponding optical microscope images of the fabricated microcavity lasers.

The lasing wavelengths are near 1570nm and red shift as the increase of the injection current，the maximum SMSR is 36dB and 37dB for r = 0μm and 7.75μm，respectively. Evident peaks appear at the wavelengths of 1564.0, 1572.6, 1571.3, and 1590.1 nm at 55mA with the wavelength intervals of 8.6, 8.7 and 8.8nm when r = 7.75μm, respectively.

Conclusion:

In conclusion, we have investigated the mode characteristics of hexagonal resonator microlasers with a center hole both numerically and experimentally. The simulation indicate that these kinds of hexagonal resonator microlasers are easy to realize single transverse mode operation. According to the optimized parameters obtained by the simulation results, we fabricated 15μm side length hexagonal resonator microlasers with a 1.5μm wide output waveguide and a 7.75μm radius center hole. Continuous wave electrically injected operation with the threshold current of 10 mA is realized, and the single mode operation with the SMSR of 37dB is achieved at the injection current of 55mA for the microlaser with a 7.75μm radius center hole.

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