Microcavity lasers directly grown on silicon

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Abstract: Monolithic integration of ultra-compact III-V light sources on silicon is promising for the Si-based on-chip optical interconnects. Here, we present quantum dots microcavity lasers monolithically grown on silicon with ultra-low energy consumption.

1. Introduction

The recent exponential growth in data traffic requires a more efficient on-chip optical interconnection method with lower energy consumption and higher density of processing unit [1, 2]. In this regard, monolithic integration of efficient and ultra-small III-V microcavity laser with low energy consumption is one of the most promising architectures for the next generation of Si-based on-chip optical interconnects. In addition, semiconductor lasers with quantum dots (QDs) as gain material have been extensively investigated due to its robust tolerance to defects.

Here, we present ultra-small QDs photonic crystal (PC) membrane lasers and microdisk lasers monolithically grown on silicon substrate [3, 4]. The demonstrated Si-based microcavity lasers with a small footprint as well as low power consumption are expected to play an important role in the next-generation nanoscale Si photonics.

2. Results and Discussion

The InAs/GaAs QDs microcavity lasers were grown on silicon substrates. The QDs within active region present a dot density of ~ 4 x 10^{10} cm^{-2} with a typical size of 25 nm in diameter and 8 nm in height. The fabricated microcavity lasers were continuous-wave (CW) optically pumped at room-temperature using a 632.8 nm He-Ne laser as the excitation source.

The measured spectra under various pumping powers of a single mode PC laser with a = 310 nm and r/a = 0.27 is shown in Fig. 1(a). The collected intensity (L-L) and the full width at half maximum (FWHM) of the lasing peak at ~ 1306 nm under various pumping powers are shown in Fig. 1(b), which exhibit the evidence of the lasing with a clear kink of L-L curve and the spectral linewidth narrowing effect.

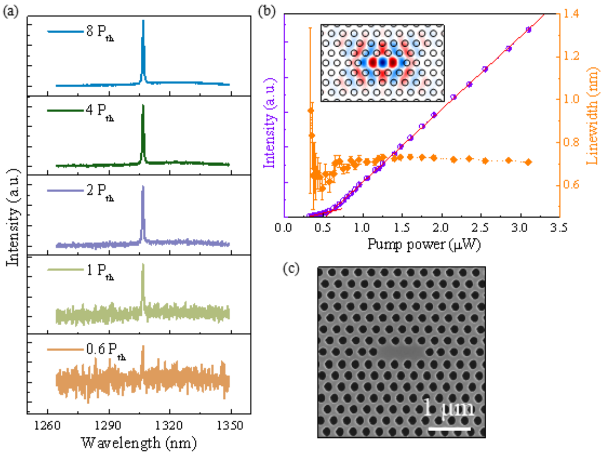

Fig. 1. (a) Measured spectra under various input pumping powers of the PC laser with a = 310 nm and r/a=0.27. (b) Collected L-L curve and linewidth of the lasing peak at 1306 nm. The inset shows the calculated Ey field profile of the fundamental mode. (c) Top-view SEM image of the fabricated PC cavity.

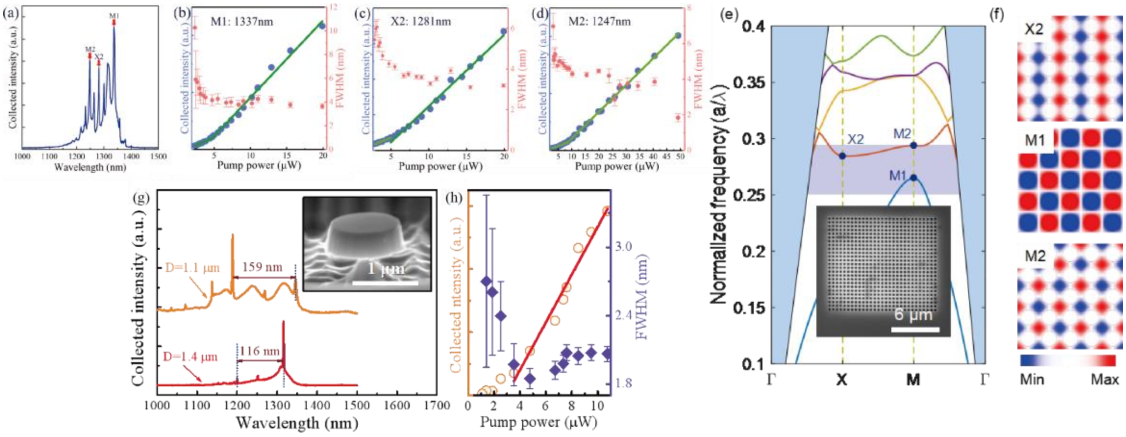

Fig. 2. (a) Lasing spectra of the fabricated photonic crystal bandedge laser under the pump power of ∼ 49.2 μW. (b-d) The L-L curve and FWHM for three lasing modes M1, X2, M2, respectively. (e) Band diagram of TE-like states for the photonic crystal bandedge slab with the parameters r/a = 0.353 and the slab thickness 1.06a. (f) The corresponding Hz field profiles. (g) Measured lasing spectra of the microdisk lasers with diameter ∼ 1.1 μm and 1.4 μm. (h) L-L curve and FWHM of lasing peak ∼ 1189 nm of the sub-wavelength scale microdisk laser with D ∼ 1.1 μm.

Fig. 2(a) presents the collected PL spectrum of a square-lattice bandedge PC laser grown on silicon with r = 120 nm and a = 340 nm. Lasing modes of M1, X2, and M2 were approximately determined by the spectral positions compared with the calculated normalized frequencies. Fig. 2(g) presents the measured lasing spectra of ultra-small microdisk lasers with diameter ∼ 1.1 μm and 1.4 μm. Single mode lasing emission was observed from such ultra-small mcirodisk lasers, owing to its large free spectral range (FSR) and well-separated resonant peaks.

3. Conclusion

In conclusion, we report the ultra-small PC membrane lasers and microdisk lasers monolithically grown on silicon substrate, which can be promising light sources in the next-generation nanoscale Si photonics.

References

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