Influence of active region and resonator design on characteristics of microdisk lasers.

St Petersburg Academic University
Russia

M. M. Kulagina, Vashanova K. A.
Ioffe Physical-Technical Institute
St Petersburg, Russia

Abstract—Microdisks with various active region and different design are studied. Lasing up to 100°C is demonstrated in microrings with outer diameter 2 μm based on InAs/InGaAs quantum dots. Room temperature single-mode lasing in 9 μm microdisk lasers with InGaAs quantum dots active region is achieved.

Keywords—microdisk, microring, quantum dots.

I. Introduction

Microdisk (MD) and microring (MR) lasers have attracted a considerable interest over the last two decades as promising candidates for on-chip light sources in optical interconnect systems [1]. These microlasers may have compact size, low threshold, high direct modulation speed, and they can be integrated in planar photonic circuits. A quantum dot (QD) semiconductor gain material may offer extremely low threshold current densities, temperature insensitive behavior, suppressed sidewall recombination rates, and long-wavelength laser emission, as it has been demonstrated with QD edge-emitting lasers. In this work microrings based on 1.3 μm InAs/InGaAs/GaAs quantum dots with outer diameter 2 μm and inner diameter from 0 to 1.4 μm are fabricated and studied. Effect of inner diameter and temperature on spectral and threshold characteristics is evaluated. Lasing up to 100°C is demonstrated. In 9 μm microdisk lasers with dense array of InGaAs/GaAs QDs active region single-mode lasing at room temperature is demonstrated.

II. Experiment

An epitaxial structures with self-organized InAs/InGa0.15Ga0.85As and InGaAs/GaAs QDs were grown on GaAs substrates. MDs and MRs with 2 μm outer diameter were fabricated using e-beam lithography and reactive ion etching. MDs with In0.2Ga1.8As/GaAs QDs with 4 - 9 μm outer diameter were fabricated by photolithography and etching. Microlasers were optically pumped with the CW-operating YAG:Nd laser (λ = 532nm, 10-200mW). Emission was detected with cooled InGaAs CCD array.

III. Results and discussion

At photoluminescence spectra we observed sharp lines, of the resonator whispering gallery modes (WGM) superimposed on broad band of spontaneous emission from QDs. All the resonators studied show lasing behavior on WGM. In case of 2-μm-diameter InAs/In0.15Ga0.85As QDs microresonators room temperature WGM lasing wavelengths are 1282 nm and 1276 nm in proximity to the ground-state gain maximum. The threshold power is as low as 5 μW. At 100°C lasing simultaneously occurs via WGMs at 1355 and 1367 nm (ground state), and WGMs at 1284 and 1292 nm (excited state) with the threshold power of about 30 μW. Emission spectra of 4-9 μm diameter microdisks with In0.2Ga1.8As/GaAs QDs measured in the 78-300K temperature range show a dominant narrow line at long-wavelength side of QD spectra. Side mode suppression ratio is higher than 20dB. The single mode emission is probably due to a specific shape of the gain spectrum in In0.2Ga1.8As/GaAs QDs used, where the excited-state gain is significantly suppressed, whereas the ground-state gain spectrum is not so flat as compared to InAs/InGaAs QD counterparts.

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References