Announcing the Final Examination of Abdullah Zakariya for the degree of Doctor of Philosophy

Time & Location: June 21, 2013 at 10:00 AM in CREOL 53 102

Title: MONOLITHICALLY INTEGRATED BROADLY TUNABLE LIGHT EMITTERS BASED ON SELECTIVELY INTERMIXED QUANTUM WELLS

A monolithically integrated broadly tunable MQW laser that utilizes a combined impurity-free vacancy disordering (IFVD) of quantum wells and optical beam steering techniques is proposed and investigated experimentally. The device consists of a beam-steering section and an optical amplifier section fabricated on a GaAs/AlGaAs quantum well (QW) p-i-n heterostructure. The beam steering section forms a reconfigurable optical waveguide that can be moved laterally by applying separately controlled electrical currents to two parallel contact stripes. The active core of the gain section is divided in into selectively intermixed regions. The selective intermixing of the QW in the gain section results in neighboring regions with different optical bandgaps. The wavelength tuning is accomplished by steering the amplified optical beam through the selected region where it experiences a peak in the gain spectrum determined by the degree of intermixing of the QW. The laser wavelength tunes to the peak in the gain spectrum of that region. The IFVD technique relies on a silica (SiO2) capped rapid thermal annealing and it has been found that the degree of intermixing of the QW with the barrier material is dependent on the thickness of the SiO2 film. The QW sample is first encapsulated with a 400nm thick SiO2 film grown by plasma enhanced chemical vapor deposition (PECVD). In the gain section, the SiO2 film is selectively etched using multiple photolithographic and reactive ion etching steps whereas the SiO2 film is left intact in all the remaining areas including the beam-steering section. The selective area quantum well intermixing is then induced by a single rapid thermal annealing step at 975Å°C for a 20s duration to realize a structure with quantum well that has different bandgaps in the key regions. Optical characterizations of the intermixed regions have shown a blue shift of peak of the electroluminescence emission of 5nm, 16nm and 33nm for the uncapped, 100nm and 200nm respectively when compared to the as grown sample. The integrated laser exhibited a wavelength tuning range of 17nm (799nm to 816nm).

Based on the same principle of QW selective intermixing, we have also designed and fabricated a monolithically integrated multi-wavelength light emitting diode (LED). The LED emits multiple wavelength optical beams from one compact easy to fabricate QW structure. Each wavelength has an independent optical power control, allowing the LED to emit one or more wavelengths at once. The material for the LED is the same AlGaAs/GaAs p-i-n heterostructure described above. The device is divided into selectively intermixed regions on a single QW structure using IFVD technique to create localized intermixed regions. Two different designs have been implemented to realize either an LED with multiple output beams of different wavelengths or an LED with a single output beam that has dual wavelength operation capabilities. Experimental results of the multiple output beams LED have demonstrated electrically controlled optical emission of 800nm, 789nm and 772nm. The single output LED has experimentally been shown to produce wavelength emission of 800nm and/or 772nm depending on electrical activation of the two aligned intermixed regions.

Major: Electrical Engineering

Educational Career:
Bachelor's of Electrical Engineering, BS, 2000, Florida Institute of Technology
Master's of Electrical Engineering, MS, 2007, Florida International University

Committee in Charge:
Dr. Patrick LiKamWa, Chair, The College of Optics and Photonics/ Dept of Electrical Engineering & Computer Science
Guifang Li, Professor of Optics, Physics & ECE/FPCE
Parveen Wahid, Department of Electrical Engineering and Computer Science
Winston Schoenfelf, The College of Optics and Photonics

Approved for distribution by Dr. Patrick LiKamWa, Committee Chair, on May 8, 2013.
The public is welcome to attend.