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AlGaAs/InGaAs DFB laser by one time selective MOCVD growth on a grating substrate

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1. Introduction

Quantum nano-structures such as quantum wire (QWR) and quantum dots (Qdots) are promising for a high performance laser and optical modulator because of their steep density of states and large differential gain. Moreover, high density QWR array is suitable for the gain guided distributed feed back (DFB) laser with enhanced modal gain at the center of Bragg wavelength[1]. At the same time, to simplify the fabrication process of opto-electronic integrated circuits (OEICs) is one of the most important key issues for the development of metro and access optical communication networks. For example, a distributed feed back (DFB) laser array with the wavelength separation of 10 – 20nm has to be realized in a cost-effective way for the coarse wave division multiplexing (CWDM) system.

We realized a gain guided InGaAs/AlGaAs DFB-QWR laser by one time MOCVD growth on a grating substrate patterned by electron-beam lithography. Modulation of thickness or shape of InGaAs active region is formed by a constant growth technique[2], in which grating profile of the substrate is preserved through 1 µm thick lower cladding region by optimizing the thermal annealing condition, buffer layer thickness and growth temperature of the cladding layer. Otherwise, 3 to 4 re-growth steps were necessary to realize the DFB laser in the conventional fabrication process.

2. Fabrication procedure

Firstly, V shaped grooves with the period of 360 and 370nm (3^{rd} order grating) across the area of 6 x 500µm were formed by an electron beam lithography and wet chemical etching (H_2SO_4:H_2O_2:H_2O=1:8:40 for 30sec) on a GaAs substrate along [1 –1 0] direction. Then a GaAs buffer, 1µm thick lower N-$Al_{0.38}$GaAs cladding layer, $Al_{0.2}$GaAs guiding layer, 3-$In_{0.2}$GaAs active region, $Al_{0.2}$GaAs guiding layer, P-$Al_{0.5}$GaAs upper cladding layer and P-GaAs cap layer were grown by one time selective MOCVD. There are clear modulation of shape and thickness in the active region as shown in the cross-sectional TEM picture in Fig.1, while gratings on a substrate are partly smoothed during the growth of AlGaAs lower cladding layer. Figure 2 shows a schematic drawing of the gain guided InGaAs/AlGaAs DFB-QWR laser. Mesa-stripes were formed by wet etching and planarized with polyimide.

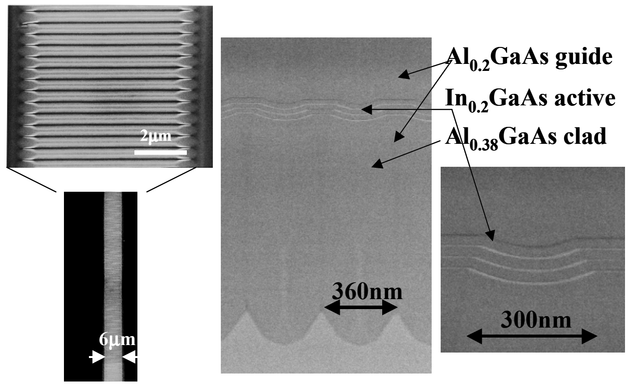

Fig.1 Top SEM view (left) and cross-sectional TEM picture(right) of the finite length QWR array on a grating substrate. Focused ion beam micro-sampling technique is employed to specify the sample location.

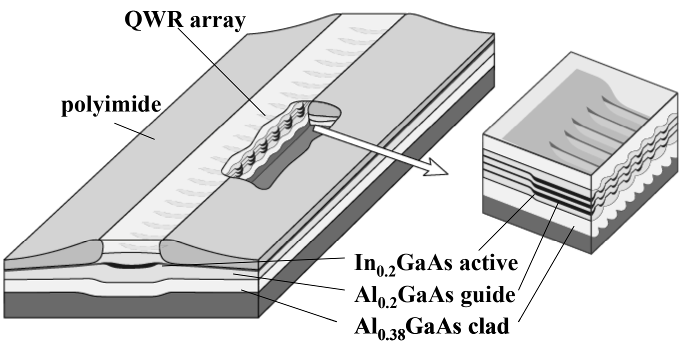

Fig.2 Schematic drawing of the Gain guided DFB laser.

3. Lasing charactristics

Figure 3 shows current vs. light output characteristics from a 500µm laser bar. Threshold current is 30mA at pulsed condition (1µsec pulse, 1msec period). Figure 4(a,b) shows lasing spectra from 360 and 370nm pitch grating at 50mA, respectively. Gain guided DFB structure ensures stable longitudinal mode assigned by the grating period. There is no parasitic oscillation peak near Bragg frequency.

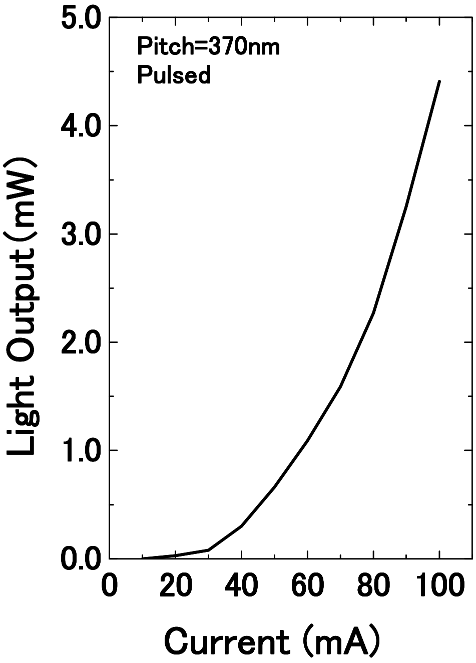

Fig.3 Current-light output characteristics of the gain guided QWR DFB laser.

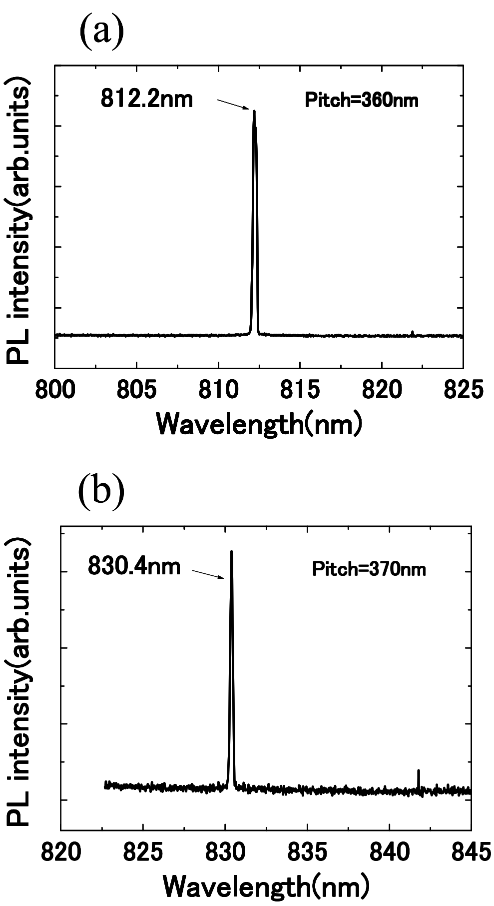

Fig.4(a,b) Lasing spectra of the gain guided QWR DFB laser with the grating period of 360nm(a) and 370nm(b) at the operation current of 50mA.

In contrast, multi-longitudinal mode oscillation is dominant at quantum well laser without grating.

4. Conclusion

Gain guided two wavelength DFB laser array is realized by one time selective MOCVD growth on a patterned substrate. There are several advantages over the conventional fabrication process of DFB lasers.

Because there needs no etch and regrowth process, aluminum containing compound semiconductors are freely employed for the cladding region without the problem of regrowth interface defects. This is favorable to ensure the reliability of AlGaAs/GaAs near infrared DFB lasers and also, to improve the temperature characteristics of long wavelength lasers by employing AlInAsP clad region. Exposure area is limited to the width of several microns in the laser stripe spacing of several hundred microns, and this reduces the exposure time of electron beam lithography drastically. Carrier dissipation along the grating is suppressed like Qdots because the width of the grating is limited within the laser stripe of several microns. Therefore, inherent advantages of QWR such as polarization selectivity, periodicity and spectral uniformity, and that of Qdots as a built-in buried heterostructure are combined in the 3 dimensional selective growth on the patterned substrate.

Acknowledgements

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References

[1] T. G. Kim, C. S. Son and M. Ogura “ Fabrication of AlGaAs-GaAs Quantum-Wire Gain-Coupled DFB Lasers by a Single MOCVD Growth Step ” IEEE Photonics Technology Letters, Vol.13, No.5, pp409-411, (May 2001)

[2] C. S. Son, T. G. Kim, X. L. Wang and M. Ogura, “ Constant growth of V-groove AlGaAs/GaAs multilayers on submicron gratings for complex optical devices ” J. Cryst. Growth, Vol. 221, No. 1-4, pp.201-207 (Dec. 2000).