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Micro-cavity GaAlAs/GaAs Surface Emitting Laser with I_{th}=6 mA

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This is a first demonstration of a micro-cavity GaAlAs/GaAs surface emitting (SE) laser with I_{th}=4.5 mA (77 K, CW) and 6 mA (300 K, pulsed). The structure of the CBH-SE micro-cavity laser by the selective meltback [1] is shown in Fig. 1. A micro-cavity of 7 μm long and 6 μm in diam. has been realized.
A circular buried heterostructure (CBH) [2] [3] and a highly reflective TiO_2/SiO_2 multilayer Bragg reflector [4] have been introduced.

Figure 1 also shows a fabrication process. The most important process is to make a small diameter active layer. This is performed by selectively melting back the GaAs active layer to make a constricted mesa in a LPE furnace for 20 seconds under the following conditions; the meltback starting temperature is 800 ℃ and employed cooling rate is 0.5 ℃/min. The degree of undersaturation for Ga and As in the solution is taken to be 4 ℃, which is the temperature drop from that for saturation. During this process the n-GaAlAs cladding layer is hardly melted back.

The present SE laser was mostly tested under pulsed condition (1 μsec pulse width, 6 kpps) at 20.5 ℃. The light-output/current (L-I) characteristic is shown in Fig. 2. The threshold current was 6 mA. Although we used rather a long pulse, decrease of light output was not observed at low level excitation. We drove the device up to 40 mA. The differential quantum efficiency was 9 % and more than 1 mW peak power was obtained. First CW operation at 77 K was achieved with I_{th}=4.5 mA.
The lasing spectra at I=20 mA and 40 mA are shown in Fig. 3. The SE laser ran single mode but the linewidth was broadened at I=40 mA.
The near field pattern of this SE laser was a circle of $2r \cong 6$ μm in diam. as shown in Fig. 3. Actually, the threshold of 6 mA can be roughly understood from Fig. 4 for the diameter of 6 μm. This means that the scaling law, I_{th} is proportional to r^2, stands without any noticeable diffraction loss. We can expect to reduce the threshold to a few mA by optimizing the micro-cavity structure.

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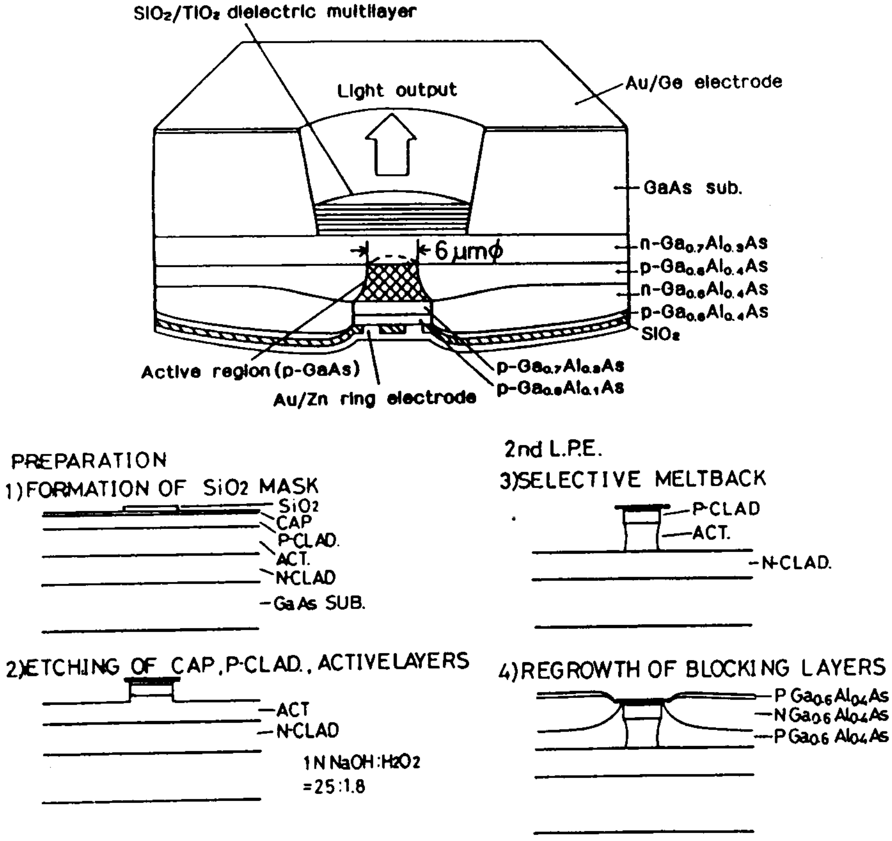

Fig. 1. Structure and fabrication of micro-cavity SE laser.

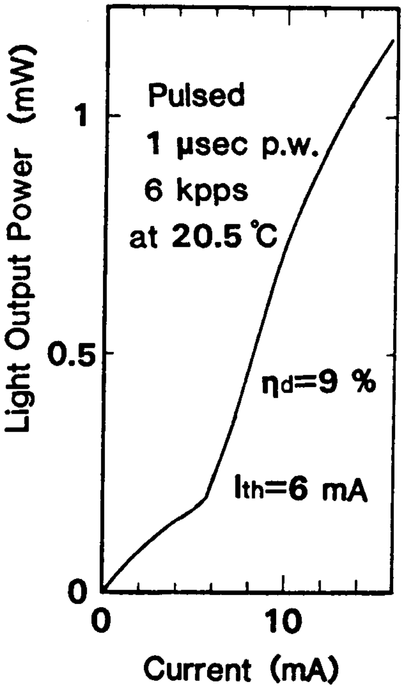

Fig. 2. Light output/current characteristic.

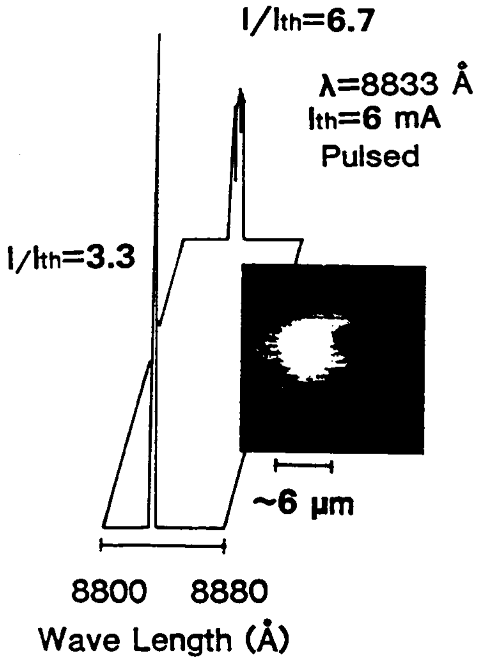

Fig. 3. Spectra and Near Field Pattern of micro-cavity SE laser.

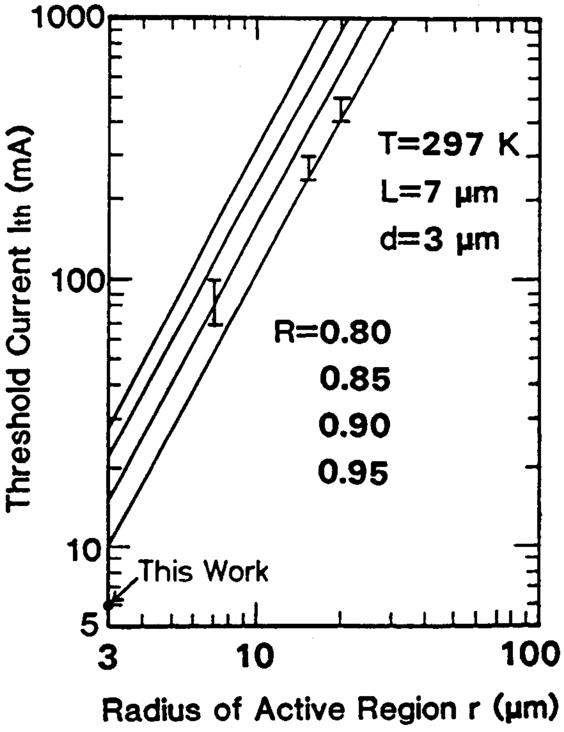

Fig. 4. Threshold current vs. radius of active region characteristic.