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Surface Emitting Bistable Multiquantum Well Lasers with a 45° Dry Etched-Mirror

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Surface emitting optical memory devices are much desired for the application to the optical computing systems and the optical switching systems. For this application, bistable lasers are attractive because they have shown high speed and high sensitivity operation(1). In this report, surface emitting bistable multiquantum well (MQW) lasers with a 45° dry etched-mirror are demonstrated. This is, to our knowledge, the first report on a surface emitting bistable laser. The 45° mirror(2-4) to obtain the emission normal to the wafer surface has been obtained by a new fabrication process using reactive ion beam etching (RIBE) technique.

Figure 1 shows the laser structure schematically. GaAs/AlGaAs MQW laser structure was grown by molecular beam epitaxy. The MQW consists of twelve 10nm thick GaAs wells separated by eleven 4nm thick $Al_{0.2}Ga_{0.8}As$ barriers. The MQW is sandwitched by n-$Al_{0.7}Ga_{0.3}As$ and p-$Al_{0.7}Ga_{0.3}As$ clad layers. The ridge stripe is 6-15μm wide, formed by chemical ecthing. The newly developed 45° mirror fabrication process is shown in Figure 2. A 2μm wide groove with 90° mirror and a 45° tilted 2μm wide groove were formed by RIBE technique using Cl_2 plasma(5), which resulted in the removal of the middle part between these two grooves. The p side electrode is separated into two segments for gain region and absorption region by 10μm wide isolation region. The value of isolation resistance between the gain region and the absorption region ranges from 1 to 8 kilo-ohms.

Figure 3 shows the light output power versus injected current characteristics under CW operation for the device with 15μm wide ridge stripe, 185μm long gain region and 65μm long absorption region. The one facet of the device was cleaved and the another facet was dry etched with a 45° mirror. When the absorption region was in the open circuit condition, the threshold current was 75mA, and no optical bistability was observed. However, when the absorption region was reversely biased, the threshold current was increased, and the hysteresis characteristics were observed. This is because the absorption in the absorption region is increased due to the exciton peak wavelength shifts by the applied reverse bias(6). When the bias voltage (V_B) is -1V, the hysteresis current width is 8mA, the light output power difference at the switching on is 1.2mW for surface emitting, and that is 6.5mW for cleaved edge emitting. Figure 4 shows the near field pattern of the two surface emitting lasers.

On the basis of the results obtained for the present device, it is believed that this approach is very effective to realize two-dimensional integrated optical memories.

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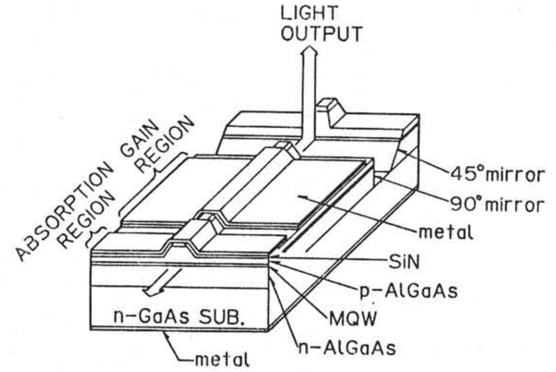

Fig. 1 The schematic laser structure diagram.

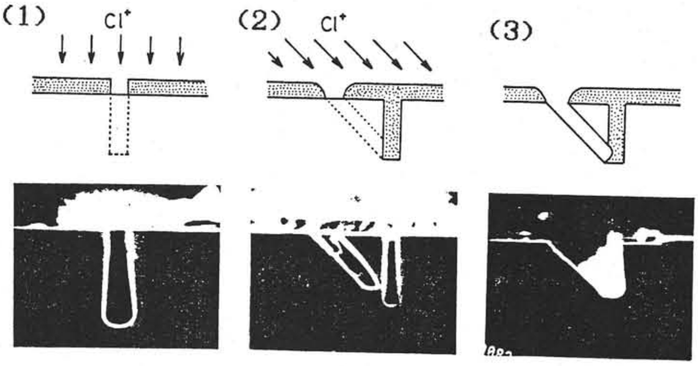

Fig. 2 The 45° mirror fabrication process using RIBE technique.

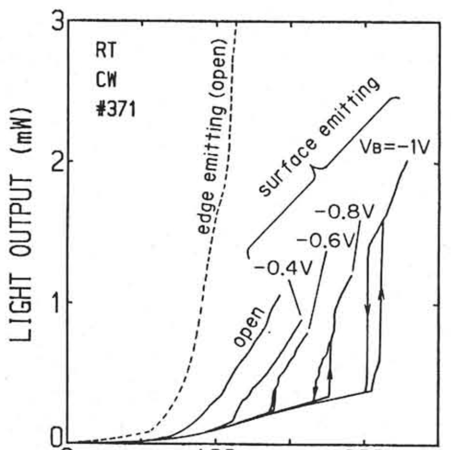

Fig. 3 The relationship between the light output power versus the current injected into the gain region.

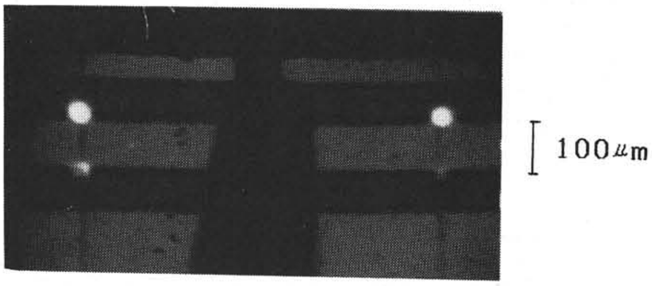

Fig. 4 The near field pattern of the two surface emitting lasers with a 45° mirror and two 90° mirrors for cavity facets, which were fabricated by the same processing as the bistable laser. The two strong light spots are from the 45° mirrors of the two different lasers. The week light spots are from 90° mirrors.