Digest of Tech. Papers The 7th Conf. on Solid State Devices, Tokyo, Sep. 1975

B-6-3 Monolithic Passivated Stripe-Geometry Double Heterostructure Injection Lasers

Y. Tarui, Y. Komiya, T. Sakamoto, H. Iida and A. Shōji
Electrotechnical Laboratory
Tanashi, Tokyo

Passivation of injection lasers with stable insulating films is considered as an important technology for extending operating lifetimes of laser diodes and controlling lasing modes[(1)] by design of insulator films[(2)], in some case, with an additional metal film.[(3)(4)]

Previously reported discrete passivation methods[(5)] have a disadvantage because it is necessary to handle each chip after cleaving a wafer.

In this paper, we report a monolithically passivated DH laser array by utilizing a selective directional chemical etching[(6)(7)] in 1 H_2SO_4 - 10 H_2O_2 - 1 H_2O system where etched channels are aligned with [100] direction in order to get the etched side walls perpendicular to the surface of a wafer. The fabricated etched resonator mirrors are in $\{100\}$ planes due to the unique properties of the selective etching, while the conventional cleaved mirrors are in $\{110\}$ planes. We have performed preliminary experiments to get technical data of the selective directional etching for (100) GaAs wafers and $Ga_xAl_{1-x}As$ - GaAs DH wafers. Fig.1 shows the lateral etching length s, the etch depth h and the hight of a perpendicular wall l as a function of etching time in a cross-section of the etched channel in a case of a (100) GaAs wafer and a DH wafer. The SEM photographs of the island shaped by the selective directional etching in a case of a GaAs wafer and a DH wafer are shown in Fig.2 and Fig.3 respectively.

Oblique stripe patterns on the etched (100) side wall are observed to intersect with the (100) wafer surface at the angle of about 45°. Judging from the orientation of the stripe patterns on four side walls, the directions of stripes are along the intersection line between a certain (111) plane and the (100) mirror plane. The unevenness of stripe patterns is found much stronger in the DH wafer than in the GaAs wafer.

In Fig.4 are shown fabrication processes of monolithic passivated stripe geometry DH junction laser by this selective etching method. A low temperature Si_3N_4 CVD deposition at 450° C in the passivation process is performed by the enhanced reaction of SiH_4 and NH_3 gas flows under the influence of a electromagnetic field generated by a RF coil.

Fig.5 shows a photograph of the monolithic passivated lasers. Two types of DH wafers shown in Table 1 are used in the device fabrication.

Threshold current density J_{th} and external differntial quantum efficiency η_D of the fabricated lasers were determined from the measurement by silicon diode detector UDT PIN-10.

Fig.6 is a light output power vs. the excitation current which gives the lowest threshold current density about 4.5 kA/cm^2 among the fabricated units of type A. Fig.7 shows emission spectra of the same laser as shown in Fig.6 at room temperature. Fig.8 shows near field patterns of the other A type laser. Table 2 shows examples of J_{th} and η_D.

Units with gold films on the passivated end surfaces, where one end is perfectly reflective and the other end is semitransparent are under development. The monolithic approach might be also promissing for the application to the devices using interaction of light beams between semiconductor lasers[(8)] because self-alignment of two adjacent lasers is possible.

This work is done for the project of Pattern Information Processing System. The authors thank the persons concerned in Toshiba and Nippon Electric Co., Ltd. for thier co-operations and H. Teshima and F. Hayashi for thier advices in the device processing.

References: 1) Y.Suematsu, M.Yamada: IE^3J.Q.E vol 9, No.2, p305, 1973. 2) M.Ettenberg et al: APL vol 18, No.12, p571, 1971. 3) Y.Nannichi, JAP vol 37, No.8, p3009, 1966. 4) F.K.Reinhart, I. Hayashi, M.B.Panish: JAP vol 42, No.11 p4466, 1971. 5) B.Schwartz, J.C.Dyment, S.E.Haszko: 1972 Symp.on GaAs, p187. 6) S.Iida, K.Ito: JECS vol 118, p768, 1971. 7) A.S.Dobkin et al: Sov.Phys. Semicon. vol 4, No.3, p515, 1970. 8) J.Nishizawa: Proc.5th CSSD (Japan, 1973) p89.

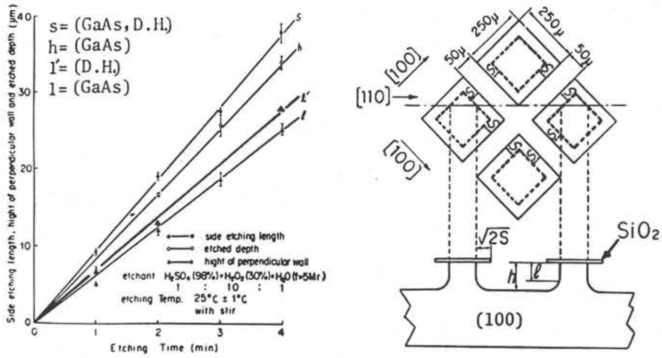

Fig.1 Etching rates of GaAs and D.H. wafers

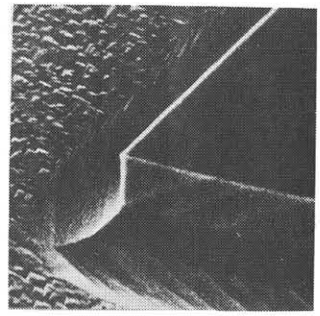

Fig.2 SEM photograph of the etched GaAs wafer

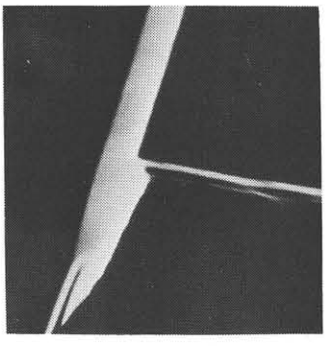

Fig.3 SEM photograph of the etched D.H. crystal wafer

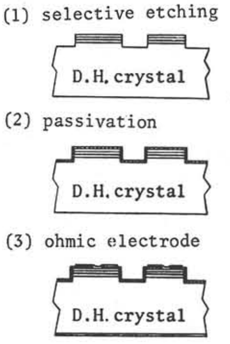

Fig.4 Basic processes of the device fabrication

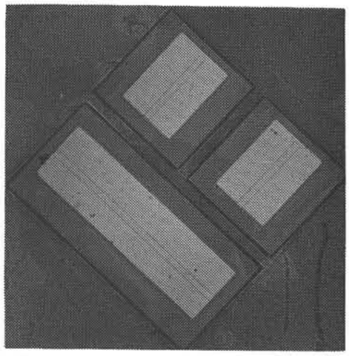

Fig.5 Photograph of the fabricated laser array

	A	B
p-GaAs	1.6μ	2.2μ
p-GaAlAs	1.2	1.6
p-GaAs (active layer)	0.2~0.3	~0.5
n-GaAlAs	2.3	4.4
n-GaAs (Substrate)	—	—

Table 1 Structure of D.H. wafers

	A	B		
	passivated			non-passivated
Stripe Size (μm)	220x15	220x18	560x18	220x18
J_{th} (kA/cm^2)	7	12	6	12
η_D (%)	15	12	12	12

Table 2

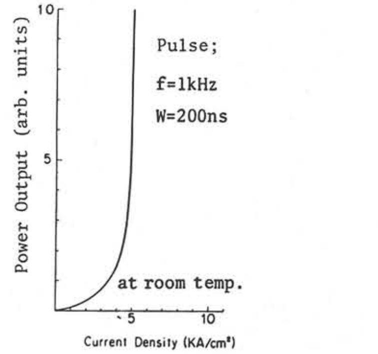

Fig.6 Characteristics of light power vs. current density

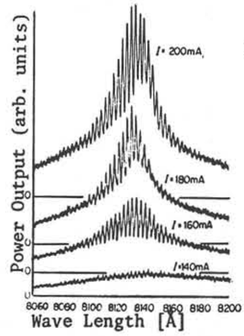

Fig.7 Spectra of the laser diode at room temperature

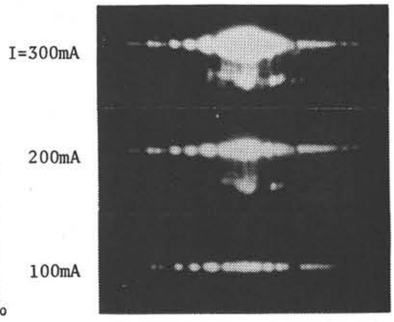

Fig.8 Near field patterns