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1. S. RATANATHAMMAPHAN, C. ANTARASENA and S. PANYAKEOW, "Research and Development Laser Diodes at Chulalongkorn University, Thailand", Fourth Optoelectronic conference (OEC'92), Chiba, JAPAN, Julu 15-17, 1992, pp.208-209.
2. S. RATANATHAMMAPHAN, C. ANTARASENA and S. PANYAKEOW, "Fabrication Techniques of GaAs-GaAlAs Single Quantum Well Devices by Liquid Phase Epitaxy", 1992 International Conference on Semiconductor Electronics, Kuala Lumpur, Malaysia, October 6-8, 1992, pp.254-258.

Domestic Conferences

1. S. RATANATHAMMAPHAN, C. ANTARASENA and S. PANYAKEOW, "Fabrication of Double Heterostructure GaAs/GaAlAs Laser Diodes", Electrotechnology Conference '91, Supported by E.I.T. and IEEE, Thailand, 23-26 May 1991, pp.217-222.
2. S. RATANATHAMMAPHAN, C. ANTARASENA and S. PANYAKEOW, "Development of GaAs/GaAlAs Laser Diodes by Liquid Phase Epitaxy (LPE)", Proceeding of 14^{th} EE Conference, Prince of Songkla Univeristy, 7-8 November 1991, pp.2-81-2-86.
3. S. RATANATHAMMAPHAN, C. ANTARASENA and S. PANYAKEOW, "Fabrication of GaAs-GaAlAs Single Qunatum Well Laser Diodes by Liquid Phase Epitaxy (LPE)", Engineering Technolgy Conference 1992, Supported by Engineering Institue of Thailand Under H.M. The King's Patronage, Bangkok, 26-29 November 1992.

Appendix

Appendix A

Cleaning of GaAs Substrates and GaAs Sources

Basic Materials

The substrates are single crystal GaAs wafers with one side mechanically polished.

The GaAs source is an undoped single-crytal or polycrystal of GaAs wafer.

a) degreasing of substrates and sources

- Boiling trichloroethylene for 5 minutes
- Boiling acetone for 5 minutes
- Rinse with DI water of purity of 18 MΩ-cm.

b) Chemical etching

- Dip in concentrate of H_2SO_4 to wet the substrate
- Etching with H_2SO_4 : H_2O_2 : H_2O (4:1:1)

The temperature of the etching bath is approximately 100 °C. It should be cooled down to 70 °C. Then, the substrate will be placed inside the bath for about 30 seconds.

- Rinse with running DI water

c) Dip in HCl : H_2O (1:1)

- Rinse with running DI water

d) Drying

- Dry with filtered dry nitrogen gas

Appendix B

Cleaning of the Impurity Sources of Ge, Sn, and Zn

Basic Materials

The impurity sources of Ge, Sn, and Zn are in the form of metal wire or ingot or shot form. The purity of these impurities is higher than 99.999%.

a) Chemical etching

- Etching with HCl : H_2O (1:1)

The etching is done at room temperature for about 5 minutes.

- Rinse with running DI water

b) Dip in methanol

c) Drying

- Dry with filtered dry nitrogen gas

Appendix C

Cleaning of Al Source

Basic Materials

The sources of Al is in the form of metal wire form. The purity of Al is higher than 99.999%.

a) Chemical etching

- Etching with H_3PO_4

The temperature of the etching bath is approximately 120°C. The Al wire will be placed inside the bath for about 30 seconds.

- Rinse with running DI water

b) Dip in methanol

c) Drying

- Dry with filtered dry nitrogen gas

Appendix D

The Photolithography with Positive Photoresist

Positive Photoresist

The positive photoresist, SHIPLEY AZ-1350 or AZ-1400, is used as photomask for chemical etching. Microposit remover 1165 is used to remove the positive photoresist of SHIPLEY AZ-1350 or AZ-1400.

a) Substrate preparation

- Boiling trichloroethylene for 5 minutes.
- Boiling acetone for 5 minutes.
- Rinse with DI water of purity of 18 MΩ-cm.

b) Dehydration

- Bake at 120°C for 10 minutes.
- Cool to ambient temperature.

c) Photoresist coating

- Spin at the speed of 1000 RPM for 1 second in spreading stage. Then, spinning speed increases to 6000 RPM with the maximum acceration rate and the spin time is 40 seconds.

d) Soft bake

- Bake at 80°C for 20 minutes.
- Cool to ambient temperature.

e) Exposure

- Expose with UV Light at the exposing energy of 75 mJ/cm^2.

f) Development

- Dip in the solution of AZ Developer : H_2O (1:1) for 5 seconds.
- Rinse with running DI water.

g) Hard bake at 120°C for 30 minutes.

- Bake at 120°C for 30 minutes.
- Cool to ambient temperature.

The Shipley photoresist can be used with all common semiconductor wet etchants processes.

h) Stripe (photoresist removing)

- Immerse substrate for two-bath in Shiley microposit remover 1165.

The remover processing is done at the room temperature for 5-10 minutes. in each bath.

- Rinse with DI water of purity 18 MΩ-cm.

i) Drying

- Dry with filtered dry nitrogen gas.

Appendix E

The Photolithography with Negative Photoresist

Negative Photoresist and its remover

The negative photoresist, OMR-83, is used as photomask for chemical etching. The OMR remover is used to remove the negative photoresist.

a) Substrate Preparation

- Boiling trichloethylene for 5 minutes.
- Boiling acetone for 5 minutes.
- Rinse with DI water of purity of 18 MΩ-cm.

b) Dehydration

- Bake at 120°C for 10 minutes.
- Cool to ambient temperature.

c) Photoresist coating

- Spin at speed of 1000 RPM for 1 second in spreading stage. Then, spinning speed increases to 7000 RPM with the maximum acceration rate and the spin time is 30 seconds.

d) Soft bake

- Bake at 80°C for 10 minutes.

- Cool to ambient temperature.

e) Exposure

- Expose with UV Light at the exposing energy of 10 mJ/cm^2

f) Development

- Dip in the solution of OMR Developer
- Rinse with OMR Rinse Solution

g. Hard bake

- Bake at 120°C for 30 minutes.
- Cool to ambient temperature.

The OMR negative photoresist can be used with all common semiconductor wet etchants processes.

h) Stripe (photoresist removing)

- Immerse substrate in OMR Remover bath.

The remover processing is done at 80°C for 5-10 minutes.

- Rinse with trichloroethylene for 10 minutes.
- Rinse with acetone for 10 minutes.
- Rinse with DI water of purity 18 MΩ-cm.

i) Drying with filtered dry nitrogen gas

Appendix F

Graphite Boat with Lateral Sliding

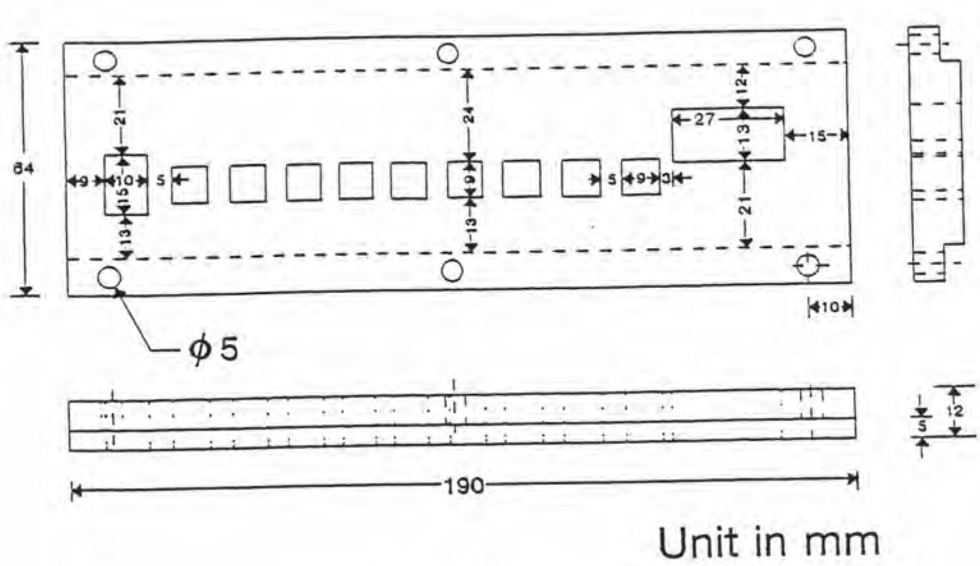


Fig.F.1 The drawing of basement part.

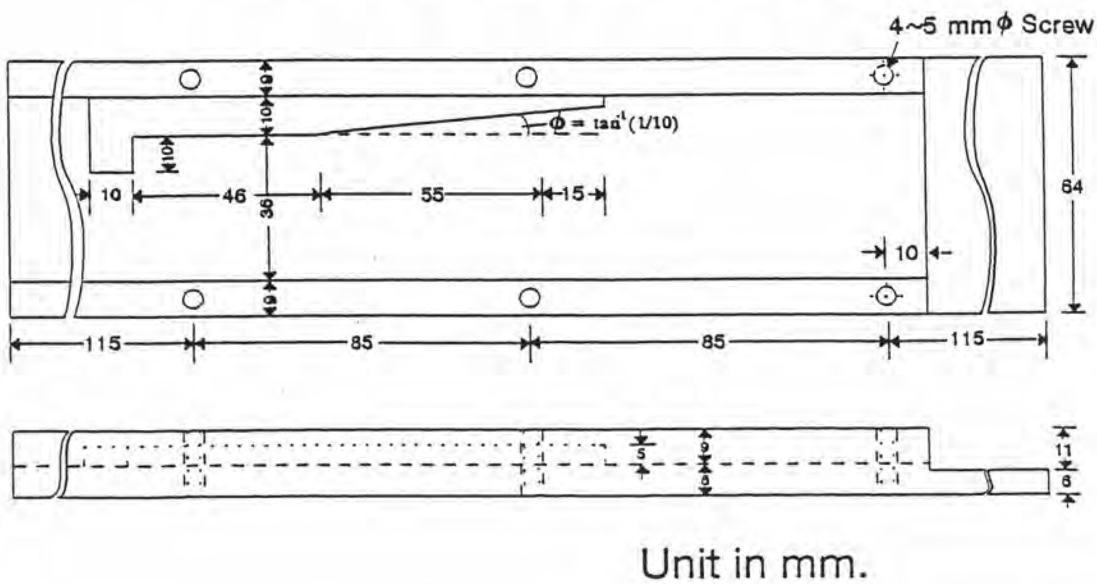


Fig.F.2 The drawing of upper part.

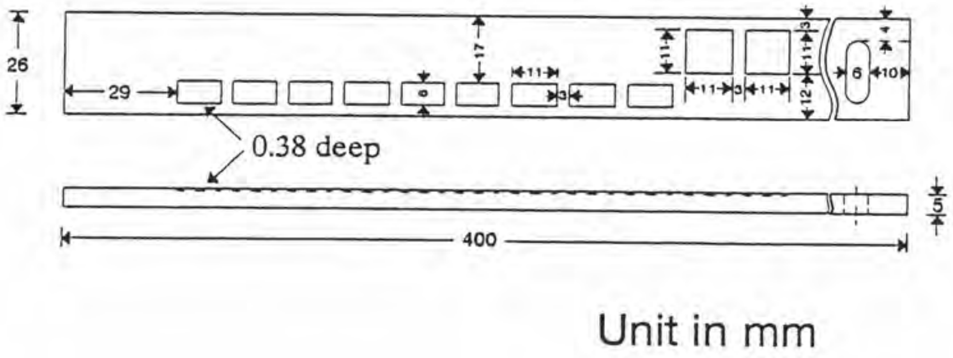


Fig.F.3 The drawing of slider.

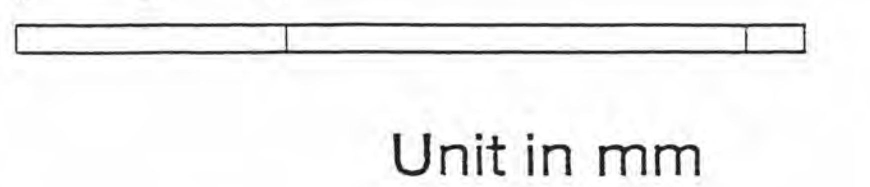
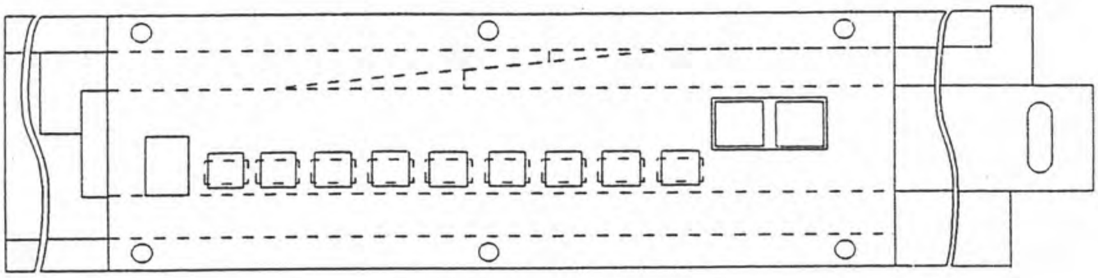


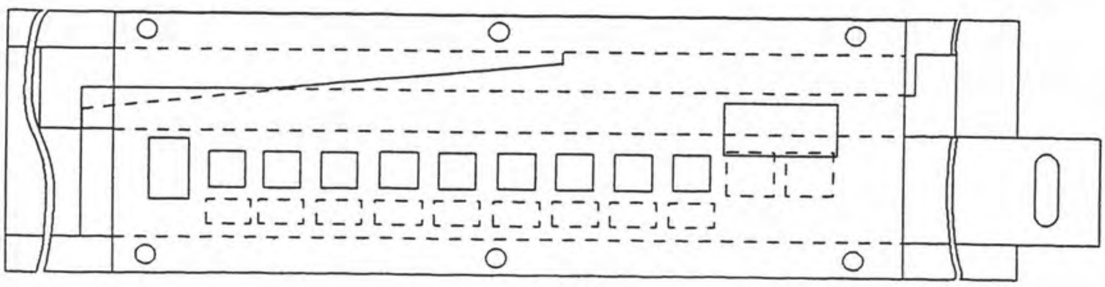
Fig. F.4 The drawing of taper slider.



a)

b)

Fig. F.5 a) The drawing of assembled boat in soaking state.
b) The boat in soaking state which removed upper part.



a)

b)

Fig.F.6 a) The drawing of assembled boat in pre-growth run state.
b) The boat in pre-growth run state which removed upper part.

VITA

Mr. Somchai RATANATHAMMAPHAN was born in Bangkok, on January 22, 1962. He recieved the B.E. and M.E.degrees in electrical engineering, all from Chulalongkorn University, in 1984, and 1988, respectively. In the graduate school, he conducted research on GaAs based optoelectronic devices.

In 1986, he spent a year for study on Molecular Beam Epitaxy (MBE) grown of III-V compound and II-V compound, the quantum well structure of GaSb/AlGaSb and CdTe/InSb, including of study on MBE system design for III-V/II-V heterostructure devices, at WASEDA University, Tokyo, as an international exchange student supported by WASEDA University.

During of 1989-1990, he joined the department of physical Electronics, Tokyo Institue of Technology (TIT) for one year and half, as a research student supported by Japanese Minister of Education (Monbusho). While at TIT, he studied the growth of InGaAsP/InP laser diodes in 1.5 μm range by Liquid Phase Epitaxy and integrated optics using InGaAsP/InP injection lasers.

In 1991, he developed the combied techniques of two-phase solution and supercooling for LPE-Grown GaAs-GaAlAs single quantum well lasers. He is presently engaged in research on GaAs-GaAlAs quantum well lasers on (110)-GaAs grown by Liquid Phase Epitaxy and Molecular Beam Epitaxy.