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Degradation of $Al_xGa_{1-x}As$ Double Heterostructure Lasers

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The large drawback of GaAs-$Al_xGa_{1-x}As$ DH(Double-Hetero structure) junction lasers for practical application is the short operating life. It has been observed in many laboratories that most of the DH lasers degrade quickly, even within minutes, when they are operated in cw. In pulsed operation, Newman et al reported DH lasers lasted 1000 to 5000 hours, but their net operating time was 100 to 500 hours.[1)]

There are many reports concerning the gradual degradation of GaAs homostructure lasers.[2,3)] Only a few reports on the degradation of $Al_xGa_{1-x}As$ DH lasers.[1,4)] Little is known about the mechanism of degradation in these lasers.

This paper reports extensive observations into degraded laser structures, which indicate mechanism of short term degradation under forward bias at room temperature. Diodes were degraded under dc bias, current densities were $(1\sim5)kA/cm^2$. A variety of measurement techniques were developed for this purpose. An S. E. M. (Scanning Electron Microscope) was used in various modes, secondary electron, junction current, X-ray probe or cathode ray emission, to investigate microscopic details of the degradation.

DH layers were grown with the conventional L. P. E. technique and diodes mostly have stripe geometry, with some broadcontact geometry.

It was found that the defects which cause the short term ($\lesssim10^2$ hours) degradation are localized. The defect is a segment of a line or a group of lines, microns to tens of microns long, which seen as a "dark line" in luminescence or junction current observation (Fig. 1).

The dark lines are in the plane of heterojunction, which is on the (001) plane, and they are approximately parallel to either the <100> or the <010> direction in the plane. All degraded diodos have these dark lines in the high current

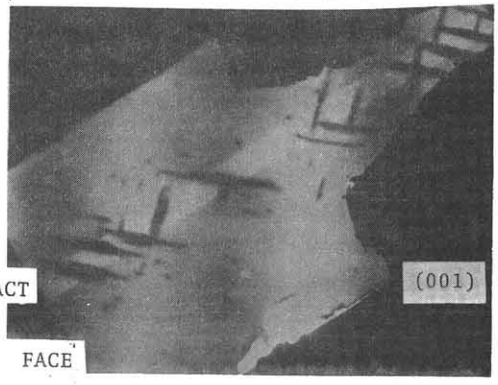

Fig. 1.

density area. The dark lines are similar to ones observed in degraded GaAs diodes by Biard et al.[5)]

Decrease in the intesity of electro luminescence, increase of threshold and change in reverse V-I characteristics are the major symptoms of the degradation.

X ray measurements indicated existence of internal strain at the hetero interface and it is natural to speculate that the strain helped to develop the defect under high current operation. However, difference of degradation rate between groups of diodes made from different crystals indicates the importance of hetero interface. Diodes from improved L. P. E. growth procedure to obtain better hetero interface showed a much slower degradation rate during a hundred hours observation.

Thermally Stimulated capacitance measurement showed no appreciable increase of deep levels with the short term degradation, and it is unlikely that mobile impurity is responsible for the short term degradation as is the case with GaP.

Details of observations as well as results of improved performace will be reported.

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References

1) D.H. Newman and S. Ritchie: IEEE, QE-9, Feb. 1973 will be published

2) H. Kressel and N. E. Byer: Proc. IEEE, 57, 25, 1969

3) H. Kressel et al: Metallurgical Trans. 1, 635, 1970

4) B. Schwartz et al: 4th Int Symp. on GaAs, Boulder, Sept. 1972

5) J. R. Biard, G.E. Pittman and J. F. Leezer: GaAs Proceeding of Int. Symp. (England 1966). pp. 113-117.