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Recent Progress in Semiconductor Lasers

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Recently efforts for semiconductor laser R & D has been expanded remarkably, because optical fiber transmission systems are approaching to practical uses and other applications, like video discs or optical printers, are in the stage of test marketing. The AlGaAs DH lasers for 0.8 μm wave-length range from several manufacturers are already on the market. Research efforts have been shifted to lasers with wave-length other than 0.8 μm, (1.2-1.6) μm and 0.7 μm ranges.

Understanding on major device characteristis, such as modes, spectra, transient responces has made large progress. Experimental as well as theoretical studies on the variety of stripe structures have revealed essential features of the mode controlling mechanism. Single tranverse and single frequency operations are reproducibly obtained in lasers with specially designed stripe structures.

The question to be answered now is "what structure will be the best" in the future. The easiness in structural design and the capability for reproducible mass production will be the most important criterion for selection of the structure.

Studies on degradation mechanisms in the bulk as well as on the surface of the crystal have provided new interests in the solid state physics. A variety of evidence shows that the basic reason for the faster degradation in light emitting devices than those in transport devices, is the "recombination enhancement" effect[1]. However more studies will be reqired to understand mechanisms for individual degradation modes.

Recent studies on the degradation in AlGaAs visible lasers with 0.7 μm wave-length range show remarkably larger degradation rates than 0.8 μm devices made of the same AlGaAs combination[2]. On the other hand $In_xGa_{1-x}P_yAs_{1-y}/InP$ devices for one micron wave-length range show rather small degradation rates. Differences in band gaps in these devices will of course produce defference in the recombination enhancement effect. However other factors, differences in composit materials itself must be examined in order to obtain the over all picture of the degradation mechanism.

The "clean heterostructures" with meterials other than AlGaAs/GaAs combination can be obtained today with several (III-V) mixed crystal combinations, such as $In_xGa_{1-x}P_yAs_{1-y}$/InP or $Al_xGa_{1-x}As_ySb_{1-y}$/GaSb. The perfect lattice matching technique is proved to be effective for obtaining the clean heterostructures at least within (III-V) compounds. Use of multicomponent (over four elements) mixed crystals provides crystals with variable band gaps even under the lattice matching condition.

Such multicomponent crystals also give us another advantage of easiness in lattice matching resulting from "a flexible lattice constant."[3)] There are interests in details of such multicomponent crystal heterostructure and electrical or optical characteristics related with the structure. Further use of multicomponent crystals and their multilayer heterostructure will open a new field of device structure not only for optical but also for electrical applications.

A wide variety of devices can be devised based on the techniques and the understandings obtained during R & D in semiconductor lasers. Visible or infrared light emitting and light receiving devices in even wider wave-length range, components in optical circuits will be developed. High mobilities, expected in some (III-V) mixed materials, will be useful for high speed FETs or integrated circuits. Possibilities to obtain high quality mixed crystals are open not only for (III-V) crystals but also for (II-VI) or other crystal combinations.

1) D. Lang & L. Kimmerling: "Observation of Recombination Enhanced Defect Reactions in Semiconductors", Phys. Rev. Letters, 33, p489, 1974.

2) T.Kajimura, private communication.

3) J.Matsui, K. Onabe, T. Kamejima and I. Hayashi; "Lattice mismatch study of LPE-grown InGaPAs on (001)-InP using x-ray double-crystal diffraction", J. of Electrochem. Soc. 126, p664, 1979.