Digest of Tech. Papers The 10th Conf. on Solid State Devices, Tokyo

B-2-1
(Invited)

GaAs Passivation and MOS Devices

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Surface passivation of GaAs is of importance for opto-electronic devices; laser diodes and light emitting diodes and also for microwave devices; MES FETs. The importance will increase when GaAs LSI emerges practical. Requirements for passivation of the above devices are different. At present, it is still difficult to point out all the conditions necessary to passivate those devices, but may be possible to speak about some evidences which show the necessity for the surface passivation. One of the degradation modes of a DH laser is related to the surface; an irregular oxidation of the facets of the laser cavity. To avoid this degradation, it was shown to be effective to cover the facets with oxide such as Al_2O_3. Another evidence is the instability of the performance of GaAs MES FETs. It is often observed that drain current changes with time after bias voltage is switched on. This type of drift is caused partly from the interface between epi-layer and substrate, and partly from the surface. To eliminate effects from a surface, poly crystalline GaAs or oxide is used.

Thus, the technique of passivation involves the formation of an insulating film on a surface. So far, SiO_2, Si_3N_4, Al_2O_3 and native oxide have been investigated. The technique to form these insulators has a variety; chemical vapor deposition, sputtering, vacuum evaporation, thermal oxidation, plasma oxidation and anodic oxidation. In this paper, these techniques will be briefly compared and properties of the films will be discussed with an emphasis on interfacial characteristics. Particularly, anodic oxide films are to be described in terms of surface states, oxide charges and ions.

Another application of insulating films is a fabrication of GaAs MOS devices such as microwave or high speed GaAs MOS FETs and MOS light emitting diodes. GaAs MOS FETs are interesting since GaAs LSI is hopeful for gigabit logic circuits and MOS FETs have an advantage over MES FETs with better controllability of the threshold voltage, i.e. normally-off type FETs are easy to be fabricated. Low leakage gate current and the possibility of applying positive voltage to the gate are also advantageous.

Recently, GaAs microwave MOS FETs were fabricated in some places. The highest maximum oscillation frequency so far reported is 22 GHz, which was attained by a depletion-type FET. Because of a high density of surface states, a real inversion type MOS FET has not been very successful. The fabrication process, in which some sophistication is necessary owing to the poor chemical property of a native oxide film, is to be presented and the RF performance of the experimental MOS FET is to be discussed. At low frequencies the transconductance is affected by surface states and oxide charges, but at higher frequencies, where surface states do not respond the signal, the characteristics are as good as MES FETs. The comparison between low frequency and high frequency characteristics gives us information of surface states, which can be compared with the one deduced from MOS diodes.

The prospect and some problems that have to be solved in future will be described on the formation of insulating films and GaAs MOS devices.