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Relationship between ionized acceptors density and hole traps in p-type GaAsN grown by chemical beam epitaxy

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1- Introduction

(In)GaAsN is a potential material for fabricating super-high efficiency multi-junction solar cells. Meanwhile, the optoelectronic properties of the new alloy are significantly degraded with incorporating a small amount of N. Such degradation was attributed to the high background doping ($\approx 10^{17}$ cm^{-3}). The first step of our strategy is to discuss the effect of thermal annealing on hole traps and ionized acceptors density by combining the results of C−V characteristic with that of DLTS method.

2- Experiment

In this work, the information provided by deep level transient spectroscopy (DLTS) are combined with that of capacitance-voltage (C-V) characteristic.

3- Results and discussion

The change in acceptor density (N_A) is shown in Fig. 1. There is an increase of N_A after annealing which is explained by the removal of some donor-type defects and/or by the reactivation of some acceptor-type defects.

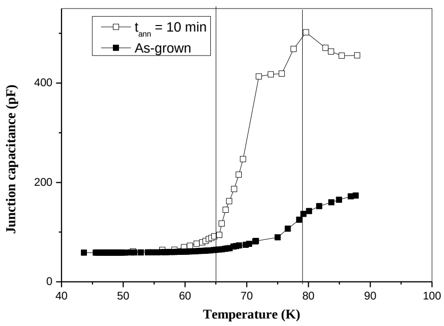

Fig.1: Temperature dependence of the junction capacitance

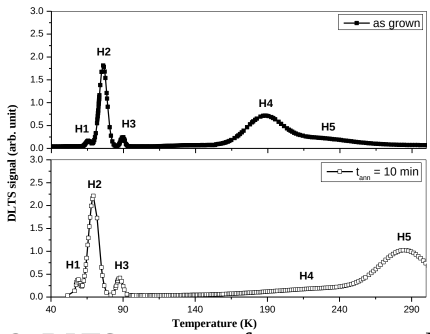

Fig.2: DLTS spectra of as-grown and annealed samples

From the CV measurement of annealed samples, the increase of capacitance by anneal is observed in the temperature range 50-70K. Using DLTS, five hole traps labeled H1-H5 were observed in the film. We found that H2 defect is observed in the same temperature range and its density increases with annealing time (Fig.2). Thus, this trap is expected to determine in great part the acceptor density (N_A).

4- Summary

We correlated between the increase of carrier concentration and the defects densities, to find the defect which causes the background doping in the film. The carrier concentration increased with annealing time in GaAsN films grown by chemical beam epitaxy. H2 acceptor was indicated to play a critical role in determining the background doping.