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TEM Studies of the Structure and Damage Distribution in Boron Implanted Gallium Arsenide

H.C. SNYMAN, J.H. NEETHLING and C.A.B. BALL

Department of Physics, University of Port Elizabeth
Port Elizabeth, South Africa

Boron implantation is a standard technique for isolating active device regions in the production of GaAs integrated circuits. It also now promises to provide an efficient gettering drain for obtaining, through annealing, device quality layers on semi-insulating bulk substrates. Clearly, an understanding of the gettering properties of the implantation damage relies on a detailed knowledge of the crystal damage produced. The purpose of this paper is to report on important new observations of the nature and distribution of such damage by transmission electron microscopy.

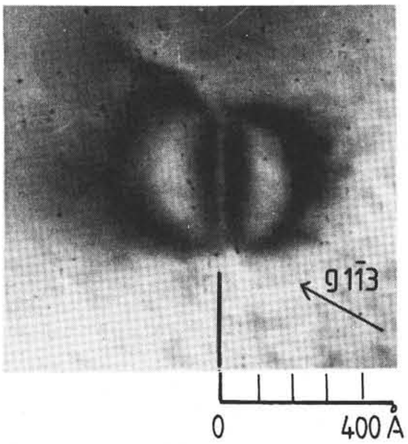
The precipitated damage in boron implanted (10^{15}-10^{16} B^+ cm^{-2}) GaAs annealed for 15 min. in the temperature range 700 to 1000°C was found to consist of Frank interstitial dislocation (see Fig. 1(a)) loops on the {111} planes. The magnitude of the Burgers vectors of the loops were obtained by matching the theoretical image profiles [1] with strain contrast images (for an example see Fig. 1(b)) and found to be in excellent agreement with the expected value of 3,26 Å.

The damage distribution in 300 keV boron implanted GaAs was found to exhibit two definite peaks as shown in Fig. 2(a). The peak of the primary damage distribution, which corresponds to the region of maximum loop density, was found to coincide with the peak of the theoretical damage distribution (at 0,7 μm as shown in Fig. 2(b)), calculated from the application of the Boltzmann transport equation to the atomic straggling process [2]. The position of the secondary band of identified Frank interstitial loops was found to agree with the calculated maximum of the net displaced Ga and As distributions at about 1 μm. This result indicates that the coalescence of recoil interstitial atoms into loops in boron implanted GaAs occurs within the depth region predicted by the Boltzmann transport model and is the first conclusive confirmation of the recoil effect. No microsplits [1] were found in these samples which confirms conclusions of earlier work that hydrogen filled platelets in proton bombarded GaAs lead to cracking on the {110} planes. The technological significance of the findings of this study will be discussed in some detail.

References

1. J.H. Neethling, H.C. Snyman and C.A.B. Ball, Proc. 13th Intern. Conf. Defects in Semiconductors, eds. L.C. Kimerling and J.M. Parsey (Coronado, Aug. 1984) p. 427.

2. M.D. Giles, Dept. of Electrical Engineering, Stanford University, U.S.A. (Private Communication).



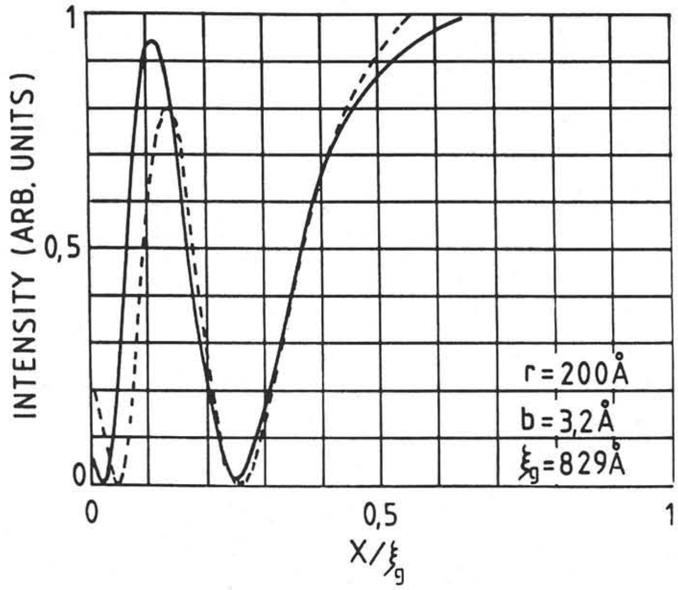
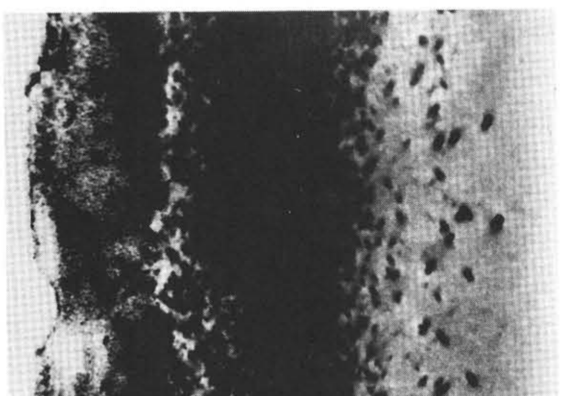


Fig. 1(a) Strain contrast image around Frank loop on {111} plane when viewed edge-on. The beam axis is close to the [$\bar{1}\bar{1}$0] direction.

Fig. 1(b) Matched computed image profile (solid line) and densitometer trace of the loop shown in figure 1(a). The profile was computed for $\underline{s}$=0, b=3,2Å and the loop radius=200Å.



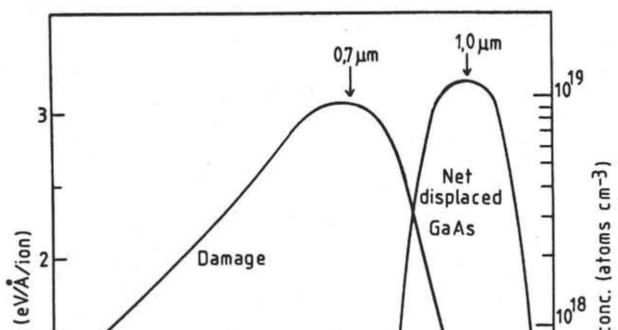


Fig. 2(a) Cross-sectional view of the damage in 300 keV B^+ implanted (10^{16} ions cm^{-2})GaAs annealed at 900°C for 15 min.

Fig. 2(b) Calculated damage and net displaced Ga and As concentration profiles for 300 keV B^+ implants (10^{16} ions cm^{-2}) in GaAs.