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EXTRINSIC ORIGIN OF RECOMBINATION CENTRES AT GRAIN BOUNDARIES IN P TYPE SILICON BICRYSTALS

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The origin of recombination centres at grain boundaries (G.B.'s) $\Sigma 9$ and $\Sigma 13$ in "CZ" grown bicrystals, doped with 10^{15} cm^{-3} boron atoms, has been investigated. L.B.I.C. scan maps at $\lambda = 940 \text{ nm}$ and global capacitive measurements (C-V plots, DLTS) applied to the space charge region of G.B.'s, have been used. The first technic allows the local determination of interfacial recombination velocity S , while the second one leads to average values of energy E_T , density N_T and cross section σ_T of recombination centres of G.B.'s. Doping atoms profiles can also be obtained within G.B.'s.

The results indicate that the two types of G.B.'s, and particularly $\Sigma 9$ have not a noticeable recombination activity in the as grown bicrystals. Annealings at temperatures about 600°C , at least, during several hours are needed to activate $\Sigma 13$ G.B.'s heterogeneously.

The average values of E_T obtained by DLTS are in the range between 0.4 and 0.5 eV. For such values, it was reported that oxygen or SiO_x precipitates could be the source of these deep levels /1/.

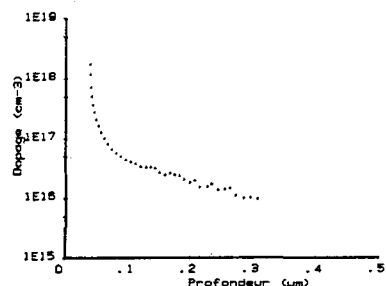
In addition, Batistella et al. /2/ have observed that the activation of G.B.'s is heterogeneous and due to localized recombining clusters.

As the investigated "CZ" silicon contains a large amount of oxygen, it could be assumed that oxygen segregation by G.B.'s explains the enhancement of recombination activity during the annealings. $\Sigma 9$ G.B.'s remain poorly recombining, probably because dopant atoms have been segregated during crystal growth, as suggested by the doping profile within a G.B. given by figure 1.

References

- /1/ K. SCHMALZ, F.G. KIRSCHT, H. KLOSE, H. RICHTER and K. TITTELBACK-HELMRICH, Phys. Status Solid (a) 100 p.567 (1987).
- /2/ F. BATISTELLA et A. ROCHER, Proc. of 6th European Photov.Sol.En.Conf. London, April 1985, pp.113-117.

Fig.1. Net density of negative charges in the space charge region of $\Sigma 9$ GB after annealing at 900°C during 24H.



(1) on leave of the E.N.S. of Takaddoum-Rabat, Maroc