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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  $10^{15} \text{ cm}^{-3}$  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  $\sigma_T$  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  $600^\circ\text{C}$ , 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  $\text{SiO}_x$  precipitates could be the source of these deep levels [1/].

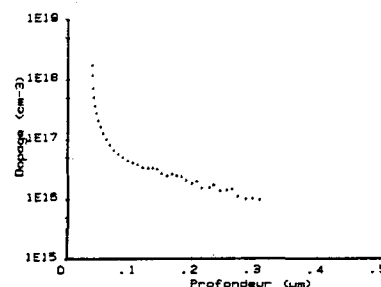
In addition, Batistella et al. [2/] have observed that the activation of G.B.'s is heterogeneous and due to localized recombining clusters.

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

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- /2/ F. BATISTELLA et A. ROCHER, Proc. of 6<sup>th</sup> 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  $900^\circ\text{C}$  during 24H.



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