IN PLANE INVESTIGATION OF SILICON GRAIN BOUNDARIES - MODEL AND EXPERIMENT

M. Stemmer

JOURNAL DE PHYSIQUE IV
Colloque C6, supplément au Journal de Physique III, Vol. 1, décembre 1991

IN PLANE INVESTIGATION OF SILICON GRAIN BOUNDARIES - MODEL AND EPERIMENT

M. STEMMER

Laboratoire de Photoélectricité des Semiconducteurs, Case 231, Faculté des Sciences et Techniques de Marseille, F-13397 Marseille Cedex 13, France

Beam induced current methods as LBIC and EBIC are in use for local characterization of defects in semiconductors. The induced current intensity depends not only on the chararacteristics of the semiconductor but also on the experimental conditions like wavelength for LBIC and primary electron energy for EBIC. Consequently these methods do not allow to assign directly the value of minority carrier lifetime τ or diffusion length L to the material or the recombination strength to the defect.

Different authors calculated LBIC and EBIC signal variations due to the recombination activity of defects like grain boundaries (GBs) /1,2/ or due to bulk recombination /3/ using analytical approaches. These solutions are limited to simple geometries (GB perpendicular to the surface or homogeneous material). For more general configurations the analytical solution becomes to complicated.

We propose a general solution for the problem by means of integration of the continuity equation for minority carriers in excess:

$$\frac{\delta n(r)}{\delta t} = -\frac{n(r)}{\tau(r)} + g(r) - D_n \Delta n(r) \qquad (1) \qquad \text{P type semiconductor}$$

n(r) is the spatial distribution of the minority carrier in excess, τ(r) is the local lifetime and g(r) the generation fonction of electron-hole pairs.

The influence of the space charge region is taken into account by the boundary condition n(z=0)=0.The induced current signal I is given by the minority carriers which cross the edge of the space charge region of the collecting junction.

$$I = q D_n \int \frac{\delta n(z=0)}{\delta z} \, dx\, dy \qquad (2)$$

We simulate a local LBIC intensity by computing the density of minority carrier excess n(r) when a defect is present, characterized by the τ(r) function. Simulated scan lines are obtained by deplacing the generation zone g(r). Then we fitted τ(r) in order to get agreement with experimental lines.

Figure 1 shows the computed LBIC signal due to a GB inclinated by an angle of 5° to the surface for different values of the recombination velocity S variaying from $S=3\cdot 10^4$ cm/s to $S=7\cdot 10^4$ cm/s for λ =797 nm.

Double seed CZ technique yields the investigated P-type silicon GBs $\Sigma 9$ and $\Sigma 13$, oxygen contents is about 10^{18} cm^{-3}. The samples are annealed at 900° C for 48 h in pure Ar flow and shaped in order to get the GB nearly parallel to the surface /4/.

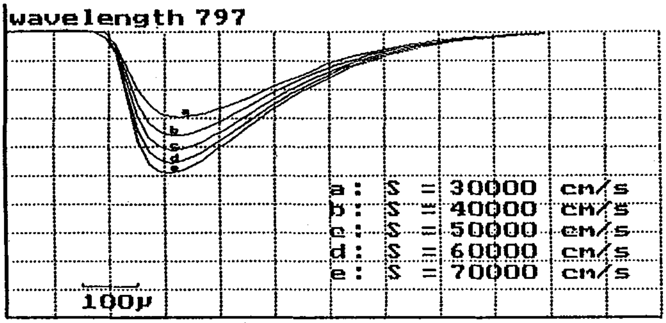

Figure 1 : Simulated scanlines for recombiantion velocities between $3 \cdot 10^4$ cm/s and $7 \cdot 10^4$ cm/s, λ=797 nm.

This geometry allows the investigation of the grain boundary plane and the influence of the recombination activity may be mesured up to some hundreds of microns far from the emergence of the grain boundary to the surface.

The samples are investigated by the LBIC technique at different wavelength (700 nm < λ < 900 nm) . Scan lines are extracted from the two dimensional scan maps and compared with the results of the simulation.

Figure 2 shows the comparison of a mesured LBIC scan line with calculated points for a recombination velocity of $5 \cdot 10^4$ cm/s.

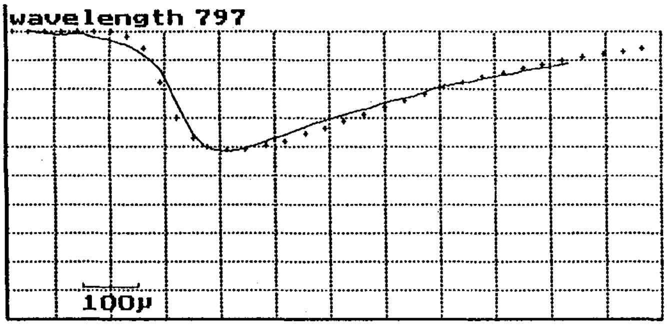

Figure 2 : Calculated points fitted to a mesured LBIC scan line S=$5 \cdot 10^4$ cm/s.

The agreement between mesured scan lines and computed points might be improved considering the influence of the GB on the local lifetime τ(r) far from the defect plane.

The proposed method might also be applied to any other kind of geometrical configuration or other types of extended defect in semiconductor, further work is in progress.

References

/1/ J.D.Zook,Appl.Phys.Lett.37,223,(1980) .
/2/ J.Marek,J.Appl.Phys.55,318,(1984) .
/3/C.Donolato,Solid-State Electronics,31,1587,(1988) .
/4/ M. Stemmer and S. Martinuzzi, communication to POLYSE 90, to be published.