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Comment on « EBIC contrast theory of dislocations : intrinsic recombination properties »

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Résumé. — Nous montrons que les faiblesses mathématiques d'une analyse récente du contraste EBIC (electron beam induced current) d'une dislocation (J. L. Farvacque et B. Sieber, *Revue Phys. Appl.* 25 (1990) 353) conduit au résultat erroné que le contraste n'est pas égal à zéro lorsque l'activité électrique du défaut disparaît.

Abstract. — It is shown that a recent analysis of the EBIC (electron beam induced current) contrast of a dislocation (J. L. Farvacque and B. Sieber, *Revue Phys. Appl.* 25 (1990) 353) has some mathematical flaws and yields the erroneous result that the contrast does not become equal to zero if the recombination activity of the defect vanishes.

In a recent paper [1], Farvacque and Sieber give a theoretical discussion of the formation of the EBIC contrast at a dislocation; in their model, the recombination of excess carriers at the defect is described by introducing in the diffusion equation a drift term due to the electric field E existing in a volume V_d around the dislocation. Although this proposal is interesting, the related mathematical treatment is open to a number of objections. In fact, the modified diffusion equation is not solved, but only used to express the additional drift term through the (unknown) carrier density and its Laplacian; after some manipulations and a specific assumption about the cancellation of two terms, they obtain the following expression for the EBIC signal δI produced by the dislocation :

$$\delta I = - (e/\tau) \int_{V_d} \exp(-z/L) p_0(\mathbf{r}) d\mathbf{r} - eD \int_{S_d} \exp(-z/L) \text{grad} [p(\mathbf{r}) - p_0(\mathbf{r})] \cdot d\mathbf{S} \quad (1)$$

where $p(\mathbf{r})$ and $p_0(\mathbf{r})$ are the densities of excess minority carriers in the semiconductor with the

dislocation and without it, respectively, S_d is the surface bounding V_d , z is the depth coordinate, e is the magnitude of the electronic charge, and D , τ , L are the minority-carrier diffusion coefficient, lifetime and diffusion length in the bulk semiconductor, respectively. Equation (1) corresponds to equation (18) of [1], after correcting an obvious sign error of the first integral; sign errors and/or omissions of factors affect equations (14), (15) and (17) as well.

The purpose of this Comment is to point out that equation (1) yields an erroneous result in the absence of the defect. In fact, in this case $p(\mathbf{r}) \equiv p_0(\mathbf{r})$, and the surface integral of equation (1) vanishes. The term containing the volume integral, however, does not; therefore equation (1) predicts some signal due to the defect even in its absence, a clearly absurd result. The similarity of the first term of equation (1) with the expression for δI previously given by one of us [2] is only apparent, since the original expression contained the factor $(1/\tau' - 1/\tau)$, τ' being the lifetime inside V_d , instead of $1/\tau$ as in equation (1). Therefore δI according to [2] correctly becomes equal to zero if the defect is absent, i.e. if $\tau' = \tau$.

Moreover, Farvacque and Sieber do not apply equation (1) correctly to the particular case of a

dislocation perpendicular to the sample surface. In fact, the surface integral in equation (1) results from a transformation of a volume integral over V_d , and hence involves the internal density $p(\mathbf{r})$, but those Authors determine and use the density outside V_d . The two densities will in general have different gradient on S_d ; specifically, the external gradient, as computed in [1], is different from zero, whereas the internal gradient of p vanishes at S_d (and also everywhere within V_d), because the assumption that « no diffusion of free carriers can occur inside V_d » entails that $p(\mathbf{r})$ should vanish identically for $\mathbf{r}$ inside V_d .

Some of the formulas of [1] as they stand are manifestly incorrect. In the identity (36), the left

term is independent of z , being the result of an integration over this variable; on the contrary, the right-hand side does depend on z through $|\mathbf{r} - \mathbf{r}'|$. The correct identity should involve $[(x - x')^2 + (y - y')^2]^{1/2}$ instead of $|\mathbf{r} - \mathbf{r}'|$; the consequent equations (37), (42) need to be corrected accordingly.

For all these reasons, we caution against the use of the results obtained in [1]. Finally, the claim that « previous theoretical treatments only dealt with qualitative contrast behaviours » is contradicted, for instance, by the work of Pasemann, Blumtritt and Gleichmann [3], which illustrates the determination of the recombination activity of dislocations from contrast measurements through a quantitative contrast model.

References

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