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PROBLEMS ASSOCIATED WITH MODELLING OF RECOMBINATION AT DEFECTS. TEMPERATURE DEPENDENCE OF EBIC AND CL

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(summary of the round table session)

Two trends can be distinguished in the literature on beam injection methods associated with recombination at defects. The first treats the defect mainly as a "black box" which is described by a global parameter characterizing its electronic behaviour, such as the recombination velocity at a grain boundary, the capture radius of a dislocation, etc. The second one attempts to give a direct insight into the physical processes at defects.

These two basic trends have been also represented at the round table. The discussion concentrated around six presentations which are listed below:

1. LBIC analysis for grain-boundary characterization in inhomogeneous materials, H. El. Ghitani and S. Martinuzzi
2. Light beam induced current imaging of the electrical activity of stacking faults in Cz silicon, A. Castaldini, A. Cavallini, A. Poggi, E. Susi
3. Recombination at dislocation levels located in the space charge region. EBIC contrast experiments and theory, J.L. Farvacque and B. Sieber
4. The theory of recombination at dislocations in silicon, P. R. Wilshaw and G. R. Booker.
5. A new approach for the physical interpretation of temperature dependent EBIC contrast measurements, M. Bode and H.-U. Habermeier

The purpose of this short summary is not to comment on the individual presentations, but to give some conclusions and to point out some more general questions which arose during the discussion.

There is still much effort to improve the accuracy of methods for quantitative imaging of defects and for the determination of the characteristic global parameters describing the defects. The determination of the "defect strength" faces many difficulties. One has to take into account the real environment of the defect, the effect of measurement conditions (for example the "defect strength" usually depends on the excitation level), and also the mostly complex nature (shape, structure) of the defect itself. On one hand, the accuracy of determination of the "defect strength" and of the quantitative defect imaging has improved significantly in recent years; this is probably due to the fact that a modern EBIC, LBIC, CL, etc. setup is equipped with a computer or even computer controlled. On the other hand, many questions are still open. For example, there is no satisfying quantitative theory of the EBIC "white contrast" or more complex situations such as the well known "dot-hallo
contrast”. Worth noticing is the work of Farvacque and Sieber (this workshop) on EBIC contrast theory for a dislocation located in the depleted region of a Schottky contact. This problem was ignored in the past.

During the discussion it was emphasized that quantitative assessment of defects by using a characteristic parameter, such as the recombination velocity at a grain boundary, constitutes an important part of applications of the beam injection methods. The purpose of many application of these methods is a “fast” examination of the “defect strength”, without going into a detailed understanding of the recombination processes. In device technology for instance, it may be of importance to know the “defect strength” expressed as a number, for example before and after a defect passivation technological process.

As underlined by many discussion participants, the pure “black box” approach, although very convenient, is not sufficient in modern defect engineering. In their opinion such factors as the history of the whole sample, the history of the defect, its chemistry, etc., must not be ignored. It seems that this aspect of defect assessment will indeed require more attention in the nearest future. There was agreement that correlation of the beam injection techniques with various other measurement methods (for example methods allowing the study of crystallographic structure of defects) is necessary for a solid understanding of the properties of defects.

Noticeable progress has been made in understanding EBIC in relation to the "physics" of dislocations. Until quite lately the existing experimental results differed remarkably from each other, making difficult any meaningful comparison among them, and there was no good theory to describe the observed temperature dependencies of the EBIC contrast of dislocations. Now the situation has improved. It has been shown that the experimental curves, EBIC contrast vs temperature, do have common features and there are now two competing theoretical models both being able to reconstruct the EBIC vs temperature curves. The model of Wilshaw and Booker (presented at the V International Symposium "Structure and Properties of Dislocations", March 1986, Moscow) combines a detailed quantitative description of the recombination process at a charged dislocation with Donolato’s formula for the EBIC contrast. Their model reconstructs not only the temperature dependence of the EBIC contrast but also the observed dependence on the beam current. Another approach has been proposed by Bode and Habermeier (this workshop). They have shown that the temperature dependence of the EBIC contrast can be reconstructed by using Shockley-Read-Hall statistics. In contrast to the work of Wilshaw and Booker they neglected the potential barrier associated with the dislocation charge, arguing that excitation in a SEM-EBIC experiment is high enough to reduce the barrier to a negligibly small value. They have suggested the possibility of using EBIC as a defect level spectroscopy method for single defects. Shockley-Read-Hall recombination was also assumed in the analysis presented by Sekiguchi et al. (this workshop).

As last point of this summary I would like to share my impression that there is no noticeable progress in quantifying the CL technique. CL is a powerful method due to its spectral character combined with high spatial resolution, and therefore any work on CL associated with quantitative modelling of recombination at defects is desirable.