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MAJORITY CARRIER ASSESSMENT BY EBIC: DETERMINATION OF DOPANT CONCENTRATION AT COMPOSITION INHOMOGENEITIES

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The EBIC mode of an SEM has generally been used to measure the minority carrier properties of semiconductors such as diffusion length \( L \). However, also majority carrier properties, i.e., dopant concentration, can be quantitatively assessed by EBIC if due account is taken of the space charge region (SCR) associated with the Schottky or p-n junction used for charge collection /1/. If energy-dependent EBIC /2/ is used, the SCR width \( W \) is obtained by best fitting of the theoretical EBIC efficiency (dependent on \( L \) and \( W \)) to the experimental one. Dopant concentration is then inversely proportional to \( W^2 \). The greatest accuracy in the determination of \( W \) (hence in dopant concentration) is achieved when \( L \) is small (\( \leq 1 \mu m \)). For high values of \( L \) (>3 \( \mu m \)), EBIC efficiency is much less sensitive to \( W \) changes because the diffusion current of the electron-beam-generated minority carriers is much greater than the drift current, which is mainly affected by \( W \), so that \( W \) determination becomes less reliable. The method is, thus, very well suited for the evaluation of the majority carrier properties in low diffusion length semiconductors, like the bulk III-V compounds (GaAs, InP). Moreover, higher sensitivity is achieved for low doping levels (\( \sim 10^{16} \text{ cm}^{-3} \)) than for high doping levels (\( >10^{18} \text{ cm}^{-3} \)). EBIC measurements of dopant concentration at composition inhomogeneities (growth striations) have been carried out in GaAs crystals. Evaluation of dopant density obtained by EBIC has been checked by comparison with the average dopant density measured by capacitance-voltage characteristics in the EBIC Schottky diode, and by measurement of \( W \) as a function of reverse bias. Very good agreement has always been found. The method has also been used to calibrate the photoetching technique in n-type GaAs /3/. It has, thus, been possible to establish the etch rate dependence on dopant concentration which resulted to be exponential over about one decade of dopant density, smaller etching rates corresponding to higher dopant concentration. The latter result is explained as being due to changes in the width of the depletion layer associated with the band-bending at the etching solution-semiconductor interface. In fact, since six (photogenerated) holes are necessary to dissolve one GaAs molecule at the surface /4/, the fewer the available holes the lower is the etching rate. Therefore, low doped regions exhibit higher etching rates than the highly doped regions because the surface depletion layer (where the holes most likely do not recombine) is larger for the low doped regions than for the high doped ones.