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LIGHT BEAM INDUCED CURRENT IMAGING OF THE ELECTRICAL ACTIVITY OF STACKING FAULTS IN CZ SILICON

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ABSTRACT

Microscopic inhomogeneities in the electrical properties of semiconductors are of great importance to device performances, particularly in advanced device technology. Then in the last few years great attention was paid to the processes which can change the material microstructure, and, above all, to the gettering techniques, on account of their wide impact on the overall yield of electronic tailored materials. With this aim, therefore, extended investigations were carried out, mainly by electron and optical beam testing. In this respect, we report here some results of a spectroscopic analysis performed on Si intrinsically gettered samples by a scanning photocurrent microscopy technique[1] similar, in principle, to the light beam induced current (LBIC) method. However, some differences in the experimental set-up have turned out to be fundamental from the point of view of the instrument-sample interaction and, then, of the information obtainable by the induced photocurrent signals. To probe the material, an above-band-gap energy light from an halogen lamp is focused onto the sample, where a Schottky barrier was provided. The light path is intercepted by interferential filters in the visible-infrared range, so as to select the beam wavelength. To probe point-by-point the object, the sample is moved in a raster fashion across a stationary spot. As in EBIC and LBIC methods, the electron-hole pairs generated by the beam give rise to an induced current I(x,y). This current is measured as analog signal corresponding to the irradiated point, amplified by the lock-in technique, converted from analog-to-digital form and, lastly, noise-cleaned by filtering algorithms. This procedure makes it possible to detect current changes as low as 10⁻¹⁵-10⁻¹⁶A.

Since a defect causes a local variation in the photoinduced carrier concentration, it is detected by the induced current changes. It should be pointed out that the investigation method described above and from now on called IRBIC (Infra-Red Beam Induced Current) method, even if very similar to the LBIC one, differs from it for an essential element: the extremely low injection level. The use of an halogen lamp as light source, instead of the laser employed in the LBIC method, gives very low values of irradiance. This gives rise to problems in the signal processing, but, on the other side, generates a very low bulk current level (as low as 10⁻¹⁸A), allowing the detection of current changes equal to some parts per cent of this value. In LBIC mode [2] the rate of above-band-gap photon emission from a 1-mW He-Ne (6328A) laser produces 3.2*10¹⁵photons/sec⁻¹. Usually it is supposed that the beam is attenuated by an amount a=0.01, so that, on impinging the semiconductor surface, 3.2*10¹³ electron-hole pairs are generated per second. In our investigation we examined the samples with a beam power equal to 3.6*10⁻⁸mW. The electron-hole pair generation rate G was calculated by the expression [3]:

\[ G = P\tau q(1-a)/(qE_g) \]

where \( P \) is the beam power, \( \tau \) the quantum efficiency, \( q \) the back-scattering coefficient, \( \tau \) the electronic charge and \( E_g \) the band gap. In our experimental conditions \( G \) is 1.2*10¹⁰sec⁻¹. The intensity of the light impinging on the sample resulted a decisive factor in the imaging the electrical activity of the stacking faults. Moreover, due to the ease of changing the wavelength of the light beam probing the sample, depth profiling of the stacking fault electrical activity was obtained. By this way we detected the occurrence of minority carrier recombination and generation processes at some stacking faults, corresponding, respectively, to dark and bright levels in a grey-shade imaging. A possible explanation based on the presence of fixed charges [4] at the defect-silicon matrix interface is proposed.

REFERENCES