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Laplace-DLTS and its Applications

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Electrically active defects, with electronic states within the band gap of a semi-conductor, can have either a beneficial or a detrimental effect on device operation. For example, if power switches fabricated on Si are implanted with protons to a specific depth, then the defects caused by proton implantation result in an increase of the switching speed. On the other hand, if Si solar cells are exposed to similar proton irradiation, then these defects lead to in a decrease of their efficiencies.

Some defects, in a given semiconductor, may have very similar emission properties. Furthermore, the same defect may have a number of closely spaced defect levels, depending on the stress it experiences or its local environment. For these cases conventional DLTS simply shows a single, sometimes broadened, peak and hence it is not possible to distinguish between these defects. High-resolution Laplace DLTS (L-DLTS) is then required to distinguish between their emission rates.

In this presentation the capabilities of L-DLTS will be reviewed, including the effect of noise and general background transients. Thereafter, examples where L-DLTS was used to distinguish between defects with similar emission rates, will be given for defects in several semiconductors: Si, Ge, GaAs, ZnO and SiC. Some applications of L-DLTS that will be discussed are: For Si co-doped with P, As and Sb we show how the corresponding E-centers can be distinguished and characterised by L-DLTS. The donor level of bond-centered hydrogen in germanium will be discussed. For GaAs the fine structure of the well known EL2 defect is investigated with L-DLTS and compared to previous work. In the case of PLD grown ZnO we show how L-DLTS was used to characterize the E300 and E370 defects. Results will also be presented for the $Z_1^{0/+}$ and $Z_2^{0/+}$ charge states of the Z_1 and Z_2 negative U centers in SiC. In conclusion it will be shown how L-DLTS can be used to study defects with a band-like energy distribution and how to avoid deleterious effects when a strong electric field assisted emission is present.