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Optical investigations techniques used for stacking faults characterization in SiC.

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Stacking Faults (SFs) are important crystal defects in 4H-SiC [1]. They can be electrically active and, in this case, behave as deep quantum well (QW) traps for electrons [2]. This leads to the degradation of high voltage bipolar diodes [3].

The basic origin of SFs in SiC is the small total energy difference between two different polytypes. The net consequence is that they can appear spontaneously, during the growth or after any mechanical or electrically stress. In 4H or 6H-SiC they manifest as a stable lamella of a different polytype, in most cases 3C-SiC [1, 4-5]. 8H-SiC has also been identified [6] but, mainly, for in-grown SFs in 4H-SiC.

Whatever is the faulted polytype, a SF is always associated with a finite thickness and a finite lateral extension in the basal plane. Since the faulted polytype has a smaller bandgap than the one of the host material, they behave like thin natural type-II quantum wells (QWs) embedded in the 4H-SiC matrix.

The binding mechanism comes from the difference in intrinsic band offsets and (internal) lattice polarization between the well and barriers [1, 6]. The difference in internal polarization not only participates in the binding mechanism, it also induces an internal macroscopic electric field in the wells [7, 8].

The experimental value has not yet been exactly determined [9] but the corresponding quantum confined Stark effect lowers the energy of the electrons in the well, the holes remaining in the outer barriers. The QWs are therefore of type II and, at low temperature, the Coulomb interaction binds together to different series of electron-hole (e-h) pairs [10].

The concept of “optical SF signature” comes from the LTPL (Low Temperature PhotoLuminescence) measurements [11] in which regular series of broad, regularly spaced, series of lines have been identified. A typical example is shown in Fig.1. It is extracted from a previous work [9, 12] and concerns 8H SF-QWs in a 4H-SiC matrix.

At 5K, the LTPL spectrum displays four large lines, noted LO, TO, LA and TA. They are indicative of phonon-assisted radiative recombination processes and the corresponding excitonic energy gap (E_{gX}) is equal to 2.672 eV. From TEM results [11] we know that this optical SF signature is associated with a 8 bilayers (BLs) thick 8H lamella which comes from a double combination of double SFs of the type 4SSFs(4,4). For details, see Ref.[13]. Moving from 8H-SF to 3C-SF and even changing the well polytype, not much varies. The only sensitive parameter is the change in energy position of the SF signature which, for a given polytype, should be a direct function of the QW thickness.

In this work, we present a review of recent LTPL, cathode-luminescence and micro-photoluminescence studies that help finding the experimental values of such parameters. For different polytypes and different acquisition conditions, we discuss the optical signature and compare with the result of model calculations. Since a SF is always a finite ribbon of 3C or 8H polytype in a 4H or 6H matrix, with a slightly different crystalline structure but a different internal polarization field, we take successively into account the effect of valence band offset, internal polarization and non homogeneity of the potential well. Finally, in the case of cathodo-luminescence and micro-photoluminescence techniques, we show that some screening of the built-in electric field can be reached.

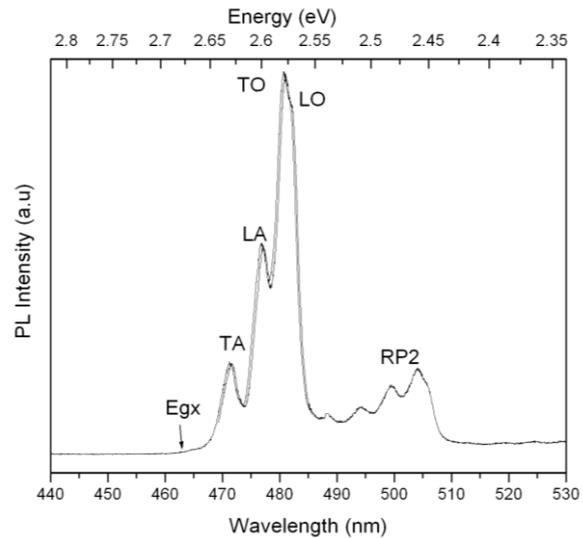


Figure 1: LPTL spectrum collected at 5K on an in-grown stacking fault in a 4H-SiC epitaxial layer. One phonon (TA, LA, LO, TO) and two-phonon assisted recombination lines (RP2) manifest. The optical SF signature is ~ 2.672 eV.

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