Results 2024

The calibration of experimental and analysis parameters for spectroscopic evaluation of Silicon by FTIR has been performed and the first DLTS tests on SiC (as-grown or irradiated with 6MeV electrons) has been performed, shortly described in the following. At this stage of the project, the IR vibrational features of various Si wafers were investigated, including high-resistivity (~10^5 Ω·cm) wafers grown by the Float-Zone and Boron-doped wafers with resistivities of <1 Ω·cm and ~10–30 Ω·cm grown by the Czochralski (CZ) method. All wafers had similar thicknesses, around ~500 µm. The vibrational structure of the samples was investigated using FTIR spectroscopy in transmission mode, with a Jasco 6800-FV-BB spectrometer, samples under vacuum at room-temperature (RT), with a resolution of 4 cm^{-1}, spectra collected as average of 128 independent scans. These tests were conducted to assess which possibly additional extrinsic absorptions interfere with the observation and association of radiation-induced local vibrational modes (LVM).The as-collected scans for all samples are presented comparatively in Figure 1. A simple visual comparison of the spectra enables a series of considerations, which provide guidelines for future specimens:

- *The thickness of future specimens should be confined to 300 – 500 µm to enable high-quality FTIR spectroscopy measurements*;
- *Double-side polished wafers should be preferred as they can allow for more consistent transmission of IR radiation, free from interference from reflection and scattering*;
- A progressive decrease in intensity was observed with the level of p-doping. Above a certain dopant concentration, extrinsic absorptions dominate, making it difficult to identify LVMs induced by irradiation. *p-doped Si wafers with resistivities > 10 Ω·cm are suitable for FTIR spectroscopy analysis.*

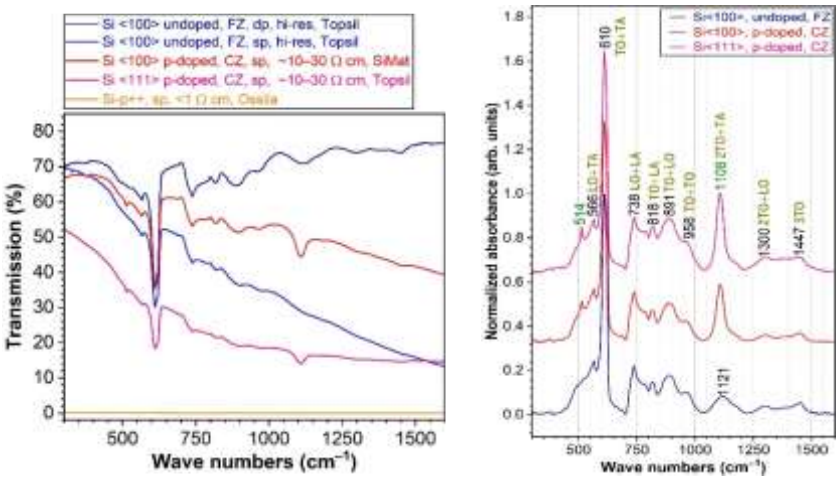

Figure 1. *Comparative FTIR spectra:* ***a)*** *collected in transmission mode for various types of Si wafers: undoped high-resistivity (~10^5 Ω·cm) and p-doped (boron) wafers with resistivities of <1 Ω·cm and ~10–30 Ω·cm, with either <100> or <111> crystal orientations, with single-side or double-side mirror polishing;* ***b)*** *of undoped and p-doped Si.*

Figure 1b presents the spectra of three representative Si wafers – undoped high resistivity and Boron-doped wafers – with different crystal orientations. Several mechanisms contribute to IR absorption processes, which can be broadly categorized into two major classes: (*i*) intrinsic, resulting from the interaction of the IR radiation with the ideal single crystal, and (*ii*) extrinsic, originating from point or extended defects (*e.g.*, vacancies, dislocations, impurities/dopants). The FTIR spectra of Si wafers are dominated by a range of intrinsic phonon absorption bands, including transverse optical (TO), transverse acoustic (TA), longitudinal optical (LO), and longitudinal acoustic (LA) modes, as depicted in Figure 1b. Impurities such as C and O are commonly present in Si crystals, regardless of the fabrication method. C- impurities are substitutional incorporated into Si lattice, with a characteristic LVM absorption band of Si–C at 605 cm^{-1}. O-impurities are interstitially incorporated into Si lattice and produce an absorption band at approximately 1107 cm^{-1}, attributed to the intense antisymmetric stretching vibrations of Si–O–Si linkages. However, both C- and O-

related LVMs are superimposed on intense intrinsic lattice absorption bands, specifically those attributed to TO+TA and 2TO+TA phonons, respectively. A higher concentration of O impurities is indicated by the intensification of the 1108 cm^{-1} band and the appearance of a new, shallow band at 514 cm^{-1} in CZ p-doped Si wafers compared to undoped FZ wafers. The latter one is distinctively associated with Oxygen interstitial (O_i) LVM, a resonant mode involving the motions of Si atoms surrounding the O atom.

We also start DLTS measurements on SiC, as processed p^+-n diodes and irradiated n-type Schottky diodes In Fig.2 are given examples of measured spectra on irradiated n-type Schottky diodes.

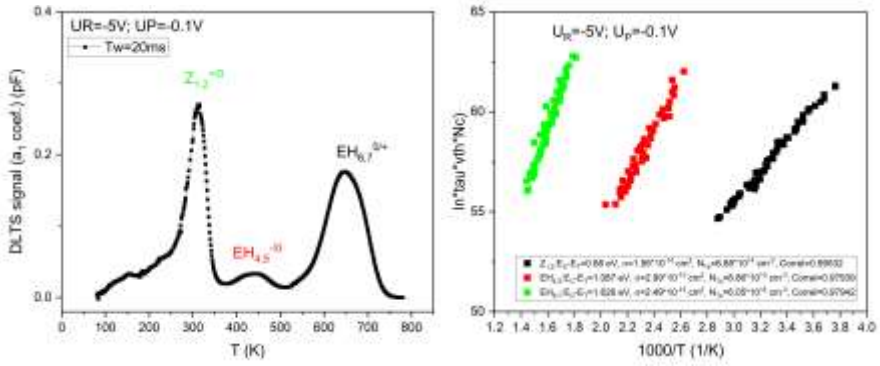

Figure 2. *DLTS spectra for 20 ms time window on Schottky diode irradiated with 6MeV electrons, Φ = $1.5 \cdot 10^{14}$ e/cm^2*