Main results 2011

Activities:

0) **Purchase of equipment and Implantations** (Oven for thermal treatments in Ar or N atmosphere and implantations with O$^{17}$ and C$^{13}$ performed at Helmholtz-Zentrum-Dresden-Rossendorf e.V.)

1) 1) **Samples preparation for EPR investigations and implants with $^{17}$O and $^{13}$C isotopes**

2) **EPR experiments on non-irradiated samples before implantations**

EPR experiments on Cz and STFZ monocrystalline silicon has been performed. The measurements have been performed in the X (9.8 GHz) and Q (34 GHz) bands using Bruker EMX-plus and respectiv ELEXSYS E500Q spectrometers over the 100 - 290 K temperature range.

On both CZ and FZ silicon samples it has been detected an isotrop EPR signal at the detection limit with $g = 2.0060 +/- 0.0003 \Delta H = 0.47 +/- 0.02$ mT. Fig. 1 shows the EPR signal recorded on Cz sample at room temperature in the X band. It is not observed any hiperfine structure of the signal (see inset in Fig. 1). The observed EPR signal, with a S/N~3, have similar characteristics in both X and Q bands, and over the temperature range 100K-290K. Its presence is attributed to the existance of some paramagnetic centers in very small concentration (C<0.1 ppm) in the fundamental quantic state with the electronic spin S=1/2.

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**Figure 1. EPR spectrum on Cz- silicon (un-irradiated) recorded in the X band, at 290K. Inset: detail in he EPR spectrum**

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On STFZ silicon samples a similar but much stronger EPR signal is observed (see Fig. 2 and the inset). The characteristics of this signal are: $\Delta H = 0.48 \text{ mT} \pm/\ 0.02$ and $g = 2.0060 \pm/\ 0.0002$. Cooling the sample to 100K we found a small change in $\Delta H$ ($\Delta H = 0.45 \text{ mT}$) while factor $g$ remains constant. According to the literature and in agreement with our experiments the observed EPR signal can be attributed to Nitrogen impurity.

Figure 2. EPR spectrum on STFZ silicon samples (un-irradiated) recorded in X band, at 290 K and 100K. Inset: detailed view at $T = 100K$.

3) Irradiations with 6 and 3 MeV

The irradiations were performed on 48 samples (STFZ, DOFZ and EPI) with fluences between $10^{12}$ and $10^{15} \text{ e/cm}^2$. The first TSC measurements after irradiation with 6 MeV electrons and fluences $6 \times 10^{14}$ and $10^{15} \text{ e/cm}^2$ on DOFZ and STFZ are shown in Fig. 3 (b, c). The main differences between DOFZ and STFZ samples are given by the Oxygen content shown in Fig. 3a. The TSC peaks labelled in blue are related to acceptors in the lower part of the gap contributing with negative space charge in the space charge region of the investigated diodes. The TSC peaks labelled in red are donors in the upper part of the gap and contribute with positive charge to the space charge region of the diodes.
Fig. 3. a) $O$ and $C$ concentration in several types of Si diodes (STFZ, DOFZ and MCz) according to SIMS measurements; b) TSC spectra on STFZ diodes; c) TSC spectra on DOFZ diodes after irradiation with 6MeV electrons and fluences of $6 \times 10^{14}$ and $10^{15}$ e/cm$^2$. 

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