Measurement of Drifttime and Signalform in a 5 mm Si(Li)-detector

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1 Introduction

In the Silicon Tracker Telescope (STT) for the ANKE-spectrometer a lithium drifted silicon detector with a thickness s of up to 7 mm will be installed. It has a sensitive area of $64 \times 64\,mm^2$ equipped with 96 strips on both sides.
By measuring the drift times in this detector the penetration depth of stopped particles will be deduced. This contribution shows that the drift times could be measured with a shaped signal and the drift velocities could be predicted as described in [1].

2 Expectation

The energy loss in a depleted semiconductor leads to electron-hole pairs in the conducting band. The electric field pulls this free charges towards the electrodes with an average velocity v ([2]). Before the charges reach the electrodes, mirror charges are influenced on these. The overall mirror charge is distributed over all strips of the segmented detector.
Thus one expects a fast, but rather low signal from the mirror charge, which does not change much in time. The signal will increase strongly when the free charge reaches the electrodes. It will finally decrease when no free charges are left in the detector.
This behaviour could be observed by connecting two or more strips together since this should cause a small increase in the mirror charges and no difference on the signal caused by the free charge itself.
Since the α-particles are stopped at the very surface of the detector, the drift time could be calculated by $t = \frac{s}{v}$. By irradiation one or another side of the detector either the electron drift or the hole drift is examined.

3 Experimental Setup

For the test measurements a 5 mm thick Si(Li)-detector was biased over a 1 MΩ resistor. An ^{241}Am source was placed near the detector to either irradiate the p- or n-doped side. The signals of each side were read out over kapton foils and the high voltage decoupling board. One strip per side was selected and connected to the preamplifier [3].
From here the energy output was shaped with a fast timing amplifier with 50 ns integration and differentiation time. The oscilloscope was used to create the delayed coincidence and to generate the plot of the signals.
The detector frame was cooled and several temperature sensors were placed on the setup. This provided the possibility to calculate the detector temperature [1].

4 Measurements

The measurements were done with the environment at room temperature. The cooling temperature has been set at 1, 5, 10, 15, 19 °C and for each temperature several bias voltages have been applied. With the oscilloscope an average of 200 coincident signals were taken. In Fig. 1 an example of such a concident signal is shown.
One can clearly see the fast signal caused by the electrons,

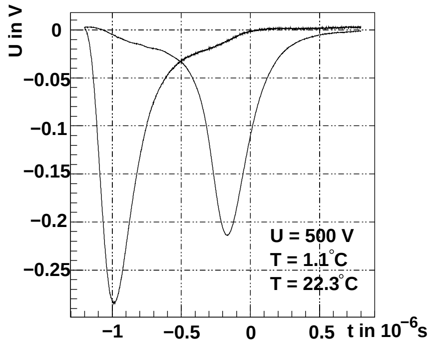

Fig. 1: Signal from ^{241}Am in the 5 mm Si(Li) with $U_{Bias} = 500\,V$ and $T_{liquid} = 1\,°C$.

since the n-side is irradiated. The holes need to drift through the detector and cause the delayed signal. The signals caused by the mirror charges are also clearly visible in the plot, too.
The peaks are localised and the drift times measured (In Fig. 1 the measured drift time is 833 ns). The comparisation with the expectation shows an agreement better than 10% (see Fig. 2).

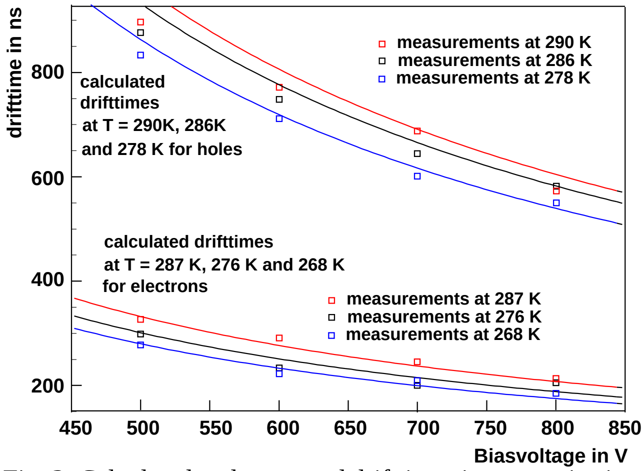

Fig. 2: Calculated and measured drifttimes in comparisation.

These measurements show, that the drift velocities can be stabilised by using the cooling temperature and the bias voltage as free parameters. This method allows to measure the drift time with a precision of ≈ 60 ns for the holes and ≈ 30 ns for the electrons. This corresponds to a systematic error of less than ±0.5 mm in penetration depth.

References:

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