Introduction

Conventional Time-of-Flight method (TOF) is used for the measurement of charge carrier mobilities. It was widely used by many workers for various detectors material characterization including CdTe and CdZnTe. Some of the first results on a high-resistive CdTe were obtained by K. Zanio et al. in 1998 [1]. By this method, the transit time of charge carriers generated close to one of electrodes is measured. Charge carrier can be produced by a pulsed electron beam, a fast laser pulse or by n-particles. Charge carrier mobility can be calculated by formula (1). In addition to the mobility, µ, one can measure a drift time, τ, or drift is calculated and can be calculated with using of the Hecht relation [2] for a charge collection efficiency, η. For a single charge collection in the planar detector, uniform electric field distribution and with ignored detrapping of charge carriers this relation will be (2).

Free drift length is equal to \( d \), where \( E_n \) is the uniform electric field intensity, \( U = E_n d \).

\[ \eta = \frac{1 - \exp \left[ -\frac{d}{\mu \tau} \right]}{1 - \exp \left[ -\frac{d}{\mu \tau} \right]} \]  

(2)

\[ \mu d \tau = \frac{1}{\eta} \]  

(1)

Influence of the \((\mu\tau)\) product nonuniformity

Shall consider only nonuniformity of \((\mu\tau)\) product dispersed by the detector area, single charge collection and uniform electric field distribution. Also we assume, that the distribution of values of \((\mu\tau)\) by the detector area submits to the normal Gaussian law of distribution (4).

\[ \phi(\mu\tau) = \frac{1}{\sigma \sqrt{2\pi}} \exp \left[ -\frac{(\mu\tau - \mu_0)^2}{2\sigma^2} \right] \]  

(4)

A distribution of drift lengths \( d \) by the detector area will also submit to the normal law of distribution with dispersion of drift lengths \( \sigma_d \). Let the value \( \sigma_d \) will be \( \sigma_d = \frac{d}{2\sqrt{2\pi}} \), where \( d \) is the non-dimensional parameter and \( \sigma \) is the average value of drift lengths. Parameter \( \mu \) define a degree of nonuniformity of drift lengths. Such replacement of variable allows to keep a given degree of nonuniformity at variation of dispersions of drift lengths.

For the uniform electric field distribution, charge collection efficiency \( \eta \) will be described by the Hecht equation for single charge collection (3). As the charge collection efficiency \( \eta \) is a function of a normal distributed random value \( \eta \), it is possible to determine density of function of the charge collection efficiency.

\[ \eta = \frac{1}{\eta} \]  

(3)

Measurements

The carrier drift time is usually measured by the rise time of the pulses from the charge sensitive preamplifier output. Presence of a ramp or a smoothly increased with one characteristic time output signal front can testify to presence of an uniform electric field distribution in the detector volume. Distorted output waveform can be a result of various nonuniformities inside of the detector volume.

Usually used method to estimate the value of \( \eta \) product is to measure charge collection efficiency as a function of the applied bias voltage \( V_f \). In practice can be measured a peak position in channels as a function of the applied bias voltage \( A(U) \). \((\mu\tau)\) product can be obtained from the measurement data by a curve fitting procedure.

There is other way of more simple direct calculation. It can be shown that with using of the Hecht relation (2) \((\mu\tau)\) value can be calculated as (5):

\[ \mu \tau = \frac{1}{\ln \left( \frac{d}{\mu \tau} \right)} \]  

(5)


Main results and conclusions

- Suggested modified methods for \( \eta \) product values calculation from the measurement data of \( A(U) \) and \( \eta \).
- Suggested \( \eta \) values calculated from the measurement data of \( A(U) \) by a curve fitting procedure as well as by using of expression (4) are depending on applied bias voltage. It can be caused by a presence of nonuniformity inside of the detectors. Value peaks presented in the measured \( A(U) \) spectra testify to presence of the nonuniformity.
- Coefficient of variation \( \sigma \) product values calculated by two methods may be evidence of the data.
- Use of too short preamplifier time leads to an additional error with using measured data of \( A(U) \), especially at low bias voltages.
- At very low bias voltage charge collection is depressed by the presence of a contact voltage drop.
- At high bias voltages there is influence of increased noise.
- Other possible sources of errors can affect the \( \eta \) product calculation.
- Non uniform electric field distribution inside of the detector volume. Uniform electric field distribution corresponds linear output signal form.

Not uniform detector output window. It must be uniform, sufficiently thin and does not depend on the applied bias voltage.
- Too small shaping amplifier shaping time. It must be longer than the charge carrier drift time.
- Too short preamplifier output signal fall time constant. It must be much longer than the charge carrier drift time.
- Unwanted charge carriers detrapping process.
- Plasma effects connected with the high density of electrons-hole pairs along the-particle track especially at low bias voltages.

**References**