Laser Induced Transient Current Waveforms in CdZnTe Coplanar Grid Detectors

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Introduction:

Coplanar grid detectors (CPG) are large volume cubic shape CdZnTe detectors with characteristic anode structure that constitutes of collecting and non–collecting grids designed in parallel meandrous structure. It can be used as a very sensitive gamma ray detector with excellent spectroscopic performance [1]. We have developed a gamma radiation detection instrument based on CPG CdZnTe detector with charge sensitive integration detection amplifier and a differential amplifier in the Institute of Physics. Standard pulse shaping amplifier and pulse height analyzer is used to record the spectrum with the resolution of 2% of the Full Width at Half Maximum (FWHM) at Cs 137 (662 keV). The determination of internal electric field profile and the charge collection efficiency belongs to important tasks in any semiconductor radiation detectors characterization. Transient Current Technique (TCT) is used as a standard method for this purpose [2, 3, 4]. Laser induced transient current technique (L–TCT) uses direct oscilloscope triggering taken from the driving generator so that it provides much higher signal to noise ratio in compare to non–synchronized sources (e.g. alpha particles) and no plasma effect influence on the current waveforms shape.

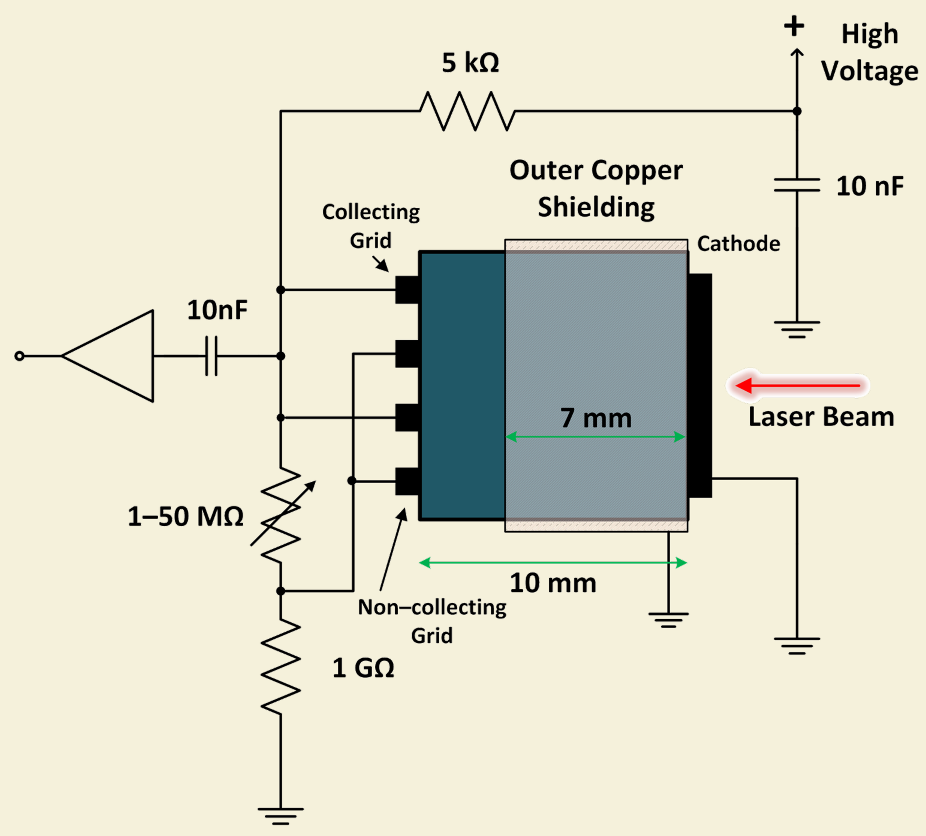

Fig. 1.: Block diagram of the coplanar grid detector wiring for L–TCT measurement with the integrid voltage control by the resistor divider. The equipotential outer copper shieldig is given schematically.

Experimental setup:

Our L–TCT experimental setup is based on the direct high frequency voltage amplification of the AC coupled detector current waveform (CWF) [2,5] that is recorded by using ultrafast digital sampling oscilloscope (40 Gs/s, resolution up to 11 bits, 4 GHz bandwidth). We also have the possibility of precise detector temperature control and stabilization in the range from 265 to 350 K. Short optical pulses (3 to tens of ns) are emitted by the laser diode (660 nm) that is powered by the ultrafast pulse generator (300 ps risetime). Adjustable collimation optics was used to focus the laser beam onto ≈ 3 mm^2 examined spot in the center of the cathode and the light intensity was attenuated by the neutral density disc filter. Due to the direct oscilloscope triggering very low level CPG detector L–TCT CWFs even with high content of additive noise component (particularly in case of the low bias) can be recorded. Intergrid voltage between collecting and non–collecting grid was realized by using a voltage divider of the detector bias (see Fig.1). Equipotential close–fitting outer shielding by a copper foil was used to examine its influence on the internal electric field intensity profile.

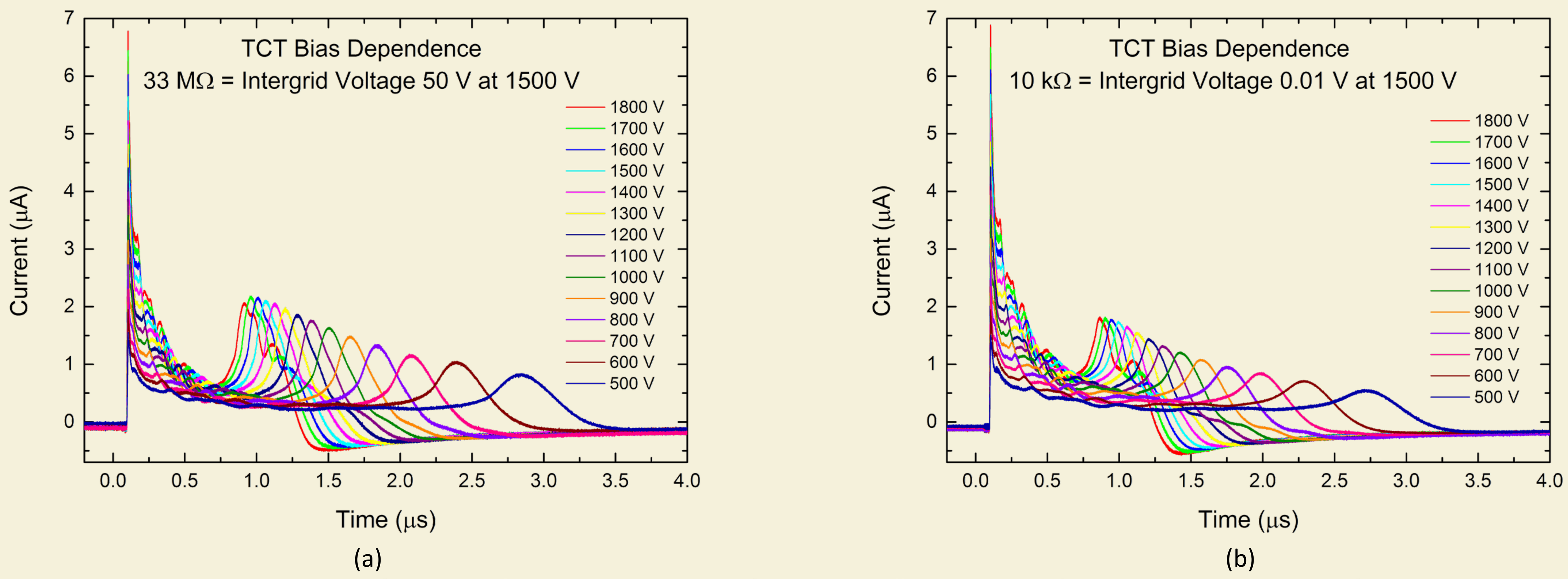

Fig.2: Bias dependence of L–TCT electron current waveforms on collecting grid of CPG CdZnTe detector for the intergrid voltage 50 V (a) and 0.01 V (b) at 1500V . Intergrid voltage is proportional to each detector bias value due to the voltage resistor divider.

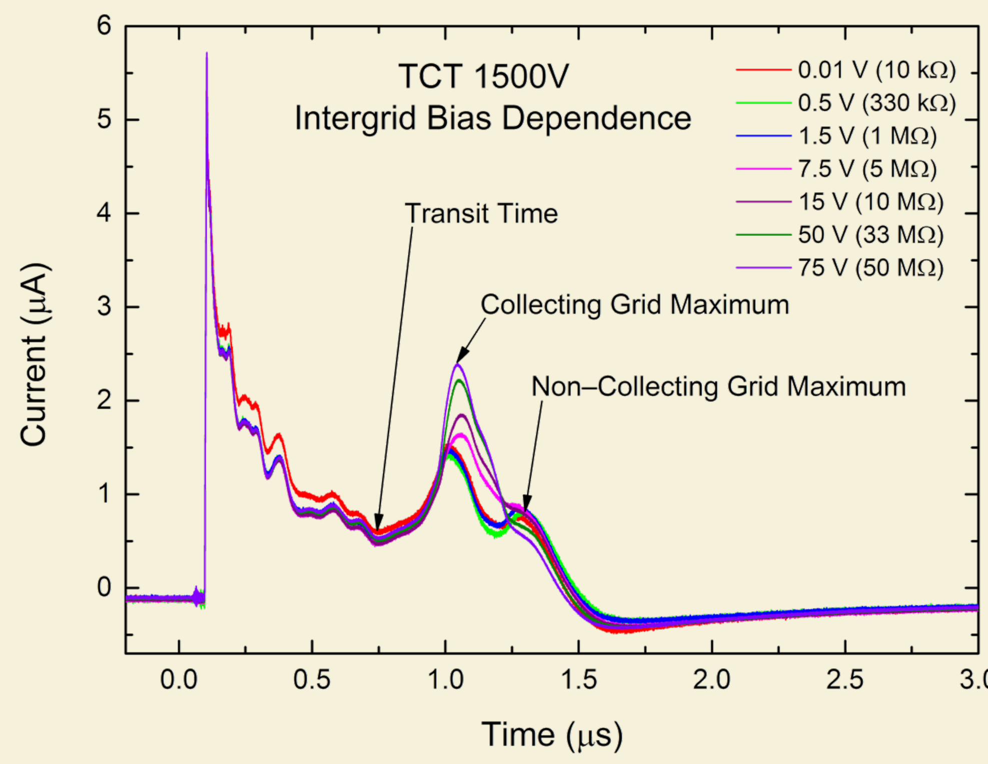

Fig.3: Intergrid voltage dependence of the current waveforms shape at 1500 V.

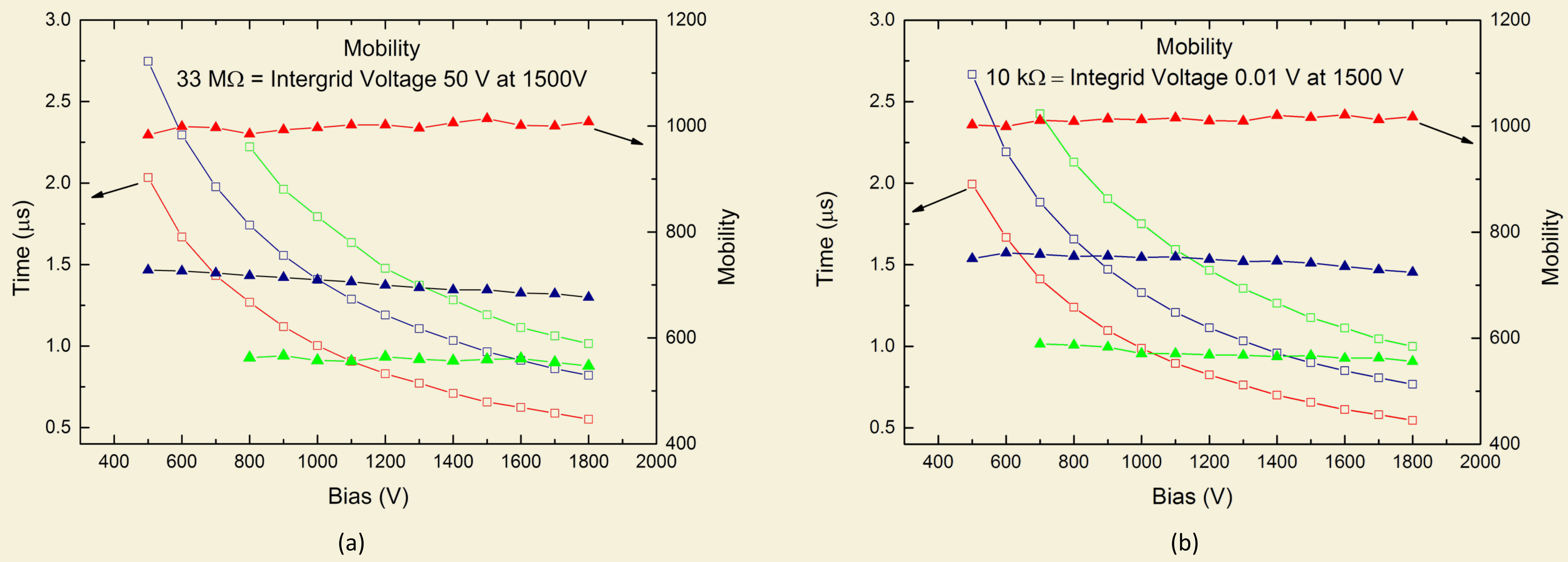

Fig.4: Bias dependence of the mobility values for the intergrid voltage 50 V (a) and 0.01 V (b) at 1500 V determined for the transit time (red) in minimum and in collecting (blue) and non-collecting (green) grid maximum.

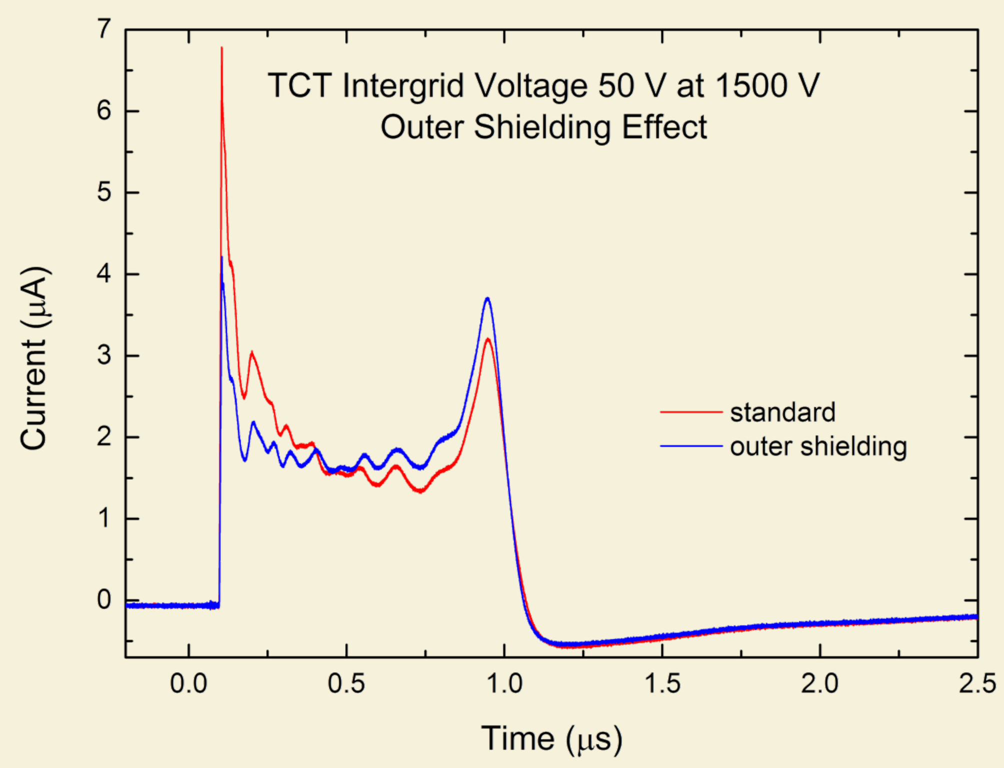

Fig.5: The equipotential outer copper shielding influence on the current waveform shape

Results:

- It was found, that L–TCT electron CWFs on coplanar grid CdZnTe detector can be measured from 500 V to 1800 V (500 to 1800 V/cm) bias very reliably. Specific CWF shape recorded on collecting grid consists of 2 variable intensity maximum that suggest to be interpreted as collecting and non–collecting grid origin
- Correct transit time readout to determine the mobility value and its bias dependence (see Fig.4 (a) and (b) – red) was found in the CWF minimum for non–shielded detector (see Fig.3). Mobility value was also determined for probable collecting and non–collecting grid CWF respective maximum (see Fig.4 (a) and (b) – blue and green)
- No remarkable intergrid voltage dependence on the determined mobility values was found (compare Fig 3. (a) and (b))
- Partial equipotential close–fitting outer copper foil shielding of the detector volume influences the CWF shape markedly. Electric field intensity profile in the detector does not decrease as in case of non–shielded coplanar grid detector (see Fig.5)

Reference:

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