Cadmium Telluride (CdTe) X-ray detectors with different passivation dielectrics

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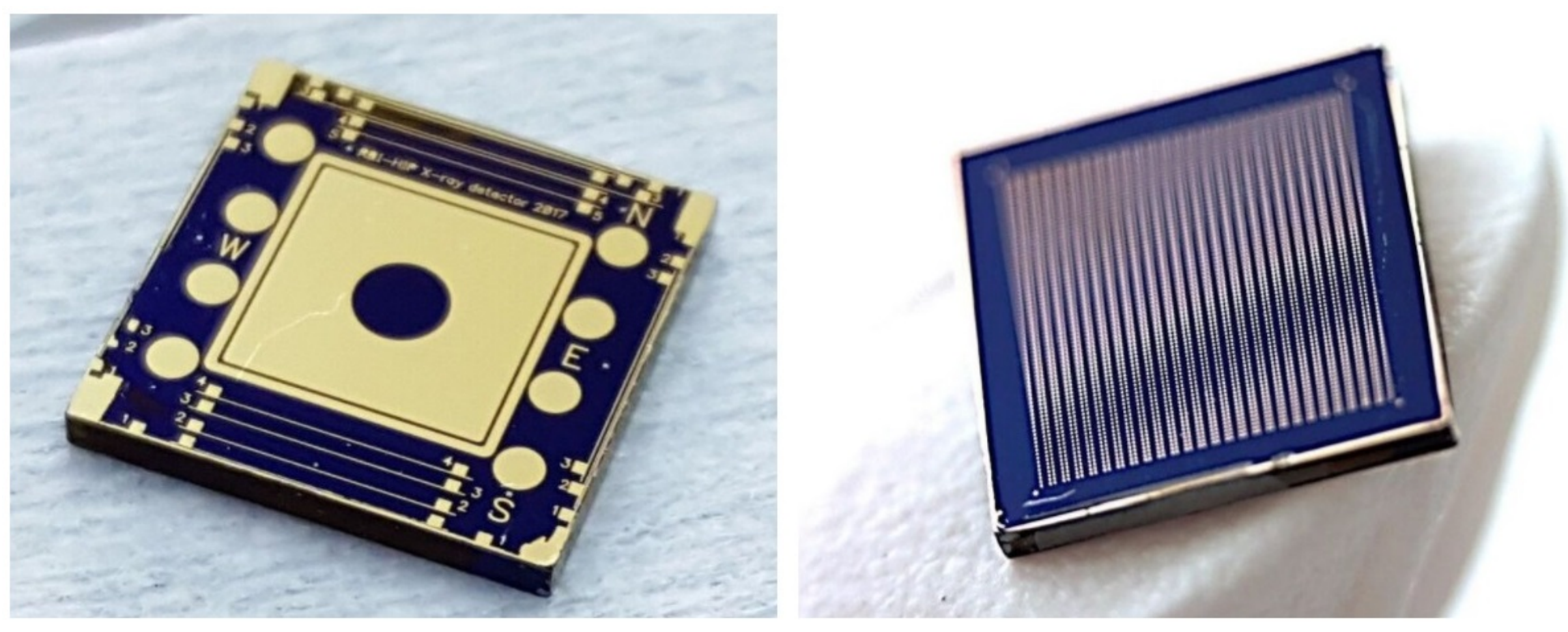
INTRODUCTION

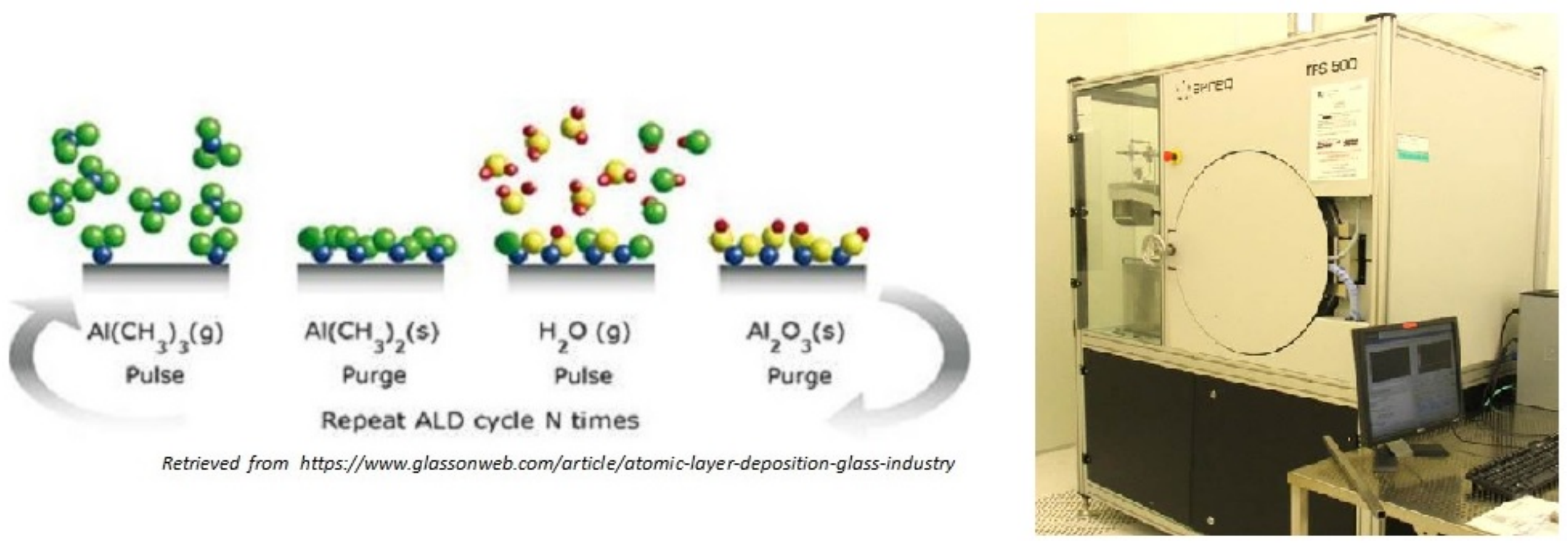
CdTe is a potential semiconductor detector material that allows direct X-ray and γ-ray conversion energy resolution measurements and if segmented, simultaneously spatial resolution. In our earlier work, we have demonstrated the fabrication of CdTe pixel detectors and Flip-Chip interconnection technology with CMOS ASIC used widely in Compact Muon Solenoid a particle physics experiment. We have investigated the influence of the two different dielectric passivation layer materials on the detector performance. For this purpose, pad detectors (a diode without segmentation) design with test structures on the same chip have been processed at the Micronova Nanofabrication Centre cleanroom facility in Espoo, Finland.
The electrical properties of the detectors obtained with this process were characterized by IV-CV and TCT methods. Prior to processing, the quality and defect density in CdTe material was characterized by infrared spectroscopy.



The reported CdTe pad (left) and pixel detectors (right).

PASSIVATION

We have studied two common thin film deposition methods used in semiconductor industry: sputtering to provide aluminum nitride (AlN), and atomic layer deposition (ALD) to grow aluminum oxide (Al_2O_3). Dielectric thin films deposited by ALD are widely used in the microelectronics industry and have been proposed to be used for fine pitch silicon pixel detectors. In this context, we have investigated their applicability to CdTe detectors as conformal, double-sided passivation coatings grown at relatively low temperature < 200° C.

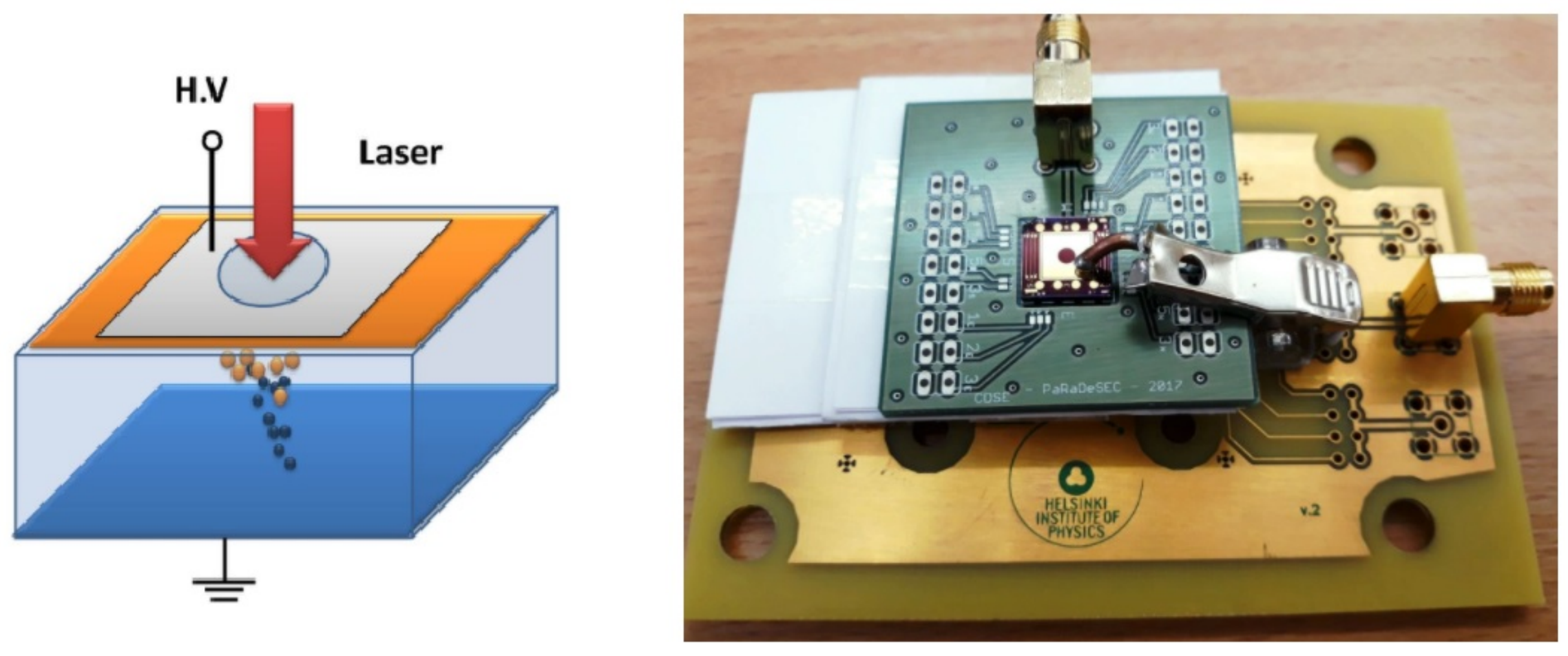


Retrieved from https://www.glassonweb.com/article/atomic-layer-deposition-glass-industry

The ALD cycle (left) and the tool we used (right).

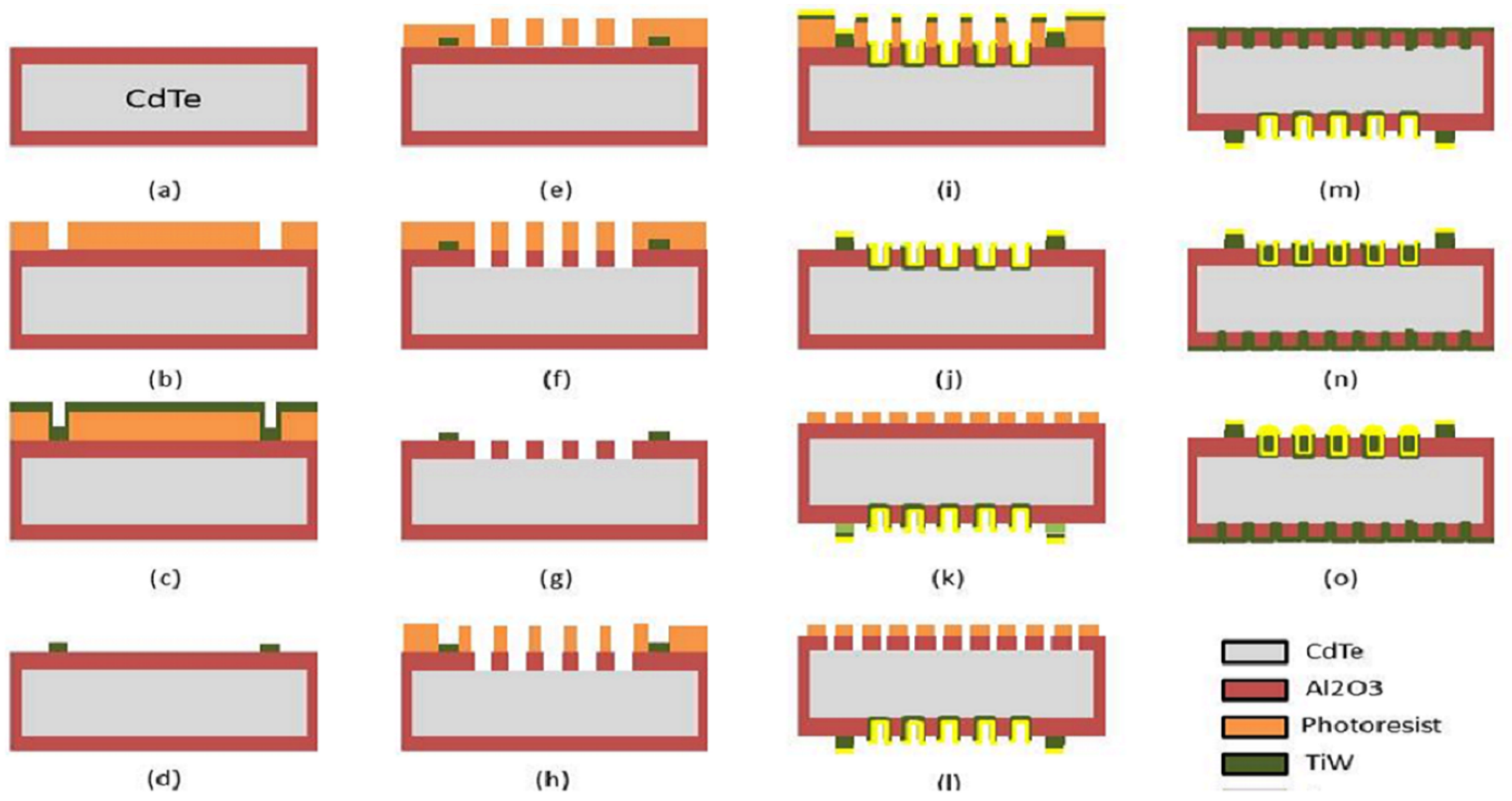
TCT MEASUREMENT

Transient Current Technique (TCT) measurement stands for illuminating a semiconductor detector by a pulsed laser for which the light absorption depth is a few micrometers, or alternatively e.g. by alpha particles. Under these circumstances, only one type of charge particles (electrons or holes) can drift across the the entire detector thickness. The current transients are recorded by an oscilloscope and parameters related to the device physics can be extracted. These include depletion voltage, effective carrier trapping, charge collection time and sign of the space charge. This promotes understanding of charge transport properties occurring in technologically challenging materials, such as CdTe.



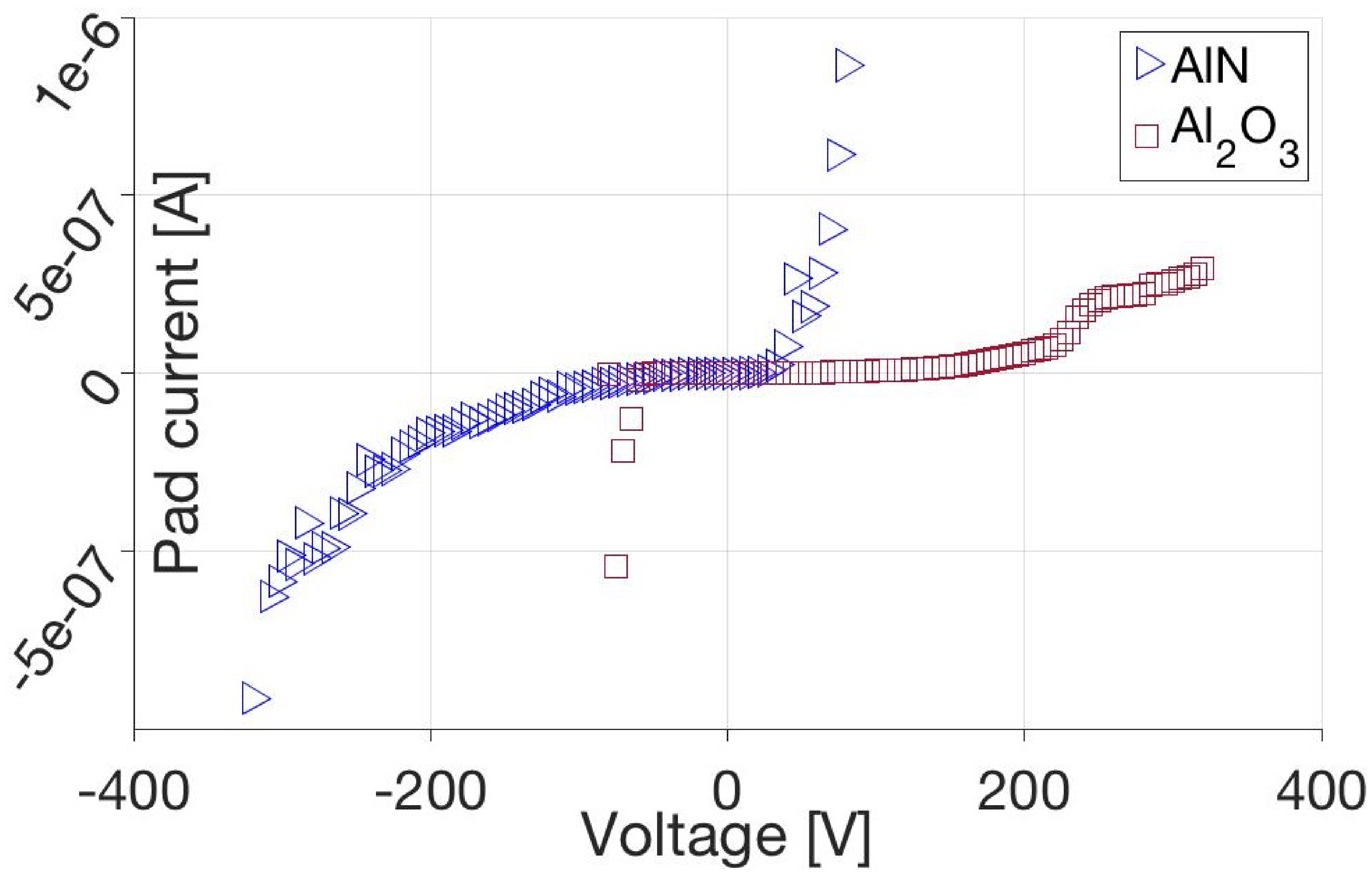
Front side illumination of the detector with a red laser ($\lambda = 670$nm, penetration depth of a few μm) (right), CdTe detector attacher to a read-out board (left).

PROCESS

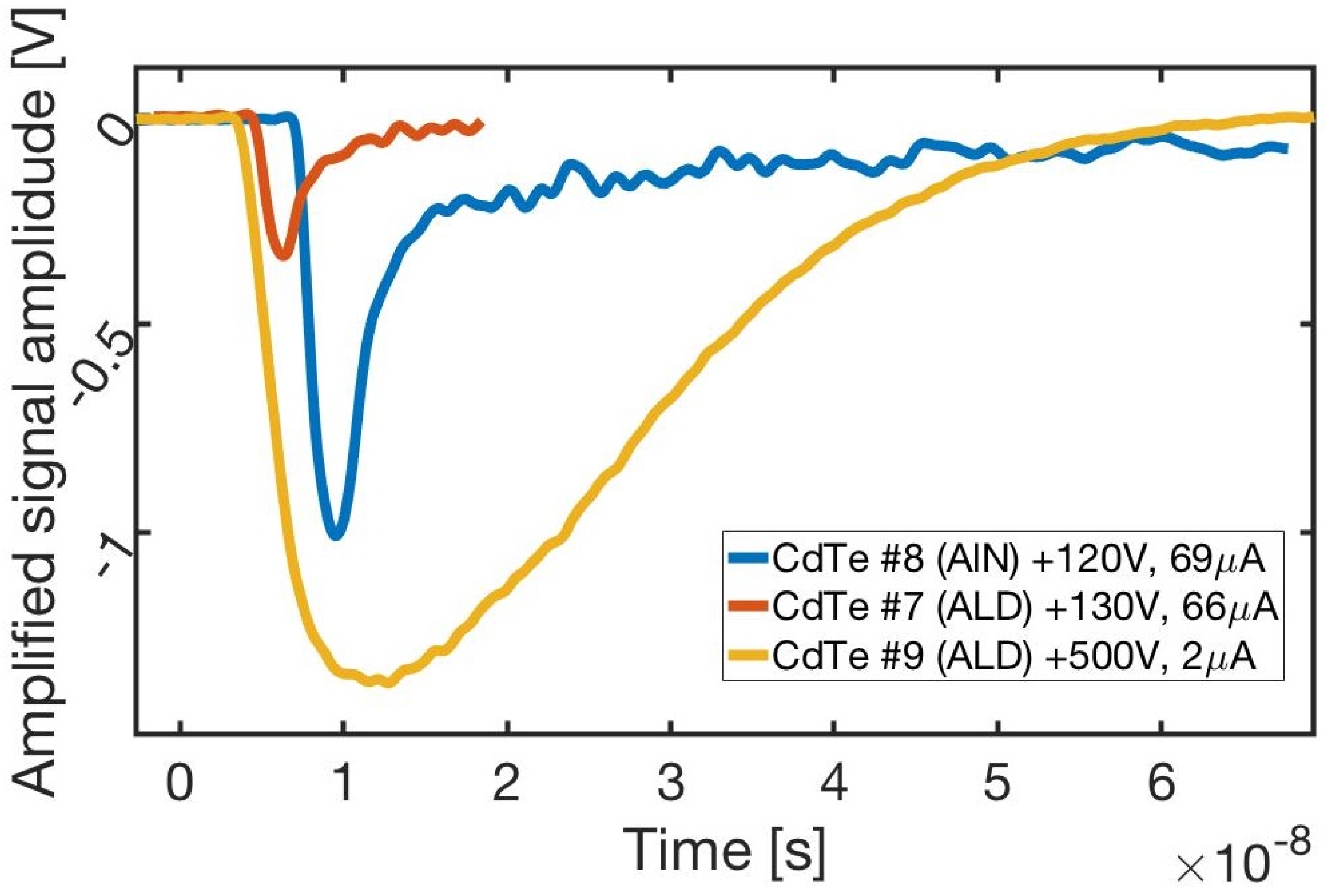


Al_2O_3-passivated CdTe sensor process flow; steps are given in alphabetical order.

IV AND TCT MEASUREMENT RESULTS



IV characteristics at room temperature of the CdTe pad detectors (10 x 10 x 1 mm^3), with different passivation.



TCT signal from the CdTe pad detectors with the different types of passivation layers.

SUMMARY

CdTe pad detectors were fabricated using sputtered AlN or ALD alumina for passivation layers. IV and TCT characterization suggests that the electrical properties of the detectors is influenced by the choice of passivation material. The measurements indicate that the leakage current and the signal intensity are dependent on the dielectric material. The atomic layer deposited Al_2O_3 exhibits excellent properties as passivation material for CdTe detectors.