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GaAs:Cr X-ray sensors noise characteristics investigation by means of amplitude spectrum analysis

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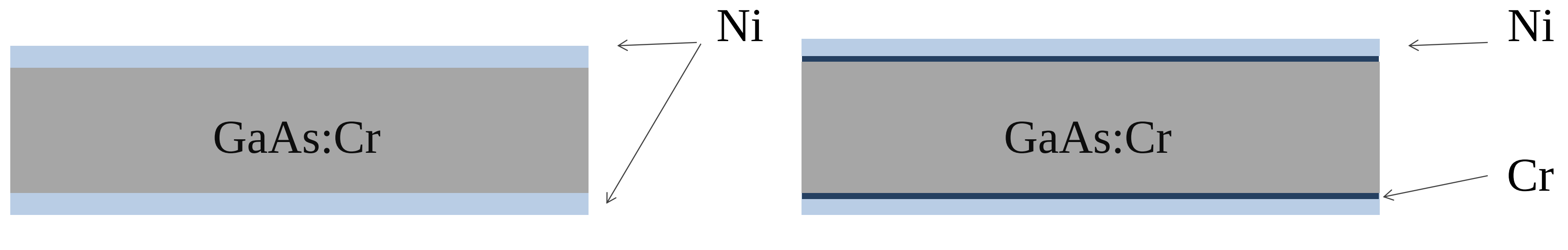
Investigated Structures

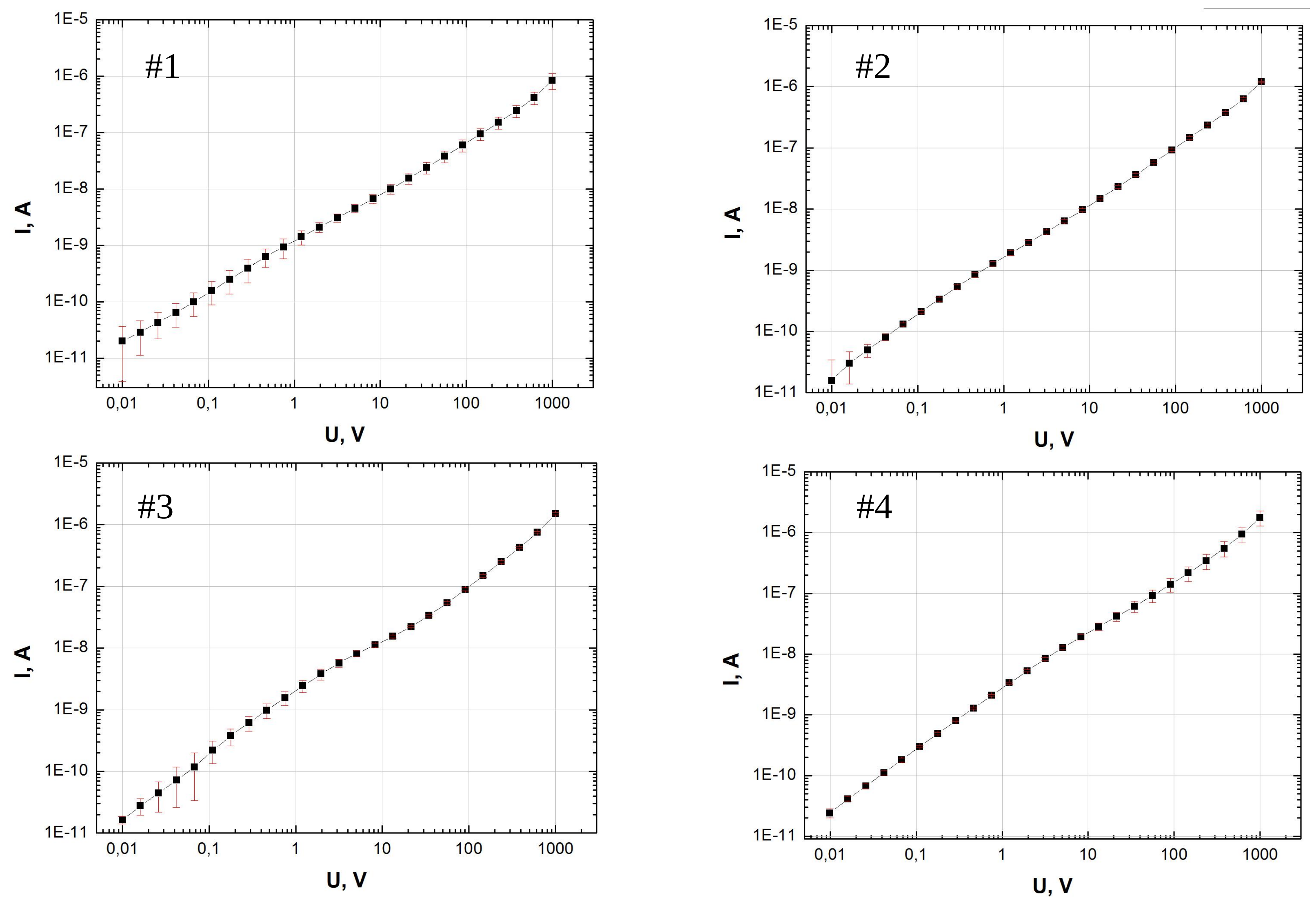
Four GaAs:Cr wafer were chosen to make investigated samples. For wafers #1 to #3 contacts were made during electroless deposition of Ni. For wafer #4 we used electron beam evaporation of two layers: Cr (20nm) and Ni (0,1um).When contacts were created pad sensors with active area size 0,09 cm^2 were made. The thickness of investigated structures was 500 um.



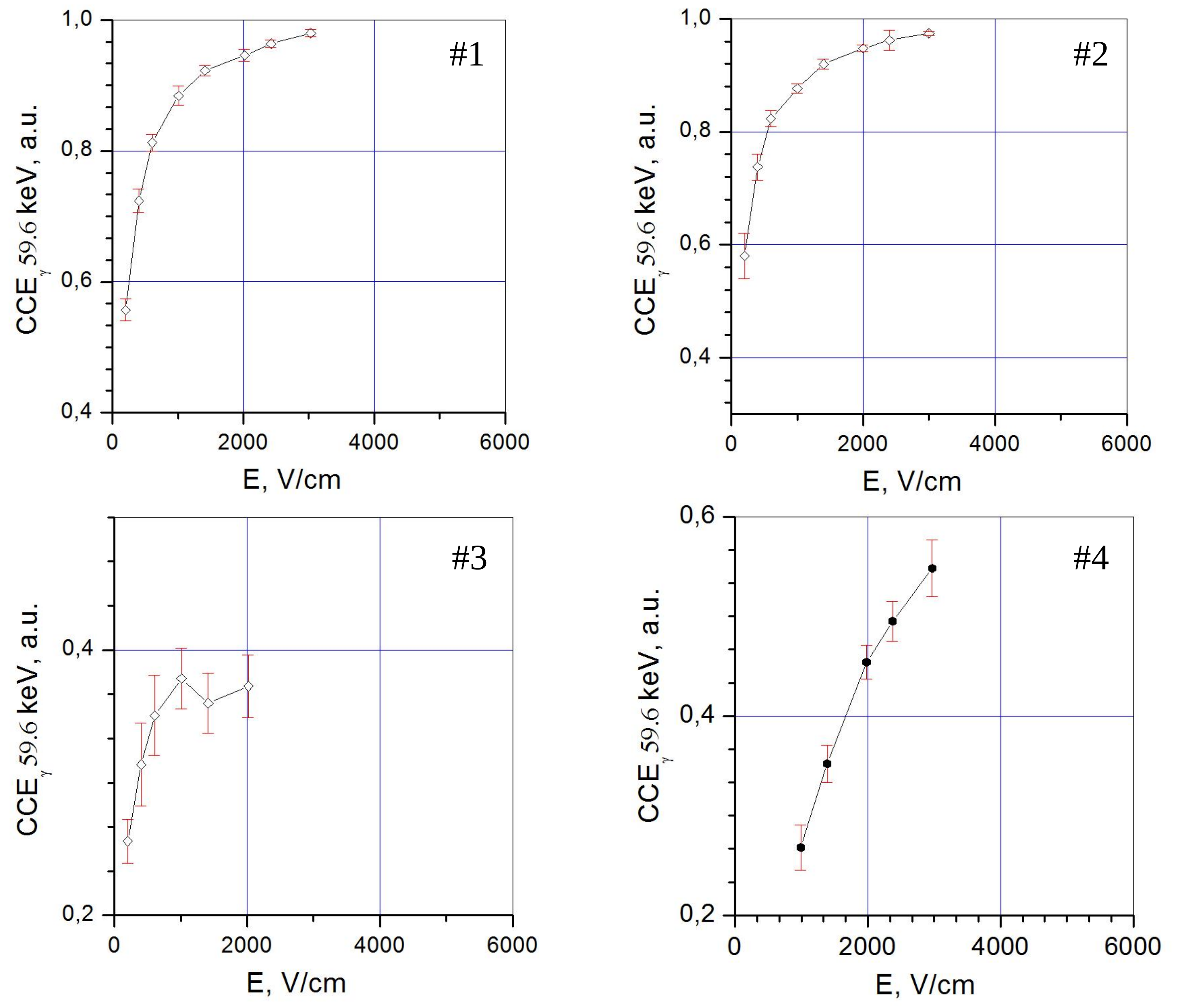
I-V curves

Prior to amplitude spectra measurements the I-V characteristics of sensors were investigated. The analysis of the experimental results suggests that in the investigated voltage range the I-V characteristics of the sensors can be described with functional dependence: I ~ U^b, where I – current, U – applied bias, b – power exponent of the current density dependency on the voltage. The current-voltage characteristics of all samples have three distinctive areas: linear (b ≈ 1); sublinear (b ≈ 0.7–0.9); and superlinear (b ≈ 1.1–1.3), the voltage range of these areas differs slightly from wafer to wafer.

We chose to conduct noise spectra measurements in the working range of applied biases of 10 – 700 V.



CCE measurement



Amplitude spectra measurements showed that wafers are characterized by different lifetime of nonequilibrium charge carriers.

# Wafer	Type of contacts	$(\mu\tau)_n$, cm^2/V
#1	Ni	$1{,}92\cdot10^{-4}$
#2	Ni	$2{,}05\cdot10^{-4}$
#3	Ni	$1{,}25\cdot10^{-5}$
#4	CrNi	$1{,}25\cdot10^{-5}$

Thus wafer with high and small values of $(\mu\tau)_n$ were chosen for noise measurements.

Noise measurement

Noise investigation was done using a CAMAC spectrometric MCA using a Cremat charge sensitive amplifier and shaping amplifier, which allowed the measurements to be carried out at different shaping times: 50, 100, 250, and 500 ns. A signal from the pulser was applied to the sample. The signal was blurred by the detector's own noises, the result was recorded on the computer. The amplitude of the pulses was chosen in such a way that it would have the same energy as 60 keV gamma quants.

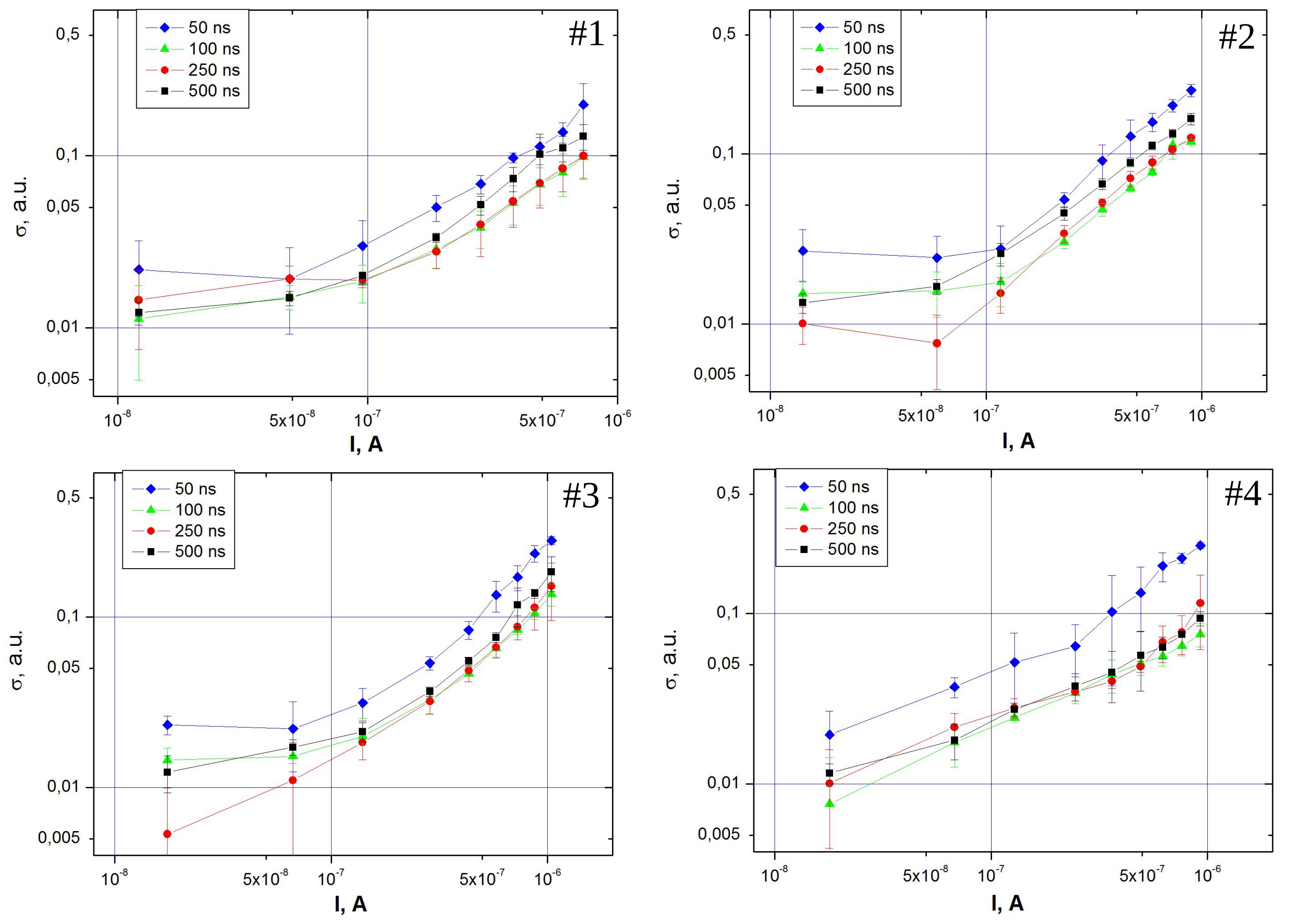
The noise was determined by measuring the σ – FWHM of the signal at zero and the bias applied to the sample. Measurements of σ_0^2 at zero bias voltage were performed to take account the intrinsic noise of the system, for which the subtraction operation was performed: $\sigma^2 - \sigma_0^2$.

Noise value at 50 ns shaping time is greater than for other times, and also 250 and 100 ns seem to have the lowest value of σ. This fact can be related to characteristics of the shaping amplifier itself.

Wafers #1 to #3 show one character of σ dependency on current: $\sigma \sim I^a$, where a comprises 0,83, 0,96 and 1,1 for samples #1, #2 and #3, respectively. This allows us to conclude, that the reasons of noise are either generation-recombination noise or $^1/_f$ noise. Taking into account the fact that electron lifetime of wafer #3 is much lower than for the first two, we can conclude the $^1/_f$ noise has the greater influence on sensors.

For wafer #4 noise dependence on current differs: a = 0,55, which means that shot noise prevails. As in this case the value of carriers lifetime also has no influence on the noise, the type and material of contacts and the state of Me-GaAs:Cr interface plays the leading role in noise nature.

The extreme energy resolution, determined from these measurements lies in the range of 2-3% @ 100V, which corresponds to previously obtained values.



Summary & Outline

It was shown that noise is mainly determined by $^1/_f$ noise for wafers with chemically made Ni contacts, whereas for samples with Cr-Ni contacts the shot noise prevails. This means that to reduce the value of noise we need to work on the Me-GaAs:Cr interface state, to improve the technology of contact deposition.

We're planning to continue these measurements and do some research devoted to different contacts in order to get more information and determine the nature of noise in GaAs:Cr.

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