Reference Characterization for Sr90 Measurements

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1 Introduction

Three HPK LGAD samples of size 1,9 × 2,2 mm from wafer number 42 were measured and compared to one another to determine the characteristics of each of them. While all three are expected to behave similarly, manufacturing tolerances can lead to significant differences in performance. A photo of the sample is shown in figure 1.

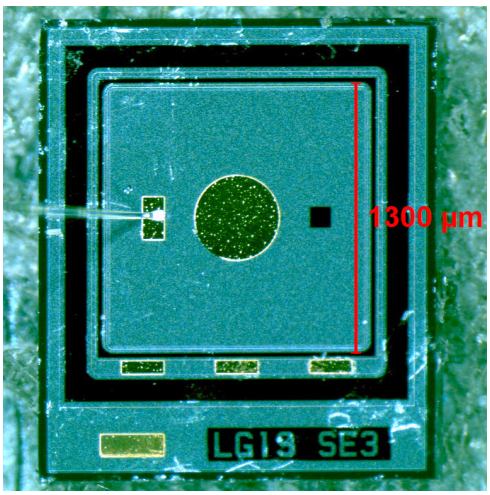


Figure 1: A picture of the sample under a microscope.

2 V_{BD} measurement

IV curves of all three samples were measured to determine the V_{BD} of each. The curves of two of the samples are shown in figure 2. V_{BD} is the voltage at which current exceeds 0,5 µA. The results are collected in table 1.

Table 1: V_{BD} values of the measured samples.

Sensor Nr.	1	2	3
V_{BD} [V]	226	245	245

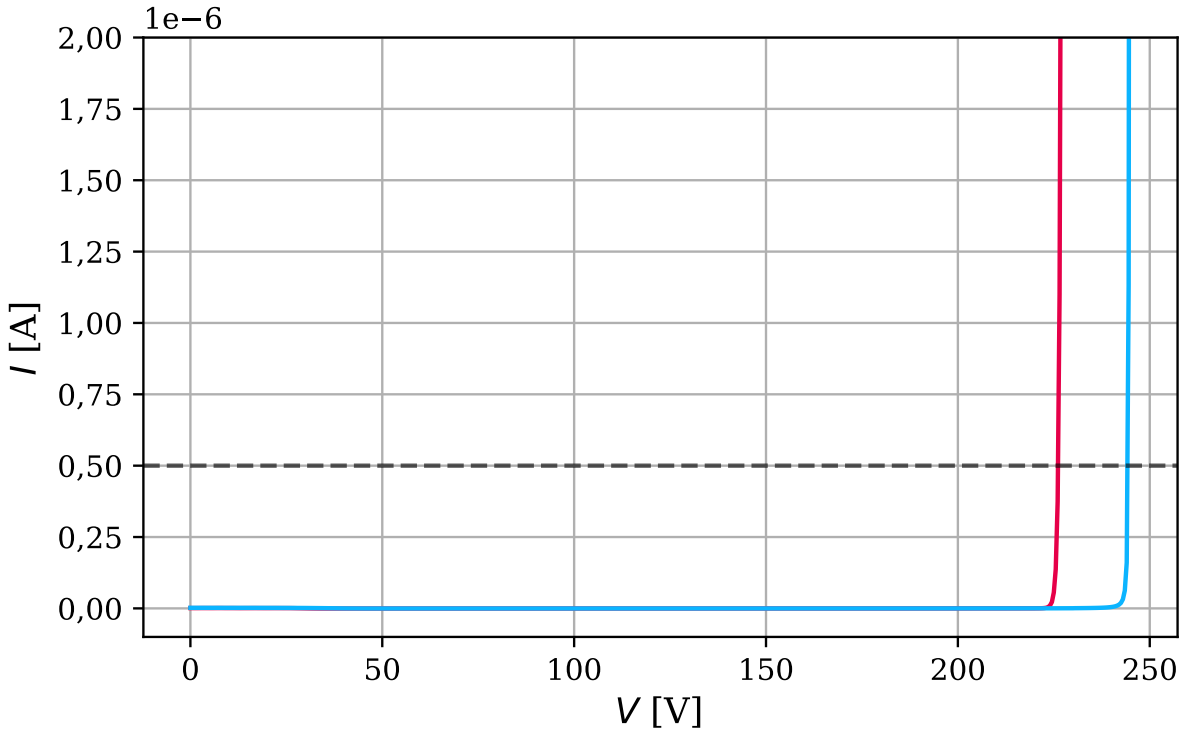


Figure 2: Plot of two IV curves, belonging to sample 1 and 2. Sample 3 was measured by hand after being mounted to a board.

3 Sr90 measurement

The samples were put into three groups of two to cover all possible permutations. Timing resolution was measured at for each pair, with one of them acting as the reference for event triggering. Each pair was measured at two different voltage values, a lower and a higher one. This was used to see how bias voltage effects resolution. All measurements were conducted at room temperature. Table 2 shows the voltages and configuration of each of the six measurements.

Table 2: Sample configuration for each measurement. The first of the pair acted as the DUT and the second as the reference. The V_B values on the left of the slash were used for the lower voltage measurement and the right values for the higher voltage.

Sample pair	V_{B1} [V]	V_{B2} [V]
1 + 2	200/210	210/220
1 + 3	200/210	240/250
2 + 3	210/220	240/250

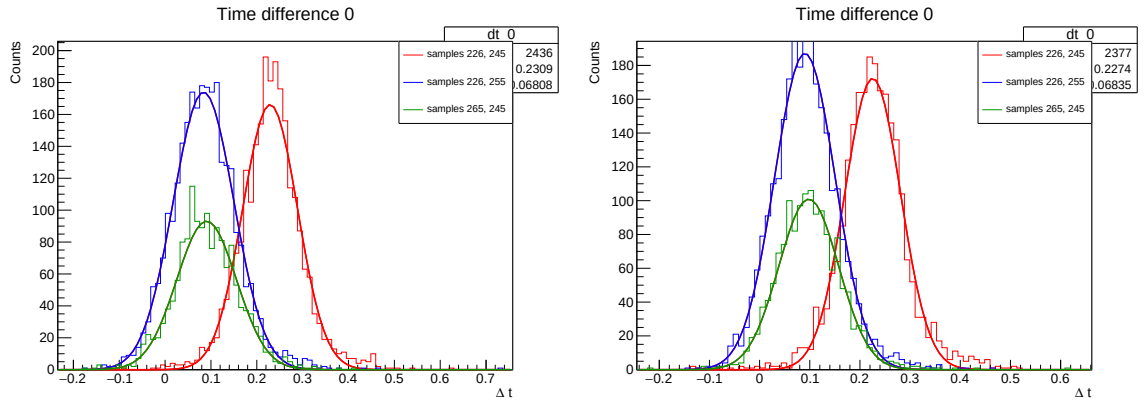
Each of the measurements were used to determine a combined timing resolution of the pair and combining all three allows us to untangle them. Figure 3 shows the distributions of the hit timing differences between sample pairs at a lower and higher bias. The results are collected in tables 3 and 4.

Table 3: Timing resolutions of sample pairs. Each pair was measured at two different bias voltages (V_{B1}, V_{B2}, see table 2).

Sample pair	σ_{ij} @ V_{B1} [ps]	σ_{ij} @ V_{B2} [ps]
1 + 2	59,9	55,5
1 + 3	66,2	60,6
2 + 3	65,2	59,7

Table 4: Timing resolutions for each individual sample, calculated from the combined values in table 3. Jitter was estimated from the rise time and noise of each sample as σ_{jitter} = (noise)/(slew rate).

Sample Nr.	σ_i @ V_{B1} [ps]	$\sigma_{i,jitter}$ @ V_{B1} [ps]	σ_i @ V_{B2} [ps]	$\sigma_{i,jitter}$ @ V_{B2} [ps]
1	43,1	16,7	39,9	14,0
2	41,6	15,6	38,6	13,4
3	50,2	37,1	45,6	29,5



(a) (b)

Figure 3: Distributions of the hit timing differences between sample pairs. (a) was measured at V_{B1} and (b) at V_{B2}. Red is sample pair 1 + 2, blue 1 + 3 and green 2 + 3.