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Breakdown Voltage of the AC coupling oxide for a VELO sensor

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Abstract

The breakdown voltage of several strips across a Silicon sensor was measured.

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1. Introduction

The LHCb VELO sensors were systematically tested for their current-voltage (IV) characteristics, depletion voltage and problem channels [1]. Below we describe additional tests which measured the voltage at which the AC coupling oxide breaks down. As these tests are, by necessity, destructive only one sensor was fully characterized this way. For production purposes all sensors had each strip measured and the breakdown voltage is known to be > 40V /strip. The measurement of the breakdown voltage is especially important as it enables some estimates to be made of to be made of the tolerance of the VELO modules to intense beam spills.

2. Setup

A silicon sensor with a radial strip design, number 2395-18E, was mounted on a Cascade 6100 probe station connected, via a Pickering switching matrix, to a Keithley K487 voltage source/current meter as in Figure 1. The bias rail of the sensor was connected, via bond wires, to ground. A negative voltage could be applied to a probe needle which was moved successively to 87 of the 2048 readout pads of the sensor. For each position of the probe needle, the voltage was ramped slowly, under computer control, from 0V in -1V steps, until the current being drawn exceeded 1nA; the voltage was noted and slowly ramped to 0V before the probe needle was moved to the next readout pad.

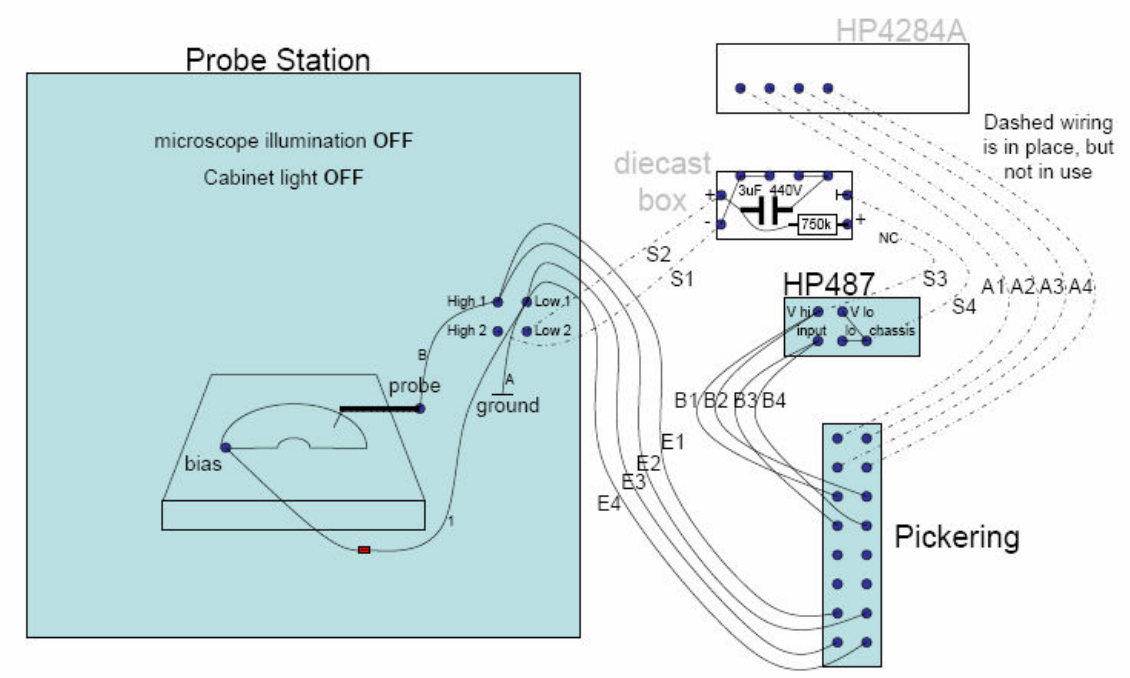

Figure 1: Electrical set-up for probing strips

3. Results

For each channel, the current rose slowly with voltage until about 170V, from where it began to rise more quickly, until finally rising exponentially at about 200V, see Figure 2

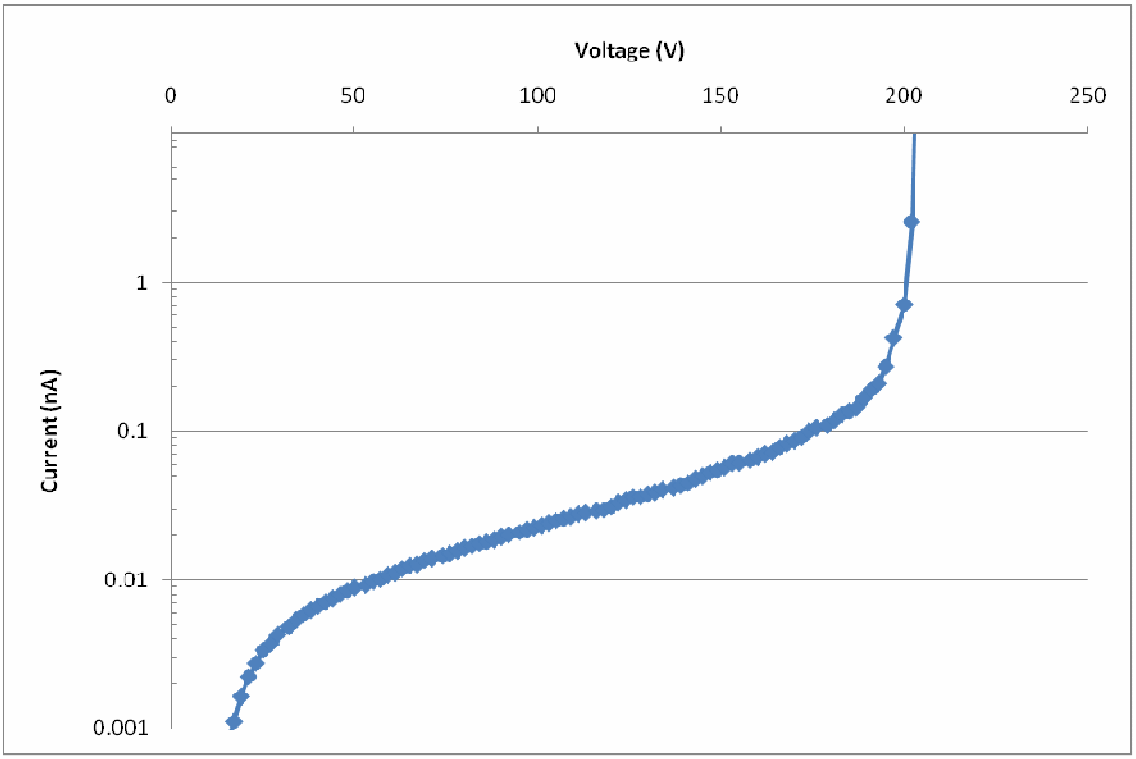

Figure 2: Current v Voltage for a typical channel

The breakdown voltage for each channel is show in Figure 3. Most channels broke down at about 200V, although a significant number of channels broke down at voltages between 160V and 200V.

Every fiftieth channel was measured across the entire sensor, and every tenth channel was measured across a quarter of the sensor: the dependence of breakdown voltage on the position on the sensor was very small, just a few volts. In addition, some odd-numbered channels were measured to detect any feature that would have been missed by regularly-spaced measurements – no such feature was observed. A few consecutive channels were probed to see if channels showed a lower breakdown voltage after a neighbouring channel had broken down – this effect was also not observed. Re-measurement of the breakdown voltage for a channel gave the same value as the previous measurement provided that the breakdown current for the previous measurement had been limited below 100nA. If the breakdown current reached the hardware limit of 2.5mA then the channel was often found to be permanently damaged: further tests would break down at one volt. Results for two channels which had been previously damaged are not included in Figure 3.

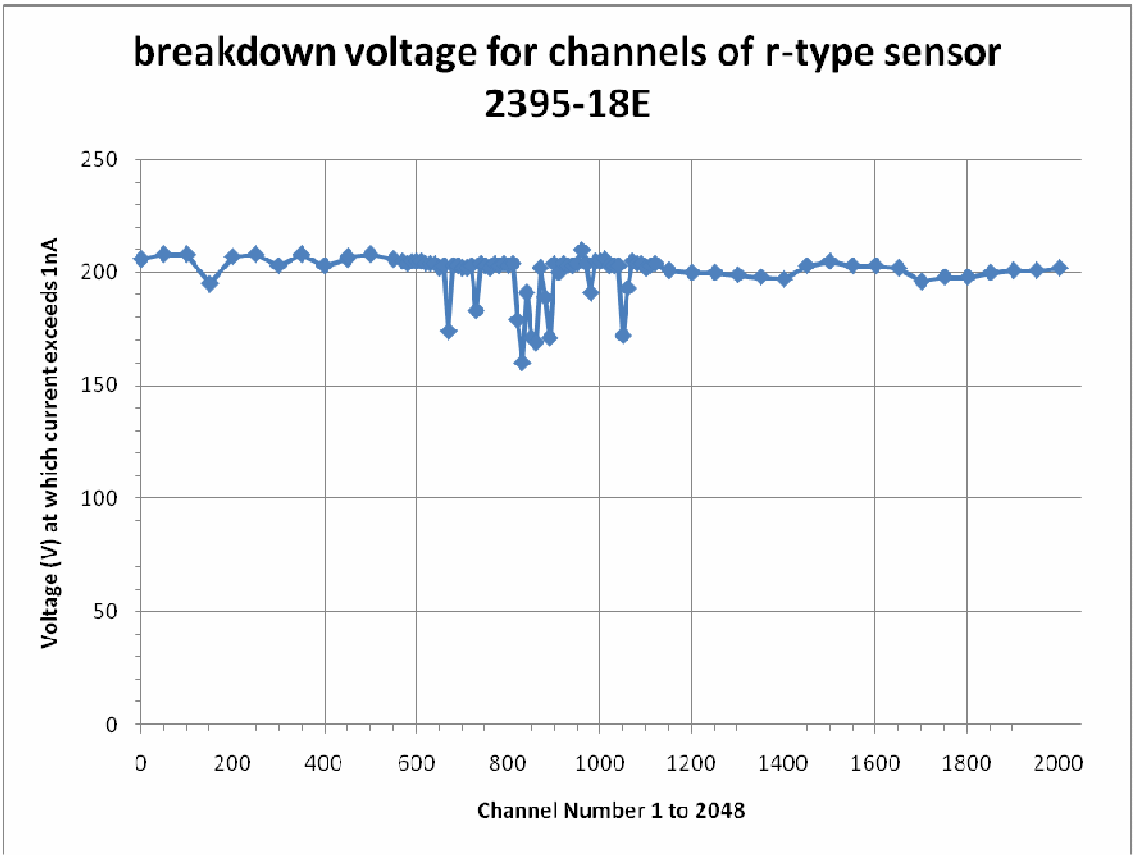

Figure 3: Breakdown voltage for strips tested

4. Conclusions

The mean breakdown voltage was 200V with a standard deviation of 10V. This is much higher than the 40V required during the testing phase of the sensor.

5. References

1. Turner, P.L., et al., *VELO Module Production - Sensor Testing.* LHCb Internal Note, 2007(072).