

Measurements of VFE Protection Diodes

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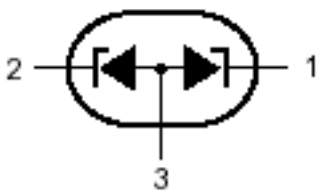
1.0 Diodes

Six diodes were received; one reference and five which had been irradiated with protons at PSI to the following fluences:

Diode	Fluence (p/cm ²)
Reference	0
I	7.0×10^{12}
II	1.2×10^{13}
III	3.2×10^{13}
IV	6.2×10^{13}
V	12.2×10^{13}

2.0 Test Set-up

The voltage was applied and the current measured with a Keithley 617 electrometer capable of pico-ampere resolution. Probes were used to apply the voltage to the diode contacts (schematic shown below).



I-V curves were measured for all diodes in 3 different configurations; with the voltage applied across 1+2, across 3+1 and across 3+2. Three measurements were taken in each configuration.

3.0 Results

The IV curves for the diodes are shown in Appendix A on mA scale and μA scale. The plateaus in the curves are due to the electrometer current-limiter. The leakage currents for the 3 configurations at 3 voltages are shown in the table below, together with the ENC (Eq. 1 below).

Diode	V	I_{12} (nA)	I_{31} (nA)	I_{32} (nA)	ENC_{12} (e ⁻)	ENC_{31} (e ⁻)	ENC_{32} (e ⁻)
I	0.5	0.01	0.0133	0.01	2	2	2
	1.5	0.07	0.0967	0.08	6	7	6
	2.5	0.427	0.707	0.593	14	18	17
II	0.5	0.0133	0.0133	0.0133	2	2	2
	1.5	0.1	0.12	0.13	7	7	8
	2.5	0.64	0.923	0.977	17	21	21
III	0.5	0.0267	0.0333	0.0367	4	4	4
	1.5	0.26	0.347	0.34	11	13	13
	2.5	1.72	2.62	2.58	28	35	35
IV	0.5	0.0533	0.0633	0.067	5	5	6
	1.5	0.49	0.683	0.693	15	18	18
	2.5	3.29	5.24	5.32	39	49	50
V	0.5	0.117	0.13	0.137	7	8	8
	1.5	1.02	1.39	1.42	22	25	26
	2.5	6.76	10.6	10.8	56	70	71

It was not possible to obtain a good characteristic curve for the reference diode. This was the only diode to have been mounted onto a board and it's possible that the diode may have sustained some damage during this procedure.

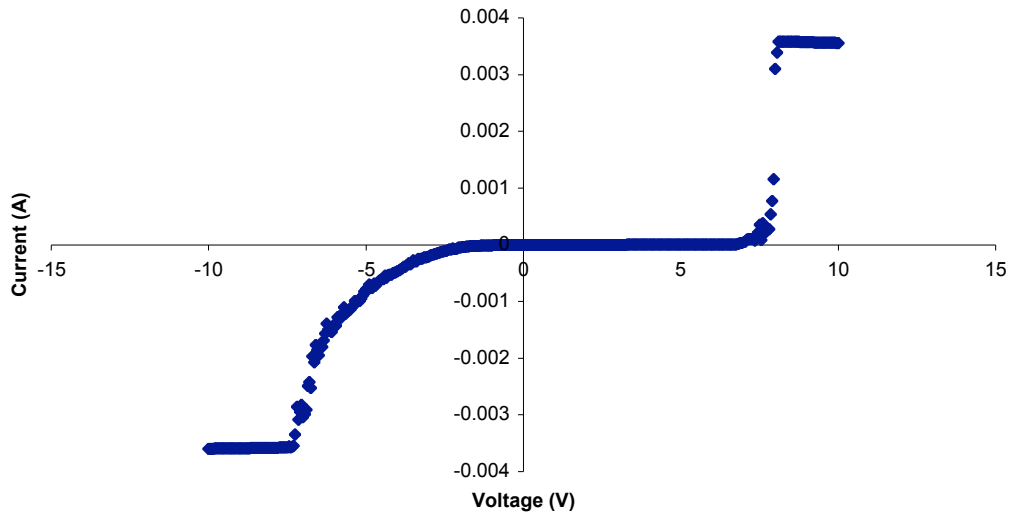
Using

$$ENC(rms) = 2.718 \sqrt{\frac{qI\tau}{4}} \quad \text{Eq.1}$$

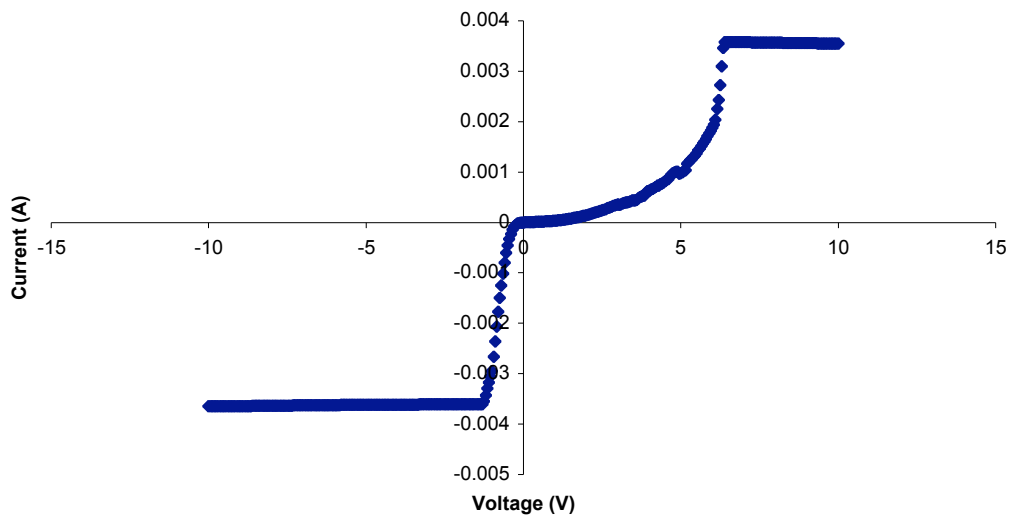
it can be seen that leakage currents approaching 10 μA would lead to an unacceptable noise contribution. The leakage currents shown above are significantly below this value and the noise contribution is extremely small even for the diode exposed for the longest time to the proton beam.

Appendix A

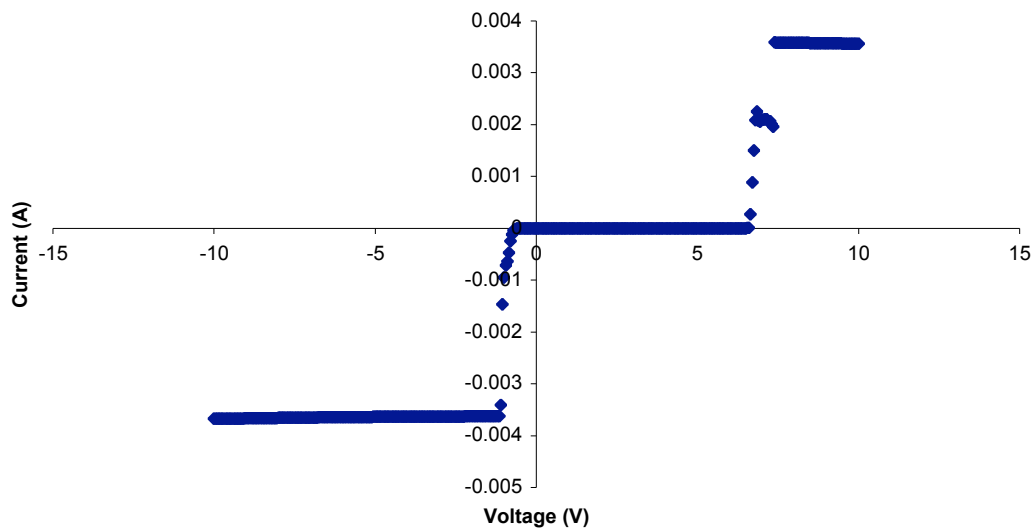
Reference 12



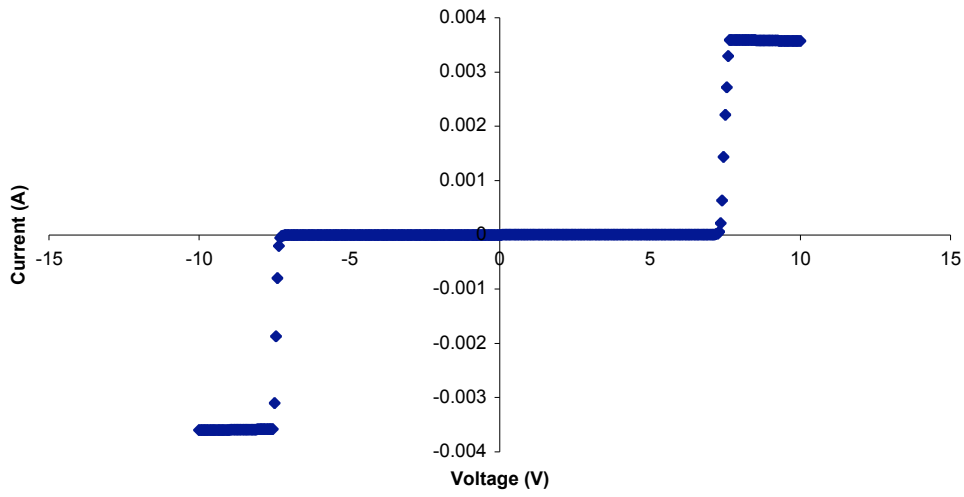
Reference 32



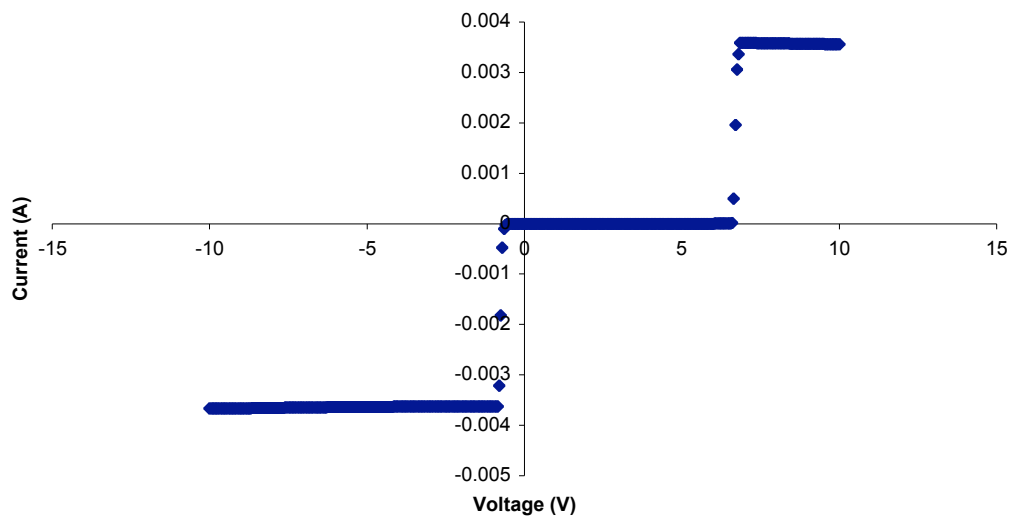
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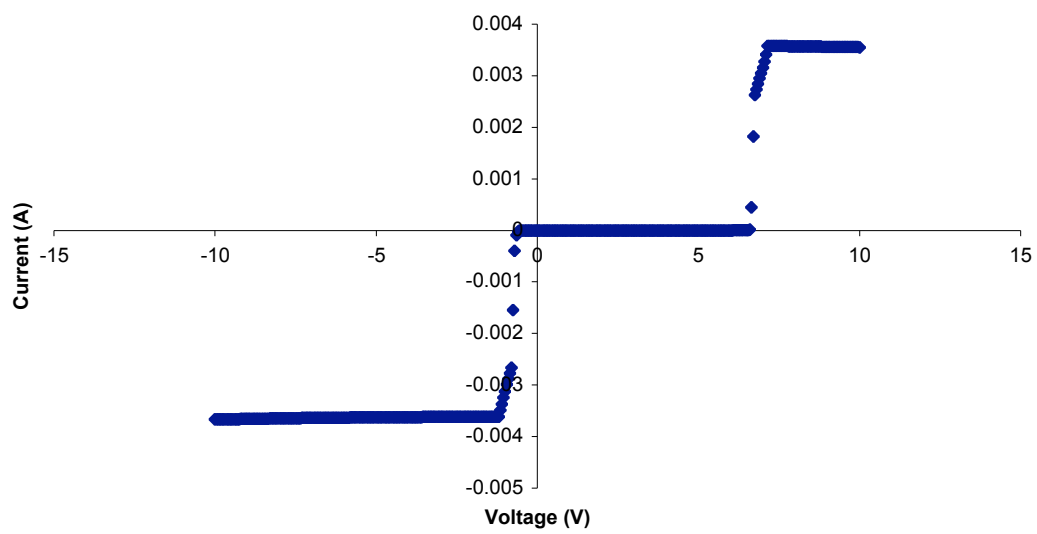
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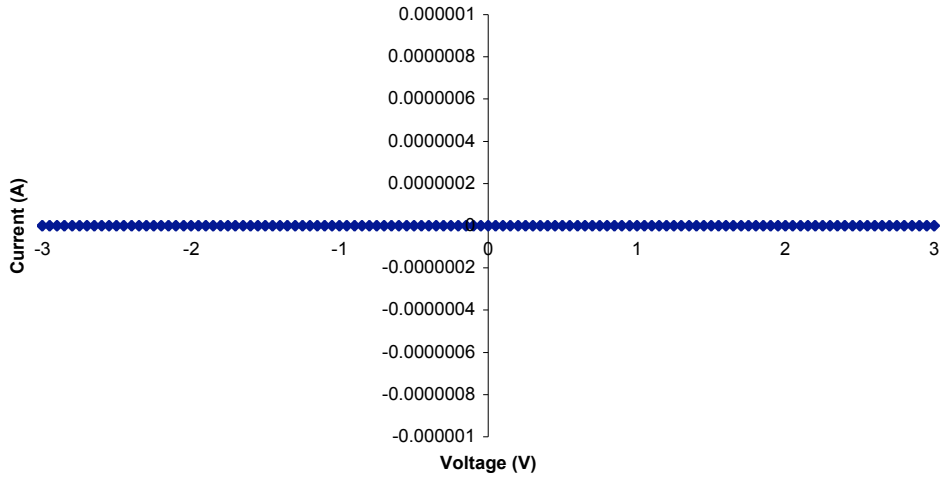
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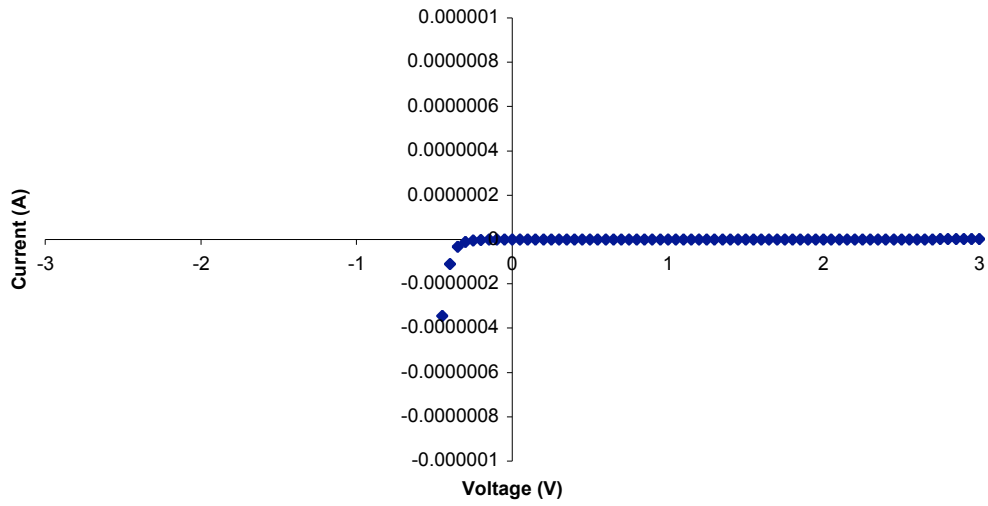
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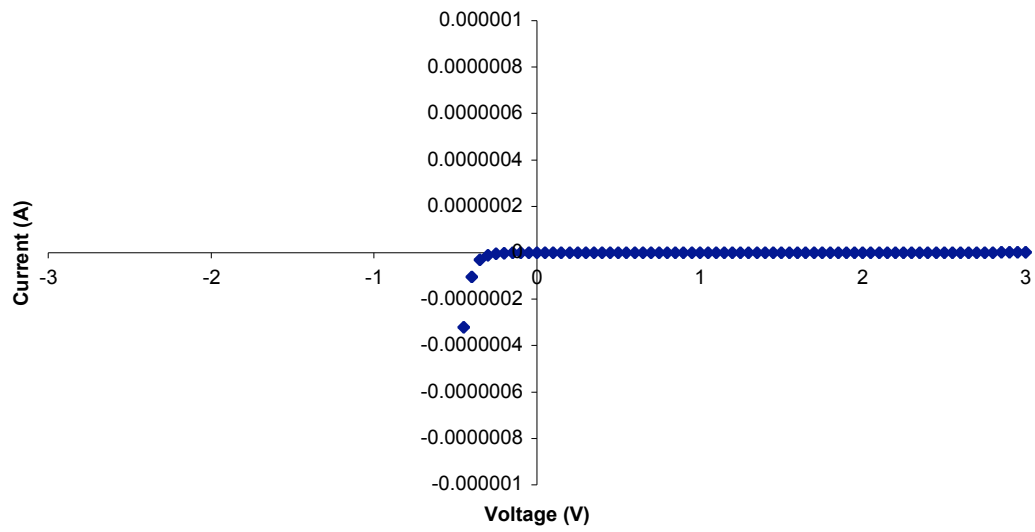
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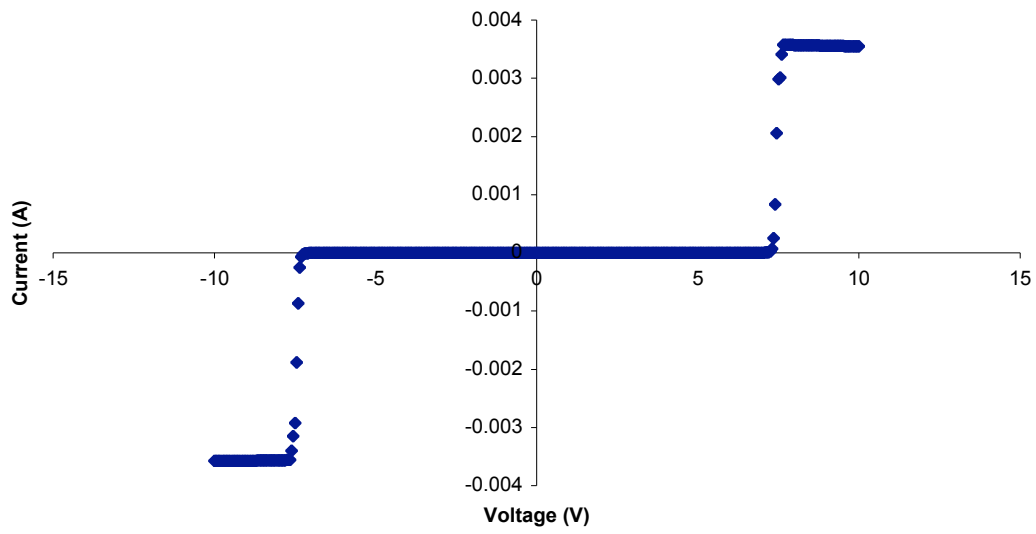
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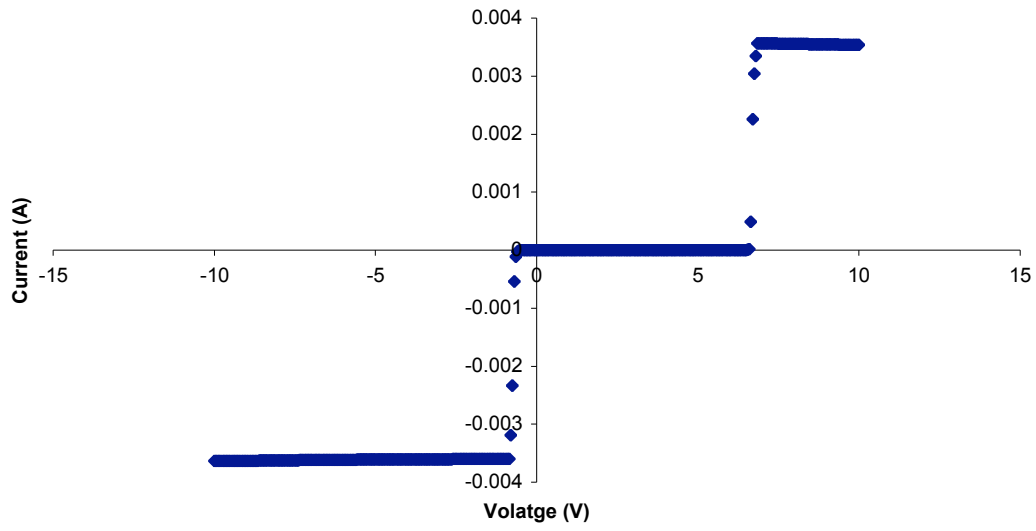
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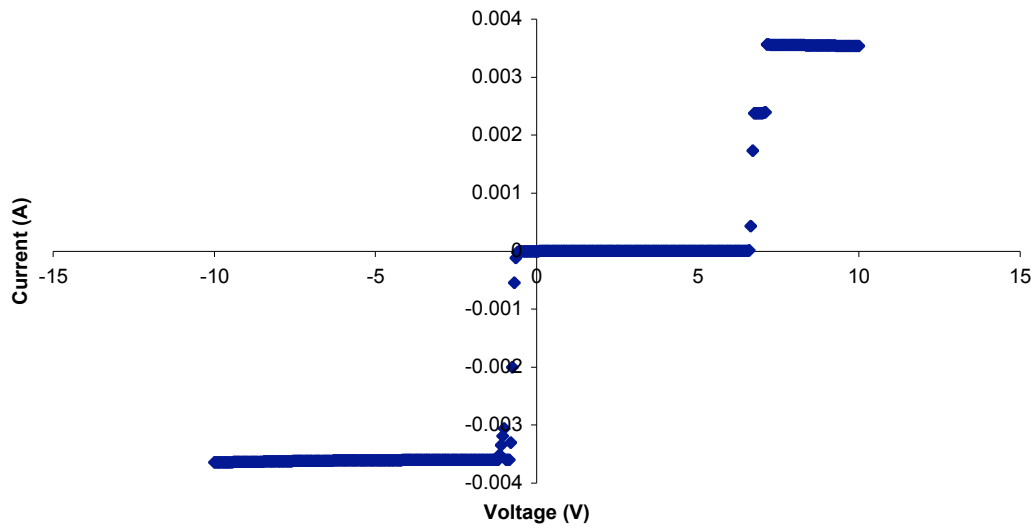
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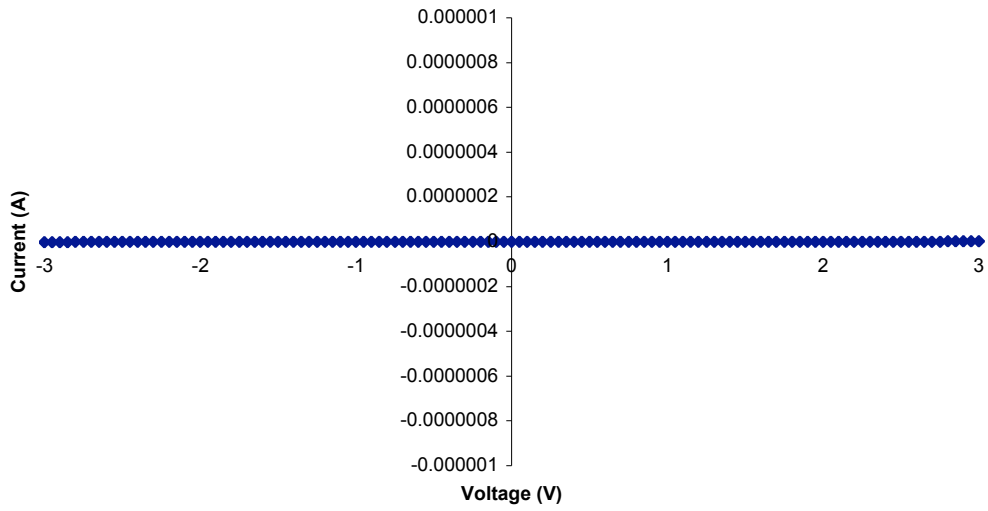
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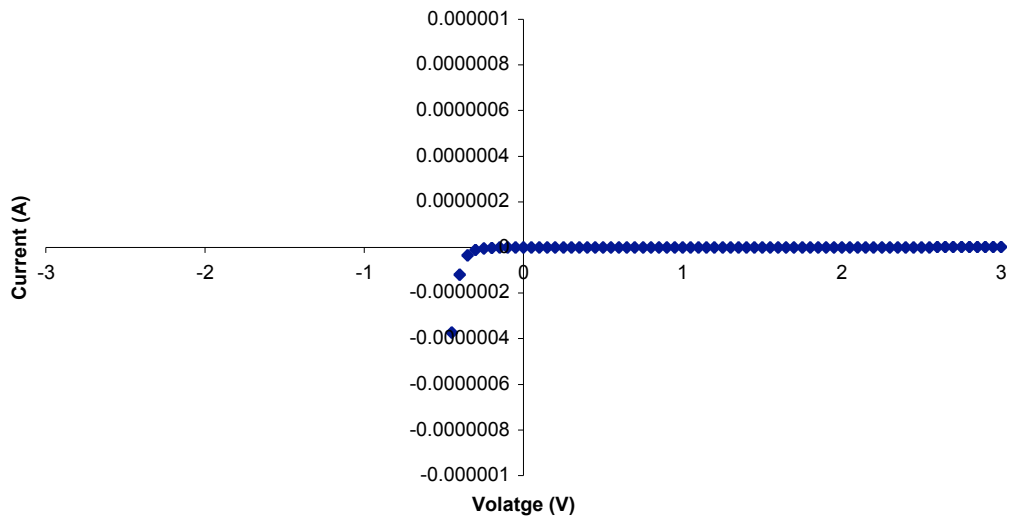
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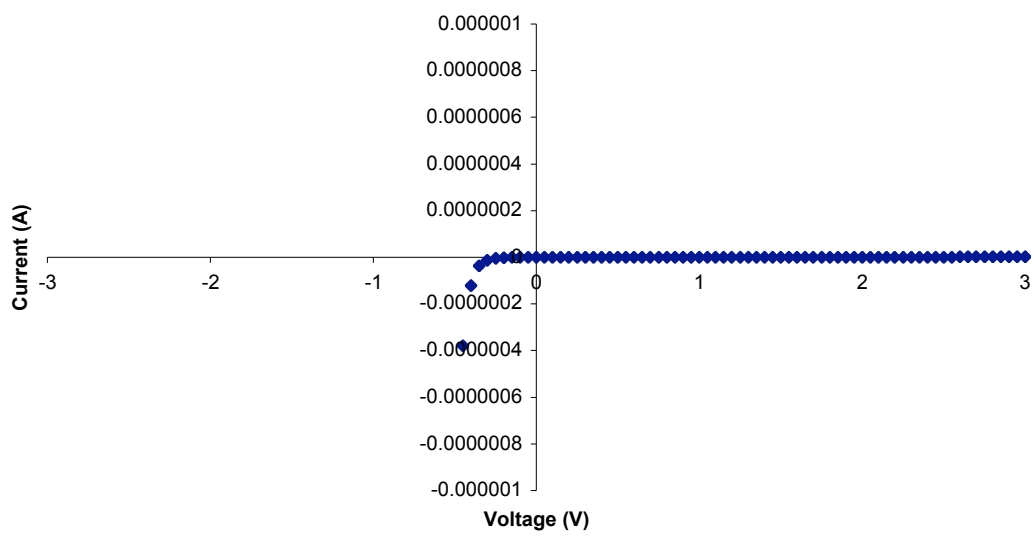
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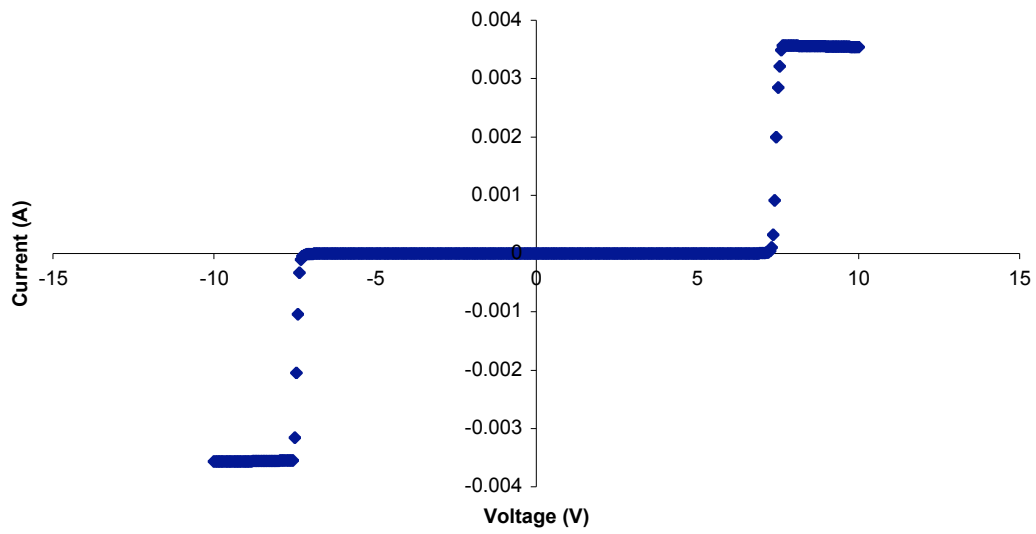
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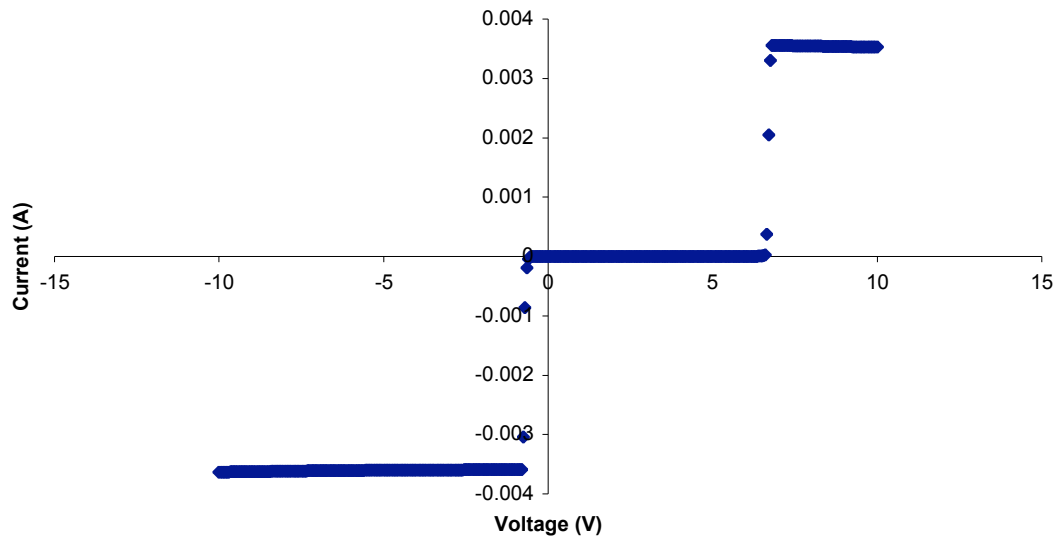
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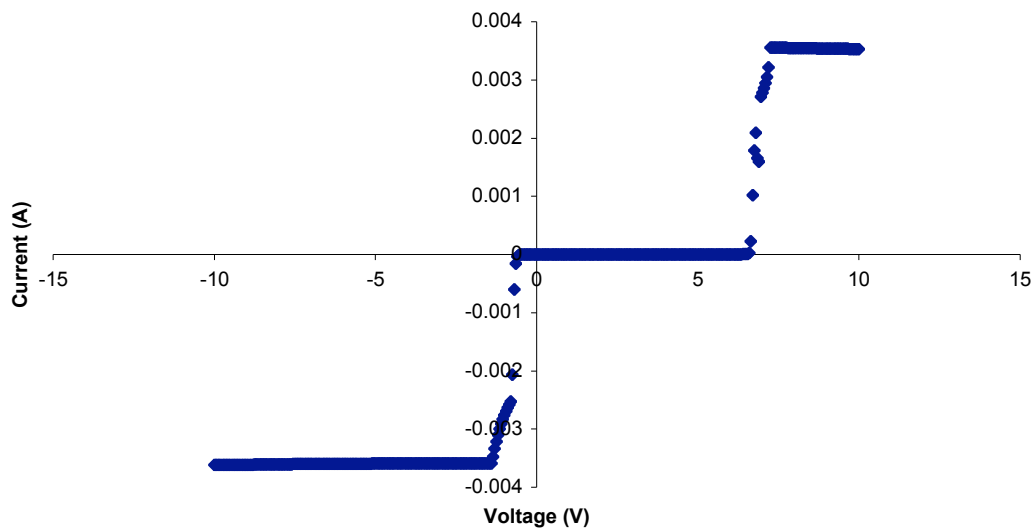
Diode III 12



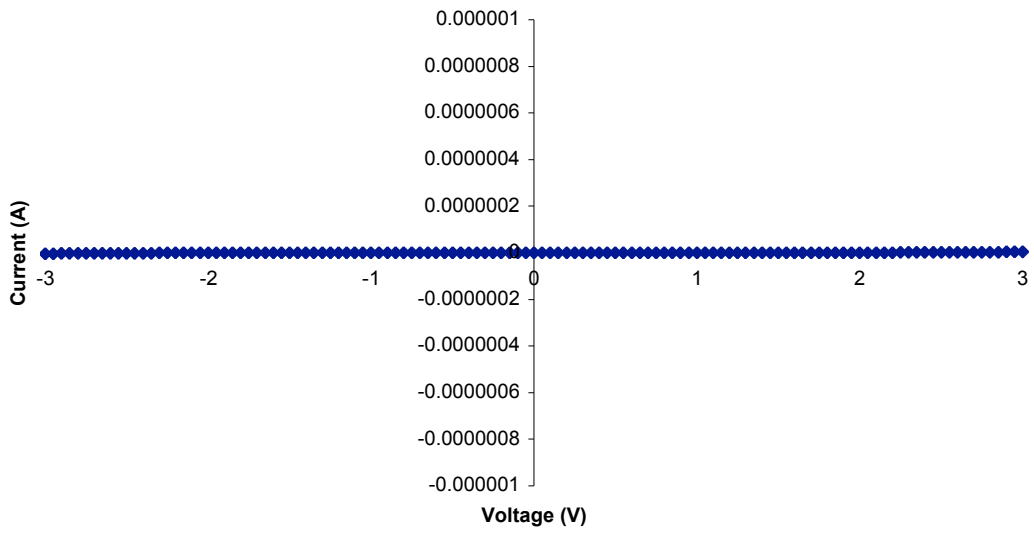
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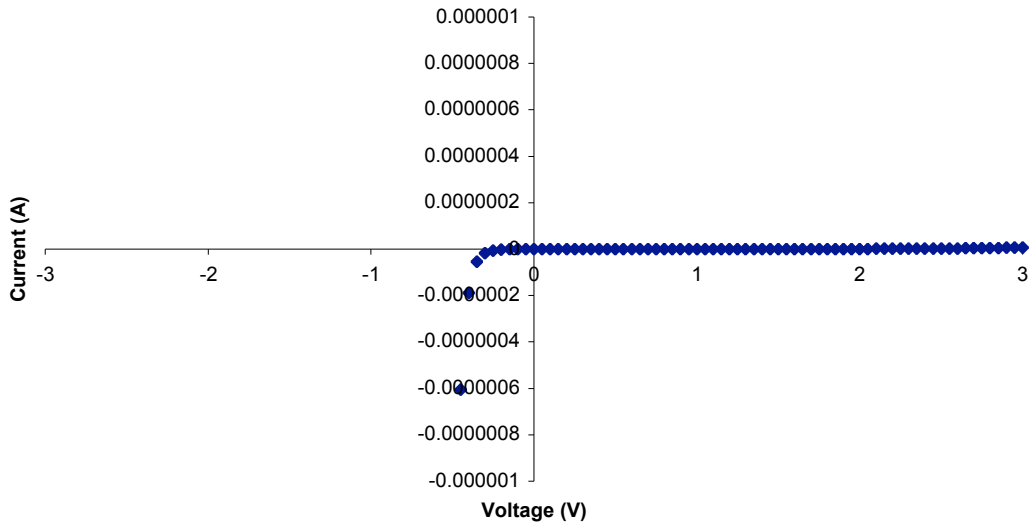
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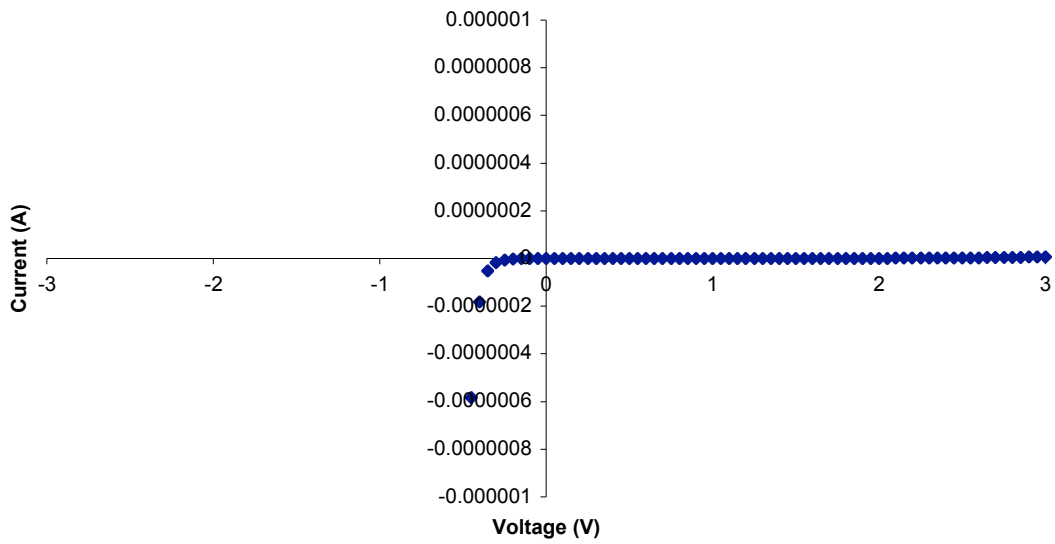
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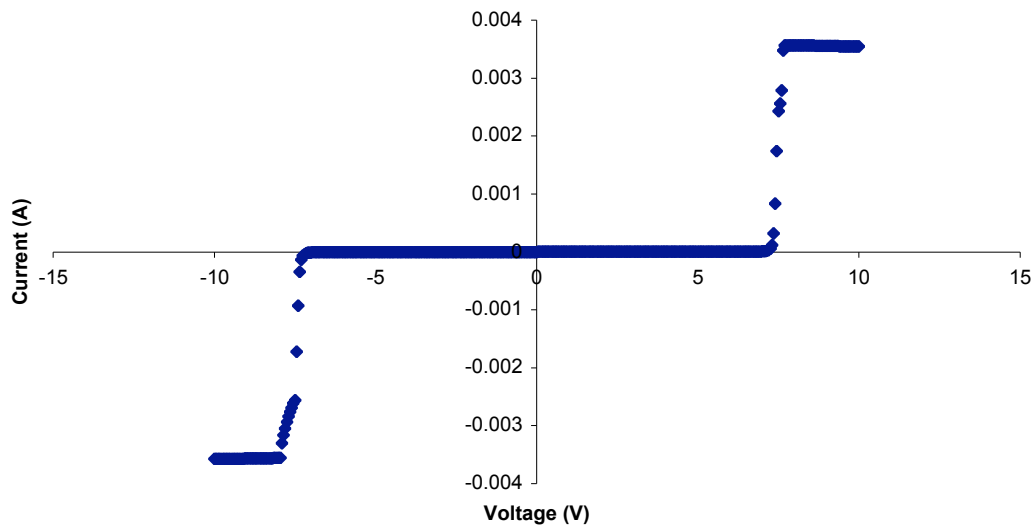
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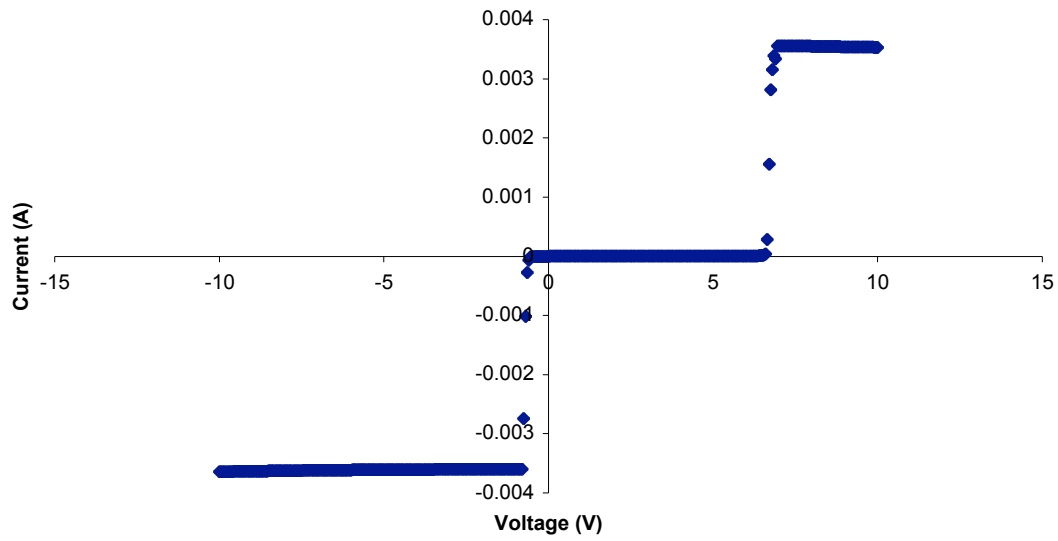
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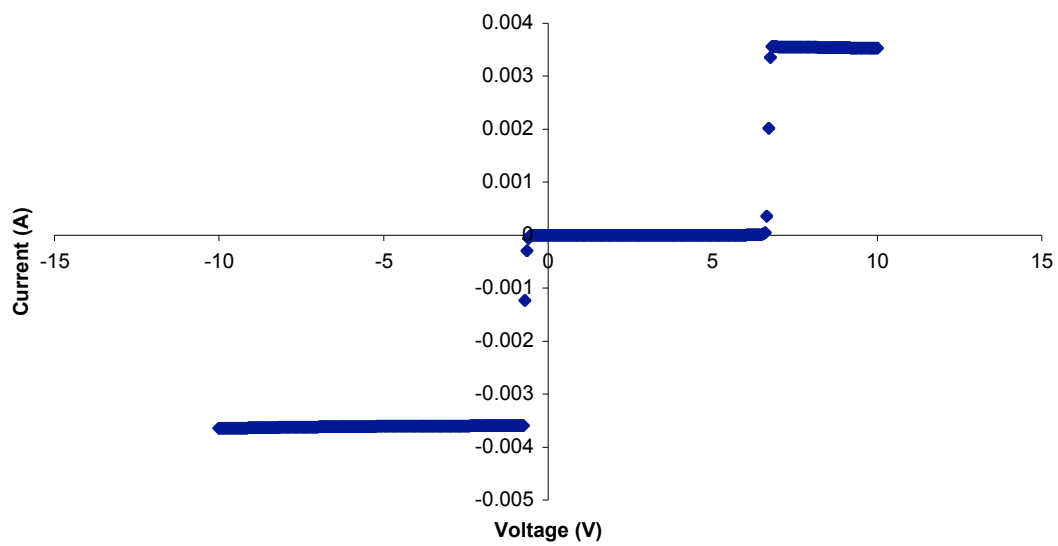
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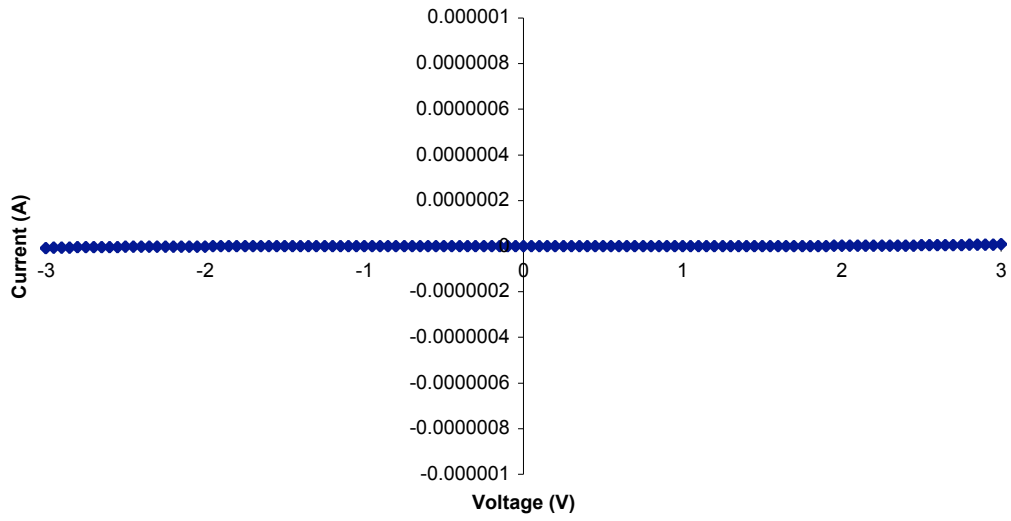
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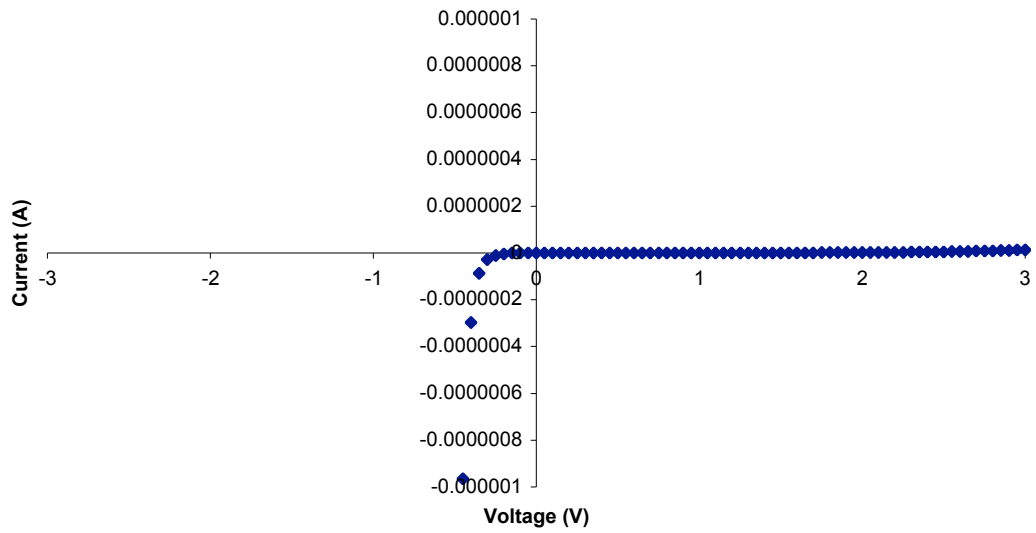
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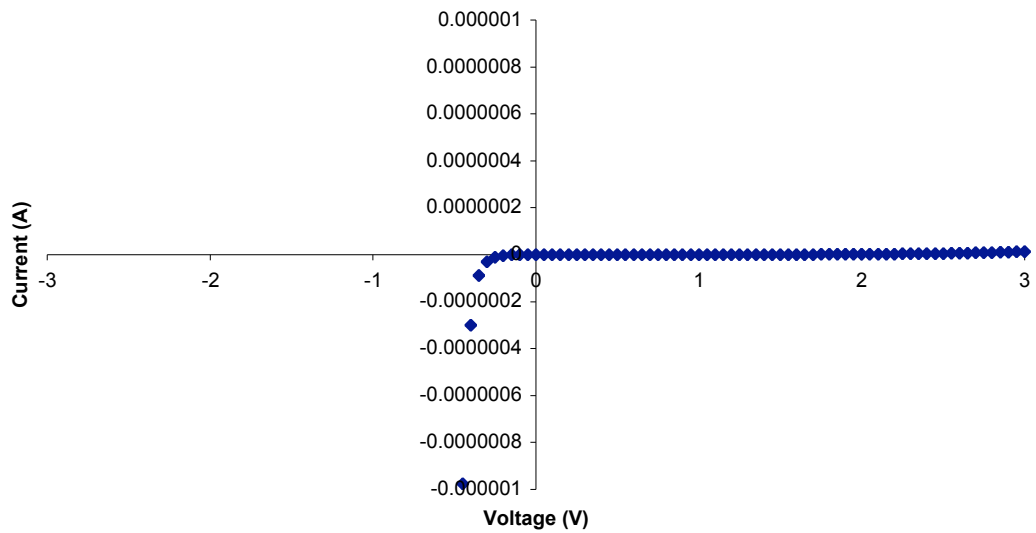
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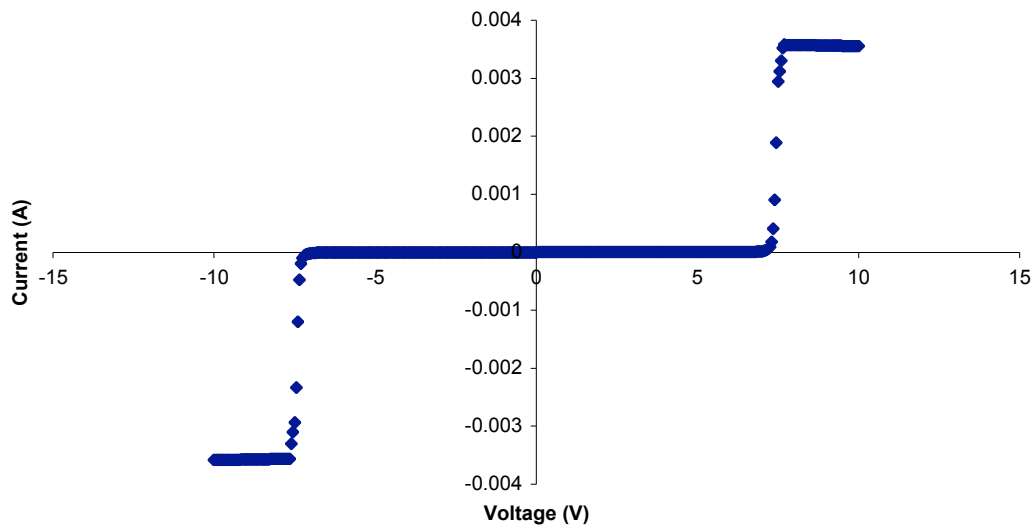
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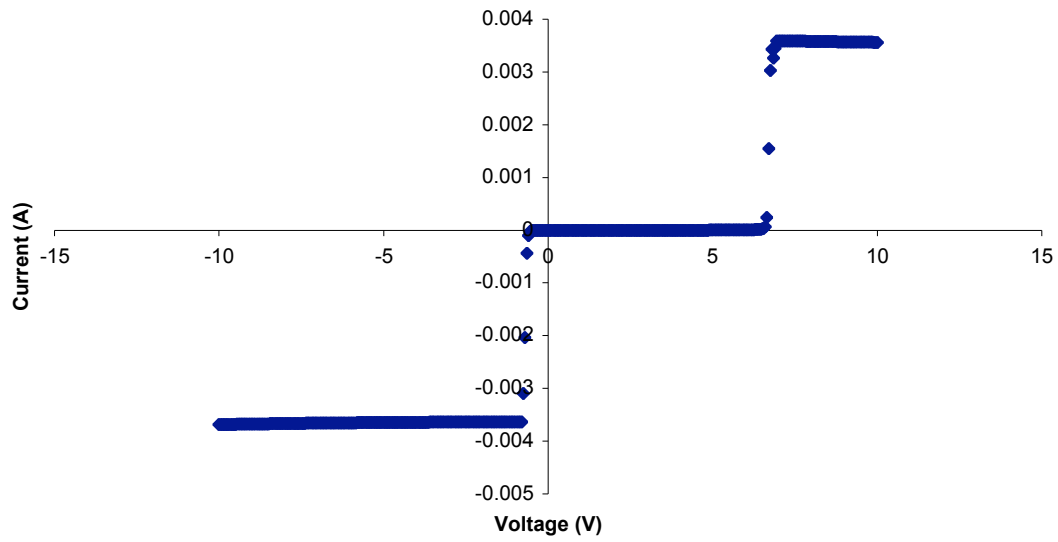
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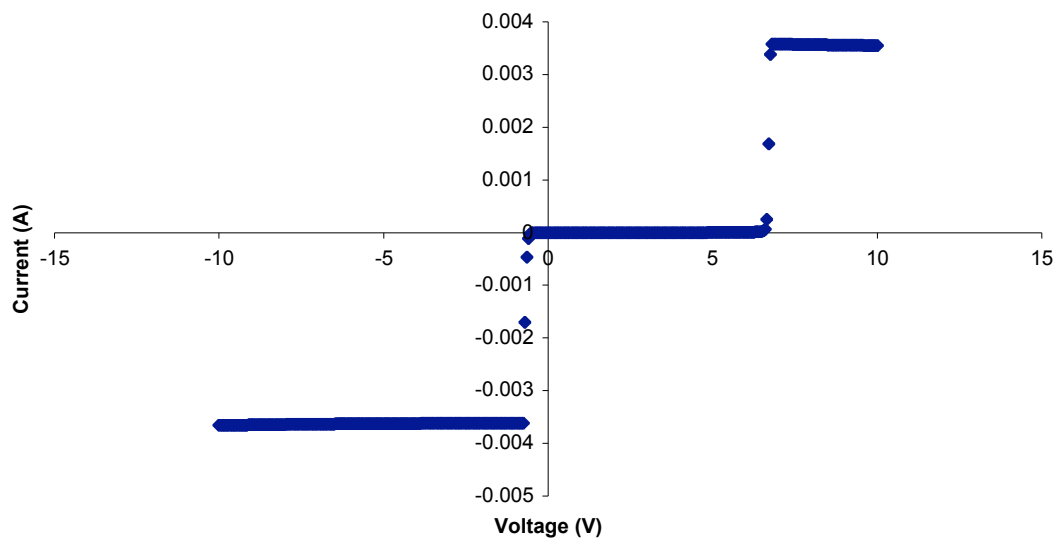
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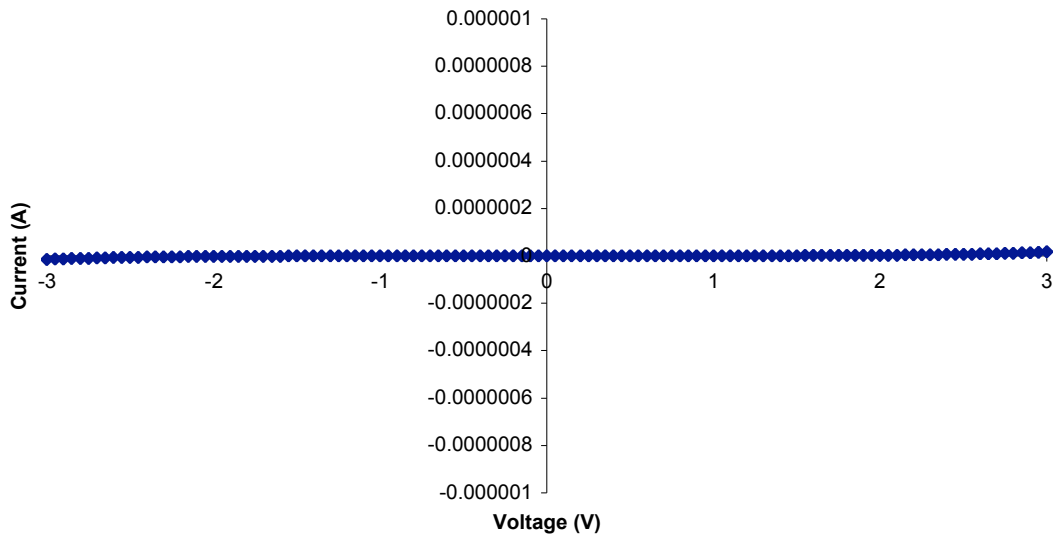
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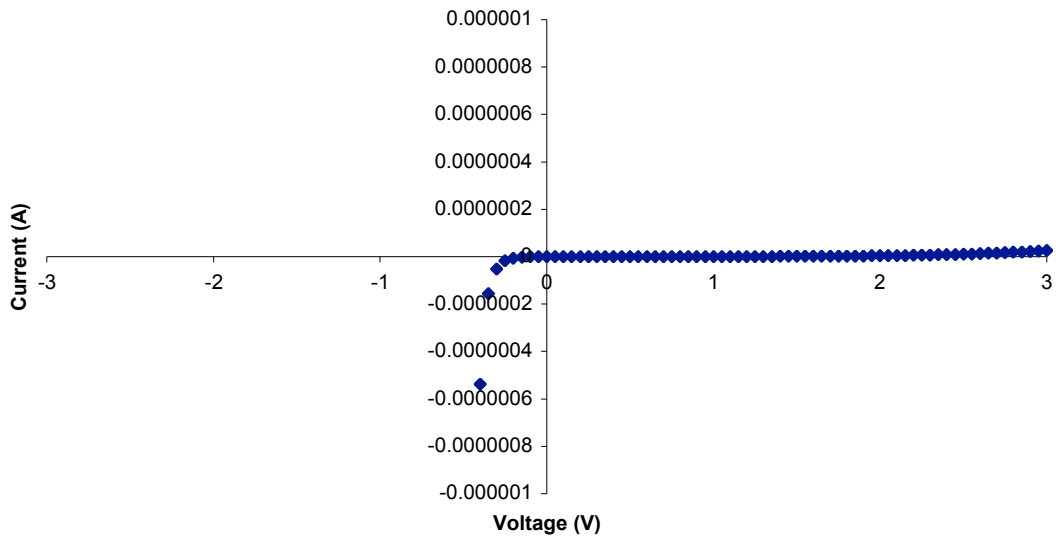
Diode V 32



Diode V 12



Diode V 31



Diode V 32

