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# TECHNICAL REPORT

# "SOLID-STATE DETECTOR"

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# SOLID-STATE DETECTOR

The TRW electrostatic microparticle accelerator is nearly an ideal facility for the development and testing of sensitive micrometeorite detectors. The results of experiments on the impact ionization effect[1] and tests of thin film capacitor penetration detectors indicate behavior similar to the properties exhibited by semiconductor particle detectors. These semiconductor detectors enjoy general use in the field of nuclear physics. The charge collection mechanisms are reasonably well understood for nuclear particles and the manufacturing processes have reached a high degree of sophistication. Furthermore, standardized instrumentation has been developed for use with the basic detector unit. For these reasons, the possibility of using a semiconductor junction detector as a micrometeorite detector were examined.

For these initial tests an n-type silicon surface barrier diode (fabricated at TRW) was used. The surface barrier detector is constructed by evaporating a thin layer of gold (100-2000 Å) onto high resistivity n-type material. A distributed p-type layer is formed by surface states at the interface between the metal and the semiconductor. A dipole layer is formed by positively-charged ionized donors in the n-type material and the p-type states. The region which is essentially stripped of conduction electrons is called a surface barrier. A depletion region is formed by the application of a reverse bias across the n-p junction, most of the extent of which is into the n-type region. The width of this depletion region is given approximately by

$$d = (\rho V)^{\frac{1}{2}}/3 \qquad (1)$$

where d is the depletion width in microns, $\rho$ is resistivity of the n-type material in ohm centimeters and V is the effective reverse bias in volts. This bias is made up of a self-bias, which for the detector used was about 1/2 volt, plus the external applied voltage. When the semiconductor detector is used on nuclear particles, for every 3.5 ev of energy lost by the particle in the depletion region, an ion-electron pair is formed, and is then collected by the detector electrodes. It should not be expected that the mechanism of the detector for micrometeorites will be at all similar to that just described for nuclear particles because of the tremendous difference ($10^6$) in mass of the particles.

In the initial tests the particles from the accelerator were incident on the gold electrode (p side) of the detector which was grounded. An Ortec preamplifier and amplifier (Models 101 and 201) were used with the detector, and these were calibrated to indicate total collected charge from the detector. Bias voltage of 0, 10 and 30 volts were used, and the detector output was not found to depend on the applied bias voltage. This was consistent, since the 0.5 volt self-bias results in a depletion depth of about 40 microns, and this is greater than the expected depth of penetration of the particles. Figure 1 is a plot of signal amplitude, normalized to particle mass, as a function of velocity. The data has a slope of about 3, which is the value obtained in earlier work on impact ionization.

It was discovered that there was a significant fraction (10-20%) of the output signals from the detector which were inverted from the expected polarity. It is not understood at this time why these occurred. It was found that if the n electrode was grounded, the fraction of opposite polarity signals was decreased to about 3%. Also, the slope of the data when plotted as before, seems to be about 5, as compared with three in the other configuration.

It was felt that possibly recombination processes might have affected the observed response. To investigate this, a biased grid was placed in front of the grounded p electrode. Signals were observed at the n electrode. Biases of both polarities and various voltages were used on the grid. The conclusion reached

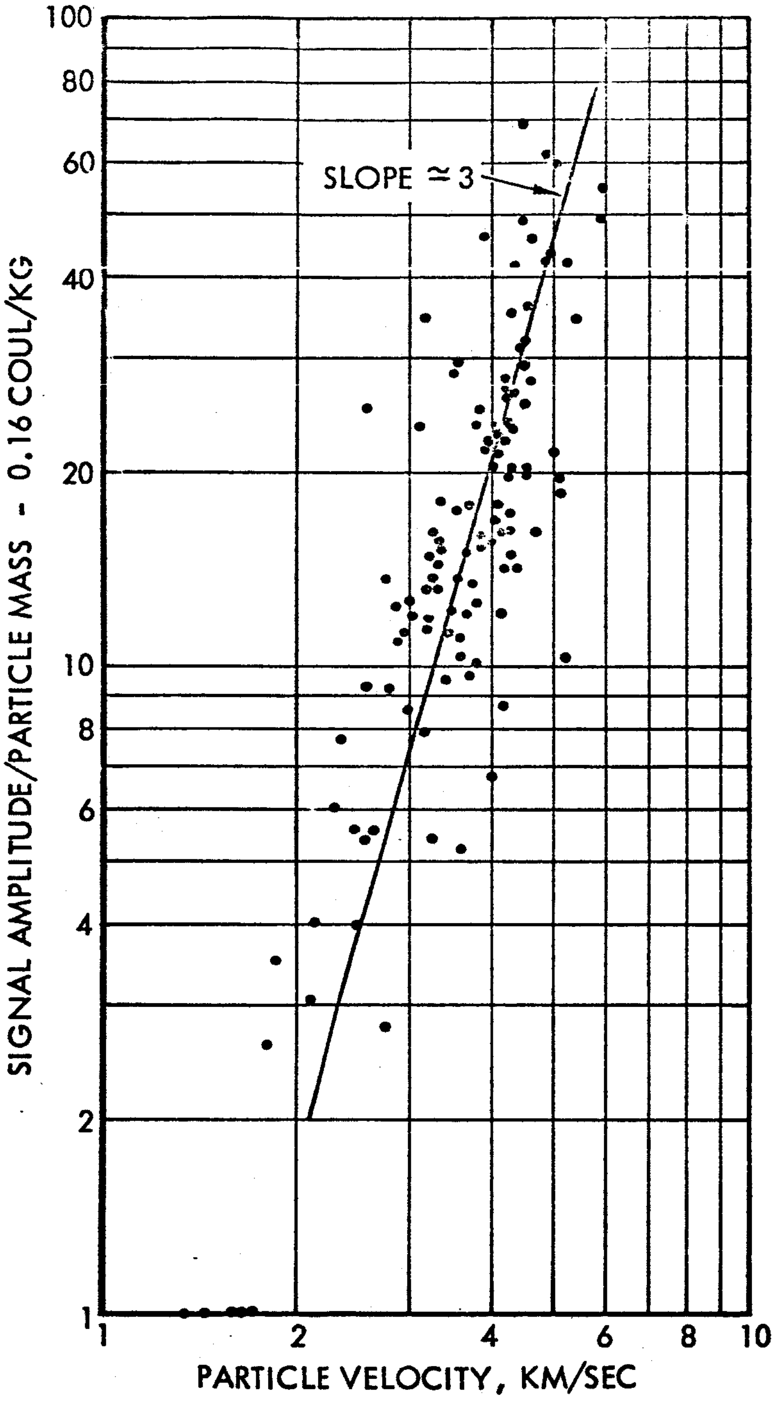


Figure 1. Signal amplitude from semiconductor meteorite detector versus incoming particle velocity.

was that a positive bias on the grid, resulting in electron extraction from the detector, reduced the number of opposite polarity signals by a significant amount.

Based on the results of this preliminary examination, and in view of the advantages that were pointed out at the beginning of this note, it is felt that these detectors certainly merit a more thorough evaluation as a possible micrometeorite detector.

## REFERENCES

1. J. F. Friichtenicht and J. C. Slattery, "Ionization Associated with Hypervelocity Impact," NASA TN D-2091.

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