

## I. PHYSICAL ELECTRONICS

Prof. W. B. Nottingham  
B. L. Blackford

C. K. Crawford  
D. F. Hall

P. J. Shaver  
L. E. Sprague

### A. PULSED LANGMUIR PROBE MEASUREMENTS IN A CESIUM-PLASMA DIODE

This report gives the final results of a project that has been described in previous progress reports.<sup>1, 2</sup>

A tungsten wire probe of 2-mil diameter was introduced midway between the emitter and collector in the interelectrode space of a specially constructed plasma diode. The diode consisted of a polycrystalline tungsten wire (10-mil diameter) emitter and a concentric nickel collector block that had a 3/8-inch inside diameter. The axial length of the diode assembly was 1/2 inch. The collector was supplied with guard rings in order to define its effective area. Appropriate press leads were provided with guard rings in order to minimize the effects of surface leakage currents. The tube envelope was made of Pyrex and all press seals were made of tungsten.

The emitter was heated by passing a dc current through it. A relay was used to interrupt the emitter heating current. A triangular voltage pulse of millisecond width was then applied to the probe. The time delay between the emitter current interruption and the appearance of the voltage pulse was 3 msec. This delay time was chosen to be larger than the relaxation time of the plasma and appreciably shorter than the cooling time constant of the emitter. The resulting probe current-voltage characteristic was displayed on an x-y oscilloscope for photographic recording. The collector current-voltage characteristic was obtained in a point-by-point manner with a second x-y oscilloscope. All voltages were measured with respect to the grounded emitter.

The final data were taken at a cesium reservoir temperature of 440°K and at an emitter temperature of 2050°K. Under these conditions, the collector current was measured as 0 amp at a collector-to-emitter voltage of -3.40 volts. For collector voltages between -4.0 volts and -1.0 volt, semilogarithmic plots of the net probe electron-current density were observed to be of the form shown in Fig. I-1.

In general, the slopes  $s_1$  and  $s_3$  were roughly equal and corresponded to kinetic temperatures of 4000°K-5000°K. The slope  $s_2$  generally corresponded to a kinetic temperature of 10,000°K. The values of these slopes exhibited little dependence on collector voltage in the range -4.0 volts - -1.0 volt. The collector electron-current characteristic exhibited a slope in the retarding potential range that corresponded to a kinetic temperature of 2500°K.

The probe floating potential and the apparent plasma potential were not strongly dependent on the value of the collector voltage over the above-mentioned range of collector voltage. A slight increase in the plasma potential was noted as the diode terminal voltage approached short-circuit conditions. This indicates that the collector modulation

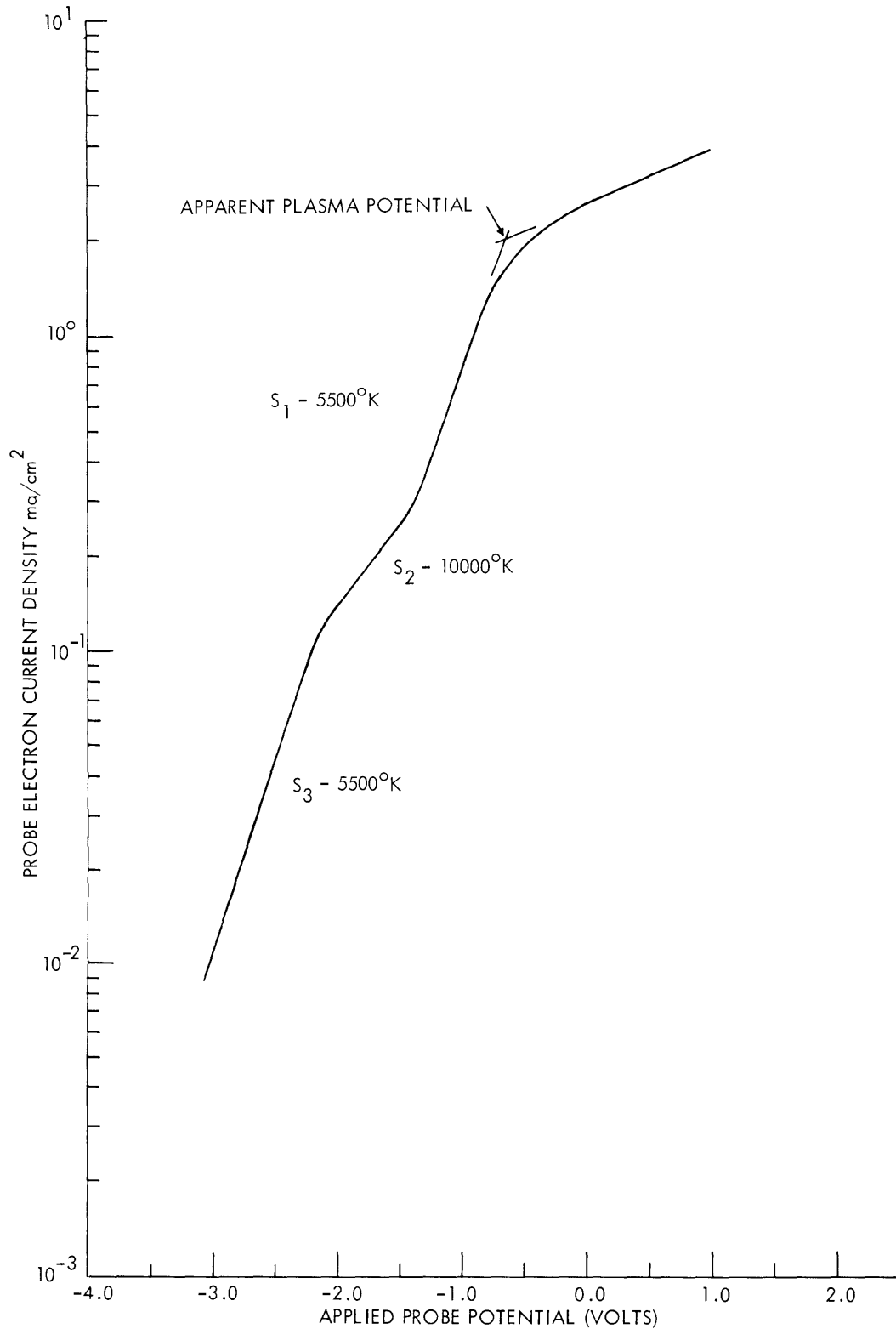


Fig. I-1. Typical electron current-density semilogarithmic characteristic. (Recorded for  $V_{\text{collector}} = -3.4$  volts;  $I_{\text{collector}} = 0$  amp.)

(I. PHYSICAL ELECTRONICS)

of the plasma potential is slight — the majority of the voltage change being absorbed by the modulation of the potential drop across the space-charge sheath at the collector.

Further details of this study can be found in the author's thesis.<sup>3</sup>

P. J. Shaver

References

1. P. J. Shaver, Pulsed probe measurements in a cesium-plasma thermionic diode, Quarterly Progress Report 62, Research Laboratory of Electronics, M.I.T., July 15, 1961, p. 5.
2. W. B. Nottingham, Quarterly Progress Report 64, Research Laboratory of Electronics, M.I.T., January 15, 1962, p. 2.
3. P. J. Shaver, Pulsed Langmuir Probe Measurements in a Cesium-Plasma Diode, S.M. Thesis, Department of Electrical Engineering, M.I.T., January 15, 1962.

