

I. PHYSICAL ELECTRONICS

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A. IONIZATION OF CESIUM AT SURFACES

Indications from voltage-current curves of thermionic power converters suggest increased ionization at, or very near, cesium-coated surfaces by low-energy electrons. Experiments have been conducted to study this phenomenon quantitatively for a low cesium concentration. The tube contained three indirectly heated tantalum surfaces surrounded by a shield. These heated surfaces, E1, E2, and E3, were tantalum tubes located at the three corners of an equilateral triangle. The extension of a line from the corner E1 perpendicular to the base of the triangle formed by the line E2 and E3 served to locate the position of a fine-wire ion collector. Electrons were accelerated from surfaces E2 and E3 to bombard E1. Ions produced at or near E1 were then accelerated toward the ion collector to serve as a measure of the ion production. Results of this experiment indicate that no appreciable ion current was produced in cesium vapor controlled by a $T_{Cs} = 350^\circ\text{K}$, by electrons having an energy less than 3.89 volts. The square root of the ion-to-electron current ratio was a linear function of the surface electron energy in excess of the ionization potential. Although not accurately determined, the ionization coefficient is given by $P_1 = P_1(V - V_1)$ with $P_1 = 20 \text{ cm}^{-1} \text{ v}^{-1}$ for the standard condition of $3.54 \times 10^{16} \text{ atoms/cm}^3$.

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B. THE ENERGY DISTRIBUTION FOR ELECTRONS IN A THERMIONIC DIODE PLASMA CANNOT BE TRULY MAXWELLIAN

For the refractory emitters, such as tungsten, tantalum, and molybdenum, operated in an energy-conversion diode, the ratio of the emitter temperature to the cesium temperature strongly influences the operating properties. If this ratio exceeds 3.2, an ion-rich sheath usually forms at the emitter surface. Electrons are accelerated in the plasma space by this injection potential. An analysis made here shows that at the open-circuit condition, the energy distribution of the electrons at the plasma edge of the emitter sheath cannot be a true Maxwellian over the entire range in electron energy. Instead, it is thought to be made up of two quasi-Maxwellians. The low-energy electrons are trapped and may have a high average energy close to that of the injection potential. The untrapped electrons will have an electron temperature equal to that of the emitter and their density will be that associated with an apparent or fictitious density many times that of the actual density.

A theory has been developed to describe quantitatively the relations that must be satisfied for the description above to apply. From typical numerical results that are

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applicable to specific diode configurations it is concluded that if the emitter-to-cesium temperature ratio exceeds 3.6, volume ionization is not required for a stable sheath. In the range 3.2 - 3.6 surface ionization is usually insufficient, and it is necessary to have volume ionization to sustain the sheath. Further studies will be required to establish the mechanism. It may be direct ionization by high-energy electrons, or ionization from excited states of the cesium atoms.

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