

I. PHYSICAL ELECTRONICS

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A. ELECTRON-EMISSION PROBLEMS

1. Work Functions and Electrical Conductivity of Oxide-Coated Cathodes

The experimental tube for this work has been completed and initial measurements are now being made. During the exhaust of the tube, some difficulty was experienced with electrical leakage. The resistance between the collector and guard rings which was originally $>10^{16}$ ohms dropped to about 10^{11} ohms after a ten-hour bake at 510°C -- presumably due to the evaporation of some material from the oxide cathode. It was found that admission of dry air to the system restored the original high-resistance state, and subsequent baking and processing produced no marked changes in the resistance.

Observation of photoelectric emission from the tantalum collector-guard ring structure under ultraviolet illumination showed that operation of the cathode at 1070°K for only two hours produced a marked contamination (probably barium) of the collector and guard rings. The fact that no emission could be detected when the outside surfaces of these cylinders were illuminated, while large currents could be obtained by illumination on the inside where straight-line evaporation from the cathode would be expected to produce a deposit, indicated that the contamination was indeed coming from the oxide cathode. The deposit could be removed by induction heating at 1600°K for several hours with the cathode cold; glowing the cathode with the other elements cold would again produce the contaminated condition. In making measurements, the cathode will not be operated above about 650°K , so no problems of this kind are anticipated.

The present plan is to complete the work-function and conductivity measurements with the cathode in its present state of high activity, and then repeat the measurements after the tube has been sealed back on the system and dosed with a small amount of oxygen to reduce the concentration of impurity centers.

W. E. Mutter

2. Determination of the Thermionic-Emission Properties of Single Tungsten Crystals by a Photometric Method

The electrons which are emitted from a single crystal tungsten wire in a radial electric field fly out in straight lines and strike the surrounding

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collector to form a pattern of received current density which is directly related to the thermionic-emission properties of the single tungsten crystal faces serving as the source. The filaments studied have been polished to remove all die marks and scratches and have been recrystallized by slowly raising the filament temperature from 1800°K . The method used to detect the current density pattern on the wall has been to coat it with a phosphor and measure the luminescence as a function of angle.

Since the light received by the photomultiplier from the filament is very constant at any particular setting, it is possible to measure the light from the phosphor quite accurately by making a correction for the filament light. Corrections are not so easy to work out, however, for the diffusely scattered radiation emitted by the phosphor at some point other than the small region under investigation. The light emitted in the direction of the [100] axis is many times greater than that emitted as a result of the bombardment of electrons which originated at a (110) plane; therefore, scattered light comes into the optical system from strongly luminescent regions and interferes very materially with the accuracy of the results. Some corrections are possible but are not so reliable as it is desired to have them.

A new tube has been designed and constructed in which only one-fourth of the cylindrical surface has been coated with phosphor, while the other 270° around the filament is coated with Aquadag. Experiment shows that this tube is far better, in that scattered light is greatly reduced. The experimental results obtained with it are still not satisfactory, because contaminating gases seem to be present in sufficient quantity to alter the emission properties of the filament with time after it has been cleaned by high-temperature flashing.

C. J. Marcinkowski

3. Determination of the Field-Emission Properties of Single Tungsten Crystals by a Photometric Method

An electrolytic-etching technique has been developed by which points believed to be suitable as sources for field-emission studies can be obtained consistently. This method involves the use of an electrolytic cell containing a 30 gram/liter solution of sodium hydroxide.

A small voltage is tapped off a 255-ohm, 1.25-ampere slide-wire rheostat across 115 volts single-phase AC and applied to a cone resistor (20 ohms), a milliammeter (0-10 ma, 1000 ohms), and the electrolytic cell in series. One electrode of the cell is made from sheet nickel in the form of a cylinder around the inner wall, while the other electrode is 3-mil tungsten wire

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from which the point is etched. The wire is firmly fastened, with about two millimeters under the surface of the NaOH solution. The current is found to be steady until the point becomes suitably etched, at which time it starts to decrease rapidly toward zero. If the voltage across the cell is cut off as soon as the current starts to decrease, sharp smooth points are obtained. The value of the current through the cell determines the general shape of the point obtained, and the former is adjusted by varying the amount of voltage tapped off. Using 9 ma (obtained with about 10 volts for the circuit constants given) the wire tapers considerably to the point, while with 3 ma (obtained with about 4 volts) the wire near the point is very narrow and straight. Any desirable degree of taper can be obtained using intermediate values of current.

A vacuum system for this project is now under construction. When this is completed, work will be started to determine the type of points and the proper vacuum techniques required to give stable field-emission patterns.

M. K. Wilkinson

B. STUDIES WITH GASEOUS DISCHARGE

1. Hot-Cathode Arc in Cesium Vapor

The tube discussed in the Progress Report of January 15, 1949, has been completed and data are now being taken with it. Briefly, it consists of a 2 1/4-inch I.D. glass tube containing a one-inch diameter nickel cathode and a one-inch diameter tantalum anode spaced five inches apart. The lowering of the work function by cesium condensation on the cathode is utilized in obtaining the required emission from the otherwise plain nickel. Both the anode and cathode are so constructed that they may be heated by built-in tungsten filaments. Between the anode and cathode are two probes, one a plane probe 0.1 inch in diameter and the other a hot-wire probe. To provide a means for varying the position of the probe along the length of the arc, the anode and cathode are mounted on an assembly which may be moved by tilting the tube. The cesium is contained in an appendix about five inches long, and its vapor pressure is controlled by adjustment of the temperature of a small oven surrounding the appendix. The main body of the tube is maintained at a higher temperature to prevent bulk condensation of the cesium on the glass, which would cause low resistance-leakage paths.

Several difficulties have been encountered in the operation of the tube which, although time-consuming, do not merit detailed reporting. Probably the most serious of these difficulties arises from the fact that even when the main body of the tube is 100°C hotter than the appendix containing

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the cesium, enough cesium is present on the glass walls to cause leakage resistances which are the order of thousands of ohms between points a few millimeters apart. Thus, over the negative portion of the probe characteristic curve where only the positive ion current is flowing to it, the glass shield acts, in effect, like part of the probe, causing the current readings to be too great. At more positive potentials, where the relatively large electron currents are flowing, the effect is less disturbing. The result is that only a limited region of the probe characteristic curve is useful in determining the plasma potential.

It has been found that there is a certain critical arc current which is a function of vapor pressure (cesium temperature) below which the arc discharge oscillates. The frequency of oscillation is irregular, but is roughly the order of one to five thousand cycles per second. The critical current varies from about 2 amperes at a cesium temperature of 125°C to about 0.25 ampere at 250°C . Also, there is a certain maximum current above which the arc becomes unstable due to the excessive heating of the cathode by the arc itself, an effect which causes limitations at the lower cesium temperatures.

To date, data have been taken utilizing only two probe positions. The distances between the anode and the center line of the probe were 6.55 and 2.85 centimeters. These data indicate, for example, that with 3.0 amperes arc current flowing, the plasma-potential gradient increases with cesium temperature from 0.1 volt per centimeter at 150°C to 0.35 volt per centimeter at 250°C . This corresponds to a range in vapor pressure from 0.009 to 0.45 millimeters of mercury. At a cesium temperature of 250°C , the plasma-potential gradient decreases with increasing arc current from 1.0 volt per centimeter at 0.3 ampere to 0.35 volt per centimeter at 3.0 ampere.

The anode fall, as indicated by assuming the potential gradient to be uniform and extrapolating to the anode, varies from about 0.2 volt negative to 0.8 volt positive, the more positive values being obtained from the smaller arc currents. The total arc drop at a given arc current and vapor pressure is dependent on cathode temperature, and was as low as 3 volts in some cases. However, the plasma potential relative to the anode appears to be dependent only on arc current and vapor pressure, indicating that the change occurs entirely in the cathode fall. But, for example, at a cesium temperature of 150°C and an arc current of 3.0 amperes, the product of the potential gradient of 0.1 volt per centimeter times the anode-cathode separation of 12.7 centimeters indicates a potential fall in the plasma of 1.27 volts. With the 3.0-volt total arc drop and 0.2-volt negative anode

fall obtained in this instance, only an apparent 1.5 volts, approximately, is left for the cathode fall. Since the ionization potential of cesium is about 3.9 volts, the results are difficult to explain unless a potential "hump" exists near the cathode. The arc current was supplied from a 120-volt direct-current source and a series resistance. An oscilloscope was connected across the arc at all times and data were taken only over the range of vapor pressures and arc currents for which the oscilloscope indicated no oscillations. It is, of course, planned to get more complete data.

R. K. Steinberg

C. EXPERIMENTAL TECHNIQUES

1. Spectral Emissivity of Tungsten and Tantalum

Since the new tube containing a tungsten specimen has not been completed, work is being continued on the spectral emissivity of the tantalum specimen already prepared. The results are similar in many respects to those obtained for the tungsten specimen. It is hoped that we will be in a position to present some quantitative data in the near future.

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2. Ionization Gauge and High-Vacuum Studies

A simplified ionization gauge has been constructed in which, in addition to the usual three elements of the gauge, there are two tungsten filaments. One is located in a manner which would permit the gas atoms evaporating off the tungsten filament when it is flashed to go directly, by straight-line travel, through the interior of the gauge. The other filament is set at the side; and although the distance to the gauge is the same in both cases, the gas atoms leaving the second filament can enter the interior of the gauge only after making a collision with other atoms or with the wall of the tube. In addition to these elements, a side tube containing a supply of barium-aluminum getter has been attached to the gauge. A vacuum-tight wall separates the getter compartment from the gauge proper. It is the intention to process this tube so as to obtain as good a vacuum in it as possible, measured either in terms of the apparent ionization current or in terms of the time rate of condensation of atoms onto the cleaned auxiliary filaments mentioned above. After suitable studies have been completed on the vacuum system, the gauge and its getter side tube will be sealed off. Following sealoff, properties of the gauge will be studied for a period of time and then the partition between the getter and the gauge will be broken to determine whether or not the presence of the getter surface will influence the background pressure or the rate of atom condensation, or both.

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