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EUROPEAN ATOMIC ENERGY COMMUNITY - EURATOM

INFLUENCE OF OXYGEN ON THE THERMONIC EMISSION OF A (110) ORIENTATED TUNGSTEN SURFACE

by

H.E.J. SCHINS and E. VAN ANDEL

1969

Joint Nuclear Research Center
Ispra Establishment - Italy
Direct Conversion

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ABSTRACT

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KEYWORDS

OXYGEN
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TUNGSTEN
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MONOCRYSTALS
MEASUREMENT
HIGH TEMPERATURE
WORK FUNCTIONS
PRESSURE

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Abstract (*)

The thermionic emission of a tungsten single crystal emitter (110) was measured in an oxygen atmosphere. The saturation current was determined in the temperature range from 1600 to 2200°K in dependence of the oxygen pressure (varying between $3.5\ 10^{-8}$ torr and 10^{-3} torr). The effective workfunction was plotted as a function of the reduced emitter temperatures (emitter temperature divided by a ficticious oxygen bath temperature). The results show the same trend as found by other investigators, i.e. the increase in effective workfunction caused by the adsorbed oxygen can be represented either by adsorption isotherms or isobars, or as a single function of reduced temperature.

Introduction

The oxygen effect on tungsten is intensively studied because of the fact that it promises a substantial amelioration in converter characteristics. This effect can be studied by field emission microscopy, by workfunction variation [1-4] by low energy electron diffraction [5,6] and by the flash-filament technique [7,8].

Although the LEED technique enables one to study the structures of the surface W-O phase, it appears nevertheless that the workfunction method is the most suitable one to use with respect to converter diode efficiency.

1. Experimental

An existing diode fig. 1 was put into a ion-pumped-vacuum system. The emitter was a large 2 cm diameter tungsten single crystal of (110) orientation and could be heated by electron

(*) Manuscript received on November 20, 1968.

bombardment of a pancake filament. The collector was guard-ringed and had provisions for out-gassing and cooling.

By nearly closing off the ion-pump with the main-valve a dynamic pressure up to 10^{-3} torr could be maintained in the belljar. This pressure could be measured by a Bayard-Alpert gauge near to the diode. P.P. oxygen (99,95%) could be admitted to the system and a mass-spectograph was attached to control the gas-composition.

Temperature measurements were made in a hohlraum in the emitter by means of a pyrometer of the disappearing filament type.

The saturation current was measured over a 1kΩ resistor. The signal passed a direct-current and a logarithmic amplifier and was then written on a X-Y recorder, fig. 2.

2. Results and Discussion

For the evaluation of the measurements we used the plots of C.G.J. Jansen and R. Loosjes [9] which allow to determine quickly the effective workfunction [10]. The results of the measurements are shown in fig. 3. The bare workfunction of the (110) single crystal used was low: 5,05 eV. The first influence of the oxygen appears at $T/T_R = 66$. The maximum workfunction variation by the oxygen layer measured was 0.75 eV. (For the determination of T_R see [1]).

In fig. 3 are shown also the results of Engelmaier [1], Dumont [3] and Batzies [4]. As can be seen there is little variation in the slope of the curves, although there is a serious shift. This discrepancy can be partly explained by the difficulty to make exact oxygen pressure measurements in the diode spacing. Also the gas-composition should be rigorously controlled as we found it particularly difficult to get rid of the carbon monoxide.

In fig. 4 we give some results for the tungsten (100) direction. Here we note both a variation in slope and a shift of the curves.

As one can see in figs. 3 and 4 the results of Zingerman [2] are not easily interpreted in this picture. Probably his method of oxyde formation by means of an oxygen-source does not allow for the evaluation of a corresponding oxygen-pressure.

In the near future we plan to repeat these measurements with an equipment based on an idea of Shelton [11] and elaborated by Batzies [12].

References

1 Engelmaier W., Stickney R.E., 26th Conf. Phys. Electr. M.I.T. (1966) 260.

2 Zingerman Ya.P., Ishchuk V.A., Sov. Phys. Sol. State 8 (1966) 728, 8 (1967) 2394, 9 (1967) 623, 9 (1968) 1992.

3 Dumont F.P., Mauries J., Second Int. Conf. Therm. En. Stresa (1968).

4 Batzies P., Second Int. Conf. Therm. En. Stresa (1968).

5 Germer L.H., May J.W., Surf. Sc. 4 (1966) 452.

6 Gorodetsky D.O. et al., Ukr. Fiz. Zhur. 12 (1967) 967.

7 Singleton J.H., J. Chem. Phys. 47 (1967) 73.

8 Ageev V.N., Ionov N.I., Sov. Phys. Tech. Phys. 10 (1966) 1614.

9 C.G.J. Jansen, R. Loosjes, Philips Res. Rep. 8 (1953) 81.

10 H.E.J. Schins, J. Bohdansky, EUR.2155.e (1964).

11 H. Shelton, Phys. Rev. 107 (1957) 1553.

12 P. Batzies 012-64-CODD. Contr. Euratom-BBC: see also First Int. Conf. Therm. En., London (1965).

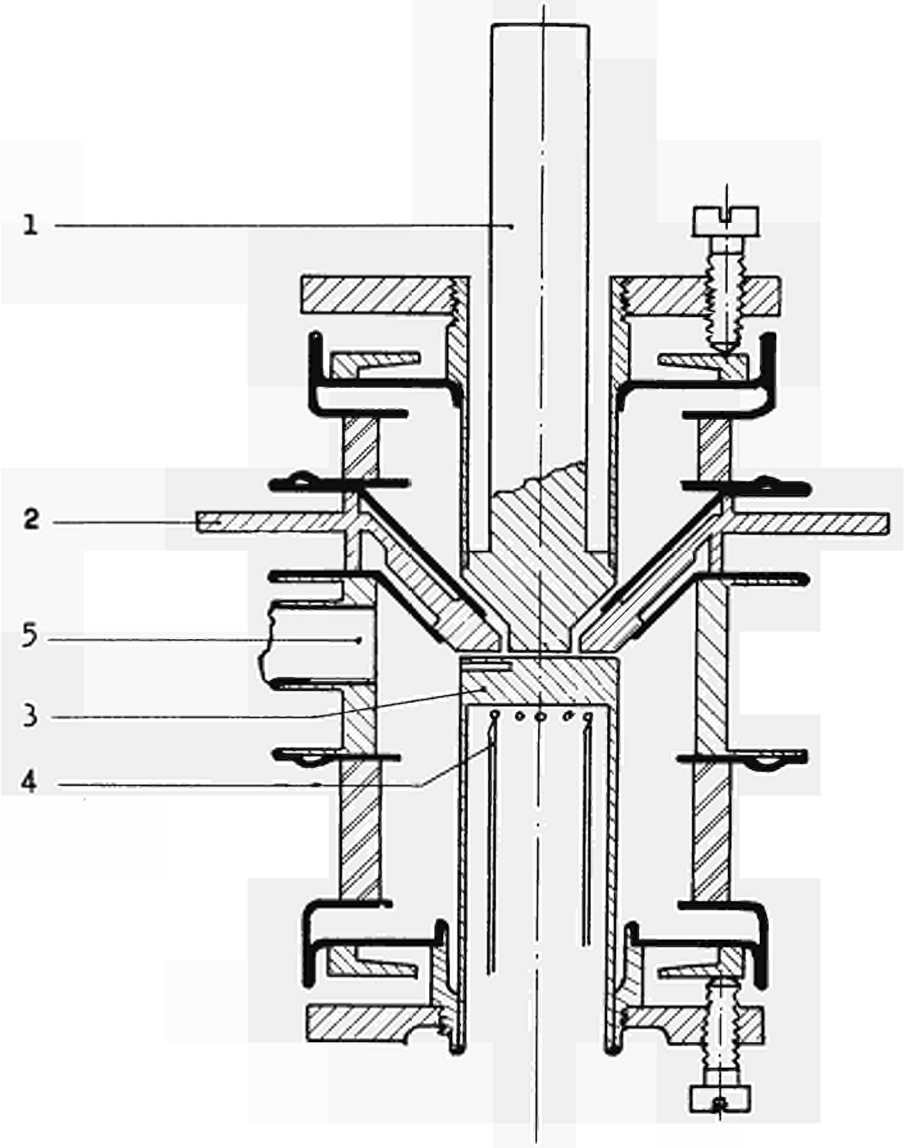


Fig.1: Experimental diode.

1-: Collector -2 : Guardring- 3 :Emitter - 4:Fil ament -5:Cut off Cs reservoir,now viewport.

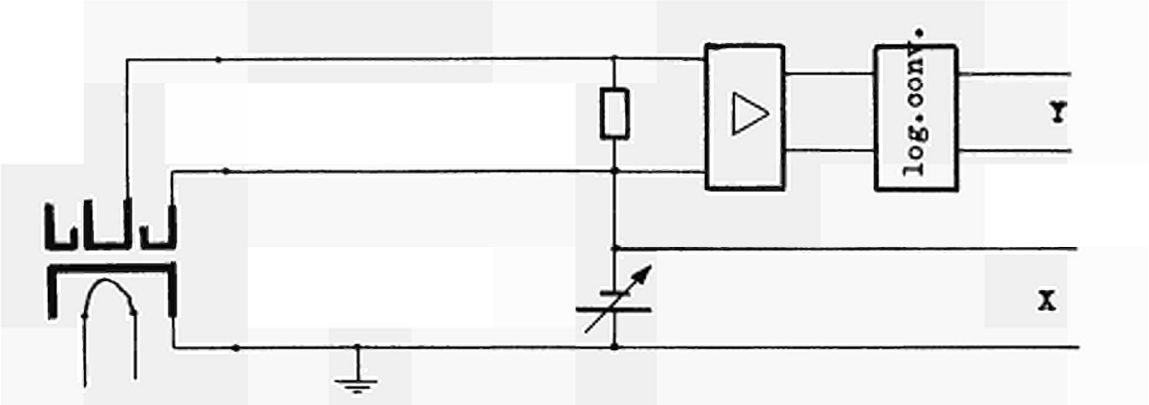


Fig.2 : Electric Circuitry.

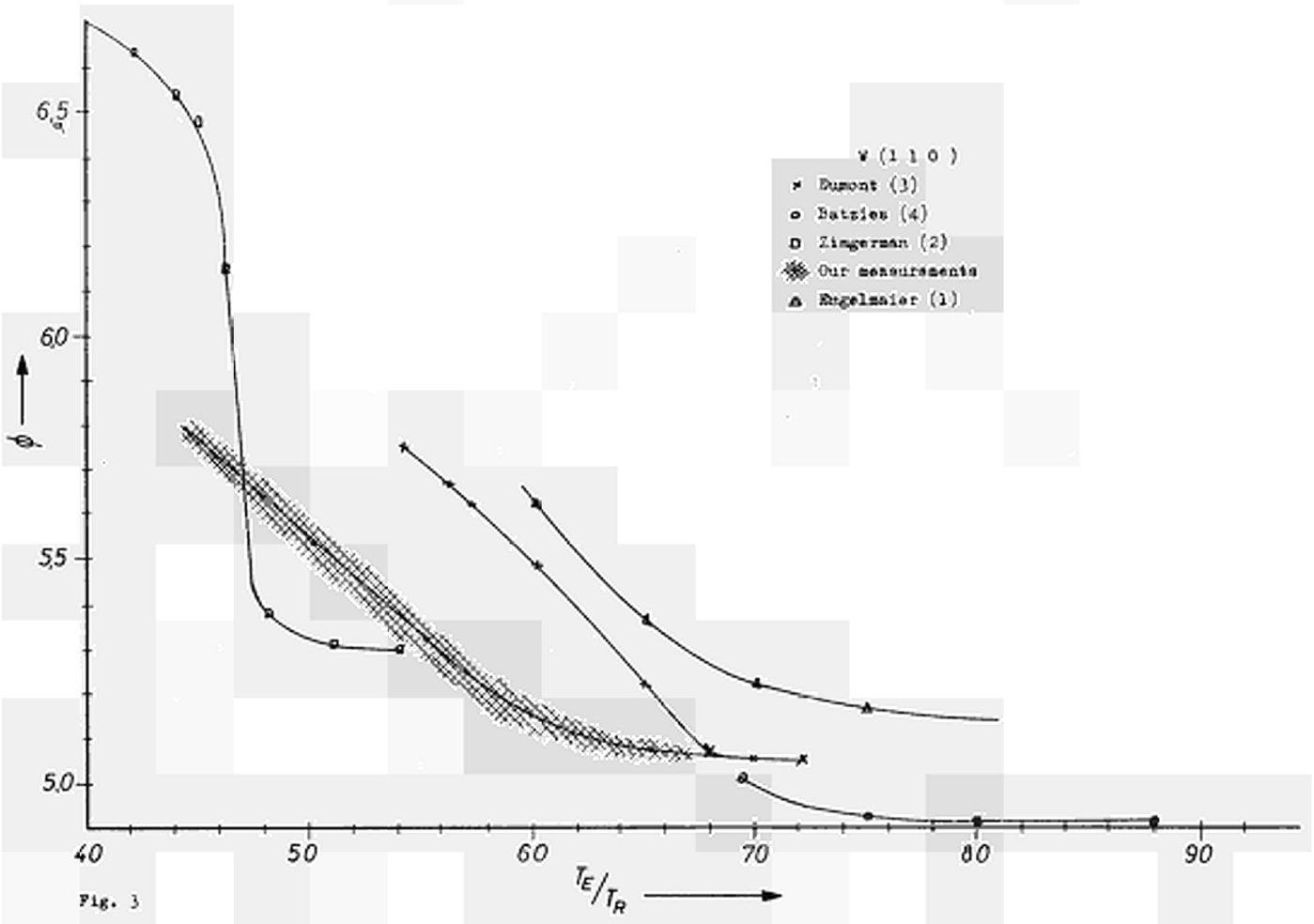

6,5
6,0
5,5
5,0
40
50
60
70
80
90
T_E/T_R
V (1 1 0)
Dumont (3)
Batzies (4)
Zingerman (2)
Our measurements
Engelmaier (1)

Fig. 3

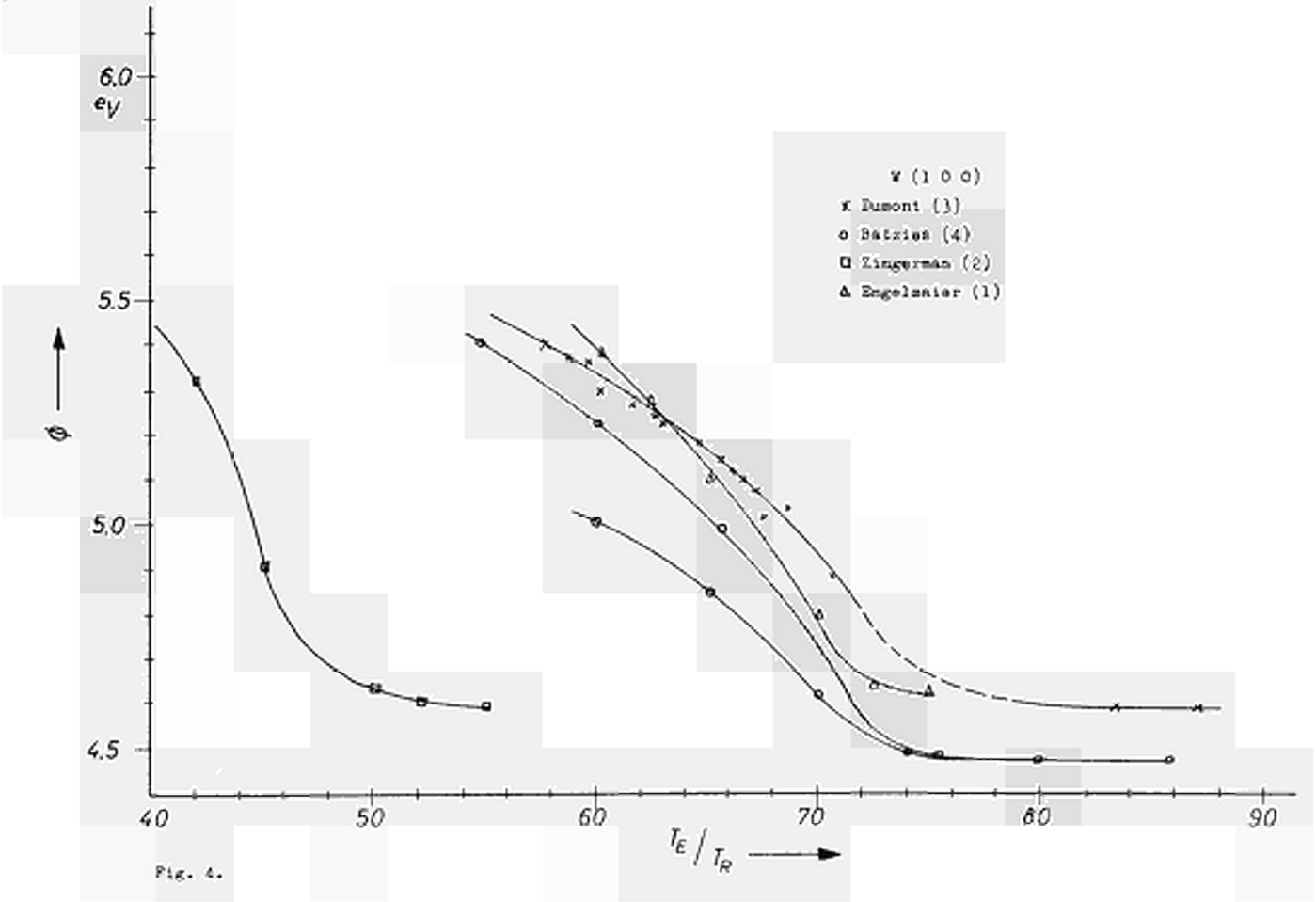
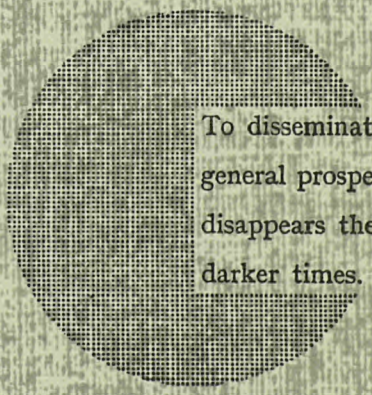

6,0
e_V
5.5
5,0
4.5
40
50
60
70
80
90
T_E / T_R
V (1 0 0)
Dumont (3)
Batzies (4)
Zingerman (2)
Engelmaier (1)

Fig. 4.



To disseminate knowledge is to disseminate prosperity — I mean general prosperity and not individual riches — and with prosperity disappears the greater part of the evil which is our heritage from darker times.

Alfred Nobel

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