CONCERNING THE DETERMINATION OF THE MEAN INTERNAL POTENTIAL IN AN ELECTRON INTERFERENCE MICROSCOPE

I. F. ANASKIN and I. G. STOYANOVA

Institute of Biological Physics, USSR Academy of Sciences

Submitted February 9, 1968

Zh. Eksp. Teor. Fiz. 54, 1687–1689 (June, 1968)

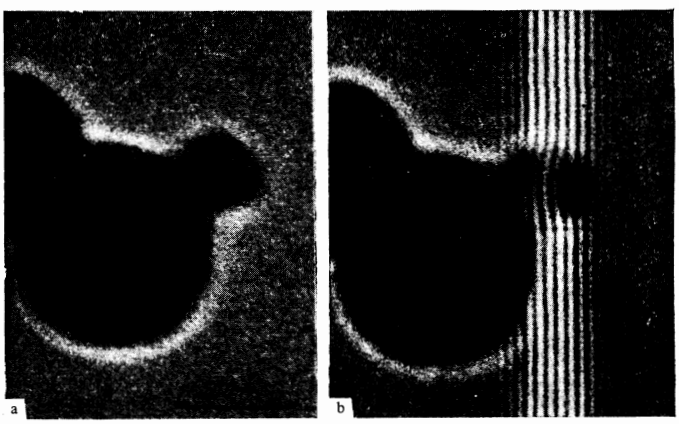
For a determination of the mean internal potential in an electron interference microscope it is suggested that the measurements be made on spherical samples of the investigated substance, with diameter on the order of several hundred Angstroms. The method of preparation of such samples is described. They are obtained by sputtering of electrodes made of the investigated material in an electric discharge. An inert gas (He) at atmospheric pressure is employed. The mean internal potentials for Mo, Cr and Tu are determined. The measurements were carried out at an accelerating potential of 100 kV.

We describe in this paper a procedure and the results of the investigations of the average internal potential of Mo, Cr, Ta, and Au with the aid of an electron interference microscope[1]. The interferometric method was used until recently to determine the internal potential of sputter amorphous and crystalline layers of C, Al, Cu, Ag, Au, Be, and Ge[2-5], prepared in the form of steplike compounds of the investigated substance.

The method of steplike compounds, which is convenient for electronic interferometers with cylindrical lenses, is not suitable for electronic interference instruments constructed on the basis of transmission electron microscopes. The latter, when operating in the interference-microscope regime, must operate at magnifications of more than 2×10^4, which makes it impossible to use the steplike compounds, in view of the fact that the boundaries of the sputtered steps are now sharp. To measure the average internal potential Φ_0 with an electron interference microscope, it is proposed to use compounds of the investigated substance in the form of spherical particles with dimensions of several Angstroms.

To obtain compounds in the form of spherical particles, we used a method similar to that of obtaining aerosols in inert gases[6], but instead of evaporating the investigated substance from a tungsten evaporator, we used discharge between electrodes of the investigated material. The volume in which the evaporation was carried out was pumped out to a pressure 10^{-5} mm Hg and filled with inert gas (He) to atmospheric pressure. The compounds for the investigation were obtained by depositing the aerosol on microscopic grids without films or with a formvar film with openings, on which a thick conducting chromium layer was deposited beforehand in high vacuum.

To determine Φ_0, we chose formations consisting of a larger number of spherical particles located outside the substrate. When such compounds were used, the influence of the charging and contact potential difference on the value of the measured Φ_0 was completely eliminated, inasmuch as the particles were not charged under the electron beam and were not in immediate contact with any substances except those investigated. In this method of preparing the compounds, the possibility of contamination of the compounds by extraneous impurities was completely eliminated.



Spherical particles of molybdenum: a—electron-microscope picture of particles, b—the same particles in an electron interference microscope.

The investigated compound was located in the objective plane of the objective lens. To determine Φ_0, the interference pattern obtained with the aid of an electrostatic biprism was superimposed on the focused image of the spherical particle (see the figure). The magnification of the electron-microscopic image of the particle was 2.8×10^4 at an accelerating voltage of 100 kV. Measurements of the shift of the fringes and of the particle diameter were made on a magnified (15 ×) photographic print from the negative, using a method described earlier[7].

The average internal potential Φ_0 was calculated by means of the formula[2]

$$\Phi_0 = \frac{\sqrt{1+\alpha U}}{1+2\alpha U} \frac{2h}{\sqrt{2em_0}} \frac{\sqrt{U}}{d} \frac{S}{\Delta},$$

where e and m_0 are the charge and mass of the electron, h is Planck's constant, $\alpha = 0.9788 \times 10^{-6}$ (V^{-1}) is the relativistic correction, U(volts)—accelerating voltage, d(Å)—thickness of the compound, S—shift of the interference fringes, and Δ—period of the interference pattern. The accuracy with which Φ_0 was determined is governed essentially by the accuracy with which the relative shift of the fringes S/Δ and the thickness d are measured. The accuracy of measurements of this kind

Metal	Number of compounds	Particle diameter, Å	S/Δ	Φ_0, V	δ, V	$-\overline{\delta}$, V
Mo	40	250—900	0.5—1.8	12.9	±1.5	±0.3
Cr	26	100—400	0.3—0.6	13.8	±2	±0.5
Ta	23	200—500	0.25—0.5	9.3	±0.8	±0.45
Au	20	130—640	0.4—1.6	16.9	±1.7	±0.3

with the aid of photographic prints is ~ 10%.

The table lists the results of the measurements of the average internal potential Φ_0, the average measurement error δ, and the rms error $\overline{\delta}$. The measured values of Φ_0 are valid also for bulky bodies, inasmuch as the density of the spherical particles is equal to the density of the bulky bodies[8].

The values of Φ_0 for Mo, Cr, and Ta were obtained here for the first time. The average internal potential of Au, determined by us for spherical particles of colloidal Au, corresponds almost exactly to the value 16.8 ± 1 V, measured in an electronic interferometer with quadrupole magnetic lenses at 90 kV[5].

[1] I. F. Anaskin, I. G. Stoyanova, and A. F. Chapas, Izv. AN SSSR Ser. Fiz. 30, 766 (1961).
[2] M. Keller, Z. Physik 164, 274 (1961).
[3] H. Hoffmann and C. Jonsson, ibid. 182, 361 (1965).
[4] C. Jonsson, H. Hoffmann, and G. Mollenstedt, Phys. Kond. Materie 3, 193 (1965).
[5] E. Kerschbaumer, Z. Physik 201, 200 (1967).
[6] M. Ya. Gen, M. S. Ziskin and Yu. I. Petrov, Dokl. Akad. Nauk SSSR 127, 366 (1959).
[7] I. G. Stoyanova, I. F. Anaskin, and M. D. Shpagina, Biofizika 13, No. 2 (1968).
[8] E. V. Shtol'ts, M. Ya. Gen, I. V. Eremina, E. N. Fedorova, and A. V. Deryagin, Fiz. Metal. i Metalloved. 24, 220 (1967).

Translated by J. G. Adashko
194