FERMI LEVEL OF CARRIERS IN THE VOLUME FILLING DEFECTS STRUCTURE BASED ON HEAT-RESISTANT METALS

Volodymyr I. Marenkov

Odessa National I.I. Mechnikov University, Physics Department,
Dvorjanskaja 2, 65026, Odessa, Ukraine

ABSTRACT

The volume filling defects structure based on metals are widely used in modern nanotechnology, especially when creating high temperature sensors and structural elements based on metal foams [1]. The development of contactless and nondestructive methods for diagnosis and test control parameters of multiply connected matrix base material is a very important and interesting aspect of the application [2]. In a heat-resistant metal with the volume filling defects (VFD) (micro- and nanopores with complex topologies and sizes, see. *Figure 1*) it is primarily its strength and electrical and physical characteristics. Almost all rapid methods of such measurements are based on both electrical measurements data and on fundamental functional relationships establishing of the microstructure parameters and the dispersion medium carriers [3]. The influence of a disordered set of volume filling defects (VFD) (micro- and nano-pores of complex topology and various sizes, Figure 1.) is the unsolved problem on the electronic properties of the micro heterogeneous materials theory.

Key words: nanopores, electronic properties, materials with VFD.

PLASMA STATISTICAL APPROACH

The new statistical "plasma" approach is proposed in this work. This method is based on the modeling statistical concept of the heterogeneous plasma system (HPS) characteristics [3-5]. The main point of this approach is the concept of an electrically neutral cell (see *Figure 2*). This cell is the smallest area of the electrically inhomogeneous material released by a multiply connected surface Π extreme of instant self-consistent system electric potential [4].

The electronic component statistical equilibrium in volume filling defects of the heat-resistant metals of both nano- and mesoscopic sizes determines the level of electrochemical potential of a homogeneous volume of the sample in any its point. Statistical equilibrium of the electronic component in FVD high-temperature metal nano- and mesoscopic size determines the level of electrochemical potential of a homogeneous volume of the sample in any its point. Moreover, according to the principle of free energy minimum, F takes the smallest value. Equilibrium distribution of the local density of the electronic component in the matrix base material and

VFD satisfies this condition and is determined by solving the effective electrostatic problem in an averaged cell C_{ξ}^{z} [3, 5].

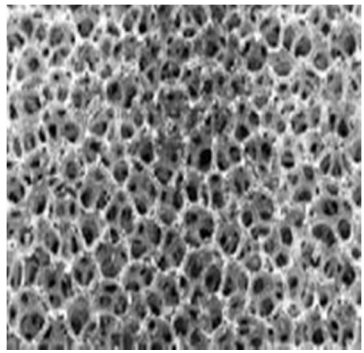

Fig. 1 – Nanoporous metal foams [1]

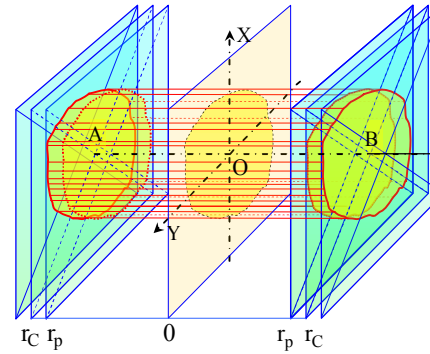

Fig. 2 – Planar cell of the micro-hulled metal with VFD

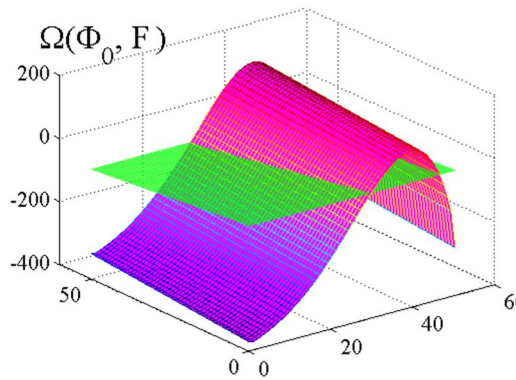

Fig.3 – 3-D graph of the dependence $F = F(\Phi_0)$

RESULTS AND DISCUSSION

The main point of this approach is the concept of an electrically neutral cell (see *Figure 2*). This cell is the smallest area of the electrically inhomogeneous material released by a multiply connected surface Π extreme of instant self-consistent system electric potential [4].

The electronic component statistical equilibrium in volume filling defects of the heat-resistant metals of both nano- and mesoscopic sizes determines the level of electrochemical potential of a homogeneous volume of the sample in any its point. Statistical equilibrium of the electronic component in FVD high-

temperature metal nano- and mesoscopic size determines the level of electrochemical potential of a homogeneous volume of the sample in any its point. Moreover, according to the principle of free energy minimum, F takes the smallest value. Equilibrium distribution of the local density of the electronic component in the matrix base material and VFD satisfies this condition and is determined by solving the effective electro-static problem in an averaged cell C_{ξ}^{z} [3, 5]. For the hulled metal sample with VFD this equation looks like

$$\Omega(\Phi_0, F) = \mathrm{tg}\left(\frac{\kappa \cdot r_p}{\sqrt{2}}\right) - \tilde{\alpha} \cdot \frac{\varepsilon_p \cdot \kappa_F \cdot E_F^0}{\kappa \cdot kT} \cdot \sinh(\kappa_F \cdot \delta) = 0 \qquad (1)$$

Here: Φ_0 is potential in the center of the cell; F is the Fermi level of the carriers; r_p, δ is respectively, the size of the defect and matrix elements of metal, which belongs to C_{ξ}^{z}; κ^{-1}, κ_F^{-1} is Debye length and the Fermi length of the electronic component; $\tilde{\alpha} = \frac{2}{3} \cdot \left[(1 + F/E_F^0 + W^0/E_F^0) - 1/\sqrt{(1 + F/E_F^0 + W^0/E_F^0)}\right]$ is the parameter of the equation; E_F^0 and W^0 is the Fermi energy and electron work function of metal; ε_p is metal dielectric permittivity; T is temperature of the sample. Equation (1) establishes a functional relationship of electrochemical potential of the carriers with the defining parameters of the sample: temperature, geometric characteristics and concentration of VFD, the electronic parameters of the base material, and particularly with the equilibrium value of the local electrostatic defects potential (Figure 3.) stabilized. The external electric field Φ_0 influence on the electrons density distribution in the sample VFD was determined in the computer experiment. The possibility of creating of the sensitive temperature sensors based on heat-resistant metal with nano-VFD was discussed in details.

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