SOME PARTICULARITIES OF CURRENT TRANSPORT IN THE METAL- DIELECTRIC -METAL STRUCTURES

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ABSTRACT.
The involved feature of current transport in the metal-dielectric-metal structures in greater degrees is stipulated by the influence of additional electrical field, appearing through spottiness of local potential barriers height along interface metal - dielectric.

Keywords: contact, additional electrical field, metal - dielectric.

I. INTRODUCTION

The thin-film instruments created on the base of metal - dielectric - metal (MDM) structures are broadly used in modern electronic devices. Current transport in such structures depending on thickness intermediate fine dielectric layer and potential barrier heights on the interface metal - dielectric is theoretically described basically by or the thermoelectronic emission, or tunneling mechanism [1]. However, in many events some elegancy current transport in MDM structures, for instance, dissymmetrical voltage-current characteristic of MDM structures, mismatch acting and geometric areas of MDM under current transport and etc, still stay not quite comprehensible from standpoints of experiment [2,3].

II.THEORETICAL POSITION.

As real contacts a metal-semiconductor [4], real interface of MDM structures practically always is an emission spottiness, i.e. unhomogeneous of the potential barrier height along surfaces of interface. This in the first place connected with the crystallography structure of metallic electrodes of MDM, as which are in practice used or cleaned metals, or alloys. Crystalline structure of such metallic electrodes of MDM are polycrystalline, with the result that their surface, turned to dielectric, present itself irregular a mosaic, contained from different borders an microcrystalline [3] with different local work functioning [4]. Besides, there is and row other objective constructive-technological reasons of emission spottiness of real MDM, i.e. origin the microareas of internal surface of metals with different work functioning [5]. Therefore study of characteristics unhomogeneous MDM presents theoretical and practical interest.

Consider unhomogeneous MDM structure, contained from parallel united multiple micro-MDM with alike geometric desksides and different local potential barriers heights on the interface metal - dielectric. For qualitative consideration will sufficiently be limited by the simple scheme of interface (Fig.1a), flat that surface of metal M_1 (will name its conditionally cathode) is kept only two parallel interleaving sort the microareas with local work functioning Φ'_{M1} and Φ''_{M1}, but surface of metal M_2 (will name its conditionally anode) - with Φ'_{M2} and Φ''_{M2}, where $\Phi''_{M1} > \Phi'_{M1}$ and $\Phi''_{M2} > \Phi'_{M2}$ (notion of local work functioning saves a sense for areas, having single-line sizes big, than 10 - 20 constant lattices [8]). On internal surfaces of both electrodes in consequence of electrical interactions the microareas with different local work functioning exists an electrostatic field [5,6], spreding on the surface of metals on the distance of order of geometric sizes of the microareas (Fig.1a). This electrical field, named by the spot field, accelerates electrons, emission from the microareas with Φ''_{M1}, Φ''_{M2} and slows - with Φ'_{M1}, Φ'_{M2}.

Energy diagrams of metals M_1 and M_2 separately submitted for Fig.1b. Hereby on microareas with Φ'_{M1} and Φ'_{M2} sport field creates additional potential barriers $\Delta\Phi'_{10}$ and $\Delta\Phi'_{20}$, preventing leaving the electrons from them. However, under the influence of sport field of value of work functioning of the microareas with Φ''_{M1} and Φ''_{M2} are lowered by the normal Schottky effect on values $\Delta\Phi''_{10}$ and $\Delta\Phi''_{20}$. Outside the sport field work functioning a leaving a cathode and anode has constant averaged values M_1 and M_2. If surface of cathode consists of two areas with Φ'_{M1} and Φ''_{M1} and with areas S'_1 and S''_1, but anode - with Φ'_{M2} and Φ''_{M2} and S'_2 areas and S''_2, hereby M_1 and M_2 are defined by following formulas:

$$\overline{\Phi}_{M1} = \frac{S_1'\Phi'_{M1} + S_1''\Phi''_{M1}}{S_1' + S_1''}$$

$$\overline{\Phi}_{M2} = \frac{S_2'\Phi'_{M2} + S_2''\Phi''_{M2}}{S_2' + S_2''} \qquad (1)$$

In the event of MDM, sport field penetrates on the depth l in dielectric, having thickness δ, permeability ε and electronic relation χ. Consider an event 2l and denoted the local barriers heights between microareas of metals with Φ'_{M1}, Φ''_{M1}, Φ'_{M2}, Φ''_{M2} and of dielectric with χ through Φ'_{B1}, Φ''_{B1}, Φ'_{B2}, Φ''_{B2}, accordingly ($\Phi'_{B1}=\Phi'_{M1}$ -

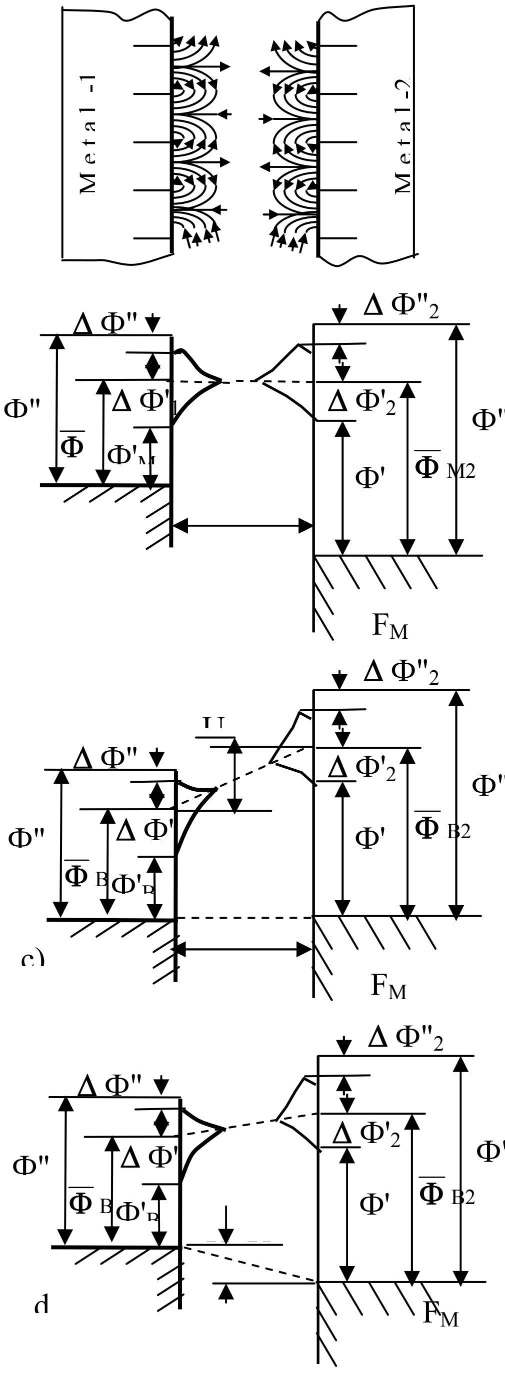

Fig.1. Energy diagrams MDM structures

χ, $\Phi''_{B1}=\Phi'_{M1}$ - χ, $\Phi'_{B2}=\Phi'_{M2}$ - χ, $\Phi''_{B2}=\Phi''_{M2}$ - χ). The averaged barrier heights denoted as $\overline{\Phi}_{B1}$ and $\overline{\Phi}_{B2}$ (where $\overline{\Phi}_{B1} = \overline{\Phi}_{M1} - \chi$ and $\overline{\Phi}_{B2} = \overline{\Phi}_{M2} - \chi$).

Under the thermodynamic balance, when $\overline{\Phi}_{B1} < \overline{\Phi}_{B2}$ tension of field of contact difference of potentials U_K anode and cathode ($qU_K = \overline{\Phi}_{B2} - \overline{\Phi}_{B1}$) will be directed parallel tension of sport field for microareas with Φ'_{B1} and Φ''_{B2}, ant parallel - for microareas with Φ''_{B1} and Φ'_{B2}. In this connection values $\Delta\Phi''_{10}$ and $\Delta\Phi'_{20}$ will reduce (accepting values $\Delta\Phi''_1$ and $\Delta\Phi'_2$), but $\Delta\Phi''_{20}$ to increase (accepting values $\Delta\Phi''_2$), Fig.1c.

III. CURRENT TRANSPORT

In equilibrium state a current I_{10}, stipulated by the electrons emission from areas with Φ'_{B1} and Φ''_{B1} and reached anode, must stay an equal current I_{20}, stipulated by the electrons emission from areas with Φ'_{B2} , Φ''_{B2} and reached cathode, i.e. $I_{10} = -I_{20}$.

At exhibit of the external field, not exceeding value of sport field, I-V characteristics of MDM in the event of big visibility of barrier heights of microareas of interface surfaces be defined in main only currents of microareas with Φ'_{B1} and Φ'_{B2}. In the same time I-V characteristics of MDM in consequence of influences of sport field will possess some particularities in forward and reverse directions, Fig.1d. So, under direct displacing, i.e. when positive potential is given to the anode, I-V characteristics must have three distinctive parts. First, under $U \leq U_K$ on the measure of increasing a voltage current will increase much more weak, than in the event of uniform MDM structures. The most further increase U up to the definite sign, under which $\Delta\Phi'_1$ becomes an equal zero, corresponds a second part , on which I-V characteristics of MDM is defined by the anomalous Schottky effect [5], i.e. current from microareas with Φ'_{B1} powerfully increases with the growing of voltage. Then follows the following, third part, on which the current, emission from of cathode surfaces, becomes equal to the current amount all microareas, values of local barriers heights which decrease an external field according to the normal Schottky effect. This part of I-V characteristics of MDM will be defined by the formula:

$$I_F = I_1' + I_1'' = \{S_1'A_1'T^2 \exp(-\frac{e\Phi'_{B1}}{kT}) + S_1''A_1''T^2 \exp[-\frac{e(\Phi''_{B1} - \Delta\Phi''_1)}{kT}]\} \exp\frac{1}{kT}(\frac{e^3U}{\varepsilon d})^{1/2}$$
(2)

At exhibit of the reverse displacing, i.e. when negative potential is given to the anode, I-V characteristics of MDM must have two parts. So, on the measure of increasing an reverse voltage up to values, under which $\Delta\Phi'_2$ becomes an equal zero, I-V characteristics of MDM will be defined by the anomalous Schottky effect [5], i.e. current from microareas with Φ'_{B2} powerfully increases. This part of I-V characteristics of MDM is the first, for which follows the second, where current from anode surfaces becomes equal to the current amount all microareas, values of local barriers heights which decrease a normal Schottky effect. This part of reverse I-V characteristics of MDM will be defined by the formula:

$$I_R = I_2' + I_2'' = \{S_2' A_2' T^2 \exp(-\frac{e\Phi'_{B2}}{kT}) +$$
$$+ S_2'' A_2'' T^2 \exp[-\frac{e(\Phi''_{B2} - \Delta\Phi''_2)}{kT}]\} \exp\frac{1}{kT}(\frac{e^3 U}{\varepsilon d})^{1/2}$$
(3)

Unlike above analyzed scheme the sport field, in real events the microareas distribution with the different potential barrier height on the interface of MDM structures is described by the complex function

IV. CONCLUSION

Thereby, in conclusion possible say that presence in dielectric the additional electrostatic field, appearing in consequence of interactions the microareas on the interface of MDM with different potential barrier heights, can render an essential influence upon the nature of running a current in real MDM in forward and inverse directions. It is necessary to note, that in the case of emission MDM structures appear some other specific particularities, which in particular stated in .

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