THEORETICAL CALCULATION OF THE INTERNAL POTENTIAL BARRIER FOR THE METAL/ SEMICONDUCTOR FILM STRUCTURE
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ABSTRACT
The layered cathodes are considered as perspective materials for the field emission devices. The theoretical solution in the framework of nonlocal electrostatics taking into account the space dispersion effects in the metal and dielectric film has been found. The decreasing of the external potential barrier for the electrons emitted from the diamond film can stimulate the lowering of the threshold voltage of the cold field emission for the layered cathodes.

1. INTRODUCTION
Recently the layered cathodes are considered as perspective materials for the field emission devices. It is known, that the deposition of semiconductor (metallic) coatings on a surface of the metal (semiconductor) results in a significant modification of the emission characteristics of a baseline material. The emission properties of ultrathin films are expected to deviate from those of the corresponding bulk materials [1] and can not be predicted simply on the basis of their bulk structure. The influence of the potential barrier to an inner interface on the performances of the layered cathodes was investigated in [1-3].

II. THEORETICAL CONSIDERATION
In this work we propose the theoretical method of the direct calculation of the potential barrier $V(x, F)$ for the metal/thin semiconductor film intimate junction based on the account of screening properties of the metal and semiconductor in the framework of nonlocal electrostatics. It is shown that the potential barrier on the internal metal/semiconductor film interface can be theoretically calculated without introduction of the additional parameters. For the system in the current regime in result of contact the common electronic subsystem is formed (the common Fermi level of the metal and semiconductor film). The potential barrier height $\Delta \Phi$ on the internal interface is determined by the contact potential $\Delta \Phi$ and by the screening properties of the metal and semiconductor film with thickness $L$.

In the present work we consider the n-type semiconductor film on the metal substrate: thin heavily doped diamond film (n-type) on the molybdenum, when the electrons emit from the diamond film into vacuum. The screening properties of the metal (Mo) was taken into account in Thomas-Fermi approximation (TFA). The screening properties of the semiconductor film $\varepsilon(\vec{k})$ was taken into account in Deby-Hukel approximation (for a nondegenerate electron gas) and in the interpolation Inksen model (for the bound electrons of ion islands).

On the Fig.1 the potential $V(x, F)$ for the considered system, when $L = 15\,\AA$, in the external electrical field $F = 3 \times 10^7\, V/cm$ (solid curve 1) and $F = 6 \times 10^7\, V/cm$ (solid curve 2) is shown. The following parameters were used: temperature is $T = 293\, K$; for the molybdenum: $n_i = 4 \cdot 10^{22}\, cm^{-3}$ is the concentration of the free electrons; $\varphi_{\text{met}} = 4.6\, e\, V$ is the work function and $m^* = 0.7759m_0$ is the effective mass, $m_0$ is the mass of the free electron; for the diamond film (n-type); bulk density of the free electrons is $n_2 = 5 \cdot 10^{17}\, cm^{-3}$; dielectric constant is $\varepsilon = 5.6$; effective masses are $m_{1s} = 0.36$ (transverse) and $m_{1t} = 1.4$ - (parallel); electron affinity in the bulk is $\chi = -E_c = 334\, e\, V$, where $E_c$ is the bottom of the conduction band. [4].

In the case of intimate contact the thickness of the double electrical layer on the internal interface $d$ is about one lattice constant (or close it). In our calculations the thickness of the double electrical layer is $d = 2\,\AA$. For the above mentioned parameters the charge density $\sigma(L)$ on the
internal interface is $\sigma(15\text{ Å}) = 2.276 \cdot 10^{13} \text{ eV/m}^2$, the contact potential is $\Delta\Phi = 0.985\text{ eV}$ and the potential barrier height (without the image forces lowering) is $h(L) = 1.316\text{ eV}$. It was shown, that the potential barrier height $h(L)$ essentially depends on the thickness $L$ and the doped concentration $n_{d}$ of the diamond film and is very sensitive to the preparation conditions.

The appropriate dotted curves in Fig.1 show the distribution of the potential $V(\chi, F)$ in the considered structure calculated in the framework of the local (classical) consideration.

III. CONCLUSION

As shown in our preliminary calculations the existence of the superthin heavily doped diamond coats on the metal surface brings to the significant downturn of the external potential barrier in comparison with the clear metal surface. This decreasing of the external potential barrier for the electrons emitted from the diamond film can stimulate the lowering of the threshold voltage of the cold field emission for the layered cathodes.