As can be seen from the results obtained, the electric field intensity in SiO_xN_y is 10^8-10^9 V/m. The current density varies in the rangeof 10^2-10^5 A/m^2 with the increasing of voltage drop and depends on the parameters of the traps and their concentration.

Estimation of emission characteristics. To obtain the current density of the field emission of 100 A/m^2, taking into account the value of the SiO_xN_y/cobalt surface barrier and the cobalt work function (4.4 eV), the current density in SiOxNy should be above 10^4A/m^2. To obtain an emission current density of 100 A/m^2 at a field intensity between cobalt and vacuum of about (2-5)107V/m, the current density of $2 \cdot 10^7 - 1.1 \cdot 10^4$ A/м^2 is required in SiO_xN_y. As preliminary estimates have shown, this can be achieved by the trap concentration of (2-5)10^{19}cm^{-3} and their energy of 0.4-0.5 eVover conduction band bottom of SiO_xN_y.

IV. CONCLUSIONS

Simulation of current transfer in the array of silicon nanocones, presenting the n-Si(Sb)/SiO_xN_y/Co nanostructure, is performed. It is established that at concentrations of traps in SiO_xN_y of the order of (2-5)10^{19} cm^{-2} and their energy of 0.5 eV, is possible to reach a current density up to 10^5 A/m^2, which will allow to obtain an emission current density of 100 A/m^2.

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SURFACE PLASMONS IN GRAPHENE HETEROSTRUCTURE

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I. INTRODUCTION

Over the past decades, it was discovered that it is possible to get the surface plasmons on the conductor/dielectric interface with the same frequency as external electromagnetic waves, but with a much shorter wavelength. This will allow to use plasmons in nanostructures to transfer the information inside the chip. In that case plasmon interconnects would be a real breakthrough in the area of increasing the operating frequencies of integrated circuits [1]. Thus, a promising way for solving this problem is the use of the effect of plasmonic oscillations in the terahertz frequency range, in particular, using graphene on a dielectric substrate [2]. However, a number of technological and physical problems for the excitation, propagation and detection of plasmonic oscillations with controlled parameters need to be solved before that.

In this paper, we present the results of simulation of plasmon effects in a single-layer graphene nanostructure, depending on the chemical potential μ and temperature in the terahertz range.

II.MODEL

A key role is played by the dynamic conductivity of graphene. As a conductivity model for graphene, the following expression was used [3]:

$$\sigma(\omega) = \left(\frac{e^2}{4\hbar}\right)\left\{\frac{8kT\tau}{\pi\hbar(1-i\omega t)}\ln\left[1+\exp\left(\frac{\mu}{kT}\right)\right] + \tanh\left(\frac{\hbar\omega-2\mu}{4kT}\right) - \frac{4\hbar\omega}{i\pi}\int_0^\infty \frac{G(\varepsilon,\mu)-G(\hbar\omega/2,\mu)}{(\hbar\omega)^2-4\varepsilon^2}d\varepsilon\right\} \qquad (1)$$

where τ is the electron relaxation time, $\hbar$ is the reduced Planck constant, k is the Boltzmann constant, T is the temperature, c is the speed of light, ω is the angular frequency, functions

$$G(\varepsilon,\varepsilon') = \frac{\sinh\left(\frac{\varepsilon}{kT}\right)}{\cosh\left(\frac{\varepsilon}{kT}\right) + \cosh\left(\frac{\varepsilon'}{kT}\right)} \tag{2}$$

Equations characterizing the interaction of electromagnetic radiation (EMR) with graphene are derived from Maxwell's equations, and the dispersion relation containing the absorption and transmission coefficients – from the nontriviality of the solutions for such equations [3]:

$$\sqrt{n^2-\rho^2} + n^2\sqrt{1-\rho^2} + \frac{4\pi}{c\varepsilon_0}\sigma(\omega)\sqrt{n^2-\rho^2}\sqrt{1-\rho^2} = 0 \tag{3}$$

where n is the refractive index at the boundary of the medium and the sample, ρ is the complex propagation coefficient of the EMR wave, and ε0 is the dielectric constant of the vacuum.

For n = 1 equation (3) is simplified to:

$$\rho = \sqrt{1 - \frac{c^2\varepsilon_0^2}{4\pi^2\sigma_\omega^2}} \tag{4}$$

The absorption coefficient of the EMR is defined as Im (ρω/c), and the EMR propagation coefficient is defined as R_e(ρ).

III. RESULTS AND DISCUSSIONS

Fig. 1 shows the frequency dependence of the absorption coefficient for various values of the chemical potential at a temperature of 300 K. It is obvious that in this frequency range the absorption coefficient varies nonmonotonically, taking both positive and negative values. In the region of small values of the chemical potential, the absorption coefficient increases with frequency, and with an increase of μ up to more than 15 meV it becomes negative. This suggests that the both modes of absorption and amplification of EMR can be realized due to plasmon oscillations.

Fig. 2 shows the frequency dependence of the transmission coefficient for different values of the chemical potential at a temperature of 300 K. Its value can either increase with frequency or change nonmonotonically in a given frequency range. Besides, with the growth of the chemical potential, the value of R_e (ρ) decreases. The reason for the decrease of R_e (ρ) is the amplification of the absorption coefficient.

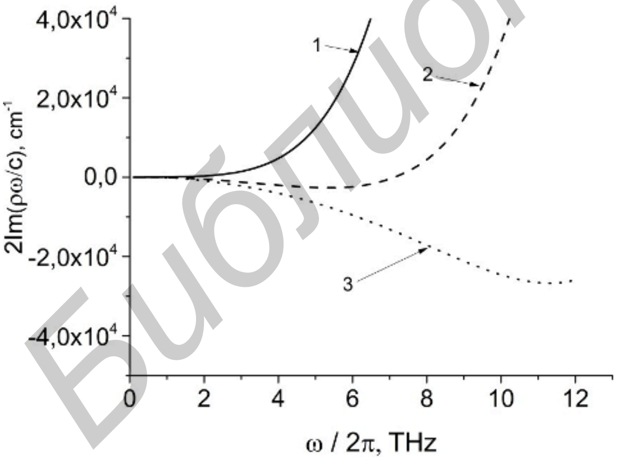

Figure 1 – Frequency dependences of the absorption coefficient of EMR at various chemical potential values (1 – μ = 0 meV, 2 – μ = 15 meV, 3 – μ = 30 meV) and at a temperature of 300 K

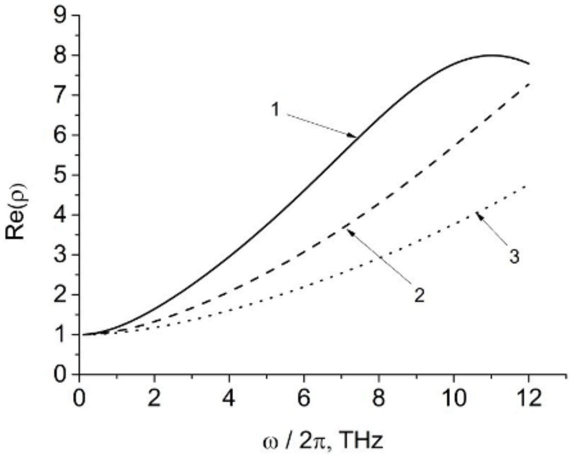

Figure 2 – Frequency dependences of the propagation coefficient of EMR at various chemical potential values (1 – μ = 0 meV, 2 – μ = 15 meV, 3 – μ = 30 meV) and at a temperature of 300 K

Fig. 3 shows the dependence of the wave vector of plasmon oscillations q = R_e (ρω/c) on the frequency of the external EMR. The surface plasmons with large wavenumbers q ~ 10^5 cm^{-1} and, hence, with rather short wavelengths λ ~1 μm and less are in the THz range.

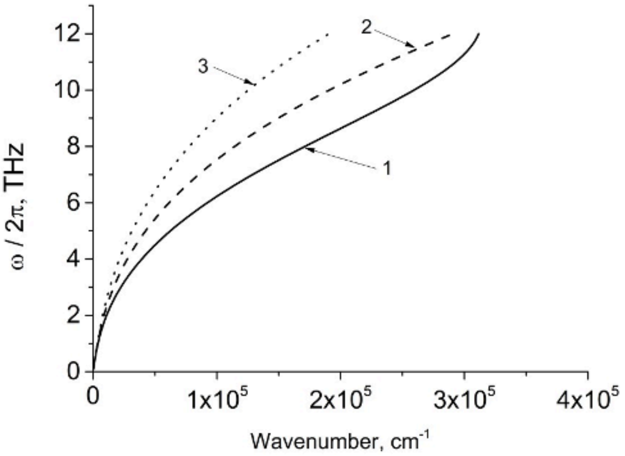

Figure 3 – The dependence of the wave vector of plasmon oscillations on the frequency of external EMR at various chemical potential values (1 – μ = 0 meV, 2 – μ = 15 meV, 3 – μ = 30 meV) and at a temperature of 300 K

The decrease of the wavelength of plasmon oscillations in graphene in the region of terahertz frequencies caused by the decrease of the propagation coefficient, is due to the strong localization of plasmons in graphene.

V. CONCLUSIONS

Thus, the plasmon effects were modeled in a single-layer graphene nanostructure, depending on the chemical potential and temperature. The obtained frequency dependences of the EMR propagation and absorption coefficients have shown that in the frequency range considered, the EMR can not only propagate due to plasmon oscillations, but also be amplified by them.

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ELECTRON TUNNELING TO THE SURFACE STATES AT PHOTOCATALYSIS

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I. INTRODUCTION

Composites with titanium dioxide nanoparticles (nanocomposite) have the widest prevalence in heterogeneous photocatalytic processes of organic compounds oxidation [1]. Titanium oxide possesses substantial photocatalytic activity in UV range, and characterized by high resistance to the photocorrosion processes and absence of toxicity, which helps to apply it as a component of self-purifying surfaces as well as in purification of domestic and industrial water and air [6]. The sunlight produces generation of electron-hole pairs in the near-surface area of TiO_2. In order to eliminate their recombination and ensuring of electron transition to the surface states, the necessity in the effective division of such pairs occurs. In many cases for this purpose heterojunctions contained titanium oxide with, e.g., silicon, are used. The electron-hole pairs, generated in titanium oxide, are divided: holes are moving to the silicon interface, where they are recombined, while electrons are moving to the surface and participate in the tunneling process on the surface states.

A spectrum of non-equilibrium electrons light-generated in the conduction band of titanium dioxide is resulted from the dependence of sunlight intensity on the photon wavelength [2]. A transfer of generated electrons to the surface states, which is determined by the tunneling transmission coefficient, depends on the surface potential reliefs created by the organic compounds on TiO2 surface. A real potential relief has a very