PLASMON PHENOMENA IN A METAL NANOTUBE OF VARIABLE THICKNESS

Malysh R.O., Korotun A.V.

National University "Zaporizhzhia Polytechnic", Zhukovskogo st., 64, Zaporizhzhia, Ukraine.

Consider the interaction of light with a two-layer cylindrical nanostructure placed in a dielectric medium with permeability ϵ_m, and this structure consists of two non-contiguous cylinders with radii a and b (the distance between the centers of the cylinders is equal to d, and the dielectric permittivity of the core and shell materials is equal to ϵ_c and ϵ_s). Due to the fact that the wavelength of the incident light is much larger than the dimensions of the system (a, b, $d << \lambda$), the problem can be considered in a quasi-static approximation. In this approximation, electric field potentials in each of the areas (*1* – core (c), *2* – shell (s), *3* – surrounding dielectric medium (m)) are determined from the Laplace equation (1) with boundary conditions on the boundaries of the division of regions (2). From the solution of the Laplace equation (1), we have the following expression for the dipole polarizability (3) and its derivatives (4 – 6).

The condition for the occurrence of SPR (in the non-dissipative approximation) has the form ($Z = 0$) where will we have it from (7 – 9).

In fig. 2 shows the dependence of the SPR frequencies for the structures SiO_2@Au and SiO_2@Ag on the distance between the axes of the cylinders, the radii of which are $a = 10$ nm, $b = 40$ nm. Qualitatively, the nature of the dependences for nanostructures with different shells is similar. Thus, the splitting of plasmon resonances corresponding to the value $x = x_1$ is more significant than for plasmon resonances with $x = x_2$. This fact is explained by the fact that $x_1 > x_2 \cong 0$

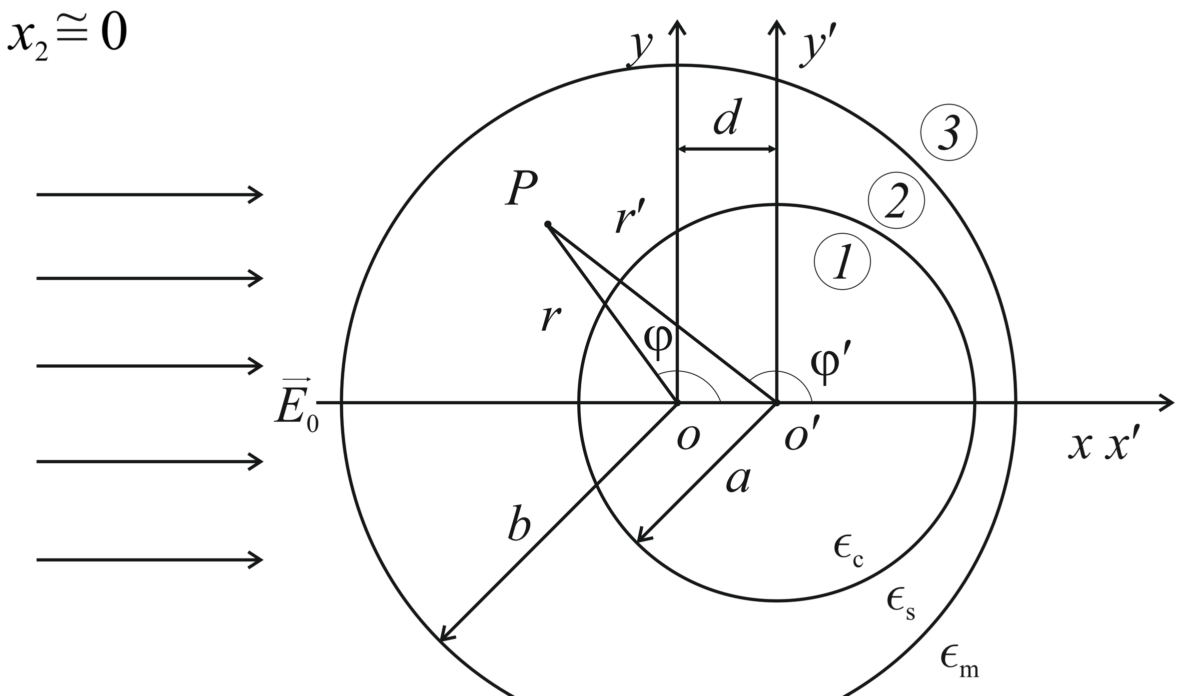

Fig. 1. Geometry of the problem

$$\Delta\varphi_i = 0 \qquad i = \mathrm{c, s, m} \tag{1}$$

$$\begin{aligned} &\varphi_c\big|_{r'=a} = \varphi_s\big|_{r'=a}; \\ &\epsilon_c \frac{\partial\varphi_c}{\partial r'}\bigg|_{r'=a} = \epsilon_s \frac{\partial\varphi_s}{\partial r'}\bigg|_{r'=a}; \\ &\varphi_s\big|_{r=b} = \varphi_m\big|_{r=b}; \\ &\epsilon_s \frac{\partial\varphi_s}{\partial r}\bigg|_{r=b} = \epsilon_m \frac{\partial\varphi_m}{\partial r}\bigg|_{r=b}. \end{aligned} \tag{2}$$

$$\alpha = \frac{\Lambda}{Z} \tag{3}$$

$$\Lambda = \left(F_{11} + G_{11}y\right)\left(F_{22} + G_{22}x\right) - yF_{21}G_{12} \tag{4}$$

$$\begin{aligned} Z = {} & \frac{\epsilon_s - \epsilon_c}{\epsilon_s + \epsilon_c}\frac{\epsilon_m^2 - \epsilon_s^2}{\epsilon_m^2} F_{21}G_{12} - \left(\frac{\epsilon_m - \epsilon_s}{\epsilon_m}\frac{\epsilon_s - \epsilon_c}{\epsilon_s + \epsilon_c}F_{22} + \frac{\epsilon_m + \epsilon_s}{\epsilon_m}G_{22}\right)\times \\ & \times\left(\frac{\epsilon_m - \epsilon_s}{\epsilon_m}\frac{\epsilon_s - \epsilon_c}{\epsilon_s + \epsilon_c}F_{11} + \frac{\epsilon_m - \epsilon_s}{\epsilon_m}G_{11}\right); \end{aligned} \tag{5}$$

$$F_{11} = \frac{a}{b};\quad F_{22} = \frac{a^2}{b^2};\quad F_{21} = \frac{ad}{b^2};\; G_{11} = \frac{b}{a};\; G_{22} = \frac{b^2}{a^2};\; G_{12} = -2\frac{bd}{a^2}. \tag{6}$$

$$\omega_{sp}^{(1,2)(\pm)} = \frac{\omega_p}{\sqrt{\epsilon^{\infty} - \epsilon_s^{(1,2)(\pm)}}} \tag{7}$$

$$\epsilon_s^{(1,2)(\pm)} = \frac{-(\epsilon_c + \epsilon_m)\left(1 + x_{1,2}\right) \pm \sqrt{\left(\epsilon_c^2 + \epsilon_m^2\right)\left(1 + x_{1,2}\right)^2 - 2\epsilon_c\epsilon_m\left(1 - 6x_{1,2} + x_{1,2}^2\right)}}{2\left(1 - x_{1,2}\right)} \tag{8}$$

$$x_{1,2} = \frac{a^2}{2b^4}\left[a^2 + b^2 + 2d^2 \pm \sqrt{\left(a^2 - b^2\right)^2 + 4d^2\left(a^2 + b^2 + d^2\right)}\right] \tag{9}$$

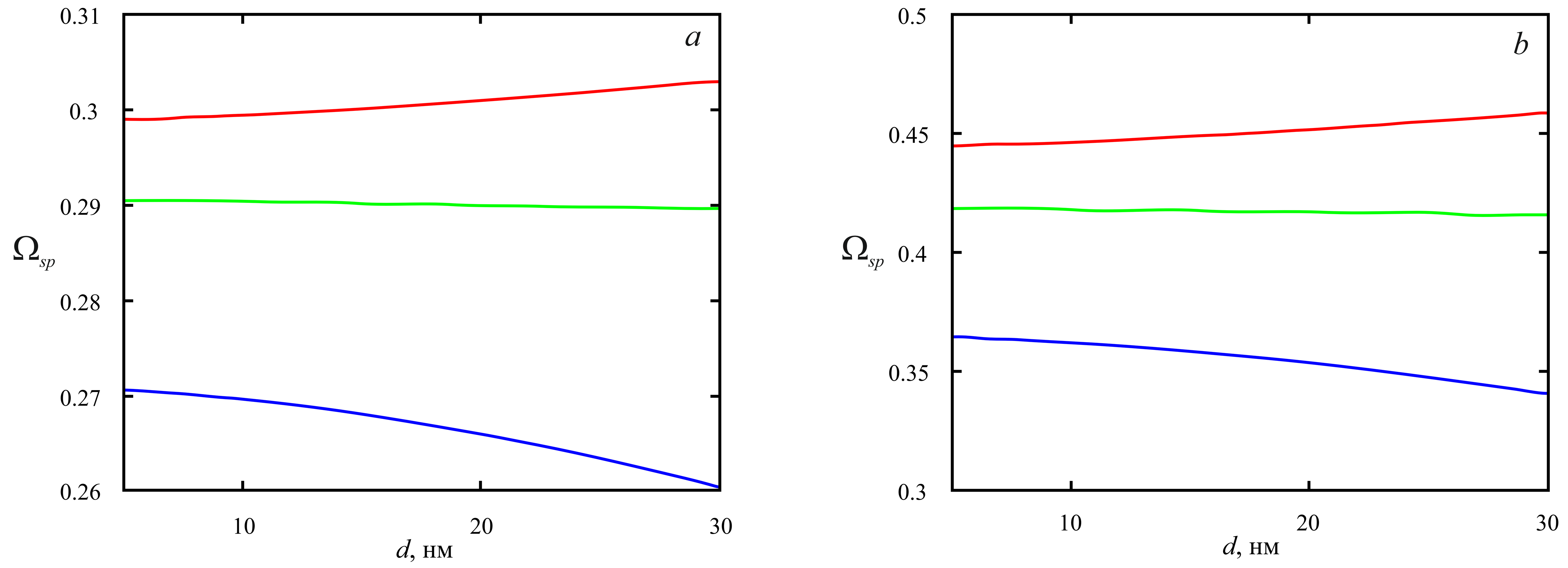

Fig. 2. Dependencies of SPR frequencies for structures SiO_2@Au (a) and SiO_2@Ag (b) at $a = 10$ nm and $b = 40$ nm on the distance between the cylinder axes