DOUBLE – LAYER ANTI REFLECTIVE COATINGS ON ABSORBING SUBSTRATES

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Elektromaqnit dalğalarının udan material səthinə çəkilmiş iki şəffaf təbəqə sistemindən əks olunmaması şərtləri alınmışdır.

Получены условия антиотражения электромагнитных волн системой двух прозрачных покрытий, нанесенных на поглощающую подложку.

The conditions of anti reflection of electromagnetic waves in the system consisting of semi-infinite absorbing substrate and consistently superimposed on it two non-absorbing layers of a coatings are obtained.

Sensitivity of receivers of radiation of infrared and optical wave bands can be essentially improved due to more total absorption in them of incident electromagnetic radiation. It is reached due to use of a transparence layer from non-absorbing material, applied on a surface of the receiver [1].

Generally, infrared and optical receivers of radiation can be presented in the form of the flat double-layer systems containing absorbing substrate of the infinite thickness (for example, silicon) and the coating of non-absorbing radiation superimposed on it (for example, silicon dioxide). As a rule, used materials of a substrate and a coating have strictly certain, given values of optical parameters. Therefore, to reduce reflection of incident radiation at such receivers it is possible at the best by selection of thickness of a layer of the coating which are carried out during its technological drawing on absorbing substrate. However, making of completely not reflecting receivers not always technically may be realized because of a essential difference between quantities of coefficients of a refractive of a substrate and a coating. These distinctions can lead to violation of the requirement necessary for the full quenching of a wave in the receiver. Therefore, expediently, not changing existing manufacturing techniques of such antireflecting receivers of radiation to view an opportunity of application alongside with the basic working coat of an additional transparence coat from not absorbing substance.

For the solution of the given problem we consider the conditions of occurrence reflectionless (full) quenching of incident electromagnetic radiation in the system consisting from a floor of the semi-infinite absorbing substrate and two non-absorbing layers consistently superimposed on it: a working layer with adjustable thickness and exterior transparence layer with thickness of an equal quarter of a wave length in a material of this layer. We shall designate coefficients of a refractive and absorption of a wave of a substrate through n , χ , and coefficients of a refractive of waves of substance of a transparence and working layers accordingly n_1 and n_2. It is supposed, that optical properties of materials of a substrate and a layer of a coat adjustable on thickness are set from technological reasons of preparation of the concrete receiver of radiation.

Complex value of a reflectivity of a wave of considered system equals [2]

$$R^* = \frac{r_1 + R_2^* \exp(-i2k_1 l_1)}{1 + r_1 R_2^* \exp(-i2k_1 l_1)}; \qquad (1)$$

Where

$R_2^* = \dfrac{r_2 + r^* \exp(-i2k_2 l_2)}{1 + r_2 r^* \exp(-i2k_2 l_2)}$; $r^* = r\exp(i\varphi)$; r_1 , r_2 , r are modules of reflectivities of a wave from boundaries of mediums; φ is a phase of a reflectivity of a wave from a surface a working coat-substrate; $k_1 = 2\pi n_1 l_1/\lambda$, $k_2 = 2\pi n_2 l_2/\lambda$ are wave numbers accordingly substances of the first and second layer; l_1, l_2 - thickness of non-absorbing layers; λ is wave length of incident radiation [2].

In the equation (1)

$$r_1 = \frac{1-n_1}{1+n_1};\ r_2 = \frac{n_1 - n_2}{n_1 + n_2};\ r = \sqrt{\frac{(n_2 - n)^2 + \chi^2}{(n_2 + n)^2 + \chi^2}};$$

$$\varphi = arctg\,\frac{2n_2\chi}{n_2^2 - n^2 - \chi^2} \qquad (2)$$

According to equation (1), the dependence of reflection coefficient module R on working layer thickness l_2 in the presented case of a quarter transparent layer also has nondamping oscillations. Extremum points of this dependence take place for thickness l_2 less than multiple of quarter wavelength in working layer [3-5].The first extremum of this dependence is maximum.

To the full quenching of incident radiation in the given system there corresponds a requirement $R^* = 0$ leading the following equation:

$$r_1 + r_2 \exp\left(-i2k_1l_1\right) + r\left(r_1r_2 + \exp\left(-i2k_1l_1\right)\right)\exp\left(\varphi - i2k_2l_2\right) = 0 \quad (3)$$

The condition $R^* = 0$ is valid only for the points of minimums in the dependence R on l_2,That is why we introduce

$$x_2 = \frac{l_2 n_2}{\lambda} = \frac{N}{2} + \Delta \ ; \quad (4)$$

where N = 1,2, 3 ….; Δ is small, but not zero quantity.

Let's consider, that on a requirement of a problem thickness of a transparent layer of a coat is chosen equal $l_1 = \lambda/4n_1$. Then, using this requirement, and also expression (4) in the equation (3), we shall gain:

$$r_1 - r_2 + r(r_1r_2 - 1)\exp\left(i\varphi - i4\pi\Delta\right) = 0 \quad (5)$$

Breaking expression (5) on real and imaginary parts, we have:

$$\Delta = \frac{\varphi}{4\pi}\ ;\ r = \frac{r_1 - r_2}{1 - r_1r_2}\ . \quad (6)$$

Substituting in the equations (6) expressions for r_1, r_2, r and φ we shall gain

$$\chi = \sqrt{\left(n_1^2 - n\right)\left(n - \frac{n_2^2}{n_1^2}\right)}\ ; \quad (7)$$

$$\Delta = \frac{1}{4\pi}\, arctg\, \frac{2n_2\chi}{n_2^2 - n^2 - \chi^2} \quad (8)$$

The gained equations (7) and (8) define the condition of reflectionless quenching of incident radiation in viewed system. If optical parameters of a substrate n, χ and a working layer of a coat n_2 are known, the equation (7) allows to find coefficient of a refractive n_1 of a transparent layer of a coat. Thus thickness of the second working layer of a coat is defined from a relation

$$l_2 = \frac{\lambda}{n_2}\left(\frac{N}{2} + \frac{1}{4\pi}\, arctg\, \frac{2n_2\chi}{n_2^2 - n^2 - \chi^2}\right). \quad (9)$$

Thus, carried out examinations allow to create a procedure of a purposeful select of a material of a transparent layer of a coat and admissible thickness of a working layer of a coat at which requirements of the full quenching of incident radiation in the chosen type of the receiver are satisfied.

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