Terahertz Band Bragg Reflectors

Naum S. Ginzburg, Andrey M. Malkin, Nikolay Yu. Peskov, Alexander S. Sergeev

Vladislav Yu. Zaslavsky

Institute of Applied Physics RAS, Nizhny Novgorod, 603950, Russia

***Abstract*—A planar narrow band Bragg reflector based on coupling of propagating and quasi-cutoff modes is considered. Coupled waves analysis together with direct numerical simulations demonstrate the operability of novel scheme up to THz frequency band.**

I. Introduction and Background

Reflectors based on Bragg coupling of counter propagating waves on the periodic structures are widely used both in quantum and classical electronics. For millimeter waves electron devices the Bragg structures based on hollow metallic waveguides with periodic corrugation allows to combine the electron beam transport with effective mode selection[1]. However, the advance to shorter wave bands is limited by the fact that increase of oversize factor will be accompanied by increasing the number of pairs of coupled modes. As a result, the radiation generated by electron beam would represent an uncontrolled mixture of waveguide modes. Besides, with the increase of oversize factor the absolute values of reflection coefficients decrease.

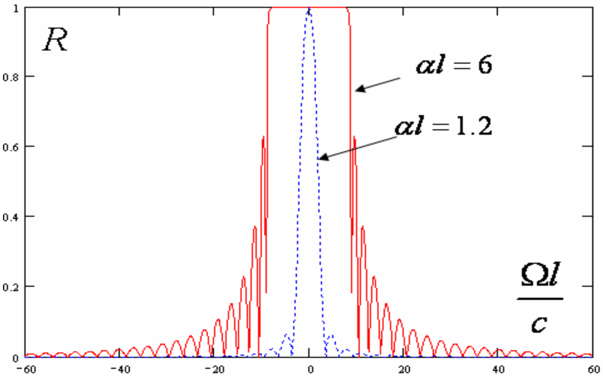

Fig.1

These problems can be partially solved in a scheme of Bragg scattering based on coupling of propagating and quasi-cutoff modes. Let us consider a Bragg reflector formed by the two parallel plates with shallow periodical corrugation $b(z) = b_1 \cos(\bar{h}z)$, where $\bar{h} = 2\pi/d$, d is the period of the structure. In the considered Bragg structure the field can be presented as a sum of the two TEM modes propagating in opposite directions

$$\vec{E}_{1,2} = \mathrm{Re}\left(A_{\pm}(z)\vec{y}e^{i(\omega t \mp hz)}\right).$$

Under the Bragg resonance condition $h \approx \bar{h}$ the coupling between these modes occurs through excitation of a quasi-cutoff TM_n mode:

$$\vec{E} = \mathrm{Re}\left(B(z)\vec{y}\sin(\pi nx/b)e^{i\omega t}\right).$$

Note that the following relation between the corrugation period and the distance between plates should be satisfied: $b=nd/2$. The process of scattering can be described by the equations:

$$\frac{dA_{\pm}}{dZ} \mp i\Omega A_{\pm} = \pm i\alpha B \qquad (1)$$
$$\frac{1}{2h}\frac{d^2B}{dZ^2} + i\sigma B + \Omega B = \alpha\left(A_+ + A_-\right)$$

where $Z = \bar{h}z$, $\Omega = (\omega - \bar{\omega})/\bar{\omega}$ is the detuning from the Bragg $\bar{\omega} = \bar{h}c$, $\alpha = b_1/2b_0$ is the coupling coefficient, L is the length of the structure, σ describes the Ohmic losses.

II. Results

Neglecting the cutoff mode diffraction one can obtain for the reflection coefficient

$$R = \frac{2i(\Omega^2 - K^2)\sin Kl}{(\Omega+K)^2 e^{iKl} - (\Omega-K)^2 e^{-iKl}},$$

where $K = (\Omega^2 - 2\alpha^2\Omega/(\Omega + i\sigma))$.

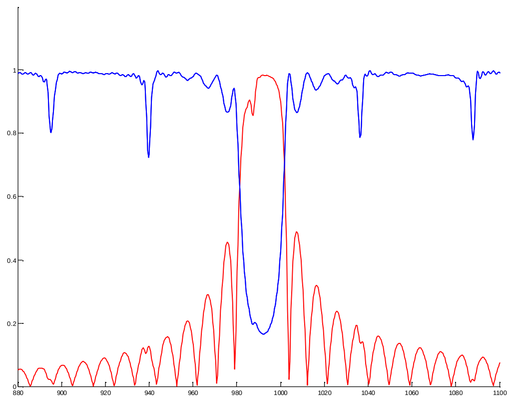

Fig.2

Fig.1 shows the frequency dependencies of the reflection coefficient, which demonstrate the operability of the novel reflector scheme. Note that unlike the traditional Bragg structures the decrease of waves coupling coefficient α makes the reflection band narrow while the maximum of

978-1-4244-2120-6/08/$25.00 ©IEEE.

reflection coefficient does not depend on α and stays close to unity at zero Ohmic losses (nonzero losses obviously lead to decrease of $R_{\max}$). Thus the coupled waves approach shows that a considered reflector effective for large b/λ .

This conclusion is confirmed by the results of numerical simulation of the novel Bragg reflector in THz frequency band with the use of 3D electromagnetic code. We took the structure period d=0.3mm, distance between plates b_0 = 6 mm, corrugation depth b_1=003 mm and length l=10 mm. At n= 20 expected resonance frequency is f=1 THz. For the TEM incident wave the frequency dependence of the reflection coefficient in Fig.2 (red) and the coefficient of transformation into the quasi cutoff mode (blue) demonstrate reflectivity close to 100% with relative bandwidth 3% near the frequency of exact Bragg synchronism.

REFERENCES

[1] V. L. Bratman, G. G. Denisov, N. S. Ginzburg, M. I. Petelin, *IEEE J. Quant. Electr.*, 19,3, 1983, p. 282.