Observation of the Tunable Non-Bragg Gap in a Periodically Corrugated Waveguide

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The principal phenomenon in wave propagation caused by periodicity is Bragg reflection. It results in the opening of a gap in the spectrum of the structure. The Bragg reflection occurs both in the case of unbounded periodic medium as well as in a case of a waveguide structure. In both cases the Bragg reflection arises at one and the same condition, $k_x = q/2$, known as Bragg's law. Here $q = 2\pi/a$, a is a period, k_x is the longitudinal wave number, $k = 2\pi/\lambda$. Bragg's law is the mathematical formulation of the constructive interference (resonance) of the waves traveling along the axis of the periodic waveguide, say, the x-axis.

In the report, we show theoretically and prove experimentally that in a waveguide structure, made of two periodically corrugated plates, besides the Bragg gap, another type of a gap appears in the spectrum. The gap is caused by the resonant interaction between the transverse modes (standing waves). Therefore, it can be observed only in the waveguide structure. The Bragg gap opens only at the boundary of the Brillouin zone, $k_x = q/2 \equiv K$, (or multiple of K), while the non-Bragg gap can open at any k_x between zero and K, depending on thickness of the waveguide d and period a. Location of the gap in the spectrum can be easily tuned by varying d and a. Besides, the width of the non-Bragg gap depends on the relative position of two periodic boundaries.

We investigated experimentally the microwave transmission properties of a planar metallic waveguide, having two parallel plates with the identical sinusoidal profile $y(x) = \xi \cos(qx)$. Amplitude ξ and a period of the corrugations equal correspondingly to 0.415 cm and 3.15 cm. Thickness the waveguide was 4 cm. A standard microwave setup (V.A. Pogrebnyak, E. Akray, N.A. Kucukaltun, Appl. Phys. Lett. 86, 151115, 2005) was used for measuring of the transmission characteristics. The 1.12 GHz non-Bragg gap in vicinity of 9.5 GHz has been observed when a shift between plates equals zero. The location of the gap was changed between $k_x = 0$ and $k_x = K$ by varying d. The gap closed when the shift between the plates equals $a/2$. Therefore, the transmission through the waveguide could be tuned, due to the non-Bragg gap, from the maximum value down to 30 dB upon a shift of one periodic plate with respect to another on the half period of the corrugation.

The non-Bragg gap, along with the Bragg gap, and the tuning mechanism can be used in different microwave, optoelectronic, and photonic applications to broaden their operation frequency range.