Wave Types Guided by the Interface Between Air and a Semi-Infinite Periodic Structure

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During the early 1990s the optical physics community rediscovered the concept that a wave can be guided in the space between a pair of periodic structures if the periodic structures are operated in their stop bands (called photonic bandgaps by them). That community was unaware that the ***identical concept*** was published many years before in the microwave community (R. P. Larsen and A. A. Oliner, "A New Class of Low Loss Reactive Wall Waveguides," Int. Microwave Symp. Digest, pp. 17-22, 1967). The specific structure that was analyzed rigorously and also measured consisted of an air space *W* between two periodic structures with period *d,* each comprised of parallel dielectric slabs, as shown in Fig. 1.

The structure in Fig. 1 is infinite and uniform in the *y* and *z* directions, and the wave propagates in the *z* direction. The field decays exponentially away from the central air region in the transverse (*x*) direction in both of the periodic arrays. At too low a frequency the lowest guided mode is below cutoff, but at frequencies above that cutoff the field in the central region is trigonometric in the *x* direction. At higher frequencies the field variation in the central region changes from trigonometric to hyperbolic, although the field remains exponentially decaying in the periodic structures throughout the whole frequency range. All these field behaviors were known from calculations made in the original 1967 publication.

When the periodic structure on one side in Fig. 1 is removed, producing an ***interface*** between a semi-infinite periodic structure on one side and a semi-infinite air region on the other side, as shown in Fig. 2, we have a new canonical structure that has not been studied previously. Our recent detailed calculations demonstrate that waves can be guided along that interface, and also show that the type of guided mode depends on the frequency range. At higher frequencies the wave is a ***surface wave***, with exponential field decay away from both sides of the interface, but the surface wave experiences a cutoff as the frequency is lowered. If the periodic structure is made finite in width, new physical results can be obtained below the cutoff frequency of the surface wave, including leaky waves with interesting properties. The novel behavioral features will be described, and the correspondences with the various propagation ranges in the waveguide in Fig. 1 will be presented.

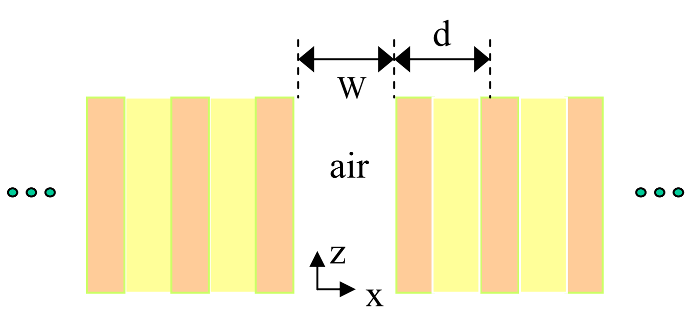

Fig. 1 A waveguide with periodic side walls that was analyzed and measured in 1967.

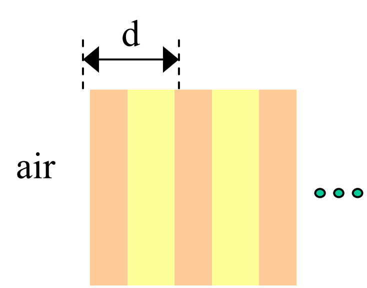

Fig. 2 Waves can be guided along the interface in this structure.