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A Leaky-Wave Antenna based on 2-D Dielectric Photonic Crystal Slab

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The radiation from 2-D lattices consisting of dielectric cylinders and excited from an embedded source can be rigorously described in terms of properly excited leaky modes [1]. The radiative structure can be modelled as an open waveguide consisting of a stack, along a transverse direction, of infinite periodic chains of cylinders (see Fig. 1 (a)-(b)-(c)). This approach allows us to have a thorough understanding of the underlying physical phenomena upon which devices acting as leaky-wave antennas can be designed.

This contribution presents an overview of our analytical and numerical methods for the design of photonic crystal leaky-wave antennas, focusing on the realization of realistic 3-D prototypes. Based on the symmetries of the observed modal configurations [1], it is possible to bisect the open waveguide with a metal plate and place the source in order to suitably excite a single leaky mode in absence of other guided modes. From the knowledge of the attenuation constant of the dominant leaky mode propagating along the waveguide [1], it is possible to truncate the antenna longitudinally in order to have a desired radiation efficiency [2]. This approach leads to the design of compact, highly directive antennas, as the prototype example shown in Fig. 1 (d). Cylindrical alumina rods are supported by lateral metal plates, which mimic the 2-D environment, and positioned above a ground plane. The structure is sized to operate at millimeter range frequency $f = 24$ GHz and it is excited by a feeding system consisting of two monopoles with counterphase sources. The numerical results show a directivity at broadside of $D = 14.4$ dBi at $f = 24$ GHz and $S_{11} = -20$ dB. More details on the practical feeder and the antenna matching will be presented at the conference.

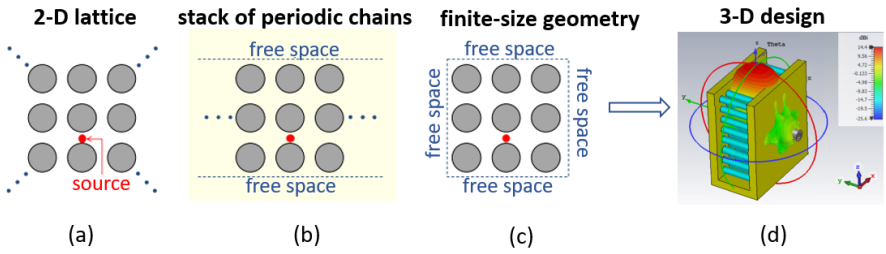

Figure 1. Photonic Bandgap structure with an embedded source: (a) 2-D infinite lattice; (b) stack of periodic chains; (c) finite-size geometry; (d) an experimentally designed 3-D structure.

1. P. Baccarelli, L. Tognolatti, V. Jandieri, S. Ceccuzzi, C. Ponti, and G. Schettini, "Leaky-Wave Radiation From 2-D Dielectric Lattices Excited by an Embedded Electric Line Source," in *IEEE Transactions on Antennas and Propagation*, vol. 69, no. 11, pp. 7404-7418, Nov. 2021.

2. D. R. Jackson and A. A. Oliner, "Leaky-wave antennas", *Modern Antenna Handbook*, C. A. Balanis., Ed. Hoboken, NJ: John Wiley Sons, 2008, ch. 7, pp. 325-367.