2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Analysis of Substrate Integrated Waveguides and Waveguide Based Passive Circuits

Vakhtang Jandieri * (1) and Daniel Erni (1)
(1) General and Theoretical Electrical Engineering (ATE), Faculty of Engineering, University of Duisburg-Essen, and CENIDE – Center for Nanointegratin Duisburg-Essen, D-47048 Duisburg, Germany
e-mail: vakhtang.jandieri@uni-due.de; daniel.erni@uni-due.de

In this review paper we analyze substrate integrated waveguide (SIW) that has promising applications to planar circuit components operating in the microwave and millimeter wave frequency range [1, 2]. The SIW is formed by periodically distributed – usually metallic – posts. It allows the "planarization" of non-planar structures such as conventional rectangular and dielectric waveguides and they can completely be integrated together with planar structures onto the same planar substrate with the same processing or fabrication techniques.

We have developed a self-contained versatile, rigorous, and efficient formulation for SIW composed of the perforated vertical posts inside the dielectric medium from the viewpoint of their use as highly efficient, small sized devices that will be able to transfer the information at high speed and in high capacity from few GHz to a few hundred GHz [3, 4]. Our special attention has been paid to the flexible realization of the passive devices in substrate integrated technology such as band-pass, add/drop filters, ring resonators and couplers. The main advantage of our work is that it covers as fundamental analysis of the SIW and circuits, as well as the experimental investigations of the device. Particularly, our work is based on: *a)* development of the rigorous formulation applicable to any configuration of the SIW and circuits; *b)* development of the numerical code that is efficient in computation time as well as memory requirements and is applicable to the real models of the SIW and circuits; *c)* experimental studies, design and fabrication of the multifunctional, integrated post-wall waveguides and circuits.

Formulation is based on the lattice sums technique combined with the theory of images. The phase constants, attenuation constants and the *S*-parameters of the SIWs and passive circuits have been analyzed. We have proofed that the developed formulation is numerically slim and very fast and thus best suited to the optimization problem for the advanced multi-functional, ultra-compact submillimeter passive circuit devices. The optimization [5] of the SIW based circuits by properly adjusting the geometrical and material parameters of the cylindrical inclusions has been studied.

Acknowledgement

V. J. acknowledges financial support from the Alexander von Humboldt Foundation. Work was partly supported by the Deutsche Forschungsgemeinschaft in the framework of DFG SFB/TRR 196 MARIE under Project C05.

[1] J. Hirokawa and M. Ando, "Single-layer feed waveguide consisting of posts for plane TEM wave Excitation in parallel plates," *IEEE Trans. Antennas Propagat*., vol. 46, no. 5, pp.625-630, 1998.

[2] D. Deslandes and K. Wu, "Accurate modeling, wave mechanisms, and design considerations of a substrate integrated waveguide," *IEEE Trans. Microwave Theory Tech*., vol. 54, no. 6, pp. 2516-2526, 2006.

[3] V. Jandieri, H. Maeda, K. Yasumoto and D. Erni, "Analysis of Post-Wall Waveguides and Circuits Using a Model of Two-Dimensional Photonic Crystals," *Progress in Electromagnetics Research M (PIER M)*, vol.56 pp. 91-100, 2017.

[4] K. Yasumoto, H. Maeda and V. Jandieri, "Analysis of post-wall waveguides using a model of two-dimensional photonic crystal waveguides," *Proceedings of the IEEE International Conference on Signal Processing and Communication* (ICSC-2015), Noida, India, pp. 74-79, April, 2015.

[5] D. Erni, D. Wiesmann, M. Spühler, S. Hunziker, E. Moreno, B. Oswald, J. Fröhlich and C. Hafner, "Application of Evolutionary Optimization Algorithms in Computational Optics", *ACES Journal: Special Issue on Genetic Algorithms*, vol. 15, no. 2 , pp. 43-60, 2000.