# A Review on Rectangular Microstrip Patch Antennas using SIW Technology

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***Abstract:***

An insight and deployment Substrate-Integrated Waveguide (SIW) based antenna using dissimilar configurations, mechanism of feed and their performance has been discussed in this paper. On the basis of available literature, the methods of improving the performance of an antenna are also presented. The methods include bandwidth enhancement, size reduction, gain improvement, etc. This technique act as a bridge between planar and non-planar technologies; which enables it to develop components operating at microwave and millimeter wave band. Therefore, antennas designed using SIW techniques has the advantage over classical designing methods. The advantage includes high gain, high power capacity, low cross polarization, and high selectivity, low profile, light weight, low fabrication cost, conformability to planar or bent surfaces, and easy integration with planar circuits.

Keywords: *Ultra-Wide Band (UWB) antenna, Microstrip Patch Antenna (MPA), Substrate-Integrated Waveguide (SIW), Vias.*

## 1. INTRODUCTION

Microwave and millimeter wave systems are still served as the conventional by the standard rectangular waveguide devices. However, the bulky size and inability of these devices to integrate with planar technology, i.e. PCB, prevent them to be used in the new generation wireless devices. In addition, the waveguide technique cannot be used to reduce the weight and volume. Hence, it is not appropriate for low-cost and bulk-production. Further, its post fabrication processing, like tuning and assembling becomes a real problem for manufacturers.

## 2. REVIEW OF LITERATURE

The planar rectangular waveguides are now possible to be realized by virtue of a latest promising technology called Substrate Integrated Waveguide technique (SIW), developed by K.

Wu [1]. This technology has earned much attention over the recent years, in the area of high density integration of microwave and millimeter wave subsystems. The SIW allows us to create Substrate Integrated Circuits (SICs), as it provides the platform to integrate all microwave and millimeter wave active and passive components on the same substrate, such as the oscillators, amplifiers, filters, couplers, antennas and many more [2,3]. In this technique, rows of narrowly spaced metallic vias between two planes emulate the adjacent walls of a thin rectangular-type waveguide filled with dielectric [4]. The properties of SIW include low loss, low profile, high power capacity, easy integration and fabrication with planar technology, and mass production. Therefore, by implementing SIW, any non-planar guided-wave structure can be converted into its planar equivalent and facilitate the merits of planar and non-planar guided structures [5-7].

Many researchers have used Substrate-Integrated Waveguide (SIW) technology either to increase the gain or to confine the directivity for specific applications. This technology is a way to make efficient connection between planar and non-planar structures. By means of using SIW the electromagnetic energy is guided to the radiating patch beneath the microstrip line in the dielectric substrate. This increases the gain of the structure and it also narrows down the radiation pattern and thus improves the directivity. SIW is the technique of inserting metallic vias or empty periodic cylindrical structures in the substrate [16-20, 28].

Owing to the design of antennas and arrays, conventional metallic rectangular waveguide feedings for achieving satisfactory radiation performances have been extensively reported in the literature. They also have the capability to handle high power, high Q-factor and are prone to radiation losses. Nevertheless, because of their bulky volume and high manufacturing cost, it makes them unfit for many practical applications [8]. Although printed antennas can overcome the above said disadvantages, they still suffer from power handling capability, making them unsuitable for designing antenna arrays. In addition, their feeding networks suffer from high ohmic losses, dielectric losses and spurious radiation, lead to the reduction of the gain and radiation efficiency of the antenna that degrade their performances.

SIW techniques have been adopted in recent years to design microwave and millimeter wave antennas and arrays as well as feeding networks. This article presents a review and discussion related to SIW-based antennas and arrays, such as slot array antennas, cavity backed antenna travelling wave antennas, horn antennas, monopulse antennas, beam forming antennas, and many others with different configurations, different feeding structures. Additionally, their performance improvement methods, the critical issues related to design mechanism of SIW-born antennas and arrays and the technological solution proposed in published papers are also reviewed and discussed.

An insight of the SIW technology for the improvement of low profile slot array antennas is introduced in this section. It includes SIW-inspired transverse/longitudinal slot antenna arrays, SIW-CRLH / metamaterial slot array, and HMSIW slot array, SIW conformal slot array etc. Further, some focuses on the size miniaturization techniques in SIW are highlighted. In the background of modern digital wireless systems, slot array antennas have been extensively studied and employed. It constitutes slots that are transverse/longitudinal on the broad side or narrow wall of the guiding structure which lead to discontinuities, hence power radiation. Firstly, SIW used in antenna design was introduced in [11], wherein the SIW-slot array antennas were designed similar to the classical longitudinal slotted waveguide antennas. Slots are etched on the top metal cladding of their substrates so that the waveguide and slots are possible to mount on the same plane. Even though the SIW-inspired slot antennas are developed similar to that of the conventionally fed slot antennas, they do not demonstrate the drawbacks of the conventional structures. For high gain and high radiation efficiency, longitudinal slot array antennas are preferred and can be achieved by Elliott's design procedure [12]. Using this method, SIW-based longitudinal slot array antenna was developed in [13,14]. Subsequently, a planar choke structure was proposed to improve Front-to-Back Lobe Radiation (FTBR) and Side Lobe Level (SLL) of the SIW slot array antenna [15]. It has a combination of short ended stubs and microstrip line which creates a very high impedance surface at the ground plane of the antenna, and ultimately eliminates the undesired surface current at the edge of the ground plane. In order to have a radiating slot on the wall of the waveguide, it is required to have it at a specific distance from the center axis of SIW walls, but at the cost of cross polarization, which will eventually degrade the antenna performance. Following that, an eight element collinear shunt longitudinal slotted array antenna was presented [16] based on Elliot's procedure with two ridges placed close to the narrow wall of the SIW. This method caused the slot located on the center axis to radiate, hence improved the cross polarization level. In order to suppress the mutual coupling neighboring elements, SIW corrugations between sub-array elements is recommended [17].

The high-$Q$ property of SIW cavities significantly is improved with the use of Frequency Selective Surfaces (FSS) on its cavity as illustrated in Figure 1. The SIW-FSS takes the advantages of low insertion loss, hence high $Q$-factor is due to the closed cavity nature, as in the conventional FSS [18,19]. When the SIW cavities cascaded with FSS, the selective performance becomes more perfect; however, insertion loss and bandwidth are insensitive to number of cavities, incident angle and polarization states. The first dual-band FSS-SIW antenna was introduced in [20], where two orthogonal slots are etched on the broad side SIW, in which they are responsible for dual-band dual-polarization. Initially, a highly efficient microstrip array antenna was proposed, pertaining to Circular Polarization (CP) at $Ku$-band. Small microstrip subarrays are combined by SIW-like structure, and the author named it as ‘Printed Circuit Board Waveguide’ [3]. It also exploits the benefits of planar technology without any compensation of radiation efficiency. A sequence of SIW-based linearly polarized (LP) resonant series slot array antennas for $Ka$-band was proposed in [21-23]. The radiating slot for these antennas are slanted at an angle of 45o, and separated by an approximately half of wavelength, in which it is able to generate alternating reactance slot pairs. Due to these alternating patterns of slots, the antenna achieved good impedance matching, uniform field excitation, and suppression of grating lobes simultaneously. A circularly polarized wave will be generated if two such slot arrays are symmetrically excited with 90o phase difference [24]. Also, SIW has the capability to solve the difficulty of integration between the array element and feed network [25]. In order to diminish the radiation loss over long distance communication, sequential-feeding network via-SIW for antenna array was suggested in [26]. The sequential-feed will minimize the radiation losses; hence, it shows a significant improvement in bandwidth in terms of CP gain and axial ratio (AR). Moreover, the SIW technology has the interesting feature of conformability. A SIW-slot array was investigated in [27] with low SSL. In this slot array, all components are conformal, including a one to eight divider, a phase compensated network and an 8×8 slot array.

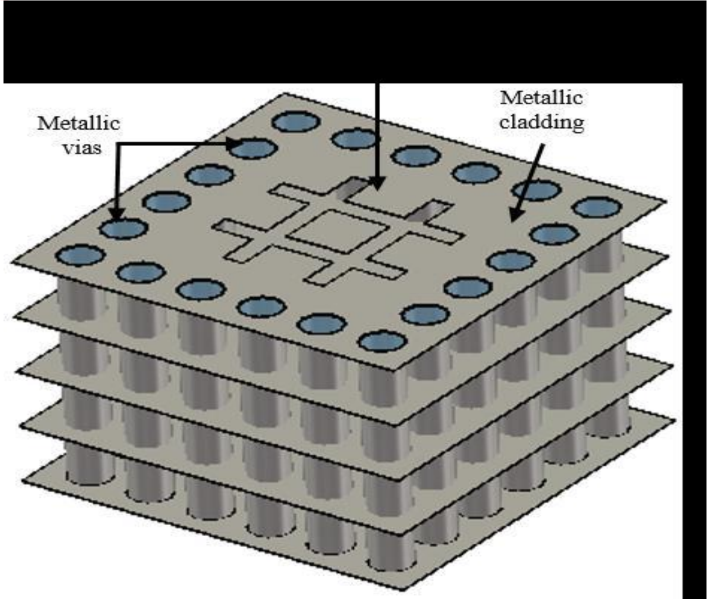

Figure 1: FSS using cascading SIW cavities [18]

## 3. CONCLUSIONS

Latest advancement antenna structures using SIW technology in the available literatures have been reviewed and discussed. Issues related to the design and modeling, and the different scientific explanations proposed for the application of SIW in modern antennas and arrays have been addressed. From the available literature, it is observed that most of the conventional rectangular waveguide fed antenna and array structure can be developed by SIW technology. Yet, most of them operate at higher frequency. The implementation of SIW in arrays and antenna structure in the lower range of frequency comes across a lot of technological difficulties like miniaturized dimensions, losses, precise manufacturing of SIW structures, fabrication limitations and selection of proper substrate, etc. It seems that SIW-based antennas and arrays in the modern wireless system open new possibilities for the development of highly compact and integrated systems.

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