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Modelling and Study of a THz Hollow Photonic Crystal Integrated Waveguide

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Abstract—We present a novel design of low-loss single-mode flat hollow photonic crystal integrated waveguide (HPCIW). The simulated propagation loss is below 1.5 dB/cm over the operating frequency range between 0.92 THz and 1.08 THz, with an averaged minimum of 0.76 dB/cm at 0.972 THz. A point of zero group-velocity dispersion (GVD) point is found at 1 THz. The proposed HPCIW possesses the merits of substrate-integrated waveguide (SIW) and photonic crystal waveguide and avoids their drawbacks, which make it a strong candidate for multilayer THz system in package (TSiP) applications.

I. INTRODUCTION

THz waveguides are fundamental and key components for functional THz devices and systems. For multilayer TSiP applications, THz waveguides are highly preferable to be flat and well isolated from the external space. SIW [1] encounter fabrication challenges at high THz band as vias become too small and difficult to metallize. Photonic crystal waveguide [2] can be extremely low loss and low GVD, but it will be greatly affected by the properties of the substrate and superstrate. In this paper, we propose a novel HPCIW which avoids the use of metallic vias and offers various functionalities as photonic crystal waveguide does.

II. RESULTS

Fig. 1 shows the schematic of the proposed HPCIW which is comprised of a line-defect photonic crystal photonic crystal waveguide sandwiched between two metal plates. The photonic crystal is made of high-resistivity silicon and air. The HPCIW is feed by standard WR1.0 rectangular waveguide (RWG). Detailed modelling of the photonic crystal structures has carried out by using MPB [3], and based on the results, two HPCIWs with different lengths have been designed and simulated by using CST. The period number of the photonic crystal along the defect line, \( P \), for the short and long HPCIWs are 20 and 40, respectively. The complex permittivity of the high-resistivity silicon is extracted and 2\( \text{nd} \)-order fitted from [4]. The operating mode in the HPCIW is TE\(_{01}\) mode which makes the structure easy to measure with standard waveguide metrology techniques. The simulated S-parameters of the two HPCIWs are presented in Fig. 2. The transmission coefficients, \( S_{21} \), indicate a low-loss single-mode operating band between 0.92 THz and 1.08 THz. Using multiline calibration method [5], the loss of the HPCIW is studied. It is less than 1.5 dB/cm over the operating band, with an averaged minimum of 0.76 dB/cm at 0.972 THz. The GVD is less than 240 ps/THz/cm, with a zero GVD point at 1 THz, numerical studied by using MPB.

III. SUMMARY

We studied a single-mode flat HPCIW with loss less than 1.5 dB/m from 0.92 to 1.08 THz and zero GVD at 1 THz. It can be a functional platform for TSiP applications.

REFERENCES