Dispersion Compensation in Terahertz Communication Links Using Metallized 3D Printed Hollow Core Waveguide Bragg Gratings

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Abstract: A novel terahertz (THz) waveguide Bragg grating is proposed for dispersion compensation. The results confirm single mode guidance of the fundamental mode, as well as large negative group velocity dispersion in the vicinity of 0.14THz.

1. Introduction

In the past decade, various THz fibers with low transmission losses (<0.01 cm^{-1}), such as subwavelength fibers [] and hollow core fibers [], have been proposed and demonstrated, and thus loss reduction in THz fibers can be considered as a solved problem. However, dispersion management in THz fibers has been rarely studied and remains unsolved. In this paper, we propose a novel hollow core THz waveguide Bragg grating, which features periodic structures on its inner surface, for dispersion compensation in the terahertz frequency range.

2. Results

The waveguide Bragg grating is realized by introducing triangular steps inside of a hollow core tube of diameter $D = 9.0$mm. Bragg grating comprises of 40 periodically arranged triangular steps of the base size $p = 1.35$mm and the height of $h = 1.9$mm. The 3D model of the proposed waveguide Bragg grating is shown in Fig. 1(a).

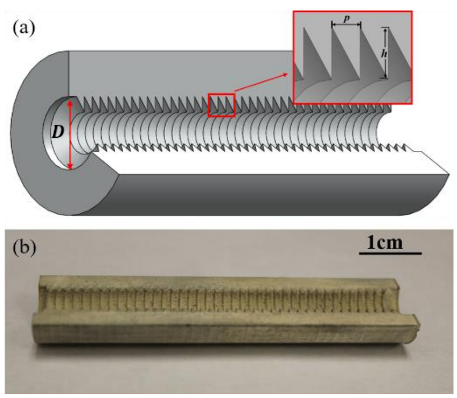

Fig. 1 (a) 3D schematic of the waveguide Bragg grating. Insert: zoom of the periodic structure. (b) One half of the dissected waveguide Bragg grating.

The designed waveguide was fabricated using a stereolithography 3D printer (Asiga® Freeform PRO2) with the photosensitive resin (PlasCLEAR), and then fully coated with a silver layer using a wet chemistry coating method as detailed in [3]. The fabricated waveguide Bragg grating is printed in Fig. 2(b) (only one half of the dissected waveguide is shown).

The computed band diagram is shown in Fig. 2. The color code for the modes in the band diagram indicates the absolute value of the modal coupling coefficient by filed from the 3D Gaussian beam into a given mode. Only modal dispersion relations of guided modes with angular momentum equal to 1 (m=1) are presented. As shown in Fig. 2 in the 100-200 GHz range, there are several bandgaps of the fundamental HE_{11}-like mode and higher order modes opened by the Bragg grating. Particularly, we are interested in operation within bandgaps of the higher order modes, where waveguides can be considered effectively single mode with maximal coupling coefficient to HE_{11} mode. We also observe that there are two such spectral regions, one is in the vicinity of 140GHz. The single modal operation ranges over 137-141GHz. While in the vicinity of 160GHz, the single modal operation ranges from 156GHz to 162GHz.

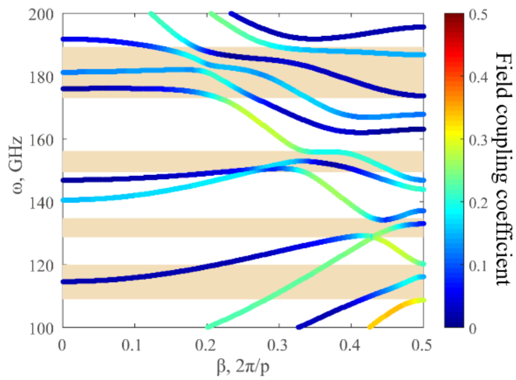

Fig. 2 Band diagram of the waveguide Bragg grating. Color refers to the modal coupling coefficient (by field) to the focused Gaussian beam of $w_0 \sim 2\lambda$.

The fabricated waveguide Bragg grating is then characterized using a THz-CW system. As a reference, we also measured the optical characterizes of a fabricated tube waveguide, as well as a commercial copper tube. The measured transmission and dispersion are shown in Fig. 3. In the frequency range of 100-200GHz, there are four low transmission windows with center frequencies of 118GHz, 135GHz, 153GHz, and 187GHz that have transmission losses in excess of 15dB. These regions coincide well with the theoretically predicted regions of week excitation of the HE_{11}-like mode shown as orange bands in Fig. 2. In Fig. 7(b), we present comparison of the experimentally measured and theoretically predicted group velocity dispersions. The results show good match. In the strict single mode regions, both theoretical and experimental results confirm the strongly negative dispersions. In the 137-141GHz range, dispersion varies from -500 to $-100\text{ps}/(\text{THz} \cdot \text{cm})$. At the same time, in the 156-162GHz range, dispersion varies from -2000 to -60 $\text{ps}/(\text{THz} \cdot \text{cm})$.

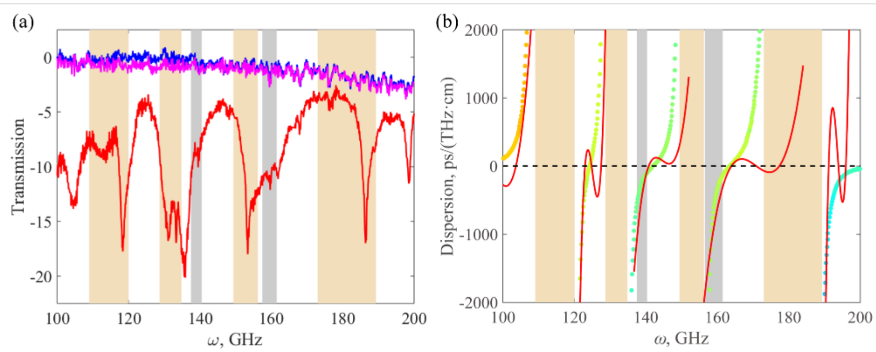

Fig. 3 (a) Measured transmission spectra of fabricated waveguides and (b) The comparison between the experimentally measured dispersion (red solid lines) and the theoretically computed dispersion of the fundamental mode (HE_{11}).

Reference:

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