Date: 05/03/2017

To

The Editor

*Photonics Letters of Poland*

Dear Sir,

Thank you so much for giving a change with major revision to make our paper suitable for publication in a forthcoming issue of your journal. Earlier, we submitted this manuscript having the following information:

**Manuscript ID:** 679

**Manuscript Title:** Ultra-low material loss microstructure fiber for terahertz guidance

The first decision regarding our initial submission was major revision. By the way, we have carefully revised the manuscript according to the reviewer comments and would like to send you for your kind review. Please have a look at our response to reviewer comments below.

We want to add another co-author (S. A. Emi) in the revised manuscript because of his significant contribution during revision. Your kind permission will be highly appreciated.

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(On behalf of authors)

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**Reviewer #B**

The manuscript reports on a concept of fiber geometry for low loss THz guidance utilizing triangular core geometry. Manuscript is well written in terms of structure and language, however it suffers from several shortcomings. I recommend accepting the article after major revision of the manuscript:

**Q.1.** The article is very similar to other papers published by the same authors:

**(a)** Ali, Sharafat, et al. "Ultra-low loss THz waveguide with flat EML and near zero flat dispersion properties." Electrical and Computer Engineering (ICECE), 2016 9th International Conference on. IEEE, 2016.

**(b)** Hasan, Md Rabiul, et al. "Low-loss and bend-insensitive terahertz fiber using a rhombic-shaped core." Applied Optics 55.30 (2016): 8441-8447.

Abovementioned publications are not referenced in the manuscript, whereas they present similar data for a fiber with changed geometry. As the number of possible geometries for the fiber structure is infinite the authors should clearly indicate what are the advantages of this specific structure in comparison to other structures.

**Author response:** Thank you so much for your comments. In the revised manuscript we have added your suggested references. Please see reference [8] and [9] in the revised manuscript.

Recently, the authors have presented very similar works with different core-cladding geometry [8–9]. However, the reported EML was comparatively higher about 0.386 and 0.562 dB/cm, respectively. Please see page 01, column 01, paragraph 02, line 16 in the revised manuscript underlined by the solid red color.

Additionally, we propose a new design that consists of square lattice air holes in the cladding whereas the core is formed by the combination of triangular lattice and circular air-hole rings. Compared to other designs, the proposed structure shows more compactness in the core region resulting in higher core porosity. As a result, significantly lower EML can be found in our reported porous core fiber than that of obtained in [8–9]. Please see page 01, column 02, paragraph 02, line 01 in the revised manuscript underlined by the solid red color.

**Q.2.** V parameter is an extremely rough assumption in terms of microstructured fibers and gives no useful information about fiber performance. Better way to examine modal properties of the microstructured fiber is to trace the confinement loss of higher order modes in the wavelength range of interest and to draw conclusion about single mode operation basing on such losses.

**Author response:** Thank you for your insightful comment. According to your comment we have modified the point of single mode propagation.

The single mode propagation of the proposed fiber has been investigated based on the confinement loss of higher order modes (HOMs). We have considered the first three core guided mode, which are labeled in LP notation as LP01, LP11, and LP21. Here, LP01, LP11, and LP21 are the fundamental mode, first HOM and second HOM, respectively. Confinement loss of these modes with the variation of frequency is shown in Fig. 5. It is clearly visible that LP11, and LP21 modes exhibit comparatively higher confinement loss than that of LP01 mode. As a result, the HOMs will be attenuated rapidly after propagating a short distance. Therefore, it can be concluded that the proposed fiber effectively acts as a single mode fiber between 0.45–1.15 THz. Please see page 02, column 02, paragraph 03, line 01 in the revised manuscript underlined by the solid red color.

**Q.3.** As the presented mode distributions look like a series of dots inside air holes it would be extremely challenging to generate a beam with high overlap with presented modes. It would greatly increase the coupling loss and put considerable amount of power to the leaky modes. Analysis of coupling efficiency with common THz sources should be presented or at least discussed.

**Author response:** We really appreciate particularly about this important point. In the revised manuscript we have discussed about the coupling efficiency of the common THz sources.

It should be noted that the mode field distributions shown in Fig. 2 consist of series of dots inside the air-holes, which may create difficulties to generate beam with high overlap. This could increase the coupling loss by leaking mode power towards the cladding region. Quantum-cascade lasers (QCLs) have been considered as a convenient and potential source, which can radiate below 1 THz. QCL based on metal-metal waveguides (MM) operates far from the optimum coupling condition. Besides, such QCLs suffer from beam divergence issue that increases the coupling loss [14]. On the other hand, QCL based on semi-insulating surface-plasmon (SI-SP) waveguides provides high output power, high efficiency and less divergent beam [15]. Therefore, in terms of coupling efficiency SI-SP based QCL can be used as a THz source for the proposed fiber. Please see page 03, column 02, paragraph 02, line 01 in the revised manuscript underlined by the solid red color.

**Q.4.** Authors include in their consideration pure material loss and confinement loss but they omit the surface roughness scattering, which is undoubtedly existent in porous structures (P. J. Roberts, F. Couny, H. Sabert, B. J. Mangan, T. A. Birks, J. C. Knight, and P. St. J. Russell, "Loss in solid-core photonic crystal fibers due to interface roughness scattering," Opt. Express 13, 7779-7793 (2005)). Surface roughness scattering may appear a dominant factor, so the Authors' opinion on this would be of interest for the reader.

**Author response:** Thank you again for your important comment. We have added the reason for omitting scattering loss in the revised manuscript.

Surface roughness scattering loss is mainly originated from the fiber nonuniformity, which can be effectively reduced by careful fiber fabrication [12]. The scattering loss is inversely proportional to the operating wavelength. At THz frequencies the induced scattering loss does not significantly affect the total loss [12]. Therefore, we have not considered scattering loss in our calculation. Please see page 02, column 01, paragraph 05, line 07 in the revised manuscript underlined by the solid red color.

**Q.5.** Effective material loss is not a common term. It is referenced, but the reference leads to another article that refers it even further (Liang, J., Ren, L., Chen, N., Zhou, C.: Broadband, low-loss, dispersion flattened porous-core photonic bandgap fiber for terahertz (THz) wave propagation?. Opt. Commu. 295, 257-261 (2013)) without proper explanation. Even further reference from article mentioned in captions refers to another article. Such practice should not be acceptable as the origins of expression remains unclear for the reader. What is more authors use as a reference for a dispersion relation their own paper, which is not their original contribution. All references should be double checked in terms of clarity and good practice.

**Author response:** In the revised manuscript we have carefully double checked the whole references. Several citations have been modified in such a way that represents only the original contributors of the expressions.

The reference of EML equation has been changed. Please see reference [11]. Moreover, the reference of waveguide dispersion has also been changed. Please see reference [13].

[11] A. W. Snyder, J. D. Love, *Optical waveguide theory* (London, Chapman & Hall 1983).

[13] G. P. Agrawal, *Nonlinear fiber optics* (Boston, Academic Press 1989).

**Q.6.** The authors present firstly the material absorption loss at 1 THz and secondly they analyze EML at 0.75 THz. The reference [11] clearly shows frequency dependence of the material loss. It should be clarified for which frequency the loss was calculated.

**Author response:** In the simulation, the bulk absorption loss of Topas has been considered to be 0.9 dB/cm at 0.75 THz [11]. Please see page 01, column 02, paragraph 04, line 10 in the revised manuscript underlined by the solid red color. In few references we have mentioned EML at 1 THz since the authors discussed at this frequency. Confinement loss and EML have been investigated at the operating frequency of 0.75 THz throughout the revised manuscript.

**Q.7.** The loss unit of cm-1 is surely proper way to define absorption but more intuitive manner is to express loss in dB/m or dB/cm.

**Author response:** According to your suggestion, the unit of confinement loss and effective material loss has been changed from cm-1 to dB/cm throughout the revised manuscript. Please see page 02, column 02 and Fig. 3 in the revised manuscript.

**Q.8.** It is not so obvious that the single mode operation is crucial to THz based data transmission. As the loss of such fibers (even theoretically) is extremely high the effective length of transmission is highly reduced to extend where an intermodal dispersion do not play a major role.

**Author response:** Thank you so much for this important comment. We agree with your point that single mode propagation is not so crucial for THz based transmission due to short fiber length. In the revised manuscript we have avoided such type of sentence. However, in this work we want to justify whether the proposed fiber is single or multimode.