# Design of 130-290 GHz rectangular polymer fibers for high-speed data links

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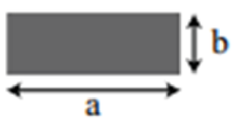
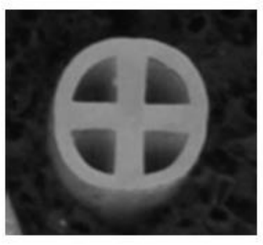
**Abstract—**A rectangular polymer fiber based on COC (Cyclo Olefin Copolymer) material is proposed for short-distance polarization–maintaining data links. Numerical study is carried out to find out the optimum dimension of the dielectric core. The proposed millimeter-wave rectangular waveguide posses low modal loss of 0.13–2.54 dB/m, low dispersion and high birefringence for the D-band frequency range (130-170 GHz). Measured loss from our preliminary characterization agrees well with the calculated values up to 290 GHz. Considering the recent advances in fiber drawing technique, these fibers can be fabricated in large quantities, potentially paving the commercialization path for polarization-sensitive, low-loss and loss dispersion THz short-range, high speed data links.

## 1. Introduction

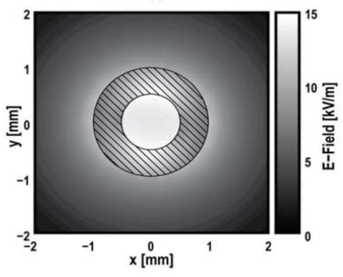



Material: PTFE
a = 1.9 mm
b = 1.0 mm
Frequency: 140 GHz
Loss: 1.5 dB/m [1]

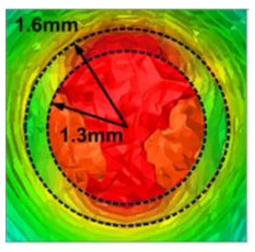


Material: PTFE
Outer dia: 3mm
Frequency: 60 GHz
Loss: 2.3 dB/m [2]

- 100 Gbps per lane is typically required for the data link between the ASICs in array antenna systems for evolved 5G/6G.
- Traditional PCB-based solutions suffer from bandwidth limitation due to their high ohmic losses at frequencies beyond 25 GHz.
- Optical fibers are superior in bandwidth, however light sources are often costly, sensitive to dust, misalignment and temperature variation.
- Polymer microwave fiber (PMF) can be an alternative for high data-rate interconnects.




Material: PTFE
Inner dia: 1.0 mm
Outer dia: 2.0 mm
Frequency: 120 GHz
Loss: 2.5 dB/m [3]




Material : PTFE
Inner dia: 1.3 mm
Outer dia: 1.6 mm
Frequency: 60 GHz
Loss: 1.5 dB/m [4]

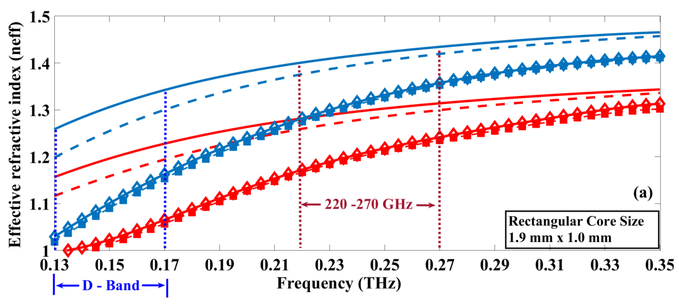
## 2. Numerical Results

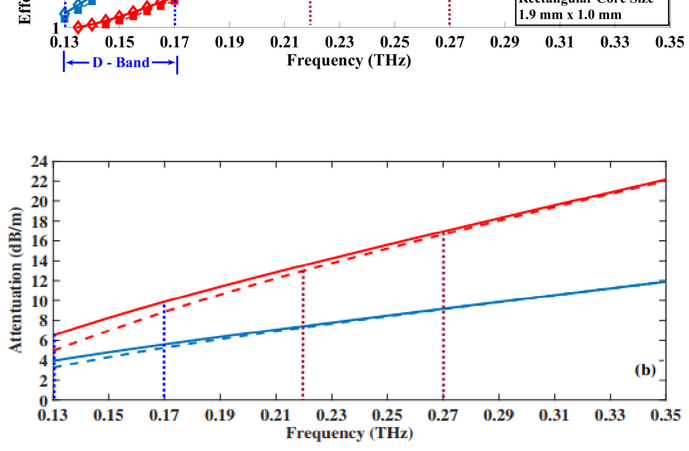
To understand the effect of hosting material properties on the performance of the fiber, we have used COC in our analysis and compared the results with PTFE as used in [1].

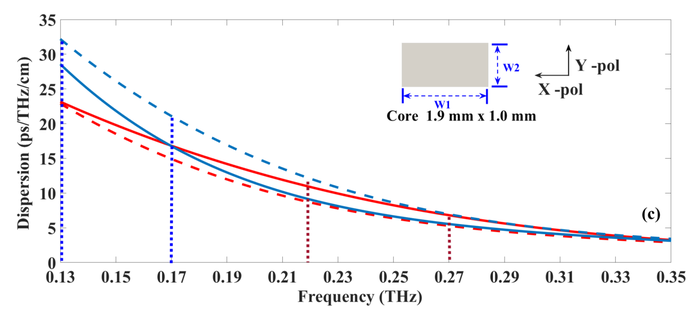
Further, we investigated the effect of the core dimensions on the fiber loss and dispersion.

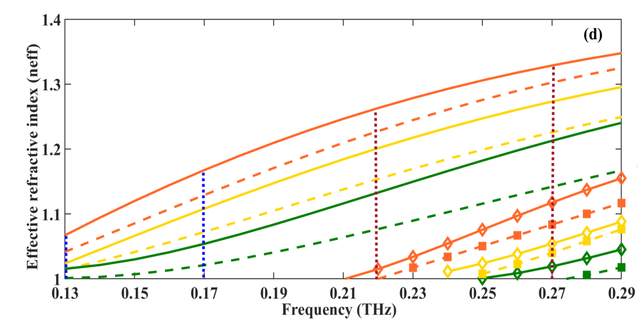
### Characteristics

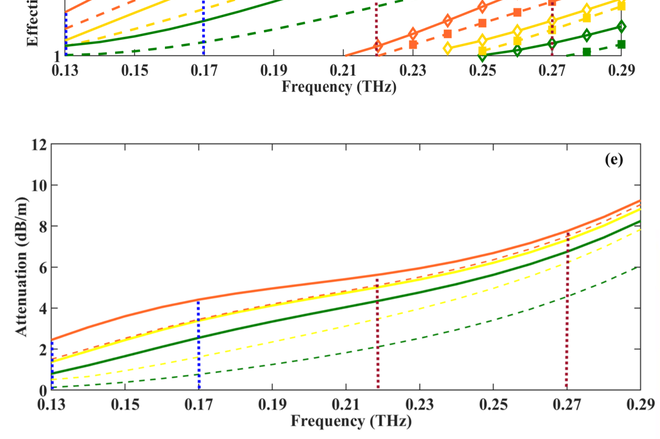
- COC fibers have higher (Neff) than PTFE, → better field confinement for same core cross-section.
- Despite of the higher confinement, the effective material loss of COC fibers is lower than the PTFE fibers.

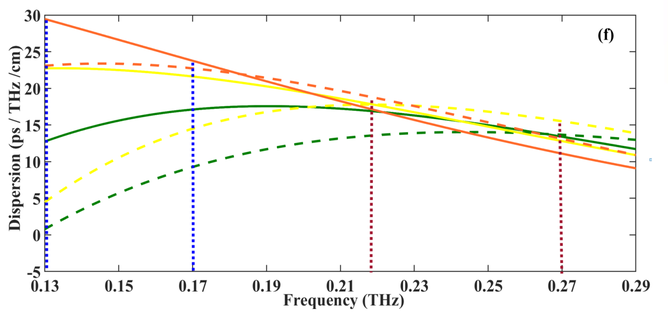


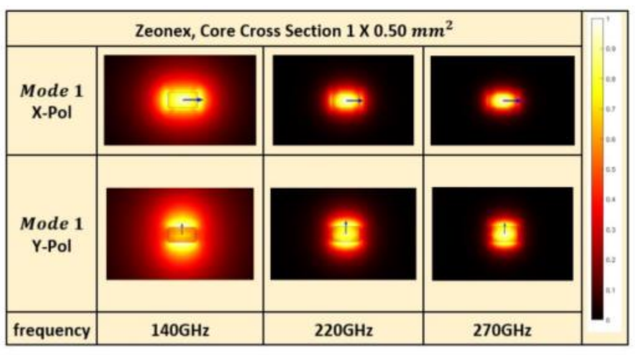




- Rectangular fibers of three different cross-sectional COC cores are designed.
- The fibers with the proposed cross-section support single mode operation for f < 200 GHz.
- At higher frequencies, the field intensity in the air cladding reduces, resulting in higher losses.




PTFE; $Ex^{11}$ Zeonex; $Ex^{11}$
PTFE; $Ey^{11}$ Zeonex; $Ey^{11}$
PTFE; $Ex^{21}$ Zeonex; $Ex^{21}$
PTFE; $Ey^{21}$ Zeonex; $Ey^{21}$

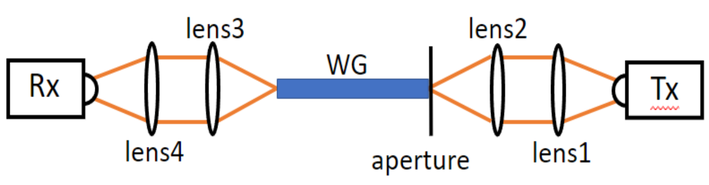
1 mm x 0.5 mm; $Ey^{11}$ 1 mm x 0.5 mm; $Ex^{11}$ 1 mm x 0.7 mm; $Ex^{11}$
1 mm x 0.4 mm; $Ey^{11}$ 1 mm x 0.4 mm; $Ex^{11}$ 1 mm x 0.7 mm; $Ey^{11}$
1 mm x 0.4 mm; $Ex^{21}$ 1 mm x 0.5 mm; $Ex^{21}$ 1 mm x 0.7 mm; $Ex^{21}$
1 mm x 0.4 mm; $Ey^{21}$ 1 mm x 0.5 mm; $Ey^{21}$ 1 mm x 0.7 mm; $Ey^{21}$

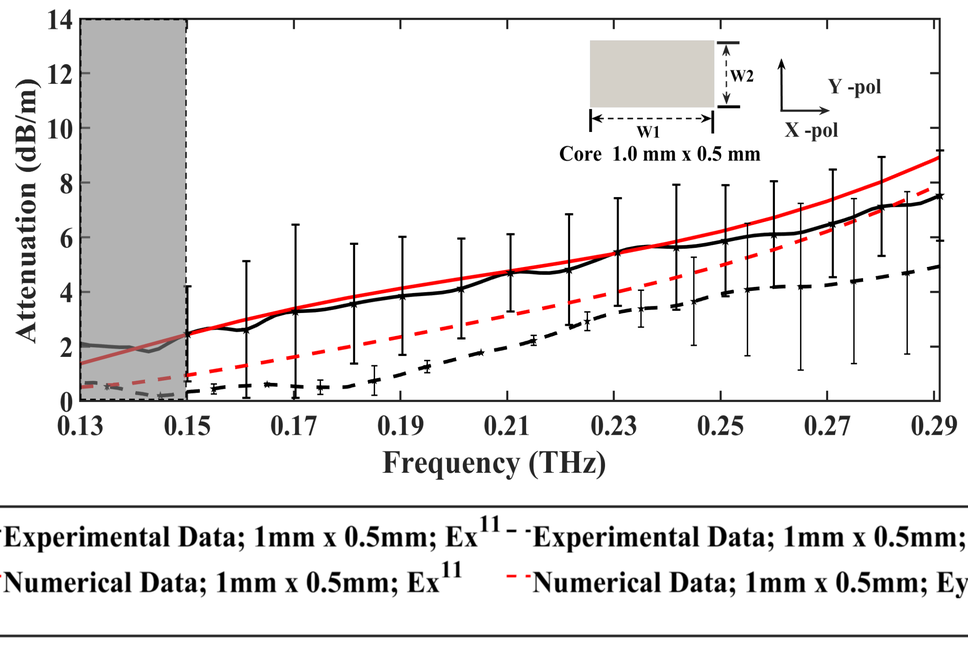
## 3. Experimental Results

- The samples are characterized using fiber-coupled THz-time-domain spectroscopy.
- Averaged loss for a fiber is calculated based on the experimental results for three different fiber lengths.
- The measured loss agrees well with the expected loss based on numerical analysis over 150-290 GHz.

THz-TDS System:

- Sample length: 30 mm, 80 mm, 100 mm
- Material: COC (TOPAS)
- Cross-section: 1.0 mm x 0.5 mm



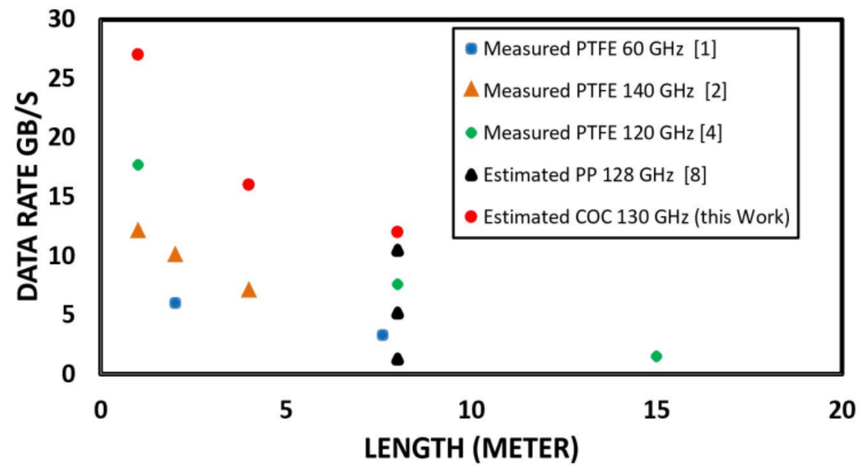




Experimental Data; 1mm x 0.5mm; $Ex^{11}$ Experimental Data; 1mm x 0.5mm; $Ey^{11}$
Numerical Data; 1mm x 0.5mm; $Ex^{11}$ Numerical Data; 1mm x 0.5mm; $Ey^{11}$

## 4. Conclusion

The proposed fiber with 1mm x 0.4mm core can support data rates 28, 16 and 12 Gbps using 130 GHz carrier for 1 m, 4 m and 8 m links distance, respectively.

- By using COC as the host material, low insertion loss and dispersion can be obtained through engineering the waveguide geometry.




## 5. Reference

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