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Effective Single HE_{11} Mode Propagation in Silver-coated Teflon Tubes for THz applications

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Developing single-mode waveguides for THz (i.e., 0.3 to 10 THz) applications with low attenuation encounters three major obstacles: in this range (i) dielectric and conductive losses are significant (D. Grischkowsky *et al.*, J. Opt. Soc. Am. B, 7, 2006, 1990), (ii) atmospheric absorption is high (Y. Yang *et al.*, IEEE Trans. THz Sci. Tech., 2, 406-415, 2012), and (iii) the dimensions required are challenging for standard fabrication techniques. Purged dielectric-lined hollow metallic waveguides offer one of the most promising solutions. They have been successfully fabricated with liquid flow polymer deposition for operation above 2 THz (O. Mitrofanov *et al.*, IEEE Trans. THz Sci. Tech., 1, 124-132, 2011) and by assembling dielectric and metallic cylinders for $\nu < 1$ THz (I.A. Tishchenko and A.I. Nosich, IEEE Microw. Magazine, 4, 32-44, 2003).

Recently, a versatile fabrication alternative based on silver-coating of polymer tubes has been demonstrated (J.E. Melzer *et al.*, Proc. SPIE, 8938, 89380I-1-10, 2014), but the fabricated waveguides have not been characterized yet. Here we study a 1 mm diameter 38 μm thick and a 2 mm diameter 120 μm thick polytetrafluoroethylene (commonly known by its brand name Teflon) tube coated with silver. Our analysis combines numerical calculations and near-field THz time-domain spectroscopy (M. Navarro-Cía *et al.*, Opt. Express, 21, 23748-23755, 2013). This measurement technique allows resolving modes in time, and thus, identifying single- or multi-mode propagation directly.

For the Ø1 mm waveguide, we observe effective single-mode (HE_{11}) propagation in the band $1 < \nu < 1.6$ THz and multi-mode propagation elsewhere. The transmission loss estimated via a cut-back experiment is ~20 dB/m. This loss is substantially smaller than commercial single-mode hollow waveguides, e.g. rectangular waveguide WR-0.65 in which the theoretical transmission loss is between 258 to 406 dB/m at 1.1 and 1.7 THz, respectively. The loss of 20 dB/m is also lower than that in many recently proposed waveguides.

Teflon has relative low absorption coefficient and is easily found in different wall thicknesses and diameters. Hence, it was the choice for this work. However, other polymers with lower absorption coefficient like cyclic olefin copolymer may lead to experimental transmission loss below 10 dB/m according to our numerical work.