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Terahertz Dielectric Property Characterization of Photopolymers for Additive Manufacturing

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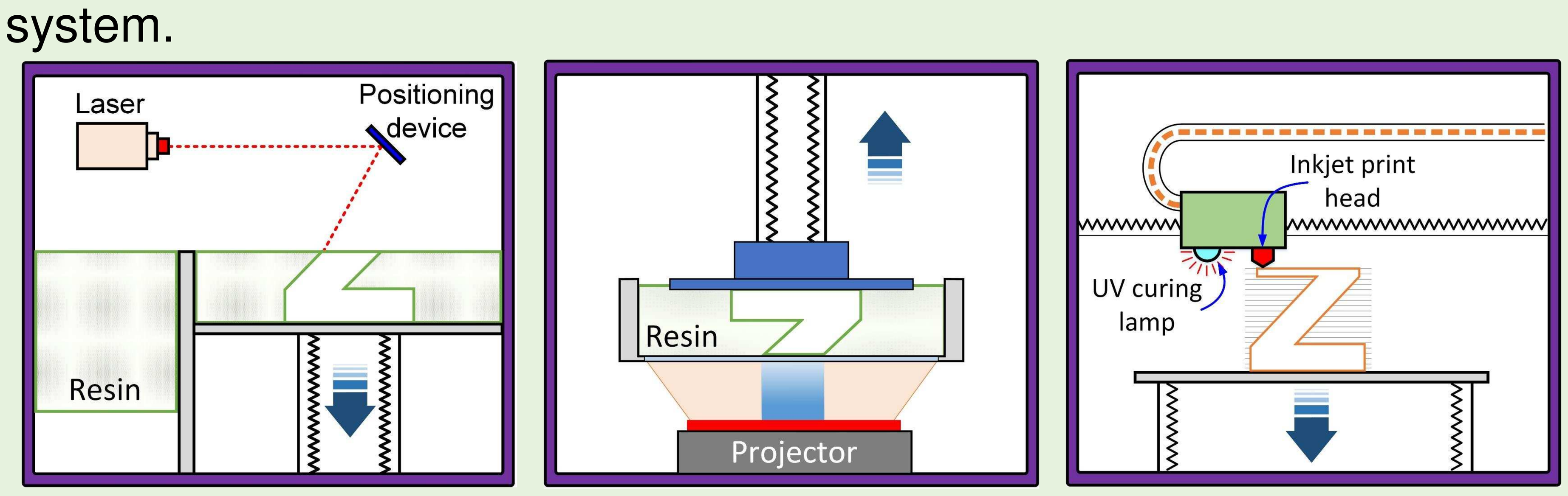
Introduction

Additive manufacturing technology has attracted much attention to modern three-dimensional (3D) fabrication processes due to its rapid prototyping capability, especially with a broad diversity of dielectric and metallic materials that can be used to fabricate design prototypes of almost any 3D structures. 3D printing techniques, normally used in mm-wave and THz technologies such as dielectric lens antenna, waveguide, sensor, and filter/splitter for realizing low-cost complex THz system.



SLA Stereolithography | **DLP** Digital Light Processing | **PJ** Photopolymer Jetting

Methodology

A schematic diagram showing the working principle of the free-space THz-TDS system used in this work, is shown in Fig. 1. The initial laser beam is divided into two beams using an 80:20 beam splitter, with the higher power beam used to generate the THz pulse and the weaker beam used for gated detection. Both the THz emitter and detector in this system are photoconductive antennas (PCA). The THz radiation is then collected, collimated and focused by a set of off-axis parabolic mirrors. The THz radiation is focused onto the sample, after which a second set of off-axis parabolic mirrors are used to re-collimate and then focus the THz transmitted through the sample onto the second PCA for detection. By delaying the pump beam with a linear delay stage, the point in time where the THz and probe beams are both incident changes, allowing for a time domain signal of the THz beam to be obtained. THz-TDS is a coherent material characterization technique, which allows both the amplitude and phase of the THz signal propagating through the material-under-test (MUT) to be simultaneously measured which in turn allows both the complex dielectric constant and loss tangent to be extracted numerically.

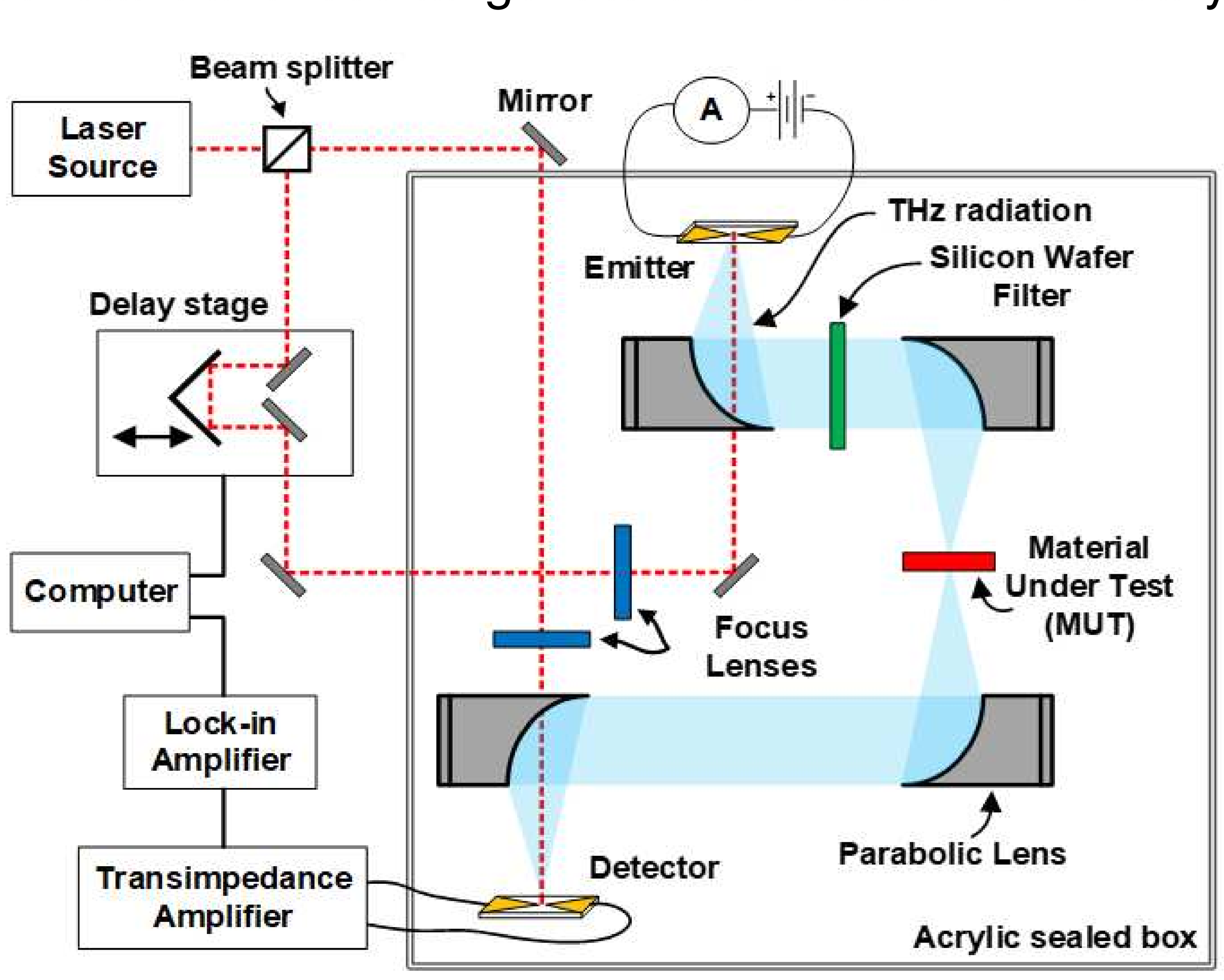


Fig. 1 Working principle of the THz-TDS measurement system used in this work.

Results

From the measurement setup, the THz-TDS system was primarily used to measure both refractive index and absorption coefficient. Both measured material properties can be used to calculate the dielectric constant and loss tangent of the materials. From the extraction of loss tangent and dielectric constant characteristics, all selected photocurable polymer specimens are suitable to be used in mm-wave and THz applications.

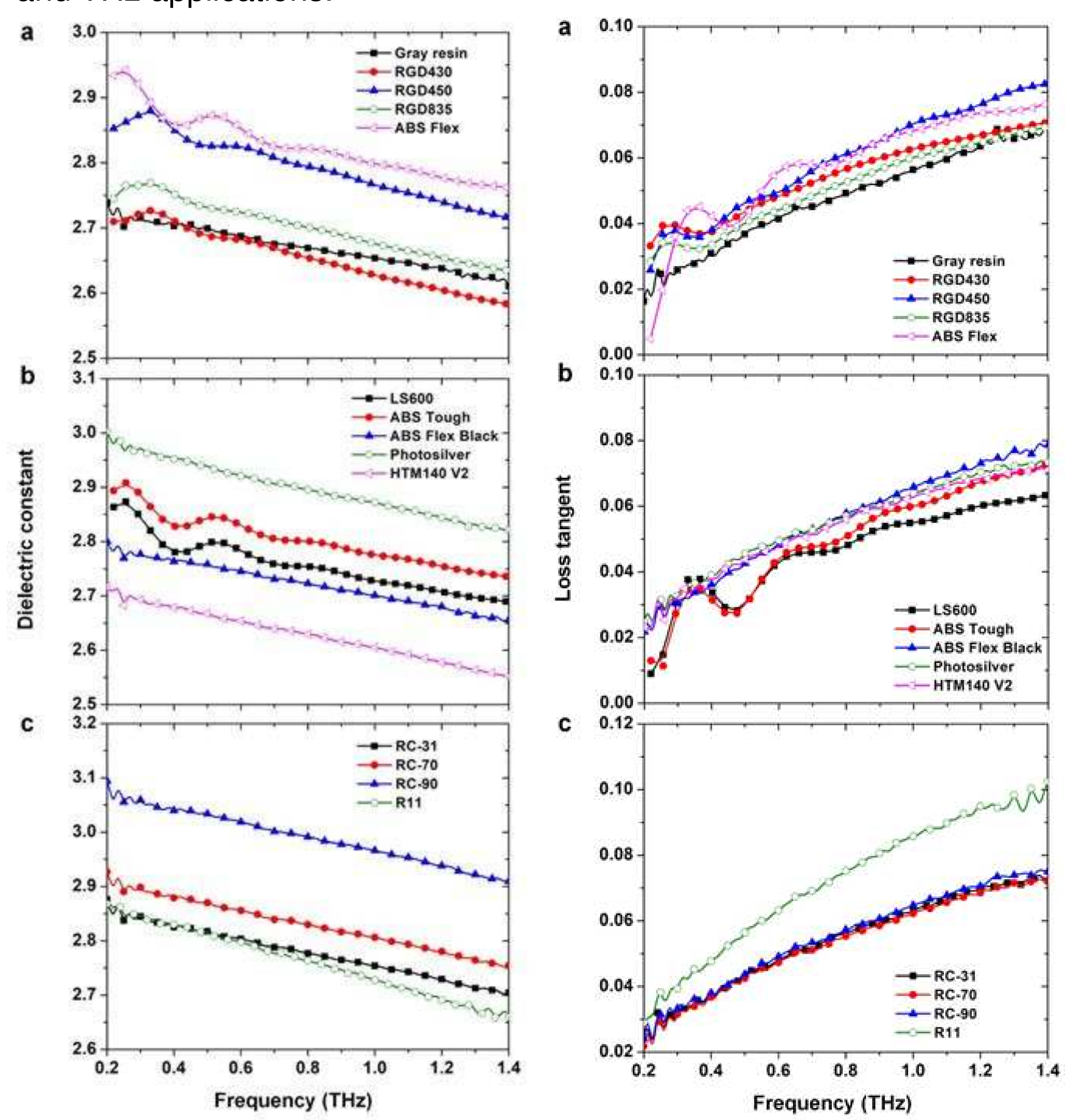


Fig. 2. Measured dielectric constants of the photocurable polymers (left). Measured loss tangents of the selected photopolymers (right).

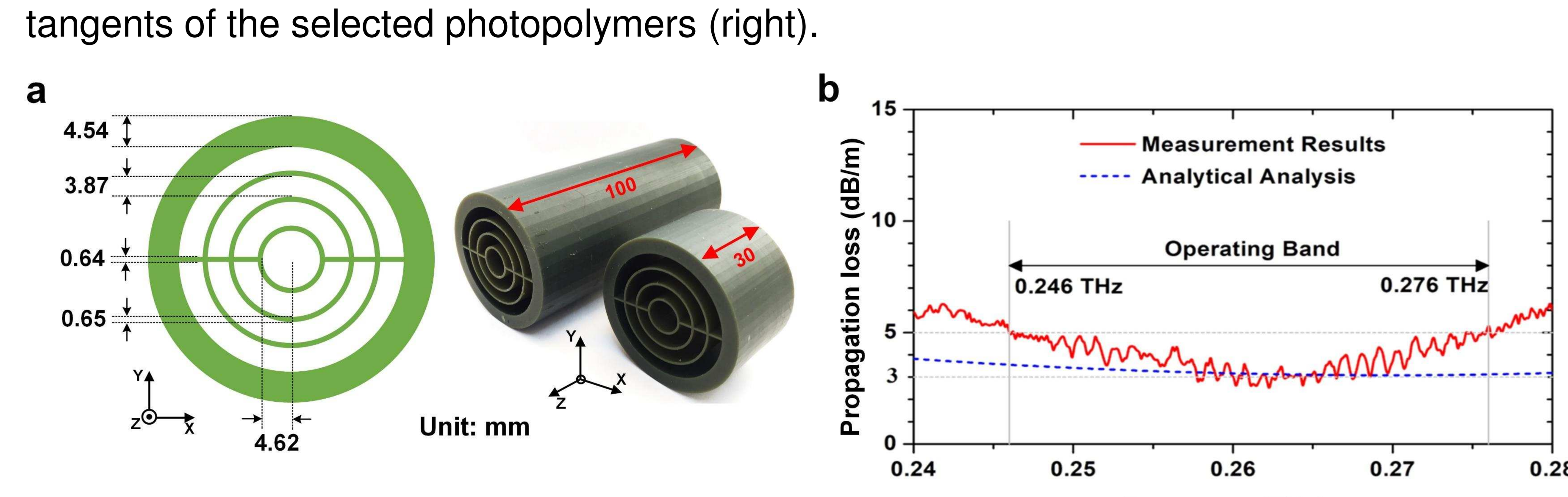


Fig. 3. (a) A cross-sectional dimensions and fabricated prototype of asymptotically single-mode Bragg fiber additive-manufactured by using HTM140-V2 photopolymer and (b) propagation loss characteristic of the Bragg fiber (right).

Conclusion

Fourteen photocurable polymer specimens for SLA, DLP and PJ additive manufacturing were characterized for their optical and electromagnetic properties from 0.2 – 1.4 THz by using laser-based THz-TDS technique. The measurement results show that all selected photopolymer specimens in this works are suitable for developing various passive mm-wave and THz components.

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