Tunable Carbon-Based Nanomaterials for THz Applications

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Abstract

In this work single-walled carbon nanotube tuning properties are studied for phase shifting applications. The dielectric rod waveguide with loaded carbon nanomaterials was experimentally studied in ultra-wide frequency band of 0.1-0.5 THz.

1. Introduction

The research and development in the frequency region of 0.1-1.0 THz is extremely significant for the wide range of applications, such as telecommunication and imaging systems, material spectroscopy, medical imaging and treatments, etc. Despite the problems in technology and high prices for basic components (phase shifters, directional couplers, etc.), the THz systems offer higher date rates for telecommunication, high spatial resolution in the visualization of objects, small size of antennas and other elements. The state-of-the-art of the THz devices reveals serious problems with radiation sources with continuous wave semiconductor-based source, electronically tunable phase shifters, amplifiers, etc.

Carbon nanotubes (CNT) offer unique properties due to their natural small dimensions and outstanding electrical properties. Their tunability properties makes them very attractive in application to the THz system [1-3]. Integration of CNTs with the dielectric rod waveguide (DRW) technology enables novel technology platform for tunable THz systems.

2. Results and Discussions

Phase shifter can be developed by introducing the optically controlled varactor to the DRW [4]. The phase change of 10-20 deg with almost negligible change in attenuation less than 0.1 dB can be achieved (Fig.1) in the frequency range of 75-500 GHz. Besides, DRWs have no cut-off frequency enabling broad band operation. In [5-6], the DRW antenna was proved to operate in the frequency band of 0.1-1.1 THz. The effect of the dielectric constant tuning of single-walled carbon nanotubes under light illumination is observed in the very wide frequency range of 0.1–1 THz. The optical absorption spectrum is not uniform and it consists of several absorption peaks related to electron transitions. Therefore, the change of capacity and resistance under different light wavelength illumination is different at different wavelengths (Fig. 3-4)

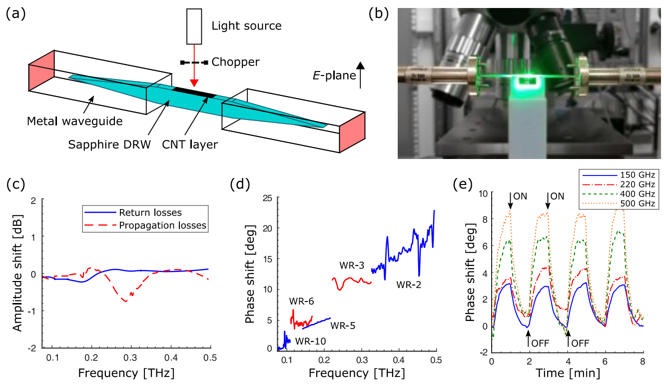

Figure 1: a) Schematic drawing of the two-port S-parameter measurement setup. DRW is loaded with a CNT layer and exposed to varying illumination conditions. b) Image of the measurement setup. c) Measured amplitude shifts due to the illumination of the CNT layer. d) Measured phase shift. e) Time dependence of the phase shift in the CNT-loaded DRW at 150, 220, 400 and 500 GHz.

3. Conclusions

CNTs are perspective materials for very wide applications in millimeter wave and THz frequency range. Phase shifter based on DRW loaded with CNT layer is a perspective candidate for ultra-wide band device application. The ultra-wide band optically controlled CNT-based phase shifter can enable THz beam steering.

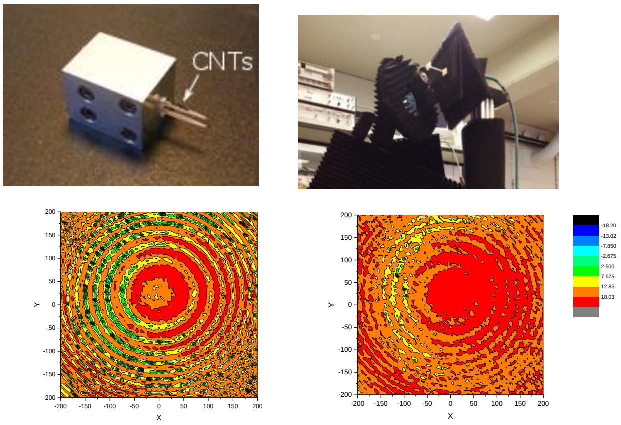

Figure 2: Radiation pattern measurements of DRW antenna array at 90 GHz without and with illumination of the CNT-loaded DRW.

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