

Planar Terahertz Goubau-line Antenna with Endfire Radiation Based on Substrate Mode

Qing Le Zhang, Bao Jie Chen, Kam Man Shum, and Chi Hou Chan

State Key Laboratory of Terahertz and Millimeter Waves, Department of Electrical Engineering, City University of Hong Kong, Hong Kong SAR, China

*corresponding author, E-mail: eechic@cityu.edu.hk

Abstract

We present a planar terahertz goubau-line antenna with endfire radiation based on the substrate mode in this paper. As the antenna substrate thickness increases, the goubau line can excite the substrate mode and thus the truncated substrate will work as an antenna to generate endfire radiation. The proposed antenna operates from 325 GHz to 430 GHz on a 300 μm thick quartz substrate, and achieves the endfire radiation with 9.5-10.85 dBi gain.

1. Introduction

Terahertz technologies have received much attention in recent years as they hold many promising applications, like sensing, material detection, communications, etc. [1]. In these terahertz systems, antennas with endfire radiation are usually desired. In microwave and millimeter-wave bands, different types of antennas with endfire radiation have been proposed. Antennas with 3D structures (horns, dielectric lens and dielectric rod antennas) have wideband, high-gain and low cross-polarization advantages [2-4]. But in terahertz region, these 3D antennas are complicated to fabricate especially when integrated with other on-chip components. Some planar antennas (Yagi-Uda antennas and Vivaldi antennas) are usually fabricated on thin substrates with multiple metallic layers, which lead to the antenna deformation and difficult fabrication in terahertz band [5-6]. In this paper, we employ the goubau line on a thick quartz substrate, which can excite the substrate mode. Such thick substrate can support good mechanical stability and the truncated structure leads to endfire radiation. Meanwhile, this antenna only has one metallic layer and can be easily fabricated by photolithography.

2. Planar terahertz goubau-line antenna design

The geometry of the proposed planar terahertz goubau-line antenna based on the substrate mode is shown in Fig.1. It is fabricated on quartz substrate with $\epsilon_r = 3.75$ and $\tan\delta = 0.0004$. Since the goubau line is a single-conductor line and propagates the transverse magnetic (TM) mode surface wave, a transition from 50 Ω coplanar waveguide (CPW) is required for the mode conversion and impedance matching. The tapered CPW ground plane provides a smooth

conversion, where the exponential function is $y = f(x) = A(e^{\alpha x} - 1)$ with $A = L_g / (e^{\alpha x} - 1)$ and $\alpha = 0.012$. The antenna parameters are as follows: $W_0 = 800 \mu\text{m}$, $W_c = 30 \mu\text{m}$, $L_c = 100 \mu\text{m}$, $L_1 = 500 \mu\text{m}$, $L_2 = 830 \mu\text{m}$, $L_3 = 350 \mu\text{m}$, $L_g = 230 \mu\text{m}$ and $g_c = 4 \mu\text{m}$. And the metallic material is copper with thickness 0.3 μm and conductivity $\sigma = 5.8 \times 10^7 \text{ S/m}$.

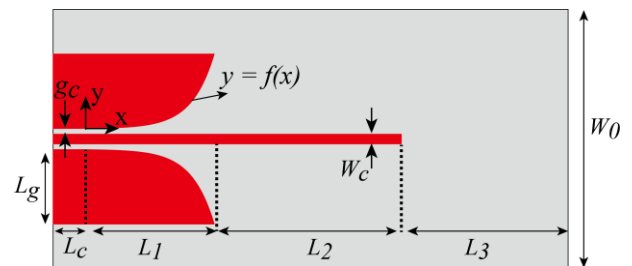


Figure 1: Geometry of the planar terahertz goubau-line antenna based on substrate mode.

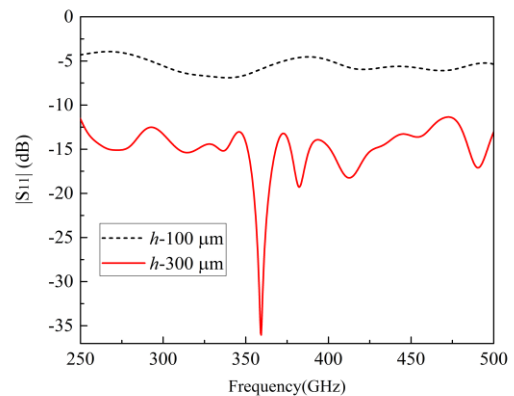


Figure 2: Reflection coefficients of the planar terahertz antenna on quartz substrate with different thicknesses.

The thickness of the quartz substrate plays an important role on the proposed terahertz goubau-line antenna. In Fig. 2, we compare the reflection coefficients of this antenna with different substrate thicknesses. When the thickness is 100 μm , the $|S_{11}|$ is about -5 dB , which means that the propagating wave is a standing wave and the field is reflected by the truncated goubau line. As the thickness

increases to 300 μm , the $|S_{11}|$ becomes below -10 dB in 250-500 GHz band and most of the energy radiates into free space. Therefore, the quartz thickness in this terahertz antenna is chosen as 300 μm . Fig. 3 displays the E_z field distribution of this terahertz antenna at 350 GHz. We can clearly observe that the TM-mode field along the goubau line is converted into the substrate mode and the truncated structure leak the energy into endfire direction. It also indicates that the polarization of this antenna is along z direction.

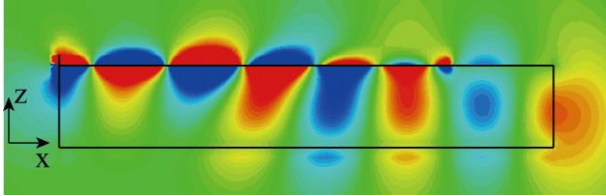


Figure 3: E_z field distribution of this terahertz antenna at 350 GHz.

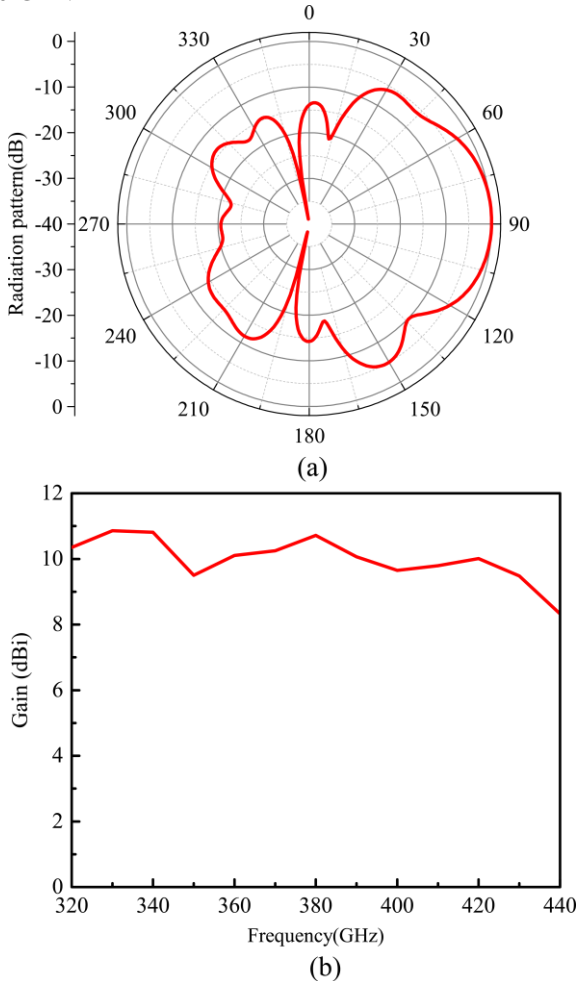


Figure 4: Radiation performance of the planar terahertz antenna, (a) E-plane radiation pattern ($\phi = 0^\circ$) at 350 GHz and (b) gain versus frequency.

Fig. 4(a) gives the E-plane radiation pattern of the proposed terahertz antenna at 350 GHz. The main beam is in endfire direction and the 3dB beamwidth is 57° . The cross-polarization is below -40 dB and not shown here. The gain

versus frequency of this terahertz antenna is depicted in Fig. 4(b). In 325-430 GHz band, the gain can reach 9.5 to 10.85 dBi. Experimental validation of the design will be provided in the presentation.

3. Conclusions

In this paper, we propose a planar terahertz antenna with endfire radiation in 325-430 GHz. The goubau line is employed to excite the substrate mode on a 300 μm thick quartz substrate. The truncated structure leads to the energy radiation into the endfire direction. The gain can reach 9.5-10.85 dBi in the operating band.

Acknowledgements

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