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A Sub-Terahertz Wide-Incident-Angle Transparent Radio-Wave Absorber

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Abstract

A wide-incident-angle radio-wave absorber for Beyond 5G/6G applications is proposed, covering wide frequency bands, including 150-GHz and 300-GHz bands It is based on a Jaumann-type radio-wave film absorber consisting of several transparent materials: dielectric, resistive, and silver-nano-wire ground layers. It shows a 90% absorbable frequency range from 139.2 GHz to 305.2 GHz at the incident angle of 20 deg to 50 deg. In addition, a 90% absorbable frequency range from 185.0 GHz to 219.5 GHz is realized at the incident angle of 20 deg to 60 deg.

1 Introduction

From 2030, Beyond 5G/6G applications will be available with ultra-high-speed wireless communication ability up to or higher than the rate of 100Gb/s. 150-GHz and 300-GHz frequencies are promising frequency bands for future wireless communication [1, 2, 3]. However, there is a lack of essential devices, such as radio-wave absorbers, to reduce undesired reflections from chips or modules for those bands since they have not been put into practical use yet [4, 5, 6]. In addition, some radio-wave absorbers require absorbable ability to reduce radiation from the antenna side lobe or to reduce the reflection owing to it at wide-incident-angle ranges for phased-array or MIMO (multi-input multi-output) applications, which adopt beam forming/steering/tracking.

2 Incident-Angle Dependancy of Film-Type Radio-Wave Absorbers

Film-type radio-wave absorbers, such as Salisbury-screen-type and Jaumann-type, are commonly adopted to prevent cavity resonance inside the package and the module or to reduce undesired reflection around the system. Generally, they consist of a resistive layer, a ground layer (metal), and one or several dielectric layers (thickness≈ $\lambda_g/4$, λ_g: guided wavelength) in Figs. 1(a), (b). A Jaumman-type (Fig. 1(b)) usually shows a wider absorbable frequency range, though its thickness is thicker than the Salisbury-type one [4, 5, 6].

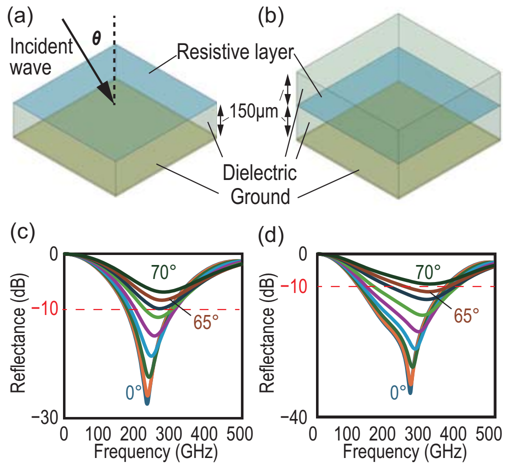

Figure 1. EM simulation model: (a) Salusbury-screen-type (sheet resistance of the resistive layer: 377 ohm/sq) and (b) Jaumann-type absorber (sheet resistance of the resistive layer: 151 ohm/sq). Simulation results by sweeping the incident angle θ (step: 10 deg): (c) Salusbury-screen-type and (d) Jaumann-type absorber.

Figs 1(c) and (d) depict the EM (electromagnetic) simulation results of both of them by sweeping the incident angle θ when the thickness of one dielectric (acrylic OCA) is 150 μm (i.e., for 300-GHz-band applications). They show that the Jaumann-type one has a wider absorbable frequency range even by sweeping the incident angle. The simulation results were achieved using the models proposed in [4].

3 Proposed Absorber

Fig. 2(a) shows the proposed absorber, which realizes transparency using a silver-nano-wire-based ground. Two PET layers are employed to make the resistive and ground layers. The thickness of the dielectrics and the sheet resistance

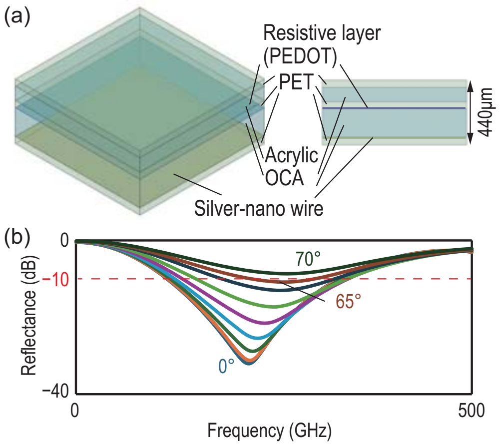

Figure 2. (a) EM simulation model (sheet resistance of the resistive layer and the silver-nano-wire-based ground: 145 ohm/sq and 12 ohm/sq, respectively) [6] and (b) simulation results by sweeping the incident angle θ (step: 10 deg) of the proposed absorber.

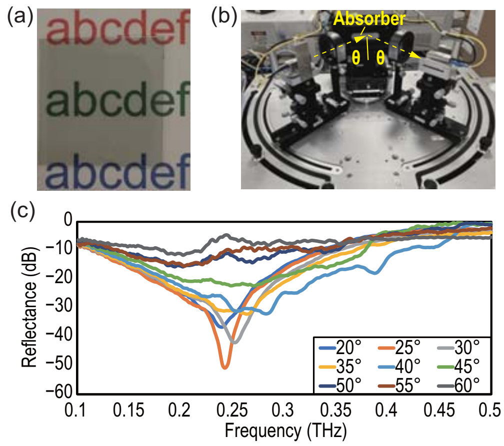

Figure 3. (a) Photograph of the fabricated absorber [6], (b) measurement setup, and (c) measurement results by sweeping the incident angle.

of the resistive and ground layers are optimized to realize the absorber for both 150-GHz and 300-GHz applications (at the incident angle lower than 45 deg). The simulation results of the proposed absorber by sweeping the incident angle are demonstrated in Fig. 2(b). It shows a wider 90% absorbable frequency range than 221.5 GHz–301.5 GHz at the incident angle up to 65 deg.

4 Measurement Results

Fig. 3(a) depicts the photograph of the fabricated absorber. It was measured using a THz-TDS (terahertz time-domain spectroscopy), which can adjust its incident angle, as shown in Fig. 3(b). Fig. 3(c) indicates measurement results by sweeping the incident angle from 20 deg to 60 deg (step: 5 deg) and shows the 90% absorbable frequency range of 139.2 GHz to 305.2 GHz and 185.0 GHz to 219.5 GHz at the incident angle of 20 deg to 50 deg and the incident angle of 20 deg to 60 deg, respectively.

5 Conclusion

A wideband wide-incident-angle transparent absorber was proposed, which is a promising device for Beyond 5G/6G phased-array/MIMO systems. It shows transparency thanks to employing the silver-nano-wire ground layer. It can cover the frequency range from 139.2 GHz to 305.2 GHz at the incident angle of 20 deg to 50 deg. After optimization, it can be adopted for 150-GHz or 300-GHz applications at an incident angle of up to 65 deg.

6 Acknowledgements

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