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Stacked metal hole array as an antenna gain enhancer at 300 GHz band

Yu Katsuue [1], Yusuke Tanaka[1], Keizo Inagaki[2], Atsushi Kanno[2], Norihiko Sekine[2], Ayumu Yabuki[3], Junichi Nakajima[3], Shintaro Hisatake [1]
(1) Gifu University, Gifu, Japan, hisatake@gifu-u.ac.jp, https://www.sh-research-lab.com/
(2) National Institute of Information and Communications Technology, Koganei, Japan
(3) SoftBank, Tokyo, Japan

Abstract

We demonstrate the stacked metal hole array (MHA) with the gain enhancement bandwidth of 10 GHz at 300 GHz band based on the simulation (CST STUDIO SUITE). The antenna gain enhancement of about 2 dB was obtained by placing the stacked MHA in front of a conical horn antenna.

1. Introduction

The 300 GHz band is expected to enable ultra-high speed wireless communication in point-to-point application such as wireless backhaul and fronthaul, intra-device communication, Kiosk download, etc [1-3]. In the wireless communication system, antenna gain is an important parameter because the higher antenna gain extends the transmission distance. For example, 3-dB antenna gain enhancement at transmitter side increases the transmission distance by about 1.4 times. To realize higher antenna gain, not only the larger antenna aperture but also the uniform phase distribution (planar phase distribution) at the antenna surface is required.

Recently, we demonstrated that the quasi-spherical wave radiated from the horn antenna can be converted into the plane wave by placing the metal hole array (MHA) in front of a horn antenna [4]. We also experimentally demonstrated that the MHA placed in front of the horn antenna enhances the total antenna gain at 125 GHz [5]. In the previous demonstration at 125 GHz, the measured antenna gain enhancement was about 1.9 dB, and the measured bandwidth of the gain enhancement was approximately 1.2 GHz. Wider bandwidth is indispensable for the terahertz wireless communications.

In this presentation, we propose and demonstrate a stacked MHA with the gain enhancement bandwidth of 10 GHz at 300 GHz band based on simulation using CST STUDIO SUITE.

2. Single metal hole array

Figure 1 shows a schematic of the simulation model with a single MHA. The MHA is placed in front of a WR-3.4 conical horn antenna. In the simulation, we set the metal as

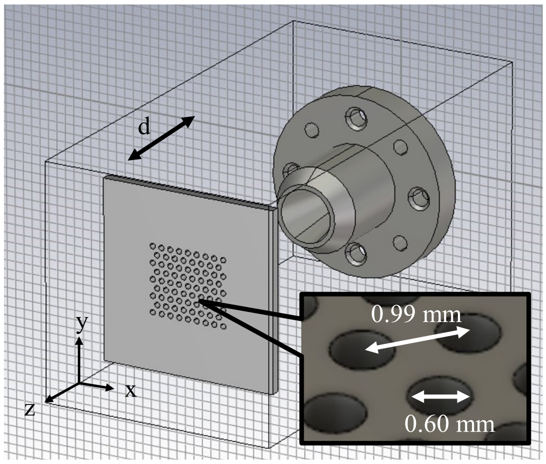

Fig. 1. Schematic of the MHA with conical horn antenna.

Aluminum with the electric conductivity of 3.56×10^7 S/m. The diameter of the hole is 0.60 mm, and the lattice constant is 0.99 mm. The thickness of the MHA is 1 mm. In the simulation, a quasi-spherical wave emitted from the conical horn antenna was irradiated on the MHA. The direction of the E-field was parallel to the x-axis.

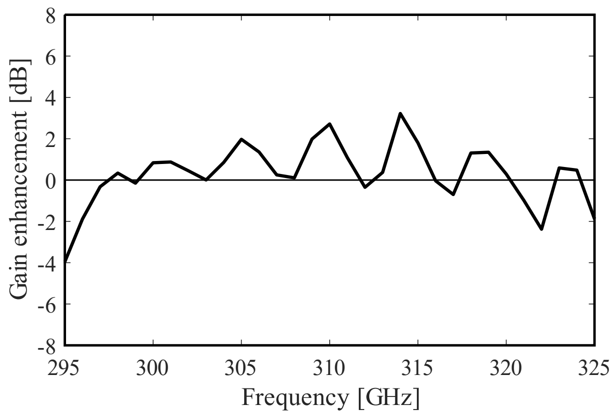

Fig. 2. Frequency characteristic of the gain enhancement realized by placing the single MHA.

Figure 2 shows the simulation result of the frequency characteristic of the gain enhancement. The distance between the conical horn antenna and the MHA was 22 mm. As shown in Fig. 2, at several point frequencies, the single MHA enhances the antenna gain by several decibels.

However, the characteristic is peaky, and the bandwidth of the gain enhancement is limited to only about 1 GHz.

3. Stacked metal hole array

To enhance the bandwidth of the gain enhancement, we propose and demonstrate a stacked MHA. Figure 3 shows the stacked MHA place in front of the conical horn antenna.

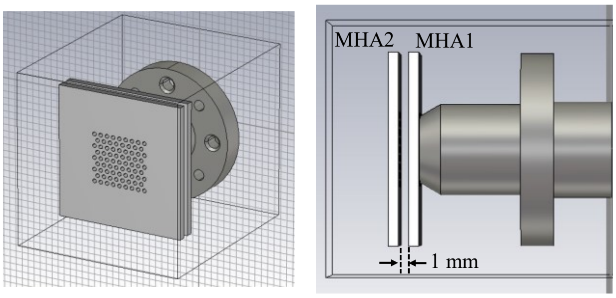

Fig. 3. Schematic of the stacked MHA with conical horn antenna.

We calculated the frequency characteristic of the gain enhancement by changing several parameters of the stacked MHA, such as lattice constant, distance between the MHA1 and the conical horn antenna, and the distance between the MHA1 and the MHA2. Figure 3 shows the frequency characteristic of the gain enhancement realized by the optimized stacked MHA. The hole diameter of each MHA is 0.60 mm. The lattice constant of the MHA1 and MHA2 was 0.95 mm and 0.98 mm, respectively. The distance between the MHA1 and the conical horn antenna is 0 mm. The distance between the MHA1 and MHA2 is 1 mm. As shown in Fig. 3, the flatter characteristic was realized by stacking two MHAs with slightly different lattice constant. The realized gain enhancement is about 2 dB. The bandwidth of the gain enhancement is about 10 GHz.

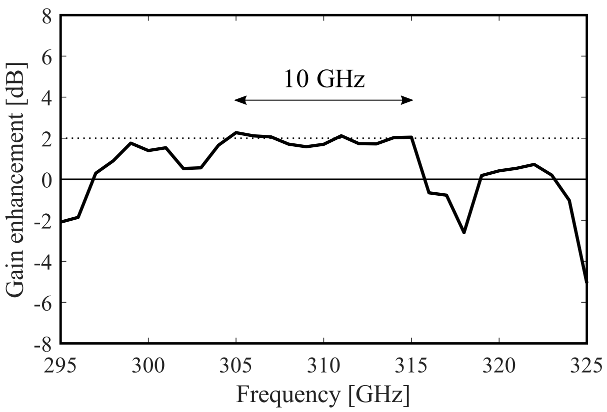

Fig. 4. Frequency characteristic of the gain enhancement realized by placing the optimized stacked MHA.

4. Summary

We demonstrated the antenna gain enhancer at 300 GHz band based on the simulation. The designed stacked MHA has the bandwidth of about 10 GHz and the gain enhancement of about 2 dB.

References

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