A 300GHz-Band Wireless Transceiver Using Si-CMOS Integrated Circuits

Minoru Fujishima
Graduate School of Frontier Sciences of Matter
Hiroshima University
Higashi-hiroshima, Japan
fuji@hiroshima-u.ac.jp

Abstract—300-GHz band is promising for wireless communication since wide frequency band and low atmospheric attenuation are available. In this presentation, the technologies of a recently-developed 300-GHz-band transceiver chip set including 105Gbps transmitter and 32Gbps receiver are discussed using CMOS integrated circuits.

Keywords—terahertz, wireless communication, CMOS, transceiver, integrated circuit

I. INTRODUCTION

Although frequency allocation over 275 GHz has not yet been determined, it is expected to be used for wireless communication. In addition, as shown in Fig. 1, in the region sandwiched between the absorption bands of 183 GHz and 325 GHz in the atmosphere, the attenuation is as small as several dB per kilometer or less, and the communication on the kilometer order is theoretically possible. In the 300-GHz band, the frequency is low even in the terahertz band, and by using the performance of advanced electronic devices, it is possible to realize a transceiver even with an integrated circuit approach. On the other hand, since only the CMOS integrated circuit can realize a large-scale circuit which is responsible for signal processing, if the terahertz front end can be realized by CMOS integrated circuit, an all CMOS terahertz transceiver can be realized and great progress will be made in dissemination of terahertz communication.

II. 300GHz-BAND CMOS TRANSCEIVER

Although it is not possible to realize a 300-GHz-band power amplifier with a silicon MOSFET, it is necessary to obtain sufficient power to realize wireless communication. For this purpose, it is necessary to arrange the final stages in parallel and synthesize power. On the other hand, since the frequency multiplier is nonlinear, it breaks quadrature amplitude modulation. Therefore, an upconversion mixer using a local oscillation signal must be used in the final stage.

Therefore, we realized a 300 GHz band CMOS transmitter with 32 cubic mixers based on a triple multiplier in parallel [1-4]. In this transmitter, the superimposed local signal and modulated signal around 100 GHz are amplified by the IF power amplifier and sent to the cubic mixer. The maximum transmission data rate is 21 Gbps with 64 QAM. Furthermore, we revised a 300-GHz transmitter with a square mixer based on a doubler in the final stage [5]. In this transmitter, as shown in Fig. 2, a modulation signal with a maximum of 105 Gbps can be obtained.

This work was supported by R&D on Wireless Transceiver Systems with CMOS Technology in 300GHz Band, as part of the R&D program on Key Technology in Terahertz Frequency Bands by the Ministry of Internal Affairs and Communications of Japan.

Fig. 1. Atmospheric attenuation around 300GHz band.

However, since the maximum operating frequency (fmax) of the silicon MOSFET used in the CMOS integrated circuit is around 300 GHz, it is difficult to amplify the 300-GHz-band signal. Under these circumstances, how can we implement a 300-GHz-band transceiver with a silicon CMOS integrated circuit?

We have realized 300-GHz-band transmitter and receiver using silicon CMOS integrated circuit by applying original method. We also performed wireless communication of 300-GHz-band CMOS transceiver and compared it with transceivers using compound semiconductor and photomixing. In this paper, we introduce the outline of our studies.

Fig. 2. Measured signal constellations, error-vector magnitudes, symbol rates, and data rates with a 300GHz-band CMOS transmitter[5].
On the other hand, since CMOS receivers cannot use a 300-GHz-band low-noise amplifier, it is necessary to use the first stage as a mixer. By using the same output stage as the 300-GHz-band CMOS transmitter, the power of the LO signal of the mixer was increased. This reduced the conversion loss of the mixer [6]. As shown in Fig. 3, it was shown that a 300-GHz-band CMOS receiver can handle a modulation signal up to 32 Gbps.

### Table 1: Performance Comparison of CMOS Receivers

<table>
<thead>
<tr>
<th>Constellation</th>
<th>QPSK</th>
<th>16QAM</th>
<th>32QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVM</td>
<td>19.0%rms</td>
<td>12.2%rms</td>
<td>8.8%rms</td>
</tr>
<tr>
<td>Sym. rate</td>
<td>14 Gbaud</td>
<td>8 Gbaud</td>
<td>4 Gbaud</td>
</tr>
<tr>
<td>Data rate</td>
<td>28 Gb/s</td>
<td>32 Gb/s</td>
<td>20 Gb/s</td>
</tr>
</tbody>
</table>

Fig. 3. Measured signal constellations, error-vector magnitudes, symbol rates, and data rates with a 300GHz-band CMOS receiver[6].

On the other hand, performances of a CMOS transmitter and those using photomixing and compound semiconductors are compared using wireless communication. Since different modulation schemes, bit error rate, antenna gain, etc. are used in the past reports, the performance of the transceivers cannot be simply compared only by the communication distance. Therefore, after normalizing these parameters, effective communication distances are compared [7, 8]. Figure 4 shows the results of performance comparison between wireless communication using a CMOS transmitter and others applying this normalization. As shown in the figure, the CMOS transmitter is comparable to transmitters using photomixing and compound semiconductor.

### III. CONCLUSION

We have realized the 300-GHz-band CMOS transmitter and receiver for the first time that can handle quadrature amplitude modulation at frequencies above the maximum operating frequency ($f_{\text{max}}$) of a silicon MOSFET. Although many challenges remain to be put into practical use, we have taken a big step toward practical application of terahertz communication. In this 300-GHz band, by allocating channels from 252 GHz to 321 GHz, which is expected to use wireless communication, aggregated data rate exceeding 300 Gbps can be obtained [9, 10]. This data rate close to optical communications is expected to spread not only to the earth but also to broadband applications in the space where communication means are limited to wireless links.

**ACKNOWLEDGMENT**

This paper is the result of collaboration with National Institute of Information and Communication Technology and Panasonic. The author would like to thank all the members involved in this project.

**REFERENCES**


