Press Release

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Terahertz radar enables contactless heartbeat measurement through clothing
—Multifunction integrated on a terahertz waveguide; from beam steering to mixing—

Together with Akifumi Kasamatsu (Executive Researcher) and Issei Watanabe (Senior Researcher) of the National Institute of Information and Communications Technology (NICT), Assistant Professor Yasuaki Monnai and his research group at the Keio University Faculty of Science and Technology, Department of Applied Physics and Physico-Informatics, developed a portable, high resolution radar system that uses terahertz waves as a probe. It is based on a novel waveguide architecture that integrates multifunction from beam steering to mixing in one package. As a proof of concept of practical applications, they demonstrated contactless heartbeat measurement by detecting a minute displacement of the surface of a person's chest through clothing.

This research was carried out as part of the Ministry of Internal Affairs and Communications Strategic Information and Communications R&D Promotion Programme (SCOPE) (165103002) and the JST Strategic Basic Research Program Sakigake (JPMJPR18J9), and the outcomes were published in the British scientific journal Nature Electronics on January 27, 2020 (UK time).

1. Main points of research

- The use of terahertz waves for radar enables higher resolution than conventional radio waves such as millimeter waves, and higher transmissivity than light.
- The lack of low-loss materials suitable for manufacturing phase shifters and circulators has prevented integrating radar systems in the terahertz range.
- By redesigning the waveguide structure and the frequency sweep scheme, terahertz radar was built without using phase shifters and circulators.
- As a proof of concept of practical applications, contactless heartbeat measurement by detecting a minute displacement of the surface of a person's chest through clothing was demonstrated.

2. Background of research

Recently, the use of millimeter-wave radar is entering a period of widespread adoption especially for automotive applications. In general, the distance and angular resolutions of radar are limited by the frequency bandwidth and wavelength, respectively. Therefore, by using terahertz waves, which have higher frequencies and shorter wavelengths than millimeter waves, radar systems with a smaller footprint and higher resolution could be realized. Meanwhile, the attenuation due to the wave diffraction increases rapidly as the wavelengths become shorter. To compensate for the attenuation, transmitting waves by forming directional beams becomes important. However, despite the advancement of today's semiconductor technology enabling terahertz oscillators, multipliers, and receivers of practical use, the lack of low-loss materials suitable for producing terahertz phase shifters for beam steering and circulators for input/output isolation prevents integrating radar systems in the terahertz range.

3. Summary and results

In this study, the research group proposed a multifunctional waveguide to integrate a terahertz radar system in one package. It combines two symmetries; the one in the excited mode from the center-fed waveguide and the one in the directional coupling of the leaky-wave, demonstrating beam steering and mixing simultaneously without using phase shifters and circulators. The group also developed a method for extracting the direction, distance, and speed of a target by processing the data acquired through frequency sweeping. The result paves a way to realizing integrated terahertz radar systems, attaining a significantly smaller footprint and higher resolution than the millimeter-wave radar, which has been adopted especially in automotive applications in recent years rapidly. As a proof of concept of practical applications of terahertz radar, the research group demonstrated contactless heartbeat measurement by detecting a minute displacement of the surface of a person's chest through clothing. The outcome opens up new applications possibilities, for example, easy and quick health checks while reducing hygiene and privacy concerns.

In this research, Keio University was in charge of conceiving the research, designing and manufacturing the system, performing experiments and analyzing the data, while the National Institute of Information and Communications Technology (NICT) provided experimentation facilities (Advanced ICT Device Lab) and was in charge of waveguide characterization based on experimental techniques specific to the terahertz range.

4. Future developments

This research established a concrete path to realizing terahertz radar with a significantly smaller footprint and higher resolution than millimeter-wave radar. The capability of measuring a minute displacement even through opaque medium opens up new applications possibilities including easy and quick health checks while reducing hygiene and privacy concerns. For such a goal, research and development focusing more on software will be important to filter disturbance caused by wave reflections from clothing and irrelevant body motions. By analyzing a large number of data sets, it will also become possible to detect physical and mental health conditions.

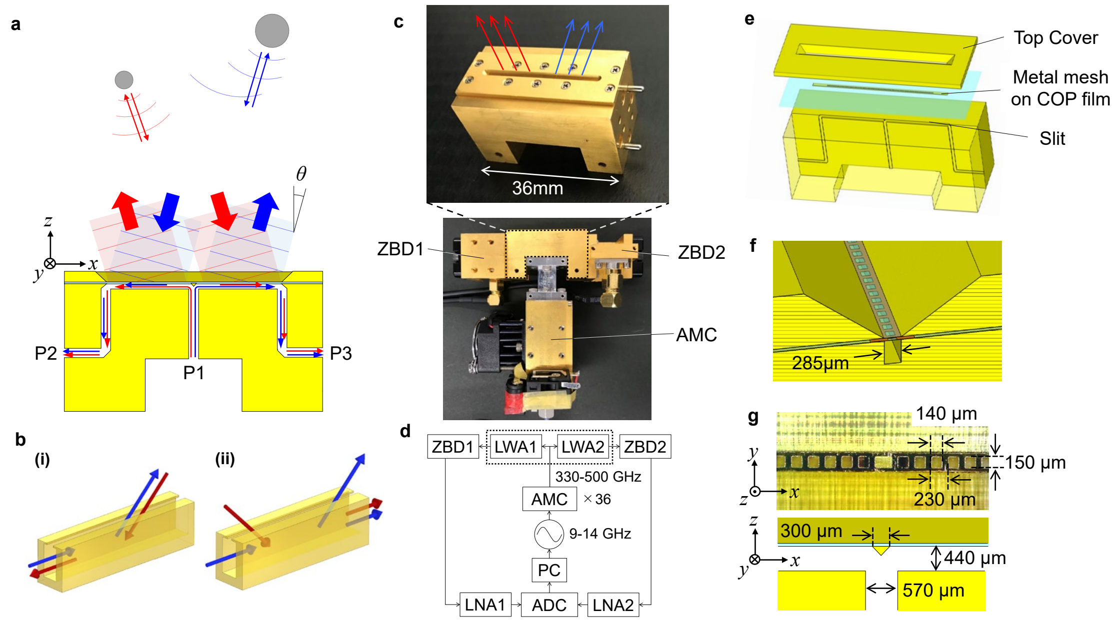

Figure 1: Structure of the proposed terahertz wave radar. (For details, see figures 1 and 2 in the paper.)

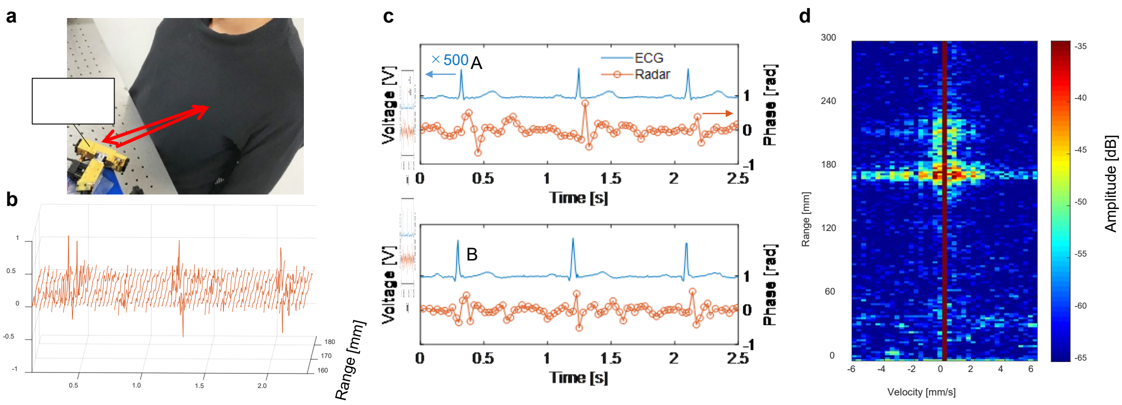

Figure 2: Clothing transmittance remote heartbeat measurement experiment. The phase difference and time-of-flight of reflected waves associated with the heartbeat are repeatedly measured and displayed as a time series signal. (For details, see figure 6 in the paper.)

＜Details of original paper＞
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