§5. Development of Microwave Computed Tomography (MWCT)

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Computed Tomography (CT) has made remarkable success not only in the medical diagnostics but in the plasma diagnostics. So far, CT using rays like the X-ray CT have been well established. Recently, CTs using waves are being intensively investigated as an interesting academic subject and for useful applications. Last 25 years, The Microwave Computed Tomography (MWCT) has been developed for the breast cancer diagnostics by many researchers. However, no MWCT device is commercially available. Usually a Vector Network Analyzer (VNA) is used as a microwave measurement system in MWCT. In the MWCT device, many sensors and measurement systems are employed but VNA is very expensive. In Nagasaki University, Takenaka has been developing MWCT method named Forward-Backward Time-Stepping (FBTS) method[1]. In Large Helical Device (LHD), Microwave Imaging Reflectometry (MIR) has been intensively developed[2]. The measurement system in MIR can be applied to MWCT. We have started the MWCT collaboration.

The cross-talk and the interference among neighboring antenna are critical issues in the imaging device. In LHD, we have developed Horn-antenna Mixer Array (HMA) to solve this problem. However, horn antenna is too big for MWCT, as the microwave wavelength for MWCT is 5 ~ 30 cm, and the horn size is bigger than the wavelength. We have developed Dielectric Laminated Dipole Antenna (DLDA) for MWCT. In this antenna, a dipole antenna layer is laminated by dielectric plates with shield. The shield works as a waveguide, and the signal reaches to the dipole as an evanescent wave. In a newly developed antenna, a 0.127 mm thick printed circuit board with dipole antenna and electronics is laminated by a pair of 3 mm thick FRP plates. The dipole in the receiver is 2 mm behind the shield, while that in the transmitter is 2 mm forward from the shield.

In our MWCT experiment, the frequency scan (1 – 7 GHz) and the illumination antenna scan will be performed, and the phase and amplitude of the scattered wave are simultaneously sampled. Schematic diagram of the MWCT system is shown in Fig. 1. Our MWCT system has two computer controlled synthesizers for the illumination wave (RF) and for the local oscillation wave (LO). Frequencies of two oscillators are scanned with the fixed frequency difference (110 MHz). As the 10 MHz clock is common in the synthesizers, waves are synchronized and the phase difference looks negligible. In order to illuminate the object from a single antenna at the particular time, the connection of the illumination wave to the antenna is changed by using a mechanical RF switch. Other electronics such as 110 MHz IF amplifiers, power detectors, IQ demodulators for the phase detection and digitizers are those of the LHD MIR system. The object is supposed to be breast cancer. The MWCT sensor head has a hemisphere enclosure in order to enclose woman's breast. In our experiment, the object is a hemisphere phantom. Since the fat has similar refractive index of FRP, enclosure is made of FRP in order to reduce reflections.

In the test, the length of dipole is 19 mm. The frequency response is flat in the region between 0.8 GHz and 6 GHz. This result is useful to design the sensor head.

1) J. E. Johnson, T. Takenaka et al: IEEE trans. Bio. Eng., **56**, 2232 (2009).
2) Nagayama, Y. et al: Rev. Sci. Instrum. **83**, 10E305 (2012).

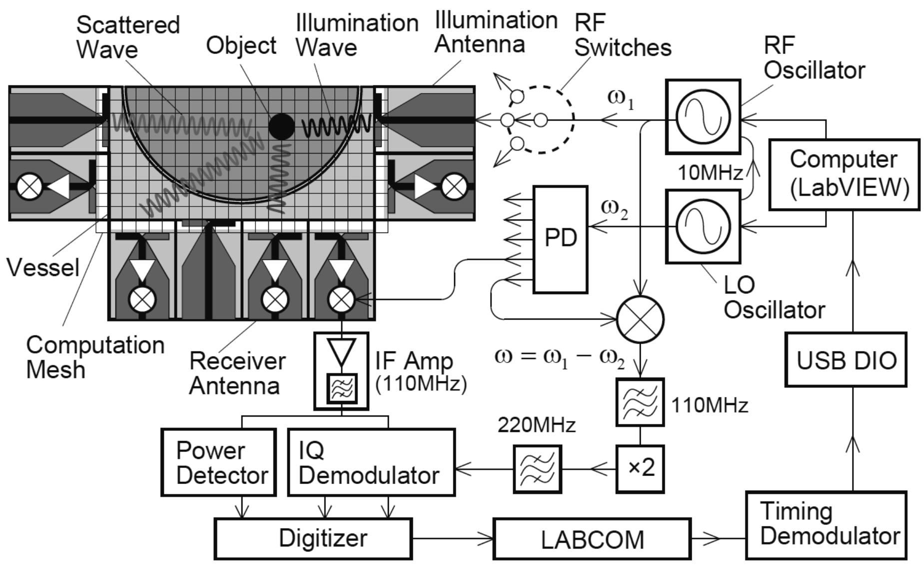

Fig. 1 Schematic diagram of microwave computed tomography (MWCT) system.