§5. Development of Dielectric Laminated Dipole Antenna (DLDA) for Micro-Wave Computer Tomography (MWCT)

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Computer Tomography (CT) has made remarkable success not only in the medical diagnostics but in the plasma diagnostics[1]. So far, CT using rays like the X-ray CT have been established. Recently, CTs using waves have been being intensively investigated. For example Seismic Tomography makes an image of the cross section of the earth using seismic waves generated by earthquakes. The Micro-Wave Computer Tomography (MWCT), which is a CT using microwaves, has an advantage that this enables a table top experiment of CT using waves. Last 25 years, MWCT has been developed for the breast cancer diagnostics by many researchers[2]. 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 Large Helical Device (LHD), Microwave Imaging Reflectometry (MIR) has been intensively developed [3]. The measurement system in MIR can be applied to MWCT. We have been collaborating with Prof. Takenaka in Nagasaki University for MWCT.

Another issue of MWCT is antenna array. The cross-talk and the interference among neighboring antenna are critical issues in the imaging device. In LHD, we have developed HMA with horn antennas 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. In the present work, we have developed Dielectric Laminated Dipole Antenna (DLDA) for MWCT. In this antenna, a dipole antenna layer is laminated by the dielectric plate and shield, as shown in Fig.1. In dielectrics, the wavelength is shortened, and the cutoff frequency is reduced as shown in Fig.2.

In order to solve the problem of the cross-talk, the DLDA is covered by the aluminum shield. The shield works as a waveguide, but the cutoff frequency is lower than the measured frequency. In this situation, evanescent wave propagates in the waveguide. Therefore, the cross-talk is reduced, but the antenna is still sensitive. Figure 3 shows the ratio of the response and the cross-talk in DLDA with shield as a function of distance (p) between the shield and the dipole. At p=2 mm, the antenna is sensitive but the cross-talk is significantly reduced.

DLDA may be useful to MWCT with following reasons: Many antennas can be installed in the limited space, as dipole antenna is so thin. The measurement area should be rectangular and the antenna should be a straight line or rectangular in order to simplify the FDTD calculation in MWCT.

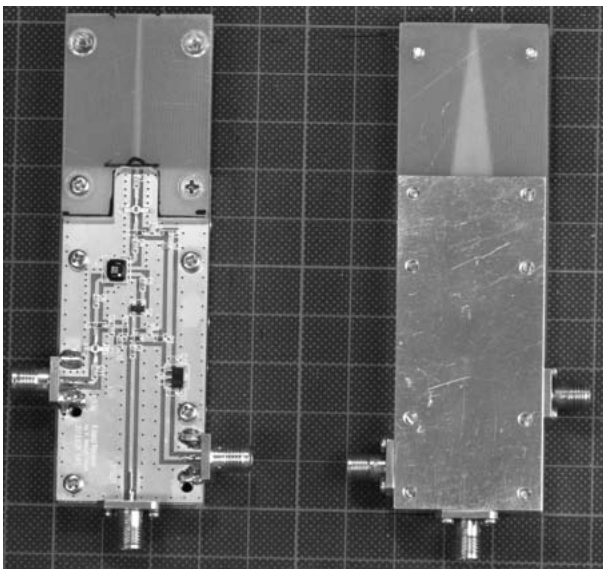

Fig. 1 Dielectric Laminated Dipole Antenna (DLDA).

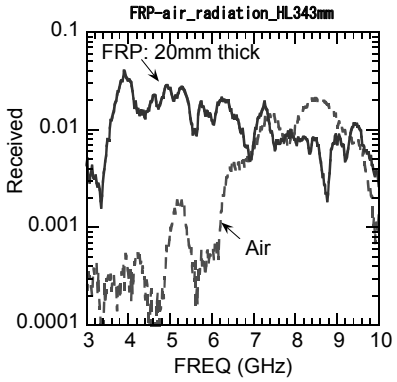

Fig.2 Frequency response of dipole antenna with/without the dielectric lamination.

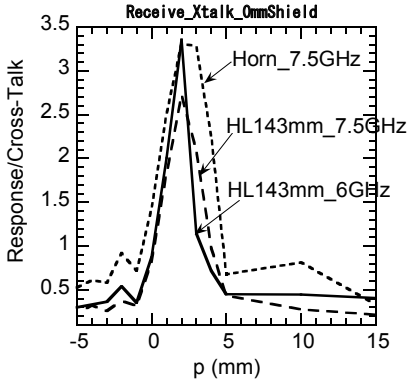

Fig. 3 Ratio of the response and the cross-talk in DLDA with shield as a function of distance (p) between the shield and the dipole.

1) Y. Nagayama: Rev. Sci. Instrum. 65, 3415 (1994).
2) Johnson, J.E., et al: IEEE Trans. Bio. Eng. **56**, 2232 (2009).
3) Nagayama, Y. et al: Rev. Sci. Instrum. **83**, 10E305 (2012).