§5. Development of Microwave Computed Tomography (MWCT) Mammography

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The X-ray Computed Tomography (CT) has made remarkable success not only in the medical diagnostics but also in the plasma diagnostics. Recently, CTs using waves, such as the Microwave Computed Tomography (MWCT), are being intensively investigated as interesting academic subject for useful applications. It is expected that the MWCT mammography provides one of powerful breast cancer diagnostics without pain or X-ray radiation exposure to young women. Last 25 years, a Vector Network Analyzer (VNA) has been used as a microwave measurement system in MWCT. Since VNA is so expensive that the MWCT device cannot be commercially available. We have developed the Microwave Imaging Reflectometry (MIR) in LHD[1]. It is supposed that the Forward-Backward Time-Stepping (FBTS) method[2] provides 3D distributions of conductivity and permittivity, which are different among cancer and other tissues.

We have developed Dielectric Laminated Dipole Antenna with Shield (DiLDAS) for MWCT. In Fig. 1, the DiLDAS transmitter and the receiver are illustrated. The receiver has the dipole 2 mm behind the shield and an RF amplifier, a double-balanced mixer, and an IF amplifier. Figure 2 shows the sensor head of the MWCT mammography. The breast is surrounded by the FRP vessel in order to prevent the reflection of microwave on the breast skin, as the permittivity of FRP is the same as the fat tissue of the breast. In the MWCT sensor head, 66 receivers and 30 transmitters are attached to the FRP vessel.

Figure 3 shows the observed power, I and Q signals in the opposite side of the transmitter. The target is a FRP block. It is surprizing that the power of perpendicular polarization is comparable to the parallel polarization. The power signal of the parallel polarization indicates the frequency response of DiLDAS. I and Q signal correspond to sinϕ and cosϕ, respectively. Here ϕ is the phase. In this case, $\phi=2\pi l/\lambda=\omega l/c$, where l is the length of target block, λ is the wavelength, ω is the angular frequency, and c is the light velocity. So the ϕ should increase as the ω increases as seen in the case of higher frequency. In the case of lower frequency than 2.3GHz, the ϕ is not well behaved. The MWCT system may need further improvements.

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

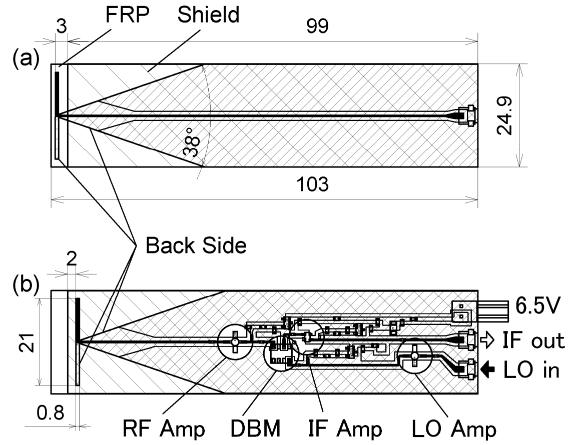

Fig.1 DiLDAS. (a) Transmitter, (b) Receiver.

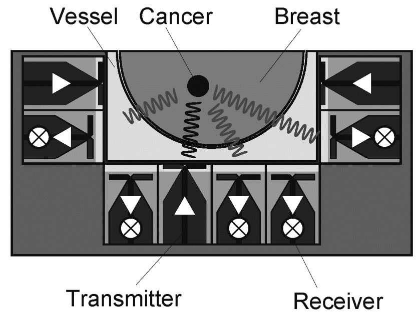

Fig.2 Sensor head of the MWCT mammography.

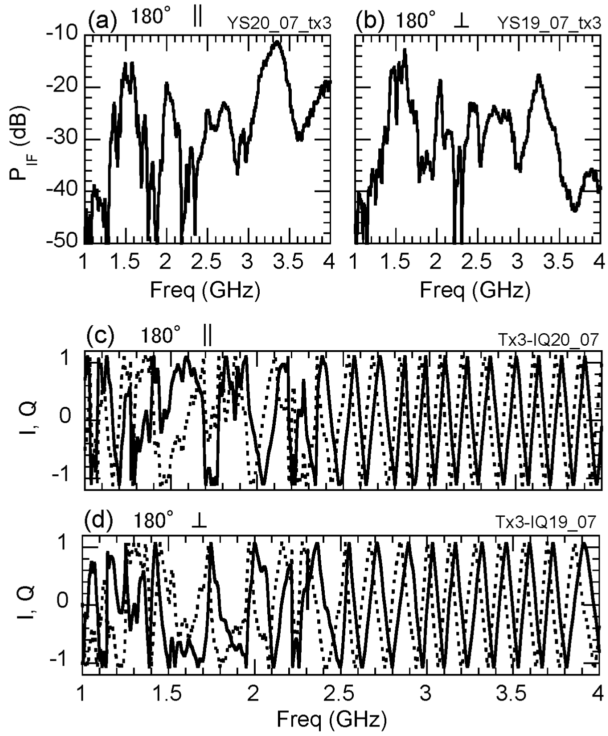

Fig.3 Observed power, I (broken line) and Q (solid line) of the microwave in the opposite side of the transmitter, of which polarization is vertical, in the case that the target is a FRP block.