§17. Development of High Resolution Microwave Imaging System for Plasma and Dielectric Object Observations

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The microwave imaging reflectometer (MIR) measurement system[1] is acquiring valuable data on LHD plasma with well-designed systems of high spatial-temporal resolution antenna array. Meanwhile, on the basis of experiences that we got through construction of these systems, we built a new diffraction microwave imaging system [2, 3] for the purpose of breast cancer diagnostics. This imaging system is expected to have a capability of getting information on the shapes of tumors that are less than 5 mm in diameter at the early stage of cancer. The system consists of two subsystems, a pulsed radar and a diffraction CT subsystems. The pulsed radar subsystem first detects the location of the tumors. The following diffraction CT subsystem reconstructs the detailed shape of the tumors.

Development of the microwave imaging system resulted two main progresses: (1) the diffraction CT subsystem has been improved to measure diffraction wave with enough spatial resolution for imaging, (2) and type of antenna of the pulsed radar subsystem is considered and designed to satisfy multiple channel array configuration.

The diffraction CT subsystem have been enabled to measure diffracting microwaves automatically at any couple of a transmitting and a receiving location, among 3,600 transmitting and 2,400 receiving position on a circle that surrounds the object. The spatial resolution is considered to be enough to reconstruct the object image by using Extended Born Approximation with MQLA[3]. Test measurement results of the CT subsystem showed good measurement performance for reflective and dielectric phantoms (Fig. 1). In the tests, the phantoms were illuminated with 10GHz planer incident wave and a line antenna received its reflected or diffracted waves. Receiving phases showed good angler symmetry for all objects. The receiving powers showed good reflective and diffractive characteristics respectively.

Antennae of the pulsed radar subsystem have been designed as lamination dielectric dipole type, by considering the two main requirements: small size as possible, and computational convenience of CT. The designed antenna is thinner than the operation wavelength, and has good low frequency receiving performance.

The MIR system has been tested for switching to the O-mode measurement. The O-mode measurement enables to observe fluctuations of plasma density on reflection surface, which could not be observed by conventional X-mode measurement. Technical hurdles in case of switching MIR to O-mode have been considered. Laboratory test results of O-mode MIR agreed well with the computational simulation (Fig. 2). By reflecting the above tests, the MIR system had rebuilt to O-mode and measured data at 17th LHD experimental campaign.

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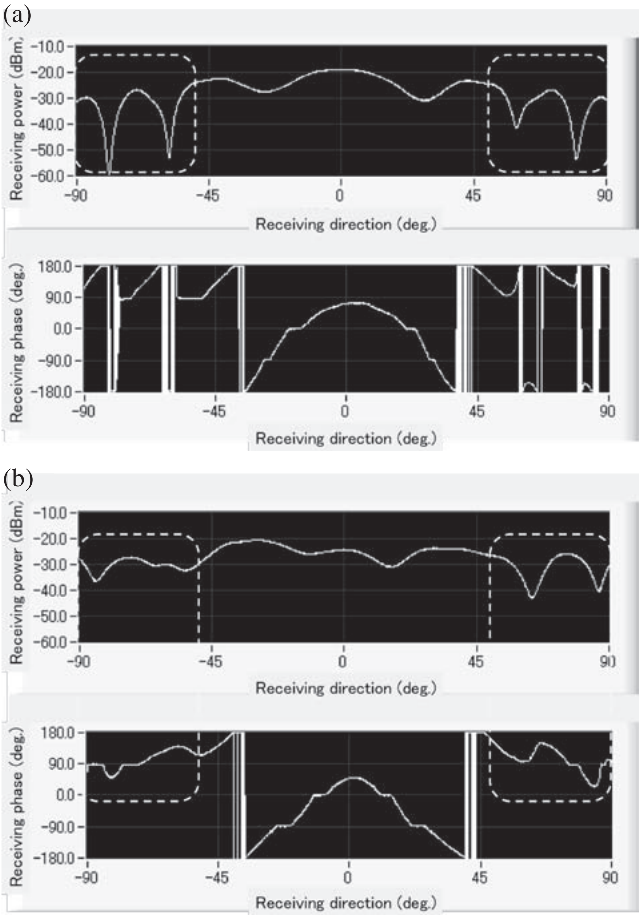

Fig. 1. Test measurements of the diffraction CT subsystem with 10GHz plane wave: (a) for a metal pillar phantom, (b) for an acryl pillar phantom.

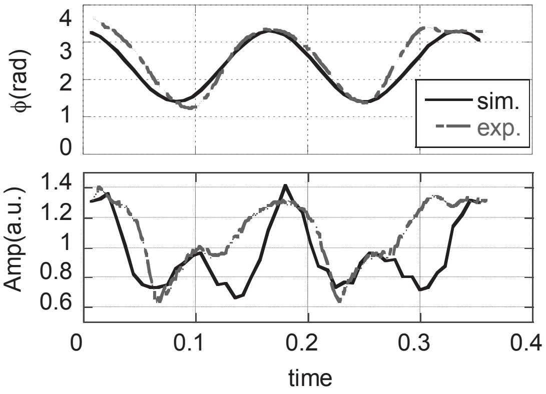

Fig. 2. Experimental O-mode MIR measurement: laboratory test (dashed line) and computational simulation (solid line).

1) Nagayama, Y. et al.: Rev. Sci. Instr., 83, p.10E305-1-10E305-6 (2012).
2) Yamaguchi, S. et al.: Ann. Rep. NIFS 2013, p.180.
3) Teranishi, M. et al.: Ann. Rep. NIFS 2013, p.472.