Clinical Setup of Microwave Mammography

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Abstract

The microwave mammography for the clinical test was experimentally manufactured. A phantom made of the diacetin solution was successfully imaged. It is confirmed through the clinical-evaluation that there was no problems in use of the sensor featured by the suction fixation.
Keywords : UWB radar, Mammography, Clinical Test

1. Introduction

The breast cancer has the highest attack-rate in the cancer of the woman and early detection and treatment are important. In Japan, cancer detection by the X-ray mammography is recommended about the woman after fortysomething. However, it has such problems as (1) X ray exposition, (2) fail of detection due to the low contrast, (3) pain at the inspection. Though an echography is known as the alternatives, the inspection quality depends on the skill of the inspector and the reproducibility of the result is poor. In literature [1], experiment results about the diagnosis percentage of the MRI, the X-ray mammography, and the echography in the high-risk group of the breast cancer are reported. The cancer patient is six in 171. In the MRI, six all were diagnosed as cancer but only two were diagnosed as cancer in the X-ray mammography and the echography. Therefore, the screening means which replaces X-ray mammography or an echography is demanded.

In recent years, the diagnosis image by a multistatic UWB radar is demonstrated and attracts attention [2][3]. The clinic equipment is featured by a conformal array of 31 wideband slots, DAS (Delay and Sum)/MAMI (Multistatic Adaptive Microwave Imaging) algorithm, and a calibration procedure by mechanical array rotating. The early stage cancer less than diameter of 1 cm can be detected. The author of literature [2][3] comments 2 problems for practical use of the equipment. One is to increase to 60 antennas to improve a resolution. Another is prevention of imaging mistake occurred by positional shift between the sensor (the cup) and the breast in inspection.

We have proposed the MS (Multistatic)-MIST(Microwave Imaging via Space Time) algorithm which extended MIST to the multistatic radar. It was confirmed by numerical simulation and experiments using the phantom that reconstruction image by MS-MIST is high resolution and low artifacts compared to MIST and calculation load is low compared to MAMI [4]. Also, we have proposed a conformal array that fixes a breast on the shape of the cup by suction [5]. In this article, we present an equipment for the clinical test, experiment using phantom, and the result of the preliminary clinical test.

2. Equipment

The schematic diagram of the developed microwave mammography is shown in figure 1. It is composed of sensor, aspirator, antenna switch, network analyzer, PC for control, and work station (WS) for the data processing. 18 stack patch antennas are embedded in the sensor. The pressure in the cup is decreased by the aspirator, the breast fixes to the inside of the sensor. The antenna switch chooses the 2 antenna connected with the input/output port of the network analyzer. A transmission-characteristic among the 2 antennas is measured by the vector network analyser. Then, the result is stored at the PC. The date is transferred to WS, and a diagnosis image is reconstructed by the MS-MIST algorithm and is displayed.

The details of the sensor are shown in figure 2. There are 2 sensor of the identical shape, in the left side, a contact sensor of transparent plastic to confirm the absorption condition to the sensor of the breast, in the right side, a sensor for imaging which material has the same electromagnetic parameter as the adipose tissue (εr=6.3, σ=0.15@6GHz). The 2 sensor can move in the horizontal and vertical directions. An antenna is designed so as to match over the bandwidth in the condition that it touches skin and is embedded in the cup.

In the clinical test, a degree-of-vacuum in the cup was measured while confirming an absorption condition using the contact sensor. Then, a breast was put in the sensor for imaging, the aspirator operates until the measured degree-of-vacuum. The absorption condition is also confirmed by measuring S_{11} for each of 18 antennas and approximately achieving the same response in the band.

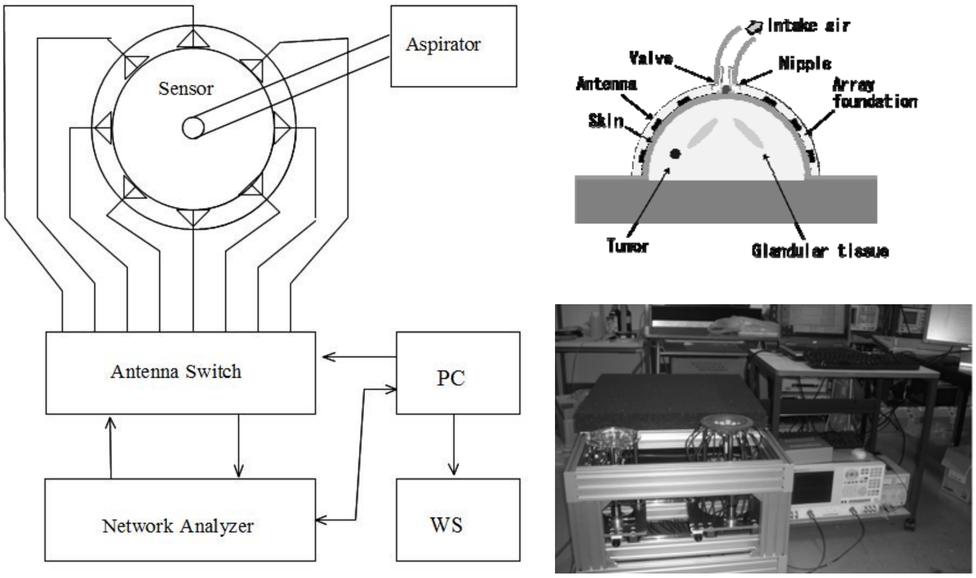


Fig.1 Trial Equipment

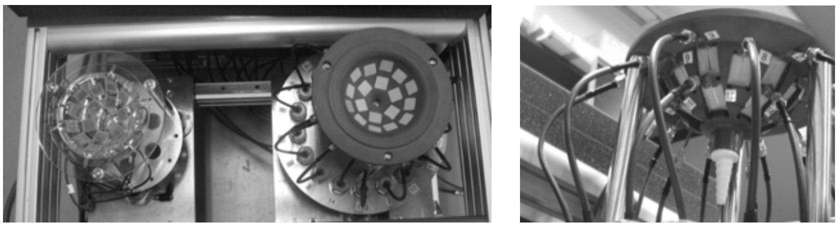


Fig.2 Sensor

3. Phantom Imaging

3.1 Phantom

The operation of this equipment was confirmed using a phantom. The photograph of phantom is shown in figure 3. Two pieces of different diacetin solution (ε_r=7, ε_r=48@6GHz) of the permittivity were used as the material of the phantom. Sensor for imaging was filled with the solution of ε_r=7 (the adipose tissue), the solution of ε_r=48 (tumor) was enclosed with the tube of 6×20 mm and was put in the imaging cup.

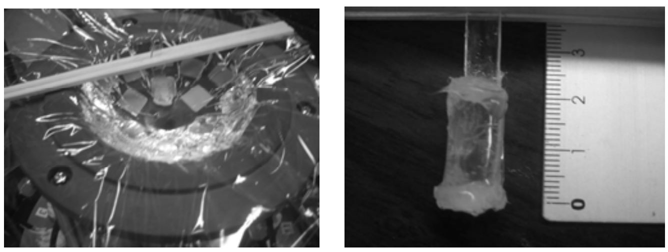
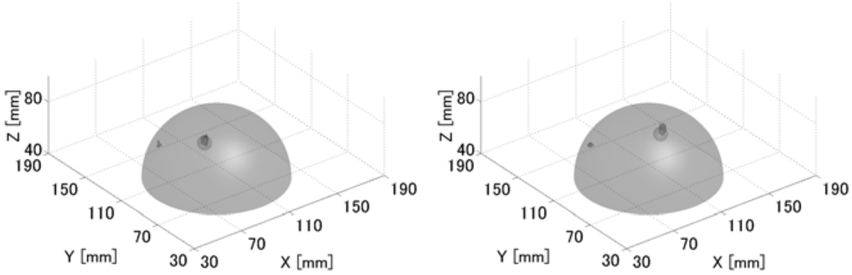


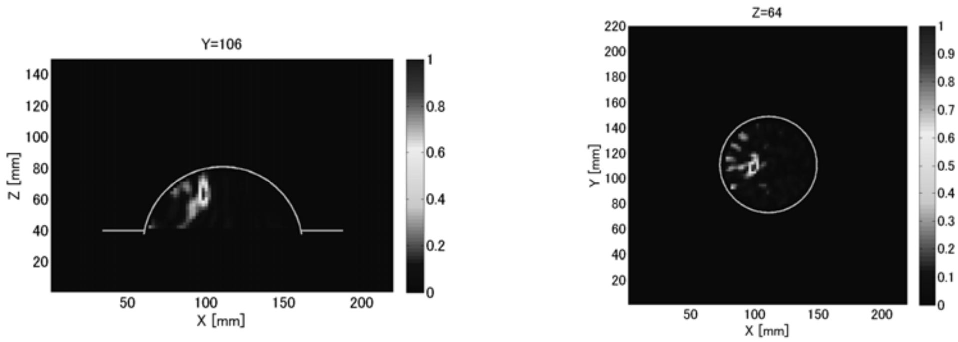
Fig.3 Phantom

3.2 Imaging Results



Position A Position B

Contour Plot



Cross section (Position A)

Fig.4 Imaging Results

Two positions of the tumour were set. Figure 4 is imaging result. In contour plot, the area where the scattered peak power declines by 20 % is shown. The position of the tumour and the strong electric power agree. For the reference, distribution of the scattered electric field in the cross section which cuts a tumor in position A is shown.

4. Preliminary Clinical Test

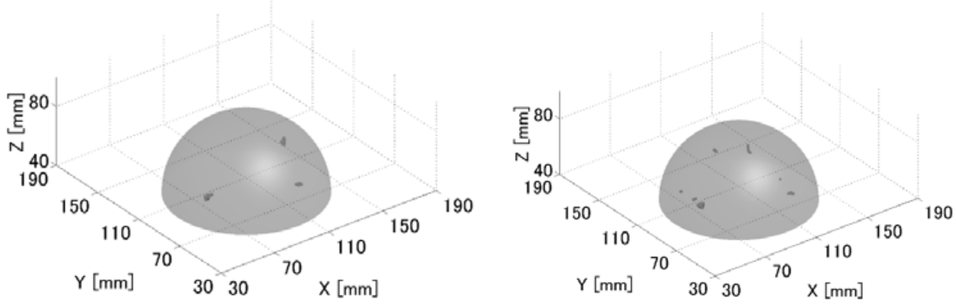
4.1 Absorption

Table 1 Results of Absorption

Name	degree-of-vacuum (MPa)	Absorption condition
A	0.018	good
B	0.02	good
C	0.02	good
D	—	Test is given up (too small breast)
E	(0.015)	No good(small breast)

The equipment is featured by the imaging sensor with suction fixation which makes the three-dimensional shape measurement of imaging part unnecessary and prevents imaging mistake. To confirm whether the suction fixation didn't give the person a pain and a fault, five healthy volunteers were recruited and a clinical test was carried out. An experimental result about the suction fixation is shown in table 1. The degree-of-vacuum was about 0.02 MPa. For person D, the breast was quite small for the cup and a test was given up. Also, for person E, suction was tried but even if it decompressed a degree-of-vacuum to 0.08 MPa which is the limit of the aspirator ability, the absorption condition wasn't complete. However, there were not a pain and a fault by the suction.

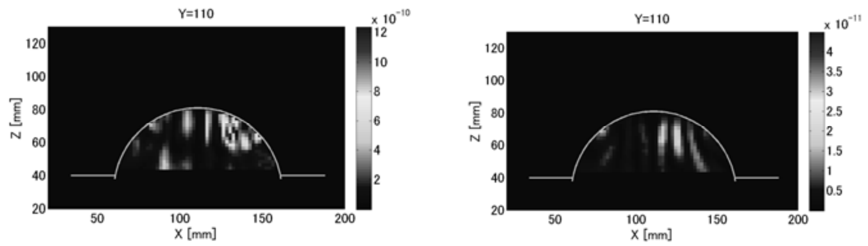
4.2 Imaging Results



Left Right

Fig.5 Imaging Results

This equipment is designed so as to detect a tumor of more than 15 mm diameter [6]. Therefore, the strong scattering isn't shown in healthy persons with no tumor as shown in figure 5. This phenomenon is also confirmed by numerical simulation in the conditions that there is cancer and is not as shown in figure 6.



cancer no cancer

Fig.6 Scattered power with cancer and with no cancer

5. Conclusions

The microwave mammography which is used for the clinical test was experimentally manufactured and a preliminary experiment was carried out. Tumor can be detected in phantom made of diacetin solution. Also, it is confirmed that there was no problems in use of the sensor featured by the suction fixation through the preliminary clinical-evaluation. In the future, we will experiment for the cancer patient.

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