Millimeter wave irradiation and invasion into living bodies using AR waveguide vent antennas and Gyrotron

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Abstract— **The microwave invasion into living bodies at a millimeter wave irradiation using gyrotron as the radiation power source is described. The irradiation antennas of the system consist of a Teflon rod dielectric antenna, and a Teflon sheet dielectric antenna set at 2.4 - 5.0 mm diameter catheter waveguide vent. Preliminary measurements on the denaturation distribution of irradiated caw livers suggest that they are suitable for common irradiation apparatus for living bodies in similar case as previous report. [1,2] The power absorption of a living body surface is large in these wavelength regions, because the reflections of the wave are well hold down (impedance-matching) by the anti-reflecting layers (ARL) of dielectrics. [3] We measured the power changing of millimeter wave with ARL antennas thickness by some TE modes using Gyrotrons. Transmission tests through catheter waveguides confirm the normal operation of the irradiation apparatus for living bodies.**

I. Introduction And Background

In the field of medical radiology, there is a growing interest in the possibility by the catheter irradiation of millimeter and submillimeter wave radiation. A novel system for applied medical studies, using one of gyrotrons developed at Fukui University (Gyrotron FU-IV)[4], has been designed in collaboration with Kagawa University. In the experiments, the irradiated region of the living body is decided by characteristics of irradiation antennas.

In order to obtain an appropriate irradiation tract, many shape antennas have been designed and tested as reported previously.

We showed characteristics of a waveguide vent antenna (WVA) with an anti-reflecting multi layer, which is located between a waveguide vent and a living body for direct coupling of the millimeter wave radiation [5].

At this time , we measured the power changing of millimeter wave with ARL antennas thickness by some TE modes using Gyrotrons.

II. RESULTS

The experimental setup used is shown in Fig. 1. The left-hand side of the figure shows the gyrotron oscillator and the right-hand side, the catheter radiation system. We used two types Gyrotrons. Gyrotron FUCW-I has been manufactured by GYCOM, Russia and set up at Fukui University in order to be used for applied science studies. And Gyrotron FUCW-IV has been manufactured by Fukui University. At the experiment level, Gyrotron FUCW-I is operated in CW regime on weak power (4 ~ 6 W at 5 mm waveguide vent) at $TE_{22.8}$ with frequency of 300 GHz. Gyrotron FUCW-IV is operated in CW (1 ~ 7 W at 5 mm waveguide vent) at $TE_{0.3}$ with frequency of 97 GHz or the pulsed oscillation at $TE_{0.3}$ with frequency of 210 GHz. The output power is transmitted by a circular waveguide whose diameter is 28 mm after through the water load. The catheter waveguid is a straight or bend copper waveguide with inner diameter of 5 mm. Irradiation antennas used are a circular WVA, made by Teflon sheet.

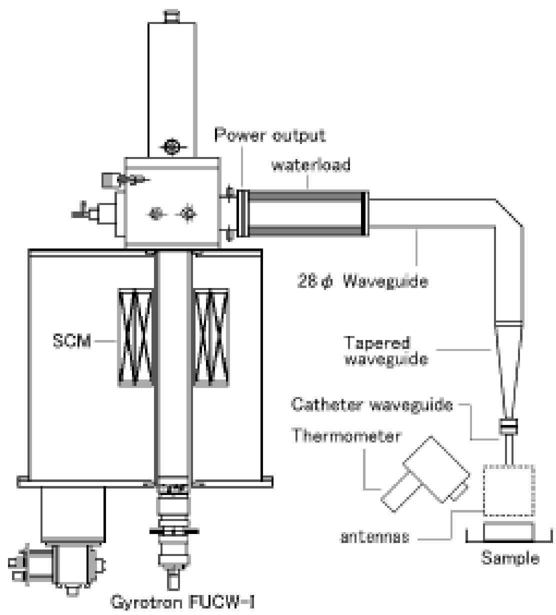

Fig.1 Schematic of Catheter irradiation apparatus using a Gyrotron FUCW-I (TE0.3 302GHz, ~100W)

The experimental antenna used in shown in Fig 2. This figure shows an irradiation antenna using anti-reflecting effect in the catheter irradiation system. The upper side of the figure connected to gyrotron oscillator. Gyrotron FUCW-I or Gyrotron FUCW-IV.

Exchanging the Teflon seats has changed the thickness of the dielectric substance. The upper part of the liquid is covered directly with thin seat made of Teflon. This device can fill the liquid so that the bubble should not enter. Stirrer is put in the liquid, and the liquid is always stirred on the magnetic stirrer.

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The change in the temperature by the stirrer is not admitted in this observation system.

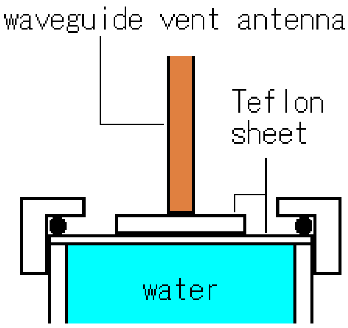

Fig.2 Waveguide vent antenna with anti-reflecting layer of Teflon sheet

We have examined so far, and the result in the effect of reinforcement by the low output is shown in Figure 3. These results were obtained using the Impatt oscillator at 90 GHz. Periodicity is seen from this figure with various samples. The cycle is decided by permittivity of Teflon (about 2.04).

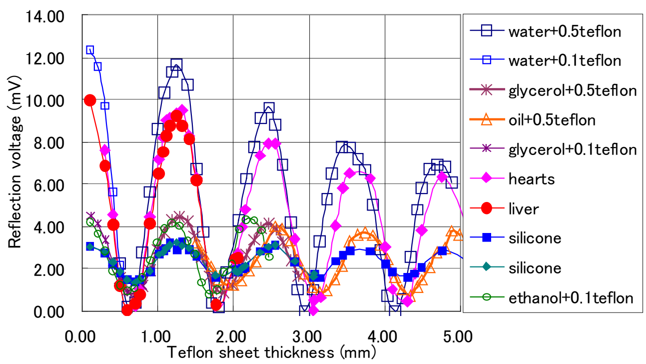

Fig.3 Transmitted power by water load apparatus using various thickness of Teflon sheet at AR antenna

At this time we measured the power of millimeter wave by some Te modes.That results shown in Fig 4. We guessed anti-reflecting effect is observed at high power irradiation using Gyrotrons.

It was weaker than the AR effect expected the measurement by using Gyrotron FU-CW-I at $TE_{22.8}$. We thought that some mode millimeter waves became cut off in the horn part because it considerably used the mode of higher-order by the experiment at this time, the modal transformation was generated, and this weakened the AR effect. To confirm this expectation, the mode was changed in addition by two frequencies and the temperature change was measured. The average was requested measuring it ten times because a minute output change of Gyrotrons had been seen. Because water always boiled soon in CW at 210 GHz, it measured by the pulsed oscillation that duty rate is 2%.

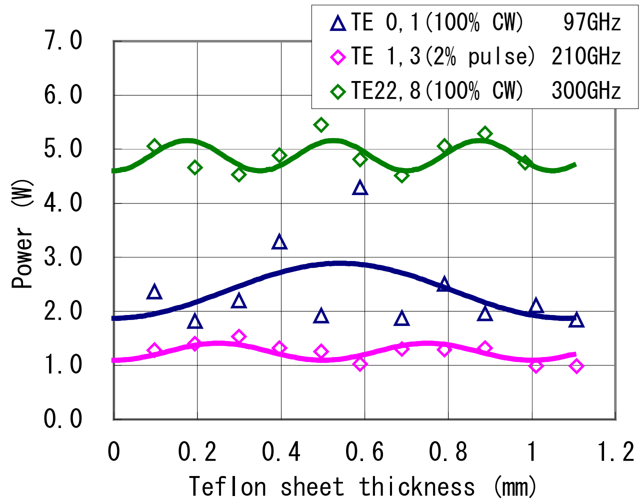

Fig.4 Transmitted power by water load apparatus using various thickness of Teflon sheet at AR antenna

These results were shown that the strong AR effect was seen at a more low-level mode when the output was made relative.

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