§6. Development of Micro-Wave TV Camera (MWTV)

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A new observation technology often leads new discovery in science. Imaging is very powerful observation technique. So far, the microwave imaging has been developed in the field of remote sensing. Recently, the microwave imaging in the near field has been investigated in the plasma physics[1-3]. In Large Helical Device (LHD), Microwave Imaging Reflectometry (MIR) has been intensively developed[2,3]. A key device of MIR is the microwave imaging device. Since many antennas are accumulated in the microwave imaging device, the cross-talk and the interference among neighboring antenna are critical issues in the imaging device. In LHD, the Horn-antenna Mixer Array (HMA) has been developed[2]. In this research, a microwave TV is developed using HMA.

In this Micro-Wave TV (MWTV) camera, a 256ch (16×16ch) HMA has been newly developed. In LHD, the signal outputs are SMA connectors. In the microwave TV, however, there is no space to install 256 SMA connectors. Therefore, D-shaped connectors for twisted flat cables are used. Since the frequency band width is limited in this cable, the intermediate frequency (IF) of output signal is 10.7 MHz. This frequency is limited due to the commercially available band pass filters (BFPs). This frequency is too low for MMIC in the HMA in LHD. We found the lower cutoff frequency of most MMIC is higher than 50 MHz. We tested many MMICs, and found few MMICs (NXP BGA2002, Maxim MAX2611) can work at 10.7 MHz. The cutoff frequency of these MMIC is 7 MHz. The output of the mixer (Skyworks DMK2790), which is installed inside the waveguide, is amplified by 60 dB by sing the 3-stage IF amplifier with 0.7 MHz ceramic filters (Murata SFECF10M7HA00-R0) with the bandwidth of 200 kHz.

The horn arrays were used to be made by the electrical discharge machining, and the surface of horn used to be rough. In this research, new technique using a tapered end mill is developed so that the horn arrays are made by the milling machine. The surface of horn becomes very smooth and the machining cost is reduced drastically.

The microwave source is made of a VCO (8 – 9 GHz), a crystal oscillator (1.78 MHz), an up-convertor and multipliers (6 times). These are employed in LHD. The up-convertor does not reject the low frequency image. The reason may be the 1.78 MHz is too low for the up-convertor. So, the frequency of the local oscillator (LO) is 48 – 54 GHz, and the frequency of illumination wave (RF) is LO frequency +/- 10.7 MHz. The power of both side bands of 10.7 MHz is similar.

Figure 1 shows the new HMA and an object that is a leaf of a rubber tree, and Fig. 2 shows a 50 GHz image of the object. Clear image is obtained, because crosstalk does not disturb the image detection.

We tried to inject LO with a beam splitter, but spurious microwave power could not be eliminated. We also tried to install new HMA in the old MIR optics, which was employed the TPE-RX experiment[4]. We found a beam splitter and optics make the TV camera system so big that the application may be very limited. This experiment suggests that the LO supply system should be improved significantly in order to establish the microwave TV camera. Actually a new idea of the LO supply system is under development. Imaging without optics is important issue and the synthesized imaging can be a solution[1].

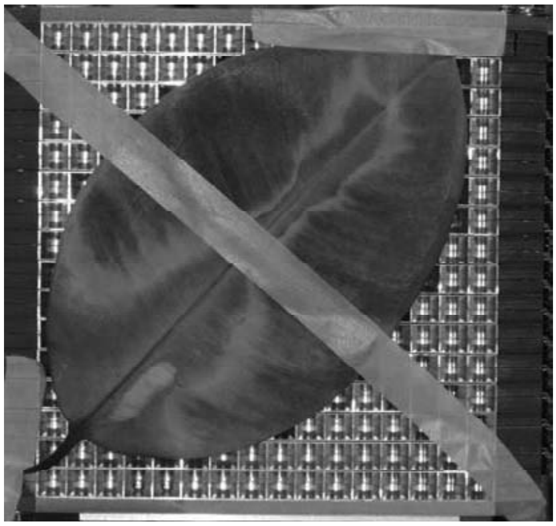

Fig. 1 256ch (16×16ch) HMA and object.

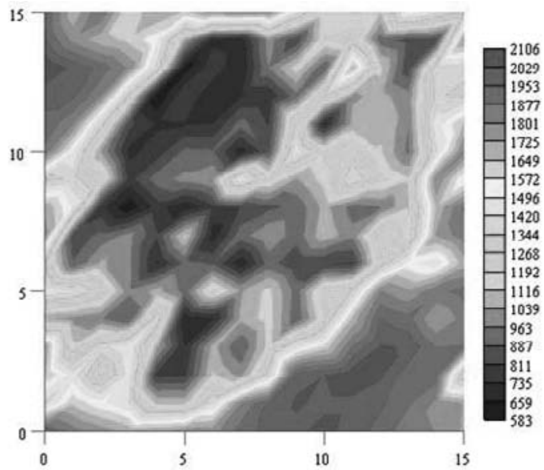

Fig. 2 50 GHz image of the object.

1) Shevchenko, V.F., et al: JINST **7**, 10016(2012).
2) Kuwahara, et al: J. Plasma Fusion Res. SERIES **9**, 125 (2010).
3) Nagayama, Y. et al: Rev. Sci. Instrum. **83**, 10E305 (2012).
4) Shi, Z.B. et al, Phys. Plasmas **18**, 102315 (2011).