§19. Development of Advanced Microwave Devices and Application to LHD Diagnostic Systems

Mase, A., Ito, N. (KASTEC, Kyushu Univ.),
Kogi, Y. (Fukuoka Inst. of Tech.),
Kuwahara, D. (Tokyo Univ. of Agriculture & Tech.),
Yamaguchi, S. (Kansai Univ.),
Kawahata, K., Tokuzawa, T., Nagayama, Y., Tanaka, K.

Microwave to millimeter-wave diagnostics have been well developed by the advancement of devices using integrated circuit and micro-fabrication technologies and of computer technologies. Microwave imaging is one of the attractive methods to visualize dynamic behavior of plasma fluctuations [1, 2]. The purpose of this research is to develop the components for these diagnostics, and apply the diagnostic systems to the LHD experiment.

In microwave/millimeter-wave diagnostic systems, such as, microwave imaging, a quasi-optical band stop filter (notch filter) is required to prevent spurious electron cyclotron heating power and thus to protect microwave/ millimeter-wave detectors from damage or saturation. The development of notch filters with good performance is one of the high-priority issues in the ITER microwave diagnostics. There are following requirements for the notch filter: i) it must cover the whole area of beam diameter to irradiate the detectors, ii) it should be relatively insensitive to the angle of incidence, iii) it is required to exhibit low loss in the pass frequency band in addition to large rejection at the notch frequency resulting in the requirement of high Q.

We have been studying quasioptical microwave filters (frequency selective surface-FSS) in collaboration with Davis Microwave Research Center (DMRC), UCD under the US-Japan Collaboration Program. This year we have designed and fabricated notch filters with notch frequency of 154 GHz and 170 GHz, since new gyrotrons with those frequencies are being operated in the LHD experiment. The filters are designed by using an electromagnetic field software, MW Studio (CST Co.) with the period moment method (PMM). The designed shape is the square loop structure, which is fabricated by the etching process.

The evaluation of the filters was performed at the UCD-DMRC by one of the group members. Figure 1 shows the outline of the measurement system. A network analyzer (Agilent N5247A) having the maximum operation frequency 325 GHz is utilized to measure the transmission coefficient (S_{21}) for 130-200 GHz. Teflon lens are applied to the transmitter and the receiver horns to focus the incident beam. The representative data of S_{21} versus frequency is shown in Fig. 2. It is seen that two filters (538A and 538 B) show the almost same performance. The notch frequency ~154 GHz is in good agreement with the designed value (theoretical calculation). The attenuation at the notch frequency was 30-35 dB in a single filter, however, it increases up to 45-50 dB when two sheets of filter are piled up in one. It is confirmed that the stack structure improves the attenuation.

In conclusion, the FSS notch filters with notch frequency of 154 GHz have been designed and fabricated for the application to the LHD microwave diagnostic systems. The characterization of the notch filters was performed by using a high-frequency network analyzer. The transmission characteristics (S21) was measured. The angle dependence of the filter is also verified. The improvement of the measurement system has been prepared for the improvement of the measurement accuracy. The notch filters of 170 GHz have also been fabricated for application to the KSTAR imaging system [3, 4].

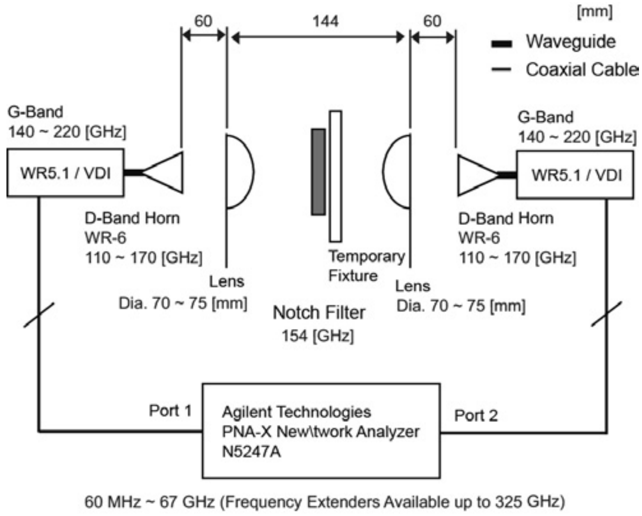

Fig. 1. Schematic of the FSS notch filter testing setup.

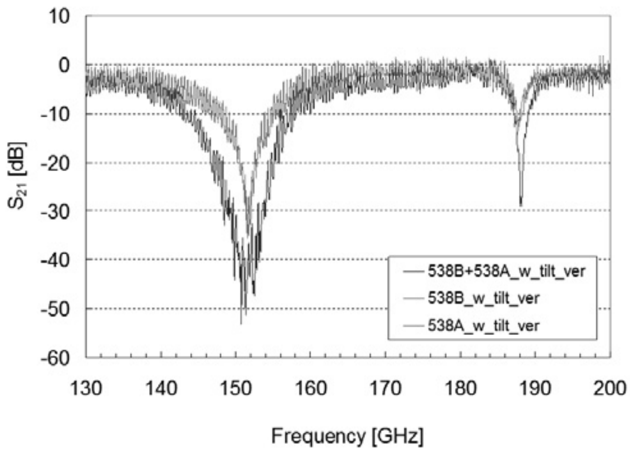

Fig. 2. Characterization of the notch filters.

[1] A. Mase *et al*., J. Instrum. **7**, 106506 (2012).
[2] Y. Nagayama *et al*., Rev. Sci. Instrum. **83**, 10E305 (2012).
[3] H. K. Park *et al*., 2013 KSTAR Conf., Buyeo (2013).
[4] G. S. Yun *et al*., 2013 KSTAR Conf., Buyeo (2013)..