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

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The diagnostic method using transmission, reflection, scattering, and radiation of electromagnetic waves has been well developed by the advancement of microwave to millimeter-wave components using integrated circuit and microfabrication technologies (MIC & MMIC) and of computer technologies [1, 2]. Imaging diagnostics is one of the methods to visualize dynamic behavior of plasma fluctuations [3]. The purpose of this research is to develop the components for these diagnostics, and to apply the diagnostic systems to the LHD experiment.

In a microwave imaging system, a quasi-optical band stop filter (notch filter) is required to prevent spurious electron cyclotron heating power and thus protect the receiving detectors from damage or saturation. The development of notch filters with good performance is one of the key issues in the ITER microwave diagnostics. There are several requirements for the notch filter: i) it must cover the whole area of the detector array, ii) it should be relatively insensitive to the angle of incidence, iii) it is required to exhibit low loss in the frequency region (60-90 GHz) in addition to large rejection at the notch frequency (77 GHz) resulting in a requirement for high Q. The notch filter was been designed with an electromagnetic field software, MW Studio (CST Co.), using the period moment method (PMM), and was fabricated by using electro-fine-forming technology (EF2) [2].

Figure 1 shows the measurement results of the fabricated filters. It is noted that the performance at the resonant frequency is insensitive to an incident angle. The rejection degree of 30 dB is obtained for 1 filter, however, it increases to 60 dB with piling 3 filters. The measured attenuation will be sufficient to protect the system from the ECRH interference.

The dichroic filter is utilized to separate the signals obtained from ECE imaging to those from imaging reflectometry and vice versa when both diagnostics are superimposed. It is simply a perforated aluminum plate with appropriate size of holes and thickness to attain the desired performance. In this report, the cutoff frequency of 200 GHz is chosen. The hole diameter is 0.88 mm and the distance between the holes is 1.32 mm. The number of hole is 9746 in the area of 50×387 mm, and the plate thickness is 6.35 mm. This dichroic filter is fabricated at the NIFS machine shop (Fabrication Technology Division). It is extremely difficult to drill the 0.88 mm holes on the plate of 6.35 mm thickness. We fabricate two 3.175 mm (half thickness) plates, and pile up together with carefully adjusting each hole position.

Figure 2 shows the measured performance together with the theoretical predictions [4]. The good agreement is obtained between the two. The measured attenuation of 35 dB at 196 GHz will be sufficient to separate two signals.

In conclusion, the frequency selective surface (FSS) notch filters and dichroic filters have been designed and fabricated. It is confirmed that the transmission characteristics, S_{21}, of the filters is sufficient to apply to the LHD diagnostic systems.

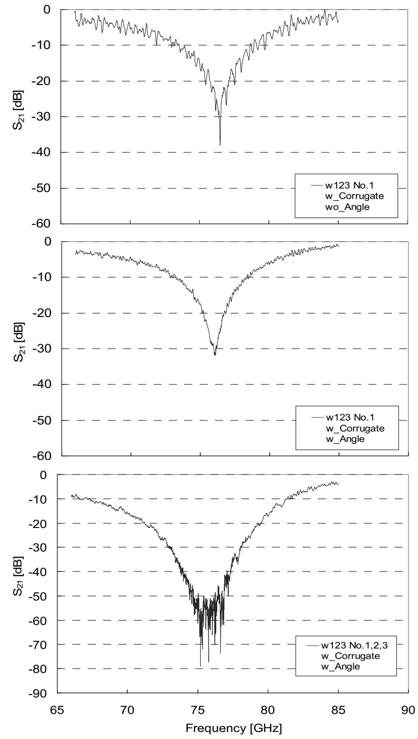

Fig. 1. Characterization of notch filters: a) 1 filter (normal incidence), b) 1 filter (oblique incidence, c) piling of 3 filters.

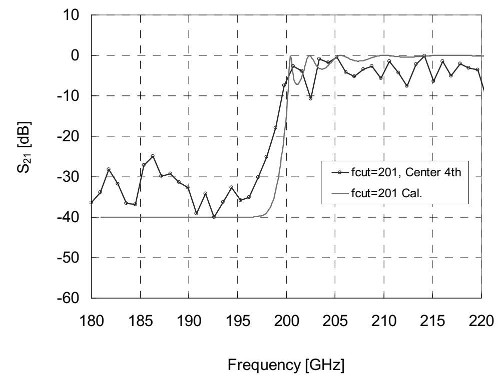

Fig. 2. Characterization of dichroic filter.

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