§10. Conceptual Investigation and Component Testing of Polarimetric and Interferometric Systems for High Density and Large Nuclear Fusion Devices

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On ITER and the DEMO reactors which are characterized by large device scale and harsh nuclear environment, it is well understood that maintenance of diagnostic systems is not easily implemented. In this collaborative study, conceptual investigation and component testing of highly reliable laser polarimetry and interferometry for diagnostics of current density and electron density profiles of steady state nuclear fusion plasmas have been conducted, especially for the fields of design of laser system, measurement of reflectivity of a tungsten mirror which was made by plasma spray process, measurement of reflectivity and transmission properties of a high-resistivity silicon beam splitter, accuracy evaluation of two polarimetric measurement techniques utilizing a rotating wave plate and photo-elastic modulators. Components and facilities which were developed and prepared by JAEA, NIFS and Chubu Univ. have been effectively combined and utilized for the testing. Consequently, several new data and important knowledge for future investigation have been obtained successfully.

1. Investigation of design of laser system

Specifications of the far-infrared (FIR) laser system (e.g. output power, laser frequency stability) which are required for ITER have been investigated and future strategy of its development has been discussed.

2. Measurement of reflectivity of a tungsten mirror

To use tungsten is desirable for fabrication of in-vessel plasma facing mirrors since its low sputtering yield against the exposure for plasma incident particles to the mirror surface. Since machining of tungsten is very hard, creation of tungsten layer on the stainless substrate by the plasma spray process combined with surface mirror polishing was considered. Reflectivity in FIR region of a tungsten test mirror which was made by the above method has been measured for the first time by the use of FIR laser systems. Consequently, it has been confirmed that the tungsten test mirror has almost same reflectivity with that of mono-crystalline tungsten mirror.

3. Measurement of reflectivity and transmission properties of a high-resistivity silicon beam splitter

It is desirable to use COTS (Commercial Off-The-Shelf) products from the view point of lower development cost, shorter development period and easier maintenance of the diagnostic systems. For this purpose, reflectivity and transmission properties of a COTS product of high-resistivity silicon beam splitter for FIR application at wavelength of 119 μm, which is the reference wavelength of the probing laser of ITER Poloidal Polarimeter system, have been measured. As the results, essential data for design of optical system of FIR polarimetry and interferometry have been obtained.

4. Accuracy evaluation of a polarimetric measurement technique utilizing a rotating wave plate

A polarimetric measurement technique utilizing a rotating wave plate was adopted as the reference design for ITER Poloidal Polarimeter system. Accuracy evaluation test of such polarimeter for the FIR region has been carried out for the first time. The result has shown that target accuracy of a polarization angle (0.1 degree) can not be achieved by the current polarimeter. Since the reason for above problem has been understood, to achieve the target accuracy is promising in future after improvement of the polarimeter.

5. Accuracy evaluation of a polarimetric measurement technique utilizing photo-elastic modulators

A polarimetric measurement technique utilizing photo-elastic modulators is attractive since its easy installation and high angle / temporal resolutions. However, there is no COTS product of a photo-elastic modulator for wavelength of 119 μm. Since COTS product of a photo-elastic modulator for wavelength of 57 μm exists and it can be used to modulate the polarization property of 119 μm laser light in principle, accuracy evaluation test at 119 μm by application of a polarimeter with the photo-elastic modulators for wavelength of 57 μm has been carried out for the first time. As the results, it has been confirmed that sufficient modulation of 119 μm lase light can be obtained by modulators for 57 μm. Simultaneously, it has been clarified that the performance of anti-reflection coating of the modulators is not enough for the accurate measurement. These results have provided important basis for future direction of the development.