## §61. Development of Fiber-Optic Diagnostic on Vacuum Vessel Current of QUEST

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We are developing a polarimeter for the measurements of the toroidal currents on the vacuum vessel of QUEST. We will wind a poloidal loop of an optical fiber around the vacuum vessel as shown in Fig. 1 and measure the toroidal current in the same way as an optical current transformer. The loop must go through the torus center since there is no room between the center stack (CS) coil and the vacuum vessel so that the vacuum-vessel current must be evaluated under significant background signals up to 1.73 MA·turns by the CS–coil current. The Ampere-turns of the CS-coil current will be separately measured with a coil of optical fiber wound at the coil feeder and it will be numerically subtracted from the total Ampere-turns measured with the loop. In order to measure the vacuum current in accuracy of less than 1 kA, the required measurement accuracy is not less than three digits.

The Verdet constant of a flint glass fiber is about six times that of a silica glass fiber and the photo elastic constant of the former is much smaller than that of the latter, which enable us to wind the optical fiver with smaller bending radii. We tested a single-mode flint glass fiber for 1550 nm with a SLD (super-luminescent diode) of wavelength 1545 nm as light source. We adopted the dual photo elastic modulator (HINS Instruments, Inc., PEM-90 I/FS50 and II/FS42) polarimetry. The modulator axes of the two modulators are at 45 degrees with the polarizer passing axis at 22.5 degrees with each modulator. The second harmonic amplitudes of the photodiode output are measured with two lock-in amplifiers. An example result of bench testing of current measurements of a solenoid is shown in Fig. 2. The standard deviation of the measured polarization angle was confirmed to be well below a required accuracy of the Faraday rotation angle measurement of 0.37 degrees.

The QUEST tokamak is normally operated with bake-out temperature of the vaccum vessel at about 100°C. We measured the temperature distribution along the planned route of the loop with thermocouples and found that the integrity of the optical fiber is preserved since the highest temperature does not exceed 50°C. The temperature dependence of the Verdet constant of the flint glass fiber, however, is slightly stronger than that of silica fibers. Figure 3 shows a preliminary evaluation result of the Verdet constant by varying the room temperature. The weak dependence may become a problem to assure the applicability of Ampere's theorem to measure the current. The averaged value agrees with the catalog value when the dependence of inversely proportional to the square of the wavelength is taken into account.

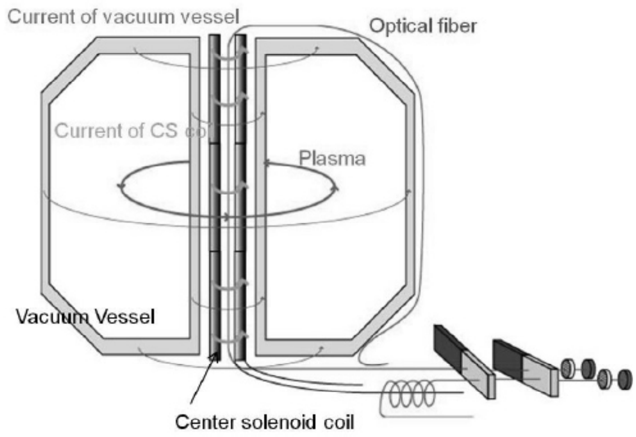


Fig. 1 Schematic illustration of the optical fiber poloidally wound around the vacuum vessel of QUEST. A coil of optical fiber is used to numerically cancel the Ampere-turns of the CS-coil current. Two plates at the bottom right indicate PEMs.

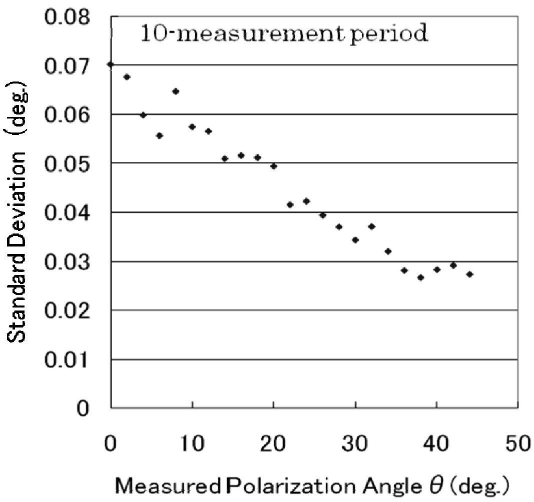


Fig. 2 Polarization angle dependence of the measurement errors with the dual PEM polarimeter.

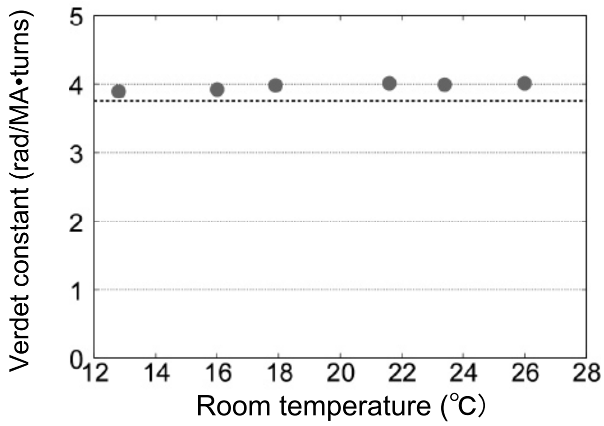


Fig. 3 The Verdet constant of the single-mode flint glass fiber evaluated as a function of the room temperature. The horizontal line indicates the catalog value at 1550 nm.