§17. Precise Wavelength Determination of 48-µm CH_3OD Laser Line Using Refractive Index Measurement Method of Optical Etalon

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We are developing a two color interferometer/polarimeter using 48- and 57-µm CH_3OD lasers pumped by cw 9R(8) CO_2 laser for LHD and ITER[1,2]. In this system, many optical windows and beam splitters with various transmission and reflection ratio are used. We selected a high resistive silicon etalon (2.8kΩ-cm) as the optical elements, because the absorption is low in the short FIR-wavelength region. To design the optical elements with desired transmission/ reflection within a few percent, the wavelength, the refractive index, and the thickness of the accuracy of five significant figures are required. The precise wavelength of the 57-µm laser (57.1511 µm) has been already reported by absolute frequency measurement, while the wavelength of the 48-µm laser (47.65 ± 0.06 µm) has been proven only at the precision of four figures. So, we have determined the precise wavelength of the 48-µm laser line using a optical refractive index measurement method.

The refractive index are obtained from the measurement of transmitted light by multiple reflection of a rotating etalon. The schematic diagram of the experimental setup is shown in Fig. 1. We used four silicon etalons with different thickness, which were 1.5441, 2.1704, 2.1708, and 2.1718 mm with the uncertainty in thickness of ±0.2 µm. The refractive indices of the silicon etalons for 57.1511µm CH_3OD laser, 70.5116 µm CH_3OH laser, and 118.834 µm CH_3OH laser lines are were measured at 10, 20, and 29 °C as shown in Fig. 2. As shown in Fig.2, the refractive indices depend strongly on temperature, while not depend on the wavelength for the wavelength region. The refractive indices for the 48-µm laser at various temperatures were estimated by extrapolation because the index did not have a drastic change in the region at 40 to 120 µm in wavelength. Using the refractive index at 19.4 °C, the transmittance of the silicon etalon was calculated for the expected wavelength of 48-µm CH_3OD laser as a function of the incident angle. Figure 3 shows the experimental measured results with the calculated results. As shown in Fig.3, the experimental results are in good agreement with the calculated results of λ =47.661 µm. As the result, the wavelength and the refractive index at 19.4 °C have been determined to be 47.661 ± 0.005 µm and 3.4164, respectively.

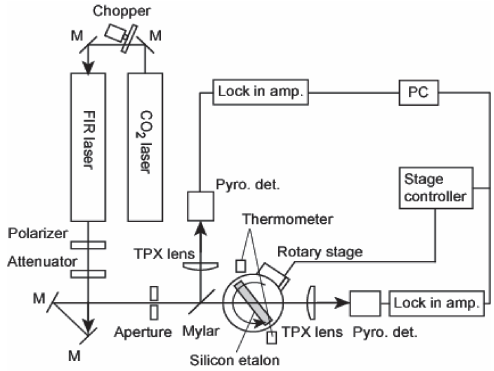

Fig. 1. A schematic diagram of the experimental setup.

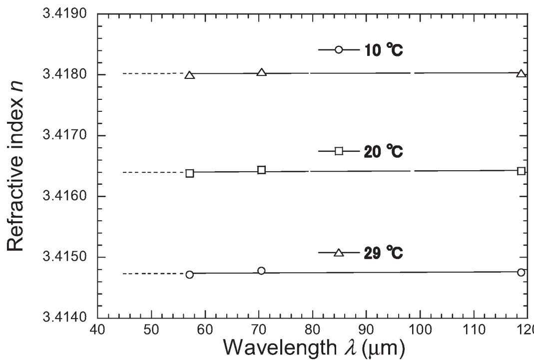

Fig. 2. Refractive index of silicon at 10, 20, and 29 °C for 57- and 71-and 119-µm FIR lasers.

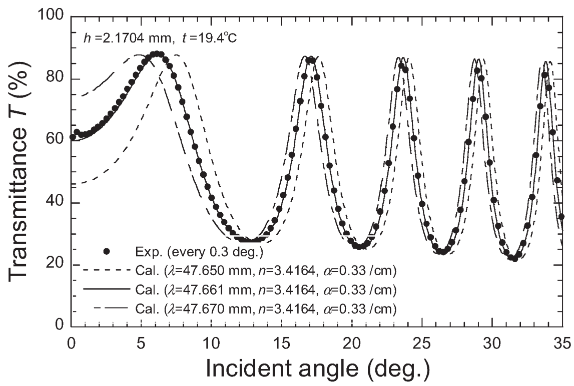

Fig. 3. Transmittance of the silicon etalon as a function of the incident angle for the 48-µm CH_3OD lasers.

[1] K. Kawahata, K. Tanaka, Y. Ito, A. Ejiri, and S. Okajima, “Far infrared laser interferometer system on the large helical device”,Rev. Sci. Instrum. 70, pp. 707-709 (1999).
[2] K. Kawahata, T. Akiyama, R. Pavlichenko, K. Tanaka, T. Tokuzawa, Y. Ito, S. Okajima, K. Nakayama, and K. Wood, “Two color far infrared laser interferometer”, Rev. Sci. Instrum. 77, pp. 10F132 1-4 (2006).