§20. Beam Delivery System for Two-color FIR Lasers

Nakayama, K., Okajima, S. (Chubu Univ.),
Akiyama, T., Tanaka, K., Kawahata, K.

In the LHD, the plasma electron density profile has been measured by a beat-modulated interferometer using a 119-μm (2.5 THz) CH_3OH laser pumped by a 9P(36) CO_2 laser, routinely. The laser beam is transmitted to the LHD from the diagnostic room by using a circular waveguide of acrylic tubes. The total length is about 40 m. For high density operation of the LHD and future plasma devices such as ITER, we assume the desired suitable wavelength range is from 40 to 70 μm from points of view of plasma refraction effect, mechanical vibration effect, fringe shift, and so on. In addition, simultaneously oscillated two-color FIR lasers are necessary for the compensation of the mechanical vibration, because the probe wavelength is shortened. Owing to the application to the LHD, we have developed a two-color interferometer and polarimeter using 48-μm (6.3 THz) and 57-μm (5.2 THz) CH_3OD lasers pumped by a 9R(8) CO_2 laser. Just like the 119-μm laser, the two-color lasers need beam delivery of the long distance. In this study, the beam delivery system using the waveguide of acrylic tubes was tested for the two-color FIR lasers.

The FIR laser is twin type (probe and local) owing to the heterodyne interferometer. We used a precise laser tube and a dielectric coated output mirror. The laser tube is a 2.9-m long, 25-mm bore, Pyrex glass with a water jacket. A coupling hole of the output mirror is 6 mm diameter. The polarization of the 48-μm laser is orthogonal to that of the 57-μm laser, and hence both laser beams can separate by a polarizer. EH_{11} mode of a circular waveguide has intensity profile which is similar to Gaussian beam in linear polarization. Figure 1 shows the experimental setup of the waveguide delivery system. We arranged three acryl tubes so that they form a U-shaped. The acryl tubes have an internal diameter of 24 mm. The total length is about 8.9 m. Atmospheric absorption of FIR light by water vapor is one of severe problems for beam transitions. The absorption of the 48- and 57-μm lasers is larger than that of the 119-μm laser. Thus, a dry air was supplied in the laboratory and the waveguide. The temperature and relative humidity of the room are 23 ℃ and 10 %, respectively. In the waveguide, the relative humidity was kept less than about 3 %.

Beam waist W_0 and beam divergence θ of the two-color FIR lasers were measured in order to decide an optical configuration of the waveguide delivery system. Figure 2 shows a beam width ($1/e^2$) as a function of the distance from the output mirror. The beam waist and the beam divergence for the 57-μm laser were W_0=2.12 mm and θ=8.58×10^{-3} rad, respectively. The beam waist and the beam divergence for the 48-μm laser were W_0=1.99 mm and θ=7.62×10^{-3} rad, respectively. The laser beam was transmitted in the waveguide, and the beam profile, the polarization state, the transmission efficiency were measured. As shown in figure 3(a), our FIR laser device obtained Gaussian beam for the two-color FIR lasers. However, the beam profile after passing through the waveguide was distorted (Fig. 3(b)). The beam distortion was caused by a bending of the waveguide and a difference of the optical axis of the two-color laser beams. The polarization state after passing through the waveguide was the linear polarization as with the input beam. The transmission efficiency was over 90 %. Two-color beat signals necessary for the interferometry were obtained by a GaAs Schottky barrier diode mixer.

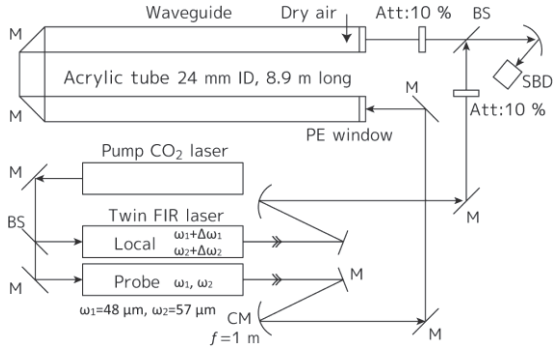

Fig. 1. Optical layout of the two-color FIR laser beam delivery.

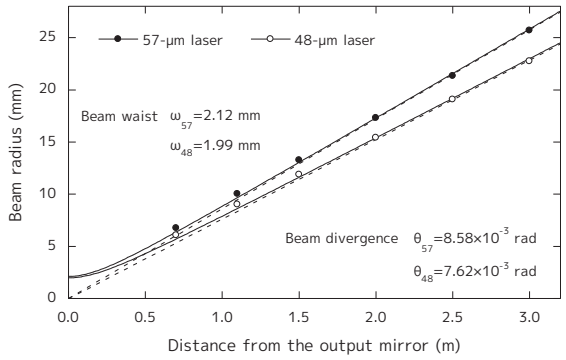

Fig. 2. Beam propagation of the two-color FIR laser.

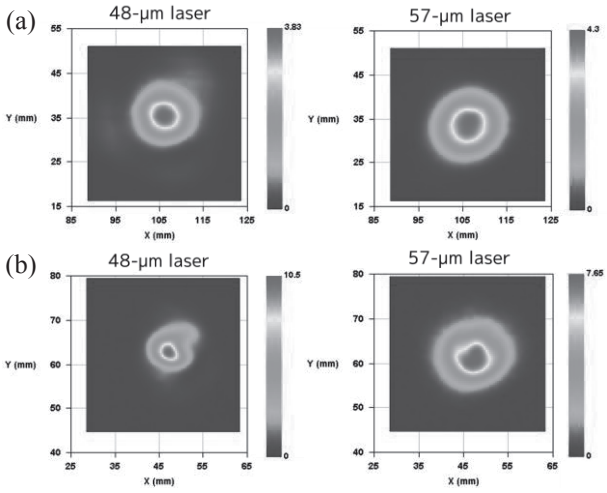

Fig. 3. Two-color FIR laser beam profiles of (a) before and (b) after passing through the waveguide.