§42-12 Development of an Optical Isolator for Optically Pumped Far-Infrared Lasers

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

Far-infrared (FIR) lasers around the 50 μm wavelength range are expected as optical sources for future plasma diagnostics. Therefore we have developed two-color interferometer and polarimeter using 48- and 57-μm CH_3OD lasers pumped by a 9R(8) CO_2 laser for high density operation of the LHD and future plasma devices such as ITER. A powerful and stable FIR laser is required for these applications. A change in FIR laser output is strongly dependent on output and frequency fluctuations of the pump CO_2 laser. A back reflection from the FIR laser cavity to the pump CO_2 laser cavity courses an output fluctuation increase of both lasers. Consequently, it is important to minimize the back reflection. We have already developed a frequency-stabilized CO_2 laser with the power stability of 107.9±0.5 W/hour and the frequency stability of ±420 kHz_{p-p}/hour at 9R(8) line center (wavelength 9.34 μm, frequency 32.1 THz). However, there remains the preventive for the back reflection.

A combination of a phase retarder and a polarizer is usually used as an optical isolator for CO_2 lasers. Although optical isolators have been used for any CO_2 laser pumped FIR lasers[1)], there is no precedent for the 9R(8) CO_2 laser pumped 48- and 57-μm CH_3OD laser. In this study, an optical isolator using a quarter wave plate and an absorbing thin-film reflector (ATFR) mirror has been investigated for a reduction effect of the back reflection at the 9R(8) CO_2 laser line.

We examined optical properties of the quarter wave plate and ATFR mirror. The quarter wave plate of CdS is multi-order wave plate. Experimentally, the transmissivity was 99.2 %. When the optic axis was set at 45° the direction of laser polarization, the phase retardation and the ellipticity were measured to be 89° and 0.99, respectively. The coating of ATFR mirror will reflects s-polarization and absorbs p-polarization. If linearly polarized light is entered to the ATFR mirror at an incident angle of 45° , the reflectivity was 99.0 % at s-polarization and 1.2 % at p-polarization. Although degree of polarization of the ATFR mirror is inferior to that of a wire grid polarizer, the ATFR mirror is excellent in the durability for a high power laser. Using the zeroth-order light of the pump CO_2 laser grating, it was confirmed that the combination of these optical components worked as an optical isolator.

Next, as shown in figure 1, the quarter wave plate and the ATFR mirror were set between the pump CO_2 laser and the FIR laser. We previously used a cavity mirror with off-axis hole of 3 mm diameter to prevent the back reflection. The output fluctuation of the pump CO_2 laser by the interference with the back reflection was ±2.8 %. In this study, the cavity mirror with center hole of 3 mm diameter was used, because output power increase of the FIR laser was able to be expected. Figure 2 shows the output power fluctuation of the pump CO_2 laser in scanning the FIR laser cavity. When the optic axis of the quarter wave plate was rotated, it is possible to change polarization between liner and circular. In the case of the circular polarization, the back reflection was isolated. It was found from the measurement result that the effect of the back reflection could be reduced at ±1 % or less. We confirmed that the 48- and 57-μm CH_3OD lasers were oscillated by circularly polarized pump CO_2 laser.

In summary, a back reflection from an optically pumped FIR laser cavity affects not only the FIR laser stability but also the pump CO_2 laser stability. An optical isolator using a quarter wave plate and an ATFR (absorbing thin-film reflectors) mirror has been tested in order to prevent the back reflection. A change in the pump CO_2 laser output by the back reflection has been decreased to under ±1 %.

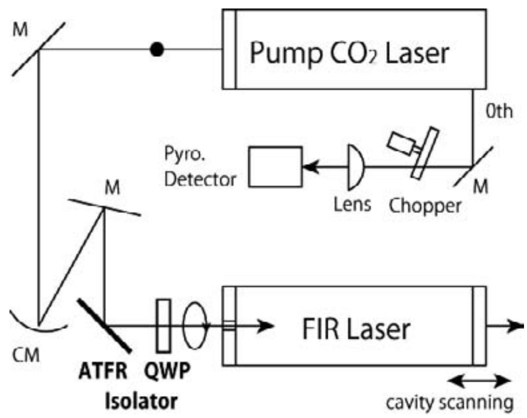

Fig. 1. Experimental setup

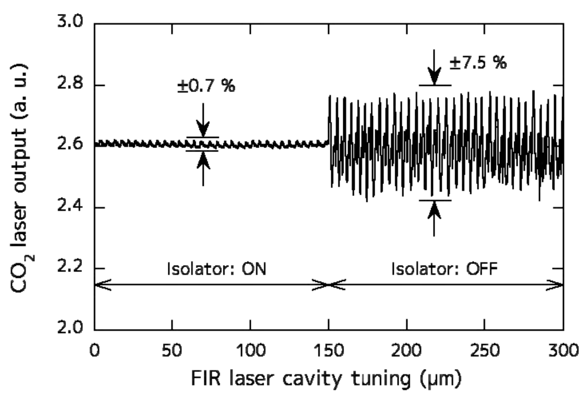

Fig. 2. A change in output of the pump CO_2 laser when scanning the FIR laser cavity

1) D. K. Mansfield et al,: Optics letters, 6 (1981) 230-232.