§14. Design of YAG Laser Dispersion Interferometer for Helical DEMO Reactor

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The electron density measurement has to be accurate and reliable even on future helical DEMO reactors because it will be a reference signal of fueling control. However, conventional interferometers suffer from measurement errors caused by mechanical vibrations. Fringe jump errors significantly degrade the reliability of the density measurement.

A dispersion interferometer (DI) [1] is insensitive to the mechanical vibrations. Since there is no phase error due to the vibrations, the small phase shift due to a plasma is allowed from the viewpoint of signal to noise ratio (SNR). If the total phase shift is surely smaller than 1 fringe, the line density can be determined uniquely. This means the DI can be free from fringe jump errors. Even if the phase shift is larger than 1 fringe, as small phase shift as possible is preferable because correction of the total fringe number becomes easier at the fringe jump. Figure 1 shows the fringe shifts of CO_2 (10.6 μm) and YAG (1.064 μm) laser in the case of the helical DEMO reactor FFHR-d1 [2], which is four times larger than LHD. The line averaged electron density and the path length in a plasma are 3×10^{20} m^{-3} and 8 m. The expected fringe shifts of CO_2 and YAG lasers are 17 and 1.7 fringes, respectively. In order to reduce the phase shift smaller than 1 fringe, the wavelength have to be shorter than 625 nm. However, beam transmission in the reactors will be difficult because the reflectivity of the in-vessel mirrors for such a short wavelength will become smaller due to plasma sputtering and impurity deposition. Hence we adapt the YAG laser as a light source. Since the probe beam of the dispersion interferometer is a mixture of the fundamental and the second harmonics of the laser light, an efficiency of the second harmonic generation is one of the important keys which determines SNR. Figure 2 shows the generated power of the second harmonics. Considering degradation of the reflectivity of in-vessel mirrors, the power of the second harmonics more than 100 mW is preferable [2]. Hence a YAG laser (Mephisto MOPA, Innolight Inc.) with an output power of 8 W and a quasi-phase matching crystal PPMgSLT (OXIDE) with a 30 mm-long are selected.

Figure 3 shows a photograph of bench testing of the second harmonic generation (without focusing optics). Conditions of the second harmonic generation (beam focusing, crystal temperature) are optimizing now. The present generated power is about 300 mW and will be increased by optimization of the phase-matching temperature of the PPMgSLT.

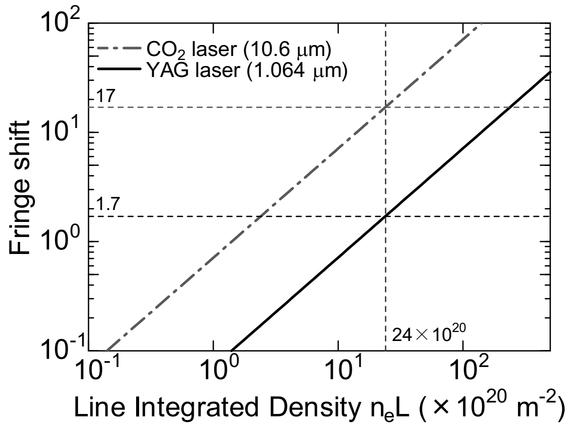

Fig. 1: Fringe shifts of CO_2 and YAG lasers in FFHR-d1.

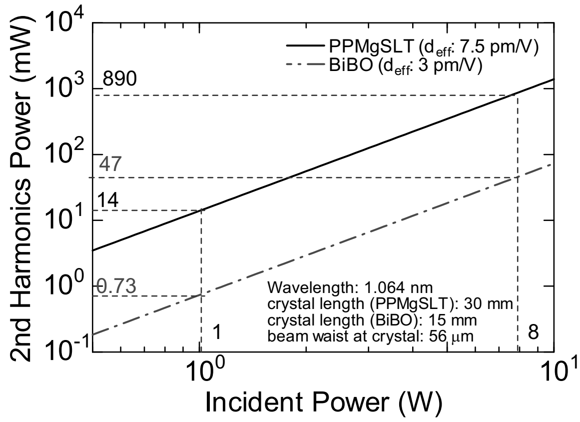

Fig. 2: Generated powers of second harmonics with PPMgSLT and BiBO cystal

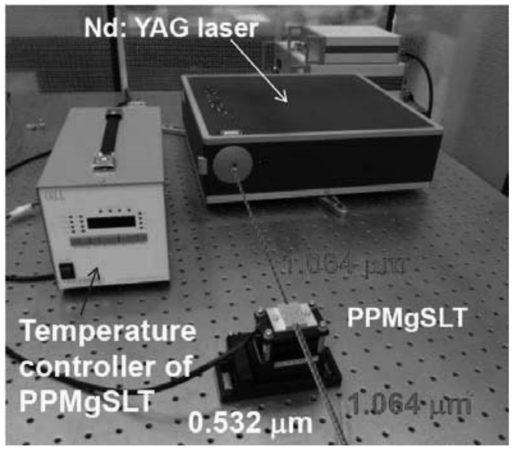

Fig. 3: Bench test of the second harmonic generation with PPMgSLT and YAG laser (focusing optics are not shown).

1) P. A. Bagryansky *et. al.*, Rev. Sci. Instrum. **77**, 053501 (2006).
2) T. Akiyama *et. al.*, Plasma ad Fusion Res. **5**, 047 (2010).