

§14. Development of a New Two Color FIR Laser Interferometer

Kawahata, K., Tanaka, K., Tokuzawa, T., Itoh, Y.
Okajima, S., Nakayama, K. (Chubu Univ.).

For high-density operation of the LHD, we have been developing a new two color FIR laser interferometer [1]. One of the key issues to construct the system is to develop short wavelength laser sources with high power. So far, we have achieved a lot of high power oscillation lines from 40 μm to 100 μm in wavelength by changing FIR laser molecules. Among these oscillation lines most powerful line was found to be a 57.2- μm CH₃OD laser line [2] and be able to oscillate simultaneously at a 47.6 μm every 5 x 57.2 μm ($\sim 6 \times 47.6 \mu\text{m}$) by tuning the FIR laser cavity length [3]. Both oscillation lines have different polarization. The 57.2- μm line is perpendicularly polarized for the CO₂ laser, while the 47.6 μm line is parallelly polarized. In order to multiplex the two colors into a single co-aligned, co-polar output beam, we constructed a conventional Martin-Pupplett polarizing Diplexer as is shown in Fig. 1(a), with a path length designed to rotate the polarization of one frequency by 90 degrees, while the other is unaffected. The shortest path difference required to do this is for wavelengths of 57.2 and 47.6 μm is 500 μm , as the attached Mathematica plot shows in Fig. 1(b). The Diplexer is of a conventional design, but with some special features for very short wavelength operation. The polarizing grid is formed by lithography to give the necessary accuracy to give good phase and amplitude transmission and reflection properties (albeit with some absorption loss not normally present in free standing grids). The grid spacing is 2 μm with a 1 μm conductive line - mounted on a 1.5 μm Mylar sheet.

Figure 2 shows the 1 MHz heterodyne beat signal firstly detected by using a GaAs Schottky barrier diode mixer mounted on a quasi-optical corner cube-type antenna structure. The single beat signal shows that the twin laser is lasing at a single transverse and longitudinal mode. The sensitivity of the detector is not good at this laser line since the whisker antenna is optimized to detect 119 μm laser line. We might have much high sensitivity when the detector is optimized at 57 μm . Responsivity of the Schottky barrier diode, however, is decreased with operating frequency, and the cut-off frequency of the diode is bellow several THz, which is close to the laser oscillation frequency. So far, we couldn't detect the 47.6 μm IF signal by using the SBD when the laser oscillate at two oscillation lines. Therefore, we need to search for other kinds of

detector, such as an InSb He-cooled detector with magnetic tuning and a Ge:Ga photoconductor, to obtain high responsivity for short wavelength laser lines.

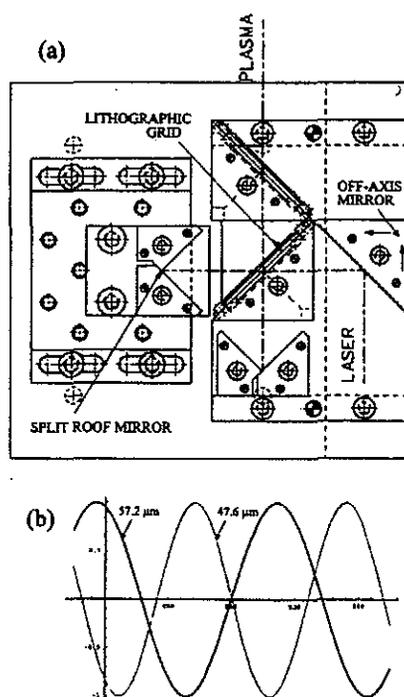


Fig.1. (a) Schematic drawing of a Martin-Pupplett polarizing diplexer. (b) Electric field amplitude polarizations as a function of a path difference between two arms. When the input polarizations are orthogonal the polarizations are both vertical at the path length difference of 500 μm .

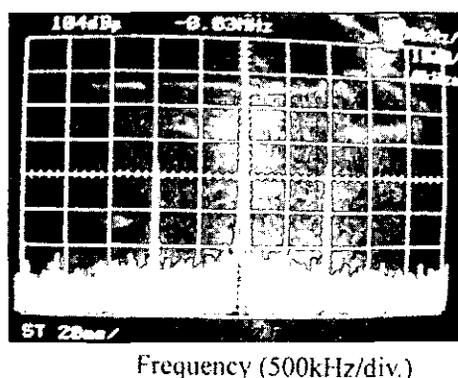


Fig.2. 1 MHz beat signal of 57.2 μm laser firstly detected by a Schottky barrier diode. The spectrum analyzer trace shows a single beat signal at 1 MHz showing single transverse mode operation.

3. References

- [1] K. Kawahata, K. Tanaka, Y. Ito et al., Rev. Sci. Instrum. **70**, 1 (1999) 707.
- [2] S. Okajima, K. Nakayama, H. Tazawa et al., Rev. Sci. Instrum. **72**, 1 (2002) 1094.
- [3] K. Nakayama, H. Tazawa, S. Okajima et al., Rev. Sci. Instrum. **72**, 1 (2002) 1094.