§16. Progress of a New Two Color FIR Laser Interferometer

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For high-density operation of the Large Helical Device, we have been developing short wavelength far infrared laser oscillation lines [1,2] by using CO_2-laser-pumped FIR laser. So far, we have achieved high power laser lines oscillating simultaneously at 57.2 μm (~1.6 W) and 47.6 μm (~0.8 W) in a twin optically-pumped far-infrared CH_3OD laser. These two color laser oscillation lines enable us to construct a new two color laser interferometer [3]. This two color interferometer system is unique one compared with the conventional two color interferometer system, where two independent lasers are used to be combined. By introducing Ge:Ga detectors operating at liq.He temperature, we have successfully detected two color beat signals with excellent signal to noise ratio.

Figure 1 shows a view of the detector/cone assemblies mounted on the cold-plate of the cryostat. The cooled detector system contains three unstressed gallium-doped germanium photoconductors. The detectors view incoming radiation via a focusing Winston cone and through a set of low-pass filters via vacuum windows located in the bottom plate of the cryostat. The detecting elements are small compared to the beam-size so they are mounted in integrating cavities immediately behind a Winston cone which has an entrance aperture of 15mm in diameter and has an f/3.5 field of view. This arrangement permits multi-pass absorption by the detector, thereby significantly improving optical coupling efficiency. Two filters are located in the detector system. The first one is mounted on the 77K radiation shield, where it serves to block and reflect unwanted higher frequencies from the 300K background radiation. This greatly reduces the thermal load on the cryogenic stages of the cryostat and generates a conveniently long run-time from a single fill of liquid helium. The second identical filter sits on the entrance aperture of the Winston cone where it ensures that no unwanted higher frequencies are incident on the detector from leakage within the cryostat.

Figure 2 shows the frequency spectrum of two color beat signals at 1.2 MHz for 57.2 μm and 0.55 MHz for 47.6 μm. It can be seen in this figure that the signal-to-noise ratio is excellent to be about 40 dB. This high signal-to–noise ratio was achieved when the input power to the detector was reduced by 30 dB. The beat frequency of each laser oscillation line can be set at the optimum value by changing the pressure of the FIR laser cavity and by tuning the cavity length. The optimum value of the beat frequency is determined from the following factors; detector band width (3dB bandwidth is 2 kHz to 3 MHz), fringe counting electronics to separate each laser beat frequency and laser tunability. So far single mode beat frequency is achieved up to ~ 2MHz without large reduction of laser oscillation power. The interference signals detected are separated electronically at different frequencies, and then introduced into phase comparators for phase measurement.

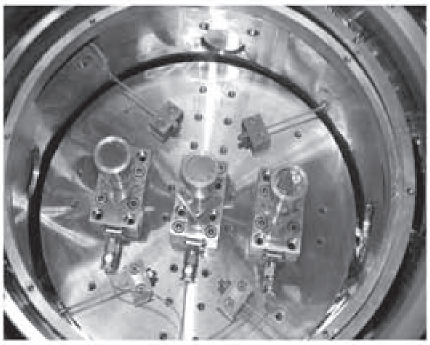
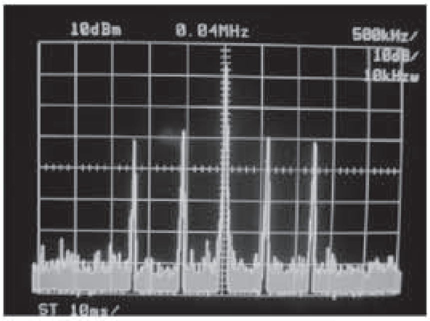


Fig.1. A bottom looking photograph of the cooled detector system which contains three unstressed gallium-doped germanium photoconductors with a focusing Winston cone.



10 dBm, 500 kHz/div.

Fig.2. Two color beat signals detected by the gallium-doped germanium photoconductor. The spectrum analyzer trace shows two color beat signals corresponding to a 57.2 μm beat of 0.55 MHz and a 47.6 μm beat of 1.2 MHz.

3. References

[1] S. Okajima, K. Nakayama, H. Tazawa, K. Kawahata, et al., Rev. Sci. Instrum. **72**, 1 (2001) 1094.
[2] K. Nakayama, H. Tazawa, S. Okajima, K. Kawahata, K. Tanaka, et al., Rev. Sci. Instrum. **75**, 2 (2004) 329.
[3] K. Kawahata, K. Tanaka, T. Tokuzawa et al., Rev. Sci. Instrum. **75**, 10 (2004) 3508.