§10. Video and Heterodyne Detections of 48-, 57-μm CH_3OD Lasers by Using a GaAs SBD Mixer

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GaAs Schottky barrier diodes (SBD) are utilized for various measurements, as it is capable of exhibiting a high sensitivity, a high S/N, a fast response time, and room temperature operation. In the LHD, the electron density profile has been measured by a 13ch Michelson type heterodyne interferometer using a 119-μm CH_3OH laser. In the system, many GaAs SBD mixers are used for the beat signal detection. We are developing a two-color interferometer/polarimeter using 48- and 57-μm (6.3- and 5.2-THz) CH_3OD lasers in order to apply high density operation of the LHD and future plasma devices such as ITER. A Ge:Ga photoconductor is sensitive for the detection of these lasers. However, it must be cooled in liquid helium temperature. Although a room-temperature operating a GaAs SBD is easy handle, practically it is not much used under 100 μm (>3 THz) because of a low responsivity. Therefore, we have measured the frequency dependence of responsivity of a commercially available 2.5 THz (119 μm) SBD mixer to know whether we can use at higher frequency region.

We have examined the video responsivity of the SBD mixer (WR0.4 FM, Virginia Diodes, Inc.). This mixer is composed of a planar SBD and a WR-0.4 waveguide of the frequency range 1.8 – 2.8 THz (107 – 167 μm) with a diagonal horn. The video responsivity at 2.5 THz is 200 - 400 V/W[1]. However, the responsivities at other frequencies were unknown. Therefore, the frequency dependence was measured by using 14 FIR laser lines in the frequency range of 1.6 – 6.3 THz (48 – 185 μm). Figure 1 shows experimental setup for the video signal detection. In this experiment, focusing optics and video amplifier were not used. Input power to the SBD mixer was estimated from the laser beam profile and the diameter of the diagonal horn (0.65 mm). The bias current of the SBD mixer was set at about -3 μA. Figure 2 shows the video responsivity as a function of frequency at normal incidence. It was found that the SBD mixer has high responsivity of about 966 V/W at 2.24 THz (134 μm). Although the responsivity lowered in proportion to frequency, the SBD mixer was able to detect the 48- and 57-μm CH_3OD lasers. These video responsivities were about 1.9 and 4.3 V/W, respectively.

By using a twin type FIR laser system (laser A and B), we have attempted a heterodyne detection of the 48- and 57-μm CH_3OD lasers. Each laser cavity length is slightly shifted, and the laser with a slight difference frequency oscillates. The beat signal was generated by the interference of two beams (A and B), and was detected by the SBD mixer. The bias current of the SBD mixer was set at about -13 μA. Figure 3 shows the two-color beat signal of simultaneously oscillated 48- and 57-um CH_3OD lasers displayed on a spectrum analyzer. These beat frequencies of the 48- and 57-μm CH_3OD lasers were about 0.4 MHz and 1.15 MHz, respectively. The SBD mixer obtained beat signals with high S/N ratio of 40 dB or more. We also confirmed that the SBD mixer could be used as a monitor for the laser cavity control.

The GaAs SBD mixer is useful for developments of the interferometer/polarimeter for plasma diagnostics by using 48- and 57-μm CH_3OD laser and the stabilization system of the FIR laser.

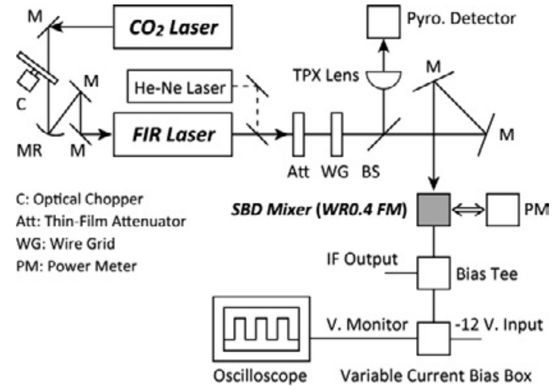

Fig. 1. Experimental setup for the video signal detection.

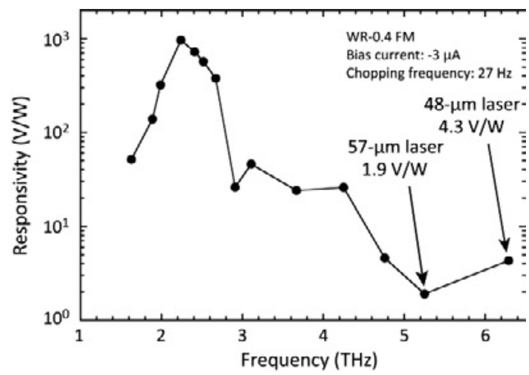

Fig. 2. Measured video responsivity of the SBD mixer.

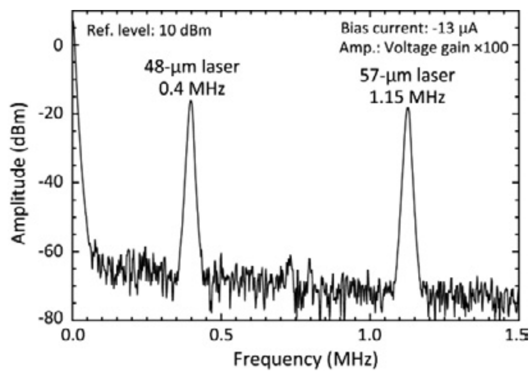

Fig. 3. Two-color beat signal of 48- and 57-μm CH_3OD lasers detected by the SBD mixer.

1) J. L. Hesler et al., Proc. 36th Int. Conf. on IR, MMW, and THz Waves, Th5.3 (2011).