Fast Sweep Solid State Spectrometer for sub-THz and THz frequency ranges

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***Abstract*—The design and development of a fast sweep submillimeter and THz spectrometer based on solid-state components is presented. A prototype laboratory model of such a spectrometer will be described and some performance characteristics as well as potential applications emphasized.**

I. Introduction And Background

Characteristic molecular signatures associated with rotational spectra are well known to be "fingerprints" for the characterization, identification and detection, of molecular species. Consequently, microwave, submillimeter and terahertz spectroscopies have become recognized as powerful tools used in many applications where high sensitivity and frequency resolution are required. This is especially true in spectroscopic and analytical investigations of many component gas mixtures. Moreover, there is great promise for a methodology which would give additional opportunities for simultaneous analysis of spectra in wide frequency ranges and the study of fast chemical processes. Such a unique method can be realized by application of fast sweeping mode, when $\frac{\Delta\omega_s}{T_s} >> \Delta\omega_l^2$, where $\Delta\omega_s$ and T_s are scan range and scan time correspondingly, and $\Delta\omega_l$ is a halfwidth of a spectral line. The fast sweeping mode was obtained by free running BWO [see for example 1]. Fast sweep spectroscopy based on PLL BWO has been presented in [2, 3]. Currently, advantages in the subTHz and THz frequency range are evident for many spectroscopic applications, since analytically many rotational transitions lie in this range. The development of fast sweep spectrometers with subTHz and THz capabilities predicates other radiation sources be employed for obtaining the fast sweep mode as BWOs only generate up to 1.2 THz, have dimensional restrictions and quite short lifetimes of operation. For many applications, it is highly preferable that the spectrometer be compact, inexpensive, with low power consumption. Application of solid state generators and quantum semiconductor superlattice devices [4] make it possible to meet these requirements.

The present paper reports development of a fast sweep spectrometer operating at subTHz and THz frequency ranges based on solid state construction.

II. Results

We have incorporated and tested a synthesizer based on a Gunn generator (97-117 GHz) with output power about 20 mW. A homemade highly stable synthesizer is used as reference. The signal from Gunn synthesizer is multiplied by a quantum semiconductor superlattice structure diode (Fig.1). The spectrometer was calibrated by the 7th harmonic by a absorption line of methanol near 766.960 GHz. Multiplication by various factors permits the spectrometer to function in different frequency ranges.

In this report, we show that detected fast passage signal can be transformed into a typical form found in Fourier-transform spectroscopy. The subsequent Fourier transformation yields a spectral function of a gas under study. Therefore, we can regard our method as a new type of Fourier-transform spectroscopy. Optimal use of the radiation power source allows one to obtain higher sensitivity than in an ordinary pulsed Fourier-transform spectrometer. The present paper also reports solution of the inverse problem of reconstructing the resonance line shape from the detector signal.

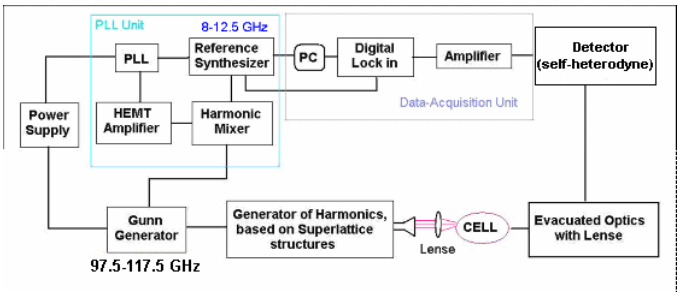

Fig.1

The spectrometer is compact, easy to use, with high precision and reproducibility including automatic measurement. Time of measurement is in the range of 4 μs to 3 min. The potential applications of the spectrometer for medical, ecological and other analytical studies will also be discussed.

References

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