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HYPER NRD GUIDE OSCILLATOR WITH GUNN DIODES MOUNTED IN THE DIELECTRIC STRIP.

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Hyper NRD guide oscillators mounted with a single and multiple Gunn diode have been investigated. The operating mode of the hyper NRD guide can be lower order by optimizing the structure of the guide. The Gunn diodes were arranged in the dielectric strip of the guide. In experiments at X–band, the oscillation frequencies could be varied by a movable shorting plane for the single diode case and an almost perfect power combining was obtained for the double diode case.

1 Introduction

Power combining of solid–state active devices is frequently necessary particularly in the millimeter–wave frequency region, because output power of a single active device decreases with increasing frequency. Recently, various power combining techniques have been investigated[1][2]. In the millimeter–wave frequency range, power combiners constituted by NRD guides[3] are promising because NRD guides have low loss and non-radiative characteristics. In an ordinary NRD guide, however, the LSM_{01} mode which is used as the operating mode of the guide is not the dominant mode, so oscillators using an ordinary NRD guide sometimes have unstable and considerably low output power characteristics, and some circuit attachments are often necessary to prevent mode conversion to undesired modes. Thus, a hyper NRD guide[4] was proposed in which the desired operating mode is a lower order. In this paper, we develop a hyper NRD guide oscillator with multiple Gunn diode mounted in the dielectric strip in order to combine output powers of the diodes.

2 Hyper NRD guide

Figure 1 shows the structure of the hyper NRD guide where a rectangular dielectric strip with a width b and a height d is sandwiched by two grooved metal plates with an interval a. The propagating modes of the hyper NRD guide are not pure LSM or LSE mode. By adjusting a depth $(d - a)/2$ of the groove on the metal plate, the cutoff frequency of LSM_{01}-like mode which is used as the desired operating mode can be lower than that of LSE_{01}-like mode. Experiments were carried out at X–band in order to reduce the effect of the error in the fabrication. The dispersion curve of the hyper NRD guide is shown in Fig.2 in case that the dimensions of the guide were $a = 8$[mm], $d = 13$[mm], and $b = 11$[mm], and the relative dielectric constant of the dielectric strip was 2.04. The cutoff frequency of the LSM_{01}-like mode is 9.44GHz while that of the LSE_{01}-like mode is 10.73GHz.

3 Single diode oscillator

Figure 3 shows the structure of a hyper NRD guide oscillator mounted with a single Gunn diode. The Gunn diode was installed at the center of the dielectric strip and was supported by two metal rods through which DC bias voltage was applied to the Gunn diode. The metal rods were connected to metal blocks with choke structures which were 20mm away from the dielectric strip. One metal block was insulated from the parallel metal plates in order to apply

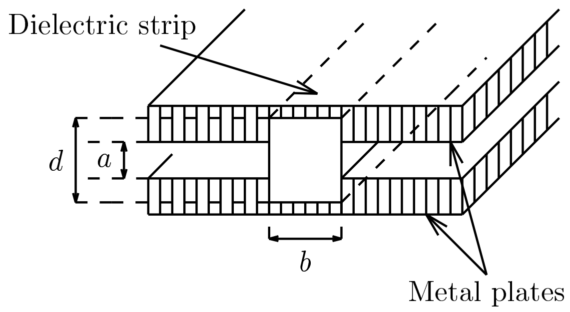


Figure 1: Hyper NRD guide

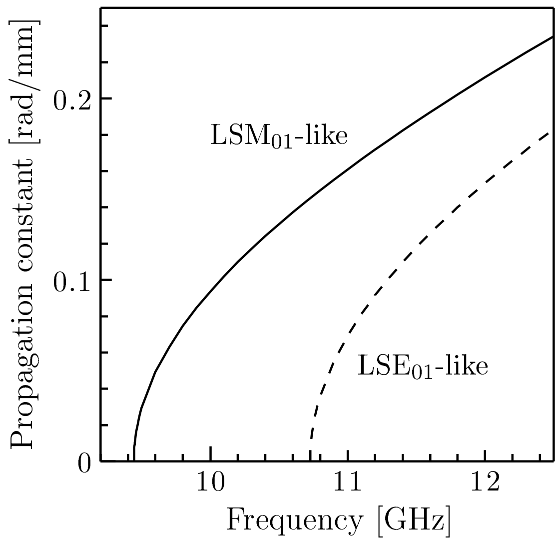
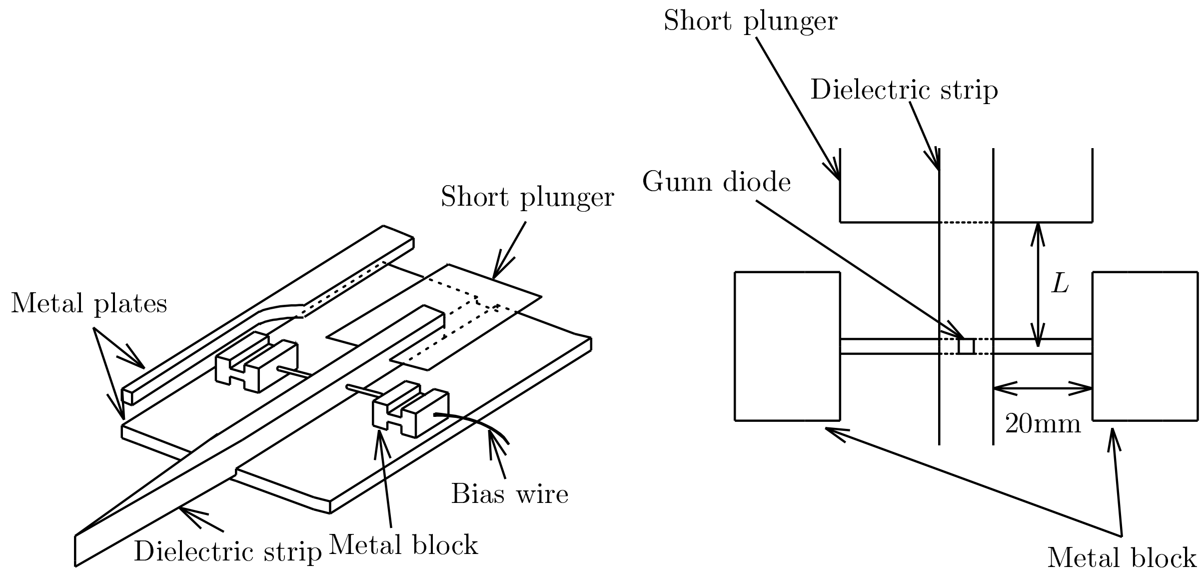


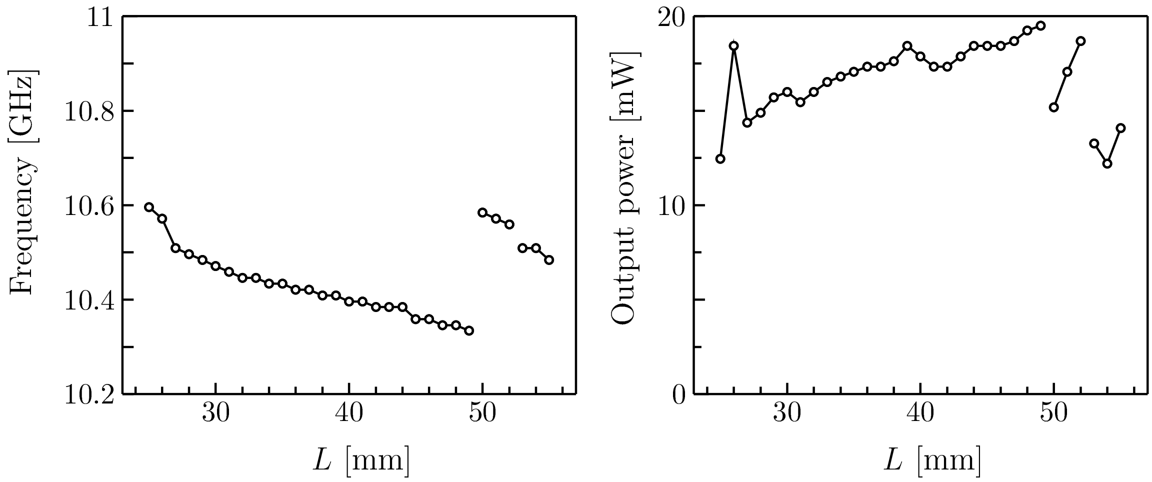
Figure 2: Propagation constant of the hyper NRD guide in case of $a = 8$[mm], $d = 13$[mm], $b = 11$[mm], and the relative dielectric constant of 2.04



(a) Aspect (b) Vicinity of diode

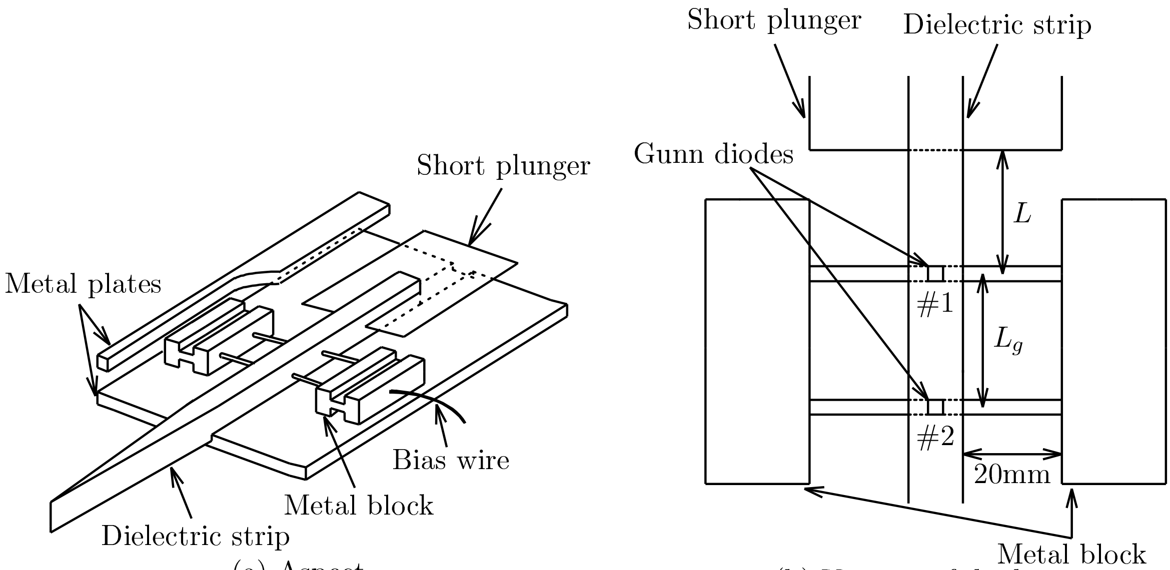
Figure 3: Structure of a single diode oscillator

DC bias and the other metal block came into contact with the parallel plates of the hyper NRD guide. A thin conductor plate was inserted into the dielectric strip to serve as an adjustable short plunger. The electromagnetic wave generated from the Gunn diode propagates along the hyper NRD guide and is reflected by the short plunger. The oscillation frequency can be controlled by adjusting the distance between the Gunn diode and the short plunger. The output power was extracted through the hyper NRD guide in the opposite direction to the short plunger. The hyper NRD guide was converted to a rectangular waveguide in the experimental setup using a transition horn. The horn has a linear taper similar to the transition horn from the ordinary NRD guide to the rectangular waveguide[5] and converts LSM_{01}-like mode of the hyper NRD guide to TE_{10} mode of the rectangular waveguide. The load of the oscillator was adjusted for maximum output power by a stub tuner on the rectangular waveguide. Figure 4 shows the measured variation of the oscillation frequency and the output power with the distance L between the Gunn diode and the short plunger. When



(a) Oscillation frequency (b) Output power

Figure 4: Experimental result of case of the single diode oscillator



(a) Aspect (b) Vicinity of diode

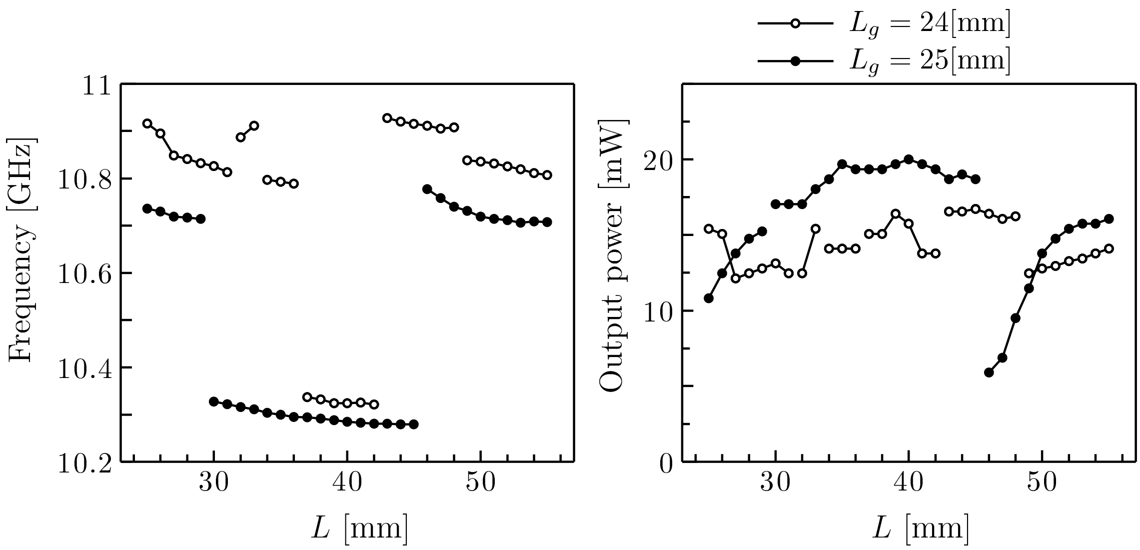
Figure 5: Structure of a double diode oscillator

$L = 49$[mm], the maximum output power 19.7mW was obtained which was nearly equal to the available power of the Gunn diode measured using a usual waveguide cavity.

4 Double diode oscillator

The structure of a double diode oscillator is similar to the single diode oscillator except that two diodes are arranged along the hyper NRD guide by using the longer metal blocks as shown in Fig.5. The oscillator of this configuration may be called a ladder oscillator[6]. For two values of the distance L_g between two diodes, the measured result of the variation of the oscillation frequency and the output power with the distance L between the closer diode #1 to the short plunger and the short plunger is shown in Fig.6. The available powers of the diodes used in this experiment were on about the half of that of the diode used for single device case.

The oscillation frequency could vary with L in narrower range compared with the single Gunn diode case because the oscillation frequency depends on not only L but also the distance between two diodes. When $L_g = 25$[mm] and $L = 40$[mm], the maximum output power 20.0mW and the maximum combining efficiency 99.7% were obtained, where the combining



(a) Oscillation frequency (b) Output power

Figure 6: Experimental result of case of the double diode oscillator

efficiency is defined as the ratio of the output power of the multiple oscillator to the sum of the maximum output powers of each diode when they are measured using the usual waveguide cavity.

5 Conclusion

A new power combining technique for solid–state active devices using the hyper NRD guide was discussed. In the experiments at X–band for the oscillator with a single or double Gunn diode mounted in the dielectric strip of the hyper NRD guide, stable operation with effective power generation was achieved. Our oscillator has a simple configuration and is suitable for mounting more many diodes. The future subject is power combining of many devices in millimeter–wave frequency range. The authors would like to thank Mr. S. Okura, former student of Okayama University for his help in experiment.

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