Review

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Abstract: A review on the sub-THz/THz gyrotrons is performed in this manuscript. The present development status of gyrotrons can be divided into three streams for the sake of better understanding: 1. low frequency (<35 GHz), medium power (< 100 kW), small size and easy to handle gyrotrons for industrial applications, 2. very high power (1 MW or more), medium frequency (100-200 GHz) gyrotrons for plasma fusion applications, 3. low power (few tens of watt to kW), high frequency (> 200 GHz) gyrotrons for various innovative applications. In this manuscript, the third stream of gyrotron development is reviewed. In last few decades several innovative applications are searched in sub-THz/THz band where the gyrotrons could be used as an efficient source of RF radiation. The applications of sub-THz/THz gyrotrons including the futuristic scope of the device are also discussed in this article. Further, several criticalities arise in the design and development when the gyrotron operation shifts towards the high frequency band. Various such design and technological challenges are also discussed here. Finally the development status of sub-THz/THz gyrotrons as per the use in various scientific and technological applications is also discussed.

Keywords: Gyrotron; THz; Sub-THz; THz Sources; THz Applications

1. Introduction

The THz radiation frequency range can be defined from 300 GHz to 3 THz. The lower region of THz radiation band and upper region of millimeter wave band (30-300 GHz) roughly can be defined as sub-THz region (200-500 GHz) [1, 2]. THz region lies between the microwave and infrared regions governed by well known technologies of microwave electronics and photonics, respectively. Almost the entire THz band is strongly attenuated in atmosphere with the exception of few narrow bands called atmospheric window [1, 3] and this makes THz radiation as an inferior choice for commercial purposes, especially in communication technology. The physics of THz radiation cannot be understood completely by the principles of microwave electronics or photonics due to the sandwich position of THz radiation band and this makes the development of THz devices different and complicated. The THz region was unexplored since long time due to several criticalities as mentioned above and lack of potential applications (also called THz-gap or T-gap) while the huge development has been seen in microwave electronics and photonics since second world war. Fig. 1 [4] explains the sandwich position of THz region and T-gap graphically. Although the THz and far infrared regions were always a subject of keen interest for astrophysicist as 98% of the photons emitted since the Big Bang fall into the sub-millimeter and far-IR regions [1, 5]. Various active and passive devices such as optically pumped THz lasers, detector arrays, etc., were explored specifically considering the astrophysical applications [6, 7]. But the scenario has been changed since last two decades because of several research breakthroughs such as THz time domain spectroscopy, THz imaging, material treatment, detection, etc., came into picture in THz region which pushed this almost unexplored region into the center stage [8-12]. For various applications, the THz/sub-THz sources of different power levels (from microwatt to kilowatt) are required. Huge success has been achieved in the development of sub-THz/THz sources in the last two-three decades and now various types of devices, such as quantum cascade lasers (QCL), optically pumped lasers, free electron lasers, vacuum electronic based oscillators and amplifiers, $GaAs_{1-x}N_x$ Gunn-like diodes, quantum wells negative effective