MM-WAVE PHOTONIC DEVICES AS OPTO-DETECTOR

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EXTENDED ABSTRACT

High frequency opto-detectors now find applications in defense. IMPATTS are accepted as the premier devices for generation of MM-wave power Devices since the entire range of mm-wave i.e. 30 to 300 GHz can be covered both in Fundamental and harmonic modes. The multiplication of saturation currents under avalanche breakdown condition (multiplication factor beyond million) of the p-n junction/carrier transit time/avalanche phase delay between charge growth process and instantaneous carrier concentration become responsible for rf negative resistance generation leading to mm-wave power generation. Any Semiconductor and any type of junction may be used in IMPATT mode. The Saturation current entering the depletion zone can be modulated through exposure of the junction fabricated from opto-sensitive materials to radiation of suitable wave-length which in turn causes decrease in carrier multiplication at avalanche breakdown. Three-independent/ very sophisticated/fast converging/accurate computer algorithm involving multiple iterations over device parameters has been framed for computer analyses of IMPATTs with or without opto-radiation for accessing device efficiency/rf characteristics/avalanche noise. Several opto-sensitive materials (binary/ternary/quaternary) like GaP or GaInAsP forming homo as well as hetero junctions are considered for which material parameters are available in literature. Drift/Diffusion/Tunnel currents, realistic doping profiles across the junction and exact variation of material parameters with physical conditions are incorporated into the analysis. The diodes are first designed for 35, 94, 140, 220 GHz frequencies and optimized against punch through factor/operating current density/diode structural parameters through several computer runs. Since the diode can exhibit negative rf resistance when total phase delay is between $\Pi/2$ to $3\Pi/2$, $5\Pi/2$ to$7\Pi/2$ and so on, the analyses is carried out from 30-350 GHz in each case for the multiplication factors varying from 1 million to 10. Some interesting results could be noticed. The magnitude of rf –ve resistance, efficiency decreases with increase in design frequency. Each diode exhibits a number of rf oscillating bands (harmonic mode of operation) and the number also gets lowered with increase in design frequency. However the diode efficiency and rf –ve resistance remain the same for the particular diode both for fundamental and harmonic modes. When the diode is supposed to be exposed to optical radiation, the optimum frequency of operation changes for heavy intensity exposure. The magnitude of rf resistance also decreases leading to lower rf power generation for the opto-exposed diodes. The changes optimum frequency as well as rf power generation and the magnitude of such changes would be indicative of optical radiation and its intensity. The frequency of 35 GHz diode becomes 40.5 GHz and rf resistance falls by 12 % for changing the multiplication from 1000 to 10. Similar trend also is obtained for harmonic mode operation. The later mode has of course the advantages of higher efficiency and rf power to make the detection more efficient. Thus the diode under such activities may find application as Opto-detectors using mm-wave frequencies which band is now in use point to point electronics communication systems.