Future Prospects of Diamond in High Power MMW Application

Uses of Diamond for electronic applications was started for development of photoconductive detectors. However, limitations in size and control of properties naturally limited the use of Diamond to a few specialty applications. With the development of Diamond synthesis from vapour phase has come a more serious interest in developing diamond based electronic devices. Diamond (band gap energy = 5.6 eV at 300K) supports peak internal electric field about 6 times higher than those of Si and GaAs, resulting in higher breakdown voltage, which is extremely important for devices handling high power. Another consequence of higher electric field and higher doping density is the width reduction in the drift region. Thus, not only high

Abstract

Use of Diamond for electronic applications was started for development of photoconductive detectors. However, limitations in size and control of properties naturally limited the use of Diamond to a few specialty applications. With the development of Diamond synthesis from vapour phase has come a more serious interest in developing diamond based electronic devices. Diamond (band gap energy = 5.6 eV at 300K) supports peak internal electric field about 6 times higher than those of Si and GaAs, resulting in higher breakdown voltage, which is extremely important for devices handling high power. Another consequence of higher electric field and higher doping density is the width reduction in the drift region. Thus, not only high
power but also the high frequency (MM/sub-MMW) operation capability is expected from this wide band gap semiconductor based devices. Hence Diamond based devices are expected to operate at higher voltage at the same operating frequency. Diamond is less noisy and is chemically very stable at high temperature. The expected excellent performances of diamond devices can be assessed by considering Keyes' FOM; FOM (considering the speed of transistors and their thermal limitations) and Johnson's FOM (considering the HF and high power capability of devices). Assuming Keyes' FOM; and Johnson's FOM for Si as unity, the Keyes' FOM; FOM and Johnson's FOM for GaAs are 0.45 and 7.1 respectively; those for Type II-diamond are 2.5 and 800 respectively. This clearly indicates that the HF and high temperature performance of Diamond devices would be much superior as compared to conventional Si and GaAs. The extensive simulation results reveal that MITATT diode based on Diamond gives better performance in terms of efficiency and output power. The design results and the proposed experimental methodologies presented in this paper will be helpful to realize Diamond MITATT oscillators for Terahertz communication.

References

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