Planar Diode Frequency Multipliers at Millimetre & Sub-millimetre Wavelengths for high sensitivity heterodyne receivers

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Introduction : for millimetre and sub-millimetre wavelengths heterodyne receivers, the local oscillator (LO) is a critical element. So far, solid state fundamental sources are not powerful enough for most of the applications at millimetre or sub-millimetre wavelengths. The local oscillator signal is generated by a low frequency (<140 GHz) fundamental source, followed by one frequency multiplier at least. Whisker-contacted Schottky barrier varactor diodes are still the most efficient devices for power generation at sub-millimetre wavelengths [1]. Nevertheless, for space-borne radio-telescopes such as the Far Infrared Space Telescope or for arrays with a large number of antennas such as the Large Southern Array, the use of much more reliable and reproducible components like planar varactor diodes is highly desirable. Thanks to the possibility of power combining, planar diodes have already compete the whisker-contacted diodes in the millimetre region [2], [3] ; but at higher frequencies, planar diodes are limited by their parasitic capacitances and their series resistance.

Schottky varactor planar diode doubler: a Neal Erickson-like balanced doubler at 260 GHz has been designed and tested at DEMIRM. The devices are Schottky planar varactors fabricated at the University of Virginia. The multiplier operates in the range 210 - 270 GHz with 8-10% efficiency when adjusting the mechanical tuners. Its 12.5 mW maximum output power was obtained at 265 GHz with 9% efficiency. The 3dB instantaneous bandwidth at 260 GHz is about 4%. For RF characterisation, DEMIRM used both a photo-acoustic absolute power sensor fabricated by Thomas Keating LTD. and a vector sub-millimetre network analyser from ABmm. The combination of both devices offers unique possibilities in terms of sensitivity and accuracy.

Heterostructure planar diode tripler developments: due to the natural symmetry of their C(V) curve, Heterostructure Barrier Varactors (HBV) generate odd harmonics only. This characteristic makes them the appropriate device for wide-band and high efficiency frequency tripler or quintupler. InGaAs/InAlAs/AlAs HBV have been designed, fabricated and tested by IEMN. Devices with two barriers stacked on the same epitaxy and several anodes in series (up to four) are planar integrated. They exhibit state-of-the-art DC characteristics with a zero-bias capacitance C_{j0} of 1fF/μm^2, a capacitance ratio of 6:1, and an overall breakdown voltage of 12 V per anode, with an extremely low leakage current. Several components from IEMN have been RF tested on the test bench developed at DEMIRM in a 250 GHz waveguide tripler designed by MMS-Toulouse and DEMIRM. State-of-the-art performances are obtained at 246 GHz with a conversion efficiency up to 12% ; 9.5 mW maximum output power was obtained with 90 mW input power.

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References

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