

Harmonic Balance Optimization of Terahertz Schottky Diode Multipliers Using an Advanced Device Model

E. Schlecht, G. Chattopadhyay, A. Maestrini, D. Pukala, J. Gill and I. Mehdi

California Institute of Technology Jet Propulsion Laboratory, Pasadena, CA 91109 USA

Substantial progress has been made recently in the advancement of solid state terahertz sources using chains of Schottky diode frequency multipliers [1-3]. The multiplier diodes are often simulated using a simple Schottky junction model plus a series resistance, R_S , because of the model's simplicity and ease of use in commercial harmonic balance simulators. The DC series resistance value is useable for R_S at low frequencies, but at high frequencies the value must be increased to match the measured RF performance. The junction properties are determined from forward I-V measurement.

Nevertheless, many other factors are well-known to participate in the diode behavior [4]. These include time-dependent velocity saturation [5], carrier inertia and shunt capacitance in the undepleted active layer, tunneling through the Schottky barrier and heating of the junction at high powers. A diode model including all of these effects has been derived. Since it includes specialized differential equations, a harmonic balance simulator based on the reflection algorithm has been built around it. The model itself must be calibrated using ensemble Monte Carlo calculations of material parameters, but otherwise no parameters are fitted other than to DC I-V measurements[5].

The program can be used to optimize the doping concentration and diode dimensions for any multiplier, based on its frequency, input power and operation temperature. Optimizations will be demonstrated for 200, 400 and 800 GHz doublers, and comparison between calculation and measurement will be shown. The match between them will be seen to be quite close.

The research described here was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

REFERENCES

- [1] N. Erickson, "Submillimeter-Wave Multiplier Development," *Ninth Intern. Conf. On Terahertz Electronics*, Charlottesville, VA, Oct. 2001.
- [2] G. Chattopadhyay, E. Schlecht, J. Gill, S. Martin, F. Maiwald, A. Maestrini, D. Pukala, and I. Mehdi, "An 800 GHz Broadband Planar Schottky Balanced Doubler" *Ninth Intern. Conf. On Terahertz Electronics*, Charlottesville, VA, Oct. 2001.
- [3] E. Schlecht, G. Chattopadhyay, A. Maestrini, A. Fung, S. Martin, D. Pukala, J. Bruston and I. Mehdi, "200, 400 and 800 GHz Schottky Diode 'Substrateless' Multipliers: Design and Results," *2001 International Microwave Symposium Digest*, pp. 1649-1652, Phoenix, AZ, May 2001.
- [4] E. Schlecht, F. Maiwald, G. Chattopadhyay, S. Martin and I. Mehdi, "Design Considerations for Heavily-Doped Cryogenic Schottky Diode Varactor Multipliers," *Twelfth International Symposium on Space Terahertz Technology*, pp. 485-494, San Diego, CA, February 2001.
- [5] E.L. Kollberg, T.J. Tolmunen, M.A. Frerking and J.R. East, "Current Saturation in Submillimeter Wave Varactors," *IEEE Trans. Microwave Theory Tech.*, vol. 40, no. 5, pp. 831-838, May 1992.