

Improvement of the Planar Schottky Diode Capacity Model for the Implementation in the Non-linear Harmonic Balance ADS Simulator for Multipliers Design

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A 2-dimensional “ensemble” Monte Carlo (MC) physical simulator, previously used to study HEMTs in [1]-[2], has been used for studying planar GaAs-Schottky barrier diode structures (SBDs) where there is a two dimensional electron transport. By using this physical MC simulator, the analytical junction capacity model proposed in [3] has been extended for structures where the existence of surface charges placed in the semiconductor-dielectric interfaces has been considered. The influence of the substrate on the junction capacity when the epilayer thickness is strongly reduced has also been studied by including a degeneracy model in MC simulations [2]. This work has been carried out in parallel with the design of a 1.2 THz heterodyne receiver for the JUICE-SWI mission project and the experimental characterization of the 600 GHz heterodyne front-end receiver presented in [4]. This study has allowed us to define the junction capacity for real geometries of the Schottky anodes used in the experimental available devices fabricated with the LERMA-LPN process, presented in [5]. The improved capacity model has been implemented in the non-linear harmonic balance ADS simulator by defining a SDD model (Symbolically-Defined Device), which reproduces the electrical behavior of the standard Schottky diode model integrated in the software, but also includes the improved junction capacity model. Both models are based on a simplification of the Lumped Elements Circuit (LEC) [6], typically used in the design of these devices [4]-[5], where the series impedance of the Schottky junction circuit is approximated by a single constant resistance. The SDD model has finally been introduced in the same ADS test-benches, linked with HFSS simulations, with which the frequency doubler and mixer used in [4] were designed and optimized.

This work has experimentally demonstrated that the implementation of the improved junction capacity model in HFSS-ADS simulations when including the approximation of the series impedance by a single constant resistance, is able to accurately reproduce the experimental results of a frequency doubler at 280 GHz as long as it works in a pure varactor mode. In addition, the good reliability of the LERMA-LPN fabrication process has also allowed us to identify a lack of accuracy of the LEC Schottky diode model when the diodes are strongly pumped by the local oscillator input signal. A non-pure varactor operation mode of the diodes has been remarked in these cases in which the second harmonic generation efficiency is a combination of the varactor and varistor operation mode. This work lays the basis for the improvement of the Schottky diode model based in the LEC model, necessary for correctly simulating the diodes in varistor operation mode in ADS-HFSS simulations.

References

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