Simulation of ferroelectric nonvolatile memory cells with MINIMOS-NT

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During recent years a special type of nonvolatile memory cells became more and more attractive, which takes advantage of the hysteresis properties of ferroelectric materials. To allow rigorous analysis of these devices several models were included into our simulator MINIMOS-NT, which allow a general transient two-dimensional simulation of arbitrary device structures.

MINIMOS-NT provides a rigorous approach to describe the static hysteresis properties of ferroelectric materials including the accurate modeling of subcycles [1] (Fig. 1). By now two different shape functions are implemented for the locus curves, based on *tanh* and *arctan*, respectively.

Two-dimensional simulation requires an algorithm that fulfills the geometrical and physical constraints especially in the context of field rotation. The algorithm implemented into MINIMOS-NT [2] is capable to serve this task both for isotropic and for anisotropic ferroelectric materials as well.

Increasing clock frequencies lead into a regime where the frequency dependence of basic material parameters like coercive voltage and remanent polarization can no longer be neglected. Simulation in the frequency regime would be numerically cheap, but leads to reduced capabilities in comparison with simulation in the time regime. Especially in the context of arbitrarily shaped signals and relaxation effects the rigorous approach of our simulator MINIMOS-NT is mandatory. By introducing three transient terms into the basic material equation, simulation of ferroelectric capacitors in a wide range of frequencies is now possible. Fig. 2 shows the simulation results for a capacitor

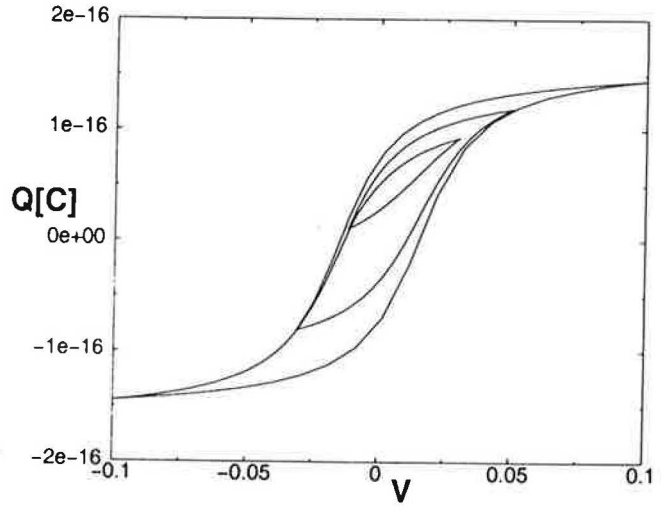

Figure 1: Simulated hysteresis including multiple subcycles

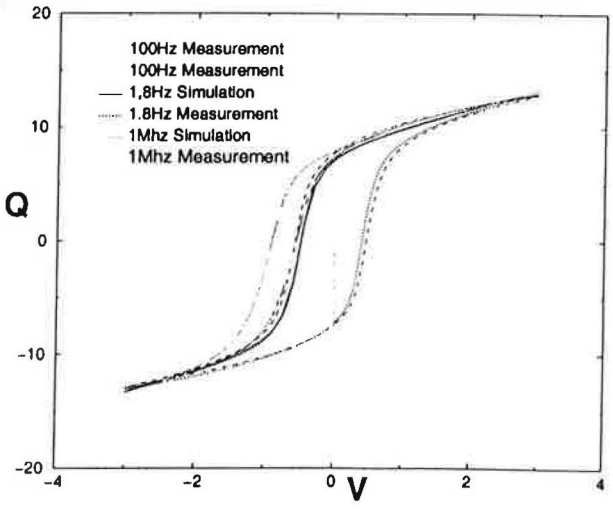

Figure 2: Q/V characteristics - Comparison simulation to measurement

and its agreement to measurements in a range beginning from 1Hz up to 1MHz. The application of the new simulation tool to circuit simulation is very promising. It can immediately be used for the extraction of specifications for the read and write cycles or the geometry of ferroelectric memory cells.

References

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[2] K. Dragosits, M. Knaipp, and S. Selberherr, »Two-Dimensional Simulation of Ferroelectric Nonvolatile Memory Cells«, in Simulation of Semiconductor Processes and Devices (K. D. Meyer and S. Biesemans, eds.), pp. 368 - 371, Leuven, Belgium: Springer, Sept. 1998.

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