SIMULATION OF FERROELECTRIC THIN FILMS

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The hysteresis properties of ferroelectric thin films open an elegant and promising way to build nonvolatile memory cells. Our basic goal is to set up a tool which is able to reproduce the macroscopic behavior of the devices by calculating current, voltage and charge at the contacts correctly. Simulation of domains needs device data like the impurity distribution which is usually not available and, furthermore, specific for one particular device. For our approach we set up the ferroelectric material as a homogeneous cluster of dipoles, each of them showing the macroscopic hysteresis properties.

Our tool, 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 shape functions for the locus curves are implemented, based on *tanh* and *arctan*, respectively. Recent developments lead to two-dimensional device designs, so the one-dimensional hysteresis model had to be generalized [2]. The remanent polarization components of former field directions are taken into account, respecting the fact that there is an upper limit to the number of dipoles as well. The generic implementation of our device simulator can handle both isotropic and anisotropic materials respectively. Additionally, we introduced three transient terms with physical meaning into the basic material equation making the simulation in a wide range of frequencies possible (Fig. 2).

The application of the new simulation tool to circuit simulation is most promising. It can immediately be used for the extraction of specifications for the read and write cycles or the geometry of ferroelectric memory cells.

[1] F.Preisach, "Über die magnetische Nachwirkung," *Zeitschrift für Physik*, vol. 94, pp. 277–302, 1935.

[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.

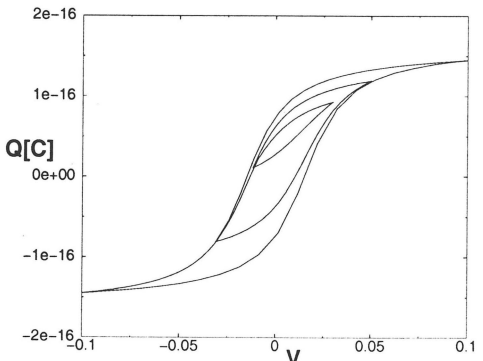

Figure 1: Simulated hysteresis including multiple subcycles

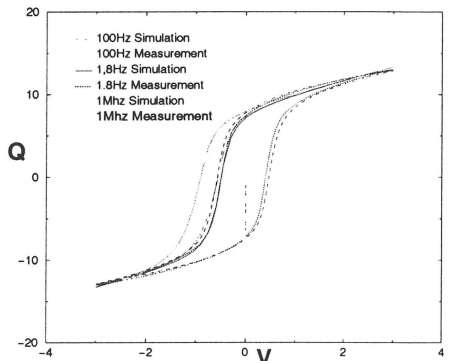

Figure 2: Q/V characteristics - Comparison simulation to measurement