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Thermodynamic Analysis of Semiconductor Structures Using a Device Simulator and Lumped Circuit Modelling

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Based on the implementation of coupled carrier and energy transport equations in a 2D object-oriented integrated package for device and process simulation, "TRENDY," electrothermal effects in semiconductor structures have been analyzed. The same approach is used for the analysis of (thermo) magnetic effects in semiconductor structures. The object-oriented approach has also made it possible to analyze, *e.g.*, ion transport in fluids for ISFET structures and stress calculations in IC-processing steps. In general the applicability of continuous domain simulation to sensors and actuators is discussed. For 3D electrothermal problems, a distributed lumped circuit modelling strategy has been examined.

1. Introduction

Traditional device simulation is concerned with the solution of the continuity equations and Poisson's equation, where fluxes introduce the effects of driving forces. Both types of equations are solved on a grid where, on each grid point, variables are determined (if a finite difference formulation is used), hence simulation is in a continuous domain. In a thermodynamic approach, driving forces can be considered to incorporate thermal, magnetic, optical and mechanical effects(1) (and energy flux and continuity equations must be added to the system). In ref. 2 these were in the form of additional equations, but a thermodynamic approach using the Onsager relationship will lead naturally to a set of consistent equations.(3)

In the literature there are many examples of device simulation packages/efforts where thermal and magnetic effects are included.(4-11) Modelling is usually successful if operating