2-D Steady State and Transient Simulation of Power Thyristors

G.A.FRANZ, A.F.FRANZ, S.SELBERHERR
Institut für Allgemeine Elektrotechnik
Abt. Physikalische Elektronik
TU Wien, Gußhausstraße 27, A-1040 Vienna, AUSTRIA

The optimum design of power thyristors requires the use of numerical analysis tools capable of simulating device behavior under various operating conditions. This paper presents a study of the steady state and switching behavior of a number of thyristor elementa. It deals with the sophisticated methods used for spacial and time discretization required by the high voltage/high current operating conditions and the results obtained thereby.

We use a "Finite Boxes"-approach for the spacial discretization which has been published recently /1/. Automatic set up and refinement of the grid by equidistribution of the local discretization error has been found an obligatory prerequisite for computing high voltage characteristics with a reasonable amount of computer resources. We use a backward Euler method for the transient solution of the semiconductor equations. For the time discretization an automatic time step control algorithm has been implemented. The new time step is calculated with a "predictor-corrector" method based on changes of the space charge in the device. Due to the possibly large variation of the solution (potential and carrier concentrations) during transient simulation it is necessary to introduce a "moving grid". This is accomplished by tracing the local discretization error which is equidistributed by deleting and inserting grid points.

We present a comprehensive set of simulation results for power thyristors : We compare 2-D planar and cylindrically symmetric structures. The influence of the geometry of the emitter contact areas (circle, ring, stripe) on the forward voltage drop is investigated. As an example of the transient analysis, the rate effect of two thyristor elements, one with an emitter shortcut and one without, is calculated. A ramp voltage U_a with 1000V/μs-slope is applied at the anode. The shorted device is not fired at the assumed dU/dt whereas simulations of the equivalent device without the emitter shortcut show firing after a time of 450ns corresponding to a voltage of 450V at the anode contact.

/1/ A.F.FRANZ et.al, IEEE Trans.Electron Devices, Vol.ED-30, No.9, pp.1070-1082 (1983).