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THE NUMERAL ANALYTICAL METHOD WITH THE DISTRIBUTED CALCULATIONS FOR THE ANALYSIS OF THE TEMPERATURE FIELDS OF FLIP CHIP STRUCTURE

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Abstract: *The numeral analytical method of analysis of the temperature fields of Flip-chip structures is described in the article. The problem of time reduction of the temperature analysis procedure of microelectronic device is considered. A problem is of current importance, since a problem of providing necessary temperature condition of device functioning is solved through frequent implementation of the temperature fields analysis. One of the effective methods of solving this problem is the use of the distributed calculations. The calculable chart of the temperature analysis method is described with the use of mechanism of the distributed calculations. The presented results of calculations specify on efficiency of application of the distributed calculations with a coefficient equal to 1,5.*

Keywords: *microelectronic devices, Flip-chip structure, mathematical model, distributed calculations.*

1. INTRODUCTION

For providing the required thermal behavior of microelectronic devices (MED) the effective methods and facilities of the thermal designing are needed. It causes the complication of mathematical models and methods, and that results in the increase of the machine time expenditure. Even rapid development of computer technics, namely the construction of more rapid numeric processors, is uncapable fully to solve this problem [1].

The task of providing necessary temperature condition comes to finding such values in enormous "space of parameters", which contains hundreds of thousands of various elements, at which the obtained values of temperature will not exceed allowed value. The analysis problem always can be solved with either one or another method, when there are all the necessary data for a calculation. As the matter of fact the task of forming of set of parameters, at which necessary temperature condition is provided, comes to sorting out of variants, i.e. solving this problem through the multiple analysis of the temperature fields [2]. Therefore a problem of the machine time reduction of the MED temperature analysis procedure is of current importance. One of the variants of solving such problem is the use of distributed calculations [3, 4].

2. THE TASK OF THE TEMPERATURE FIELDS ANALYSIS

The Flip-chip structure construction is considered here. MED of this class have a number of structural, technological and operating advantages, and that caused extraordinary distribution in modern microelectronics and their application in various devices.

The basic components of Flip-chip construction (fig.1) is a chip and sublayer, flat sources of heat, placed on the lower active area of chip, hard outlet. Outlets are distinguished by the geometrical form, the material they are made of, by a contact with the layers of sublayer and by the role in the process of heat taking. The type of outlets is determined depending on the depth of contact with sublayer. In the case of contact of outlets with the surface of sublayer it is talked about alarm outlets, in the case of penetration of column of outlets in the layers of sublayer – about structural outlets.

Mathematical model of the stationary three-dimensional temperature fields of multi-layered chip and sublayer is set as two edge problems of heat-conducting in the form of differential equations systems in the partial derivates of the second order (1) with edge conditions which modulate heat dissipation from the surfaces of construction structure (2)-(7). Between the layers of chip (sublayer) the conditions of ideal thermal contact are set (8). On the basis of

conditions of the thermal streams continuity through outlets, which link the areas of chip and sublayer, the system of linear algebraic equations is formed for the determination of powers of thermal streams through outlets from the chip area to the sublayer area [1, 4].

The algorithm of the temperature value calculation in the arbitrary point of the MED construction consists of four calculable procedures (fig.2). The first part of algorithm of calculable process has most calculable complication. In its turn, it is possible to distinguish 2 components: initialisation of matrix of the linear algebraic equalizations system (8) and solving of the system by the Gauss method. Every element of the matrix is calculated independently of each other and is determined by the input data which describe a construction.

Each element of matrix is the result of calculation of expression from the sums of the trigonometric Fourier series with 80 members of row. For this reason a calculation of elements of aij needs a lot of time.

Thus, the amount of hard outlets of model constructions sets necessary requirements in resources for the analysis of the temperature fields.

3. THE APPLICATION OF THE MECHANISM OF THE DISTRIBUTED CALCULATIONS

One of the problems of temperature calculation for the above-described construction is the duration of calculation of powers of calorification through outlets. The process of initializing of matrix of the linear algebraic equations system for finding unknown powers takes 85% from the general volume of calculable process.

As elements of matrix A are calculated independently of each other, initialization of lines of matrix A is selected for the distribution of calculations. The problem of initialization of the whole matrix A is the unique calculation process for the system of the distributed calculations. The calculation of lines of matrix A is the calculation subprocess (subgoals). On these bases the algorithm which takes into account the application of the distributed calculations is created (fig.3).

The offered system of calculations distribution for the temperature analysis of MED with a Flip-Chip consists of three constituents – subsystems which have the different functional preordination: the subsystem of analysis of calculable analysis, the subsystem of construction of the distributed calculations, the control subsystem (fig.4).

The basic criteria for the construction of parallel processes are time characteristics of the calculation process or the amount of operations [3, 6]. The subsystem of the calculation process analysis conducts the preliminary analysis of the calculation process and the analysis on presence of parallel operators. The subsystem of construction of curriculum of parallel calculation conducts the choice of operators (here operator is understood as a part of the program module, subprogram, cycle etc.), choice of network computers and carries out its basic function – distribution of tasks. At distribution of tasks for network computers the fast-acting of these computers and time of information exchange between computers are taken into account.

The third subsystem is a control subsystem of the calculation process. This subsystem has the following functions:

- to control the distributed tasks by queries to the network computers. At the loss of control of the calculation task on one of the computers, the control subsystem must appeal to the subsystem of the parallel calculation process construction to conduct replanning;
- to control network computers, namely the support of connection channels between computers;
- to switch to the next step of the calculation process only after completion of all of the distributed tasks;
- to verify the results accuracy and correctness.

One of the main requirements for the designed system of calculations parallelization is distribution of tasks between computers which are connected in a local and global network, which work on the different multitask operating systems. Therefore it was necessary to choose the mean for organization of data exchange between remote computers, which is universal for different multitask operating systems. One of such systems is network interface library of Windows Sockets. The programming system Microsoft Visual C++ was used for program realization of the system.

The research of application efficiency of the distributed calculations system (tablet. 1) was conducted for the calculation of different structural models on one local and on two network computers, which have the identical productivity with the processor of Athlon-2,20 GHz.

Introduction of calculations parallelization for the design of the temperature fields of Flip-chip allowed to decrease time expenses of calculation on 30% and to confirm efficiency of application of the system of calculations parallelization for the thermal planning of MED.

4. CONCLUSIONS

With the purpose of time reduction the system of the distributed calculations has been built for the analysis of the temperature fields of Flip-chip. The distributed calculations system works on network computers. Application of the distributed calculations for the analysis of the MED temperature fields with a chip on hard outlets allowed decreasing the machine time expenses on 30%.