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Multiobjective Optimum Design for IC Fabrication Process

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Abstract

A new multiobjective optimization algorithm coupling the reference point method and the modified filled function method is presented to pursue satisfactory global Pareto-optimal solutions. An illustrative example of IC process design shows the satisfactory compromise of each objectives.

I. Introduction

The design optimization for IC fabrication process is to get a whole set of process parameters to have each device parameters (as objectives) optimized simultaneously. However, it usually can not be done since some objectives may be conflicting each other, that is, the further improvement of a objective may deteriorate some other objectives. So it is faced with making tradeoffs among these mutually conflicting objectives. This paper tries to solve this problem by using a powerful mathematical tool, the multiple objective optimization (MOO) approach.

II. Multiobjective Optimization Algorithm

The IC process design optimization problem can be formulated as an MOO problem by assigning the process parameters as the variables and the required device parameters as the objectives. The best result that one can get is a set of noninferior solutions called Pareto-optimal solutions, in which any component of the solution can not be further improved without sacrificing one or more other components.

The new MOO algorithm proposed by us is based on the reference point method and the modified filled function method. The modified filled function method is a globally convergent single objective optimization algorithm which converts the global optimization problem into a series of local optimization problems of the objective function and an auxiliary function[1,2]. The reference point method proposed by Wierzbicki[3] in the late seventies is one of the most promising MOO approaches because of its strong mathematical basis and because problems are solved directly with user's aspiration levels of objectives (i.e., the point in the objective space which called the reference point) without any subjective choices of weighting coefficients. It employs an achievement scalarizing function to find from within the Pareto-optimal solution set the satisfactory Pareto-optimal solution "nearest" to the reference point. Reference points can be chosen by the user interactively to obtain satisfactory Pareto-optimal solutions. Thus, it may be viewed as a way of guiding a sequence of Pareto-optimal solutions generated from a sequence of reference points. A new achievement scalarizing function and a new interactive procedure to change reference point are proposed to make the reference point method become much more convenient and efficient[2].

The procedure of this new algorithm can be briefly stated as follows[2]. At first, choose a reference point according to user's satisfaction, maximize the achievement scalarizing function by using a local optimization algorithm to obtain a local Pareto-optimal solution. Then, assign the solution as the reference point and guide it to a better local Pareto-optimal solution (if it exists) by maximizing the achievement scalarizing function using the modified filled function method, and this procedure repeats until a satisfactory global Pareto-optimal solution is obtained.

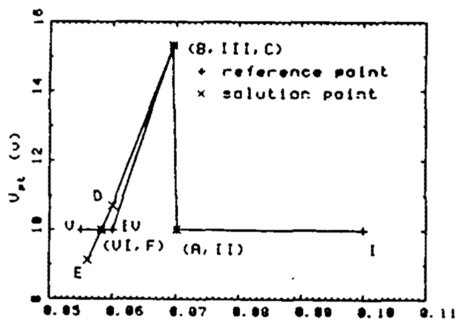
III. An Example of IC Process Optimization

Following is an illustiative example of IC process optimization problem . The two objectives are the substrate modulation coefficient γ_s and the source-drain punch-through voltage V_{pt} of a short-channel enhancement nMOS-FET. The three design variables are the doping density of the substrate N_{sub}, the source/drain junction depth X_j, and the thickness of gate oxide T_{ox}. The effect of these variables on the objectives are shown in the following table.

	N_{sub} ↑	X_j ↑	T_{ox} ↑	desired trend
γ_s	↑	↓	↑	smaller
V_{pt}	↑	↓	↓	larger

Table   Effects of variables on objectives

The procedure to get a satisfactory global Pareto-optimal solution is shown in the figure. The sequences of reference points and the corresponding local Pareto-optimal points are {I, II, III, IV, V, VI} and {A, B, C, D, E, F}, respectively. The initial reference point I is at (0.1, 10). The corresponding solution point A is a satisfactory local Pareto-optimal point since it is better than point I. Point II and point A are the same point. It is guided to a better local Pareto-optimal point B, which is a satisfactory global Pareto-optimal point with V_{pt} equals to 15.31 v and minimum γ_s. If only 10 v is needed for V_{pt}, the reference point component of V_{pt} can be fixed at 10 v to get better γ_s. Finally, the satisfactory global Pareto-optimal point F with V_{pt} equals to 10 v and minimum γ_s is obtained.



γ_s $(v^{\frac{1}{2}})$

Figure Procedure to obtain a satisfactory Pareto-optimal solution

IV. Conclusions

IC process design optimization can be realized via the application of the global multiobjective optimization method. Tradeoffs among conflicting device characteristics can be made satisfactorily to achieve optimum design.

References

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