A VE COST-SAVING METHOD FOR SEMICONDUCTOR PRODUCTS USING THREE FUNCTIONAL PARAMETERS

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ABSTRACT

Aimed at the aspects of the semiconductor production process that hamper ready application of VE technique, we propose a new VE approach to improving the "upstream" manufacturing process of "the materials for semiconductor production." This approach should be meaningful when the greatest portion of semiconductor manufacturing cost at present is the materials, rather than the process costs.

To reduce such material costs, we developed a method of using three functional parameters... Weight Cost(yen/gram), the reciprocal of yield (1/yield) and unit material cost per product (yen/piece) ... so as to derive required cost data. Depending on the conditions of material use, we may consider a combination of other parameters.

A MOTIVE FOR DEVELOPING THIS VE TECHNOLOGY

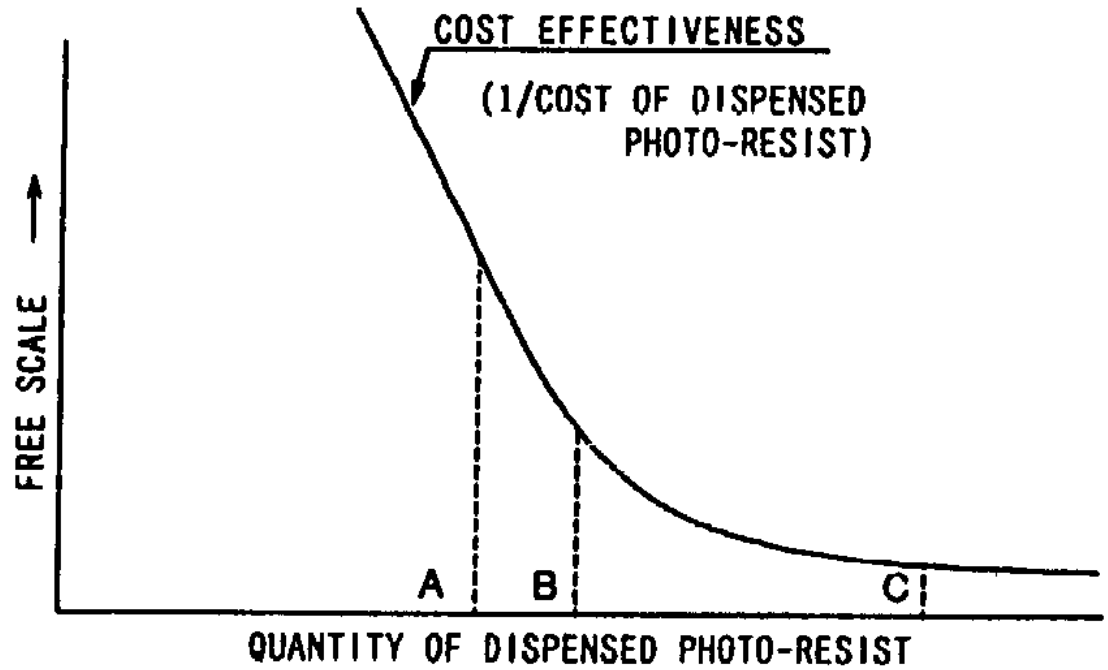
When we watch carefully the semiconductor wafer (chip) manufacturing process, the losses of materials for the production are greater than that of other industries, in spite of using expensive materials such as photo-resist, sputtering materials and special gases. The motive for developing this approach was to eliminate loss of materials used under such conditions and to motivate process engineers, who are responsible for elimination of loss of material costs, by numerical index.

RELATION BETWEEN PRODUCT YIELD OR COST EFFECTIVENESS TO MATERIAL CONSUMPTION

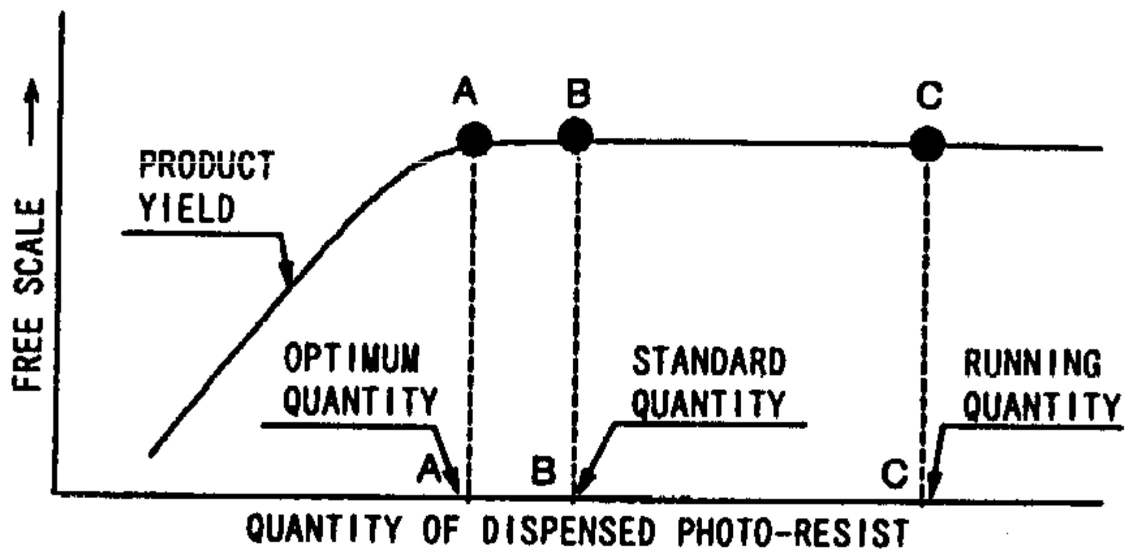
Fig.1 shows product yield and cost effectiveness of photoresist to the quantity of dispensed photoresist.

There are three dots A, B and C. Dot A means optimum point that is critical corner not to degrade product yield, dot B means standard quantity specified and dot C means running quantity.

Generally dot A and B have the same value, but more often these will be set to dot C to get process margin. Actually it is very difficult to decide optimum quantity, but usually we decide it from viewpoint of equipment performance and process specification.



(a) MATERIAL SPENT TO COST EFFECTIVENESS IDEAL CURVE



(b) MATERIAL SPENT TO PRODUCT YIELD IDEAL CURVE

(An Example of Photo-resist Coating Process)

FIG.1 MATERIAL SPENT TO YIELD OR COST EFFECTIVENESS IDEAL CURVE

In eliminating losses of material it is better to treat standard quantity as optimum quantity. The effectiveness of this VE technology will be dominant in saving material costs of these types.

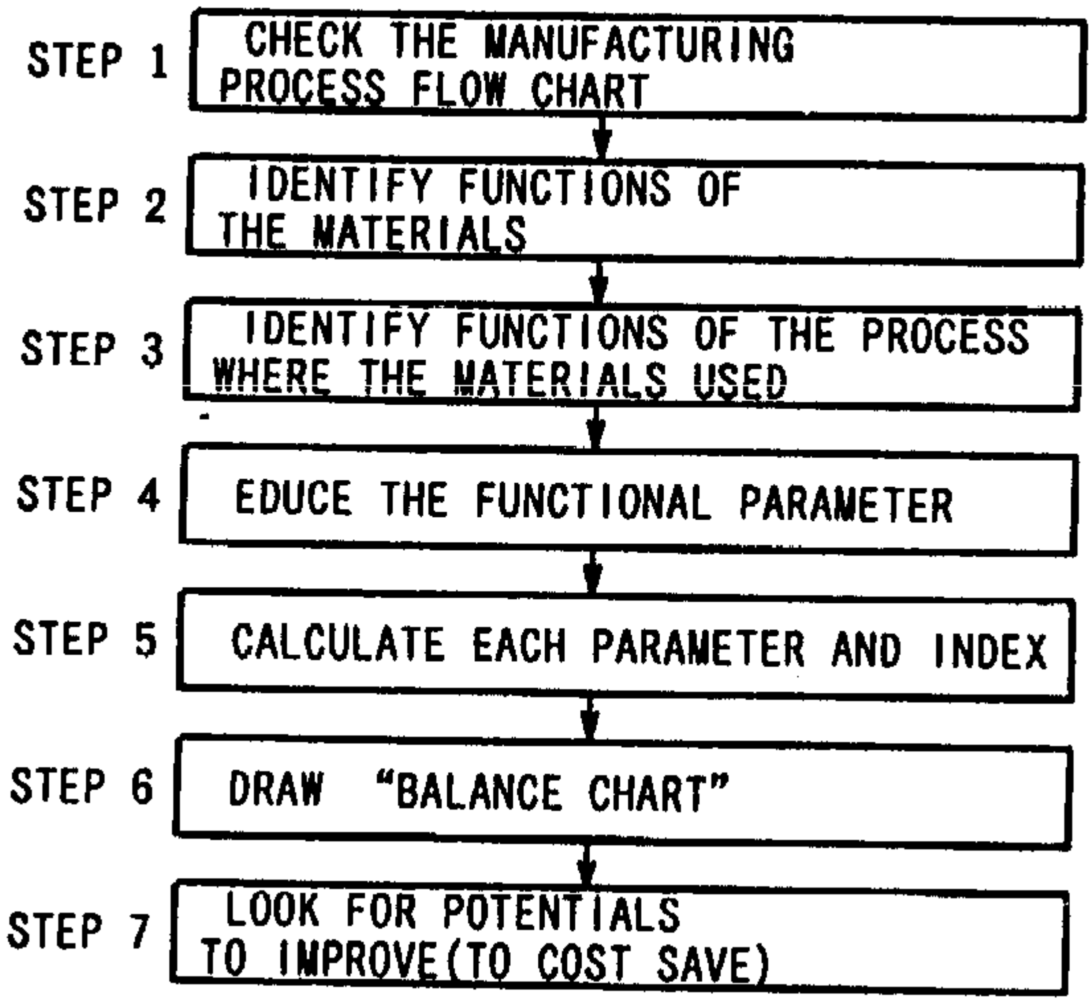


FIG.2 JOB PLAN FOR DETECT POTENTIAL TO IMPROVE

VE JOB PLAN

Fig. 2 shows VE job plan potentiality to find the loss. There are 7 steps in this job plan. Each step generates questions to be checked by answers as follows:

STEP 1 Check the semiconductor manufacturing process flow chart.
Question: At which process will the material be used?
Ans. Photo-lithography process.

STEP 2 Identify function of the materials.
Question: Why use this material ?
Ans. To give conducting function to each element formed on wafers.

STEP 3 Identify function of the manufacturing process where the material will be used.
Question: What is the purpose of the process? (Define basic and secondary function).
Ans. Basic function - to coat photoresist on the wafer (to get circuit function). Refer to fig. 3.
Secondary function - to form wiring patterns between elements.

STEP 4 Educe the function parameter.
Question: What is the means to quantify the function?
In this case we define the function translated into the measurable noun as "means to perform function". This is preparing process for deducing functional parameter in next. Then we select the most important parameter for measure of cost losses and define it "the functional parameter". In fig. 3 there are some relations among quantity to be purchased, quantity to be spent and optimum quantity. If the purchased materials were used 100% the following is given.

[Quantity of purchased materials]=[quantity of used material] and [Quantity of used materials]-[optimum or standard quantity]= [quantity to be wasted]

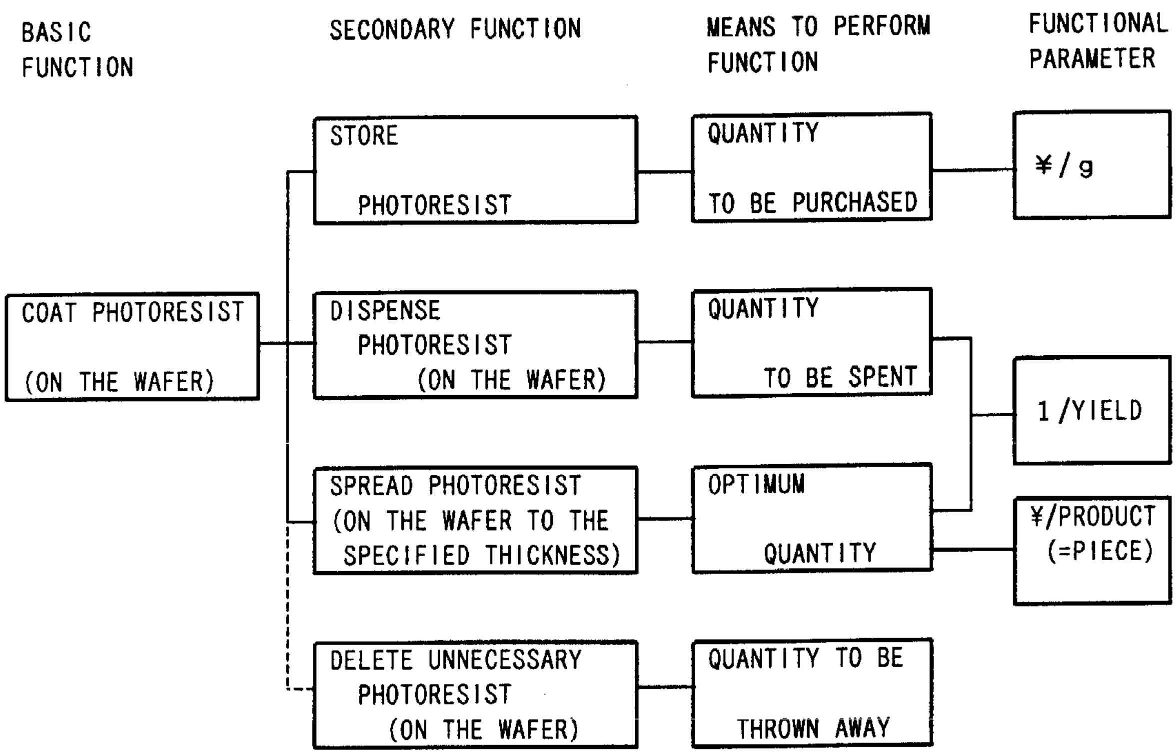
Ans.:

(i) ¥/g (Material cost of unit weight at purchasing) ---representing purchasing cost.

(ii) ¥/yield(Loss rate of the material at process)

(iii) ¥/piece(Material cost attached or used effectively to a product)

In our case (fig. 3) we selected three functional parameters as measures.



(EXAMPLE;RESIST COATING PROCESS OF PHOTO-LITHOGRAPHY)

FIG.3 AN EXAMPLE OF IDENTIFYING THE FUNCTIONAL PARAMETERS

(1) Parameter for quantity to be purchased; ¥/g.

Purchasing cost [yen] per [g] (¥/g) which is common unit to all kinds of materials.

(2) Parameter for quantity to be spent; 1/yield

We define the rate of effective material used as yield. Yield=(optimum quantity)/(quantity to be used) The potentiality of losses will be expressed as [1/yield]

(3) Parameter for optimum quantity; ¥/piece

Effective material cost will be considered the materials to be used effectively or attached to products. We define this "optimum quantity (fig. 1) and expressed this as [¥/piece]

STEP 5 Calculate the index from functional parameters. Now we can get the index for potentials to improve material cost through three functional parameters. Definition of [index] is: Index = (¥/g) x (l/yield) x (¥/piece)

Table 1 shows examples of some semiconductor materials.

TABLE 1 THE PARAMETERS AND INDEX TO COST SAVING

MATERIALS & PARTS / PARAMETER	A	B	C		D	E	F	G	H	J	K
			MAX	MIN							
¥/g (X)	12	46	12.4	5.2	0.3	413	220	2.3	0.5	0.7	1096
1/YIELD (Y)	250	200	1.4	1.4	6.0	1.0	1.5	4.2	2.5	11.8	1.0
¥/PIECE (Z)	1.6	5.1	10.7	7.8	0.8	0.6	14	5.7	1.1	0.4	0.8
INDEX (XxYxZ)	4800	49650	190	58	3.0	236	4620	55	1.2	3.3	912
POTENTIAL TO COST SAVING	2	1	6	7	10	5	3	8	11	9	4

STEP 6 Draw "Balance chart" To get visual understanding. We reformed this index to "Balance chart". In fig.4 three axes (X, Y, Z) represent three functional parameters (¥/g, ¥/piece, l/yield) and each figure shows the plots of table 1.

STEP 7 Look for potentials for VE to improve.

(1) Ranking the materials for larger potential for improvement.

In table 1 we considered that larger values of index show larger potential for cost losses to the materials. In other words larger index values would have larger potential for VE (cost down). So we ranked the materials as shown in the table 1.

One of the distinctive point of this technology is to get ranking of the materials from the potentials for VE. For example, in the conventional approach we ranked the materials for VE from the point of volume or numbers purchased. But in this method rank would be changed frequently.

(2) To get direction for VE to improve. In fig.4 "magnitude (length) from zero", and also "body formed by three triangle" in each axis shows potential for VE to improve cost. For example, when we watch "balance chart" A (Fig.4), sharp angle and its parameter with big magnitude (1/yield) indicates the direction having high priority for VE. Magnitude "250" shows that the material is spent 250 times as much as optimum quantity.

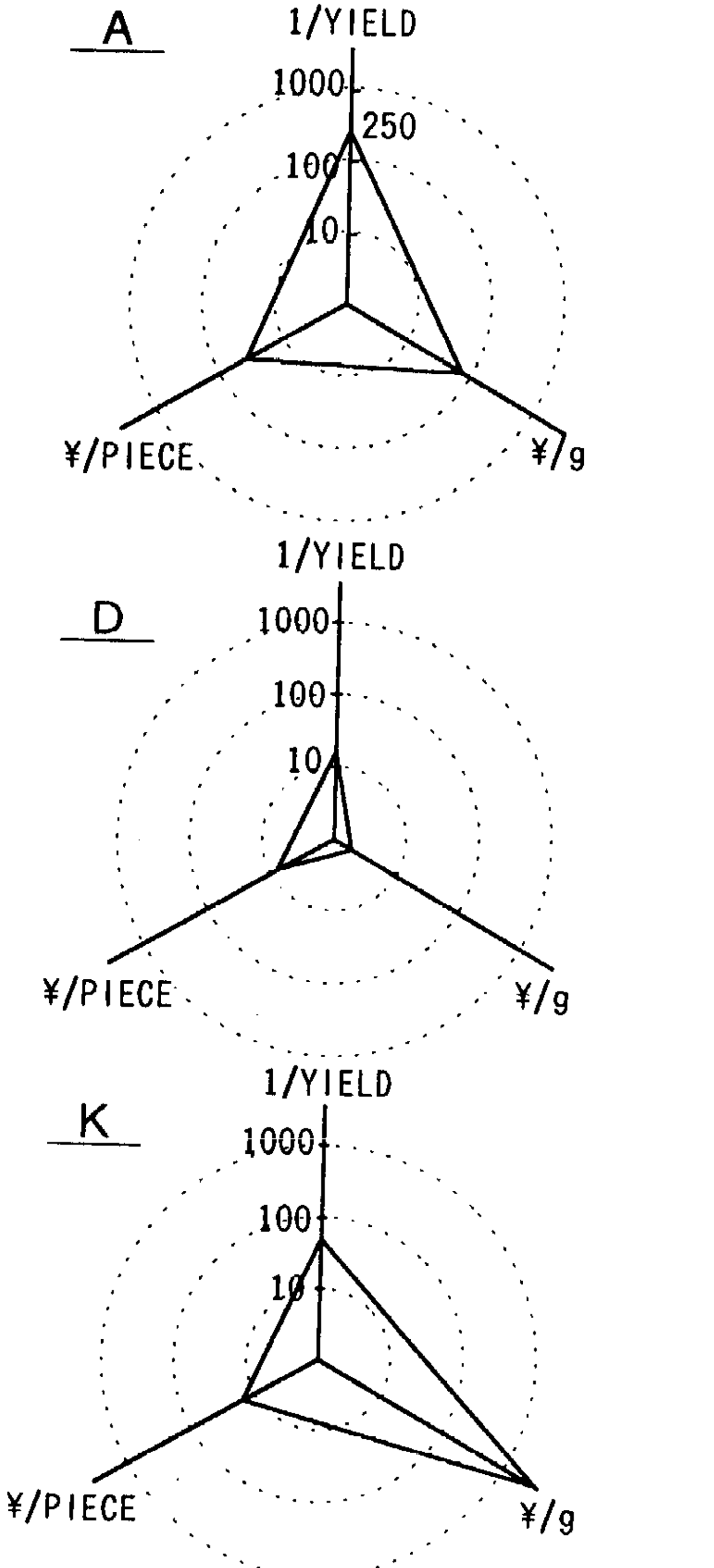


FIG. 4 BALANCE CHART FOR EVERY MATERIALS

Potentials for VE to improve will be found by such a method. But to proceed to the next creativity step efficiently we prepared a check list not shown on this paper.

AN EXAMPLE OF APPLICATION (SAVING OF PHOTO-RESIST)

In photo-lithography processes we disperse photo-resist on wafer to form thin photo-resist film. But most of the dispensed photo-resist was wasted because of spin-dry method, and "Index" was 4700. We picked up this material for VE to eliminate and analyzed the coating process with process engineer to develop a new coating process. The new coating system includes changes of r.p.m.", timing of the dispersal and reconstruction of the photo-resist coat.

By this approach we can reduce "Index" to 1/3 of the original values.