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OPTIMIZE THE PROCESS OF SLICING OF SILICON WAFER WITH NEURAL NETWORKS AND DETERMINATION OF CUTTING FORCE

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Abstract: *This article proposes a method to optimize slicing proces of silicon wafer with neural networks. Slicing process is analyzed as a grinding process of both the initiation phase and all stages of this. On the ather hand, this paper contains a methodology to calculate cutting force during slicing process based on slicing power consumtion.*

Key words: *slicing, networks, cutting, grinding, power*

1. INTRODUCTION

ID slicing is an abrasive grinding process. Slicing is one of the most critical operations in processing of semiconductor materials.

To optimize a technological system, the previous evolution of this process must be known and discovered, by means of extrapolation, the future evolution of this process. This activity presents the following problems:

- The variability of the solutions, to function below optimum, is very high, and in many unlimited cases;
- The novelty and the character often unexpected, unpredictable, of the problems.

Regardless of the chosen process, the first phase is a correct view of the problem.

2. THE PROCESS OF SLICING AS A SYSTEM

Slicing with diamond wheel, as any abrasive process, is influenced by the: abrasive, slicing machine, slicing material and/or operational variables. All these interact between them, then result the slicing process which are described in figure 1. We also described it in Fig. 1.the I/O of the „system" of the slicing process. The optimized slicing regime is another element of a normal running in the slicing process. As it can be changed freely even during the slicing process, optimization can be realized off-line (outside the slicing process), thus using structured data, as well as on-line (during the slicing process), in which case both unstructured data (adaptive systems) and structured data (diagnosis systems) can be used.

3. OPTIMIZING BY MEANS OF NEURAL NETWORKS

The characteristics of the slicing machines such as:

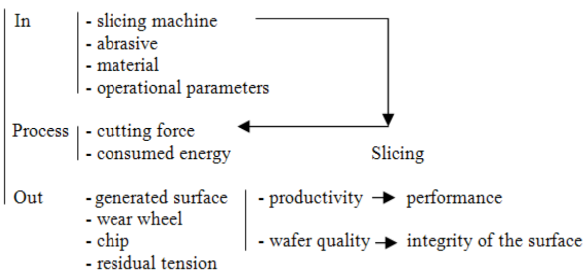

Fig. 1. The system of the slicing process

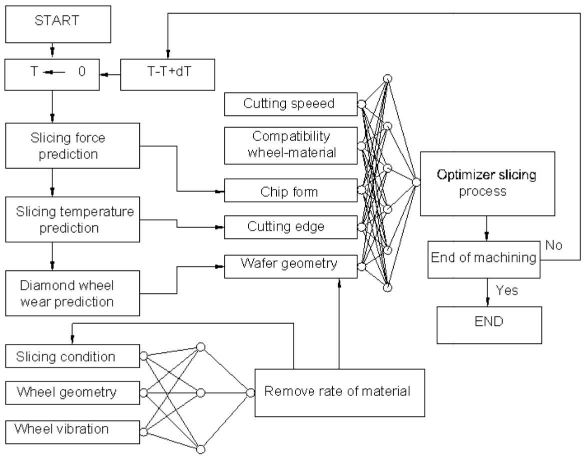

Fig. 2. The neural network used for optimizing the slicing process

cutting force, thermal deformation and main shaft vibrations, all these have a major influence in the slicing process.

Power and kinematics of the machine are most important in evolution of the slicing machine characteristics.

There are two points of view regarding the characteristics of the slicing machines.

One is based on the influence of the structure and components of a slicing machine. This depends on the design of the slicing machine.

The other point of view is based on the influence of the characteristics of the slicing machine on the slicing process, characteristics such as: the wear of diamond wheel, the resulted surface and main shaft vibrations (Fig.2.).

4. DETERMINATION OF CUTTING FORCE DURING SLICING PROCESS BASED ON SLICING POWER CONSUMTION

At the level of grain, while material removal process, one can distinguish three phases including: 1- friction, 2- fragmentation and 3- cutting chips (Fig. 3.).

When the grain is committed to cutting on the workpiece surface, it will slide involving the elastic deformation of the system, this phenomenon occuring in the friction phase.

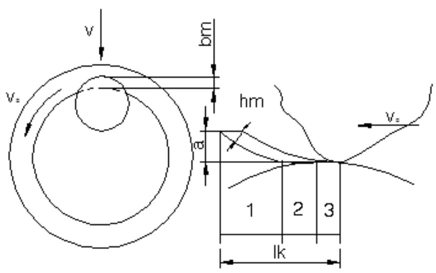

Fig. 3. Chip formation process

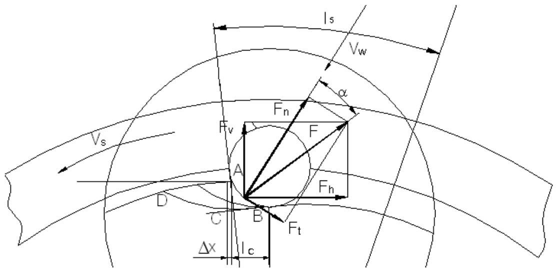

Fig. 4. ID slicing scheme

V- cutting speed is the peripheral cutting edge speed of the granules and can be calculated with the help of this mathematical formula:

$$V = \frac{\pi \cdot D \cdot n}{60 \cdot 1000}\,[m/s] \quad (1)$$

Where: D - the diameter of the diamond wheel [mm]; n - the speed of the diamond wheel rotation [rot/min];

The speed-act to a single diamond wheel rotation is determined by V_w:

$$s_r = \frac{1000 \cdot V_w}{n}\,[mm/rot] \quad (2)$$

Feed rate on grain can be determined as the ratio between speed-act to a complete rotation of the diamond wheel and the number of grains per unit area of contact length “C”.

$$s_c = \frac{s_r}{C} = \frac{1000 \cdot V_w}{n \cdot C}\,[mm] \quad (3)$$

$$s_c = \frac{1000 \cdot V_w}{n \cdot N_{gce}^{3/2}} = \frac{1000 \cdot V_w}{n \cdot [N_{gc} \cdot W_{gc}]^{3/2}}\,[mm] \quad (4)$$

Where: N_{gce} - the number of abrasive grains per unit volume; N_{gc} - the number of abrasive grains per carat or per unit weight; W_{gc} - abrasive grain weight corresponding unit volume of grinding wheel; V_w - the feed rate of diamond wheel; s_c - feed rate on grain.

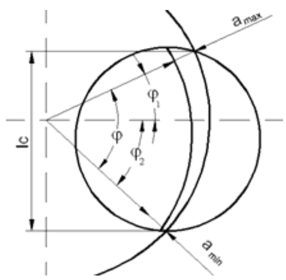

Fig. 5. The thickness of the chip

The speed-act on the thickness of the chip is (Fig. 5.):

$$a_m = (a_{max} + a_{min})/2 \quad (5)$$

$$a_m = \frac{s_c \cdot cos\varphi_1 + s_c \cdot cos\varphi_2}{2} = \frac{s_c(cos\varphi_1 + cos\varphi_2)}{2} \quad (6)$$

Considering specific mechanical work necessary for slicing we can write cutting force in the following form:

$$F_{as} = \frac{L}{b \cdot a_m} \quad (7)$$

Where: L - specific mechanical work of slicing; b – the width of cutting is equal to the bulge of the diamond wheel; a_m - the number of abrasive grains per unit volume.

Specific mechanical work of slicing is given by this formula:

$$L = P \cdot t \quad (8)$$

Where: P - power consumption.

$$V = \frac{l_c}{t} \Rightarrow t = \frac{l_c}{V} \quad (9)$$

Considering the relations (7), (8) and (9) one may reach to a formula of cutting force on grain, on theat form:

$$F_{as} = \frac{P\frac{l_c}{V}}{b \cdot a_m} \quad (10)$$

Entering into the formula (7), relations (4) and (6) one may obtain:

$$F_{as} = \frac{2P \cdot n \cdot l_c [N_{gc} \cdot W_{gc}]^{3/2}}{V \cdot b \cdot (cos\varphi_1 + cos\varphi_2) \cdot 1000 \cdot V_w} \quad (11)$$

Arranging equation (11) and defining “k” as the cutting angle factor, result:

$$F_{as} = \frac{P \cdot n \cdot l_c [N_{gc} \cdot W_{gc}]^{3/2}}{1000 \cdot V \cdot b \cdot V_w} \cdot k \quad (12)$$

$$k = 2/(cos\varphi_1 + cos\varphi_2) \quad (13)$$

5. CONCLUSION

The method of optimization by means of neural networks can be applied on adaptive command machine or with a diagnosis system. Slicing regime (characterized by: slicing speed, feed rate and the depth of chip) represents the imput element in the system thatvcan be modificated. This is a parameter which helps to optimize the slicing process. The cutting force, the power and the energy all these are variable in time because of the mechanical phenomenons which that happen and due to the wear of diamond wheel. Obtained formula has the advantage that: power consumption can be measured during the process and thus may lead to choosing the optimal parameters of cutting process and the calculation of cutting force.

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