Improvement of zone control induction heating equipment for high-speed processing of semiconductor

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IMPROVEMENT OF ZONE CONTROL INDUCTION HEATING EQUIPMENT FOR HIGH-SPEED PROCESSING OF SEMICONDUCTOR

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Introduction

Due to the high efficiency, precise control, rapid heating and low pollution properties, the induction heating is widely used in the industry. In order to process a semiconductor of high quality, a uniform heating is necessary, but it is not easy to heat uniformly by using the conventional induction heating equipment.

In order to realize uniform heating, it is necessary to supply the electric energy uniformly to the graphite. When only one exciting coil is used in the induction heating, the temperature in the graphite cannot be controlled. Then, a new technique called as zone control (shown in Fig. 1) is introduced. In the technique, the exciting coil is divided into several small coils and each coil is connected to an independent power supply of high frequency, and the current and frequency in each coil is controlled to realize uniform heating. However, there may be no report about the optimization of the current and frequency for uniform heating.

In this paper, the effect of dividing into several small coil groups having differnet current and frequency on heating characteristics is investigated using FEM (finite element method). The heating characteristics of graphite of each coil is examined, and a useful information for controlling current and frequency, which realize the nearly uniform heating, is obtained.

Zone Control Induction Heating Equipment

Fig. 2 shows an analyzed model of zone control induction heating equipment. The heating coil is divided into eight zones where the high frequency inverters are connected. The graphite is set just under the excitation coils and is heated by eddy losses produced by the exciting coils. The graphite is divided into eight regions (p_1 - p_8) as shown in Fig. 2. The currents and frequency in the eight exciting coils are changed in order to obtain the uniform distribution of the eddy current loss in graphite. The eddy current is taken into account in the graphite, wafer and exciting coils.

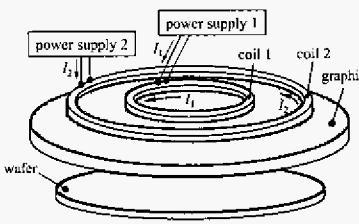

Fig. 1 Induction heating equipment with zone control.

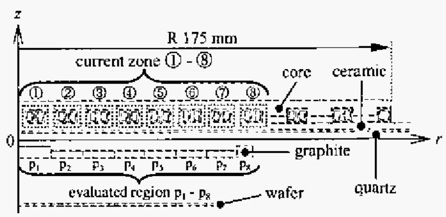

Fig. 2 Analyzed model.

Results and Discussion

Fig. 3 shows the flux distribution when the same current and frequency are impressed in all coils. The flux density at the end of the graphite is high due to the skin effect. Therefore, the eddy current loss is not uniform.

Fig. 4 shows the distribution of eddy current loss when only one coil is excited. The frequency of coil 1 (inner part) (200kHz) is increased compared with those of other coils (40kHz), because the eddy current loss density is considerably samaller than other part. But, the distribution of eddy current loss is not uniform. The eddy current loss under coil 2 can be increased by changing the frequency of coil 2 to 150 kHz as shown in Fig. 5. Fig. 5 suggets that the distribution of eddy current loss can be improved by changing the frequency especially of inner coil (such as coil 2).Fig. 6 shows an example of obtained distribution of eddy current loss of twelve zone control induction heating equipment.

The detailed results when both current and frequency are changed will be shown in the full paper. If the induction heating technology can be improved by using magnetic field analysis discussed here, it will contributie to the development of the industry in this field.

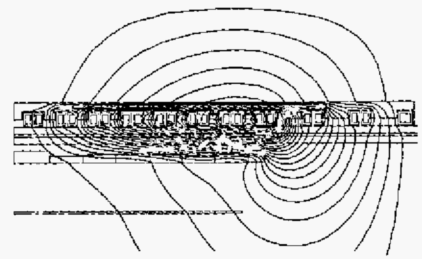

Fig. 3 Flux distribution when the same current and frequency are impressed in all coils.

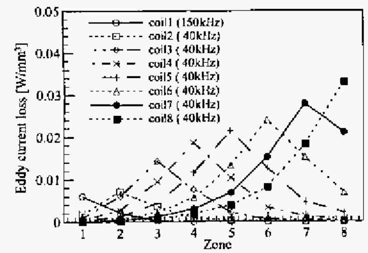

Fig. 4 Distribution of eddy current loss when only one coil is excited.

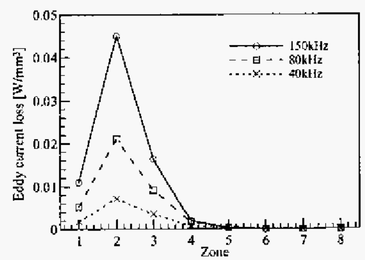

Fig. 5 Distribution of eddy current loss by changing the frequency of coil 2

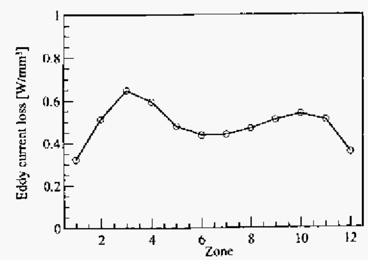

Fig. 6 An example of obtained distribution of eddy current loss of 12 zone control IH.

References

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