Vibration Reduction of Spin Etcher

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1. Introduction

Spin etcher can process frontside and backside on the wafer, which is used for etching, stripping, cleaning and wafer reclamation. A new generation of spin etcher has been designed to meet 300mm wafer processing. The larger header and higher spin speed make vibration problem a severe problem in developing equipments. The pratical researches have studied methods of reducing the vibration in semiconduct equipments[1]. In most researches, they tried to identify the principal causes through field tests, such as, spectum analysis and modal test[2,3].

This study shows schematic process of solving practical vibation problems, where it is required to analyze the principal causes of vibration problem and find out the method of vibration reduction in spin etcher. The vibration under normal operation is measured in time domain and is analyzed in frequency domain. And modal parameters are obtained thruough modal test. Using the modal parameters from experiments, the model of finite element method is formulated. From diagnosis using many measurements and analyses, it can be shown that main cause of vibration is unbalance of head.

2. Investigation of system condition

Fig. 1 shows the structure of spin etcher, which consists of a head, a DC motor, nozzle and frames. Vibration problem of a head should be investigated to have the better performance of uniform coating and ething processes on a wafer.

2.1 Vibration measurement

In order to investigate the vibration level and pattern under normal operation, accelerations at several points are measured and analyzed as shown in Fig. 1. Table 2 shows the change of vibration level as spin speed varies. It can be shown that there is no resonance during operating rotation.

Fig. 2 shows auto-spectum of vibration acceleration measured on the bearing of rotor including a head. Vibration energy in frequency of rotating speed (1250 rpm) is even larger than that in other frequency. From spectrum pattern, unbalance may be expected to be one of main causes. Thus unbalance of rotor system are calculated, which is more than specification presented in handbook[4].

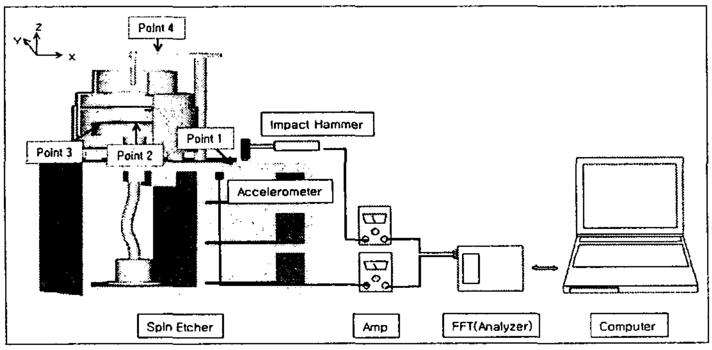

Fig.1 Schematic Diagram of Experimental Setup

Table.1 Position & Direction of Measurement

	Position	Direction
Point 1	Base	Z
Point 2	Protection of Case	Y
Point 3	Protection of Case	X
Point 4	Case of Rotor	X
Point 5	Case of Motor	X

Table.2 Acceleration of Vibration for Speed

Speed (Rpm)	Vibration Level of Measurent Point			
	Case of Rotor : X		Base	
	Max	Min	Max	Min
0	0.04	-0.0	0.01	0.003
1000	0.04	-0.04	0.02	-0.01
1100	0.05	-0.05	0.03	-0.01
1200	0.07	-0.06	0.03	-0.01
1300	0.07	-0.06	0.03	-0.01
1400	0.07	-0.05	0.03	-0.02
1500	0.06	-0.06	0.04	-0.02

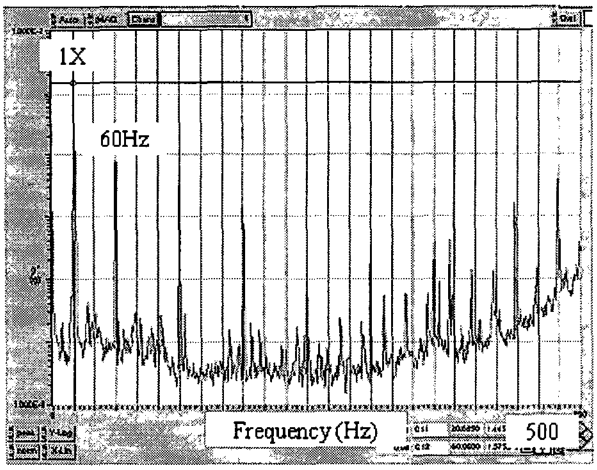

Fig.2 Auto Spectum : Point 4

2.2 Modal Test

In order to investigate dynamic characteristics of rotor system, modal test is carried out as shown in Fig. 3. Since operating equipment at factory is difficult to be disassenbled, measurement points are limited. Thus, by combing numerial results of finite element method, natural frequencies and mode shapes are identified as shown in Table 4. It can be shown that stiffness of rotor system is sufficient to increase current rotating speed by two or three times. Increasing speed is required to have the better manufactue performance.

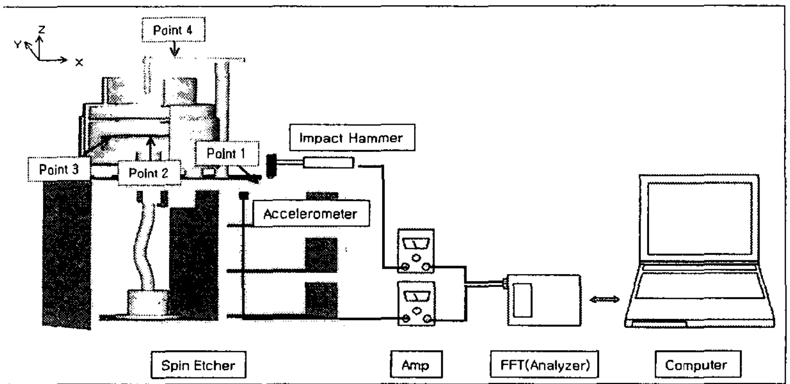

Fig.3 Schematic Diagram of Experimental Setup

Table.3 Position of Measurement

	Sensor	Impact Hammer
Point 1	Base	Base
Point 2	Spin Head	Spin Head
Point 3	Spin Head	Spin Head (90° Trans.)
Point 4	Nozzle Arm	Nozzle Arm

Table.4 Result of Modal Test (Hz)

Mode	Base	Spin Head	Spin Head (90° Trans)	Nozzle Arm
1st	250	150	150	400
2nd	350	370	400	

2.3 Resoance of belt

Compared with conventioanl spin etcher, rotor driving mechanism changes from direct coupling to belt. Thus the effect of belt on vibration should be investigated whetcher belt vibration is main cause or not. In general, fundamental excitation frequency can be estimated, in case of belt with one connetion travelling between rotors with different diameters D, d (D≥d), as follows:

$$f_{belt} = v \times D \times \frac{\pi}{L} \tag{1}$$

$$L = 2c \times 1.57(D + d) + \frac{(D - d)^2}{4c}$$

Here

f_{belt}: frequency of belt v: speed of pulleys

L : length of belts   c: distance of center

Consider belt as travling string with tension T and hinge boundary conditions as

$$\rho\frac{\partial^2\omega}{\partial t^2} + 2v\frac{\partial^2\omega}{\partial\omega\partial t} - (T - \rho v^2)\frac{\partial^2\omega}{\partial x^2} = f(x,t) \tag{2}$$

Table 5 shows excitation frequencies at maximun spin speed. Even though main rotor operates up to maximun spin speed, excitation frequency of belt is even less than natural frequency (78Hz) of belt caculated in Eq. 2. Thus resonance is diffcult to occur in current spin speed.

Table.5 Excitation frquency of belts (Hz)

Harmonics	Spin Etcher
1	10
2	20
3	30

3. Conclusions

Vibration problem of a head in spin etchers is schematically analyzed by using measurements and numerical results. In condered model, unbalance of rotor is main cause of vibration. Thus, vibration can be reduced by balancing the considered rotor.

Acknowledgments

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