A Study on Analysis of Vibration Characteristics of Ultrasonic Au Wire-Bonder

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In the assembly process of most of semiconductor integrated circuits such as LSI, the ultrasonic Au wire-bonder is used as the main equipment. The aim of this study is to clarify vibration characteristics of its horn and capillary system by experimental and theoretical analyses. Though such characteristics are of fundamental importance in adjusting and improving ultrasonic vibration applied by the wire-bonder, systematic and detailed studies about them have been hardly done.

In this study, resonance characteristics of a 65kHz Au wire- bonder are firstly measured by a laser Doppler vibrometer in both cases with the capillary tip free and pressed to a simulated work piece (SK4). From these results, the relation between resonance frequency f and capillary length l (f-l curve) is made clear, and resonance modes of the horn and the capillary are also shown clearly in two cases of different l. For the resonance mode of the capillary, measurements are also carried out by using other simulated work pieces including Au ball.

Secondly, natural vibrations of the horn and capillary system are analyzed theoretically based on a tapered beam model, and the results are compared with the above experimental results. In this analysis, general solutions of free vibration are mainly used, and the shear force at capillary tip is assumed to be a spring force. It is shown that main experimental results are explained well by this analysis.

Finally, the effects of damping on characteristics of natural vibrations are treated. Experimentally, damped free vibrations after ultrasonic excitation are measured to know the degree of participating damping. Theoretically, assuming the shear force at capillary tip is composed of spring force and equivalent viscous damping force, damped natural vibrations are analyzed on the tapered beam model by using the transfer matrix method. From these results, the relation between natural frequency f and equivalent viscous damping coefficient C is obtained, and a mechanical method to evaluate the shear force at capillary tip is given based on this relation and the capillary mode.