World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:4, No:12, 2010

Development of Electric Performance Testing System for Ceramic Chips using PZT Actuator

Jin-Ho Bae, Yong-Tae Kim, S K Deb Nath, Seo-Ik Kang, Sung-Gaun Kim*

***Abstract*—**Reno-pin contact test is a method that is controlled by DC motor used to characterize electronic chips. This method is used in electronic and telecommunication devices. A new electric performance testing system is developed in which the testing method is controlled by using Piezoelectric Transducer (PZT) instead of DC motor which reduces vibration and noise. The vertical displacement of the Reno-pin is very short in the Reno-pin contact testing system. Now using a flexible guide in the new Reno-pin contact system, the vertical movement of the Reno-pin is increased many times of the existing Reno-pin contact testing method using DC motor. Using the present electric performance testing system with a flexible hinge and PZT instead of DC motor, manufacturing of electronic chips are able to characterize chips with low cost and high speed.

***Keywords*—** PZT Actuator, Chip test, Mechanical amplifier

I. INTRODUCTION

CHIPS are widely used to manufacture electronic, communication devices as well as devices of information technology. The core of IT products and electronic devices are especially MLCC, Chip inductor, Chip Varistor and so on. For mass production of semiconductor products, high speed chip testing system with high precession is required. In order to check electrical characteristics of chips, Reno-pin contact test system has been used. In the Reno-pin contact test system a DC motor is used as an actuator to move the Reno-pin for characterizing chips. Using a DC motor in a Reno-pin test system causes electromagnetic noise and vibration of the driving displacement and it is impossible to control that phenomenon [1]. To remove this problem, a Piezoelectric sensor is used instead of a DC motor.

Jin-Ho Bae, Division of Mechanical and Automotive Engineering, Kongju National University, Republic of Korea, (e-mail: bustercc@kongju.ac.kr)
Yong-Tae Kim, Division of Mechanical and Automotive Engineering, Kongju National University, Republic of Korea, (e-mail: ytkim@kongju.ac.kr)
S K Deb Nath, Division of Mechanical and Automotive Engineering, Kongju National University, Republic of Korea, (e-mail: sanker_20005@yahoo.com)
Seo-Ik Kang, Division of Mechanical and Automotive Engineering, Kongju National University, Republic of Korea, (e-mail:auto@kongju.ac.kr)
Sung-Gaun Kim*, Division of Mechanical and Automotive Engineering, Kongju National University, Republic of Korea, (e-mail: kimsg@kongju.ac.kr)

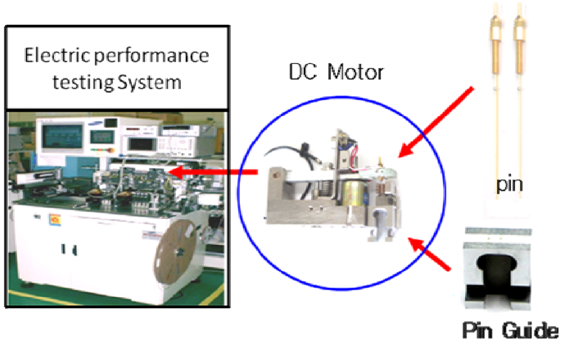

Fig. 1 Existing Reno-pin contact test device

For magnifying the displacement obtained by the Piezoelectric Transducer (PZT), a lever mechanism is designed and it is included in the Reno-pin contact test system [2]. By considering different design parameters, the lever mechanism is designed. Performance tests of the present PZT driven Reno-pin contact test system to characterize the electrical properties of chips are carried out to show its superiority over the DC motor driven Reno-pin contact test system. The newly developed PZT driven Reno-pin contact test system will be helpful for rapid and precession characterizing the electrical properties of semiconductor chips in electronic and IT industries.

II. MECHANISM DESIGN

Fig. 2 shows the flexure guide in which left end of the flexure is rigidly fixed. Two grooves are made on the top and bottom faces of the flexure guide along the middle region as shown in Fig.2. *b* is the width of the flexure guide; *H* is the thickness; *R* is the radius of the grooves of the flexure guide; $\theta_{\max}$ represents the maximum angular rotation along *z* axis. The following parameters are used for the perfect design of the flexure guide.

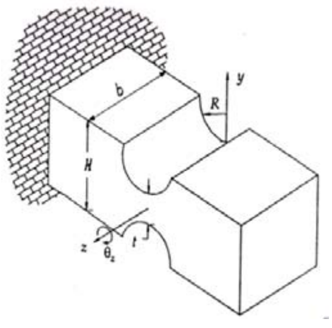

Fig. 2 Geometry of the flexure guide

$$t < R < 5t \tag{1}$$

$$K = 0.565\frac{t}{R} + 0.166 \tag{2}$$

$$K_t = \frac{2.7t + 5.4R}{8R + E} + 0.325 \tag{3}$$

$$\theta_{max} = \frac{4K}{K_t}\frac{R}{E_t}\sigma_{max} \tag{4}$$

Where K= Correction factor, K_t=Stress concentration factor, E= Young's Modulus Vibration displacement of the PZT actuator (t) is 0.05mm. Reno-pin of the probe is moved away 6 times with the help of lever mechanism as shown in Fig.3[3].

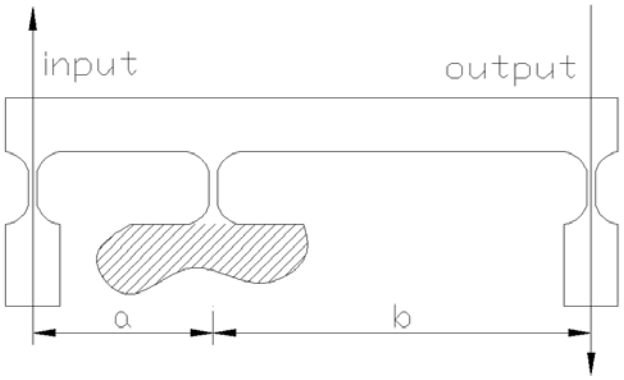

Fig. 3 Lever mechanism

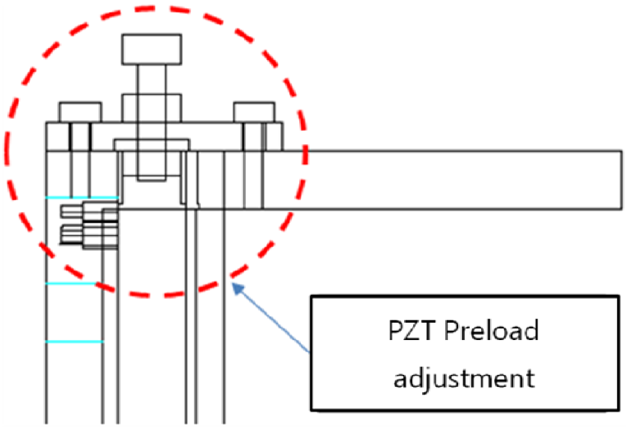

Fig. 4 Joint of PZT with lever mechanism

When power is supplied to the PZT to a great extent it expands and crosses a line as shown in Fig.4. But when power is removed, it contracts which is 1/500 times of the expansion. Therefore, a certain amount of power is given for tightening the PZT actuator bolt [4].

III. FINITE ELEMENT SIMULATION AND DISCUSSIONS

Actuator mechanism is designed using the design software CATIA V5 as shown in Fig.5. Then it is imported im ANSYS Workbench 11.0 for structural analysis. PZT Actuator, Fixture, Reno-pin guide, Lever and Preload adjustment is shown in Fig.5. The main objective of 3D finite element analysis is to check the amplification factor of the vertical displacement of the Reno-pin applying the vertical displacement on the top contact joint of the PZT Actuator.

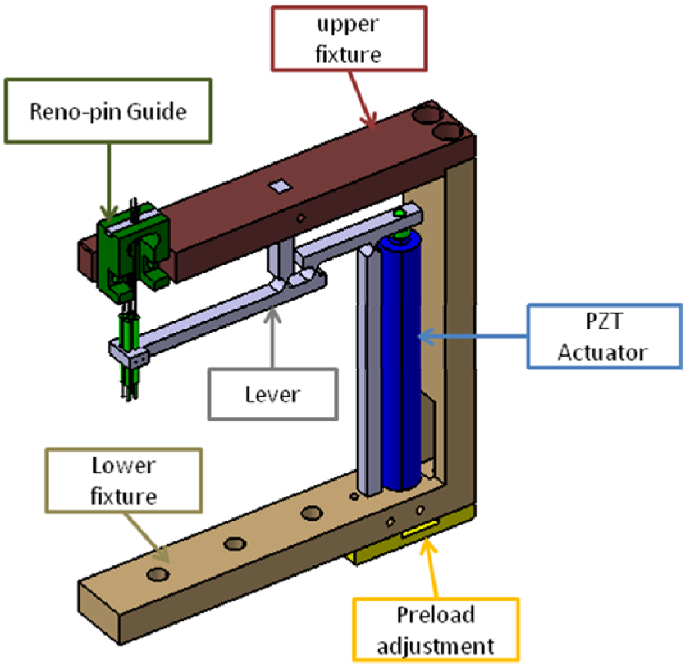

Fig. 5 3D model of electric performance testing system

When the Reno-pin contact testing system is modeled in FEM environment using ANSYS finite element software, the PZT actuator is removed and the produced vibrational vertical displacement by the PZT actuator is applied at the top cotact zone of the PZT actuator with the flexible lever mechanism as shown in Figs. 6.

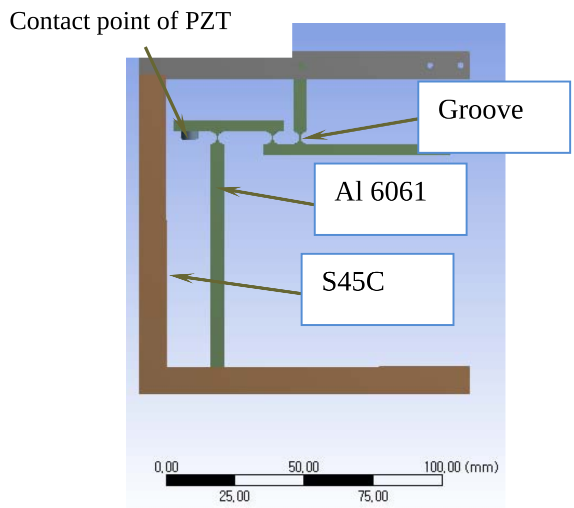

Fig. 6 3D model of the electric performance testing system without the PZT

Whole structure as shown in Fig.6 is meshed. At different parts of the structure, mesh density is different. At critical zones, where there is possibility to concentrate higher stress, higher mesh density is made to bring the higher accuracy of the solution as shown in Fig.7.

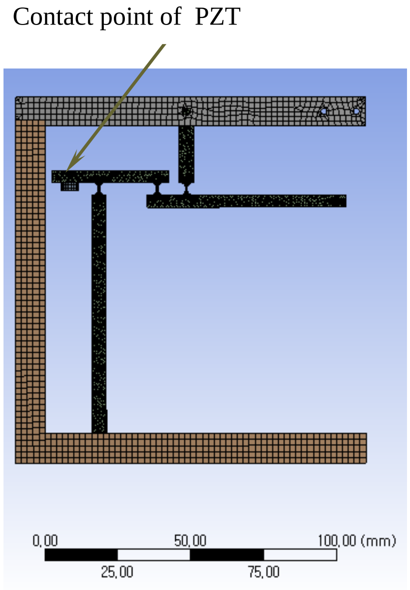

Fig. 7 3D Finite element meshing of the electric performance testing system

The structure as shown in Fig.6 is made of two different materials namely, Al6061 and S45C. The effective mechanical properties of those materials are given in Table 1. 3D hexagonal solid element is used to mesh the structure. The number of elements used in the present FE simulation is 64626. After meshing the structure as shown in Fig.7, the mechanical properties as shown in table 1 are used for the solution of the problem using 3D FE modeling. The finite element meshing of the structure is shown in Fig.7.

TABLE I
MECHANICAL PROPERTIES OF AL6061 AND S45C

Mechanical Properties	Aluminum 6061	S45C
Young's Modulus	68.9GPa	205GPa
Poisson's Ratio	0.330	0.290
Density	2.7e-006 kg/mm^3	7.85e-006 kg/mm^3
Tensile Yield Strength	276MPa	343MPa
Tensile Ultimate Strength	310MPa	569MPa

The bottom surface of the fixture is fixed, that means, all degrees of freedom of its bottom surface are stopped. And a vertical displacement, 0.05 mm is applied at the contact point of the PZT with the lever mechanism. At rest parts of the structure, the reliable boundary conditions are set by default by ANSYS FEM software.

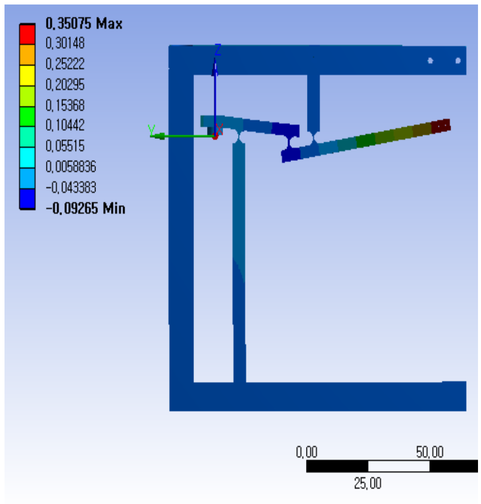

Fig. 8 Directional deformation of the lever mechanism

Fig. 8 shows the vertical deformation of the lever mechanism. From the figure it is clearly observed that at the contact point of the PZT actuator with the lever mechanism, the input vertical displacement is 0.05 mm, the output vertical displacement at the contact point of the Reno-pin with the lever mechanism is 0.35075 which is more than 6 times of the input vertical displacement.

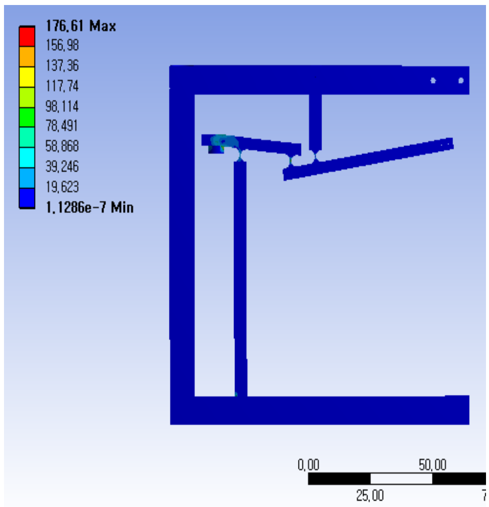

Fig. 9 Equivalent stress of the Reno-pin contact structure

Fig. 9 shows the equivalent stress of the lever mechanism including fixture. From the figure it is clearly observed that at the grooves of the lever mechanism, the highest equivalent stress generates which is smaller than the tensile yield strength. That means it is clear that the present developed testing system is safe during operation. From detailed design and simulation, it is confirmed that the dimensions of the elements of the fabricated testing structure are right and the testing system is safe during operation.

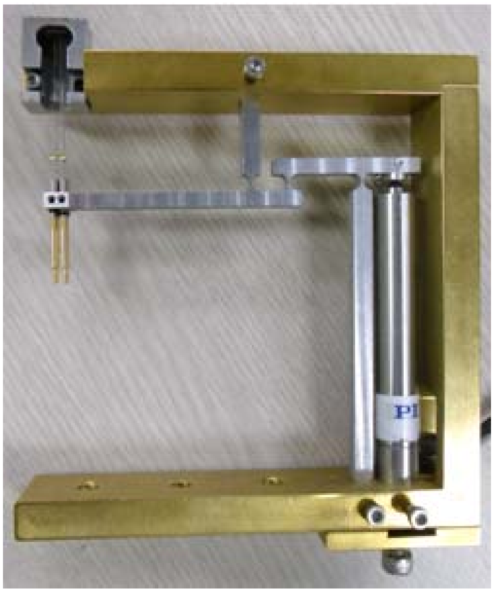

Fig. 10 Testing structure including Reno-pin and PZT

In order to drive a prototype PZT Actuator drive controller is required. Controller used in a computer-controlled DAC to generate analog input signal can be controlled by a PC and connection, and control software was used for the LabVIEW Software. Sin Wave program for Piezo Amplifier controller and a constant frequency and voltage of the analog is given to control. At this point, the frequency and amplitude of the voltage is controlled [5].

Due to high-speed production of semiconductor chips according to accelerating the testing of chips, the required testing numbers to characterize the electronic chips is increased more than 3000 per minute when the maximum distance between the chips and Reno-pin is kept 0.35mm. To identify the driving speed of the probe of the Reno-pin, high speed vision cameras, high-speed 500fps filming with the camera for about 3 seconds per observation of 60 meetings with the probe were identified.

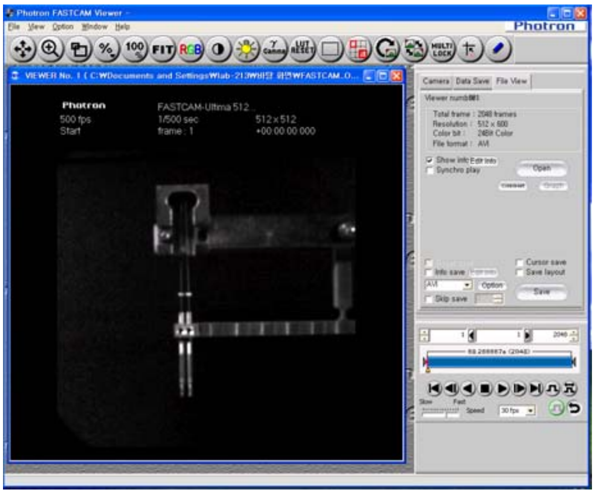

Fig. 11 Image of the electronic chip testing structure during operation

Distance between the chips and Reno-pin with time is measured by using displacement sensors. Figure 12 shows the variation of the distance between the chips and Reno-pin contact point as a function of time. The nature of the curve is sinusoidal and the minimum and maximum amplitude are 0.006 and 0.34mm respectively.

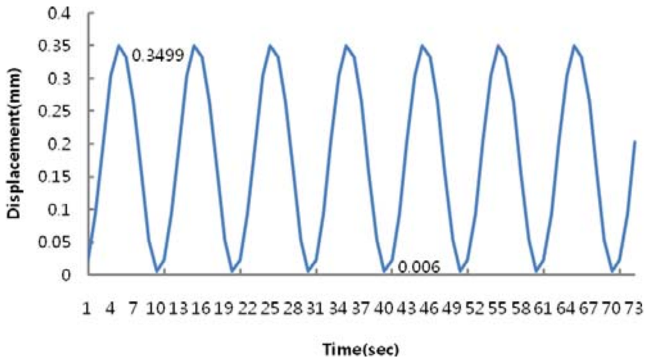

Fig. 12 Variation of the vertical displacement of the Reno-pin as a function of time

IV. CONCLUSIONS

In the heart of IT products, electronic components, MLCC, Chip inductor, Chip Varistor are used and to characterize electrical properties of such chips at a high speed is necessary for mass production of IT products and electronic devices. A high speed Reno-pin contact testing system has been developed to characterize the electrical properties replacing and modifying the existing Reno-pin contact testing system. The present developed Reno-pin contact testing system is made free from noise adding PZT replacing DC motor and the driving speed is increased using the flexible lever mechanism. While the driving speed of the existing Reno-pin contact testing system is 300 times per minute, that of the developed Reno-pin contact testing machine is 3600 times per minute which is 20% more than that of the existing Reno-pin contact machine.

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