Introduction of JSPE Technology Awards 2009

1. Ultrasonically assisted dicing technology for semiconductor device

Xiaoming QIU, Souu KUMAGAI, Fumiteru TASHINO, Naritoshi OZAWA (DISCO CORPORATION)

In order to dice difficult to process materials such as glass, ceramics, metal and composites, the new dicing approach has strong expectations. By way of theoretical analysis, experiments, and optimizing the structure of the air spindle and blade, an ultrasonic-wave air spindle was developed, which is able to rotate at high speed and make the very thin blade vibrate only in its radial direction. Combined with the development of a non-contact power supply, automatic amplitude measuring system, a dicing saw which can effectively utilize the ultrasonic-wave vibration was realized. Dicing tests were carried out and the processing resistance could be significantly reduced, while the feed speed could be greatly increased when ultrasonic-wave vibrations were applied in the dicing process. The test result also indicated that the ultrasonic-wave vibration could effectively prevent the blade from glazing and improve dicing quality.

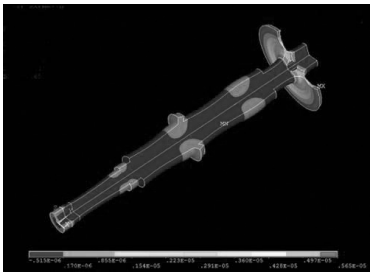

Fig. 1 The vibration mode of the ultrasonic-wave air spindle developed

2. Development of Ultra-high Accuracy Wire Electrical Discharge Machine " UPN-01"

Yoshiyuki TAKASE, Shigeyuki NANJYO, Toshitake MAIDA, Shuji SASAKI, Hisashi ONODERA (Makino Milling Machine Co., Ltd.)

UPN-01 is the world's first horizontal wire EDM machine that uses a wire electrode diameter of only 0.015 mm. As electronics components become miniaturized and multi-functional, it becomes necessary for precision machinery to produce precise molds and precise shape.

For example in high-precision mold industries, connector parts, IC-lead Frame, Micro gears uses a maximum wire diameter of only 0.10 mm or less and demands machining accuracy of 0.001 mm or less. When these parts are fabricated from design blueprints, machining tolerance becomes tighter and the accuracy and error margin of the Machine used is utmost important. In addition, part processing time might require 100 hours or more, making it necessary for automatic 24 hours 7 days a week operation.

Our company foresees this demand and need in the market by launching the world's first wire EDM machine that is able to machine with diameter of 0.015 mm wire and slit width of only 0.0169 mm. As a result, Micro gear of only module 0.018 in size becomes possible.

Research and development in wire cut machine has resulted in achievement mentioned above.

Fig. 2 UPN-01

3. Linear motion ball guide for superior rigidity and running accuracy in a narrow range

Hiroshi FUNAHASHI, Hiroshi NIWA, Tohru TAKAHASHI, Katsuya IIDA, Hiroyuki KISHI (THK Co., Ltd.)

In a previous study, we found that optimizing the shape of the crowning machined to the ends of a carriage raceway is an efficient method of enhancing the running accuracy of a linear motion ball guide (LMBG) in a narrow range. In this study, we attempt to design an ideal LMBG for further improvement of the running accuracy.

On the basis of theoretical and experimental studies, we concluded that for a given carriage, the smaller the ball, the higher is the running accuracy in a narrow range. Furthermore, it has been theoretically clarified that the rigidity increases when the number of balls is increased for the purpose of decreasing the load per ball. Thus, in the optimum design, the size of

the balls should be decreased to the maximum possible extent, and the number of balls in the carriage should be increased so that the running accuracy is enhanced in a narrow range. However, under these conditions, the load ratings may decrease. Therefore, we devised an 8-row LMBG which has double raceway by comparison with a common 4-row LMBG. This arrangement is expected to help enhance the running accuracy in a narrow range, as well as the rigidity and load rating.

Figure 3 shows the novel LMBG developed on the basis of the abovementioned idea. The running accuracy in a narrow range was enhanced to 8 nm, although the existing LMBG was up to about 30 nm. In addition, both the rigidity and load rating were far higher than the linear motion roller guide.

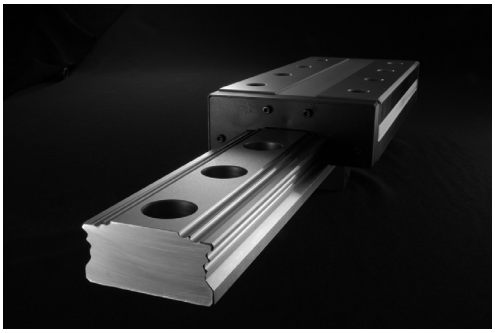

Fig. 3 Newly developed Linear Motion Ball Guide

Introduction of JSPE Numata Memorial Paper Awards 2009

1. Study on the Copper-Chemical Mechanical Polishing Method Using Water-Soluble Fullerenol Slurry -Investigation of Polishing Performance-

Hideyuki TACHIKA, Yasuhiro TAKAYA, Terutake HAYASHI, Hiroki TANADA, Ken KOKUBO and Keisuke SUZUKI

Chemical mechanical polishing (CMP) is a key process used for the multilayer copper interconnects. In recent years, the most common problem encountered in this regard is the inability of conventional abrasive grains to adapt to the next generation semiconductors owing to their large particle sizes. Hence, this study proposes a water-soluble fullerenol ($C_{60}(OH)_{36}$) as a novel abrasive grain for Cu-CMP because of its advantageous features such as high water solubility and uniformity of particle size (1 nm); further, there is no risk of contamination of the metal when using $C_{60}(OH)_{36}$. In this paper, the excellent grain abrasive properties of $C_{60}(OH)_{36}$ and its chemical affinity for copper are reported. It is experimentally confirmed that owing to its high chemical reactivity, a slurry containing $C_{60}(OH)_{36}$ can be used to improve the rms surface roughness from 20 to 0.5 nm.

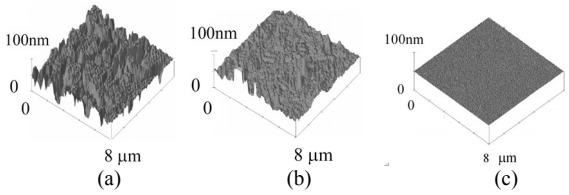

Fig. 4 Birds-eye views of the copper surface (a) initial roughness, (b) polished surface using $C_{60}(OH)_{26}$, (c) polished surface using $C_{60}(OH)_{36}$

2. High-accuracy displacement metrology and control using a dual Fabry-Perot cavity with an optical frequency comb generator

Youichi BITOU

A displacement metrology and control system using an optical frequency comb generator and a dual Fabry-Perot cavity is developed with sub-nm accuracy. The optical frequency comb generator has expanded the displacement measurement range and the dual cavity system has suppressed the environmental fluctuation. We evaluated the absolute uncertainty of the developed displacement measurement system to be approximately 190 pm for the displacement of 14 μm and the accurate displacement control using a phase-locked loop was demonstrated with a resolution of approximately 24 pm.

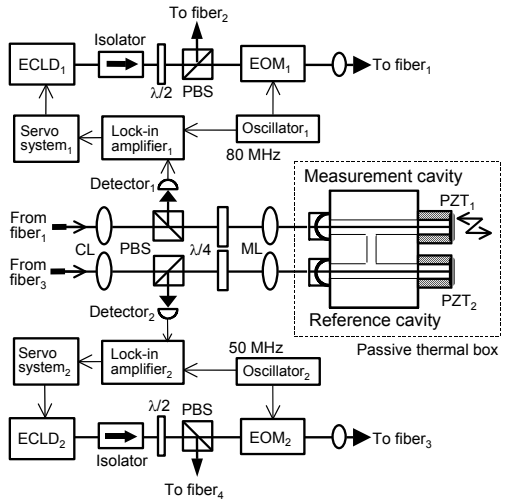

Fig. 5 Schematic layout of the laser-frequency-based displacement measurement system using a dual FP cavity