Assembling Ball-Ended Styli for CMM's Tactile Probing Heads on Micro EDM

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Abstract

A hybrid gluing and assembling process was presented in this study to produce micro ball-ended spherical styli tips for micro CMM's tactile probing heads. Combining Wire Electro Discharge Grinding (WEDG) technology and position controlling function of EDM, a micro ball with a 0.07mm diameter could be glued onto the cantilever successfully.

***Keywords**:* Micro-EDM, Micro-CMM, WEDG, Micro spherical styli tip

1 Introduction

Micro spherical styli tips with diameters smaller than 0.125mm are not yet available on the commercial market. Even the One-pulse electro-discharge (OPED) process for forming micro ball-ended styli tips has been previously introduced [1][2][3]. However, control of the roundness and deviation of the styli tips remains problematic due to the instantaneous electro-discharge shock energy. Moreover, microprobes composed of ruby or sapphire cannot be produced by the OPED process. In this study, a hybrid fabrication-assembly approach with combination WEDG technology [4] and position function of EDM was proposed to fabricate micro spherical probes for CMM. In addition, adhesion strength and simple profile measurements were carried out to evaluate the quality of micro spherical styli tips.

2 Assembling and gluing process on micro EDM

A micro electrode tool of only 40μm diameter can be easily produced by WEDG technology without removal from the spindle. Some reports pointed out that a micro tool with a diameter just a few micrometers can be fabricated by WEDG technology. This technology can obviously be applied to cantilever fabrication for CMM probe

stems. The experimental equipment was based on WEDG technology. Figure 1 shows the basic configuration of this process. In order to verify the position alignment and observe the assembling process, CCD1 and CCD 2 were attached to the system. A micro vacuum gripper with a glass ball was mounted on the table. After manufacturing the cantilever, the gluing and assembling processes are carried out on the same micro-EDM. CCD1 photo images on-machined measurement was used to evaluate the quality of micro spherical styli tips.

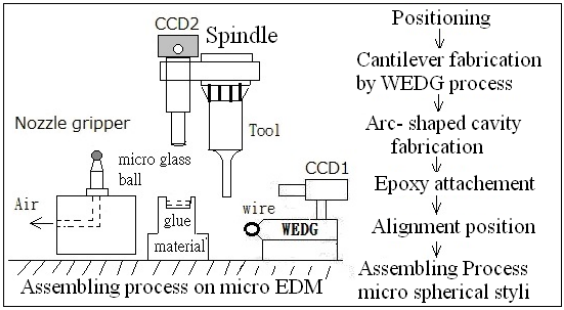

Figure 1. Schematic structure of micro spherical probes assembling process

A straight cantilever of approximately 40μm diameter was produced using WEDG technology. The cantilever retains the micro ball for 12 hours after completion of the alignment and attachment of the micro ball, to avoid inconsistent curing.

3 Micro ball-ended styli assembling results

3.1 Styli tips measurement

A low-voltage detecting measurement process has been introduced to evaluate the metal styli tip's quality [5]. However, this measuring process is not available for non-conductive ball-ended styli profile measurement. On-machined CCD photo image measurement was used temporarily to evaluate quality of spherical styli. Manual operations are likely to result in even lower reliability and greater uncertainty of the geometry measurement. However, no commercial metrology device is currently available to measure the geometry and profile of micro spherical styli of which the diameter is only approximately 0.07mm. This is the reason why on-machined images measurement was conducted as a temporary measure to evaluate the styli quality in this study. Figure 2 shows the CCD photo images measurement results of glass ball-

ended styli. The eccentric error deviation between the axis of cantilever and the center of glass ball is as small as 0.613μm.

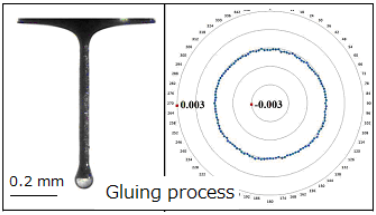

Figure 2. Micro glass ball-ended styli measurement by CCD photo images

3.2 Optimal diameter of cantilever

Adhesion strength between micro ball and cantilever increases with the diameter of cantilever as shown in figure 3. Obviously a large contacting area boosts adhesion strength as shown in the figure. However, undesirable contact will lead to the lower metrology accuracy of the CMM due to the larger diameter of cantilever. In this paper, a cantilever having a diameter between 40μm and 50μm boasts reasonable adhesion strength when the micro ball is approximately 0.07mm in diameter. On the other hand, another parameter of adhesion strength is epoxy layer thickness. The larger amount of epoxy will result in reduced profile accuracy. Increasing contact area will more efficiently boost adhesion strength with optimal epoxy layer thickness.

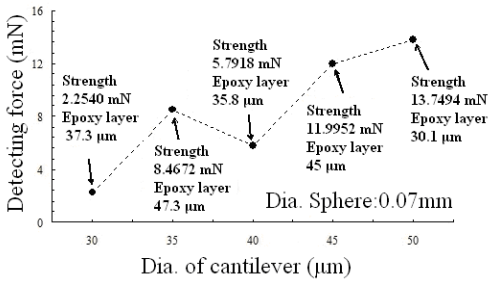

Figure 3. Adhesion strength of spherical styli with different cantilever diameter

3.3 Commercial micro ruby styli tips gluing

A glass ball was used to confirm the practicability of the assembling process on EDM. Figure 4 shows the examples of commercial CMM's probing heads. Micro ruby balls with respective diameters of 0.15mm and 0.3mm were assembled onto cantilevers.

Epoxy glue was distributed uniformly on the adjoining surface between the ruby ball and cantilever without any dripping, as illustrated in the figure. Epoxy glue dripped onto the ball surface when the diameter of the cantilever was approximately 0.04mm due to small contact area. On the other hand, it appears possible to distribute epoxy glue uniformly on a large contact area while increasing the ball and cantilever diameter.

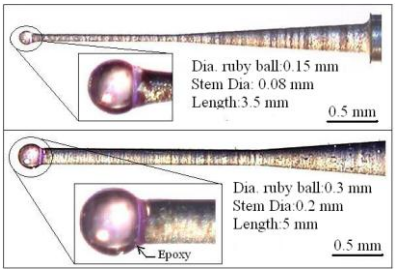

Figure 4. Ruby ball-ended styli tip assembling for commercial micro-CMM

4 Conclusions

Combining WEDG (Wire Electro Discharge Grinding) technology and a position controlling function of EDM, a micro ball-ended styli tip with a diameter of only 70μm could be successfully glued onto the front-top of cantilever. The roundness of the largest profile micro ball-ended styli could be as small as 0.613μm.The spherical styli maintained an adhesive strength of approximately 12mN without any detachment or bending of cantilever. Ruby ball-ended styli for commercial CMM could be assembled successfully without any epoxy glue dripping.

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