DEVELOPMENT OF A MICRO SCREW THREAD AND A MICRO GEAR UTILIZED EXTRA FINE WIRES

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1. Introduction

Micro-mechanical parts for a micro-machine are mostly produced by two methods of a photolithography1) 2) or an ultra-precise milling3). If we choose the photolithography method to make the micro parts, we can produce a lot of the micro-mechanical parts at a time like IC manufacturing; also, the parts are fabricated into the micro-machines through the processes of multi-layered deposition/electroforming and etching of sacrificial layers. However, the parts are shaped into a planar figurer with constant thickness, and their materials are selected from a few materials example of poly-silicon or tungsten. Moreover, the method requires photolithography equipments for IC manufacturing systems; besides, their equipments must be kept in a clean room. The price of the lithography equipments is over several million dollars and running cost for the clean room runs up to considerable sum. Therefore, the researchers working on the development of the micro-machines which parts are produced by the photolithography method are only a handful of researchers in a few research institutes.

If we choose the ultra-precise milling method to make the micro parts, we can produce only one micro part in one manufacturing cycle; also, the part is not fabricated into the micro-machine. Nevertheless, the micro part is shaped into three dimensional shape by CNC (computerized numerical control) machine tool with CAD/CAM system, and their materials are selected from many materials. However, the method requires a super-precision CNC machining center to enable to control five-axis machining simultaneously; besides, the CNC machining center needs diamond tools which cutting edges are fabricated to special profiles with the accuracy of sub-micrometer. The price of the super-precision CNC machining center is over several million dollars. Therefore, advanced researches for the micro-machine which parts are produced by the ultra-precise milling method are carried on the shoulders of limited researchers.

Many researchers and engineers wait for the third method to developed micro-mechanical parts with simple and inexpensive processes and without special equipments. A novel method to make the micro mechanical parts utilized extra fine wires is thought up in this paper. A micro-screw, a micro-nut, and an external micro gear, an internal micro gear utilized extra fine wires are developed in this paper as prompt results.

2. Micro screw utilized extra fine wires

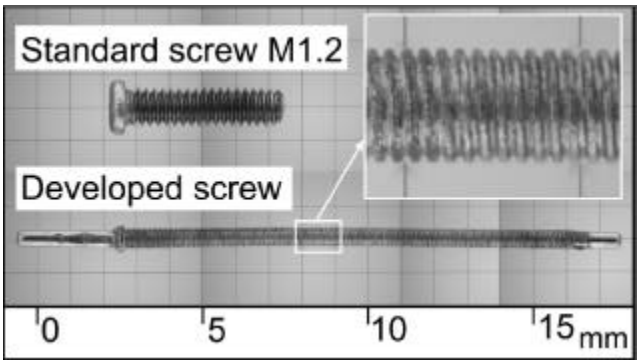

Figure 1. Micro screw utilized extra fine wires and the standard screw of M1.2.

The micro screw utilized extra fine wires and the standard screw of M1.2 are shown in figure 1. The micro screw is made by brazing an extra fine wire which is coiled around a needle pin. The micro screw has following dimensions; its major diameter is 0.6 millimeters, its pitch is 0.1 millimeters (i.e. 100 micrometers), and its length of threaded portion is 14 millimeters. Just for reference, the standard screw of M1.2 has following dimensions; major diameter is 1.2 millimeters, its pitch is 0.25 millimeters (i.e.

250 micrometers), and its length of threaded portion is 6 millimeters. Although the minimum screw thread of S0.3 standardized by ISO/R 1501:1970 has nominal diameter of 0.3 millimeters and pitch of 0.08 millimeters (i.e. 80 micrometers), the author has not been obtained the minimum screw thread of S0.3. The minimum screw thread of S0.3 may not have been manufactured. A pair of a miniature screw of M1.2 and a miniature nut of M1.2 is obtained commercially as a pair of the minimum screw and the minimum nut. ISO/ R 1501:1970 is same as JIS B 0201:1973. An enlarged photograph of the micro-screw utilized extra fine wires is shown in figure 2.

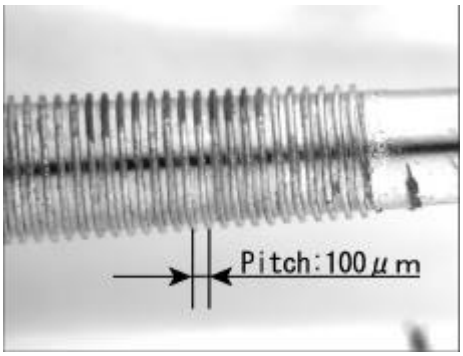

Figure 2. Enlarged photograph of the micro screw.

3. Making processes for the micro screw utilized extra fine wires

The micro screw utilized extra fine wires is made through following processes as shown in figure 4. Firstly, a needle pin to be firmly soldered is prepared. We used a terminal pin of a hybrid IC as the needle pin. The pin is undercoated with nickel plating and is plated with gold. Its diameter is 0.5 millimeters and its length is 15 millimeters. Secondly, a pair of one extra fine wire to be firmly soldered on the needle pin and another extra fine wire to be hardly soldered on the needle pin is closely coiled each other around the needle pin like a double-start thread. We used a tinning copper wire as the extra fine wire to be firmly soldered and used a tungsten wire as the extra fine wire to be hardly soldered. Both diameters of the tinning copper wire and the tungsten wire are same size of 50 micrometers. The pair of the wires is coiled by hand. Thirdly, solder is melted upon the double-coiled part mentioned above, and the melted solder flows into gaps between the needle pin and the coiled wires. The extra fine wire to be firmly soldered is brazed around the terminal pin, yet the extra fine wire to be hardly soldered is not brazed around the needle pin. We used the solder which consists of 50 percent tin (Sn) and 50 percent lead (Pb). Finally, the wire to be hardly soldered is removed, and the extra fine wire to be firmly soldered is remained as a ridge of the external thread. Axial cross section of the micro screw shapes a profile to connect semicircle concave ditches and semicircle convex ridges alternatively as shown figure 4. We removed the tungsten wire by hand.

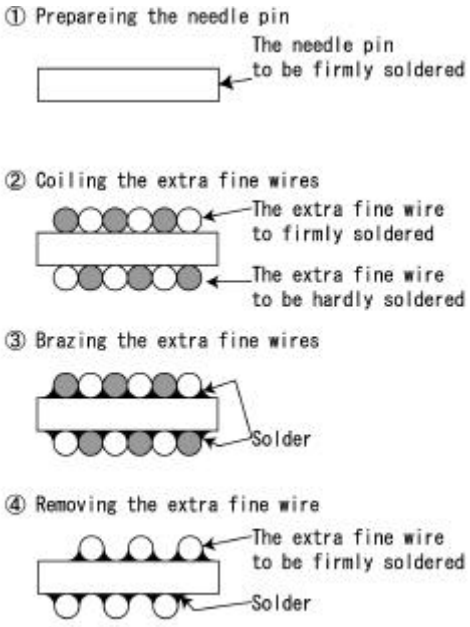

Figure 3. Making processes for the micro screw.

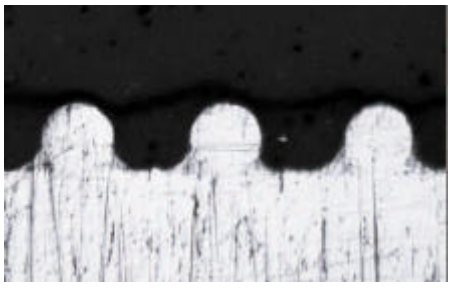

Figure 4. Axial cross section of the micro screw.

4. The micro nut utilized extra fine wires

The micro nut utilized extra fine wires and the standard nut of M1.2 are shown in figure 5. The nut utilized extra fine wires is made by brazing an extra fine wire which is coiled on the inside of a small tube. The micro nut has following dimensions; its major diameter is 0.65 millimeters, its pitch is 0.1 millimeters (i.e. 100 micrometers), and its thickness is 4 millimeters. Just for reference, the standard nut of M1.2 has following dimensions; its major diameter is 1.2 millimeters, its pitch is 0.25 millimeters (i.e. 250 micrometers), and its thickness is 1.2 millimeters. An enlarged

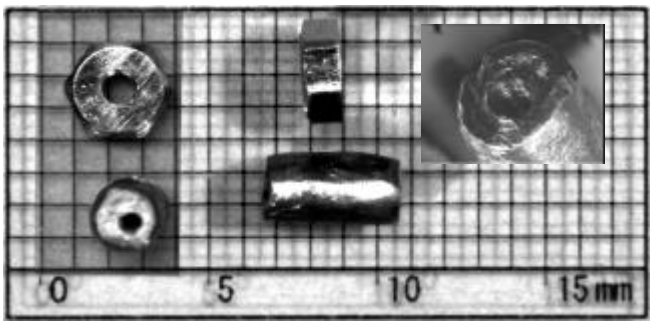

Figure 5. The micro nut utilized extra fine wires and the standard nut of M1.2.

photograph of the micro nut is shown in figure 6.

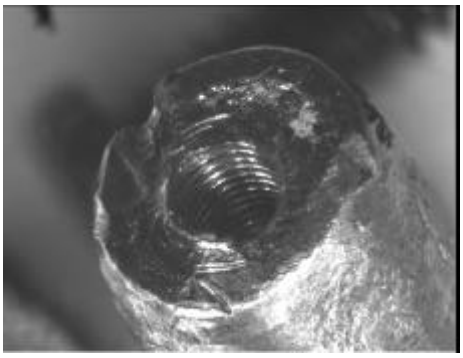

Figure 6. Enlarged photograph of the micro nut.

5. Making processes for the micro nut utilized extra fine wires

The micro nut utilized extra fine wires is made through following processes as shown in figure 7. Firstly, a needle pin to be hardly soldered is prepared. We used a hypodermic needle as the needle pin. The pin is made of stainless steel and is hardly soldered. Its diameter is 0.55 millimeters and its length is 15 millimeters. Secondly, a pair of one extra fine wire to be firmly soldered and another extra fine wire to be hardly soldered is closely coiled each other around the needle pin like a double-start thread. We used a tinning copper wire as the extra fine wire to be firmly soldered and used a tungsten wire as the extra fine wire to be hardly soldered. Both diameters of the tinning copper wire and the tungsten wire are same size of 50 micrometers. The pair of the wires is coiled by hand. Thirdly, the double-coiled part mentioned above is inserted in the small tube, and the melted solder is poured into gap between the double-coiled part and the small tube. The extra fine wire to be firmly soldered is brazed on the inside of the small tube, yet the extra fine wire to be hardly soldered and the needle pin are not brazed. We used an electric sleeve as the small tube. The sleeve is made of copper and is plated with tin inside and outside. Its external diameter is 2.1 millimeters, and its internal diameter is 1.1 millimeters. Its length is 4 millimeters. The solder consists of 50 percent tin (Sn) and 50 percent lead (Pb). Fourthly, the needle pin is drawn out from the brazed part mentioned above. Finally, the wire to be hardly soldered is removed through the center hole which is made by removing the needle pin. The extra fine wire to be firmly soldered is remained as a ridge of the internal thread. Axial cross section of the micro nut shapes the profile to connect semicircle concave ditches and semicircle convex ridges alternatively as shown in figure 8. We removed the hypodermic needle and the tungsten wire by hand.

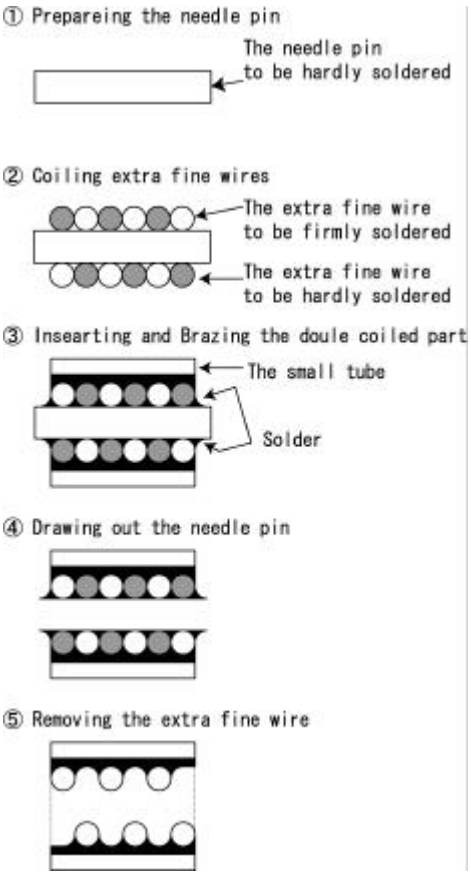

Figure 7. Making processes for the micro nut

Figure 8. Axial cross section of the micro screw

6. Pitch error of the micro screw utilized extra fine wires

Pitch of the micro screw utilized extra fine wires is measured by a surface roughness measuring instrument with diamond stylus. Axial profile of the micro screw is measured as shown figure 9 because the bottom points in the figure are recorded when both slopes of stylus tip are in contact with surfaces of adjoining the ridges of the micro screw. Distance between adjoining bottom points indicates the pitch of the micro screw. From the result of the measurements, the maximum pitch was 103 micrometers, the minimum pitch was 100 micrometers, and the average of pitch was 100.4 micrometers.

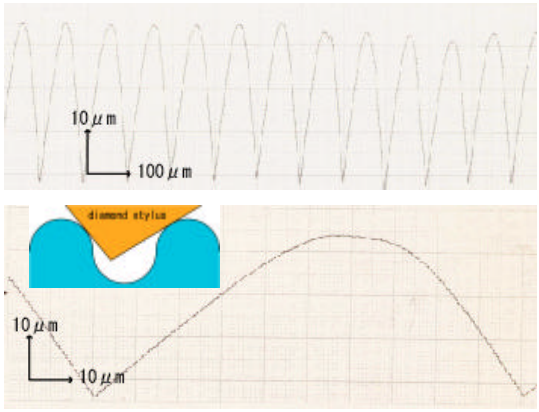

Figure 9. Axial profile of the micro screw measured by the surface roughness measuring instrument.

7. The external micro gear and the internal micro gear utilized extra fine wires

The external micro gear and the internal micro gear utilized extra fine wires are developed as shown in figure 10 as prompt results. We could rotate the micro gears engaged each other with angular velocity of 1000 rpm. The external micro gear and the internal gear have a same module of 0.127 millimeters (i.e. their pitches are same length of 400 micrometers), and the number of teeth of the external gear and the internal gear are 9 teeth and 11 teeth respectively.

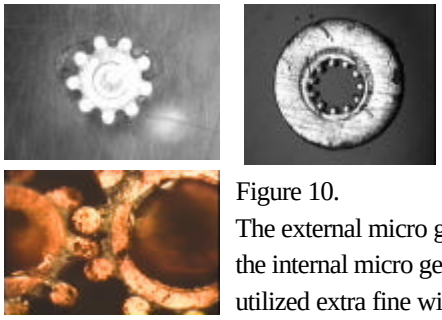

Figure 10.
The external micro gear and the internal micro gear utilized extra fine wires.

8. The screw drive mechanism by using the micro screw and the micro nut

The screw drive mechanism in which the micro nut travels 60 micrometers by one turn of the micro screw is developed as shown in figure 11. An angle plate is connected to the micro nut for restricting rotation. The micro screw and the micro nut are manufactured by using the extra fine wires of 30 micrometers in diameter, and both pitches are same length of 60 micrometers.

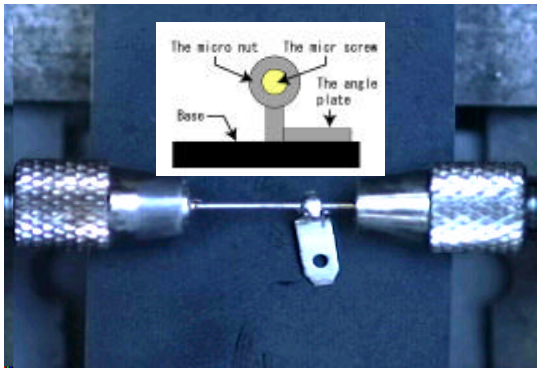

Figure 11. The screw drive mechanism

9. Conclusions

The micro screw and the micro nut with pitch of 100 micrometers are developed by utilizing extra fine wires of 50 micrometers in diameter. The external micro gear, the internal micro gear, and the screw drive mechanism are manufactured as prompt results.

References

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