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Study on new float polishing with the MCF

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ABSTRACT

Purpose: As a continuation of a previous paper [1], the report demonstrates the various possibilities of float polishing utilizing the present improved magnetic compound fluid (MCF). The MCF developed by one of authors, Shimada, in 2001, was improved by the addition of α-cellulose, thereby achieving a clearance as great as 8mm as shown in another paper [1]. The present paper describes the possibility of the application of the MCF float polishing technique with α-cellulose.

Design/methodology/approach: First, the results obtained under various polishing conditions of the MCF float polishing technique are described. These conditions include the various shapes of the magnet employed in the polishing tool, magnetic field strength, the concentration of α-cellulose, the motion of the specimen, the existence of a magnet fixed underneath the polished specimen, and initial surface roughness. Secondly, the present MCF float polishing technique can be used in many types of polishing, including polishing the inner surface of an acrylic resin tube, a wide flat surface through the use of a orbital polishing tool, and simultaneous float polishing of all surfaces of a three-dimensional complex shape. In addition, as other examples, the polishing on the integrated circuit (IC) substrate is shown.

Findings: By the various polishing conditions of the MCF float polishing technique, the polishing effect is changed. On the other hand, as for the many applications of the MCF float polishing, inner surface, wide flat surface, rough initial surface, three-dimensional complex shape and IC substrate can be polished.

Research limitations/implications: The data under various polishing conditions of the MCF float polishing technique helps to clarify the present polishing technique's possible practical applications. As shown in a previous paper [1], since MCF contains long magnetic clusters, the present polishing technique allows float polishing with large clearance. Therefore, many applications of the MCF float polishing are useful in the polishing fields.

Practical implications: The present study indicates the practical application in the polishing.

Originality/value: The present technique of MCF float polishing is new in the field of float polishing. In addition, the ordinary float polishing technique having large clearance has not been proposed. Therefore, the present paper is very useful in the polishing field.

Keywords: Surface treatment; Magnetic Compound Fluid (MCF); Magnetic cluster; Float polishing

1. Introduction

In a previous paper [1], with the improvement of MCF [2] by the addition of α-cellulose, the clearance could be as large as 8mm. The report examines the results of float polishing two using polishing tools, each employing a different type of motion. The results show a finely polished, mirror-like surface can be obtained with nm-order *Ra* for various kinds of material. The polishing mechanism of the new polishing technique is explained in terms of a magnetic cluster model. The results obtained using this polishing technique are also compared to those obtained using ordinary magnetic responsive fluids, MF or MRF [3, 4].

The polishing, coating and so on are very important process in the manufacturing materials and machine [5-9]. As for MF and MRF polishing with using a magnetic field, many studies have focused on float-polishing techniques by many authors until recent [10-15].

The present float polishing technique is effective for many types of polishing because it provides two advantages over contact polishing. The first is float polishing's ability to avoid degeneration or plastic deformation of the polished surface created by contact between the abrasive and magnetic particles and the material's surface [16]. The second advantage lies in float polishing's ability to polish a surface of any shape.

In the present paper, we first investigate the effects of large-clearance MCF float polishing with the addition of α-cellulose under several conditions. Next, we show several possible engineering applications of MCF float polishing.

2. Experimental procedure

Figure 1 shows the experimental apparatus used for MCF float polishing, as described in a previous report [1]. The other polishing tools, as well as the polishing procedure and MCF, are also used as the same as those described another report [1].

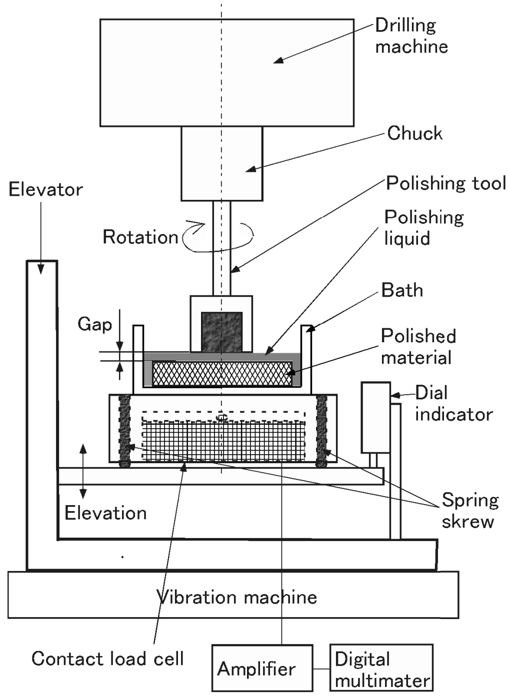


Fig. 1. Schematic diagram of MCF float polishing machine

3. Results of MCF polishing

Figure 2 shows the effects of the type of polishing tool, its rotation speed under a knitted brow rotation as shown in a previous report [1], without bath, with a clearance δ of 1mm, using brass as the polished material, and a polishing time of 1 hour. Figure 3 shows the effects of specimen's motion and clearance δ under a rotation of 515rpm, without bath, using brass as the polished material, and a polishing time of 1 hour. The effects of polishing vary according to the types of polishing tool, its rotational speed, and the specimen's motion.

As another experiment, the optimum magnetic field strength was applied during polishing to create an optimum polishing effect, and the polishing effect is seen to increase with the addition of more α-cellulose.

Figure 4 shows the effect of the specimen's initial float polishing machine. roughness when polishing tool was used at a rotation speed of 515rpm, with a clearance δ of 1mm, using brass as the polished material, and a polishing time of 1 hour. It is seen that MCF float polishing can polish a relatively rougher surface, and its polishing effect is improved by using a bath.

A permanent magnet is placed beneath the polished specimen as shown in Fig. 5. If the upper magnet in the polishing tool No. 1 and the lower magnet are repulsive, the magnetic field lines are positioned vertically in relation to the specimen, and the magnetic clusters are thus aligned vertically to the specimen. As a result, the polishing effect increases. However, when the lower magnet is not present or it is attractive to the upper magnet in the polishing tool, the magnetic clusters are aggregated at the weak magnetic field area as shown in Fig. 5, and thus creating a non-uniform polished surface.

4. Engineering applications

The MCF float polishing as described here allows for many types engineering applications. The MCF referred to here is the same as that described in another report [1].

The present polishing technique is suitable for plastic materials such as acrylic resin or for the inner surfaces of tubes. The result was a finely polished surface, as shown in Fig.6.

Next, we made an orbital-type polishing tool by using Figure 5 Effect of magnet position an orbital polishing tool employing three permanent magnets of 8mm in diameter as shown in Fig. 7, a flat area 8cm wide with Ra=0.0057μm, Ry=0.039μm can be polished as shown in Fig. 8 and 9. Each magnet's rotational speed was 520rpm, with each of the three magnets rotating the in the same direction at a speed of 50mm/s and a transverse motion with a pitch of 5mm and speed of 50mm/s.

Next, the present polishing technique was demonstrated to be effective for barrel finishing. Of 50 brass tips (0.3mm in thickness and 3mm square), the mean surface roughness before polishing was Ra=0.0636μm and Ry=0.454μm, and after Ra=0.0320μm, Ry=0.234μm.

Next, a convex shape having a height of 1.8μm and made of liquid phase epitaxial (LPE) on a Ga-Gd-garnet (GGG) plate of IC tip as shown in Fig. 10(a) was polished to a fine surface, the convex shape being polished flat as shown in Fig. 10(b). This demonstrated that the present MCF polishing technique is also effective in polishing a thin film.

Since the clearance δ achieved by the present MCF technique can reach a maximum of 8mm as shown in a previous paper [1], it can be also used to polish shapes with convex and concave surfaces. All the surfaces of the specimen can be polished.

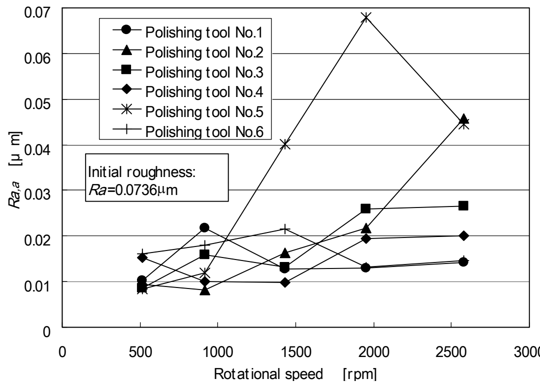


Fig. 2. The effects of types of polishing tool and their rotation speeds

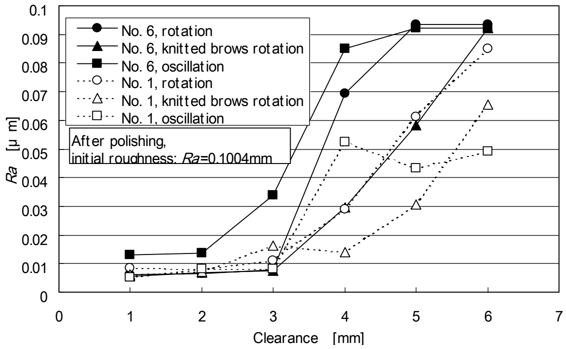


Fig. 3. The effects of the specimen's motion and clearance

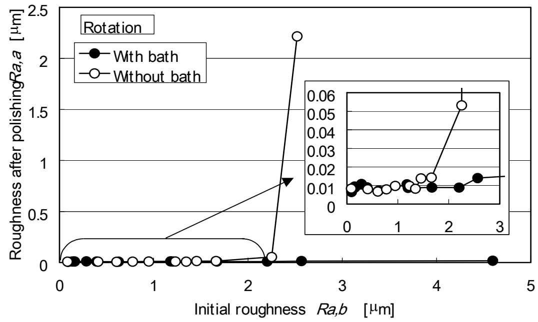


Fig. 4. The effect of initial roughness

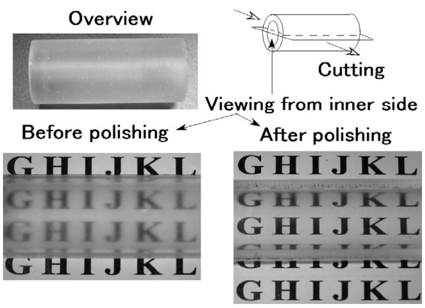


Fig. 5. Images of specimen

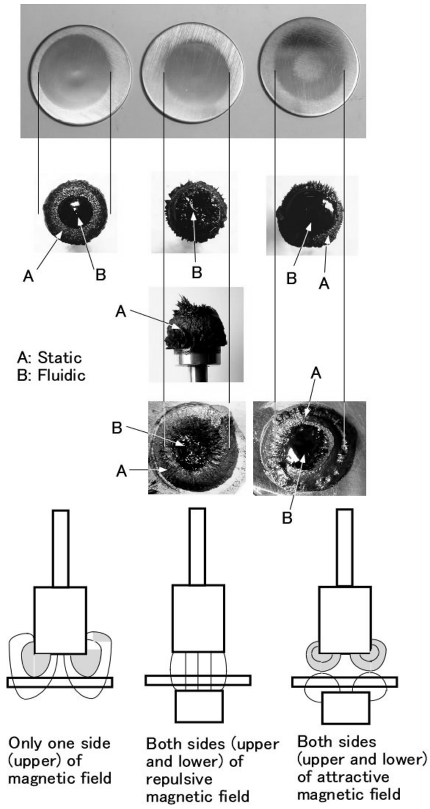


Fig. 6. Effect of magnet position

Fig. 7. Orbital polishing tool

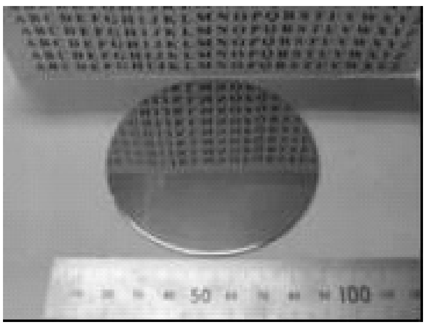


Fig. 8. Polished surface

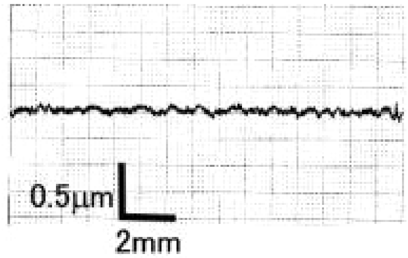
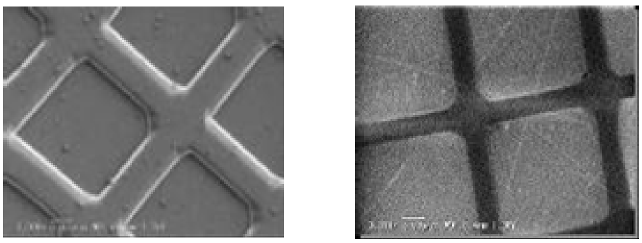


Fig. 9. Roughness line



(a) Before polishing (b) After polished
Fig. 10. LPE on GGG

5. Conclusion

The effects of the present MCF polishing technique depend on the various magnet shapes of the polishing tool, magnetic field strength, the concentration of α-cellulose, the motion of the specimen, and so on. The present MCF polishing technique is applicable to many types of polishing, widening the variety of uses of magnetic float polishing (MFP).

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