

SELF-ALIGNMENT OF MICROPARTS USING LIQUID SURFACE TENSION – EXTENSION OF FUNCTION BY VIBRATION FORCE: SELF-ALIGNMENT OF A GROUP OF MICROPARTS AND SELF-STANDING

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INTRODUCTION

Microsystems have become an important research field and 2D or 3D microsystems composed of microparts of which materials and shapes differ have been investigated. In order to realize such systems as industrial products, an assembly technique of the microparts is necessary with alignment being a very important task in the assembly. The purpose of this research is to establish a self-alignment technique for microparts assembly using liquid surface tension[1][2]. Up to date, the method for aligning the flat microparts one by one has been proposed and evaluated experimentally.

This series alignment can be widely used and it is reliable. However, the time required for the alignment becomes long as the number of the microparts increases. Thus, the method to align a group of microparts at a time is also needed in addition of the series self-alignment method. For manufacturing 3D microsystems, the methods of rotational alignment out of the base plane using surface tension of melting solder and some electrostatic actuators are examined[3][4]. However the out of plane rotational alignment methods using liquid surface tension are not shown yet.

This paper describes the extension of function of the self-alignment using liquid surface tension. The extended functions are the self-alignment of a group of microparts at a time and the self-standing as an important function of the out of plane rotational alignment. For the functions, the vibration force is used with liquid surface tension.

SELF-ALIGNMENT METHOD OF A MICROPART GROUP USING LIQUID SURFACE TENSION

The surfaces of the microparts used in the self-alignment of [1][2], are divided into two areas, namely, high and low wettability areas and have the same pattern of the high wettability area. In the alignment, a micropart needs to be put on the other micropart so that a liquid droplet comes in contact with the high wettability areas of the two microparts. It becomes more difficult to put all the microparts under the condition simultaneously as the number of the microparts increases. This may become an obstacle of practical use in mass production although the series alignment can be widely used and reliable.

For overcoming this problem, the vibration force is used with the liquid surface tension in the alignment. Figure 1 shows the method of the self-alignment of a micropart group at a time. It is carried out as follows;

(Step 1) Droplets of the liquid are put on the high wettability area of a base part. As described later, they can be put on all the areas at a time.

(Step 2) Microparts are put on the base part. In this case, the droplets do not need to always come in contact with the

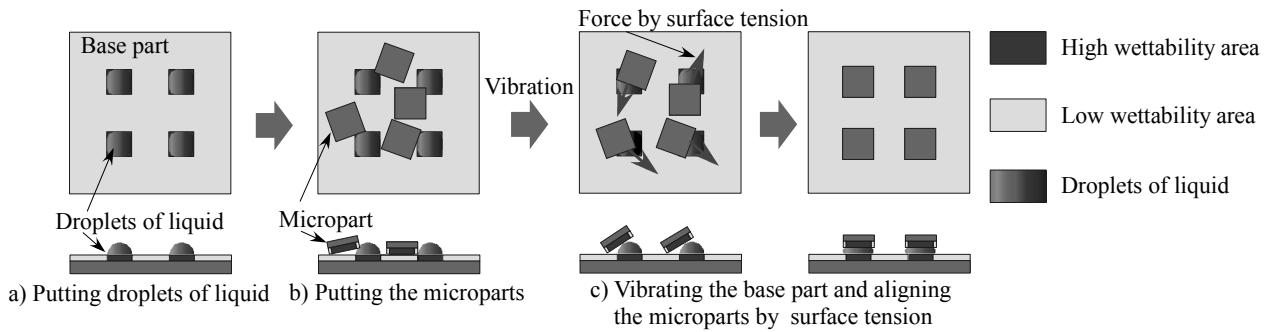


Fig.1 Method of self-alignment of a group of microparts

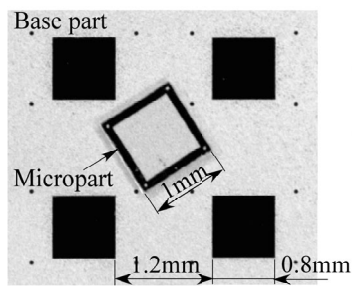


Fig.2 Experimental base part and micropart

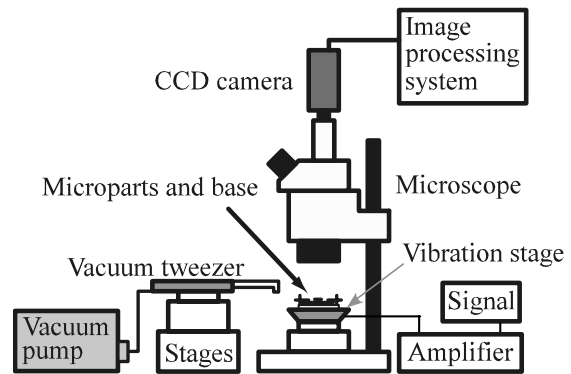


Fig.3 Experimental setup

high wettability areas of the parts.

(Step 3) The base part is vibrated so that the microparts move on the base part. When the high wettability areas of the microparts come in contact with the droplets, the liquid surface tension force drives the microparts so that the high wettability area patterns of the microparts overlap with that of the base part.

In [2], the friction force between the parts often deteriorates the accuracy of the alignment using only liquid surface tension. However the vibration force reduces the bad influence and can improve the alignment accuracy.

EXPERIMENTAL SELF-ALIGNMENT

Self-alignment of a micropart group using conventional microparts

The experimental micropart and base part shown in Fig.2 are used in this experiment. Figure 3 shows the experimental setup for the self-alignment. Circular symbols are marked on the parts. The position and the inclination angle of the microparts are measured by using these symbol and an image acquisition and processing system with a CCD camera connected to a microscope. The stage which the base part is set on (vibration stage) can be vibrated by a voice coil actuator. Water is used as the liquid which produces a surface tension force.

The alignment experiments were carried out as follows. (1) A large liquid drop is put on the base part so that the drop comes in contact with all the high wettability areas of the base part (four areas) and then is absorbed by a syringe. This action results in the liquid being only on the high wettability areas. (2) Four microparts are put on a

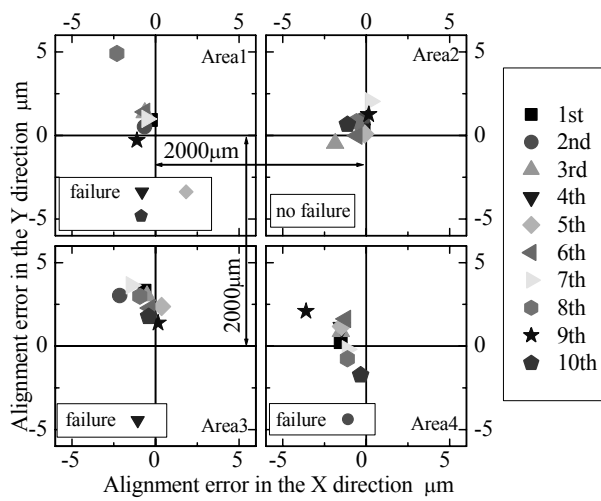


Fig.4 Experimental alignment error in the x and y directions

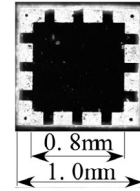


Fig.5 Improved experimental micropart

base part. (3) The vibration stage is vibrated. The alignment experiment based on this procedure was made 10 times. Figure 4 shows experimental alignment error in the x and y directions. In the experiments, 35 out of 40 microparts used were finally aligned by liquid surface tension. The average and standard deviation of alignment errors of the aligned microparts are almost the same as those by the method in [1]. Some out of the misaligned microparts were turned upside down and the others were moved far from the goal. These motions are caused by the low wettability area around the high wettability one of the microparts. The low wettability area sometimes prevents the liquid droplet from coming in contact with the high wettability area.

Improvement of reliability of the self-alignment

The low wettability area of the micropart sometimes hinders the liquid droplet coming in contact with the high wettability area of the micropart and forces the microparts fail in the alignment. On the other hand, the restoring force caused by the liquid surface tension is proportional to the length of the boundary line between the low and high wettability areas. For improving the reliability of the self-alignment, in this paper, the low wettability area on a micropart is divided into several areas so that the liquid is easy to spread over the high wettability areas of the microparts. Figure 5 shows the improved experimental micropart. The experimental self-alignment using these improved microparts and the conventional base part was made. In the experiment, all the improved microparts were not turned upside down and not moved far from the goal.

Self-standing

In manufacture of 3D microsystems, the out of plane rotational alignment is often needed. The 3D microsystems often include standing microparts. In this section, a self-standing method using liquid surface tension and vibration force is proposed and the experimental self-standing result is shown. The self-standing method is based on the self-alignment one of a micropart group. Only one surface of the micropart used in the self-standing includes the high wettability area. The base part has the same high wettability area on its one surface. Figure 6 shows the behavior of the micropart in the experimental self-standing experiment. The size of the micropart in Fig.6 is 1.0mm

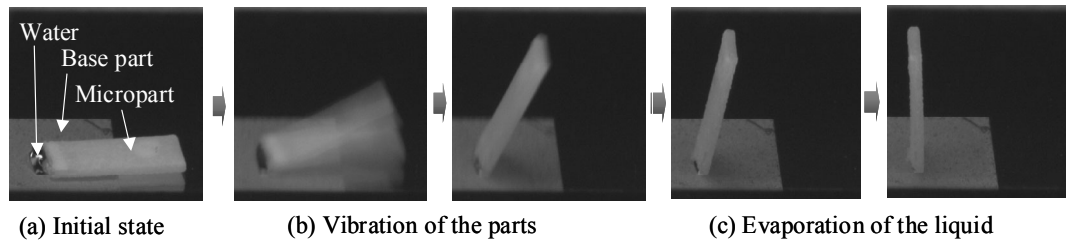


Fig.6 Behavior of the micropart in the experimental self-standing

x 2.6mm x 0.15mm. The areas of high wettability on the parts are 1.0mm x 0.15mm. The edge of the micropart keeps in contact with the base part by the liquid surface tension even if the vibration force is applied. The micropart stood up as the liquid evaporates and the droplet shrank. In case the length of the micropart is short enough, the micropart can stand up with the only liquid surface tension.

CONCLUSION

Microsystems which has 3D structure and comprises various microparts have been studied as advanced systems. In the assembly process for the microsystems, the alignment of a micropart group at a time and the out of plane rotational alignment are very important tasks. In this paper, first, the alignment methods for them using liquid surface tension and vibration force were introduced. And then their performances were evaluated experimentally. The experimental results show that the reliability of the introduced self-alignment method of a micropart group is very high by using the improved microparts and the proposed self-standing method is useful.

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