Automatic pick-and-place of 40 microns objects using a robotic platform.

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Abstract

Robotic micro-assembly is one way to manufacture new generation of out of plane and/or hybrid microsystems. This approach requires the study of micromanipulation strategies adapted to the microworld and especially to the surface and adhesion forces. We are focusing our works on the study of robotic assembly methods applied to objects whose size is below 100 micrometers. The handling strategy used is based on a two fingered gripper. In order to reduce the adhesion between the gripper and the manipulated objects specific end-effectors have been developed. Moreover, to improve the release reliability we are using a polymer substrate which induces high adhesion with the objet. Some automatic pick-and-places on objects whose typical size is 40 micrometers have been done (cycle time of 1.8 second). There show the reliability of the proposed approach.

1 Introduction

In a general way, design of Micro Electromechanical Systems (MEMS) is limited to monolithic structures which can be manufactured directly by microfabrication methods. In fact, the microfabrication capabilities highly reduce diversity and functionalities of microsystems. Innovative ways are required to build new generation of out of plane and/or hybrid microsystems [1,2].

One way to produce more complex microsytems is to assemble microcomponents. The robotic micro-assembly requires new manipulation strategies adapted to the microworld and especially to the surface and adhesion forces [3,4].

In these last five years, the performance of the micro-assembly has grown and this approach is now considered as a future means of MEMS fabrication.

Active gripper is one of the more common ways to micromanipulate. The grasp is obtained by clamping and the release requires specific repulsive forces (inertial release, DEP release, etc.) [5,6]. As the trajectory of the object after release cannot be currently controlled, these strategies are able to grasp a micro-object but cannot position it with a sufficient precision. Moreover, current efficiency of these release strategies stays low. A new and reliable release method is proposed in this paper.

2 Handling Strategy

We are proposing a new reliable and reversible method to position micro-object on a substrate. The principle is a hybrid strategy between adhesion manipulation and gripping and is based on a hierarchy of forces. In one hand, to guarantee the release of the object, the adhesion force between object and substrate must be higher than the adhesion force between object and gripper (see in figure 1):

$$F^{adhesion}_{object-substrate} >> F^{adhesion}_{object-gripper} \quad (1)$$

This method is inspired from adhesion handling [7] which enables reliable release but is not able to grasp again the object from the substrate. In order to grasp the object, a gripping force higher than the adhesion force between substrate and object along the direction $\vec{n}$ is required (see in figure 1):

$$F^{gripping}_{object-gripper} >> F^{adhesion}_{object-substrate} \quad (2)$$

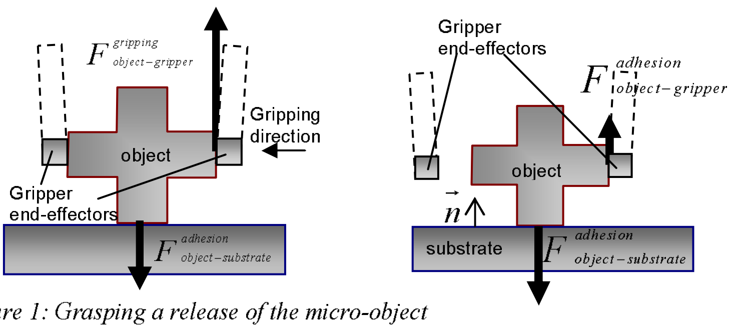

Figure 1: Grasping a release of the micro-object

One of the best technological solutions is to use gripper with two fingers where the gripping force could be easily higher than adhesion between the object and the substrate. Our hydrid method uses advantages of both adhesion manipulation and gripping. It enables a reliable release and grasping of micro-object.

3 Experiments

Two ways have been chosen to guarantee first object's manipulation: increase adhesion forces between the substrate and the object and decrease adhesion force between the object and the gripper.

Firstly, we chose to use as substrate a transparent gel film well-known in microelectronics: Gel-Pak®. This material is in fact softly adhesive, it consequently enables accurate pick and places. Moreover, the low mechanical stiffness of this polymer induces natural compliance of the substrate required for micro-assembly [8].

Secondly, efforts have been made on end-effectors shaping. First, surface in contact with the micro-object has been reduced by using end-effectors with a small thickness (12 μm). Moreover, the fabrication process called DRIE has been used to give the gripping surface a specific texture. Etching anisotropy of this process is made by a short succession of isotropic etching/protection cycles. These cycles create a phenomenon called *scalloping* which increases roughness and thus decreases adhesion [8,9].

In order to test the approach, a micro-object whose dimensions are 5x10x20 μm^3 has been placed on the substrate. First, gripper is moved above and fingers are opened to grip the object (see in figure 2). Then the object is hold by the gripper and separated from the substrate. The substrate is moved to a new position (target position). Finally, release is performed by moving down the gripper to create a contact between object and substrate then the opening of the gripper induces the release of the object.

Firstly, tests have been done in teleoperation. The operator controls the trajectories of the gripper and the substrate with a joystick without force feedback. 60 operations have been done. The time cycle stays always between 3 and 4 seconds.

Secondly, tests have been done in an automatic cycle without force and position feedback. The pick and place was repeated 60 times and the time cycle was 1.8 s.

4 Conclusion

The robotic assembly is one way to produce new microsystems with improved functionalities. This article focused on the pick and place operation of microparts in order to produce microscopic assembly systems. An original hybrid method between adhesion manipulation and gripping has been proposed. The experiments have validated our method and prove the high reliability of this new approach compared to the other methods. Future works will focus on the automation of the assembly.

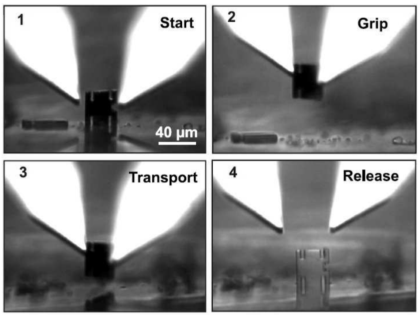

Figure 2: Teleoperated pick-and-place of a 40 µm micro-object

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