

Strategy and progress to establish a micro-assembly technology archive considering the mechanisms of joining- and manipulating- processes

Kunio Takahashi

Dept. of International Development Engineering,
Graduate School of Science and Engineering,
Tokyo Institute of Technology,
Meguro-ku, Tokyo 152-8552, Japan
<http://www.ide.titech.ac.jp/~takahak/>

ABSTRACT For the purpose of the optimization or the break through of production processes, it is essential to understand or theoretically interpret dominant mechanisms of the processes, and further more, archive them, and utilize them combining some of them which are needed. Especially in the technology for micro- or nano-scaled objects, adhesion phenomenon is no more negligible, because the adhesion force is proportional to the size of objects meanwhile gravity force is proportional to the third power of it. Author has been working about the mechanisms for micro-assembly processes, which include joining processes and manipulation processes. In the present paper, the strategy and the progress to establish the micro-assembly technology archive are introduced. Some of the mechanisms are introduced with related basic approaches to the adhesion phenomena. Also it will be expressed that our data base project for the surface and interfacial energies is strongly related to these basic approaches.

1. Introduction

Recently, nano-technology is focused by many researchers. Also micro-electro mechanical systems (MEMS) technology is more and more realistic. However, almost all of them are based on silicon processes. The silicon process by itself is not almighty. Its applicability is very limited. If manipulation processes and joining processes are combined with the silicon processes, remarkable flexibility would be achieved. Since the nano-processes are based on the micro- processes, also the micro-processes are significant for the nano-processes. Many processes should be analyzed theoretically in many scales and archived for further flexible applications. Then, it would give rise to revolutionary materials, devices, and systems as well as the packaging technology.

Down-sizing without scientific consideration gives no effective performance. For example, it is well known that adhesion of objects can not be neglected for micro-scaled objects, because adhesion force is proportional to size of the objects, meanwhile gravitational force is proportional to the third power of it. Adhesion phenomenon is more significant for smaller objects and it can not be neglected in the nano- and the micro- technology.

Author has been working about mechanisms of several processes for the micro-assembly. In the present paper, I would like to introduce my strategy and the progress up to now. Theoretical approaches are examined by experiments under well defined conditions. Also the mechanisms for the joining and the manipulating processes are introduced.

2. Strategy for micro-assembly technology

Recent MEMS technology is mainly based of the silicon processes. However, if other processes are introduced into it, the much more possibility would be derived from it. The micro-manipulation is the key process, because it can not be replaced by the silicon processes. For the purpose of the micro-manipulation, many mechanisms would be available. Even if a mechanism is useless for some process for some production, it might be useful and sometimes essential for other processes. The micro- and the nano-technology are lack of tools comparing with the conventional technology. We have to stack up such tools step by step.

In the accumulation of the manipulation technology, it is significant to make up a diagram, which clarifies the condition or the parameters to be selected in the processes. It is often the case that a mechanism is not negligible for micro processes, although the mechanism can be negligible in the large scaled processes. The adhesion phenomenon is the typical one. Adhesion force is proportional to size of objects meanwhile gravitational force is proportional to the third power of it. The adhesion is no more negligible for the smaller objects which would be treated in the nano- and micro-technology.

Fig.1 shows the schematic illustration of the strategy for the nano- and micro- fabrication technology. Three mechanisms are explained. Other mechanisms will be added in the tree after the investigation. All of them are based on the theoretical understanding of the adhesion phenomena

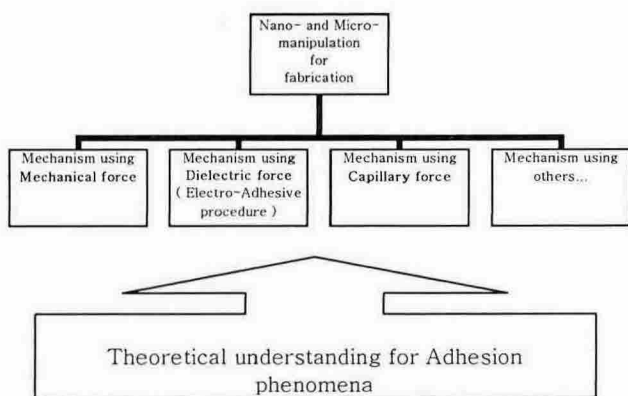


Figure 1 Schematic illustration for the strategy to establish a micro assembly archive

3. Mechanical manipulation

Mechanism using mechanical force has been investigated in the Ref.[1]. Fig.2 shows the schematic illustration and the SEM image of the manipulation using the mechanical forces. In the manipulation of small objects less than 1mm, adhesion force is not negligible, so two or more fingers are not essential for the manipulation. The object can be picked up and placed using the adhesion force. However, then, dynamics of the object must be taken into account. In the Ref.[1], the diagram is published, although it is not expressed here, because the purpose of this paper is not the each diagram but the strategy for the real fabrication.

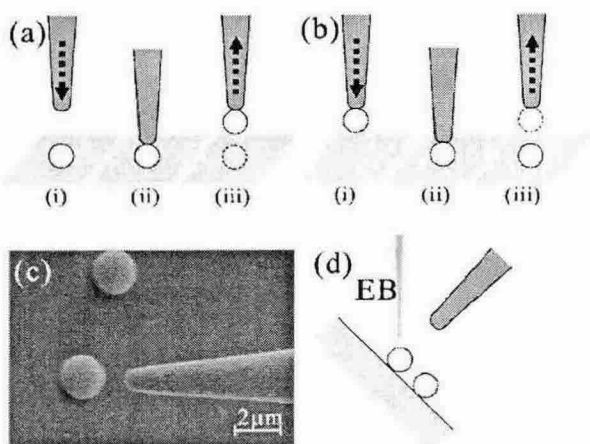


Figure 2 Schematic illustrations for the mechanical manipulation

4. Dielectric manipulation

Mechanism using mechanical force has been theoretically predicted in Ref.[2]. It is experimentally investigated. The prediction is found to be accurate and useful in the Ref.[3]. Even if the voltage is applied and the object can be detached, it must softly land on the surface. The process for the soft landing is expressed in Ref.[4].

The Fig.3 shows the schematic illustration of the process. At the first step, some voltage is applied to the probe on which an object is adhered. Then the object is detached and flies to the substrate. By the applied voltage, the object is accelerated. So, next, the reversed voltage will be applied for the breaking. Finally, the object lands on the substrate. The voltage required for the detachment is clearly expressed in a diagram in Ref.[2]. It is experimentally investigated in the Ref.[3]. The voltage required for the breaking is predicted in the Ref.[4]. Since details of the diagram are not the main subject of this paper, it is not expressed here. Without such diagram, any one would not be able to find the condition for the detachment, the acceleration, and the breaking. Anyway, we have already constructed the tool using the dielectric force.

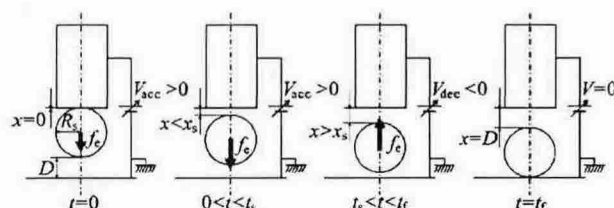


Figure 3 Schematic illustration of the manipulation using the dielectric force [2~4]

5. Capillary manipulation

Mechanism using mechanical force has been theoretically predicted in Ref.[5]. Also precise investigation will be published in the near future. Fig.4 shows the schematic illustration of the manipulation using the capillary force [5]. Using the capillary force, we pick up and place the object. The diagram for the capillary force is published in the Ref.[5], although it is not write here, because the details are not the subject here. However, without the diagram, no one could find the optimum volume for picking-up and placing, i.e., for the manipulation.

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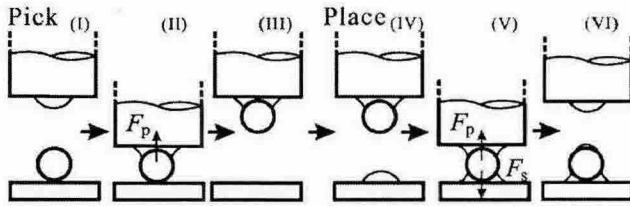


Figure 4 Schematic illustration of the manipulation using the capillary force [5]

6. Significance of diagram

We can not complete the nano- and micro- assembly with only above three mechanisms. Another mechanism should be investigated. Then, to make up the diagram is the most significant. Without the diagram, any mechanism can not be utilized for the real fabrication. In order to realize the processes, in order to optimize the process, and in order to break through the limitation, the diagram is essential and always treated just like as Bible, Koran, or something. Another mechanism will be published in the near future.

Such investigation must be based on the physical interpretation of the adhesion phenomena. Authors have been measuring the adhesion force under the well defined ultra vacuum chamber of Auger electron microscope [6]. The results are interpreted using the theoretical interpretation based on the contact mechanics [7,8,9], the quantum mechanics [10], and the molecular mechanics [11,12]. The works [1~5] were possible because they are based on the physical understanding [6~12].

7. Conclusions

The author's strategy to stack up the tools for the nano- and micro- fabrication is introduced. And the mechanisms for three processes are expressed with the diagram. They all are based on the physical interpretation of the phenomena. It is suggested that both of the precise measurements and the theoretical interpretation are essential for the accumulation of the tools. They must be done step by step, even though they seems to be slow.

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