International Training Program

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As a part of International Training Program (ITP), I have studied about micro analysis chip with low cost material in University of Twente. The duration of visit was two months (from 31th August 2012 to 5th November 2012). I worked at the BIOS, Lab on a Chip group of Prof. Albert van den Berg. The summary of the visit is reported as follows.

1. The life in Twente University and Enschede

University of Twente is located in Enschede, close to the border to Germany. It is in full of nature. The campus has a supermarket, a sports gym, a playground, a hotel, a barber shop, and so on. In this program, I lived in the ITC international hotel, close to Enschede station. In the square near the hotel, market is held twice a week. They sell cheese, clothes, flowers, fruits, and so on. There is a convenient sight for living. I went to the university by bike or bus. Most of students go to school by bicycle, because there are well-paved and wide cycle lane. I was amazed that people in Netherland ride a bicycle without raingears. In the laboratory, most of members worked from 9:00 to 18:00 including the time for lunch and a couple of coffee break. However, they can obtain the results efficiently, since they are supported superior technical staffs and discuss with their supervisor frequently.

2. The background and purpose of my research

I have been studying the molding process of PDMS by using SU-8 resist-die in Hiroshima university. However, the total chips' cost with PDMS is relatively expensive for the practical clinical use. Then, plastic such as polystyrene was picked up as the cheaper material. On the other hand, the micro-fabrication process and the condition to form the minute structure on that polystyrene resin have not been established yet. The feasibility study of hot embossing process by using PDMS-die for polystyrene resin has been done by the former visitor. Besides of his results, I would study about implanting magnetic particles to polystyrene for practicability.

3. The content of my research

In this program, I studied hot embossing process using PDMS mold onto Polystyrene (PS) that known as low cost material. The PS has such advantage for micro devices as low cost, rigidity, chemical stability, and facility molding. The mold with PDMS has several advantages. Due to its elasticity and low surface energy, it is easy to separate PS from PDMS after embossing process, and to replicate structure at the nanoscale. However,

since PDMS is a soft material, especially for microstructures with large aspect ratio and small cross-sectional area such as the micropillars might be damaged mechanically. Furthermore, it should be noted that, because of the softness of the PDMS mold, excess embossing force should be avoided during embossing to prevent the excess geometrical deformation of the PDMS mold which results in poor replication.

In this program, Dr.ir. Séverine le Gac as supervisor and Dr. Zhenxia Hao have been a great support to me. First, I learned hot embossing basic process. I had micro channels made on Si wafer by Dr. Zhenxia, by using SU-8 resist(width: 10～120 μm, depth: 50,100,150 μm). Then I made PDMS mold for hot embossing by using the wafer. A PDMS prepolymer (10 : 1 w/w) was cast onto the wafer and cured at 60 ◦C for all night. The hot embossing process was done by using hand-made tool shown in figure 1. PS plate was placed above copper disc. The disc was heated to the given temperature by soldering iron. Polystyrene is heated only the region contacted with copper melts. The pressure loading can be varied by adjusting screw. After setting PS plate and PDMS mold on copper plate, it is started to emboss (temperature: 200 ℃, embossing time: 10 min). After that, it is cooled at room temperature on holding applied pressure (cooling time: 10 min). Finally, the PDMS mold is carefully peeled from PS after unfixed from the equipment. An example is shown in figure 2. As a result, the value more than 50 μm were appropriate for width of channels. Therefore I decided to choose the value over 50 μm as width of channels.

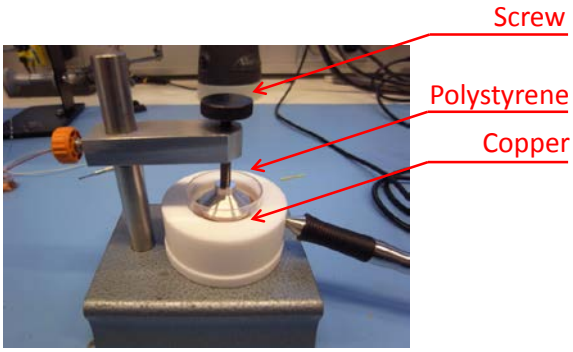

Figure 1: Hot embossing tool

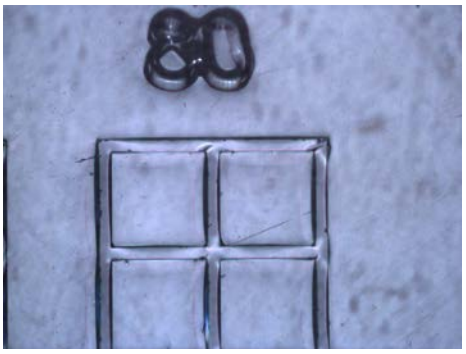

Figure 2: PS plate with micro structures

Second, I tried to implant magnetic particles to channels in PS plate. I am studying about a micro channel to separate cells by using magnetic force. When a magnetic field is applied to the channel, magnetic particles nearby channel are magnetized, and they catch cells (Figure 3). Now, we are using PDMS as the material of channel, but I wanted to use polystyrene as the alternative.

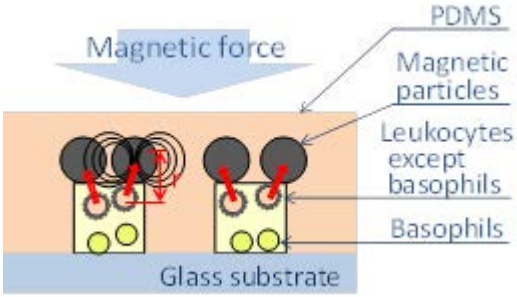

Figure 3: Separation method of basophils by magnetic force

The fabrication process is shown in figure 4. First, the glass slide is covered with one layer of magnetic particles. PDMS mold is placed on it. Then magnetic particles are attached to PDMS surface. PDMS mold with magnetic particles presses PS plate by hot embossing process. Then, PS plate is cooled on holding applied pressure. Finally, the PDMS mold is carefully peeled from PS plate. The magnetic particles are transfered and implanted to PS plate. The result is shown in figure 5. As far as I checked the pictures taken by microscope, magnetic particles were only transfered to channel of PS plate.

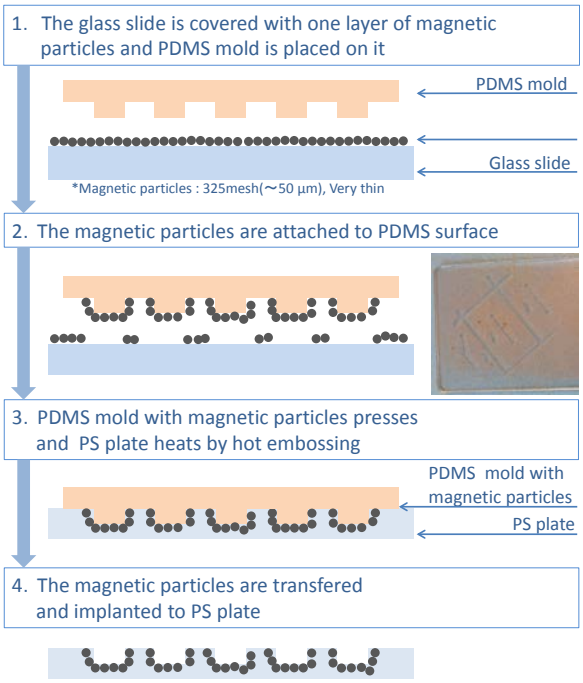

Figure 4: The process of hot embossing PS plate with magnetic particles

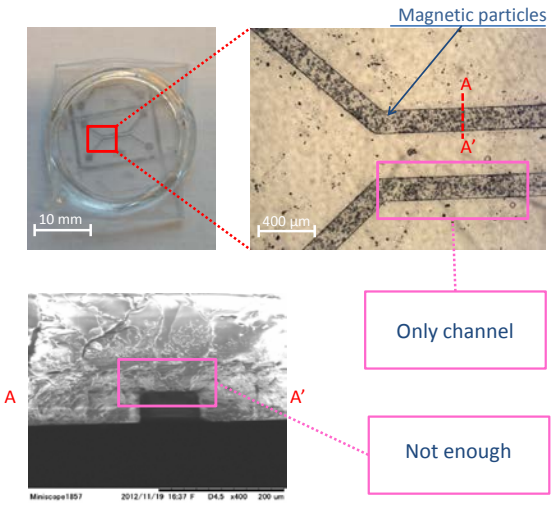

Figure 5: PS plate with magnetic particles

Next, I checked the picture of SEM, and the density of the magnetic particles is small. There I proposed 2-step process for hot embossing (Figure 6). I aligned of PDMS

mold with the PS plate by using micro scope. I expected to increase magnetic particles on the PS plate. The result is shown in figure 7. The density of magnetic particles has increased. However, still there has some gap with the channel configuration in between first and second process. We have to improve the aligment method.

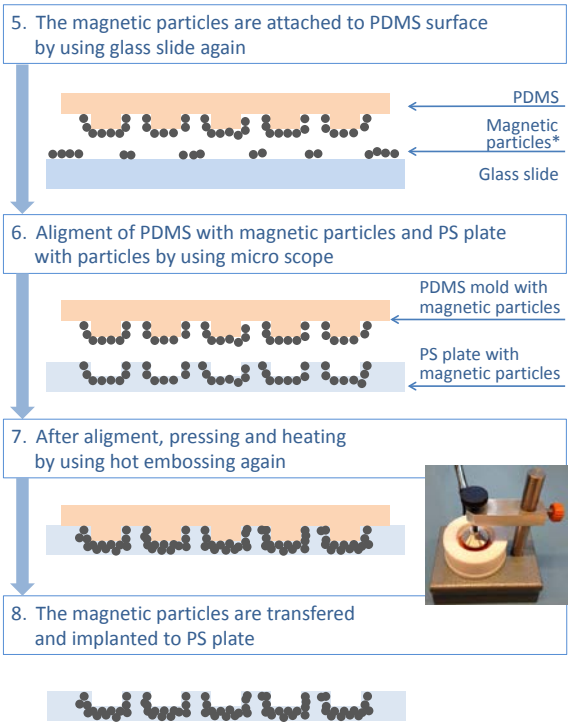

Figure 6: 2-step hot embossing process

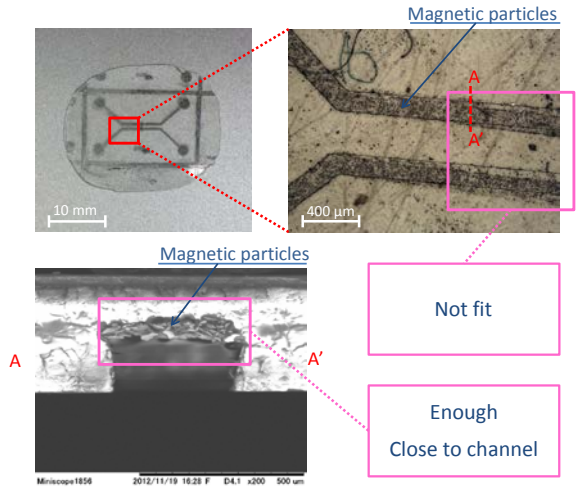

Figure 7: PS plate with magnetic particles by 2-step hot embossing

4. Summary

In this program, I learned various knowledge related to my research field. Furthermore, through the trips to the Netherland and another countries, my communication skill has been advanced very much and I was to gain lots of experience which I couldn't have unless I was in other countries. And I came in touch with foreign cultures and people, then I could recognized good and bad things of Japan. I could find out another aspect of our own culture. I convince that I would like to make use of the knowledge and the experience acquired through the program for my carrier.

Thanks to support from many people, I could finish this program. I deeply appreciate to BIOS, Lab on a Chip group staffs in University of Twente and Research Center for Plasma ITP Secretariat staffs in Nagoya University.