BLOOD PLASMA SEPARATOR USING MICRO PILLARS ARRANGED LIKE A LABYRINTH

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ABSTRACT
The goal of this research is to realize a blood plasma separator from whole brood, which enables to be fabricated in a healthcare devise using MEMS technology. This plasma separator has an idea that many micro pillars are arranged like a labyrinth. When whole blood is injected, blood cells are captured sequentially by a labyrinth and are finally captured over the whole area of the blood separator, and as a result blood plasma is extracted outside efficiently. We report a concept of this blood plasma separator, fabrication method and experimental results.

KEY WORDS: Blood Cell, Blood Plasma, Separator, Micro Pillar

INTRODUCTION

Many kinds of blood plasma separator have been developed to be fabricated into micro devices. Almost all separators have narrow gaps, weirs or micro pillars in micro capillaries to prevent blood cells from passing through. Because micro capillaries become clogged with blood cells easily, cross flow-type separators have been experimented with and reported; in those, the directions of the flow of whole blood and the flow of blood cells intersect with each other [1], [2], [3]. However, they were not efficient enough. This paper reports a new blood plasma separator that enables separation and collection of blood plasma efficiently.

We propose a blood plasma separator in which many micro pillars are arranged to form many pockets over the blood plasma separator area like a labyrinth. When whole blood enters the blood plasma separator, blood cells are captured in pockets sequentially in the whole area of the blood plasma separator, and blood plasma passes through gaps between the pillars of pockets and then exits the blood plasma separator.

METHOD

Figure 1 shows a schematic diagram of the blood plasma separator that has many micro pillars arranged to form many pockets over all separation area like a labyrinth. When whole blood is injected from the left side and flows to the right side, blood sells enter pockets and are captured; on the other hand, blood plasma passes through gaps of these micro pillars. By distributing these micro pillars over the entire surface of the blood plasma separator, blood cells will be trapped gradually from the front side of the separator and blood plasma will pass through micro pillars and be extracted in a forward direction. Finally, blood sells will be trapped over the entire surface of the blood plasma separator, and blood plasma will be extracted in a forward direction.

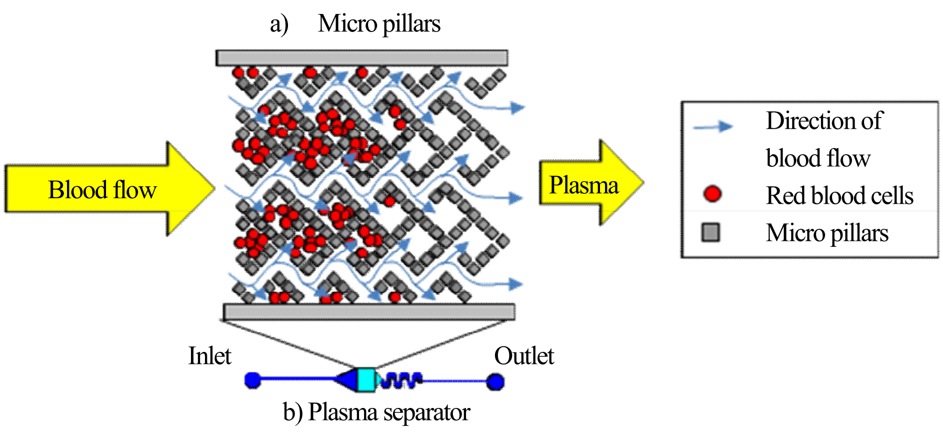

Figure 1. Schematic views of a plasma separator, a) micro pillars arranged to form many pockets over a blood plasma separation area like a labyrinth. b) whole area of the blood plasma separator.

The blood plasma separator was fabricated by using photolithography. Figure 2 shows photo masks. Two photo masks were used to fabricate the blood plasma separator; one was for the fluid path and another for micro pillars of the blood plasma separator. These photo masks were prepared on the glass substrates by using Micro Stereo-lithography System ACCULAS, and vapor deposition process.

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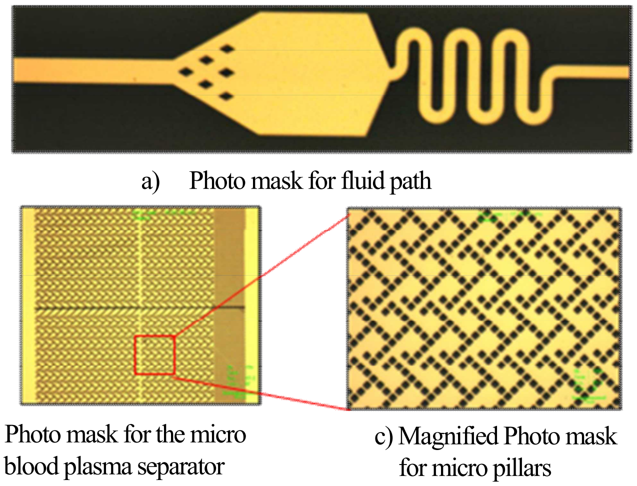

Figure 2. Photograph of Photo masks. a) shows photo mask for fluid path, b) shows photo mask for the micro blood plasma separator consisted of micro pillars. c) shows magnified micro pillars arranged like a Labyrinth.

It is very difficult to fabricate micro pillars on a glass substrate accurately and stably, we proposed an idea that the micro pillars were fabricated on a photo mask substrate. The fabrication process had two steps. First step was that the photo resist was coated on a photo mask for blood plasma separator and exposed with conventional UV radiation from the back side of the photo mask substrate. Second step was that the resist coated photo mask was aligned with the photo mask for fluid path and exposed again with conventional UV radiation from the side of the photo mask for fluid path. After the developing process, the structure of the blood plasma separator and the fluid path was obtained.

Figure 3 shows photographs of the blood plasma separator and the micro pillars. a) shows a whole view of the blood plasma separator. b) and c) show micro structures measured by using laser scanning confocal microscopy. Micro pillars were fabricated by photolithography using photo resist SU-8 3010. The micro pillars were 3.4×3.4 μm^2 at the base and 10 µm in height. The gap width of each micro pillars was 0.86 µm and the entire area of the blood plasma separator was 510 × 510 μm^2. The micro plasma separator had the end structure which prevent from passing blood cells threw the blood plasma separator.

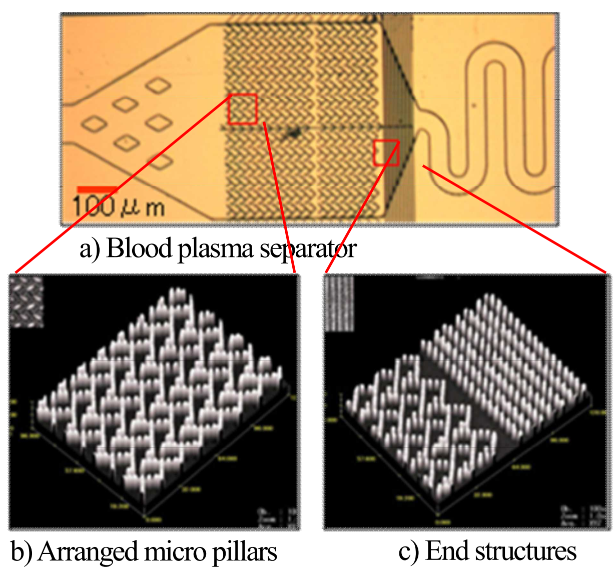

Figure 3. Photographs of the blood plasma separator and arranged micro pillars. The blood plasma separator is 510×510 μm^2, each micro pillar is 3.4×3.4 μm^2 at the base, 10 µm in height and 0.85µm in gap.

EXPERIMENTAL RESULTS

Figure 4 shows experimental results obtained by using human whole blood. No.1 to 7 shows series of the experimental results taken in time series. 1 shows the moment when whole blood reached the front edge of the blood plasma separator. 2 to 4 show the moments when the whole blood was separated into blood cells and blood plasma. The dark red area in these pictures shows red blood cells captured by pocket surrounded by micro pillars. The glowing light yellow zone shows separated blood plasma. 5 to 7 show blood plasma extracted from the end of the blood plasma separator. Finally, blood cells were captured over the whole area of the blood plasma separator and blood plasma was extracted.

Figure 5 shows the enlarged photograph of the blood plasma separator filled with red blood cells. The photograph shows that a lot of blood cells were captured and filled by many pockets over the whole area.

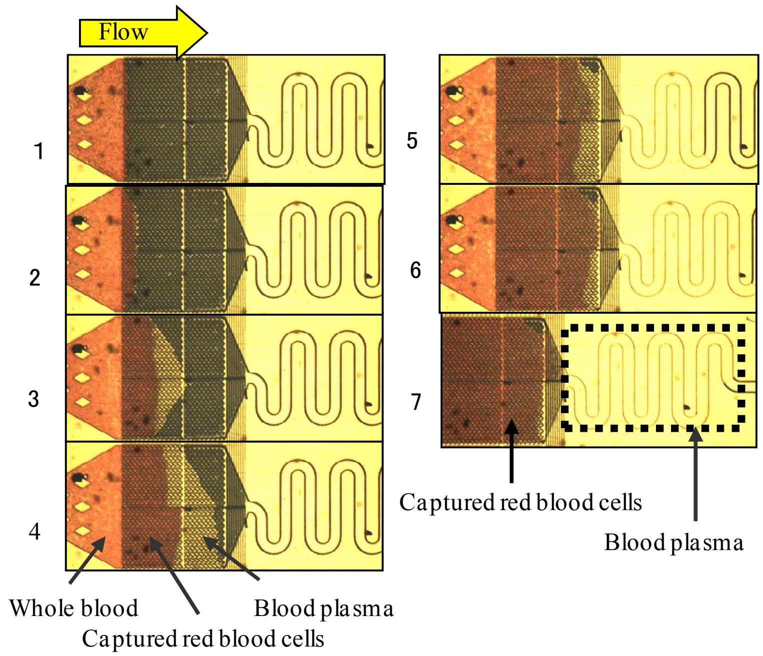

Figure 4. Experimental result using human whole blood. 1 to 7 show series of the experimental results taken in time-series.

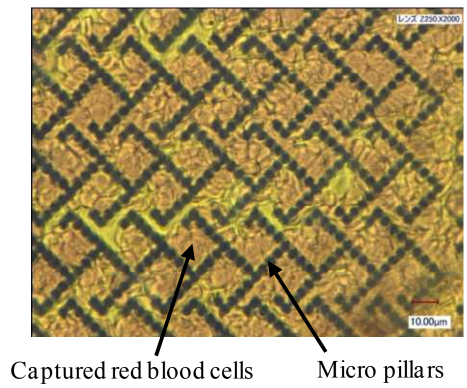

Figure 5. Photograph of captured blood cells

CONCLUSION

A blood plasma separator that is able to be fabricated into a micro device was designed and experimented with. It was demonstrated that micro pillars arranged like a labyrinth, captured red blood cells successfully and separated blood plasma. Because this plasma separator does not have to be added pressure from outside, there is no destruction of the blood cells. In the experimental result, whole blood penetrated in a filter and blood cells were captured and almost plasma was extracted by front course. But this study of this paper was a feasibility study, it will be necessary to optimize the size and the arrangement of micro pillars.

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