A Microfluidic System for Capturing Malaria-Infected Blood-Cells Using an Array of Nickel Structures

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Abstract

Treatment and prevention of malaria, a disease having an anopheles mosquito as a carrier, have become a severe medical issue to many countries in a tropical zone. It was reported that there have been patients about 300-500 millions all over the world[1]. Many countries in South East Asia including Thailand have a high rate of seasonal spreading between the borders of the country. In the last decades, many alternative techniques have been proposed to reduce time and work-force for malaria diagnosis. Among various techniques, an employment of a magnetic force was extensively studied due to malaria-infected red blood cells exhibit a unique magnetic property that is different from healthy blood cells. However, the magnitude of the exerted magnetic force is very small and typically effective within a small area close to a magnetic source. Therefore, the system design needs an improvement to efficiently capture infected red blood cells.

For few years, our research group has studied and developed a lab-on-a-chip technology to tackle this issue[2]. Infected red blood cells were captured using an array of magnets placed beside the microchannel in which the blood sample was fed through. However, the magnitude of magnetic force was inappropriate to achieve the goal; therefore, this work proposes the additional microstructures inside the microchannel to increase the capturing possibility.

To enhance the effectiveness of the system, this study proposes to use nickel microstructures, which would disturb the external magnetic field and increase the magnitude of magnetic force locally. These microstructures are uniformly placed inside the microchannel so that the opportunity that the infected blood cells would be captured under the influence of magnetic forces increase. One important issue is that the placement of microstructures should be in a proper and right position in order to maximize the magnitude of magnetic force and minimize the magnitude of hydrodynamic drag force exerting on the cells. For this reasons, this study aims to examine the effects of microstructure alignment that could provide the desired condition.

AC/DC and Microfluidic module with 2-D simulation were employed in order to compare the magnitude of both magnetic and drag force at a certain position. According to Fig. 1a exhibiting the velocity field of fluid flow around the square microstructure, the stagnation point at the frontal area tends to be a location where the magnitude of drag force is small while a high gradient of magnetic field could be created as well as shown in Fig. 1b. Therefore, the examination of the effects of the placement as well as the alignment of the microstructures on the magnitude of both forces is very important in order to find a proper design of the system.

Figures used in the abstract

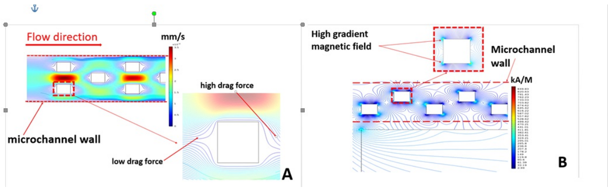

Figure 1: Fig. 1 Simulation results on magnetic and velocity fields: (a) streamline around a nickel microstructure and (b) magnetic field induced by a nickel microstructure.