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The Real-time Detection of Micron-sized Magnetic Beads for a Chip-cytometer

Jong Wook Roh[1], Young Taek Lee[1], Oh-Taek Son[2], Hyo-Il Jung[2], and Wooyoung Lee[1]*

[1]Department of Materials Science and Engineering, Yonsei University, Seoul, South Korea
[2]School of Mechanical Engineering, Yonsei Univ., Seoul, South Korea

*Corresponding author: wooyoung@yonsei.ac.kr, Phone: +82-2-2123-2834, Fax: +82-2-312-5375

The development of a chip-cytometer based on the detection of magnetic beads using spintronic devices has recently attracted great interests since they are capable of realizing both cell-separation and cell-counting on a chip at the same time. In order to implement a chip-cytometer, the real-time detection of magnetic beads moving in a microfluidic channel is one of the key issues. The sensing elements for the detection of the moving magnetic beads are to have characteristics such as high sensitivity, good signal to noise ratio (S/N) and low detection limit. Spin-valve devices offer sufficiently these characteristics compared with the other spintronic devices such as anisotropic magnetoresistance (AMR) devices, Hall effect devices and magnetic tunnelling junction (MTJ) devices. However, to date, no one has attempted yet to apply a spin-valve device as a sensing element for a chip-cytometer. In the present work, we report on the real-time detection of moving magnetic beads using highly sensitive spin-valve devices integrated in a microfluidic channel for the application of a chip-cytometer.

The generic structure of a spin-valve was $Co_{84}Fe_{16}$(20)/NOL/$Ni_{81}Fe_{19}$(25)/$Co_{84}Fe_{16}$(10)/Cu(17)/ $Co_{84}Fe_{16}$(20)/$Ir_{22}Mn_{78}$(75)/Ta(50) (Å). In this work, nano-oxide layers (NOLs) were employed to enhance the sensitivity and to enlarge the range of a magnetic field resolved by a spin-valve sensor. The spin-valve sensor was observed to exhibit about 10 % magnetoresistance(MR). A combination of photo lithography and a lift-off process has been utilized to fabricate a spin-valve sensors (w = 4 μm, l = 20 μm). A polydimethylsiloxane(PDMS) microfluidic channel with a height of 25 μm and a width of 30 μm was fabricated in order to transport superparamagnetic beads with d = 2.8 μm (Dynal bead 280).

Prior to the real time detection, the motion of magnetic beads in the fluidic channel was simulated by computer simulations (incompressible Navier-Stokes module in COMSOL 3.2b. COMSOL Inc.) in order to stabilize the real-time signal voltage. It was found that the required channel length to finish their sedimentation and the velocity of the particle after settling down at a flow rate of 0.01 μl/min was 0.92 mm and 85 μm/s, respectively. In order to generate a magnetic dipole field of magnetic beads, a DC magnetic field of 34 Oe was applied to the longitudinal direction of the spin-valve structure. The real time detection of a single-bead was observed by the direct measurement of a magnetic dipole filed from a moving magnetic bead using a spin-valve sensor. It was found that the real-time signal voltage of 0.3 μV sharply dropped when a magnetic bead approached the active area of the spin-valve sensor. This signal voltage was consistent with calculated value of ~ 0.4 μV. The signal voltage output recovered the initial voltage as the magnetic bead completely passed over the active area. This signal voltage drop is attributed to a fringe field of the magnetic bead, which partially cancels the applied field in the free layer of the spin-valve structure. Our results demonstrate the possibility of implementing a chip-cytometer for biological applications using high-sensitive spin-valve sensor integrated with a microfluidic device.

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Measurement of Spatial Arterial Pulse Waveform Using Mutiple Hall Devices

Sang-Suk Lee[1]*, Gi-Wang Kim[2], Jong-Gu Choi[3], Do-Guwn Hwang[1], and Myung-Cheon Ahn[4]

[1]Dept. of Oriental Biomedical Engineering, Sangji University, Wonju, Gangwondo, South Korea
[2]Dept. of Oriental Medicine, Sangji University, Wonju, Gangwondo, South Korea
[3]Oriental Medical Industry Development Center, Sangji University, Wonju, Gangwondo, South Korea
[4]Dtron Research Development Institute, Sangji University, Wonju, Gangwondo, South Korea

*Corresponding author: Author1 Sang-Suk Lee, e-mail: sslee@sangji.ac.kr

The simulation of the magnetic field distribution for the permanent magnet using the finite element method (FEM) shows two-dimensional distribution of the magnetic field for magnet array in a sensing surface [1]. It is corresponded with the distribution of height displacement slightly changed by arterial pulse fluctuation. To analyze the magnetic field distribution of special wave form, the FEM simulation for the array detection system was done. By varying the contact pressure and so the height of a permanent magnet on the skin, a method of characterizing the spatial pulse wave based on the degree of floating, the width, and the depth was introduced when the magnetic field was 0.05 T. It is expected that not only the blood pressure and velocity of radial artery can be measured, but also the three dimensional spatial imaging graphics of pulse wave can be obtained by SAPW (spatial arterial pulse waveform).

When a pressure controlling apparatus is adhered to the pressure chamber, it is possible to get pulse qualities easily at the state of "Bu", "Jung", and "Chim" of the traditional pulse diagnosis [2]. However, to show the function of the pressure controlling apparatus properly, it is necessary to embody the detecting sensor according to the SAPW into a wrist watch or a bracelet and to transfer the increased pressure to the skin contacting part when pressure of the pressure chamber is increased.

We measured signals at the "Chon", "Gwan", and "Chuck" region, as shown in Fig. 1(a) using the SAPW system. The passed signals through the voltage detecting hard ware system made a differential input, an automatic zero set, a noise filtering, a high power gain and output attenuation, and output them with 12 bit resolution at 30 FPS (frame/s). It simulated the result with a predetermined computer processing, and obtained three dimensional image of Fig. 1(b). By the computer processed 3-dimensional image of signals detected by SAPW, wherein is marked one point pulse to analyze the temporal pulse wave, we can select it. Fig. 1(c) shows an example of measuring time (second) versus temporally typical signal of one point pulse obtained from the analysis for an arbitrary 3-dimensional pulse image of one position of small size permanent magnet. The spatial change of the pulse height in arterial pulse incurred one permanent magnet within 1 mm. We confirmed that one example of measuring pulse signal was reproducible and provided many information for oriental medical diagnosis.

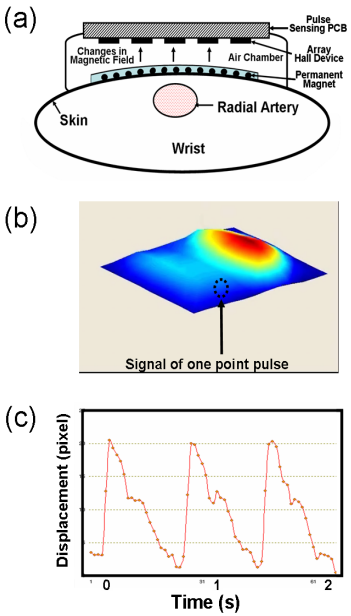

Fig. 1. (a) Schematic of sensing part of SAPW system, (b) the computer processed 3-dimensional image of signals detected by SAPW, and (c) example of measuring time (second) versus temporally typical signal of one point arterial pulse.

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REFERENCES

[1] S. W. Kim, Y. G. Choi, H. S. Lee, D. H. Park, D. G. Hwang, S. S. Lee, G. W. Kim, S. G. Lee, and S. J. Lee, J. Appl. Phys. 99, R908 (2006).
[2] E. M. Ka and D. R. Son, J. Mag. 13, 34 (2008).