Status and trends in high performance magnetic sensors and their applications

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Planar Hall resistance (PHR) sensors has many advantages (such as high signal-to-noise, small offset voltage and very linear response at low field range) compared to other magnetoresistive sensor [1]. Until now, multilayer sensor structures have been studied to improve the sensitivity of PHR sensor using cross-shaped sensor junction. At this time, the sensitivities of the PHR approximately 3, 7 and 12 μV/Oe respectively [2]. Among these structures, the sensitivity of trilayer structure was higher than others because its interlayer (Cu) reduced the exchange bias field and shunt current. In order to obtain more improvement of sensitivity, we have designed a new geometry (ring-shaped) of the sensor with Wheatstone bridge configuration over existing cross-shaped. For a constant ring width, both the sensitivity and the output voltage is proportional to the ring radius.

We have integrated multiple rings in a one ring junction of the sensor called multi-ring sensor. In using this magnetic sensor, we have made the on-chip magnetometer [3]. The on-chip magnetometer has been made by integrating a planar Hall magnetoresistive (PHR) sensor with microfluidic channels. In order to make this on-ship magnetometer, we uses successive hard and soft photolithography method. The in-plane field sensitivities of the integrated PHR sensor with trilayer structure was approximately 8 μV/Oe. The monitored PHR signals during the oscillation of magnetic nanoparticles droplet of 40 pL showed the reversed profiles for positive and negative z-fields, and their magnitudes increased with the applied z-field strength. The measured PHR signals versus applied z-fields are well fitted with the magnetization curve by vibrating sample magnetometer (VSM) for 3 μL volume; herein the PHR voltage of 1 μV is calibrated to be 0.309 emu/cc volume magnetization. In addition, I will introduce the biochip system based on spintronic devices.

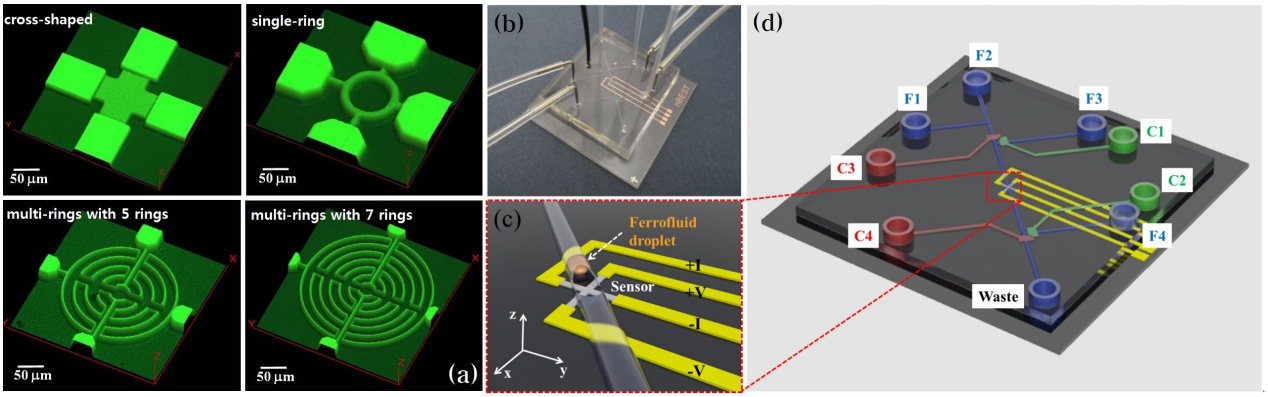

Figure: (a) 3D-microscopic images of various PHR sensor, (b) on chip magnetometer chip, (c) Schematic drawing of ferrofluid droplet coming towards the PHR sensor, (d) Schematic drawing of on chip magnetometer in which the channels (F1, F2, F3 and F4) represented in blue color are flow channels for generation of ferrofluid droplets and the channels (C1,C2,C3 and C4) represented in red color are control channels (valves) for operation of ferrofluid droplets oscillation.

Reference

[1] P.P. Freitas, H.A. Ferreira, D.L. Graham, L.A. Clarke, M.D. Amaral, V. Martins, L. Fonseca, J.S. Cabral, in: *Magnetoelectronics*, edited by M. Johnson, Elsevier, Amsterdam, 2004.
[2] T.Q.Hung, S.Oh, B.Sinha, J.R.Jeong, D.Y.Kim and C.G. Kim, J. Appl. Phys. 107, 09E715 (2010).
[3] Kun Woo Kim, Venu Reddy, Sri Ramulu Torati, Xing Hao Hu, Adarsh Sandhu, and Cheol Gi Kim, Lab Chip, 15, 696 (2015).