Improving Magnetic Field Detection Limits of Spin Valve Sensors Using 3D Magnetic Flux Guide Concentrators

Z. Marinho, A. Gualdino, S. Freitas, R. Chaves, R. Ferreira, J. P. Conde, and P.P. Freitas

Instituto Nacional de Engenharia de Sistemas e Computadores
Microsistemas e Nanotecnologias (INESC-MN), 1000-029 Lisbon, Portugal
Instituto Superior Técnico (IST), 1000-029 Lisbon, Portugal

zitamarinho@gmail.com

***Index Terms*—1/f noise, flux concentrator, low field detection, magnetoresistive sensors, spin valve sensitivity.**

This work will conduct a study regarding the improvement in low amplitude static magnetic field detection, following the research line of A. Guedes [1] [2]. To achieve measurements below the nano Tesla range an integration of magnetoresistive sensors, magnetic flux concentrators and microelectromechanical systems (MEMS) has been carried out. The operation range frequency is shifted from DC to high frequencies in order to decrease the 1/f noise. This process is achieved by mechanical modulation of a static magnetic field by the MEMS resonator [3].

The improvement made here is given by the optimization of the magnetic flux concentrators based on CoZrNb or CoFeB/Ru/CoFeB multi layers, increasing the detection limit of the magnetoresistive sensor [5]. 3D Magnetic Flux Concentrators were created [see Fig.1] in order to study its effect on the magnetic field gain at the sensor level. A 10 to 100 fold increase is expected to be obtained when integrating these concentrators with spin valve sensors or MgO based magnetic tunnel junctions. In addition an improvement in the design was made [4] in order to achieve a better performance of the overall system.

Different processing approaches for the fabrication of the concentrators have been studied and compared, both by ion milling under controlled angles and lift off processes. This work challenges the detection limits of low static magnetic field signals, aiming at the pico Tesla range.

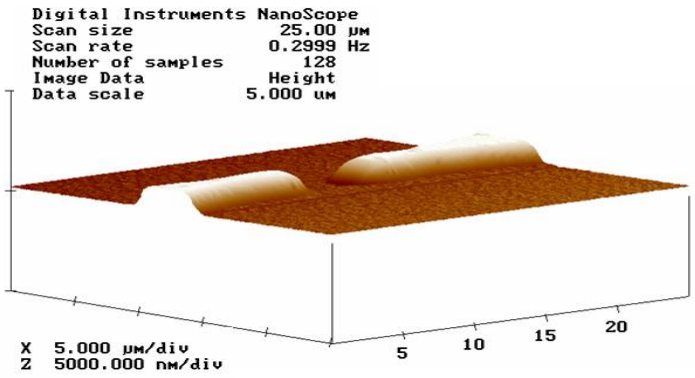

Fig.1 - Flux concentrator gap image obtained from AFM measurement. A 25.6 degree angle profile is obtained by ion milling processes in a CoZrNb 7000A layer.

References:

TNT2010 September 06-10, 2010 Braga, Portugal

[1] For the starting point of the research line see, _Improving Magnetic Field Detection Limits of Spin Valve Sensors Using Magnetic Flux Guide Concentrators ; A. Guedes , J. M. Almeida , S. Cardoso , R. Ferreira , and P. P. Freitas, (INESC-MN), IEEE Transactions on magnetics, Vol. 43, no. 6, June 2007.

[2] Hybrid Magnetic Tunnel Junction – MEMS High Frequency Field Modulator for 1/f Noise Suppression; A. Guedes , Samadhan B. Patil , Piotr Wisniowski , Virginia Chu , João P. Conde, and P. P. Freitas; IEE Transactions on magnetic, Vol. 44, no. 11, November 2008.

[3] Hybrid magnetoresistive microelectromechanical devices for static fiel modulation and sensor 1/f noise cancellation; A. Guedes, S.B. Patil, S. Cardoso, V. Chu, J.P. Conde, and P.P.Freitas; Journal of Applied Physics 103,07E924 (2008).

[4] P. Drljacca, F. Vincent, P. Besse, and R. Popovic, "Design of planar magnetic concentrator for high sensitivity Hall devices" *Sens. Actuators A*, vol. 97–98, pp. 10–14, 2002.

[5] C. Fermon, M. Pannetier-Lecoeur, N. Biziere, and B. Cousin, "Optimizing GMR sensor for low and high frequencies applications" *Sens. Actuators A*, vol. 129, pp. 203–206, 2006.