Electromagnetic Microsystem for the Detection of Magnetic Nanoparticles in a Microfluidic Structure for Immunoassays

A. Rabehi[1], H. Kokabi[1], K.A. Ngo[2], V. Dupuis[3], S. Neveu[3], S. Graff-Dubois[4], H.-J. Krause[5]
E-mail address: amine.rabehi@upmc.fr

[1] Sorbonne Universités, Univ Paris 06, UR2, L2E (Laboratoire d'Electronique et Electromagnétisme), Paris
[2] Sorbonne Universités, UPMC, Univ Paris 06, UMR 8235, LISE
(Laboratoire d'Interfaces et Systèmes Electrochimiques), F-75005, Paris
[3] Sorbonne Universités, UPMC, Univ Paris 06, UMR 8234, PHENIX
(Physicochimie des Electrolytes et Nanosystèmes interfaciaux), Paris
[4] Sorbonne Universités, UPMC, Univ Paris 06, CR7 - Inserm U1135 - CNRS ERL 8255, CIMI
(Centre d'Immunologie et des Maladies Infectieuses), Paris
[5] Institute of Bioelectronics, Peter Grünberg Institute (PGI-8), ForschungsZentrum Jülich (FZJ), Germany

Abstract:

Magnetic nanoparticles are commonly used in numerous applications such as magnetic resonance imaging (MRI), local hyperthermia treatment, magnetic separation, information storage, and medical diagnostics using magnetic immunoassays [1]. The latter field has become increasingly popular in the last years because of the favorable properties of magnetic particles. In fact, the particles can be used both for magnetic actuation as well as for magnetic detection of biomolecules. In the case of immunoassays, the magnetic beads are bound to the biological target substance using the highly specific antibody-antigen interaction [2]. The most common assay format is the sandwich immunoassay in which the analyte is captured by an immobilized primary antibody and the streptavidin-coated magnetic particles are bound to the analyte by a biotinylated secondary antibody.

This work present the design and optimization of a magnetic detection system that encompass a microfluidic structure along with multilayer designed printed circuit board set of planar coils. The challenge is to measure the magnetic marker particles with high accuracy and with high selectivity. The magnetic frequency mixing technique [3] is very well suited for this purpose, thus allowing the use of the system for immunoquantification. Analytical calculations along with Comsol Multiphysics model have been used in order to optimize the dimensions of the coil and the microfluidic reservoir.

Keywords: Lab on chip system; magnetic detection; pathogen sensing; multiphysics simulations.

References

[1] U. Häfeli, W. Schütt, J. Teller, M. Zborowski (eds.), Scientific and clinical applications of magnetic carriers, Plenum, New York, 1997.
[2] Darwish, Ibrahim A. Immunoassay methods and their applications in pharmaceutical analysis: basic methodology and recent advances. Int J Biomed Sci, 2006, vol. 2, no 3, p. 217-235.
[3] H.-J. Krause, N. Wolters, Y. Zhang, A. Offenhäusser, P. Miethe, M.H.F. Meyer, M. Hartmann, M. Keusgen, Magnetic particle detection by frequency mixing for immunoassay applications, J. Mag. Magn. Mater. 311, 436 (2007).