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Abstract

Two Orders of Magnitude Improvement in the Detection Limit of Droplet-Based Micro-magnetofluidics with Planar Hall Effect Sensors †

Julian Schütt [1,*], Rico Illing [1], Oleksii Volkov [1], Tobias Kosub [1], Pablo Nicolás Granell [1,2,3], Hariharan Nhalil [4], Jürgen Fassbender [1], Lior Klein [4], Asaf Grosz [5] and Denys Makarov [1,*]

[1] Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany
[2] Escuela de Ciencia y Tecnología, UNSAM, Campus Miguelete, B1650KNA San Martín, Buenos Aires, Argentina
[3] Instituto Nacional de Tecnología Industrial, Av. Gral Paz 5445, B1650KNA San Martín, Buenos Aires, Argentina
[4] Department of Physics & Institute of Nanotechnology and Advanced Materials, Bar-Ilan University, Ramat Gan 5290002, Israel
[5] Department of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Israel
* Correspondence: j.schuett@hzdr.de
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Abstract: The detection, manipulation and tracking of magnetic nanoparticles is of major importance in the fields of biology, biotechnology, biomedical applications as labels as well as in drug delivery, (bio-)detection and tissue engineering. In this regard, the trend goes towards improvements of existing state-of-the-art methodologies in the spirit of timesaving, high-throughput analysis at ultra-low volumes. Here, microfluidics offers vast advantages to address these requirements as it deals with the control and manipulation of liquids in confined microchannels. This conjunction of microfluidics and magnetism, namely micro-magnetofluidics, is a dynamic research field, which requires novel sensor solutions to boost the detection limit of tiny quantities of magnetized objects. We present a sensing strategy relying on planar Hall Effect (PHE) sensors in droplet-based micro-magnetofluidics for the detection of a multiphase liquid flow, i.e., superparamagnetic aqueous droplets in an oil carrier phase. The high resolution of the sensor allows the detection of nanoliter-sized superparamagnetic droplets with a concentration of 0.58 mg cm^{-3}, even when they are biased in a geomagnetic field only. The limit of detection can be boosted another order of magnitude reaching 0.04 mg cm^{-3} (1.4 million particles in a single 100 nL droplet) when a magnetic field of 5 mT is applied to bias the droplets. With this performance, our sensing platform outperforms the state-of-the-art solutions in droplet-based micro-magnetofluidics by a factor of 100. This allows us to detect ferrofluid droplets in clinically and biologically relevant concentrations and even below without the need of externally applied magnetic fields.

Keywords: droplet microfluidics; planar hall effect; sensorics; contactless sensing; ferrofluids