Magnetoresistive biosensors for quantitative lateral-flow bioassays using magnetic nano-markers

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Lateral-flow assays are commonly used for the detection of biological activity in a solution. In the standard format, a solution flows through a membrane which has been locally imprinted with proteins targeting the bioanalyte under study. Upon immunorecognition at the test area of the membrane, the biological agent is immobilized and its presence can be readily identified by the photoluminescence of the colored particles that the analyte has been labeled with. Quantitative measurements of the concentration can only be achieved via chromatographers (immune-chromatic test). However, in the past decade the magnetic thin film technology has been successfully implemented into the bioanalytical science [1]. In this paper we propose an efficient and unexpensive method substituting the colored particles by magnetic nano-beads and the photodiode detection by magnetoresistive sensors [2]. The sensing mechanism is thus the same as in the reading heads for the magnetic bits of commercial hard drives: giant magnetoresistence (GMR) or tunnel magnetoresistence (TMR). We pattern a chip containing arrays of such sensing units with micrometric footprint. A strip-shaped sample membrane is scanned by the chip, resolving the magnetic signature of the sample with micrometric resolution. In terms of sensibility, this method is at the same level as former techniques based on the coil inductance [3,4], but in addition, the large spatial resolution brings about the possibility of multianalyte single shot assays. Furthermore, reference magnetic motifs can get immobilized/sensed in the same membrane and environment as the test region, extending the concept to a field-deployable device.

We will describe the design and performance optimization of the biosensing station utilized to carry out immune-magnetic tests. It features micrometric xyz positioning and controlled pressure ($\Delta P<4$ psi) of the sample membrane over the sensor surface. The detection limit has been pushed beyond the visual limit, with a figure of merit of 1 μemu sensibility (equivalent to 2 nano-grams of maghemite), which surpasses the SQUID sensibility in this sort of sample system. Test measurements on both artificial sample membranes and real biological assays will be shown, and compared with results from alternative characterization tools.

References

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