Magnetic detection structure for LOC immunoassays

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Summary

The aim of this work is to develop a completely integrated Lab-On-Chip (LOC) for easy, rapid and cost-effective immunoassays. The pathogen sensing system is composed of a microfluidic channel surrounded by planar microcoils which are responsible for the emission and the detection of magnetic fields. The system allows the detection and quantification of superparamagnetic beads used for immunoassays in a "sandwich" antigen-antibody configuration. We successfully integrated and validated the magnetic detection of nanoparticles by using a structure composed of a microfluidic channel and a set of coils Printed in a multilayer Circuit Board (PCB). We could test the limit of detection and the linearity of the response by testing different concentrations of nanoparticles. Using the magnetic frequency mixing technique [1], a limit of detection of 15 ng/mL of 20 nm core sized nanoparticles has been achieved with a good linearity over 3 orders of magnitude.

Motivation and results

Superparamagnetic nanoparticles are particularly well suited for the biomedical domain. These particles are described by two characteristics: the magnetization curve and frequency-dependent relaxation effects. The magnetization curve is nonlinear, non-hysteretic and it saturates at high fields [2]. To exploit this nonlinearity, we use the frequency mixing method in order to detect the presence of particles in a microfluidic channel [1].

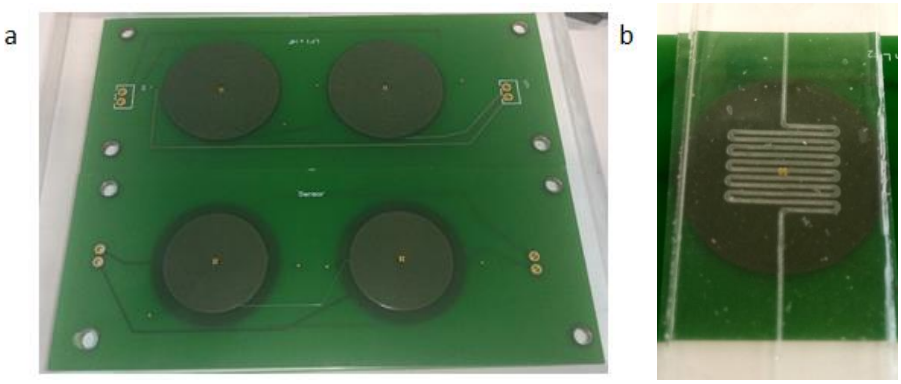

Figure 1: (a) PCB structure that includes excitation coils (HF and LF) and detection coils (sensors); (b) Realized microfluidic reservoir.

The structure is composed of 3 set of planar copper coils. Two coils emit the electromagnetic field, one for low frequency and the other for high frequency; the third one is the detection coil for which we had to define the inner and outer radius by choosing a good compromise between sensitivity and minimum detectable moment. These coils are embedded in two PCB structures surrounding the microfluidic channel which can contain 14 µL of magnetic nanoparticles solution. The excitation and pick-up coils are made in the same PCB (Figure 1). One set of coils is used to do the measurements and another set is for the reference. This differential signal between the two sets of coils compensates external noise.

The magnetic response curve for different concentrations of iron nanoparticles in the microfluidic channel has been mesured. We clearly observe a very good linearity for a linear range of 3 orders of magnitude. Furthermore, the test was repeated in day's intervals and proved to be very reproducible. With an accepted error of less than 15 %, our limit of detection is about 15 ng/µL which is very promising for a LOC. A small quantity of solution sample was used which is very convenient for future cost effective biological tests. These preliminary results validate the magnetic detection of nanoparticles under the conditions presented above. Further improvements are expected regarding the limit of detection, especially with a further miniaturized device which is under development. With our magnetic detection system validated, this structure will be used for implementing immunoassays for detecting C-reactive protein.

References

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