Giant-magnetoresistive magnetic sensors for magnetic tracking for catheterization procedure

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X-ray fluoroscopic imaging is the standard method to obtain catheter position during catheterization procedures, a minimally invasive surgery for diagnostic and treatment of the vascular network [1]. However, this method exposes both patients and doctors to ionizing radiation. To address this issue, we propose a new method to track the catheter by installing a magnetic sensor at the catheter tip and generating a known magnetic field (MF) around the operative zone.
Due to the mandatory small size of the catheter, we utilized micrometer-sized giant-magnetoresistance (GMR) sensors for this tracking system [2, 3]. GMR sensors require only two connection wires, have a wide bandwidth that allows flexibility in selecting the working frequency and can detect low-intensity MFs down to the nano Tesla range [4]. In this work, a 300µm x 700µm GMR chip (shown Fig.1b) is prepared and installed on a catheter to show the integration feasibility. The presented results are obtained with GMRs connected in a Wheatstone bridge configuration in a larger chip for ease of manipulation and its characteristic response is presented Fig.1a. Both present a similar magnetic response.
Our novel tracking method is based on the time detection of a moving null MF, known as the Field-Free Point (FFP) inspired by Magnetic Particle Imaging (MPI) [5]. Rather than measuring the MF intensity to compute the position [6], the time detection of the FFP gives the information on the position. We constructed an experimental setup to demonstrate the feasibility of this method in one dimension [7].
On a 1D setup, along a line from -15cm to 15cm, we measured the positions and standard deviations every cm. The results are shown in Fig.1c. The average of all standard deviation is 1.3mm with an average deviation from the actual position of 4.9% showing promising results for further steps.

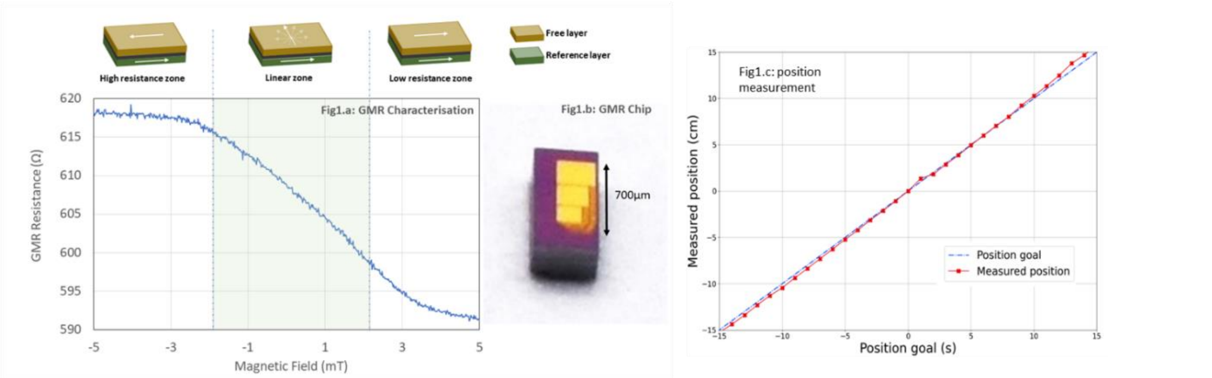

Figure 1. a – Resistance of the GMR alone vs. an external magnetic field. The top sketches show the corresponding ferromagnetic layers' magnetic orientations. b - Manufactured chip with 2 GMRs. c - Comparison between the position goal and the measured positions

References

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