Fabrication and Characterization of Giant Magnetoresistive Biosensors for Cancer Diagnostics

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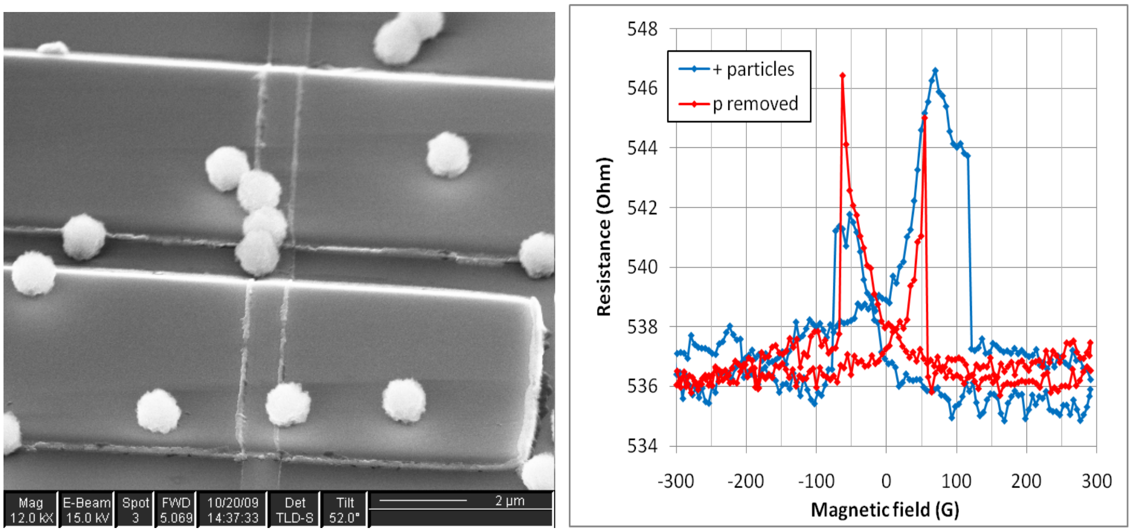
Various transducers of biomolecular signals have attracted the attention of the scientific and engineering communities for their potential applications in proteomics, medical diagnostics, and molecular cell biology. Biomolecular sensors need to be tailored for specific applications, be stable under the given test conditions, and be robust against false-positive interactions. A continuing challenge in many clinical applications is the extremely small size of many biopsy samples, requiring great sensitivity for detection of analytes such as DNA, RNA, and proteins.

The giant magnetoresistance (GMR) phenomenon is manifested by a large change of the magnetic material's resistance under the application of an external magnetic field. GMR sensor materials are magnetic multilayers where the relative orientations of the magnetization in the individual magnetic layers control the sensor resistance. GMR sensors have been used extensively in magnetic hard-drive technology and have sensitivity sufficient to detect individual magnetic bits with sub-100nm dimensions. As such, GMR sensors are well suited for magnetic nanoparticle-based assays tailored for biomolecular recognition.

Applying nanomagnetic device engineering to biosensing technology, we have developed a GMR sensor that is extremely sensitive to external magnetic fields and is capable of detecting individual magnetic biolabels. Electron beam lithography was used to pattern the 200nm-wide GMR sensors shown in Figure 1(a) where a pair of copper contacts, also patterned by e-beam lithography, define the length of the sensing area (about 1um). GMR multilayers (Co/Cu/Co) were deposited by UHV magnetron sputtering with the base pressure of 1.0×10^{-8} torr. The sensors were conformally overcoated with 20nm alumina thin films to electrically insulate the device and protect it from highly corrosive biological media. Such coatings enable reliable sensor operation in a PBS (phosphate-buffered saline) solution commonly used in biological research for up to 48 hours. Magnetic particles attached to the sensor surface are detected by the change in magnetoresistance due to stray fields generated by the particles as shown in Fig. 1(b).

This presentation will focus on the challenges of GMR sensor design, fabrication, and biofunctionalization to enable the production of a highly sensitive, specific device for the detection of early stage cancer biomarkers, which is the long-term goal of our research.



(a) (b)

Fig.1: A micrograph of a GMR sensor with two magnetic particles located over the sensor's active area (a); and the measured detection signals of a GMR sensor with and without particles (b).