Magnetoresistive Sensors aiming room temperature detection of biomagnetic fields

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Abstract

Magnetoresistive devices and magnetic nanostructures are key building blocks in a large number of commercial electronic products across a wide range of applications [1-4] covering industrial positioning sensors, automotive sensors, hard disk drive read heads and embedded memories.

This presentation will focus on the key developments carried out at INL during the last 4 years concerning the development of state-of-the-art magnetoresistive devices using CoFeB/MgO/CoFeB Magnetic Tunnel Junctions. Key challenges include the development of a high yield process able to provide sensors with well controlled dispersion of key specifications and linear transfer curves [5,6].

Despite the large sensitivities of MgO based sensors, the detection of low frequency weak magnetic fields at room temperature remains challenging due to the large 1/f noise noise present in the devices. This capability is required to address applications such as Magneto-Cardiography (MCG), a non-invasive and non-contact technique used to monitor the transient activity of the human heart which generates magnetic fields in the range of 1pT-100pT at frequencies in the range of 1Hz. MCG is currently performed with SQUID magnetometers requiring cryogenic setups and with limited spatial resolution.

The solution developed at INL to address MCG applications with MTJ sensors is described, including the device stack, geometry and acquisition setup used to minimize the 1/f noise in MTJ sensors down to levels of 30pT/Hz @ 4 Hz. The current low frequency detection limits [7-10] are already small enough to pick up the magnetic field of the heart but still require an improvement of about one order of magnitude in order to resolve the field in the time domain.

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