Bismuth Micro and Nano Hall Sensors on Photo-plastic Cantilevers for Scanning Hall Probe Microscopy

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Conventional Hall devices are widely employed to measure magnetic fields produced by millimetre sized (or larger) current-caring conductors or permanent magnets with a standard active area of about (100 μm)^2. Micro-Hall sensors have recently emerged as a powerful and sensitive tool for the investigation of local magnetic field properties of the micro and nano-structures. The conventional Hall effect devices are based on non-magnetic materials (typically semiconductors e.g: AlGaAs/GaAs and InSb or semimetals such as Bi). Bismuth is a semi-metal that presents a very long mean free path, a large spatial extension of the electron wave function, and a low electron density. This explains the amazing galvanomagnetic properties of bismuth nanostructures.

Recently, Hall sensors having dimensions down to (100 nm)^2 have been fabricated [1-3]. By mounting them on micro-scanning systems, a new magnetic imaging method, called Scanning Hall Probe Microscopy (SHPM), has been introduced for simultaneous magnetic and topography imaging. Miniaturized Hall sensors are employed to measure highly inhomogeneous magnetic fields such as those produced by ferromagnetic nanoparticles [4], vortices in superconductors [3], magnetic domains in ferromagnetic materials [5], magnetic force microscopy tips [6], and magnetic recording media [7].

We have developed an alternative route to fabricate micro and nano Hall sensors on cantilevers. The approach was to incorporate bismuth Hall sensors of dimensions down to 100 nm on photo-plastic cantilevers made with SU-8 (see Fig.1-2), a material already used for the fabrication of atomic force microscopy (AFM) and near field scanning optical microscopy (NSOM) [8]. The smallest active area of the Hall sensors obtained by the focused Ion beam (FIB) is (60x60) nm^2 (Fig.3). The electrical characteristics of our bismuth Hall sensors are comparable to the best results reported up to now [9]. For instance, a device with an active area about (0.1x0.1) μm^2 the current sensitivity, the Hall coefficient and the field resolution measured are 2 V/AT, 180x10^{-9} m^3/C and 120 μT/Hz$^{1/2}$, respectively.

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Figures:

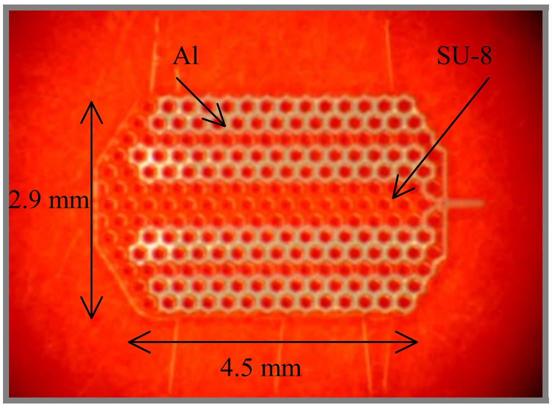

Fig.1: *Bismuth Hall sensor and aluminum electrical contacts*

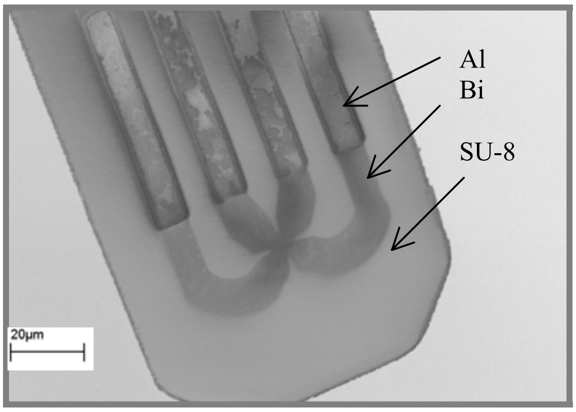

Fig.2: *SEM close-up of bismuth Hall sensor (2 x 2 µm2) on SU-8 cantilever.*

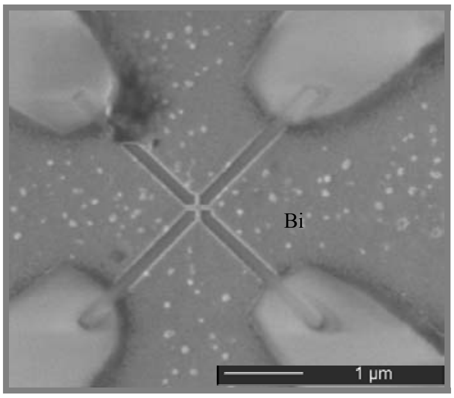

Fig.3: *Bismuth Hall sensor (60 X 60 nm2) structured by FIB.*