CoFe and NiFe-based Planar Hall Effect sensors

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Magnetic sensors based on the Planar Hall Effect (PHE) have gained in popularity in recent years thanks to a number of advantages, such as their ease of fabrication, high sensitivity, and remarkable thermal stability, which make them one of the most promising technologies on the market today. As a result of these advantages, PHE sensors are being introduced as candidates in a wide range of modern applications, such as lab-on-a-chip devices and nano-tesla magnetometers. The ferromagnetic material in a PHE sensor ideally has a very low coercive field and a high magnetization saturation. The most commonly used ferromagnetic material is permalloy (NiFe), owing to its magnetic softness and high AMR ratio. Although other materials, such as CoFe, show great promise due to their high magnetization saturation, they have extremely high coercive fields, which are unsuitable for use in the detection of small magnetic fields. The magnetic properties of the ferromagnetic layer can be dramatically altered by using different buffer layers, and therefore, a number of different combinations, geometries, and materials are being investigated as promising candidates for their use in Planar Hall effect sensors. The aim of our study was to design and fabricate trilayers using different ferromagnetic materials, as well as capping and buffer layers so as to optimize the performance of PHE sensors. The films were grown by magnetron sputtering at UHV conditions using CoFe, CoFeB, and NiFe as ferromagnetic materials, as well as Ta and W as capping and buffer layers. Various geometrical Hall crosses have been microfabricated on the stacks by Direct Laser Lithography combined with Ion Milling to investigate the Planar Hall Effect. The magnetic and electrical properties of the different devices were measured at room temperature. We found that, although the CoFeB and NiFe structures have different magnetic and electric properties, the geometry of the Hall crosses was the main delimiting factor in the voltage response of every single structure. For every cross, the sensor's sensitivity is limited to values close to 10 mV/T.