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Abstract

Printed Anisotropic Magnetoresistive Sensors on Flexible Polymer Foils †

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Abstract: The experimental approach to the fabrication of flexible anisotropic magnetoresistive (AMR) sensors for magnetic field detection in the mT range is validated. It is based upon a combination of screen printing with high-power diode laser array post-processing, both of which are scalable and high-throughput methods. The whole process chain is evaluated, including powder preparation, paste formulation, screen printing, laser sintering, and characterization of microstructure and magnetoresistive response of the resulting sensors. Using high-quality permalloy powder with platelet geometry, the sensors with an AMR effect of 0.5–0.6% at 2–3 mT were realized on polymer substrates. The further optimization of the sensors' preparation steps is in progress.

Keywords: printed electronics; flexible electronics; anisotropic magnetoresistance; printed magnetic field sensors; screen printing; high-power diode laser array processing

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1. Introduction

Anisotropic magnetoresistive sensors as rigid surface-mounted devices are widely used for the detection of motion (displacement, rotation, vibration) and contactless electric current measurements [1]. The integration of the sensors in flexible substrates using printing technology is expected to enable novel applications like contactless human–machine interfaces [2]. However, this requires resolving a number of experimental challenges, such as the preparation of high-quality powder material, formulation of printable paste, and realization of the functional AMR structures. The present work expands on the experimental approach tested in [2] for Bi-based materials to the AMR sensors.

2. Materials and Methods

The preparation steps of the AMR sensors based on permalloy powder material (Ni80Fe20) are shown in Figure 1. The resistance of printed and post-treated sensors on polyimide foil was measured in a magnetic field applied by 2 coils with a high-precision multimeter (Tensormeter RTM1, HZDR Innovation, Dresden, Germany). The AMR effect was then calculated by Equation (1), where R_H is the resistance in the magnetic field, and R_0 is the resistance without the magnetic field.

$$AMR\ effect[\%] = 100\% \times \frac{R_H - R_0}{R_0} \quad (1)$$

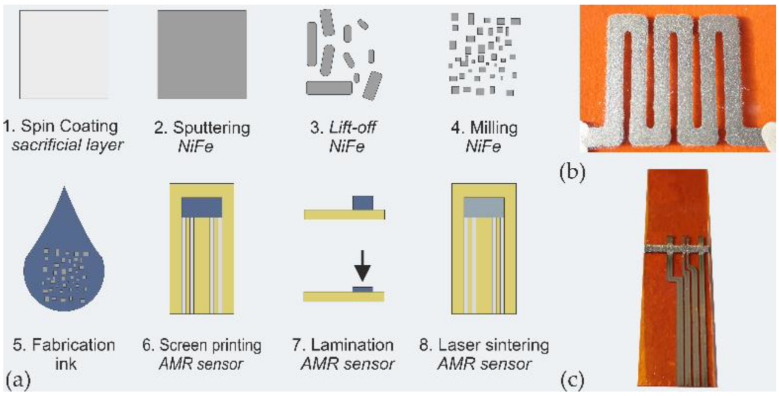

Figure 1. (**a**) Schematics of process chain. (**b**) Photo of printed and laminated meander structure on polyimide foil and (**c**) photo of printed, laminated, and sintered structure on also printed contacts.

3. Discussion

The printed AMR sensors show resistance and AMR effect depending on the applied post-treatment. The as-printed layers are not conductive. After lamination, the resistance of the layers is in the kOhm—range depending on the used screen printing parameters. Laser sintering enables very good resistance in the Ohm—range and a good AMR effect of up to 0.6%, depending on the laser fluence. Maeander structures also show angle dependency of the applied magnetic field. In Figure 2, two magnetoresistive plots are shown, which illustrate the sensing response of the sensor in the parallel and perpendicular directions to the current.

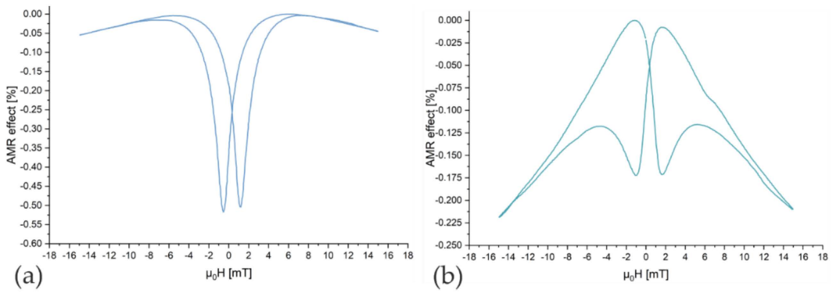

Figure 2. MR plots of meander structure sintered with an optimal fluence of 17.4 J/cm² where the magnetic field is parallel to the long axis (**a**) and perpendicular (**b**).

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