Micro-fluxgate core made of novel multilayer material to reduce eddy currents at high excitation frequencies

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The core of a fluxgate must be deeply saturated in order to minimize noise and perming. This becomes highly challenging when operating on high excitation frequencies. Pulse excitation is used to reach deep saturation while reducing power consumption. However, short pulses contain high frequency harmonics that are unable to penetrate deep enough into the core. In this work, we examine usage of novel material with thin layers in order to reduce eddy currents in the core.

Keywords: fluxgate; micro-fluxgate; racetrack; thin layer

1. Introduction

A miniaturized fluxgate has been developed by our team and published in [1]. The sensor uses an 8 mm long racetrack-shaped core made of 25 µm thick sheet of VITROVAC 6025F. Testing shows that excitation frequencies over 1 MHz are needed to reach optimal performance. The maximum sensitivity is reached at 1.5 MHz excitation, but the noise and perming (remanence) are increasing at high frequencies.

Pulse excitation [2] was tested but brought no significant improvement compared to a sinewave excitation. According to calculations of penetration depth, the material is saturated only down to 6 µm below the surface at 1 MHz excitation, which is less than half of the core thickness. We assume that using a core with thinner layers will improve the performance significantly.

A 5 µm multilayer Co-Zr-Ta-B magnetic stack is magnetron sputtered onto a silicon wafer with a spun-on polymer release layer. After deposition, they were liberated from the Si substrate through application of mechanical stress to the release polymer layer [3]. Then the released magnetic films were patterned into a racetrack core shape for device integration.

2. Characterization of the material

Hysteresis loop of the new material was measured at 1 Hz frequency using a racetrack shape sample with a length of 32 mm (4 times larger than the core of the micro-fluxgate).

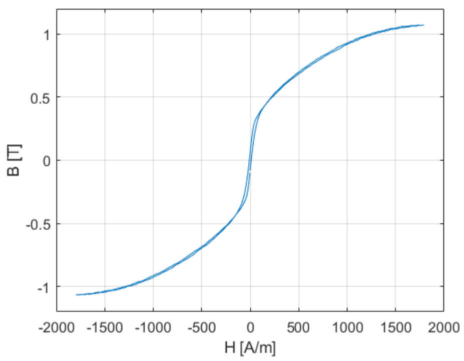

Figure 1: Hysteresis loop of the new material measured at 1 Hz

In comparison with the VITROVAC 6025F used in the original core, the multilayer material has lower permeability, which means that the fluxgate sensor will require higher excitation current. However, using pulse excitation with very short pulses, the power dissipation can be reduced.

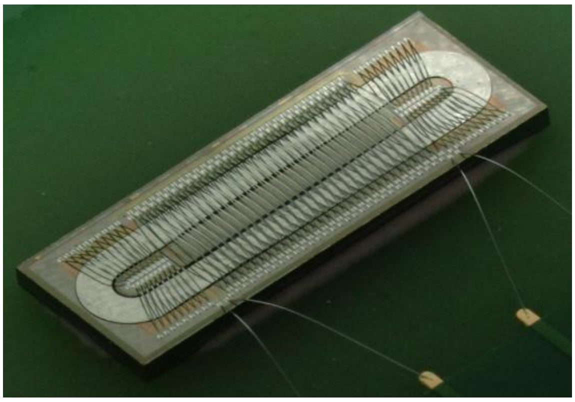

Figure 2: Micro-fluxgate chip fitted with a racetrack core made of the new multilayer material

3. Application in integrated micro-fluxgate

Thanks to the low thickness, the excitation waveform can consist of very short pulses, reducing the power while maintaining high peak value of the current.

Due to the low number of turns of the pickup coil, its high resistance, and low cross-sectional area of the core, the Q factor of the output coil is low. Therefore, it is not possible to tune the output to the second harmonics. Demodulation should be done digitally by convolution with pulse reference signal.

References

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