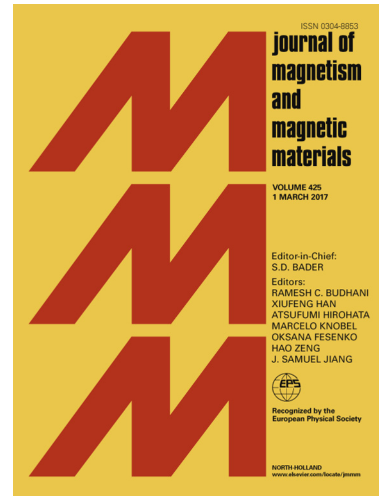
Accepted Manuscript



A New Piezomagnetic Film Force Sensor Model for Static and Dynamic Stress Measurements

Lin Qianying, Zhu Zhenghou, Chen Jie, Liu Dengyu, Zhao Hui

PII: S0304-8853(18)30673-5
DOI: https://doi.org/10.1016/j.jmmm.2018.06.073
Reference: MAGMA 64093

To appear in: *Journal of Magnetism and Magnetic Materials*

Received Date: 8 March 2018
Revised Date: 15 May 2018
Accepted Date: 25 June 2018

Please cite this article as: L. Qianying, Z. Zhenghou, C. Jie, L. Dengyu, Z. Hui, A New Piezomagnetic Film Force Sensor Model for Static and Dynamic Stress Measurements, *Journal of Magnetism and Magnetic Materials* (2018), doi: https://doi.org/10.1016/j.jmmm.2018.06.073

A New Piezomagnetic Film Force Sensor Model for Static and Dynamic Stress Measurements

Lin Qianying[1], Zhu Zhenghou[1]*, Chen Jie[1], Liu Dengyu[1], Zhao Hui[2]*

1 School of Materials Science & Engineering, Nanchang University, Nanchang 30031, China;

2 Institute of Space Science and Technology, Nanchang University, Nanchang 30031, China

Abstract
In this study, an $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ amorphous alloy film was used as a sensing chip for the development of a novel piezomagnetic force sensor model with a closed inductance loop. The sensor exhibits an excellent anti-interference ability against the electromagnetic effects from the environment. Reliable data is obtained at temperatures smaller than 60 °C. Furthermore, the piezomagnetic properties of the $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ films annealed at different conditions were investigated. After annealing at 350–555 °C, the elastic hysteresis of the sensing chip was weakened, which is beneficial in dynamic stress measurements. The optimal stress range for static and dynamic measurements is 0–2 kPa, where the sensitivity is 3.5 μH/kPa. When the annealing temperature is 150 °C, the piezomagnetic effect of the film is significant and elastic hysteresis is obvious, which is suitable only for static stress measurements. In the range 0–10 kPa, the force-sensitivity performance curve is linear with a sensitivity of 3 μH/kPa, which demonstrates its excellent force-sensitivity properties.
Keywords: piezomagnetic, force sensor, static and dynamic,

1. Introduction

Iron-based amorphous alloys are used in various applications including high-frequency transformers and inductors owing to their excellent soft magnetic properties [1–7]. They exhibit piezomagnetic behavior, which makes them promising for the development of force sensors [8–11]. Piezomagnetism is the phenomenon of the variation in magnetic permeability μ upon the application of an external mechanical force on a ferromagnetic material[10-11]. Piezomagnetic force sensors are promising owing to their high sensitivity, fast response, small volume of materials, and stable measurement data.

Currently, piezoelectric-based force sensors are mainly based on force-sensitive films; the most commonly used are the polyvinylidene-fluoride (PVDF)-film-based sensors [12–15]. However, the charge generated by the PVDF film upon the application of external forces rapidly vanishes. Therefore, these piezoelectric sensors are mostly employed for dynamic pressure measurements, less suitable for static pressure measurements, which limits their applications [16–20]. In the development of piezomagnetic-type force-sensitive film sensors, it has been observed that the sensing films exhibit elastic hysteresis. Such sensors can be employed to detect only the loading pressure; they cannot be reliably used in unloading tests. Therefore, they are only suitable for static measurements (and not dynamic measurements), which is opposite to that observed with the sensors based on PVDF. In this study, by controlling the internal stress state of a force-sensitive film chip, the elastic hysteresis effect of the film can be weakened, which enables the sensor to be used in both dynamic and static stress tests.

In practical applications, the sensor's environment is complex and changeable. The Fe-based