CONDUCTIVE MICRO-BEAD ARRAY DETECTION BY HIGH-FREQUENCY EDDY-CURRENT TESTING TECHNIQUE WITH SV-GMR SENSOR

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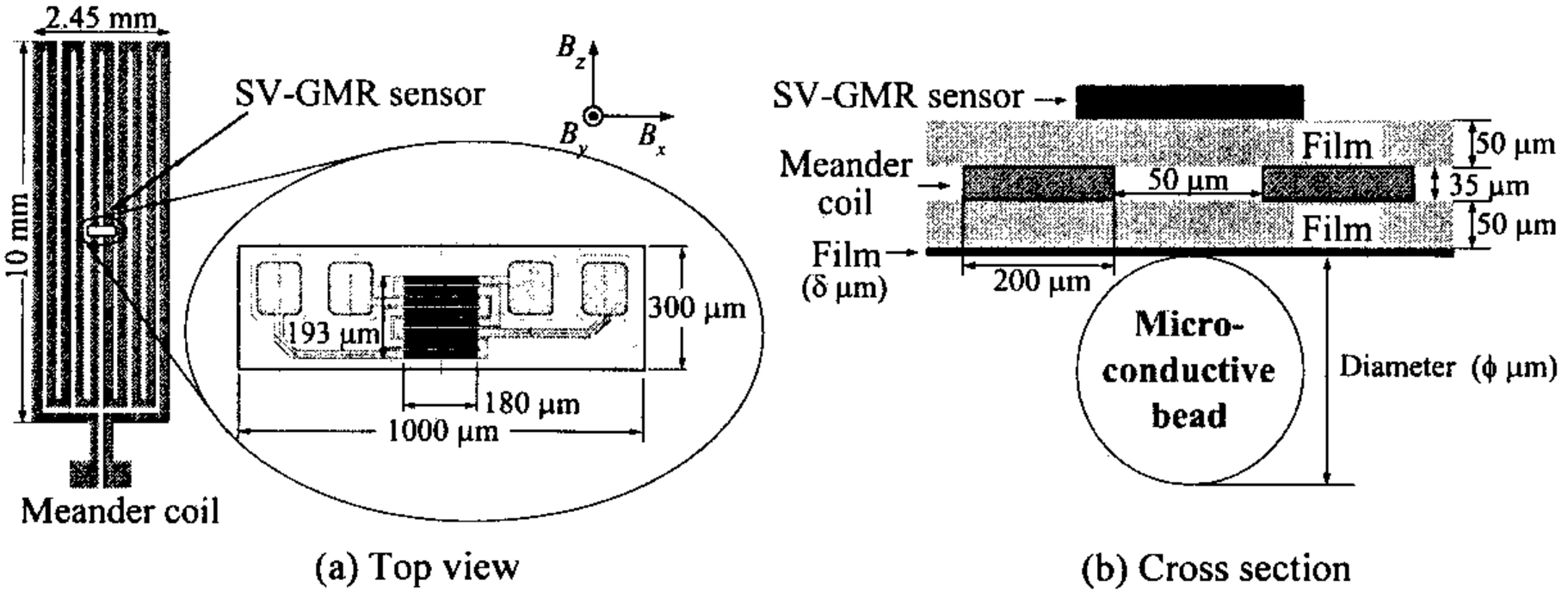
1. Introduction

Applying of eddy-current testing (ECT) probe with spin-valve giant magnetoresitive (SV-GMR) sensor to high frequency excitation provides the feasibility of micro-defect detection for example high-density printed circuit board inspection [1]. In this paper, the detection of conductive micro-bead with 250 to 760 μm diameter, and its feasibility are discussed. The analytical model is discussed and compared with experimental results to verify that the proposed technique is able to detect conductive micro-bead.

2. ECT probe structure and analysis

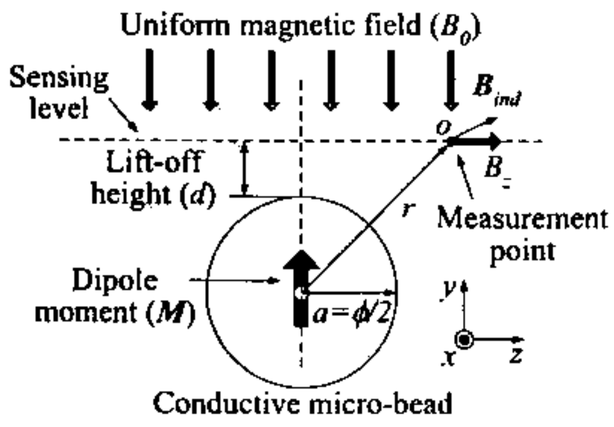
The structure of the proposed ECT probe is shown in Fig. 1. The high frequency exciting current at 5 MHz is fed to the meander coil to generate magnetic field only in x- and y-axis and to induce eddy-currents flowing in conductive micro-bead. The SV-GMR sensor was mounted on the meander coil and detects only magnetic field B_z that, usually, occurs when micro-conductive bead is found.

Simple model as shown in Fig. 2(a) was used to analyze magnetic field B_z at sensing level. Assume that a bead is placed under uniform magnetic field $\boldsymbol{B_0}$ at the frequency approach to infinite because of high frequency excitation, the magnetic dipole moment of bead equals to $\boldsymbol{M} = 2\pi a^3 \boldsymbol{B}_0$. Therefore, the magnetic field $\boldsymbol{B}_{ind}$ over the sensing level can be expressed as Eq. (1). The calculated results of magnetic filed B_z and signal variation versus the diameter of bead is shown in Figs. 2(b) and (c), respectively.

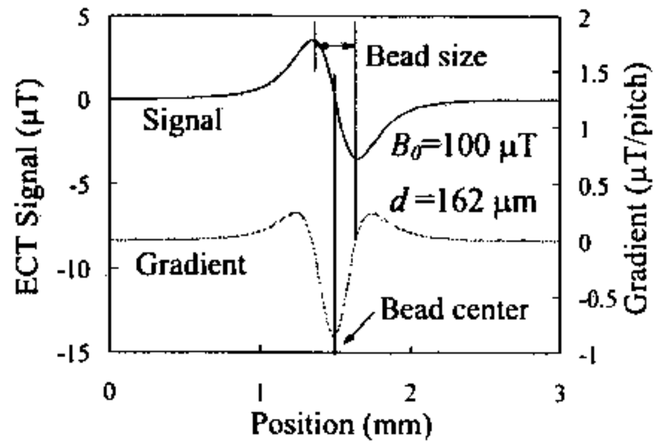


(a) Top view (b) Cross section

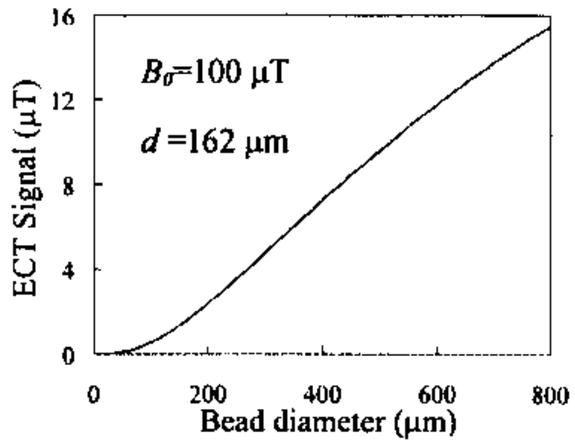
Fig. 1 Structure of planar ECT probe with SV-GMR sensor for conductive micro-bead detection.



(a) Analytical model

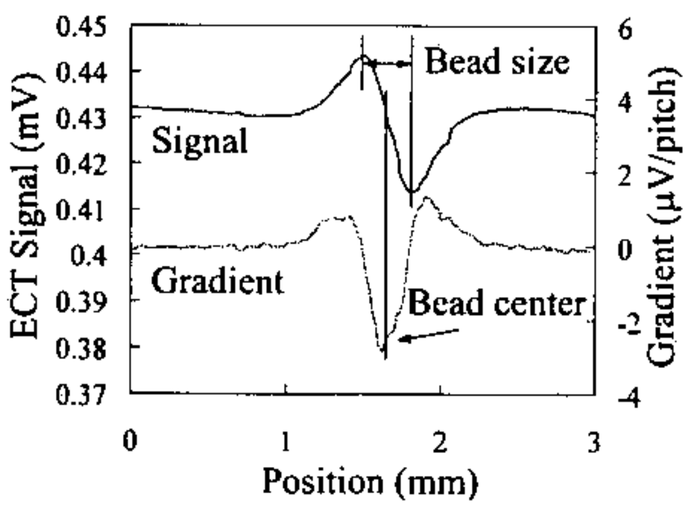


(b) B_z and its gradient on the sensing level

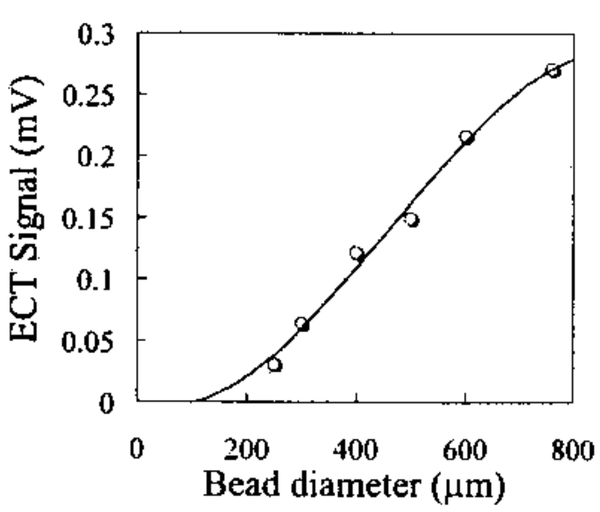


(c) B_z vs. bead diameter

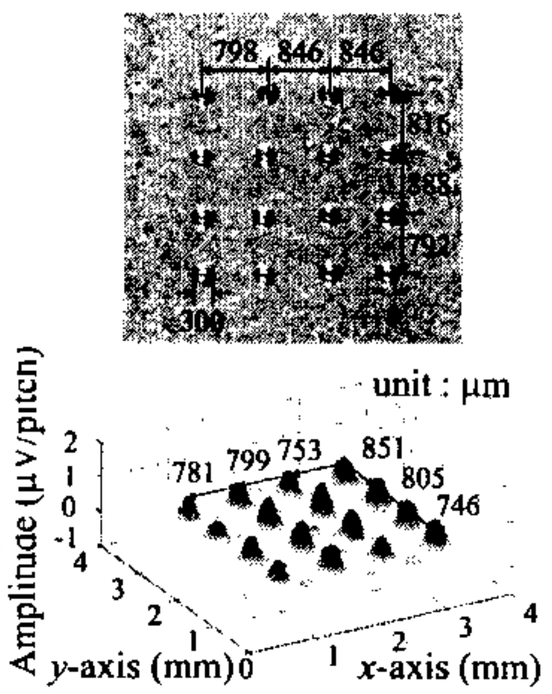
Fig. 2 Analytical model and its calculation results.



(a) Signal by SV-GMR probe



(b) Signal vs. bead diameter



(c) Detection of bead array

Fig. 3 Inspection signal obtained from SV-GMR sensor and 2D image of bead array.

$$\boldsymbol{B}_{ind} = \frac{1}{4\pi}\left(-\frac{\boldsymbol{M}}{r^3} + \frac{3(\boldsymbol{M}\cdot\boldsymbol{r})\boldsymbol{r}}{r^5}\right)e^{j\omega t} \qquad (1)$$

Experimental results

ECT signal in Fig. 3(a) obtained from detection of micro-conductive bead with 250 μm. The SV-GMR sensor can detect the magnetic field occurred by eddy-currents flowing in conductive micro-bead. Fig. 3(b) shows ECT signal versus bead diameter.

Conductive micro-bead array models and its detection results are shown in Fig. 3(c). The micro-bead diameter is 300 μm. The results show that the proposed probe is able to detect conducting bead precisely.

Conclusion

The analytical and experimental results were discussed to verify that ECT technique is possible to detect conductive micro-bead. The de tion of conductive micro-bead spreads some applications on electronics and bio-engineering.

References

[1] S. Yamada, K. Chomsuwan, Y. Fukuda, M.Iwahara, H. Wakiwaka, and S. Shoji, IEEE Trans. on Magnetics, Vol. 40, No. 4, 2676 (2004).