High-Density Double-Layer Printed Circuit Board Inspection by Using High-Frequency Eddy-Current Probe

Komkrit Chomsuwan, Sotoshi Yamada, Masayoshi Iwahara

Institute of Nature and Environmental Technology, Kanazawa University, Kanazawa, Japan

1. Introduction

Many kinds of magnetic sensor have been successful and applied to eddy-current testing (ECT) probe to improve the capability of inspection. GMR sensor is very interesting because it provides a high performance versus its cost as denoted in [1]. Therefore, the application of GMR sensor to ECT probe for PCB inspection is possible to identify the defect points easily.

Microelectronics such as high-density single-layer PCB inspection [2] and solder ball detection [3] is a new application of ECT technique that has been proposed. In this paper, inspection of high-density double-layer PCB by ETC probe composed of planar meander coil and SV-GMR sensor is proposed. Microdefects occurred on both top- and bottom-layer of PCB can be identified by scanning only over top-layer. Characteristics of the proposed ECT probe are investigated to verify that the probe is able to inspect microdefects on both top- and bottom-layer of high-density double-layer PCB.

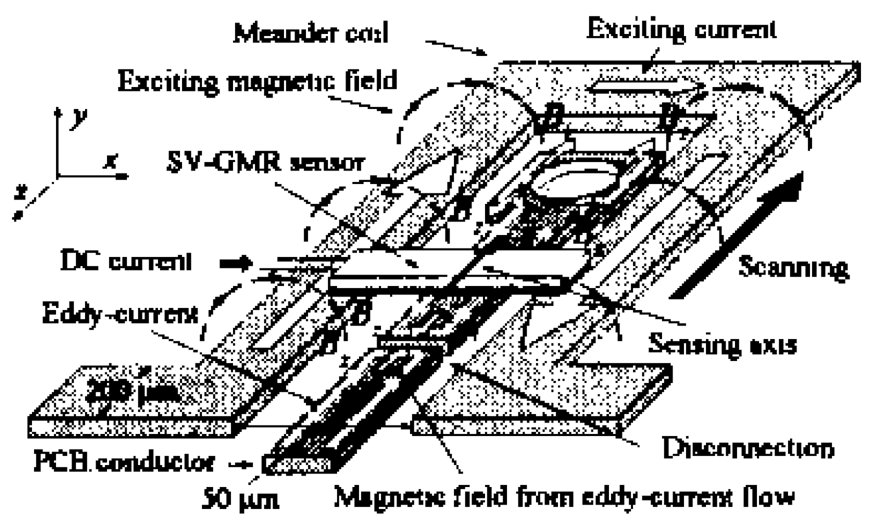

Fig. 1. Proposed ECT probe

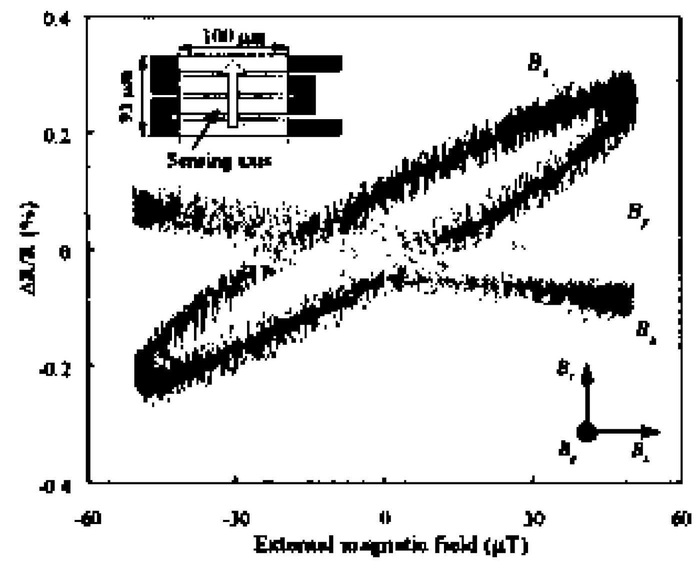

Fig. 2. Characteristics of the SV-GMR sensor at each of axis tested at frequency of 500 kHz

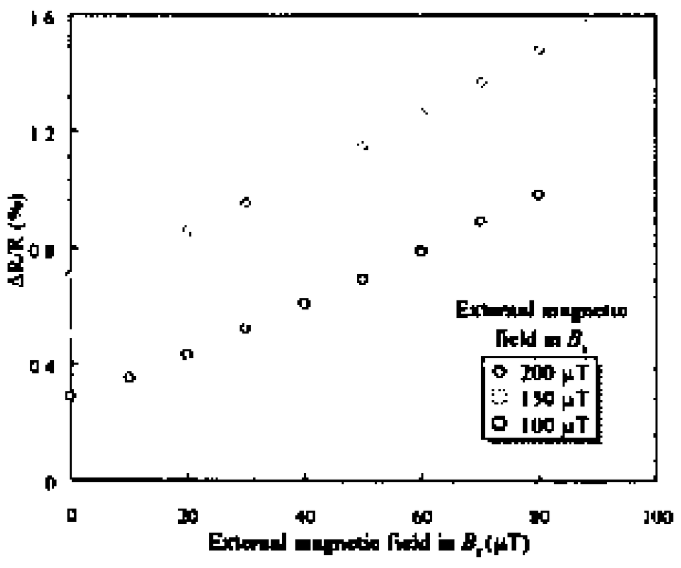

Fig. 3. Effect of constant external magnetic field B_x to the detection of external magnetic field B_z

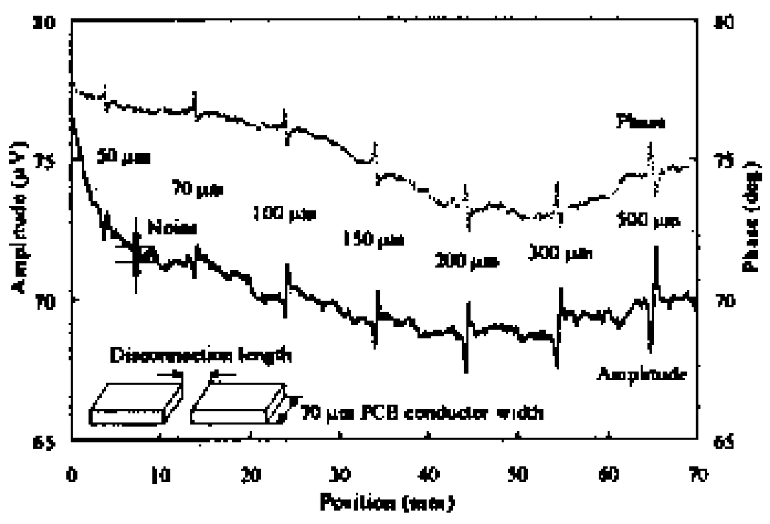

Fig. 4. ECT signal obtained from scanning over 70 μm PCB conductor with conductor disconnection

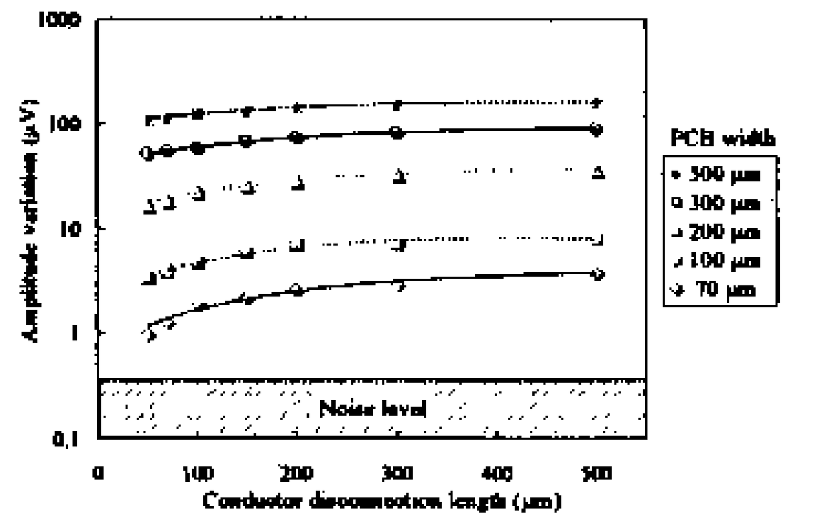

Fig. 5. ECT signal variation against conductor disconnection length

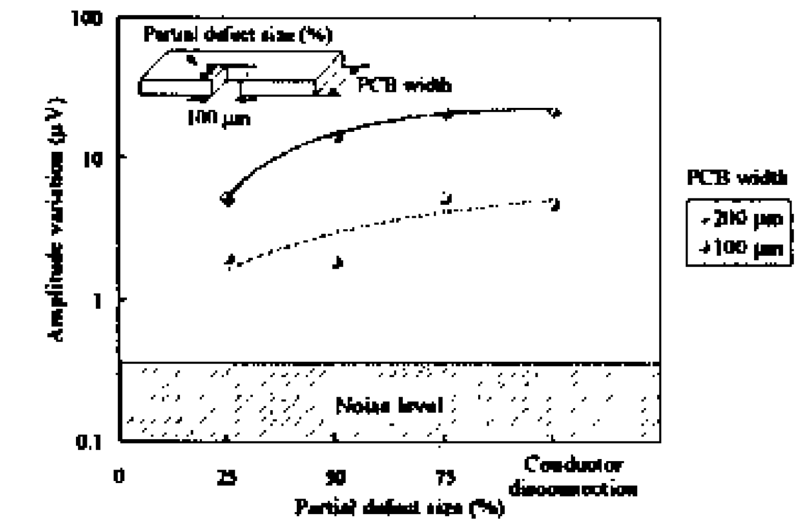

Fig. 6. ECT signal variation against partial defect on PCB conductor track width

2. High-Frequency ECT Probe

2.1 Proposed ECT Probe Construction Structure of the proposed high-frequency ECT probe is shown in Figs. 1. The planar meander coil uses as an exciting coil to keep the shortage distance between the PCB and magnetic sensor and carries high-frequency exciting current to generate the uniform magnetic field distribution only in *x*- and *y*-axis. The SV-GMR sensor was mounted on the planar meander coil with 135 μm distance from SV-GMR sensor to top-layer of PCB.

High-frequency sinusoidal current is fed to the planar meander coil to generate eddy-current flowing in the PCB conductor. Sensing direction of the SV-GMR sensor was set to detect magnetic field B_z that is parallel to scanning direction because the magnetic field B_z occurs at the defect point or PCB conductor boundary that perpendicular to scanning direction.

2.2 SV-GMR sensor characteristics Normal resistance of SV-GMR sensor used in this paper is around 400 Ω. Small signal characteristics of the SV-GMR at each of its axis are shown in Fig. 2. Sensitivity of the SV-GMR sensor in sensing axis B_z is around 0.5 %/100 μT and it is lower than 0.15 %/100 μT and 0.05 %/100 μT in *x*- and *y*-axis, respectively.

The SV-GMR sensor is detectable the magnetic field not only in sensing axis but also in the other axis as discussed above. Fig. 3 shows the effect of constant magnetic field B_x at the same frequency with magnetic field B_z to the detection of magnetic field B_z. The magnetic field B_x provides constant resistance variation whereas resistance variation depends on the magnetic field B_z.

3. Experimental Results

3.1 Experimental Setup Sinusoidal current of 200 mA at frequency of 5 MHz was fed to the planar meander coil. Constant DC current of 5 mA was also fed to the SV-GMR sensor. Lock-in amplifier was used to measure the voltage drop at the SV-GMR sensor. From the SV-GMR sensor dimension, scanning pitch was set at 20 μm.

3.2 Detection of Microdefect on PCB Conductor PCB model with 9 μm PCB conductor thickness made from Cu coated by 0.05 μm Au was used in the experiment. Conductor disconnections and partial defects on the track width were allocated on the model to study the characteristics of the proposed ECT probe applied to PCB inspection.

As shown in Fig. 4, the SV-GMR sensor can detects the magnetic field variation at conductor disconnection points with 500 to 50 μm disconnection length and provides variation of signals both amplitude and phase. The variations of signal are directly proportional to the defect size and they also depend on conductor width whereas noise signal, defined in Fig. 4, are constant with less than 0.6 μV as shown in Fig. 5. Inspection of partial defects on PCB track width is also performed by the purposed ECT probe as shown in Fig. 6. The partial defect point was fixed the disconnection length at 100 μm. The partial defect size effects to decreasing of signal variation, comparing with the signal variation in the case of conductor disconnection.

3.3 Lift-Off Height Effect Distance between PCB conductors and sensing level is very important for the inspection of bottom-layer PCB conductor. As shown in Fig. 7, inspection results obtained from scanning over PCB conductor with 100 μm width are represented in complex plane. Conductor disconnections ranged from 500 to 50 μm were also allocated on the PCB conductor width. The results show that the proposed ECT probe is able to inspect the defects on the PCB conductor although the lift-off height is 235 μm however the signal variations are very small.

3.4 **High-Density Double-Layer PCB Inspection** High-density double-layer PCB with dimension of 5 mm × 5 mm as shown in Fig. 8 (a) was used as a model. The PCB conductors that parallel to *x*-direction are the top-layer conductor and the others are the bottom-layer conductor. 2D-images reconstructed from ECT signal obtained from scanning over the top-layer of the PCB model in *x*- and *y*-direction are shown in Figs. 8 (b) and (c), respectively. The 2-D images show that the proposed ECT probe is capable of inspection the defect points both of conductor disconnection and partial defect clearly although the defect points are allocated on the bottom-layer PCB conductor.

4. Conclusion

High-frequency eddy-current probe developed for high-density double-layer PCB inspection was studied. The experimental results present the possibility of the proposed ECT probe for applying to the microelectronics industry.

References

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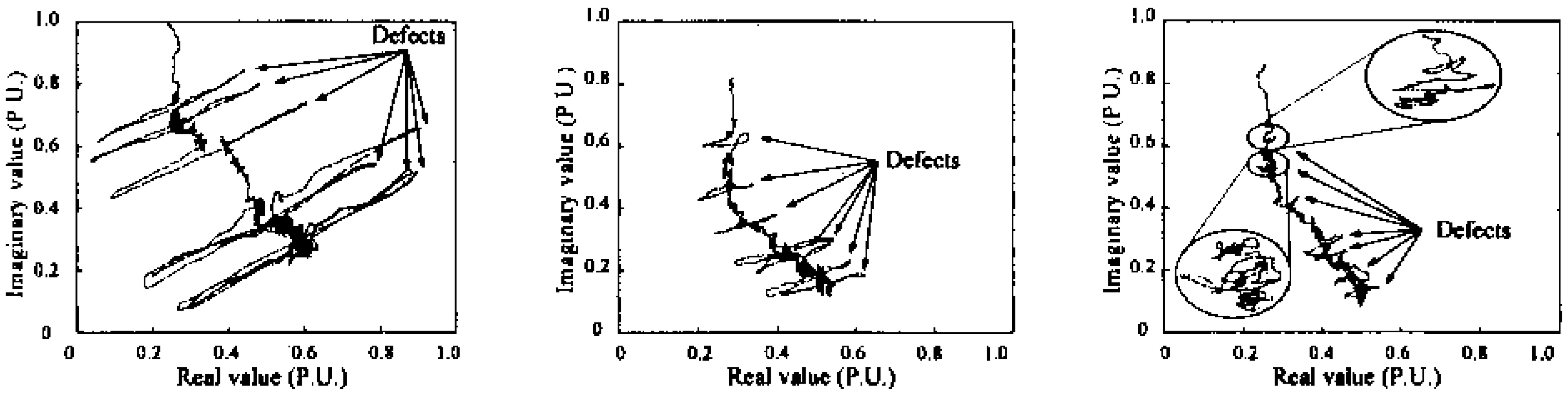
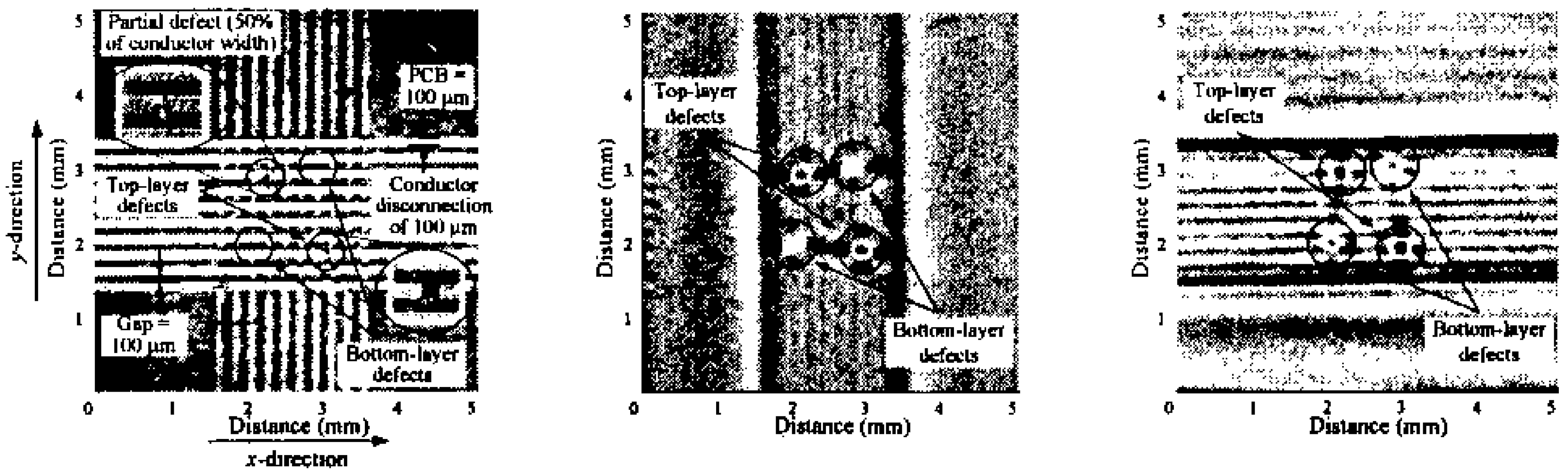
(3) S. Yamada, K. Chomsuwan, T. Hagino, M. Iwahara, and H. Tian : "Metallic bead detection by using eddy-current probe with SV-GMR sensor", *Review of progress in QNDE*, **24**, pp. 479-486 (2005)



(a) 135 μm lift-off height (b) 185 μm lift-off height (c) 235 μm lift-off height

Fig. 7. Effect of lift-off height to the ECT signal variation



(a) PCB model (b) *x*-direction scanning (c) *y*-direction scanning

Fig. 8. High-density double-layer PCB model and its inspection results obtained from the proposed ECT probe