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***Abstract*—The detection of imperfections (such as disconnec- ions, chipping cracks, nonuniformity in thickness and short-cir- :uit, etc.) on the traces of bare printed circuit board (PCB) using a ıew high-sensitive eddy-current testing (ECT) probe has been re- ›orted in this paper. The ECT technique is composed of planar neander type exciting coil and a new multiple solenoid sensing :oil. The image processing method is used to analyze the results. This paper has discussed the structure of the new probe, the char- ıcteristics of the measurement technique to inspect high-density PCB with narrow conductor-width. And the possibility of detecting micro-metal ball has been explored.**

***Index Terms*—Eddy-current testing, meander coil, metal ball, printed circuit board, resolution, sensitivity, solenoid coil.**

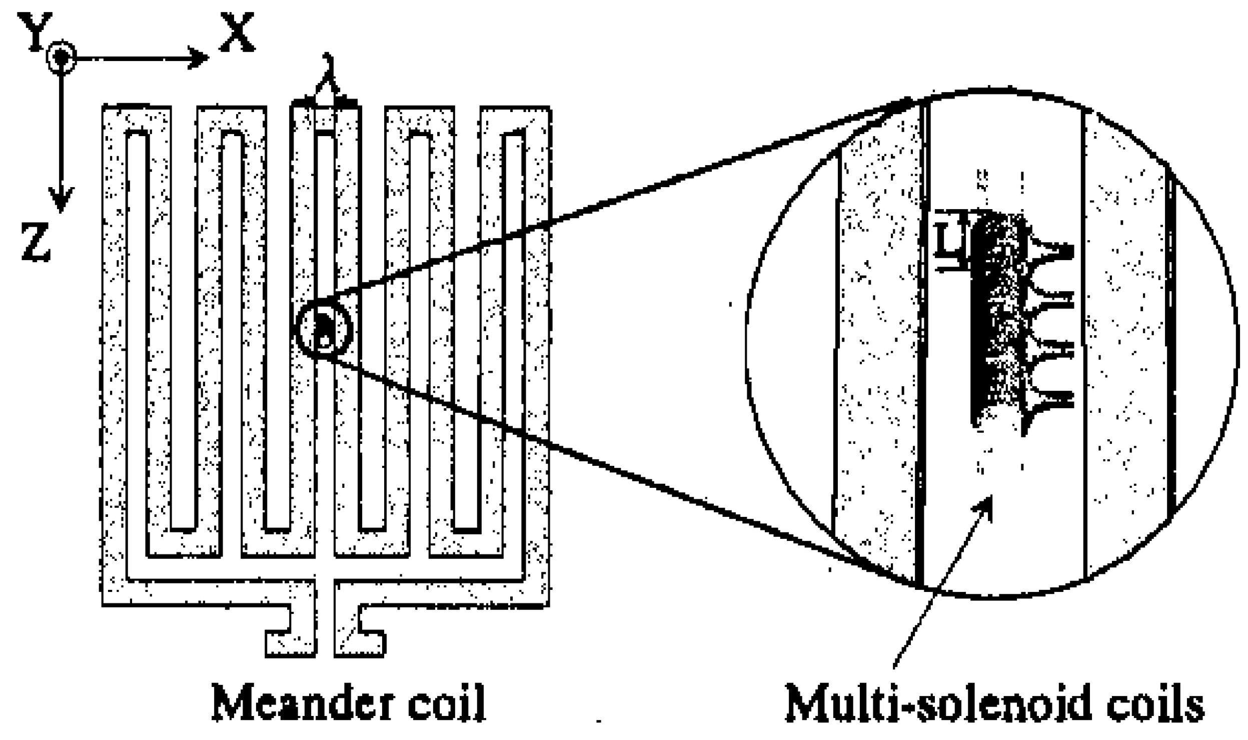

Fig. 1. Configuration of ECT probe.

I. Introduction

THE EDDY-CURRENT testing (ECT) technique because of its noncontact feature makes itself attractive to inspect the imperfections on the conductors of bare printed circuit board (PCB). By fabricating a high sensitive ECT probe [1], [2] in the combination with image processing method [3], it is possible to detect different kinds of imperfections such as disconnections, chipping cracks, nonuniformity in thickness and short-circuit, etc., on the traces of bare printed circuit board (PCB). In this paper a multiple solenoid pick-up coils have been reported. The structure of the probe and use of image processing method has been described to apply the eddy-current testing technique for the inspection of high-density PCB with narrow conductor width and the detection of micrometal ball.

II. Configuration of ECT Probe

The basic structure and configuration of ECT probe used for the inspection of bare PCB is shown in Fig. 1. The long meander coil is the exciter and carries a high frequency alternating current (1–10 MHz). Due to this high frequency excitation, the eddy currents are induced on the PCB conductor. The sensing or pick-up coil is of solenoid type and is placed on the top of the exciting coil between its two conductors as shown in Fig. 1. The multiple solenoid pick-up coils are used to increase the resolution and enhance the sensitivity.

The detailed dimensions of the probe are shown in Fig. 2. The thickness of the meander conductor is 0.5 mm and the pitch,

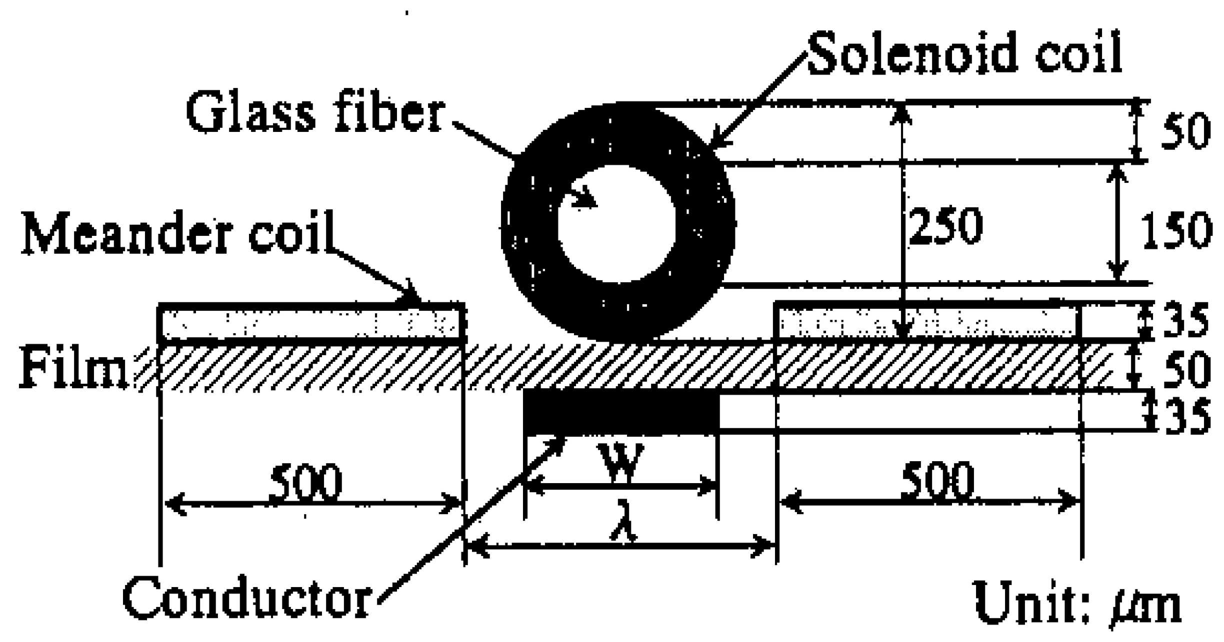

Fig. 2. Detailed representation of the probe.

λ is varied between 0.2–0.8 mm. The winding of the sensing coil is wound on a glass-fiber form of 0.15 mm diameter. The outer diameter of the sensing coil is 0.25 mm. The liftoff height between the PCB upper surface and the probe assembly is kept at 50 μm. For the purpose of conducting experiment the fabricated width, W, of the PCB conductor is varied from 0.1 to 0.6 mm.

III. Operating Principle of ECT Probe

The fundamental operating principle of ECT probe is explained with the help of Fig. 3. The exciting current in the meander coil is flowing along the Z direction. Under normal operation (i.e., no-defect situation), the flux is flowing along the X and Y axis and will not pass through the solenoid pick-up coil resulting in zero output voltage across the sensing coil. Theoretically the voltage across the sensing coil is zero under no-defect condition but due to noise, misalignment and unavoidable adjustment, an offset voltage appears across the sensing coil. Whenever there is a discontinuity in the PCB conductor, the eddy current changes its path and that will results in the generation of Z axis component of flux density and is picked-up by the sensing coil. So the Z direction component of magnetic flux at the region of disconnection gives the important signal for detection. The magnitude of the pick-up voltage will dictate the

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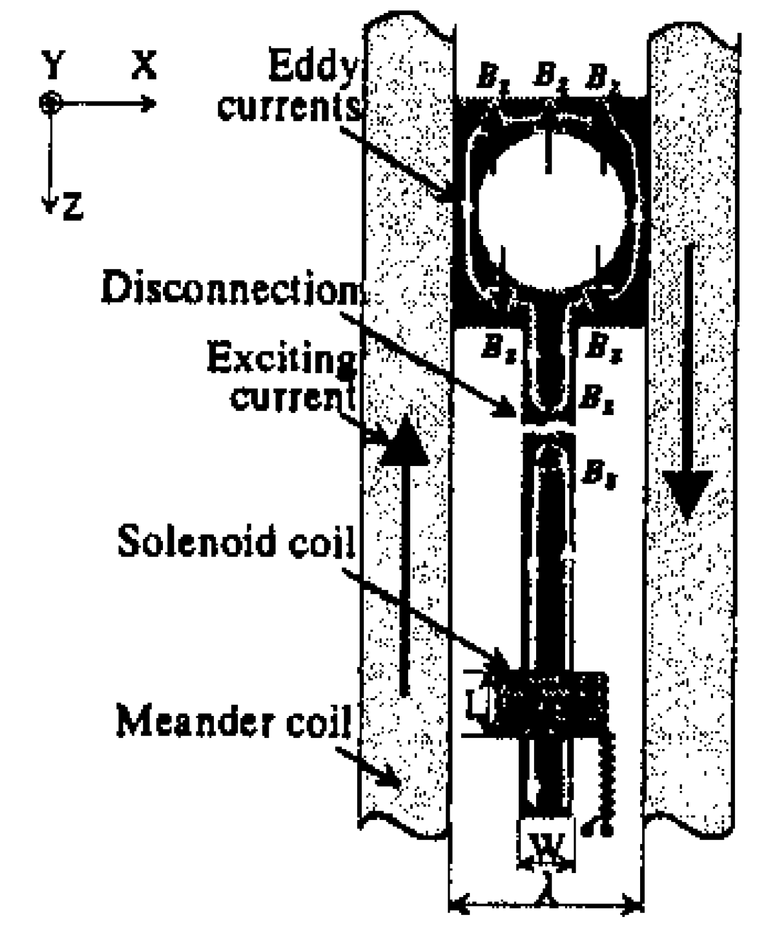

Fig. 3. Operating principle of ECT technique.

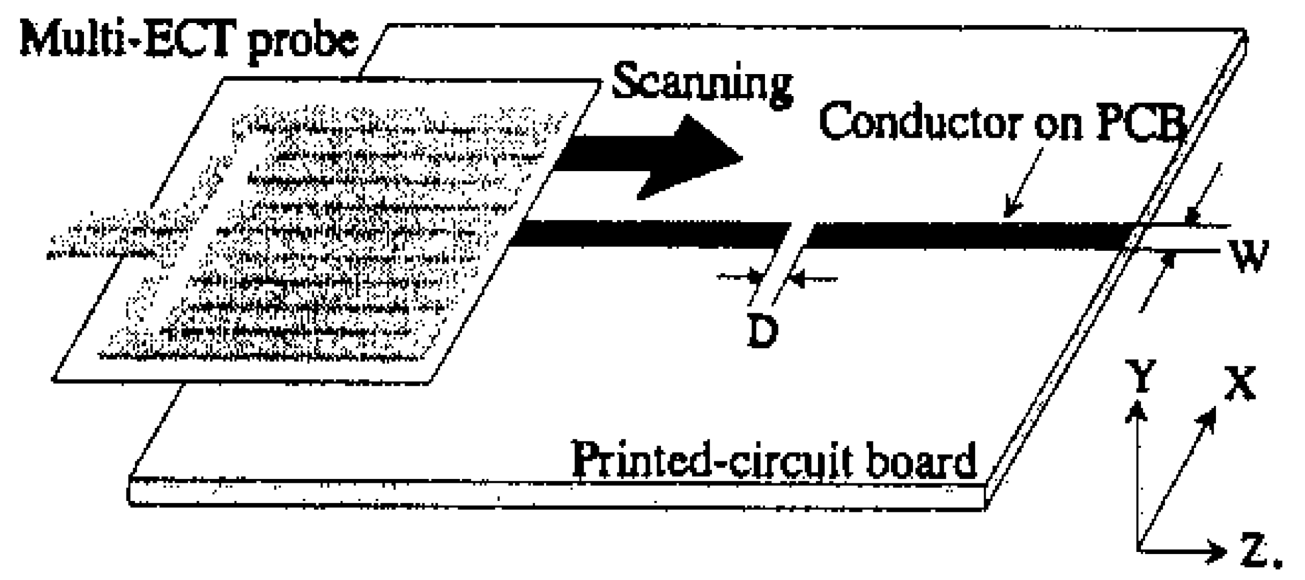

Fig. 4. Scanning of the PCB.

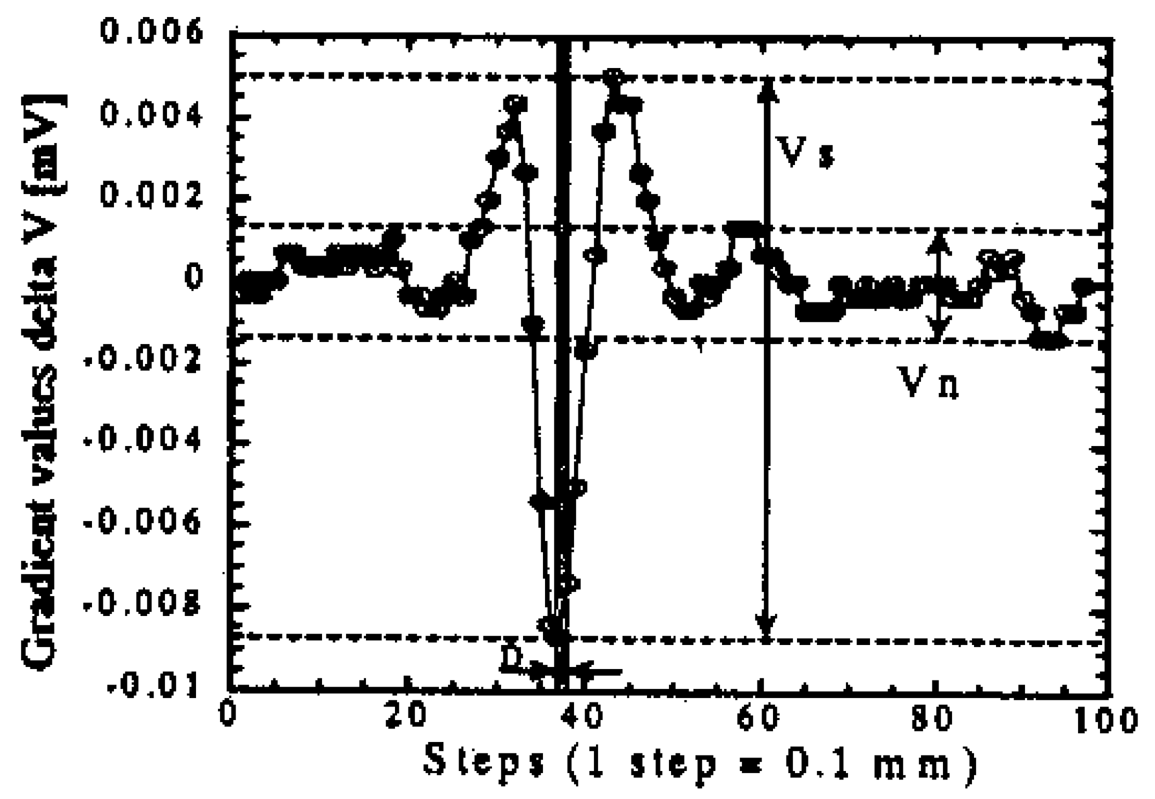

Fig. 5. Typical output across the pick-up coil with a disconnection.

presence of a defect and its characteristics such as position, size, depth, etc.

IV. Experimental Results

The sensor probes with different pitches as well as the PCB with different conductor widths have been fabricated for the experimental evaluation. The fabricated probe is moved on a PCB conductor having defects maintaining constant liftoff. Fig. 4 shows a representation of the scanning motion.Fig. 5 shows a typical gradient voltage across the sensing coil while it is moved along the length of the PCB conductor with a disconnection, D of 0.2 mm. The signal V_s is the peak to peak amplitude of the gradient values of the pick-up signal. The noise voltage is represented by V_n and is due to the liftoff disturbances and the unavoidable adjustment of two coils.

Fig. 6 shows the variation of the amplitude of the signal across the pick-up coil as a function of its number of turns. It is seen that the pick-up signal initially increases with the increase of turns and after attaining a maximum value it starts decreasing. On the other hand the noise signal steadily increases with the number of turns. In order to choose the optimum number of turns of the pick-up coil the signal-to-noise ratio (R_{sn}) is calculated by (1)

$$R_{sn} = 20 \log_{10} \frac{V_s}{V_n}. \tag{1}$$

The variation of R_{sn} with the number of turns of the pick-up coil is shown in Fig. 7. It is seen from Fig. 7 that R_{sn} is slowly decreasing with the increase of number of turns which suggests that the pick-up coil should not have many turns.

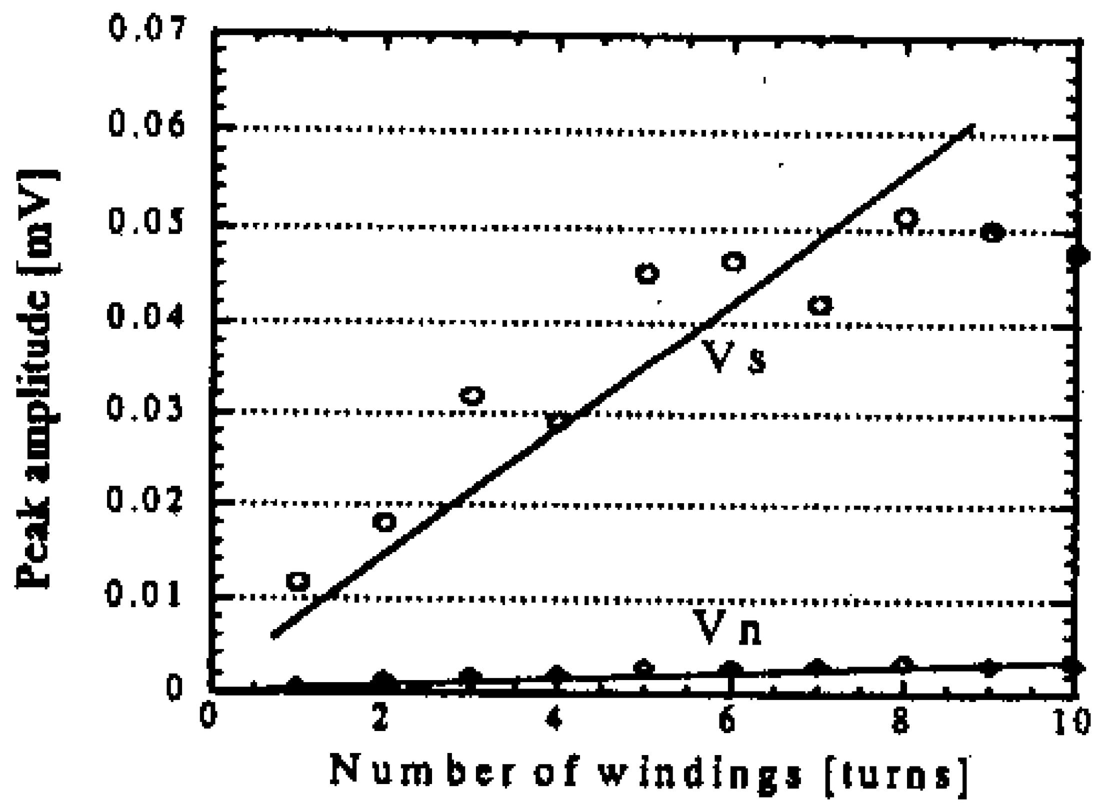

Fig. 6. Variation of pick-up signals with number of turns.

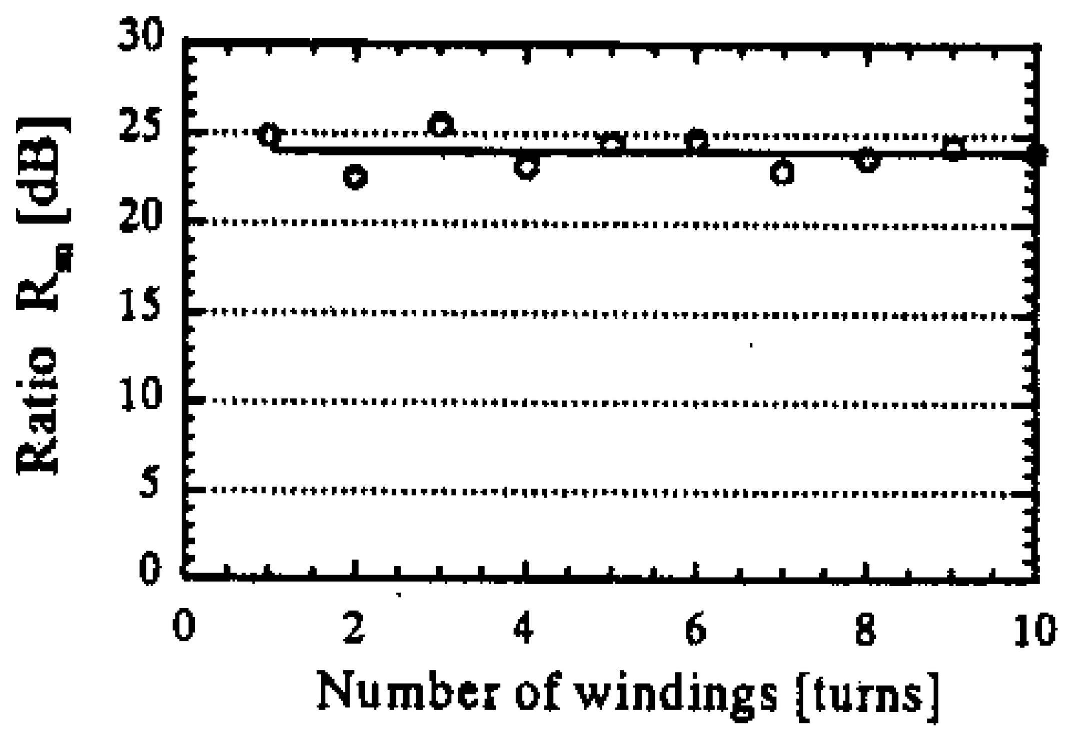

Fig. 7. R_{sn} as a function of number of turns.

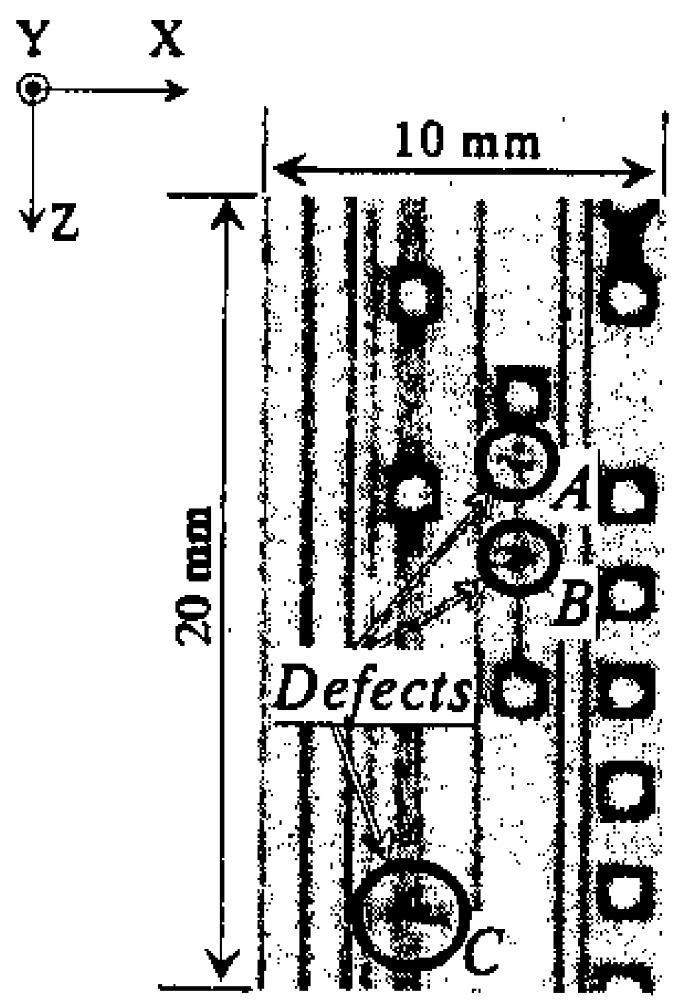

Fig. 8. Model PCB to be used for image processing.

V. Use of Image Processing Method

The measured signal across the sensing coil is a combination of signals due to defects superimposed with noise signals. Sometimes the R_{sn} is very low and it is very difficult to get the actual information about defects. In order to obtain the actual signal information from this noisy signal an image processing method has been applied. By simple manipulations inside the image processing technique it is possible to eliminate undesired

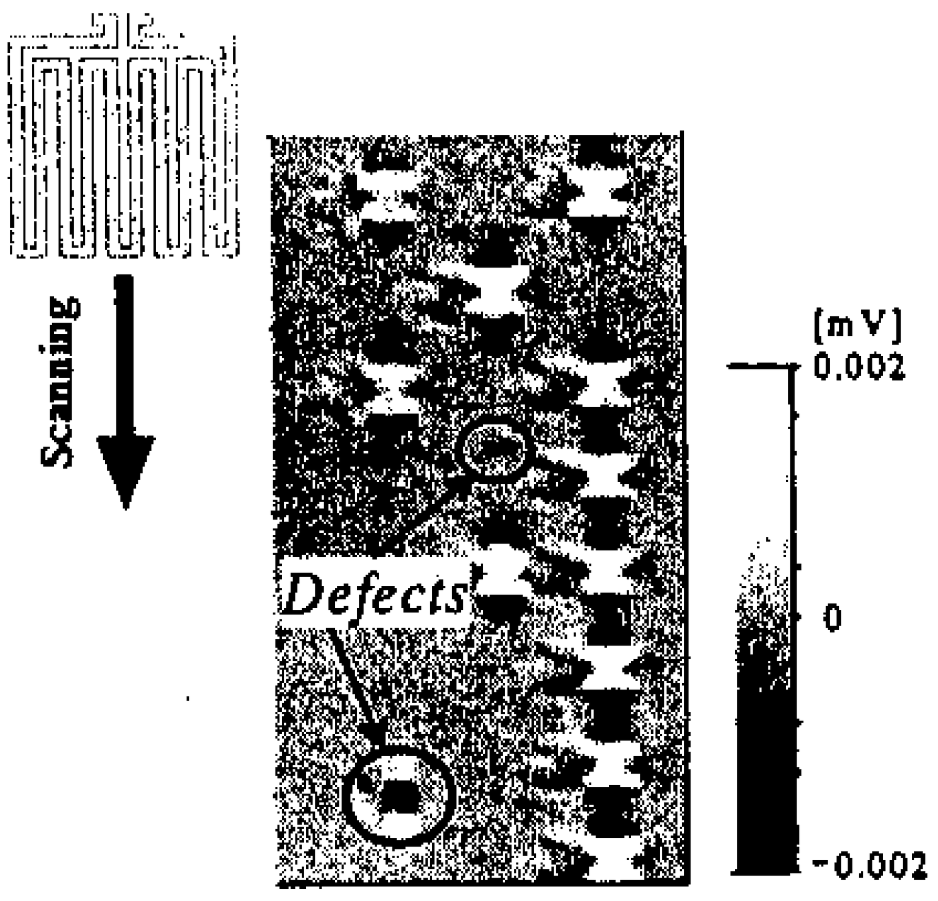

Fig. 9. Resultant image of ECT inspection, scanning along Z axis.

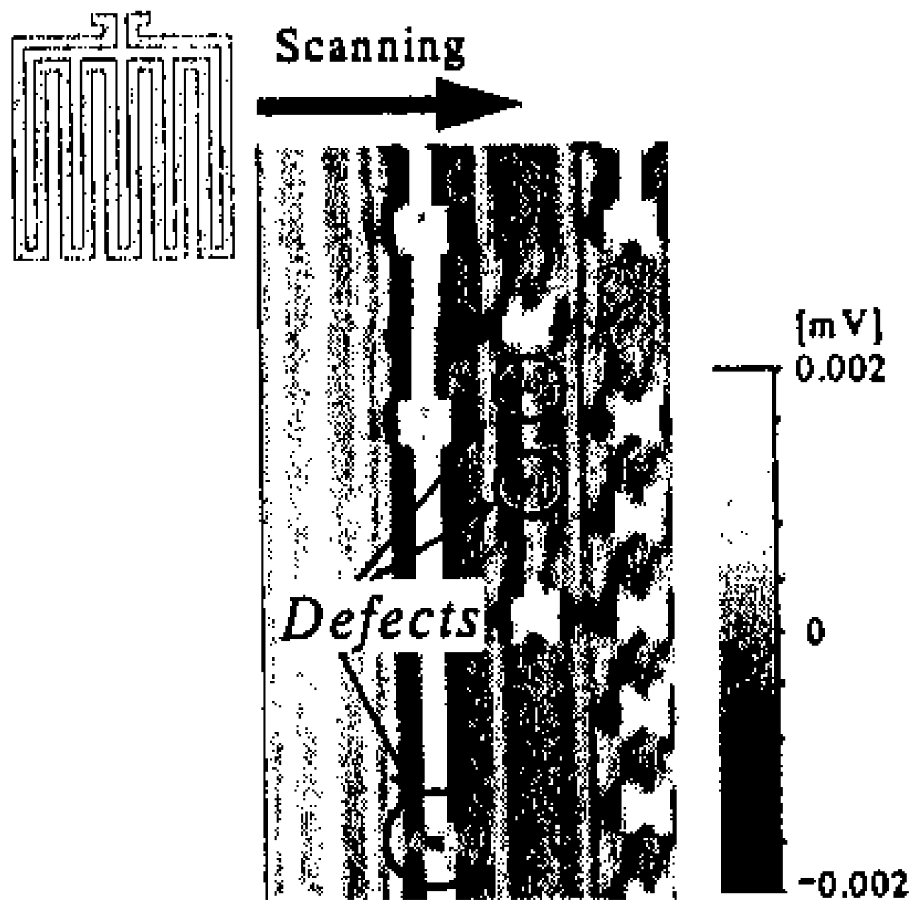

Fig. 10. Resultant image of ECT inspection, scanning along X axis.

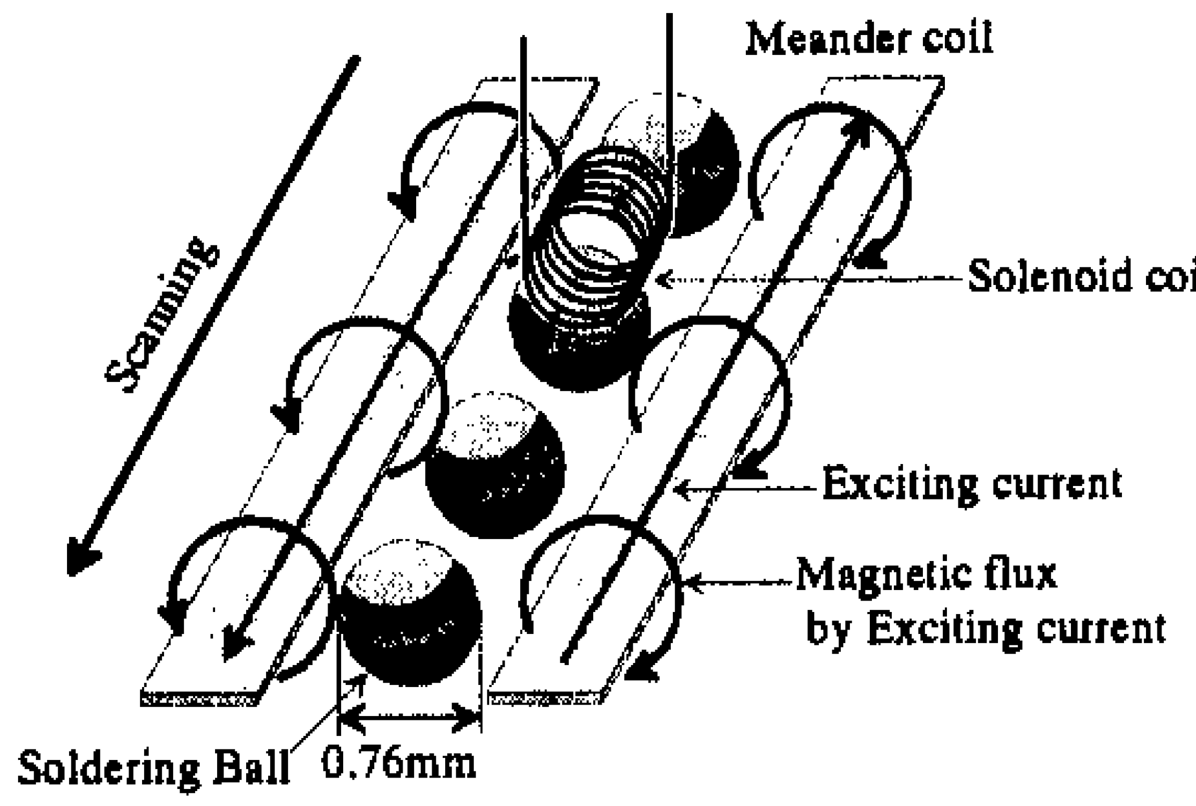

Fig. 11. Configuration of detecting micrometal ball.

components of noisy signals without affecting the actual signal due to defects. Fig. 8 shows a sample model of the printed circuit board used for the experiment. In the model there are two types of conductors of width 0.2 and 0.8 mm, respectively, soldering points and disconnections. The printed conductors are cut at three different points to make defects of sizes 0.1–0.2 mm as shown in Fig. 8 and labeled as A, B, and C. The PCB is scanned by the probe both along the X and ZZ axis, respectively. The gradient signals are used for the analysis of images. Fig. 9 shows the resultant image of ECT inspection when the PCB is scanned along the Z axis and Fig. 10 corresponding to scanning along X axis. These results correspond to a pick-up coil with two turns and the scanning step is 0.1 mm. It is seen from Fig. 9 that the resultant image of the inspection does not show the defect A. This is due to the fact that the defect A lies very close to a big soldering point and the signal due to the defect A is negligible with respect to the signal due to soldering point. But while the resultant image along the X axis is taken all the defects are clearly

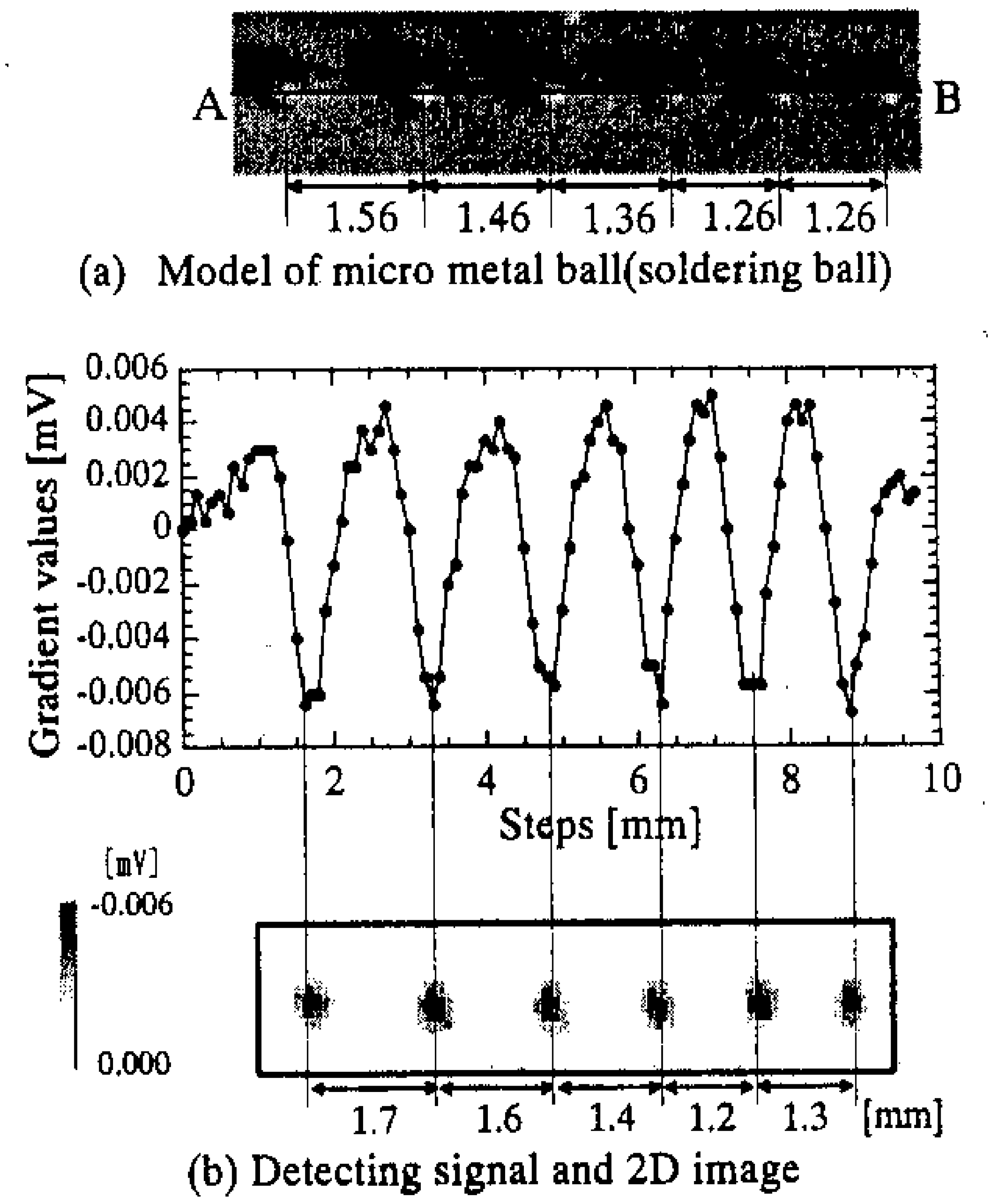

Fig. 12. Detection of micrometal ball by ECT.

observed. So the scanning both along the X and Z axes are required. Since the ECT image includes many kinds of signals originated from disconnections as well from PCB patterns, in order to effectively utilize this type of noisy signals due to defect a pattern matching method is adopted as discussed in our earlier paper [3].

VI. Detection of Metal Ball

The micro ECT probe is excited by high frequency up to 10 MHz. Then the probe enables us to detect micrometal ball with the dimension of 0.1–1.0 mm. The former ECT technique is applied to inspect the defect as nonconductive part on the uniform metal object. On the contrary, we must detect the microconductive material in which eddy currents flow.

Fig. 11 shows the configuration of detection used the probe as shown in Fig. 1. The metal ball is soldering ball (Sn63Pb37) with 30 mil diameter. Fig. 12 shows the resultant image when exciting frequency is 5 MHz and the scanning step is 0.1 mm. It is possible to find the metal ball clearly and measure the position with 20% error.

VII. Conclusion

In this paper, an eddy-current testing probe composed of planar meander coil and the multiple solenoid pick-up coil has been reported for the purpose of inspecting imperfections on the traces of printed circuit board. And the micrometal ball can be detected by the new ECT probe.

References

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