PROCESSING TECHNOLOGY OF EMBEDDED RRSISTORS IN PRINTED CIRCUIT BOARD ASSEMBLY

S. G. Wang, X. F. Qi

School of Information Science and Technology, Northwest University, Xi'an 710127, CHINA
wang718@nwu.edu.cn.

The achievement of shorter distance between the embedded passives and ICs reduces the parasitic effects, resulting in better signal transmission, less cross talk, lower loss, and lower noise, which are attractive characteristics especially at high frequency applications. The fabrication processing for embedded resistors by lamination method [1] was investigated.

The initial board for embedded resistor in the experiment was nickel phosphorus (NiP) covered with copper foil from Ohmega technologies, so the resistor material was NiP layer. A testing pattern with four different size values was designed by using Conductor Analysis Testing (CAT) equipment as shown in Fig. 1. Four different patterns A, B, C, and D were designed shown in Tab. 1. Each module was then putting into a 450mm×600mm laminate core panel for fabrication in the PCBA (Printed Circuit Board Assembly) processing line as shown in Fig. 2. The total number of embedded resistors fabricated per panel will be 1408 pieces. Manufacturing of embedded passives by lamination method were performed essentially by shaping and etching resistor material layers and electrode layers with photolithography process and six panels were a batch.

Choose 960 pieces different size embedded resistors randomly from 4 batches, 6 panels per batch and 40 pieces per panel, the minimum, maximum resistances for every resistor size are tested as shown in Fig. 3. The scatter degree of the resistance data will be described by the standard deviation σ, which can be gotten in a statistical method. The Relativity Standard Deviation (RSD) for the embedded resistors can be defined by

$$RSD = \frac{\sigma}{R_{mean}} \quad (1),$$

which is a unified principle to judge the manufacturing quality consistence for different patterns as shown in Fig. 4. The resistance value ranges of the embedded resistors give expression to the manufacturing yield, which can be calculated by

$$Yield = \frac{R_{\max} - R_{\min}}{2R_{mean}} \quad (2).$$

Fig. 5 gives the manufacturing yield for every pattern in different resistance values. There are differences between the design values and the manufacturing values, which is called the manufacturing tolerance and can be gotten by

$$\eta = \left| \frac{R_{design} - R_{mean}}{R_{design}} \right| \quad (3),$$

where R_{design} is the design resistance value as shown in Fig. 6. In order to evaluate the control ability or the manufacturing stability for a fabrication processing, Process Capability Index (C_p) is proposed as

$$C_p = \frac{0.1R_{design}}{3\sigma} \quad (4).$$

If the resistance value range is limited 10% from the design target, the ability of the manufacturing control C_p for the embedded resistors are given by totally 960 pieces resistors as shown in Fig. 7, which show the manufacturing process capabilities are sufficient for patterns C and D with bigger value resistors, eligible for patterns B and C with middle value resistors, and inadequate for pattern A and smaller value resistors. The process capability shows the manufacturing process in the experiment can be used to fabricate the embedded resistors in multiple layer PCBA in the future.

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References

[1] W. Steplewski, T. Sezysko, and G. Koziol, "Preliminary assessment of the stability of thin- and polymer thick-film resistors embedded into printed wiring boards," *Microelectronics Reliability*, vol. 52, no.8, pp.1719-1725, August 2012.

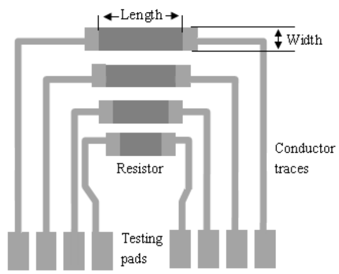

Fig. 1 Testing pattern of embedded resistors.

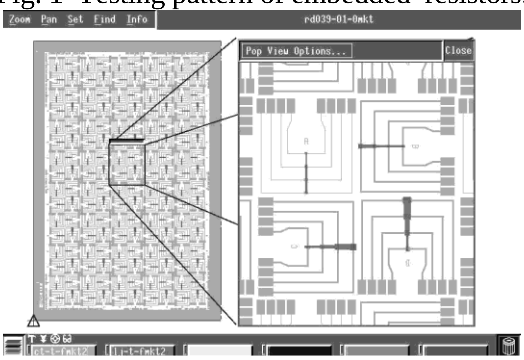

Fig. 2 Computer Aided Design (CAD) software interface for artwork design.

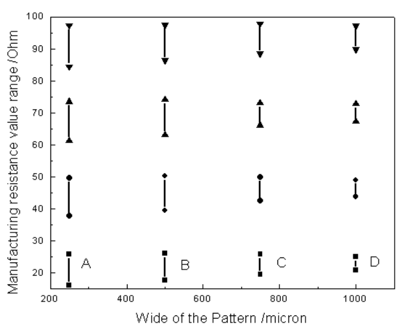

Fig. 3 Resistance values ranges tested for every embedded resistor size.

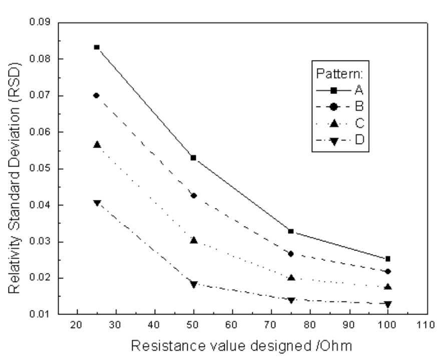

Fig. 4 Relativity standard deviations for every testing pattern.

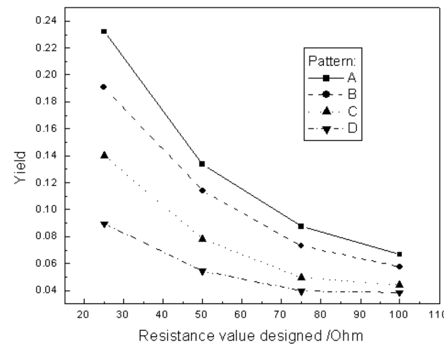

Fig. 5 Manufacturing yields for every testing pattern.

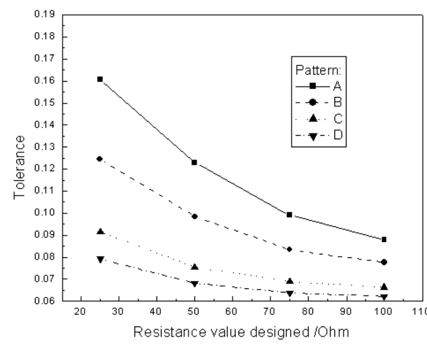

Fig. 6 Manufacturing tolerances for every testing pattern.

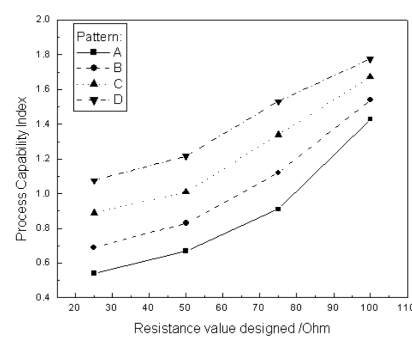

Fig. 7 Process capability for the manufacturing embedded resistors.

Tab. 1 Size list of each pattern in a module.

Pattern	Width /μm	Length /μm			
A	250	125	250	375	500
B	500	250	500	750	1000
C	750	375	750	1125	1500
D	1000	500	1000	1500	2000
R /Ω		25	50	75	100