DEVELOPMENT OF SUBSTRATE CARRIER SYSTEM

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The Substrate Carrier System (S. C. System) is a new manufacturing technique for small size hybrid IC with IMST (Insulated Metal Substrate Technology) substrate which is used for power hybrid IC (STK series). The point of this system is to treat both substrate process and assembly process in the manufacturing process of hybrid IC, with several IC substrates at the same time. In the printing process, multi-IC pattern are made on a large IMST substrate at the same time and the substrate after completion of printing process are slit-punched to have the frame configuration where individual IC substrates are conected by tie-bar. Moreover in the assembly process which involves die-bonding and wire-bonding, the substrate is carried by the pitch of IC substrate, utilizing the frame construction, which can provide the automatic processes.

This Substrate Carrier System is applied to many kinds of hybrid IC for low-frequency applications as a system of high reliability and productivity.

1. INTRODUCTION

As substrates for thick-film hybrid IC, ceramic substrates which have excellent high frequency and insulation characteristics are used usually. Recently, porcelain substrates are noted for their good heat dissipation property. Substrates should be chosen according to the circuit type and IC production method.

For the last 10 years, we have produced audio power IC with insulated metal substrates (IMST STK-series), and we have confidence that their IC have given great value.

On this occasion making use of the excellent processing property of this insulated metal substrate, which advantage is due to the metal plate used, we were able to establish a fabrication system of small-sized and high reliability thick-film hybrid IC for low frequency and small signal circuit.

This system has the following advantages:

The system has good adaptability to automation process.

The system is able to reduce the use of noble metal materials.

Because this system can utilize substrates themselves as "Carrier" and can facilitate automatic assembly, we call it Substrate Carrier System (S.C. System). This system, different from the snap-state system which is introduced in the production system for ceramic substrates, has such a remarkable characteristic that the substrates can be processed in their connected form even in assembly process. In this system, various new press techniques are used in addition to conventional IMST fabrication processes.

In the paper, is described the production system applied to the noise canceller IC for car stereo set.

2. INSULATED METAL SUBSTRATE

An insulated metal substrate is a composite material consisting of several layers as shown in Figure 1. It is 1060 mm × 1060 mm in a original size and is fabricated in the same way as printed circuit boards of bakelite type. Epoxy resin is coated on to the proper side of copper foil by use of a reverse roll coater and dried in the oven. Putting this copper foil upon an anodized aluminium plate, which size is 1060 mm × 1060 mm, epoxy resin is cured in the same hot press as is used in a printed circuit board laminater.

3. PRODUCTION PROCESS OF SMALL SIZE HYBRID IC, NOISE CANCELLER IC

First of all, we needed to know the limit of line and space width considering stencil-making technique, screen printing technique and etching technique. Therefore, we made test pattern with various line and
space widths ranging 50 to 500 μm and examined it. Then, taking mass-production into consideration, we adopted 250 μm line and space width, and designed IC pattern according to this standard. Of course, if we consider screen printing technique only, it is possible to design 100 μm line and space width.

The whole production process may be classified into two groups, substrate process and assembly process. The flow chart is shown in Figure 2.

3.1 Substrate Process

1) Print of circuit-pattern. This time, we introduce IMST substrate with the size of 200 mm × 53 mm which can contain 12 pieces of individual substrate. In order to attain fine line pattern and automatic assembly process high accuracy of print was needed. However, it is said commonly that printed pattern will expand in size. For this reason, we made the screen printing machine by ourselves and could get a satisfactory result (Figure 3).

2) Blanking-press. As a substrate of 200 mm × 53 mm size is processed by means of shearing, its accuracy is poor. But taking screen printing process and assembly process into account, it is necessary that the variation of substrate size must be less than ±50 μm. That is why the substrate is pressed by the blanking press (Figure 4).

3) Silver conductor and resistor printing. Resistor material used is resin-based carbon resistive paste of high temperature type, specially developed for IMST hybrid ICs. And the resistance value ranging from 100 Ω to 100 KΩ can be obtained by choosing the paste with a different sheet resistivity and these pastes are cured for 6 hours at 200°C.

4) Overcoat printing. After trimming, overcoat is screen-printed all over the substrate except the areas for bonding and soldering, then dried at 150°C for one
hour. This overcoat is intended to protect printed resistors and conductors from moisture and chemicals as well as to protect them from soldering.

5) Solder paste printing and flux removal. In this process solder paste is screen-printed on outer lead mounting areas, and then melting, cooling, washing and drying are done in this order.

6) Slit-punching press (Figure 5). These punched slits are used as an accurate pitch of substrate carrier in all assembly processes.

3.2 Assembly Process

1) Die-bonding. Transistor chips and monolithic chips are attached with conductive adhesive resin on the substrate.

2) Chip condenser soldering. The soldering of chip condenser is carried out by stamping solder paste.

3) Wire-bonding (Figure 6). There are two methods for lead wire bonding of small signal transistor and monolithic-IC, that is, one is ultrasonic bonding of aluminium wire, and the other is nail-head bonding of
gold wire. We adopted ultrasonic bonding method of 40 μm aluminium wire on nickel-plated pads. Nickel-plated pads, as bonding pads, exhibit excellent bondability and reliability for ultrasonic bonding of aluminium.

4) Protective coating. Transistor chips or monolithic-IC chips are coated with epoxy resin. And they are protected electrically and mechanically (Figure 7).

5) Cut-off press and outer lead attaching. It is cut into final size IC substrate. And then outer lead is soldered to it.

6) Packaging. The packaging is by means of powder coating of epoxy (Figure 8).

7) Completed IC (Figure 9). In an example of noise canceller IC, the following elements can be assembled in the size 12.5 mm × 43 mm (final substrate size).

Active element;
- Monolithic-IC chip: 1 piece

Passive element;
- Screen-printed resistor: 13 pieces
- Chip condenser: 14 pieces
4 CHARACTERISTICS OF NOISE CANCELLER IC (STK 2101) USING S.C. SYSTEM

STK 2101 can effectively eliminate incoming pulse noise such as an engine noise, etc. This should be placed between FM detector and stereo multiplex demodulator.

The equivalent circuit and measurement circuit of STK 2101 are shown in Figures 10, 11. In regard to all characteristics, STK 2101 got a similar result in comparison with monolithic-IC.

In particular, frequency characteristic is shown in Figure 12. And its specification is shown in Table I.

FIGURE 10 Equivalent circuit of STK 2101.
FIGURE 11  Measurement circuit of STK 2101.

FIGURE 12  Frequency characteristic of STK 2101.
TABLE 1
Specification of STK 2101.

| Specification                  | Value 1     | Value 2     | Unit |
|--------------------------------|-------------|-------------|------|
| Maximum Supply Voltage (Vcc)   | Vcc max     | 16          | V    |
| Allowable power dissipation    | Pd max      | 520         | mW   |
| Operating temperature (Top g)  | -20         | +75         | °C   |
| Storage temperature (Tst g)    | -30         | +100        | °C   |

Recommended operation condition (Ta = 25°C), Vcc = 8 to 16 V operatable,

| Supply voltage (Vcc)           | 12          | V           |

Operation characteristics (Ta = 25°C), Vcc = 12 V, at the specified measurement circuit,

| Characteristic                  | Min         | Typ         | Max         |
|--------------------------------|-------------|-------------|-------------|
| Quiescent current (Icco)       | 16          | 23          | mA          |
| Voltage gain (VG)              | -0.4        | 0.6         | 1.6 dB      |
| Input signal dynamic range (VD)| 30          | 45          | 60 KΩ       |
| Input impedance (Zin)          | 0.1         |             | %           |
| THD                            | 13          | 26          | μS          |
| Gate time (t gate)             | 50 Hz       | 500 Hz      |             |
| Noise sensitivity (Spn)        | 100 mV      | 500 Hz      | dB          |
| Low pass filter (fLPF)         | 50 Hz       | 500 Hz      | dB          |
| Frequency characteristic (VNO)| 6           |             | 120 dB      |

CONCLUSION

The points of this system are:

- Flexible design of substrate size and form due to the excellent processing property of aluminium.
- Availability of automatic production.
- Reduced use of noble metal materials.

We made it possible to produce many kinds of small size hybrid IC in a relatively low frequency range which has high reliability and productivity. Now, to attain the higher productivity and smaller substrate size, we are thinking of the following developments:

- S.C. System where the maximum length of IMST substrate is 1060 mm.
- Application of tape carrier method to the S.C. System Fine line pattern.
- ICs in a higher frequency range.

ACKNOWLEDGEMENTS

The authors wish to thank Y. Uchida and A. Kazami for valuable discussions, and also K. Tamura, S. Toyooka, T. Kubota, H. Asado, Y. Ohsawa and H. Motohashi who belong to the project team of the S.C. System.

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