NOTE

Development of Environmentally-Friendly Technology by Spot Coating - Reduction of amount of coating liquid -

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1 Introduction

Generally, coating is applied to the electronic component for installation in an electronic product to prevent failures including bad continuity from occurring on the electronic component caused by internal condensation due to the air inside the electronic product warmed by the air inside the vehicle cabin.

The coating is a technology for applying liquid material over an electronic component on a printed board and drying the applied material to form a film. The formed film protects the covered electronic component from moisture, obstacles and other disturbances.

A dip coating method and a curtain coating method are well known as the coating technology. However, these methods for applying coating in wide area at a time have some problems: waste of coating material; dealing with coating prohibited areas; and expensive equipment cost. This paper introduces a new coating technology that uses a drastically-reduced amount of the coating material and provides spot-coating at a pinpoint as needed.

2 Necessity of Coating

As seen in recent in-vehicle electronic products, various-shaped and bigger front panels (**Fig.1**) have been in demand. Thus, the outer air comes inside the electronic product through increased slits due to its complicated shape (**Fig.2**). The outer air coming inside causes condensation on the printed board installed at the back of the panel (panel board) and the condensation causes a failure.

Fig.1 Front panel for in-vehicle product

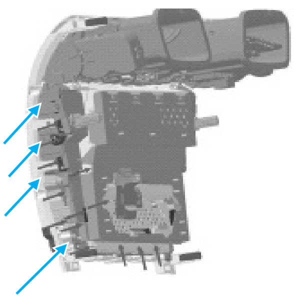
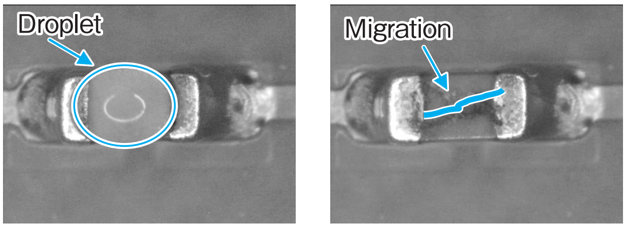


Fig.2 Outer air coming inside panel

Here, the failure caused by the condensation is described based on **Fig.3**. **Fig.3(a)** shows a simulated condensation state where a voltage is applied to the both ends of an electronic chip component (hereinafter, referred to as a chip) and a droplet is on the chip. In the case of an uncoated chip, migration [1] (**Fig.3(b)**) occurs with time in the form of connecting the two electrodes of the both ends of the chip, which results in bad continuity. In this case, coating over the electrodes of the chip (**Fig.4**) can prevent the migration and an electric failure from occurring.



(a) (b)

Fig.3 Migration phenomenon

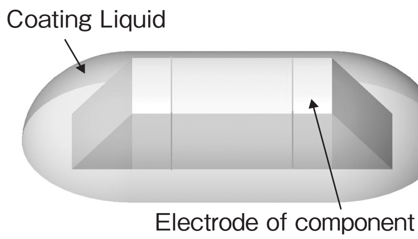


Fig.4 Typical coating pattern

However, condensation forms if even a part of the electrodes of the chip is uncovered (or with no coating material), and the condensation causes the migration. Thus, the entire chip has to be firmly covered by coating material. The film made of dried coating material has to be thick enough not to be ruptured to prevent the migration from occurring at the ruptured part.

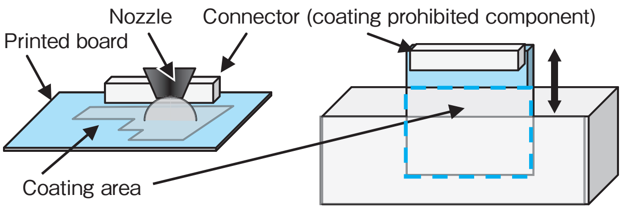
＊(1) Migration refers to a phenomenon where metal used as an electrode or a wire is transported over an insulator.

3 Current Coating Technology and Task at FUJITSU TEN

An in-vehicle electronic device has to be prepared against condensation depending on its installation condition. Coating technologies are essential for FUJITSU TEN's products as well. The curtain coating method (**Fig.5(a)**) and the dip coating method (**Fig.5(b)**) are available as coating methods. However, these methods have following tasks.

(1) Reduction of coating material amount

In the current coating methods, coating material is applied over the entire printed board, which results in covering even the area not requiring the coating with the coating liquid. That is, the coating liquid is wasted.



(a) Curtain coating　　(b) Dip coating

Fig.5 Types of coating method

Here, coating efficiency is used as a quantitative index for checking a wasted amount of the coating liquid. The coating efficiency is calculated by dividing the necessary weight by the actually-coated liquid weight, as shown in **Fig.6**.

Coating efficiency (%) = ①necessary weight (mg) ⁄ ②actually-coated liquid weight (mg)

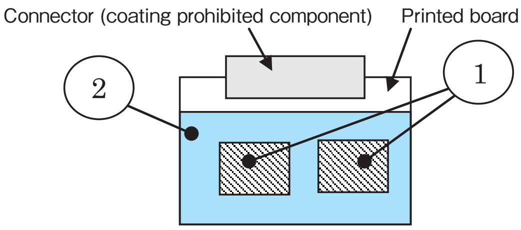


Fig.6 Concept of coating efficiency

The current coating efficiency by the curtain coating method is 7% and that by the dip coating method is 5%, which means that 90% or more of the coating material is wasted due to application to the unnecessary part. Therefore, the first task to be achieved is developing a new method for improving the coating efficiency to reduce the amount of the coating material.

(2) Improvement in accuracy regarding coating area

The other task to be achieved is developing a new coating technology that can apply the coating liquid accurately to a predetermined area. On the front panel mentioned above having some connectors and switches, coating-necessary areas and coating-prohibited areas are dotted. Thus, coating over a chip arranged near the coating-prohibited area requires a high-precision coating technology.

4 Development of Coating Technology

First, we selected a coating method to achieve these tasks. The method to be selected enables the amount of the coating liquid to be minimized for an coating-necessary area. There is a coating technology for applying liquid through a needle-nozzle, which has been used for another purpose. We have decided to develop a new method by adopting this coating technology toward efficient development as well. **Fig.7** shows a relation between a coating amount and a coating area for each type of the coating methods.

Hereafter, a needle-nozzle coating method is introduced in terms of its coating efficiency in consideration of its development processes.

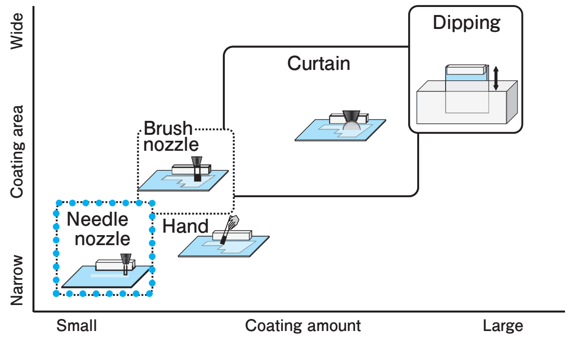
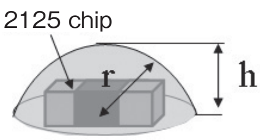


Fig.7 Types of coating method

4.1 Target Setting for Needle-Nozzle Coating Method

(1) Target setting regarding coating amount

In this method, each of the chips is fully covered by the coating material discharged through a needle. The formula shown in **Fig.8** is available for theoretical calculation of a coating amount required for one chip.



Formula

$$V=\frac{\pi}{6}h(3c^2+h^2)$$

$$c=\sqrt{h(2r-h)}$$

V : 7mm³　h : 1.5mm

c : 1.5　r : 1.5mm

Fig.8 Coating amount calculation

The value obtained by subtracting a chip volume from the value (V) of the formula above indicates the coating amount required for one chip. The needle-nozzle coating method can achieve in theory the coating efficiency of 50% or above. However, the coating film has to be thick enough not to be ruptured to prevent the migration from occurring. Therefore, our development target was set at the minimum coating amount with which a predetermined film thickness can be ensured and the coating efficiency achieves 50% or above.

(2) Target setting regarding diffusion width of coating liquid

Controlling the liquid diffusion is also critical element in order to apply accurate coating to a predetermined area. The target value regarding the liquid diffusion was set at less than the distance from the boundary of the coating-prohibited area prescribed in house to the component under the most stringent conditions. (Fig.9)

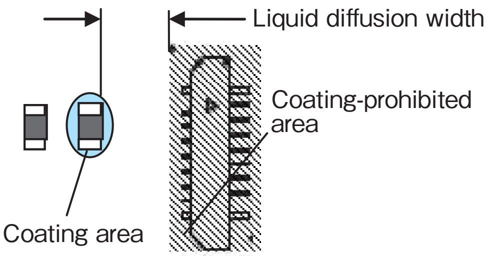


Fig.9 Target width of liquid diffusion

4.2 Condition of Needle-Nozzle

A needle-nozzle for use was determined in consideration of the relation between a discharge pressure and a discharge amount for one spot.

The needle-nozzle with surface treatment shall be used so as to ensure uniform coating shapes. A needle-nozzle without the surface treatment tends to acquire the coating liquid on the surface of the needle-nozzle. The coating liquid is attracted by the coating liquid acquired on the surface, which results in inaccurate coating (Fig.10(a)). However, the needle-nozzle with the surface treatment shown in Fig.10(b) can discharge the coating liquid without being acquired on the surface of the needle-nozzle, and can provide uniform coating shapes with less variation in size.

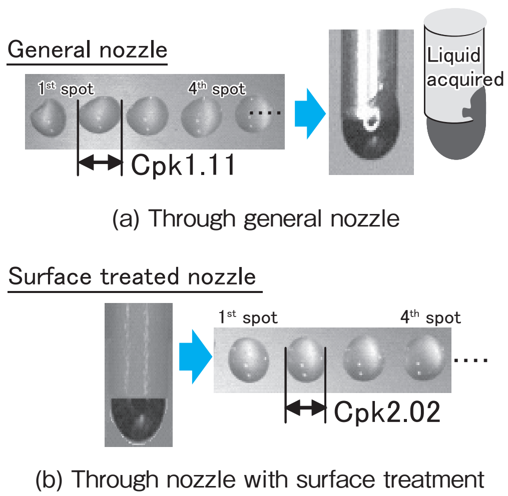


Fig.10 Coating through nozzle

4.3 Examination of Coating Method

Fig.8 shows a theoretically appropriate coating area by use of the needle-nozzle. However, if the required amount of the coating liquid is actually discharged at a time, the coating liquid spreads beyond the target area as shown in Fig.11. Thus, we need to examine the method for minimizing the spread of the coating liquid so as to improve the coating efficiency.

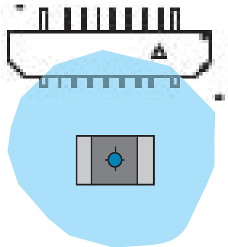


Fig.11 One-point coating

We have checked the spread of the coating liquid discharged by small amounts multiple times; two, three, or four times (Fig.12). We confirmed that while multiple-point discharging enables the spread of the liquid to be controlled, it lowers productivity. Then, we determined to advance a method for discharging by two points at a maximum to control the spread of the liquid.

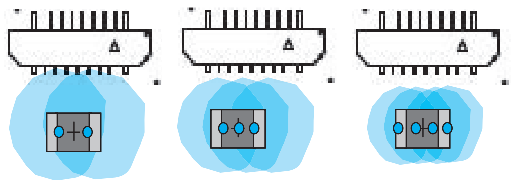


Fig.12 Multi-point coating

Flow vectors of the liquid applied by the two-point coating repel each other at the contacting surface as shown in Fig.13, but the liquid applied by the two-point coating spreads concentrically at the non-contacting surface due to the surface tension effect, as shown in Fig.13. That is, applying two-point coating only is not enough to control the spread of the liquid.

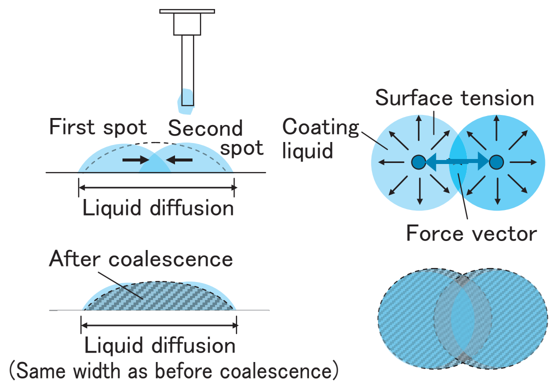


Fig.13 Liquid diffusion by multi-point coating

However, we found that applying external force to the second spot allows the spread direction of the coating material to be controlled as shown in **Fig.14**. With many trials, we have succeeded in reducing the spread from 2.0 mm or more to 1.5 mm or less. This method enables the coating liquid to cover the entire target chip without the second spot flowing outside and enables the spread of the liquid to be controlled.

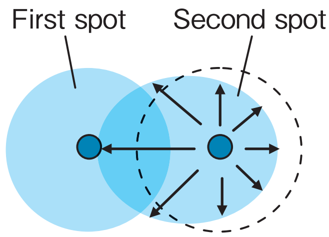


Fig.14 Image of method for controlling liquid diffusion

4.4 Determination of Coating Amount Control Range

Fig.15 shows a distribution of a coating amount and spread of the liquid. The control range appropriate for minimizing the coating amount was determined in consideration of variations in conditions through processes after finding the range where no part of electrodes of a chip is exposed.

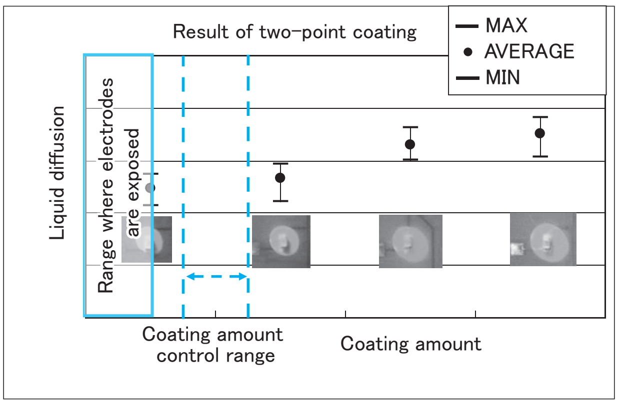


Fig.15 Coating amount control range

5 Effect by Developed Needle-Nozzle Coating Method

The newly-developed needle-nozzle coating method provides a higher coating effect of 56%, and reduces the amount of the coating liquid to one-eleventh or less compared to the amount by the dip coating method. It also controls the spread of the liquid below 1.5mm. That is, this method can provide precise coating to a necessary point. Further, since the apparatus for the newly-developed coating method is simple enough to be converted from general-purpose apparatus, it requires only considerably-less costs compared to the dedicated apparatus for the current coating method (**Fig.16**).

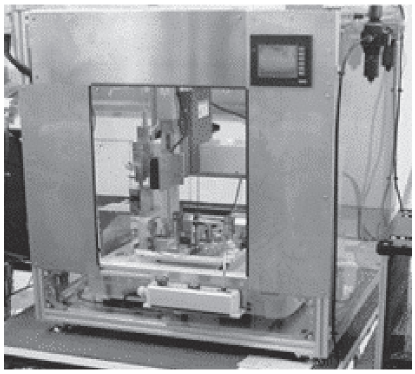


Fig.16 Coating apparatus

6 Conclusion

FUJITSU TEN has achieved results in the mass production requiring precise coating over the components having tight coating prohibition areas by the needle-nozzle coating method, but the productivity by the method remains as an issue to be solved. We will work hard to improve productivity mainly for the coating speed and keep developing the needle-nozzle coating method for diffusion of the method.

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