Packaging of SAW Devices with Small, Low Profile and Hermetic Performance

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1. Abstract

Cellular-phone markets are moving quite aggressively towards module integration and as a result, the miniaturization of devices has been accelerated. Especially SAW filters, which are the key devices in the RF parts, are demanded to realize a small size, low profile with high reliability performance. Conventional SAW filters use a HTCC package with cavity structure and metal sealing to obtain high reliability performance. This structure restricts the miniaturization of SAW filters. In order to reduce size, HTCC without cavity structure and resin sealing are commonly used. However, this structure does not contribute to the high reliability performance. This paper describes the realization of a new miniaturized SAW filter which is a combination of HTCC without cavity structure and metal sealing by using a unique packaging technique to achieve a low profile with high reliability performance. The technique has been realized by using cluster sealing with solder.

The optimization of the PKG design and sealing pressure was performed in solder sealing. In addition, by using plating in the outer coating, a high reliability performance can easily be achieved. Results of reliability testing including mechanical, electrical and moisture sensitivity will be discussed.

2. Introduction

Recently, the competition for miniaturizing, the cellular phone and making progress of the multifunctions has intensified, as the cellular phone market expands. Therefore, the modulation of parts used has rapidly advanced. The demand for miniaturizing and making progress of the low profile is growing very much. SAW devices have advantage of easily obtainable steep characteristics and small-size design. Therefore, the saw device market for cellular phone is widely expanding. On the other hand, the SAW filters have the feature that the filter characteristic the reliability cannot be maintained if an active surface is not protected in the air-gap. Because it is important for miniaturizing the SAW devices to secure the air-gap, a new technology is essential. [1-2]

3. Development policy

The size of current RF SAW filters for the cellular phone and the size of newly developed filters are shown in Table 1.

The dimension of new single-band filters are 1.4mm*1.0mm*0.5mm, which is 37% of volume of current single-band filters. Development is aimed to keep both the electrical characteristic and reliability performance. Especially, high hermetic performance is absolutely necessary for humid environment.

Table 1 Comparative table of RF-Filter Size

<table>
<thead>
<tr>
<th></th>
<th>Single-band</th>
<th>Dual-band</th>
</tr>
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<tbody>
<tr>
<td>Current</td>
<td>2.0<em>1.6</em>0.6mm</td>
<td>2.5<em>2.0</em>0.6mm</td>
</tr>
<tr>
<td>Developed</td>
<td>1.4<em>1.0</em>0.5mm</td>
<td>1.8<em>1.4</em>0.5mm</td>
</tr>
<tr>
<td>Vs Current</td>
<td>VOLUME –63%</td>
<td>VOLUME –60%</td>
</tr>
</tbody>
</table>

4. New packaging technology

Figure 1 shows a new package structure. Developed SAW filters use 2Layer HTCC PKG without cavity structure. The SAW chip is connected to plain PKG HTCC base by FCB. The SAW chip is molded with Sn-Ag solder, and the outside is coated by the Ni plating. Ni protects Sn-Ag solder from heat treatment.

Generally, the melting point of Sn-Ag solder series is about 220degree C. When the SAW device is mounted on the board of cellular phone, the temperature goes up to the Sn-Ag melting point again. Therefore, Sn-Ag melts again when mounting, and a high reliability securing is difficult. However, if the Ni plating is carried out properly,
enduring the reflow becomes possible. In the resin sealing that uses a conventional epoxy, cannot avoid the penetration of moisture over a long term. Therefore, an excellent result cannot be obtained for THB and PCT. This structure has the reliability of THB1000H, PCT96H and Moisture Sensitivity Level 1(JEDEC-MSL1), because it can achieve the Hermetic performance.

5. DETAIL OF SEALING

The most unique technology is in sealing that use of Sn-Ag to achieve a new packaging. Sn-Ag is a very common material used also for SMD mounting, and has the example of practical use such as bumps and dams in various packaging.[3]

However, the new package is an unparalleled structure in the point of covering the whole of the chip with Sn-Ag. Details of sealing are as follows. Fig.2 shows the image of the contact angle of melting Sn-Ag. Left figure shows the state that the SAW chip is mounted with the flip chip like the array in a HTCC package. In this situation, Sn-Ag is supplied from the upper side and heat is applied. If pressure is not applied to Sn-Ag, melting Sn-Ag becomes the Ball shape, like a Right figure. Because the Sn/LT contact angle is 90 degrees or more, this figure shows the state that the capillary action doesn't occur to the space of the SAW chip.[4]

\[ \text{Contact Angle } \theta = 90\text{deg.} \]

The pressure to push the melting metal into a constant space is shown by the formula of Washburn(1). This formula is sued to show the pressure magnitude to push mercury into the hole of the radius=R. Moreover, the relation between pressure (P) and GAP (2r) can be led from this formula.

**Formula of Washburn**

\[ P = -2\gamma \cos \theta \quad (1) \]

The chip space and pressure have the relation of negative correlation. High pressure is needed when the space is narrow.

Fig. 3 shows the image of the sealing process.Sheet LID from which Sn-Ag is combined to KOV is supplied from the upper side of the chip as the first step. Afterwards, if an appropriate pressure is applied at a temperature higher than the melting point of Sn-Ag, melting Sn-Ag starts to infiltration into the GAP of the chips. (a)

When Sn-Ag reaches the Au plating pattern on the surface of the HTCC, Sn-Ag starts the capillary action. This is because the contact angle to Au is 90 degrees or less. Sn-Ag begins to flow in the depth direction of figure. (b) Afterwards, sealing is completed. (c)

![Fig.3 Image of sealing process](image)

6. CONCLUSIONS

New structural SAW filter sealed with the Sn-Ag solder was developed. The reliability of a new structural SAW filter and current structural SAW filter are the same level in all items. New structural SAW filter has a humidity tolerance MSL level 1. The volume of new structural SAW filter decreases by 60% compared with the current structural SAW filter, and is the smallest RF filters in the world. Fig.4 shows the appearance of the SAW filters.

![Fig.4 APPEARANCE OF PRODUCTS](image)

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REFERENCES