Development of G/SV Series Tantalum Capacitors with New Structures

KATO Kazuyuki, ABE Satoshi, YAMASHITA Daisuke

Abstract

Mobile electronic equipment as represented by cell phones and digital cameras is rapidly decreasing in size and the electronic components used are being subjected to strong pressures for size and thickness reductions. In order to meet these needs, NEC TOKIN is developing tantalum capacitors with compact sizes and large capacitances and has already commercialized the F/SV Series of tantalum capacitors from the 2012-size with face down structures that offer an electrostatic capacitance of 100μF.

This paper introduces the results of the new developments with regard to meeting market needs for further capacitance increases. The G/SV Series tantalum capacitors that began production in 2008 offer 220μF from the 2012-size.

Keywords

tantalum capacitor, capacitance increase, face down, board, 2012-size

1. Introduction

The most impressive features of the tantalum capacitors are the compact sizes and large capacitance that are made possible by using fine grade tantalum powder. Meanwhile, the laminated ceramic capacitors are also increasing their capacitances thanks to thin film implementation and these devices are in competition with the tantalum capacitors. In addition, the recent trend of reducing the size and thickness of sets is imposing requirements for decreasing the dimensions and increasing the capacitance values of the tantalum capacitors.

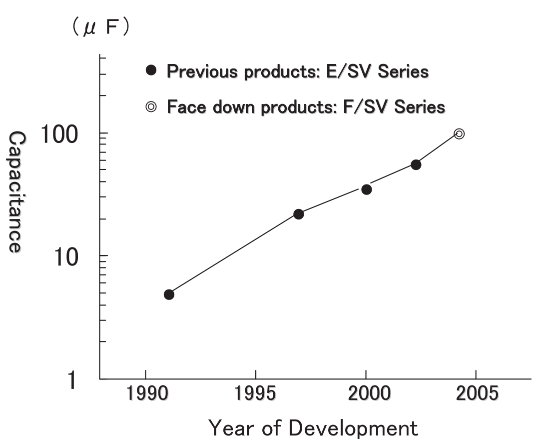

Fig. 1 Change in capacitance of 2012-size products.

Ways to increase the size and capacitance of tantalum capacitors can roughly be divided into the following two methods;

(1) Increasing the opposite electrode (common electrode) area by using finer grade tantalum powder in the anode;

(2) Increasing the volumetric efficiency (device size) by improving/modifying the structure.

Up to the present, we have been endeavoring to increase the

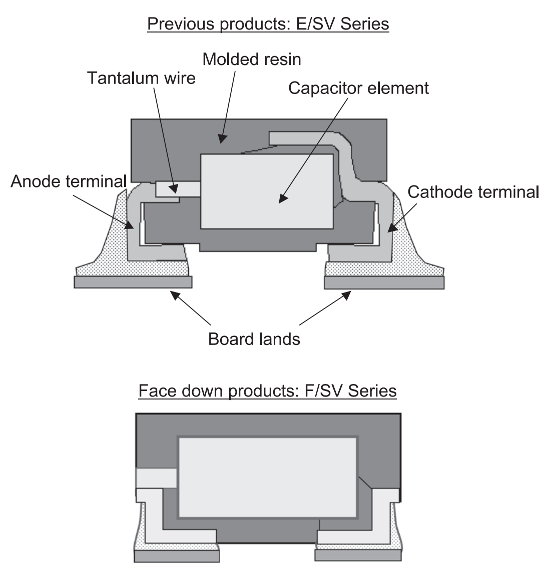

Fig. 2 Structures of previous and face down products.

capacitances of the 2012-size (2.0L × 1.25W) capacitors by decreasing the tantalum powder grain size and by improving the volumetric efficiency of products with traditional structures (**Fig. 1**). In particular, since 2004 we have been mass-producing the face down capacitors that are shown in **Fig. 2** .

With regard to the face down capacitors, we have succeeded in improving the volumetric efficiency by 50% by applying structural modifications and by decreasing the board land pattern by increasing the board mounting density by 50%. As a result of these two improvements, our face down capacitors achieve twice the mounting efficiency compared to the previous products.

However, the reduction in the grain size of the tantalum powder has at the present time almost reached a technical limit. On the other hand, the volumetric efficiencies of face down capacitors are still low for products of smaller size and the volumetric efficiency of the smallest 1608-size capacitors is as low as 33%, even for the highest capacitance products.

We have proceeded therefore to develop a tantalum capacitor with a higher volumetric efficiency than that of the face down capacitors by focusing on modifications to the basic structure.

2. Volumetric Efficiency Improvements by Board Structure Modifications

The electrolytic substance used in the cathode layer of tantalum capacitors is either manganese dioxide or a conductive polymer. In the present development, we selected manganese dioxide because it allows the capacitance to be increased by the thin film implementation of a dielectric film.

One of the factors degrading the volumetric efficiency is the necessity of using an L-shaped terminal in the cathode connection between the capacitor element and the product terminal in order to ensure connectivity. This design makes it necessary to reserve a space of at least 0.3mm on the cathode connection area at the side of the product.

The previous products used a lead frame for the connection terminal, but we have reviewed this design radically. We have adopted a thin PC board with an overall thickness of about 0.1mm and increased the dimensions of the capacitor element by expanding the terminal area inside the cathode and limiting the area for connection of the capacitor element to the bottom side only. This change in the cathode design has led to a 15% increase in the volumetric efficiency.

3. Assembly Accuracy Improvement by an Eccentric Pellet

In adopting the new board structure, we decided to use metal blocks in the anode connection between the tantalum wire and the PC board. This arrangement was in order to ensure the connectivity of the tantalum wire (**Fig. 3** (a)). The height of the 2012-size product is 1.2mm and the metal block height would be 0.5mm if the traditional technique was used. However, this would make the metal block too long with a height of 0.5mm and width of 0.2mm, and lead to a dimensional accuracy problem due to the deformation produced during resistance welding of the tantalum wire and metal block.

To deal with this problem, we adopted the eccentric tantalum wire structure shown in **Fig. 4** for the first time, in

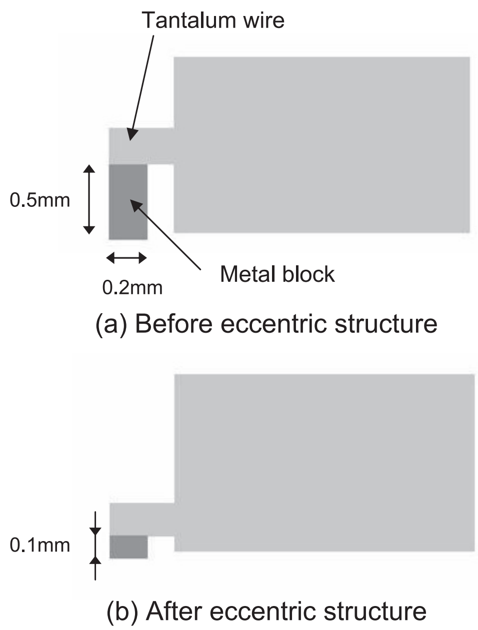

Fig. 3 Comparison of eccentric structures of tantalum wires.

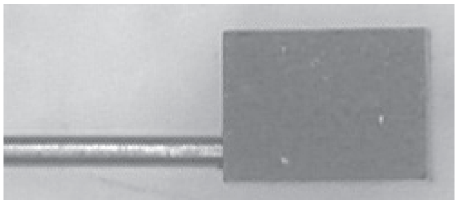

Fig. 4 Eccentric element.

order to reduce the metal block height and thereby minimize the deformation of the metal block during resistance welding. As a result, we succeeded in positioning the tantalum wire at 0.1mm from the tantalum element bottom (Fig. 3(b)), thus improving the assembly accuracy and reducing the dimensional variance by 1/3rd.

4. Board Adhesion Improvement Using a New Molded Resin

As the new design necessitates the forming of the PC board carrying the capacitor element with external resin, the problem was also posed of how to ensure the connection strength between the flat PC board and the external resin.

One of the solutions for this problem is to provide the PC board with surface irregularities in order to improve the external resin connection strength by means of the anchor effect. However, the additional work for providing the PC board with irregular surfaces required by this method would increase the cost and make it necessary to decrease the capacitor element size due to the surface irregularities. This would hinder the main purpose of increasing the device capacitance.

So we decided to adopt a molded resin that was newly developed by a materials manufacturer. This procedure has allowed us to improve the connection strength between the PC board and the molded resin as shown in **Fig. 5** , even with the flat PC board structure.

The improvement of the adhesion between the PC board and the molded resin as well as that of the sealing of the internal capacitor element have also decreased the amount of change to the capacitor characteristics with regard to the long-term reliability evaluation that included high temperature shelf testing as shown in **Fig. 6** .

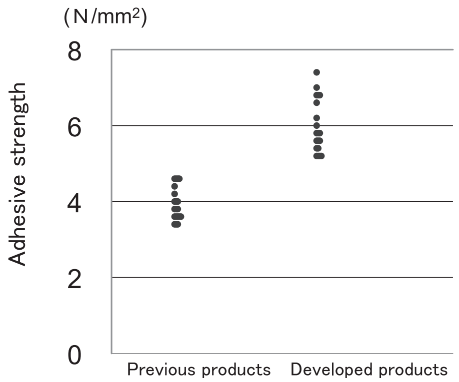

Fig. 5 Comparison of PCB adhesive strengths of molded resins.

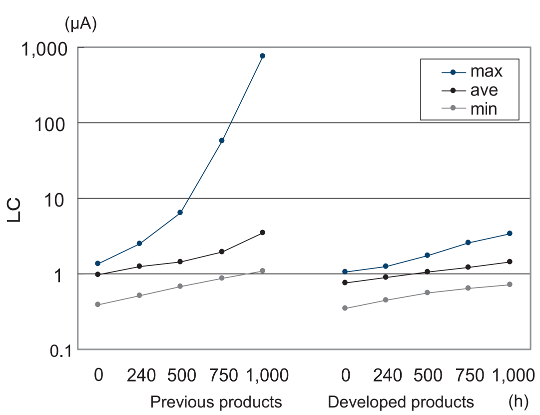

Fig. 6 LC reliability in 150°C high-temperature shelf test.

5. Volumetric Efficiency Improvement by Fillet Review

The terminals at the sides of the product should be equipped with soldered parts in order to allow the user to check the condition of the capacitor mounting. These parts are called the fillet formation areas and the existing face down capacitors are installed separately in this part so that the solder-plated surfaces are exposed after the lead terminals are cut.

In the present development, we formed the fillet areas inside the PC board in order to reduce their size and to thus improve the volumetric efficiency of the capacitors. This fillet formation method has actually improved the volumetric efficiency by 15%.

6. Volumetric Efficiency Improvement by Improved Dimensional Accuracy

For the manganese dioxide, graphite and silver paste used for the cathode layers we adopted a technique for reducing the thickness and variance of each layer and reduced the interface resistance.

We also introduced techniques and facilities for improving the accuracy of the resulting assembly and succeeded in halving the variance in the assembly accuracy to around 20μm. As a result, this has made it possible to expand the capacitor arrangement and improve the volumetric efficiency by 5%.

7. Developed Products

The procedures described above have allowed us to develop products with new structures (**Fig. 7** and **Fig. 8**).

The developed products feature significant improvements in the volumetric efficiency of the 2012-size capacitors compared to the previous as well as to the face down products (**Table 1**). The maximum capacitance has been increased from 100μF in the case of the face down products to 220μF.

The developed products have already been put to mass-production under the name of the G/SV Series.

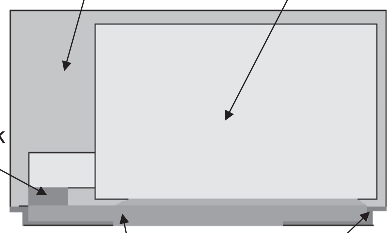

Fig. 7 Developed product structure.

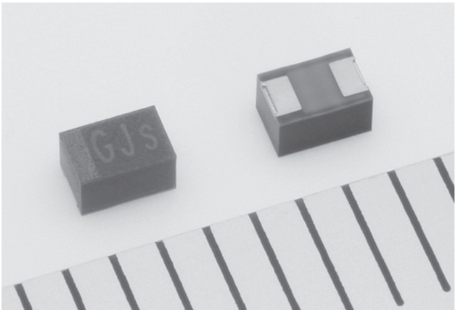

Fig. 8 External view of the developed products.

Table 1 Comparison of volumetric efficiency and capacitance with existing products.

Structure	Volumetric Efficiency	Max. Capacitance
Previous product	19%	47 μF/2.5 V
Face down product	38%	100 μF/2.5 V
Developed product	55%	220 μF/2.5 V

Table 2 G/SV series product map.

	2.5V	4V	6.3V	10V
33μF				
47μF				
68μF				
100μF			(P)	
150μF		(P)		
220μF	P			
330μF				

(P)：Product under development

Table 3 Dimensions of G/SV series products.

Length	Width	Height
2.0±0.1	1.25±0.1	Max 1.2

Unit: mm

Table 2 shows the product map of the G/SV Series and **Table 3** shows the dimensions of the products.

8. Conclusion

In the above, we describe the results of the development of the 2012-size, 220-μF G/SV Series capacitors that have been put to mass-production.

The G/SV Series is suitable for various purposes, including the audio circuit of portable audio equipment that requires a momentary high power supply to enable the reproduction of powerful base. It is also suitable for digital cameras that handle a significant amount of data in order to deal with the increased pixels and improve the movie capability. It also contributes to a reduction in the number of components used.

In the future, we intend to expand the line of products with more compact and thinner types and also with low-ESR types by adopting conductive polymer material (we will call these the NeoCapacitors).

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Authors' Profiles

KATO Kazuyuki
Expert,
Product Engineering Dept.,
Capacitor Division,
NEC TOKIN Corporation

ABE Satoshi
Product Engineering Dept.,
Capacitor Division,
NEC TOKIN Corporation

YAMASHITA Daisuke
Product Engineering Dept.,
Capacitor Division,
NEC TOKIN Corporation