Conductive Adhesive-Compliant Capacitors Boost Lead-Free Trend

To ensure product reliability, Murata has designed the electrodes to contain Ag and Pd and has implemented a structure that can adapt to very hot environments.

The development and adoption of lead-free products in the electronic equipment industry have been very active. At present, the conductive adhesive, as an alternative product for solder, is drawing attention as a lead-free product from the standpoint of environment protection. Aside from their application on electronic components like multilayer ceramic capacitors, conductive adhesives are currently used for the attachments of light-emitting diode (LED) dies, for modules of CCDs with low thermal resistance, for resin-sealed modules that are prone to defects caused by joints meltdown, and for automotive modules that require high thermal resistance and temperature cycle resistance.

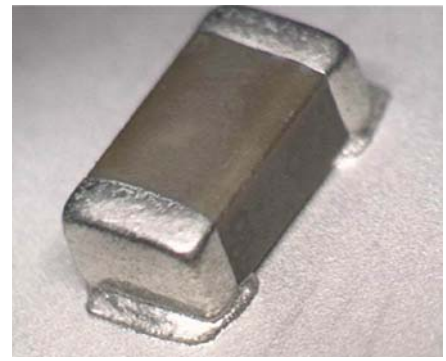
Conventionally, when a component mounted on a printed circuit board (PCB) by soldering is placed under an environment with severe temperature changes, the problem of the occurrence of cracks happens. The cracks are due to the increase in the load imposed upon the soldered portions, which in turn is caused by the difference in the expansion and shrinkage rates between the component and the PCB subjected to thermal shock. On the contrary, when a component is attached to a PCB using conductive adhesives, there are almost zero occurrences of such risks. Photo 1 shows an example of a component mounted by using conductive adhesives.

From now on, it is expected that the conductive adhesives will be used for wide-ranging applications and will also replace some usages of the conventional solder in the mounting market after passing international standardization.

Development Background

In anticipation of such demands, Murata Manufacturing Co., Ltd. has developed the GCG multilayer ceramic capacitor series. The external electrodes of the GCG Series are made of silver (Ag) and palladium (Pd) and can be securely bonded by conductive adhesives. The GCG Series has a structure suitable for mounting on electronic components that are placed under a severe-temperature environment, for example, in automobile engine control units and in various sensors. Fig. 1 shows a comparison of the structures of the GCM Series conventional external electrode plating products and the new GCG Series, while fig. 2 shows a comparison of their adhesive strengths.

The conductive adhesive, which has demonstrated a strong component adhesive force in energy-saving and low-temperature processes, features a design that contains Ag filler in the epoxy resin. As opposed to this, existing capacitor structures with tin (Sn)-plated terminal electrodes cannot assure sufficient adhesive force because of their smooth surface. In addition, it is difficult to assure reliability because of the electric potential corrosion that occurs as time elapses due to the potential difference on the contact surface between Ag and Sn. To resolve these problems, Murata has formed an external electrode with a structure that contains Ag. The uneven surface peculiar to baked thick-film electrodes assures a secure contact area with the adhesive, and also potential corrosion is avoided by contact between the Ag material in the external electrode and the Ag material in the adhesive.



Example of a component mounted with conductive adhesives

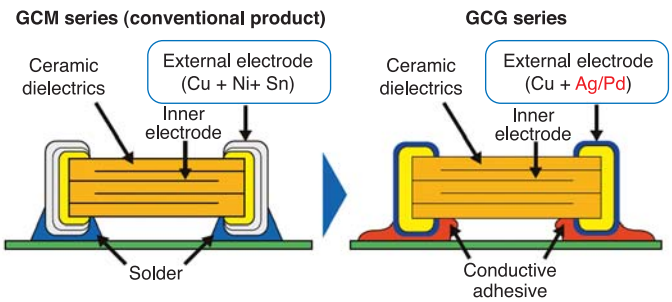


Fig. 1: Comparative structures of a capacitor compatible with conductive adhesive and a conventional product

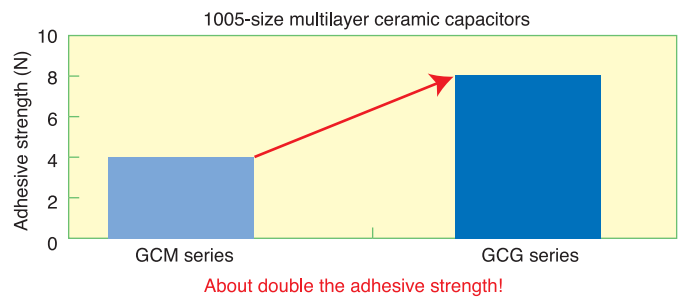


Fig. 2: Comparison of adhesive strengths of a capacitor compatible with conductive adhesive and a conventional product

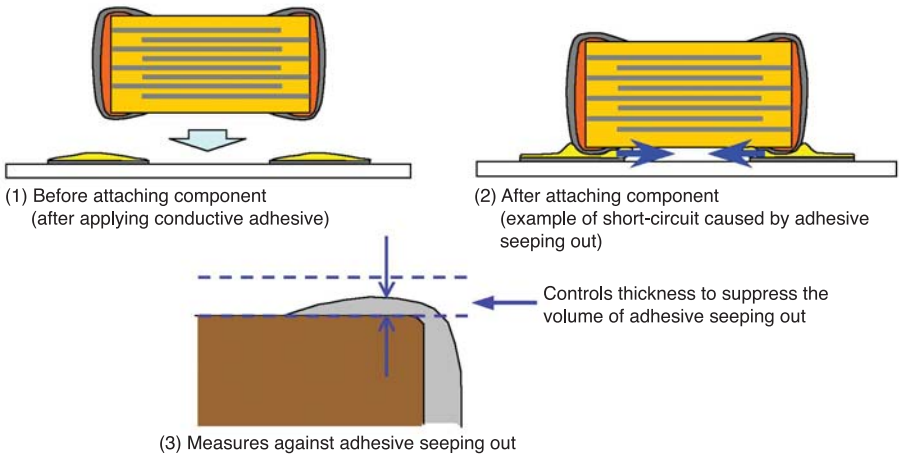


Fig. 3: Example of defects that occur during component attachment and countermeasures

Furthermore, the external electrode contains Pd so it can prevent oxidation of the Ag surface.

Electromigration Problem

For the conductive filler metals contained in the conductive adhesives and for the Ag used in the external electrode, the risk of decline in insulation due to electromigration between positive and negative lands or between capacitor electrodes is possible. This condition happens when a potential difference occurs under extremely high humid environments. In order to reduce this risk, various measures, such as optimization of the Ag and Pd proportions in the alloy has been applied for capacitors, eventually resolving these problems in recent years.

As a result, Ag can be used safely over a long period of time under severe environmental conditions for narrow-pitch conductive adhesives as well as for various electronic control circuits installed in the automobile engine room. (There may be, however, conditions that are different from the results obtained in the tests because of the operating environment of circuits or elapsed time. Therefore, it is recommended to provide sealing measures using moisture-proof silicon in order to assure operational safety.)

Ensures Mounting Stability

When a component is mounted on a PCB using conductive adhesives, in some cases, the adhesive agent seeps out to the underside of the component while mounting, causing a short circuit between the electrodes.

Figs. 3-(1) and 3-(2) show the diagrams before and after a component is attached through conductive adhesive mounting. There are cases where the defects, such as short circuits caused by the conductive adhesive that seeps out toward the direction in-between electrodes, occur in the external electrodes with certain shapes. To prevent this problem, it is necessary to adjust the volume of the adhesive and optimize the print patterns. The structure of Murata's capacitors controls the component shape and prevents the occurrence of such mounting defects (Fig. 3-(3)). This innovative structure can prevent the adhesive from seeping and assures higher safety in the use of the capacitors.

GCG Series Capacitor Lineup

By combining the abovementioned technology that uses Ag for the external electrodes with Murata's extensive lineup of temperature characteristics series and rated voltage series ceramic capacitors, the company was able to design the same broad portfolio in the GCG Series. Under this product line, Murata offers capacitor products from 1005-size (GCG15 Series) to 3225-size (GCG32 Series) in a wide range of capacitance, giving users varied options for their desired applications. The company has also developed versions of its 125ºC (X7R characteristics) and 150ºC (X8L/X8R/X8G characteristics) support capacitors that can withstand higher temperatures.

The GCG Series capacitor lineup is introduced in Table 1 below.

Conclusion

Among the issues related to mounting capacitors on a PCB, Murata must provide adequate measures for severe thermal shock and mechanical shock that are especially important for applications in the automobile market. These newly developed capacitors for use with conductive adhesives can meet the requirements of severe thermal shock.

Murata is also commercializing the GCJ capacitor series that use resin in some portions of the external electrode in order to meet the requirements of severe mechanical shock.

It is expected that environment-friendly component mounting methods, including the use of lead-free materials, will further advance. Murata intends to actively develop optimal products for relevant component-mounting methods by keeping up with the changes in mounting processes in the future.

Table 1: GCG Series capacitor lineup

Mass-production product Development product

Series	L × W Dimensions (mm)	Rated voltage (V)	Capacitance range (F)
			1.0pF 10pF 100pF 1000pF 0.01μF 0.1μF 1.0μF 10μF
GCG15	1.0 × 0.5	10—100V	0.3pF — 0.1μF
GCG18	1.6 × 0.8		10pF — 0.22μF
GCG21	2.0 × 1.25		100pF — 1.0μF
GCG31	3.2 × 1.6		0.1μF — 4.7μF
GCG32	3.2 × 2.5		3.3μF — 22μF

About this Article:

This article was contributed by the Product Development Sec. 2 , Capacitor Engineering Dept. 2, Izumo Murata Manufacturing Co., Ltd.