Epoxy/$BaTiO_3$ composite films and pastes for high dielectric constant and low tolerance embedded capacitors fabrication in organic substrates

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Abstract

Embedded passives technology is one of the effective packaging technologies for further miniaturization and higher electrical performance of electronic systems. One of the promising materials for embedded capacitors is polymer/ceramic composite, which combines excellent processability of polymers and high dielectric constant of ceramic powders. Epoxy/$BaTiO_3$ composite embedded capacitor films (ECFs) and pastes (ECPs) were newly developed for high dielectric constant and low capacitance tolerance (less than ±5%) embedded capacitor fabrication on selective areas of organic substrates.

Epoxy/$BaTiO_3$ composite embedded capacitor films are composed of specially formulated epoxy resin, latent curing agent, and high dielectric constant BaTiO3 powders in terms of materials formulation. This materials combination is for the capability of good film formation (on a releasing film or copper foil), long shelf life (1 year at refrigerator condition and 3 month at room temperature), good adhesion strength, and thermo-mechanical stability after final epoxy cure. In terms of film formation process, a roll coating method was used. This process has advantages such as no waste of materials, high productivity, and good film thickness uniformity, resulting in uniform capacitance, which means low capacitance tolerance. The embedded capacitor films are in B-stage and can be cured within 5 minutes at 180° C. Dielectric constant over 90 using two different size powder mixtures, leakage current less than 10^{-6} Amp/cm^2 at 50V, adhesion strength more than 0.8kgf/cm were obtained. ECFs with these properties are excellent enough for real decoupling capacitor applications. Typically, capacitors of 10 nF/cm^2 with less

than ± 5% capacitance tolerance were successfully demonstrated on PCBs using newly developed 7 μm thickness epoxy/$BaTiO_3$ composite ECFs. These capacitor films can be embedded on selective areas of PCBs during sequential build-up processes or other substrates such as Si and ceramic substrates. Embedded PCBs test vehicles, containing ECFs in inner layers of multilayer PCB, were successfully fabricated, and reliability tests such as 85/85 test, thermal-cycle test, and quick soak test, were performed. And high frequency performance of embedded capacitors using ECFs up to 10GHz will be also discussed.

Alternative material

Embedded capacitor pastes (ECPs) were developed to fabricate embedded capacitors using a screen-printing method. One of advantages of the ECPs is the fabrication of a dielectric layer on selective areas of substrates. Thickness uniformity of dielectric layer was achieved by controlling the rheological properties of the ECPs such as leveling behavior using several additives and also applying pressures (30~110 psi) during paste curing after a screen-printing deposition. Using this methods, 10㎛ thickness dielectric layers with thickness tolerance less than ±5%, dielectric constant over 70, and capacitance over 5nF/cm^2 were successfully demonstrated. And reliability test results such as thermal cycling and 85/58 test will be also presented.