ULTRATHIN COMPOSITE DIELECTRICS FOR USE IN PRINTED CIRCUIT BOARDS

FIELD OF TECHNOLOGY

Aspects relate generally to printed circuit boards, including high density interconnect (HDI) printed circuit boards, and, more particularly, to dielectrics for use therein.

BACKGROUND

Thinner dielectrics are needed for next generation products pertaining to chip packaging substrates, mobile devices and communication technologies such as 5G. These thin dielectrics also need to have a low dissipation factor and a low dielectric constant to improve signal integrity. In addition to the thickness requirements, the dielectric materials also need to be easily laser drillable. In the current state of art, glass-reinforced materials are typically used, but these lead to issues with laser drilling, as the glass requires more energy than the polymeric resin to ablate, which leads to poorer hole quality. Additionally, glass-reinforced materials are also limited in the ability to produce very thin dielectrics.

SUMMARY

In accordance with one or more aspects, a printed circuit board is disclosed. The printed circuit board may comprise at least one dielectric material layer comprising a thermoplastic liquid crystal polymer (LCP) substrate coated or impregnated with a thermosetting resin.

In some examples, the at least one dielectric material layer may have a dielectric constant (DK) value of less than about 3.4. The at least one dielectric material layer may have a DK value of less than about 3.0. The at least one dielectric material layer may have a DK value of less than about 2.8.

In some examples, the at least one dielectric material layer may be characterized by a dissipation factor of less than about 0.005. The at least one dielectric material layer may be characterized by a dissipation factor of less than about 0.0025.

In some examples, the at least one dielectric material layer may have a thickness of less than about 125 microns. The at least one dielectric material layer may have a thickness of less than about 50 microns. The at least one dielectric material layer may have a thickness of less

than about 40 microns. The at least one dielectric material layer may have a thickness of less than about 25 microns.

In some examples, the at least one dielectric material layer may comprise a prepreg or a laminate.

In some examples, the thermosetting resin may be a crosslinked thermosetting polymer resin selected from the group consisting of: an epoxy resin, a bismaleimide resin, a cyanate ester resin, a BT resin, a polybutadiene resin and a PPE/PPO resin. The thermosetting resin may be a crosslinked thermosetting polymer resin comprising at least one resin selected from the group consisting of: a vinyl functional PPE resin, an OPE resin, a Bismaleimide resin, a Triallyl Cyanurate resin and a Tri Allyl Isocyanurate resin.

In at least some non-limiting examples, the thermosetting resin may be substantially halogen free.

In some examples, the thermosetting resin may further comprise at least one of: a flame retardant, a curing agent, a hardener, a filler and an additive.

In some examples, the at least one dielectric material layer may be copper clad.

In some examples, the LCP substrate may comprise a polyarylate resin.

In some examples, the LCP substrate may be characterized by a basis weight of less than about 25 GSM. The LCP substrate may be characterized by a basis weight of less than about 10 GSM.

In some examples, the at least one dielectric material layer may be characterized by a glass transition temperature (Tg) of greater than about 150 ºC.

In some examples, the at least one dielectric material layer may be characterized by a tensile modulus in plane directions of greater than about 5 GPa.

In some examples, the printed circuit board may be a high density interconnect (HDI) printed circuit board.

Described herein are liquid crystal polymer (LCP) substrate reinforced dielectric material layers with a thermosetting polymeric matrix for use in printed circuit boards and high density interconnect (HDI) printed circuit boards. LCP is a thermoplastic, and the use of thermoplastics in multilayer printed circuit boards has been limited to double sided applications mainly because these materials melt above 290 °C. Multilayer boards including HDI boards need to go through multiple pressings or lamination cycles. Since the LCP materials melt at such high temperatures,

this is not feasible in most printed circuit board (PCB) shops. Additionally, reliability is adversely affected when going to such high temperatures. In high density interconnect manufacturing the vias are fabricated at each layer and exposure to high temperatures (i.e. greater than about 260 °C) would accelerate via failures. In the present disclosure, these problems are solved by using a LCP substrate as a reinforcement which is impregnated or coated with a thermoset resin and cured to a B-stage so that it can then be used to form copper clad or unclad laminates and prepregs for use in printed circuit boards.

One example of the disclosure is the use of an LCP substrate, e.g. sheet or fabric, coated or impregnated with a thermosetting resin for use as a single or multiple dielectric material layer in printed circuit boards.

In some examples, the thickness of the LCP sheet is less than about 50 microns prior to processing and/or pressing.

In some examples, the dielectric material layer may or may not be clad with copper.

In preferred examples, the Tg of the thermosetting resin is greater than about 150 ºC.

In some examples, the at least one dielectric material layer may have a dielectric constant (DK) of less than about 3.5.

In some examples, the thickness of the dielectric material layer may be less than about 15 microns.

In some examples, the LCP substrate is based on polyarylate resin.

In some examples, the LCP substrate is a sheet.

In some examples, the LCP substrate is a nonwoven fabric or veil.

In some examples, the LCP substrate has a dissipation factor of less than about 0.005 at 10 GHz.

In some examples, the LCP substrate has a dissipation factor of less than about 0.0025 at 10 GHz.

In some examples, the dissipation factor of the at least one dielectric material layer comprising thermoplastic LCP with thermosetting matrix material is less than about 0.005 at 10 GHz.

In some examples, the dissipation factor of the at least one dielectric material layer comprising thermoplastic LCP with thermosetting matrix material is less than about 0.0025 at 10 GHz.

The disclosure contemplates all combinations of any one or more of the foregoing aspects and/or examples, as well as combinations with any one or more of the embodiments set forth in the detailed description and any examples.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

FIG. 1 presents a schematic of a dielectric material layer for use in printed circuit boards in accordance with one or more embodiments.

DETAILED DESCRIPTION

Current state of the art thin dielectric material layers for printed circuit boards use either pure thermosetting films or thermoplastic films, which have issues relating to thickness control, handling, stiffness and reliability.

Thermoplastic films or sheets are not suitable for multilayer lamination. The thermoplastic films must have a high melt temperature so that they can be used during PCB processes and assembly in the printed circuit board application. For a thermoplastic material to be usable, the assembly and soldering temperatures cannot exceed its melting point. Given that these processing temperatures are set by choice of the solder, only thermoplastics with sufficiently high melt points can be used. However, this renders these thermoplastic films unsuitable for multilayer boards because board fabrication will require the material to exceed its melting point to bond to other layers. Additionally, for HDI boards requiring sequential laminations, the temperature would have to exceed the melting point multiple times, and this would lead to a number of problems, such as melting and distortion of the circuit layer, and could also lead to what is called circuit swimming wherein the circuit can separate from the substrate. Exposing the circuitry to such high temperatures, especially in the context of high density interconnect (HDI) boards, poses major reliability challenges and therefore thermoplastic films and sheets are not used for multilayer printed circuit boards. There is a need for a low loss, low DK, ultrathin dielectric material layer that can be easily laser drilled and has the right