

Printed wiring boards —

Part 22: Guide to the use of printed wiring board substrate materials: surface mount technology

Committees responsible for this British Standard

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- ERA Technology Ltd.
- Electrical and Electronic Insulation Association (BEAMA Ltd.)
- Electronic Components Industry Federation
- GAMBICA (BEAMA Ltd.)
- Institute of Circuit Technology
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Foreword

This British Standard has been prepared under the direction of the Electronic Components Standards Policy Committee.

This Part of BS 6221 provides guidance on the manufacture and properties of printed wiring board base laminate materials with particular reference to their use in surface mount technology and should therefore be used in conjunction with BS 6221-3, BS 6221-4, BS 6221-5, BS 6221-6, BS 6221-7, BS 6221-8, BS 6221-20 and BS 6221-21.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 6221 provides guidance on the manufacture and properties of printed wiring board base laminate materials. Particular emphasis is given to their use in surface mount technology (SMT).

While the major types of resin systems are covered, together with the appropriate reinforcements, this guide is not exhaustive. For definitive properties of the resin/reinforcement systems described, and of other available systems, the laminate manufacturers should be consulted.

2 General

2.1 The material for printed wiring boards will usually be metal-clad synthetic resin bonded sheet or metal-clad polymeric film where the conductor pattern is chemically etched or mechanically milled, or unclad synthetic resin bonded sheet or polymeric film where the conductor pattern is formed by additive methods such as plating, die stamping or by discrete wiring techniques.

2.2 The material selected should have a specification which is properly matched to the performance required. The aim should be to achieve reliability at minimum cost.

2.3 Where properties of particular materials are quoted in this document they are intended only for guidance. When considering specific applications the material specifications should be consulted in conjunction with the material manufacturer.

2.4 Although most substrate materials can be used for the surface mounting of components there are certain copper-clad laminates and combinations of copper-clad laminates which are most suited to this application. Such materials and combinations of materials assist in minimizing the thermal coefficient of expansion (TCE) differences between the substrate materials and the components.

3 Introduction to base laminate materials

3.1 General

A printed wiring board (PWB) substrate laminate is composed of an insulating material with copper foil bonded to one or both sides. The insulating material is normally a composite comprising a resin matrix and a reinforcing filler.

3.2 Insulating material

3.2.1 Resin types in usage include the following:

- a) phenolic;
- b) epoxide;
- c) polyimide;

d) silicone;

e) PTFE.

3.2.2 Resins have differing characteristic properties which determine their suitability for particular applications. Taking just two examples the characteristics of phenolic and epoxide resins differ as follows.

a) *Phenolic*. Low cost. Workhorse for non-critical consumer PWB market. Reduced mechanical and electrical properties (compared with epoxide). High moisture uptake.

b) *Epoxide*. Medium cost. Workhorse for professional PWB market. Excellent processability. Reasonable performance in all mechanical and electrical properties.

3.2.3 Resins used for PWB laminate manufacture fall into two categories.

a) *Thermoplastic*. These can be repeatedly softened and moulded by heat and pressure.

b) *Thermosetting*. These can be cured and set by the action of heat to form a cross linked relatively infusible structure.

3.2.4 The most widely used PWB laminate resin type is epoxide, which is thermosetting and as such once formed is permanently set in position and cannot be remelted on heating. Cured epoxide resins are produced in two stages:

a) production of incompletely reacted prepolymer, which is accomplished during resin blending and impregnation;

b) conversion to final cross linked product, which is accomplished during lamination.

3.2.5 Reinforcements (fillers) are mainly comprised of glass fibre or paper. Some examples are:

a) glass fibre which may be woven or random (non-woven);

b) paper;

c) aramid;

d) composite (such as paper plus woven glass or random (non-woven) plus woven glass).

3.2.6 The most widely used reinforcement is woven glass. The particular grade normally chosen is designated "E" (for electrical) glass. The properties required of the woven glass include the following:

a) good electrical properties;

b) good dimensional stability;

c) good chemical resistance;

d) low water absorption;

e) high tensile strength;

f) good heat resistance.

3.2.7 The glass is formed from a melt into filaments of between $4\text{ }\mu\text{m}$ and $12\text{ }\mu\text{m}$ which are then gathered into strands of up to 1 600 filaments. These strands are then woven into a fabric. The woven fabric has an organic coating, known as a finish, applied to its surface to aid the subsequent bond to the resin used.

3.2.8 The decision as to which particular resin/filler combination is selected depends on the application. Some considerations are as follows.

- a) *Electrical properties*: dielectric constant, dissipation factor, volumetric and surface resistance, dielectric strength.
- b) *Mechanical properties*: tensile, compressive, shear, flexural and impact strength, dimensional stability, processability, glass transition temperature, coefficient of thermal expansion.
- c) *Environmental properties*: water absorption, copper migration resistance, operating temperature, flammability.

3.3 Copper foil

Copper foil is produced mainly by electrolytic deposition giving a typical minimum purity of 99.5 %. The method of production involves electroplating from an electrolyte containing a copper salt onto a revolving highly polished stainless steel or titanium drum. The side facing away from the drum (matt side) is further processed in order to increase its surface area which will then ultimately impart a high peel strength to the final laminate. Properties required from copper foil include the following:

- a) low electrical resistance;
- b) freedom from pinholes, scratches, holes and nodules;
- c) controlled ductility;
- d) controlled thickness;
- e) good solderability.

3.4 Laminate production

3.4.1 Stages

PWB laminates are normally produced in three discrete stages:

- a) impregnation of reinforcement;
- b) lay-up of prepregs;
- c) lamination.

3.4.2 Impregnation

During the impregnation stage the reinforcement is coated with a blend of resin dissolved in a solvent or a solvent mixture. The reinforcement is drawn through a trough containing the resin blend and then through a multi-zone oven where the solvents are evaporated and the resin is allowed to partially react leaving a coating of dry resin advanced to a controlled degree of cure. Woven glass materials are normally impregnated in vertical machines, whereas paper and non-woven fabrics are normally impregnated in horizontal machines. The material produced by the impregnator is known as “prepreg” (for pre-impregnated) or “B” stage.

3.4.3 Lay-up of prepregs

The prepreg is assembled into the correct number of pieces for the required laminate thickness. In the case of 1.6 mm epoxide resin/woven glass this would normally be eight plies. The assembly is then faced with copper foil and each individual laminate (copper foil/prepreg/copper foil) is separated with polished stainless steel plates to impart a high quality surface finish. Laminates are produced as above in stacks suitable for loading into a multi-opening laminating press.

3.4.4 Lamination

Laid up laminate stacks are loaded into multi-opening laminating presses where they are subjected to a hydraulic pressure and temperature cycle for the period of time necessary to achieve a satisfactory level of curing reaction. Following this they are cooled and trimmed to the required size awaiting inspection and testing.

3.5 Inspection and testing

Parameters measured on finished laminates include the following.

- a) *Electrical*: resistance of foil, surface resistance, volume resistivity, surface corrosion, corrosion at the edge, comparative tracking index, permittivity (dielectric constant), dissipation factor, electric strength, resistance to copper migration.
- b) *Non-electrical*: bow, twist, pull-off strength of lands, peel strength of conductors, blistering after heat shock, punching and machining, surface finish, solderability, dimensional stability, flexural fatigue, flexural strength, mass of foil, thickness, flammability, water absorption.