Powder Coating Using Electromagnetic Brush Technology

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Abstract

Powder coatings were deposited on metal foils in a reel to reel process using EMB technology. The thickness of the obtained layers was in the range of 20-100 µm with deviations of +/- 3 %.

Atotech Company

The company Atotech is a 100 % affiliate of the French Total group. Its headquater is based in Berlin, Germany. Atotech works in the field of electroplating both for general metal finishing and electronics. In the year 2002 a new branch was established in Basel which is dedicated to the research and development of materials for the electronics industry. Fields of interest are photo resists for the inner layer structuring of printed circuit boards, dielectrics for micro-via technology, solder masks etc. In 2003 a project was initiated targeted at the use of powder technology for the production of build-up materials.

Technical Background

Figure 1 shows the lay-up for the production of a typical multilayer printed circuit board (PCB) which is used in mobile applications, e. g. cell phones [1]. The insulating layers consist of epoxy formulations. On pressing the b-staged resin coated foil (RCF) on the core, which typically is a four to six layer conventional multilayer, the epoxy resin of the RCF fills the gaps between the tracks and after heat curing the laminted board is ready for interconnection of the conductor layers.

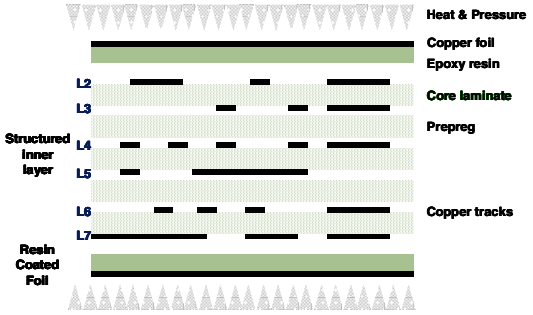

Figure 1. *Press lay-up for the production of a typical multi layer.*

The further stages of the PCB manufacturing process include laser drilling of microvias and mechanical drilling of through holes (Figure 2), subsequent metallization, and further structuring process of the outer layers L1 and L8.

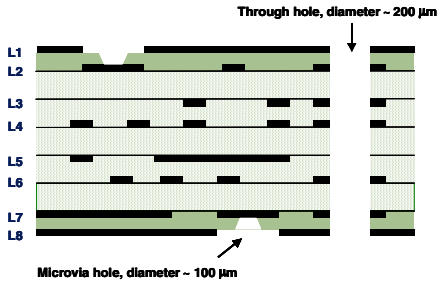

Figure 2. *Drilling of micro via and through holes.*

Target

The aim of the project was the solvent free production of dielectric materials such as an RCF [2]. Currently this product type is manufactured by coating a copper foil with an epoxy formulation dissolved in solvents and slow removal of the solvent in an oven and concomitant b-staging. This approach limits the freedom of the formulator to quite some extent and requires substantial investment. Long ovens are needed to avoid overskin when removing the solvent from the coating and extensive installations to reclaim solvents from the exhaust airstream. The quality and performance of all materials and processes demanded by the customer in the electronic industry is extremely high. This high standard and the fact that powder technology has not been used before for such a product type, made the overall project a particularly challenging one.

Some main requirements on the epoxy resin formulation are:

- good flow behaviour to fill the tracks
- high thermal stability, usable in lead free solder process
- good mechanical properties in order to pass relevant industry tests (drop test)
- flame retardant, halogen free
- processability of the cured coating in typical PCB manufacturing process steps
- processability of the raw materials in typical manufacturing steps used for powder coatings (extrusion, milling, sieving), sufficiently high powder Tg
- price competitiveness.

The coating process is also highly complex:

- powder coating method which reliably achieves full area coverage of 620 mm wide copper foil
- thickness layers variable and adjustable from 10-100 µm (with an accuracy of ± 5 %)
- handling of copper foils as thin as 9 µm without wrinkle formation, high temperature gradients and high stress within the process of coating and subsequent melting/-b-staging

- cleanliness of the uncoated side, especially no epoxy spot contamination.

Whereas in solvent based processes the Tg and/or melting point of the raw materials plays no import role, powder coating formulations must have a sufficiently high Tg (at least 40 °C) in order to be usable. The availability of halogen free flame ratardants not affecting the curing mechanism is severely limited. Our development work resulted in a system which gave a good overall product profile in terms of thermal, mechanical, and dielectric properties and also a good processability in the later stages of the PCB manufacturing process.

Results

One potential technology for the deposition of the powder on the copper foil was found in the so called Electro Magnetic Brush process (EMB). The layout of the coating line and the principle of the electro photographic deposition is schematically shown in Figure 3 and 4.

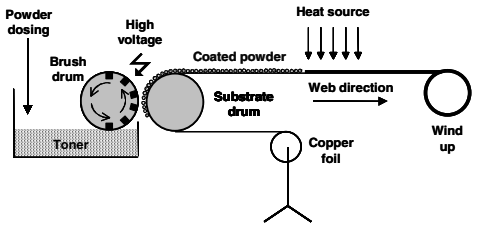

Figure 3. *Press lay-up for the production of a typical multi layer.*

The ground copper foil is running on the substrate drum in the indicated direction. Coating takes place in the nip between the so called brush drum and the substrate drum. The coated powder adheres electrostatically on the foil. Melting, film formation, and b-staging happens in an infrared oven. The coated and b-staged foil is wound up and in a subsequent step cut to customer defined sheets.

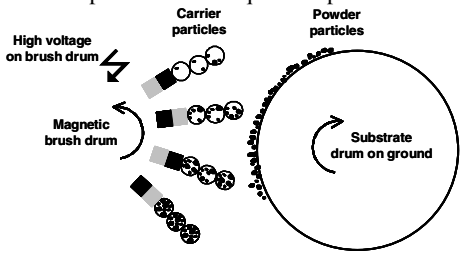

Figure 4. *Principle of the deposition process.*

The principle of the coating process can be described as follows: In the electro magnetic brush process (EMB) the powder is continuously mixed with magnetic carrier particles. This mixing builds up an electrostatic charge on the carrier and the powder. Depending on the specific surface coating on the carrier and the powder type, the powder particles are charged positively or negatively, the carrier particles vice versa. This mixture (toner) adheres to the rotating shell of the brush drum through magnetic forces due to permanent magnets which are located within the drum. The powder deposition on the copper foil happens when a bias voltage is applied on the brush drum. For example when the powder is charged electrostatically against the carriers in the positive sense, a positive bias voltage will force the powder on the ground foil. The magnetic carriers are constantly flowing back into sump and are not transferred.

Coating thicknesses as low as 15 µm were achieved on a 620 mm wide substrate with a deviation of only ± 1 µm. This is unmatched by any other powder coating technology known so far.

References

[1] Martin W. Jawitz, Printed Circuit Board Materials Handbook (McGraw-Hill, New York, 1997) chapter 12.

[2] Pieter Gillis de Lange, Powder Coatings-Chemistry and Technology (Vincentz Network, Hannover, 2004).

Author Biography

Juergen Kress studied chemistry at the Universities of Erlangen, Germany and at Imperial College, London (Erasmus fellowship). He finished his PhD (synthesis of chiral dendrimers) under the supervision of Prof. A. Hirsch in 1999. Then he spent two years as a postdoctoral fellow with Prof. M. Bradley in Sauthampton, UK (confocal microscopy on polmeric materials). In 2002 he joined Atotech as a research chemist specializing in polymer chemistry, electronic materials and powder coating processes.