Chapter 4

PHOTOIMAGING

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4.1 INTRODUCTION

Photoimaging, the process of transmitting an original image by radiation, either directly with a laser or through a phototool template, is being used extensively in the printed board (PB) industry to generate circuits, dielectric patterns, and alphanumeric labelling ('legend').

Originally, only photoimageable liquids were available to the industry. In 1968[1] E. I. Du Pont de Nemours and Company introduced a 'dry film' photoimageable resist which gained acceptance quickly because of ease of handling and higher imaging yields. Now both liquids and dry films are in use, with liquids dominating the solder mask market and dry film resists being the photoresist of choice in primary (circuitry) imaging.

This chapter describes the use of photoresist in PB fabrication. Emphasis is on primary imaging and dry film resist processing. The scope of the 'photoimaging' process will not only cover the actual application of the resist, its exposure and development, but will also include aspects of upstream and downstream processing steps, to the extent that these steps have an impact on the performance or selection of the resists. Dry film resist processing is covered in detail. Liquid resist processing is highlighted where it deviates from dry film processing. Because of commonalities between liquids and dry films regarding resist formulations and their function in the photoimaging process, 4.1.3 covers formulation and function for both resist types.

4.1.1 The Function of Photopolymeric Materials in the Fabrication of Printed Boards (PBs)

Photoresists are first used to create the 'primary' circuitry image. The 'primary' circuit pattern does not necessarily have to be a circuit: it could actually be a ground plane pattern or a 'pads-only' pattern. Resists may then be employed selectively to mask off large areas of the board in precious metal plating or to provide a mask for the selective plating of solderable surfaces for surface mount interconnections. Then resists are used in the formation of a solder mask pattern that becomes a permanent part of the board assembly. Finally, resists may be used in printing 'legend', i.e., written or numerical information, for example to designate the location and type of chip attachments, see Chapter 3.

In a more recent development, see 4.6.4, photoresists are also being used as dielectric layers separating layers of circuitry in multilayer boards. Such an application offers the capability of photo-via formation, an alternative to the mechanical drilling of conductor vias.

When 'resists' are used in conductor formation, the resist pattern actually allows the selective removal or deposition of metal by masking off selected areas on the surface. In these processes, the resist, as the name implies, has to resist the action of etchants or plating chemistries. In the case of 'full build' electroless copper conductors, a process where the conductor metal is built up to its full height (about 25 μm) on a dielectric material, the resist has to withstand a particularly harsh environment over a long time.

4.1.2 Application of Photoresists as Liquid or Dry Film

The resist formulation, a complex mixture of ingredients, see 4.1.3, can be applied as a liquid or a dry film. The liquid can be a homogeneous solution of the resist components in a solvent or may be an aqueous emulsion of stabilised resist micelles. Following the liquid resist application or coating step is a drying step to remove the solvent vehicle. The coating of the liquid to the PB substrate can be a purely mechanical process, such as roller coating, spraying, or dipping, or it can be electro-deposited, e.g., in the (electrophoretic) 'ED'-resist process, or in a hybrid process such as electrostatically assisted spraying.

By contrast, the dry film resist process offers the resist formulation as a very viscous ('dry') liquid, sandwiched between a polyolefin sheet and a polyester base, rolled up on a support core, cut, or finished to various widths and roll lengths. Since the resist is not diluted by solvent, no drying step is needed. However, to make this very viscous liquid or 'dry' layer conform to the substrate surface, heat and pressure are applied in a lamination step. The polyolefin sheet is first removed, the film is then brought in contact with the board, resist facing the copper surface. Conformation is achieved by heating under pressure or vacuum. The board is then imaged, and the polyester cover-sheet is removed before development.

Resist conformation and uniform thickness are important performance parameters. Liquids, naturally, tend to conform better than dry films, whereas dry films generally yield a more uniform thickness. The perfection of the coating (e.g., absence of pin-holes) has historically been superior with dry films, because the coating was performed under optimised conditions in a clean room environment by the dry film manufacturer, off-line, so to speak, from the less perfect PB fabrication environment. Liquid resist application by the board fabricator, on the other hand, can be improved with proper surface preparation and cleanliness.

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