# Microsystems Packaging; Printed Wire Boards

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**Purpose**
The purpose of this project was to find ways to develop new methods for making electronic substrates both cheaper and more effective.

**Background**

A printed wiring board (PWB) is the base both literally and figuratively for practically all electronics in the world. It is the platform upon which electronic components such as integrated circuit chips and passive components are built. The PWB, or printed circuit board (PCB) provides both the physical structure for mounting and holding electronic components as well as the electrical interconnection between components. A PWB consists of a non-conducting substrate (typically fiberglass with epoxy resin) upon which a conductive pattern or circuitry is formed. Copper is the most prevalent conductor, although nickel, silver, tin, tin-lead, and gold may also be used as etch-resists or top-level metal. There are three types of PWBs: single-sided, double-sided, and multilayer. Single-sided boards have a conductive pattern on one side only, double-sided boards have conductive patterns on both faces, and multilayer boards consist of alternating layers of conductor and insulating material bonded together. The conductive layers are connected by plated through-holes, which are also used to mount and electrically connect components. PWBs may also be either rigid, flexible, or a combination of the two (rigid-flex). There are many types of printed wiring boards and an even greater number of manufacturing methods. In this description, the fabrication of rigid multilayer PWBs is divided into different process steps. These steps combine to form a generic process flow and a number of processes and potential alternative processes can be used for each function.

Making Circuit Boards
1 Raw Material
2 Clean & Apply Photoresist
3 Expose & Develop
4 Etch Inner Layers
5 Strip Photoresist
6 Electroless Copper & Strike Plate
7 Apply Photoresist
8 Outer Layer Expose & Develop
9 Pattern Plate
10 Strip Resist
11 Etch Copper
12 Tin/Lead Strip
13 Soldermask

The electronic substrate is the part of the board that all other mechanism are connected to. Its size and effectiveness in turn determines the size of the electronics it is used in and how effective that piece of electronics is. With this process you start off with the raw material, a copper clad dielectric, measured in ounces, which converts to inches of thickness (1 oz is ~ .0014 inches thick). The best way to measure the thickness of a board is through the Dektak Profiling machine. Measurements are made by the stage, upon which the board rests, moving beneath a diamond-tipped stylus. The stylus then records changes in height as electrical signals corresponding to its movement are converted from analog to digital impulses. The digitized impulses from a single scan are then stored in computer memory for display and manipulation. The operating system also allows you to store the graph in permanent memory.

Cleaning can be done mechanically or chemically.  Photoresist is a coating of photosensitive material, which is used to place the image of the inner layer circuit pattern on the clad material. Photoresist is a light sensitive material used in the process of photolithography to form a patterned coating on a surface. Photoresists are classified into two groups: positive resists, in which the exposed areas become more sensitive to chemical etching and are removed in the developing process, and negative resists, in which the exposed areas become resistant to chemical etching, so the unexposed areas are removed during the developing process. Photoresist is dispensed in a liquid form onto the wafer as it undergoes rotation. The speed and acceleration of this rotation are important parameters in determining the resulting thickness of the applied photoresist.  This process of coating can be done with the meniscus or the spin coater

THICKNESS: Up to 100 µm.b
· SIZE: Sizes from 2" x 2" right up to 12" X 12".
· SPEED: From 10rpm to 3000rpm is achievable.
· PROGRAM: Stores up to 7 programs for operation.
· ACCELERATION: 100 TO 1,000 rpm/s
· SPIN TIME: 1 to 999 sec
· VACUUM: 500 Toors minimum

THICKNESS: Controllable from less than 3µ up to 50µ.
· SIZE: Handles surfaces up to 16" X 16 " X (0.5mm to 5.0mm)
· FOOTPRINT: 44" wide x 106" long x 40" high
· MATERIALS: Suitable for substrates such as glass, ceramic,metal, Si & Ge wafers.
· PERFORMANCE: Efficiently applies photoresists, polyamides, dopants, metallo-organics, silica films, and similar materials.
· SUBSTRATE HOLDER: 12" X 12
· TEMPERATURE: 25 - 95° C (water to water heat exchanger)

The photoresist coated wafer is then transferred to a hot plate where a "soft bake" is applied, the purpose of this bake is to drive off excess solvent before introduction into the exposure system.

HUMIDITY RANGE: 10% to 98%RH
• TEMPERATURE RANGE: -68°C to +177°C
• APPROX CHANGE RATE: 3 to 4°C/min

Photolithography is a process used in semiconductor device fabrication to transfer a pattern to the surface of a wafer or substrate. The transfer of this pattern will allow for the definition of features to be etched in underlying film or to provide a mask for ion implantation.

When the image is projected onto the wafer, the photoresist material undergoes some wavelength specific radiation-sensitive chemical reactions, which cause the regions exposed to light to be either more or less acidic. If the exposed regions become more acidic, the material is called a positive photoresist, while if it becomes less susceptible it is a negative photoresist. The resist is then "developed" by exposing it to a alkalai solution such as sodium hydroxide (NaOH), which removes either the exposed (positive photoresist) or the unexposed (negative photoresist) photoresist. This process takes place after transfer from the exposure system back to the wafertrack. A post-exposure bake is performed before develop typically to help reduce standing wave phenomena caused by the destructive and constructive interference patterns of the incident light. The develop chemistry is delivered in a similar fashion to how the photoresist was applied. The resulting wafer is then "hardbaked" on a bake plate at high temperature in order to solidify the remaining photoresist to serve as a protecting layer against future ion implantation, wet chemical etch or plasma etch.

As the copper revolution continues, chipmakers continue to use copper instead of aluminum to build devices that run faster because of copper's high conductivity and its resistance to electro migration, which allows a reduction in the number of steps required in the manufacturing process. But there's more to it than simply replacing one metal with another. Copper creates new problems even as it solves old ones. One major hurdle is etching. Copper processing has specific challenges with respect to etching because it requires low volatility for CuClx (for chlorine etching) species, it has a high oxidation rate, and it does not self-passivate. An experiment was conducted with single damascene copper wafers to determine the amount of thermal temperature required for successful copper etching. Success of the experiment was determined by the amount of residue left behind after etching. To activate, or increase, the desorption from the sample surface, requires higher temperatures. One of the drawbacks to using higher temperature is sample heating. The whole wafer, from back to front must be thermally heated or soaked in order to transfer energy to the wafer surface where the reaction is taking place. This can be a drawback in front-end processing where temperature limits are imposed. It also limits any practical etching with photoresist. So, the key is to increase the desorption rate of CuClx without heating the entire wafer.

The UV exposure tool is designed to flood specific areas of the photoresist with UV light and with the help of the mask, which determines the pattern of copper on the board. Exposing is the photo process of transferring the circuit image, which is on working tools, to the copper surface. The photo light causes the resist to harden (polymerize) and be retained during the subsequent process steps. Develop chemically removes the remaining resist that was not exposed to the light source, as defined by the tooling. Next you would etch to remove the unwanted copper, while the pattern is protected by the photoresist. Once you strip the photoresist, the copper circuit pattern will remain. This is basically the main process of making a printed wire board, because after the pattern's photoresist is removed, the steps to create a new layer on top of that are repeated.