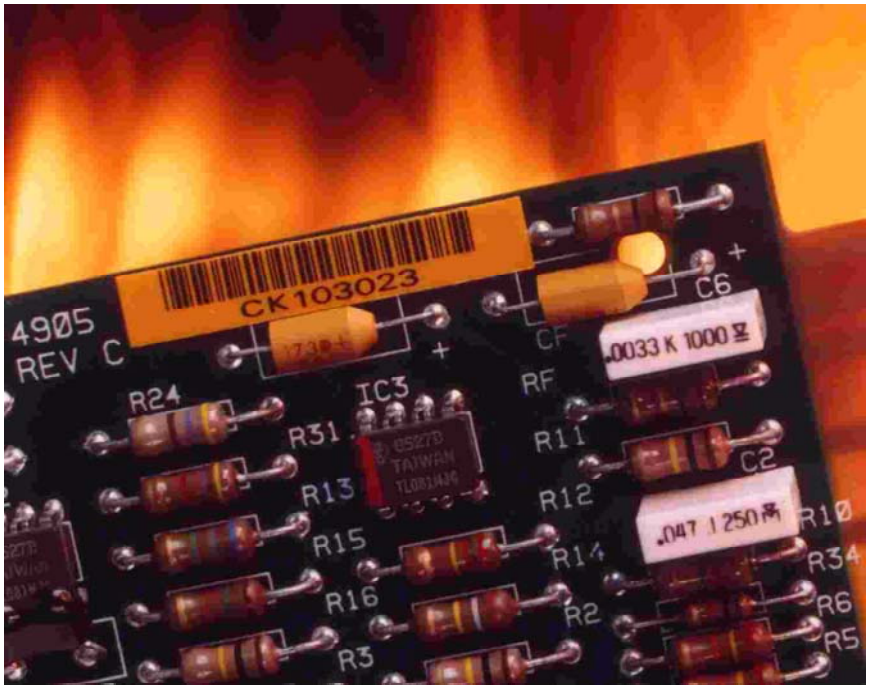
POLYONICS



Bar Code Labels for Circuit Boards

OVERVIEW

Electronics manufacturers face incessant pressures to increase the reliability and functionality of their products, while reducing costs. Bar code technology is effective as a tool to help them achieve these goals simultaneously. To enhance electronics manufacturer's bar code implementation programs, POLYONICS offers the broadest label materials product line available today for bar code labeling printed circuit boards, allowing optimum choices between costs and benefits. The bar code label and the symbol it contains is the foundation on which the implementation of a bar code data collection system depends**.** ***Bar code label users must pay attention to the structure of the label relative to its intended use, and must put it through every process condition it is likely to encounter during its service life before recommending its use.***

The purpose of this discussion is to explore the bar code label materials available to circuit board manufacturers, and to understand the price/performance tradeoffs available to them.

Figure 1 shows a flow chart of a typical electronics/circuit board manufacturing process. Generic classes of suitable label materials are designated for each process environment as a visual aid. The bar code label can provide a "birth certificate" for the circuit board, beginning with the raw boards, through assembly, into the final products, and "out the door", if the correct label material is used from the outset. Bar code data collection is commonly used in these operations to:

1. Track overall inventory
2. Track WIP
3. Measure productivity (throughout, yields, rework rate, and proper routing).
4. Implement engineering changes on WIP
5. Automatically set process conditions (solder temperatures, flux densities, burn-in conditions, testing protocols, etc.) and testing parameters.
6. Scan products in and out of all work-stations.

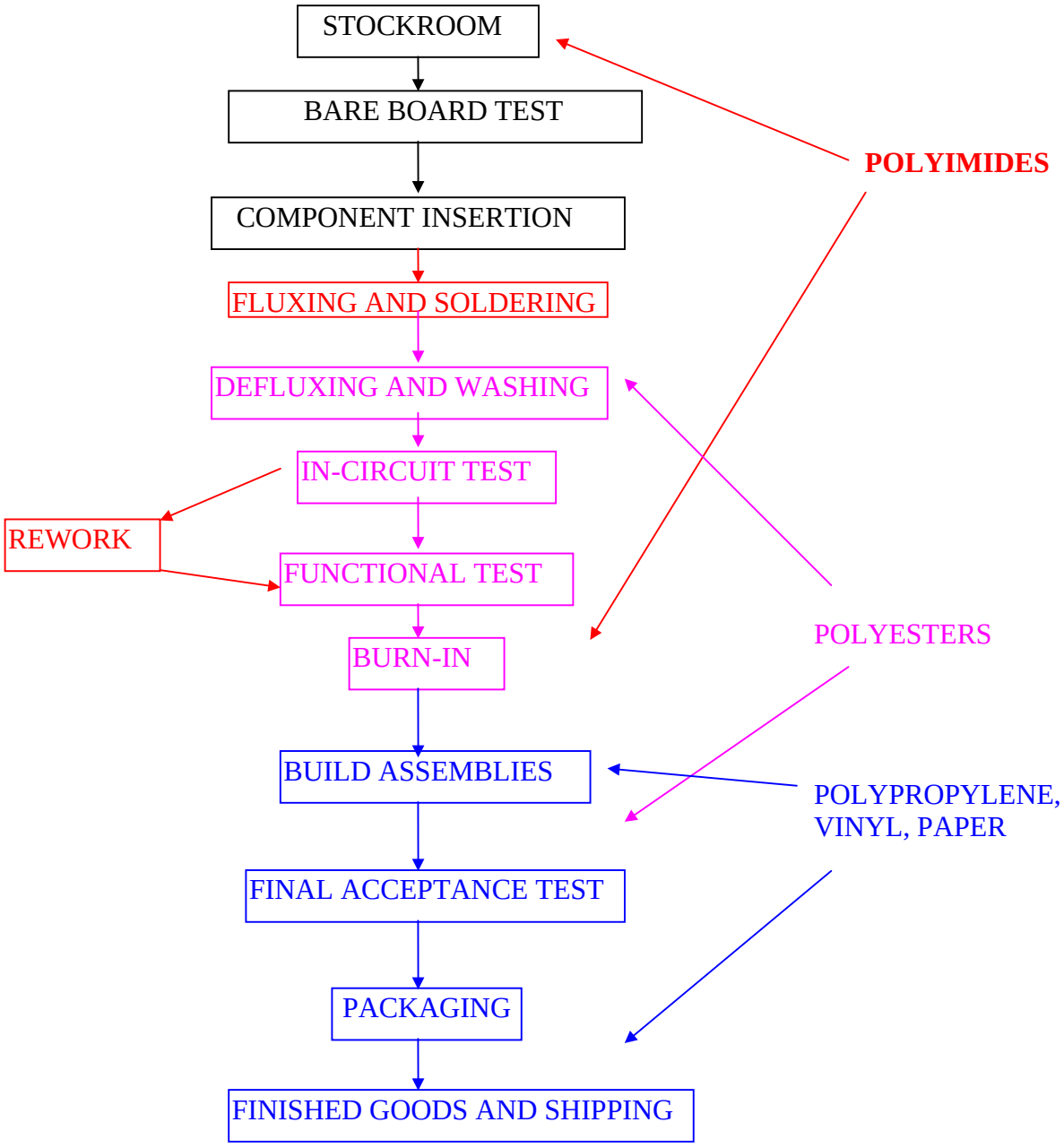
IN OTHER WORDS, JUDICIOUS USE OF BAR CODE DATA COLLECTION PROVIDES THE ELECTRONICS MANUFACTURER WITH A MEANS OF TOTAL THROUGH-PROCESS CONTROL.

In order to implement this type of bar code data collection system, several fundamental questions must be answered.

HOW TO USE THE DATA?
HOW TO COLLECT THE DATA?
WHERE TO AFFIX THE LABELS ON THE PRODUCTS?
WHAT LABEL MATERIALS SHOULD BE USED/WHERE IN THE PROCESS?

POLYONICS' mission is to help provide answers to the last question.

Figure 1. Printed Circuit Board Manufacturing Process Steps



Temperature Color Code

400-500°F	**PEI, Polyimides**
200-400° F	**Polyesters, PEN**
Ambient - 200° F	**Polypropylene, Vinyl, Paper**

General Considerations

There are at least three areas to consider in detail before using bar code labels on PCB's:

1. Physical requirement - how much real estate is available;
2. Location - ”hot” side or “cold” side, this relates to the type of soldering process(es) used;
3. Process conditions - what chemical and/or thermal processes that the bar code information must endure, yet remain scannable.

The **physical requirement** seemingly involves only the label size. However, the height and length of a bar code symbol relative to the available space on a circuit board may violate existing applications standards designed to assure that printing and scanning equipment will be compatible, and to maximize first read rates and minimize character substitution errors. There is usually no problem, as long as the narrow bar of the printed symbology on the label and the aperture of the scanning device are matched. The second major consideration (**location on the board**), and third (**process conditions**) are interrelated in that they influence the material composition of the bar code label.

Anatomy of a bar code label

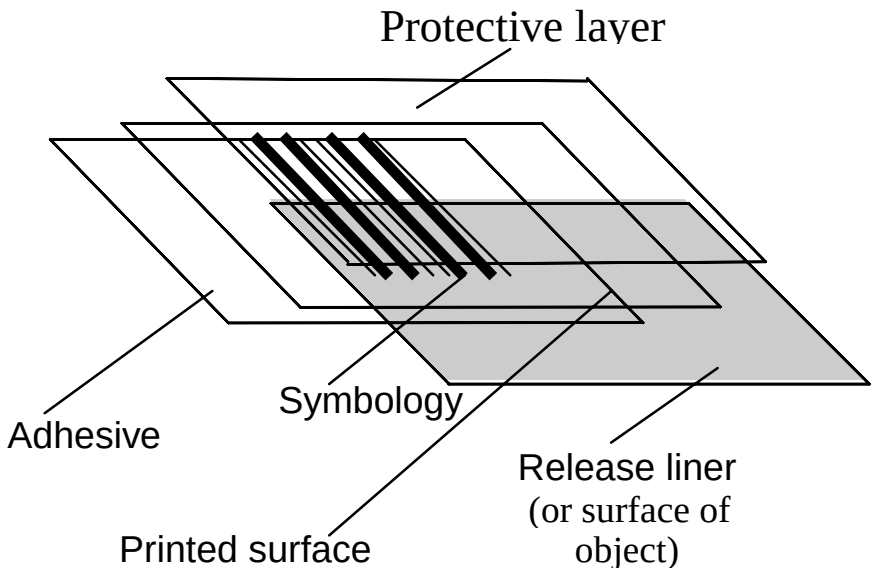
As depicted in **Figure 2**, a typical pressure sensitive bar code label is composed of several layers of materials, each with a well-defined purpose. At the bottom is the **release liner**, made from a material that can be easily removed from the adhesive. The label must remain attached to this release material until it is intentionally removed and applied to the circuit board.

The **adhesive** has the critical job of keeping the label attached to the board for as long as necessary. It is imperative to use the correct adhesive, otherwise the frustration of having labels disappear in a solder bath or vapor phase cleaning process can be the result. If the manufacturing process is changed, or the cleaning solutions are changed, the performance of the adhesive, which previously had performed adequately may be impaired.

The next layer is the **substrate** which provides such physical properties as stiffness, thermal resistance, solvent resistance, and dimensional stability. If significant physical deformation of the label occurs due to temperature changes, then the bar and space widths of the bar code may change and make the bar code symbol unreadable. **Solvent resistance** is as important for the label material as it is for the adhesive. Solvent attack can smear or totally wash away the printed bar code symbol, or dissolve some of the synthetic plastic label materials. **Stiffness** of the label material is most important for the automatic application of bar code labels in an automated environment. If the label material is not sufficiently rigid, then it will not reliably dispense onto a label applicator head for application to the circuit board. Because of these difficulties, polyester (or MYLAR®) and polyimide (or KAPTON®) materials are the two most commonly used label materials today for circuit board marking. [NOTE: MYLAR® and KAPTON® are registered trademarks of E.I.DuPont].

The printed bar code symbol is the next layer, and is the one that provides the cost benefits to the user, as noted above. The printing technology used is critical, and must match the surface and print receptivity of the substrate for highest bar code print quality. As we’ll discuss later, the choice of printing technology chosen must be in response to the process environment the label will endure in the customer’s process.

Figure 2. Anatomy of a Durable Bar Code Label



Protection of the bar code label is the function of the **protective layer** of plastic film, or coating (known as "laminate"), and may be required whenever certain harsh environments, or prolonged exposure to solvents is encountered. This is particularly true if the printing is done by flexographic or toner printing (so-called “laser printing”) since these inks have very poor solvent resistance. **In the majority of cases today in which bar code labels are printed by thermal transfer printers using properly matched ink ribbons and label materials, lamination is not required, resulting in significant cost savings !!** This is true regardless of the soldering processes employed. More on this subject later on.

Actual circuit board (or “PCB”, also called “PWB” for “Printed Wiring Board”) processes are more complicated than depicted above. A typical board can go through a “thru hole” process which is typically a “wave soldering” operation. In this process, holes are drilled through the boards, components are inserted through the holes from one side of the board (the “component side”), and then the boards are passed over a bath of molten solder on the other side of the board (the “solder side”). Temperatures on the solder side can exceed 500° F for periods of up to 10 seconds, whereas the component side temperatures may reach temperatures up to 400° F during that same time. So, in wave soldering, the “top” side is “cold” while the “bottom” side is “hot”. **This means that materials which cannot withstand the temperatures of molton solder cannot be used on the bottom side of the board.**

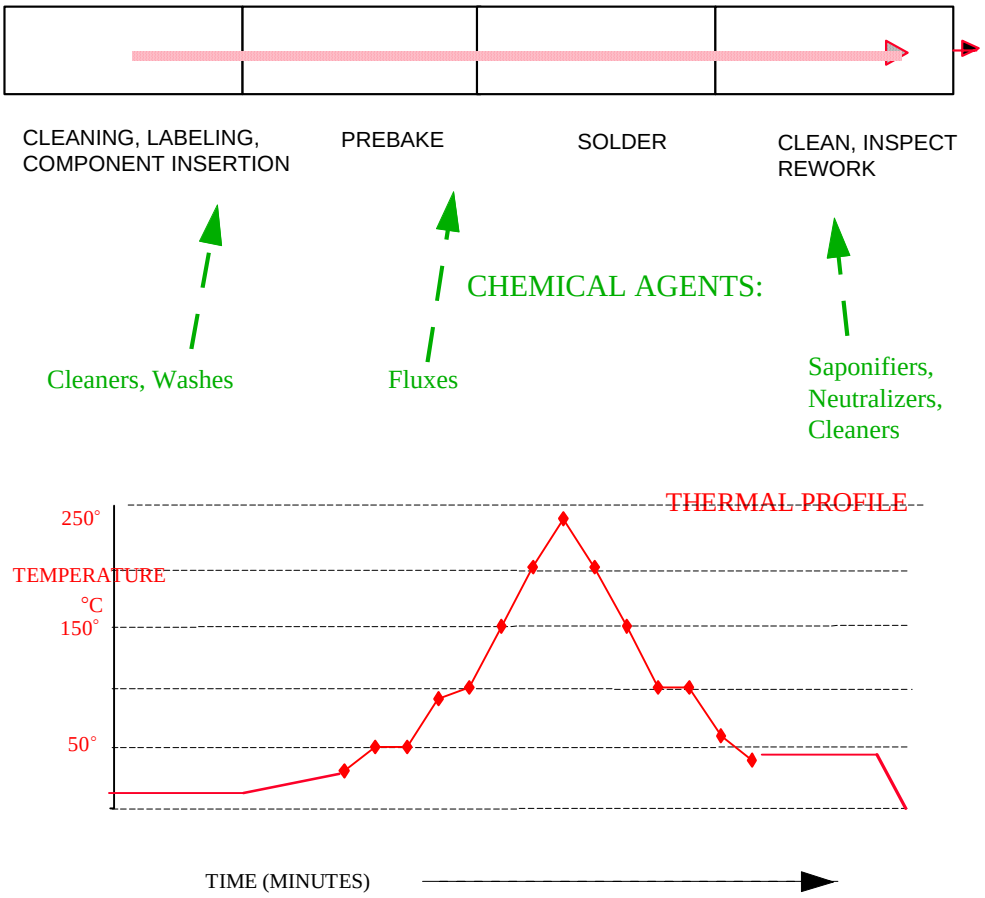
SURFACE MOUNT TECHNOLOGY (or “**SMT**”) is the core manufacturing process for the new generations of electronics devices, enabling increasingly smaller components to be interconnected, but with different soldering techniques than wave soldering. The connections for soldering the components to the circuits are silkscreened on the boards with patterns of “solder paste”. The components are then precisely placed on the pattern of paste, and the boards heated by infrared radiation (or “IR”). As the paste absorbs the IR light, it heats up and the solder melts to complete the connection. In this process the “component side” is the “hot” side, while the side not

exposed to IR (which may also have components on it from previous operations) is the “cold side”.

Finally, to really keep it interesting for bar code label problem solvers, there are “hybrid processes” which utilize both processes discussed above, usually in multiple passes.

In summary, then, as a board is manufactured, it will be exposed to a variety of chemicals, cleaners, washes, neutralizers, **while experiencing different temperatures,** as depicted in **Figure 3** (which is a simplification of **Figure 1**).

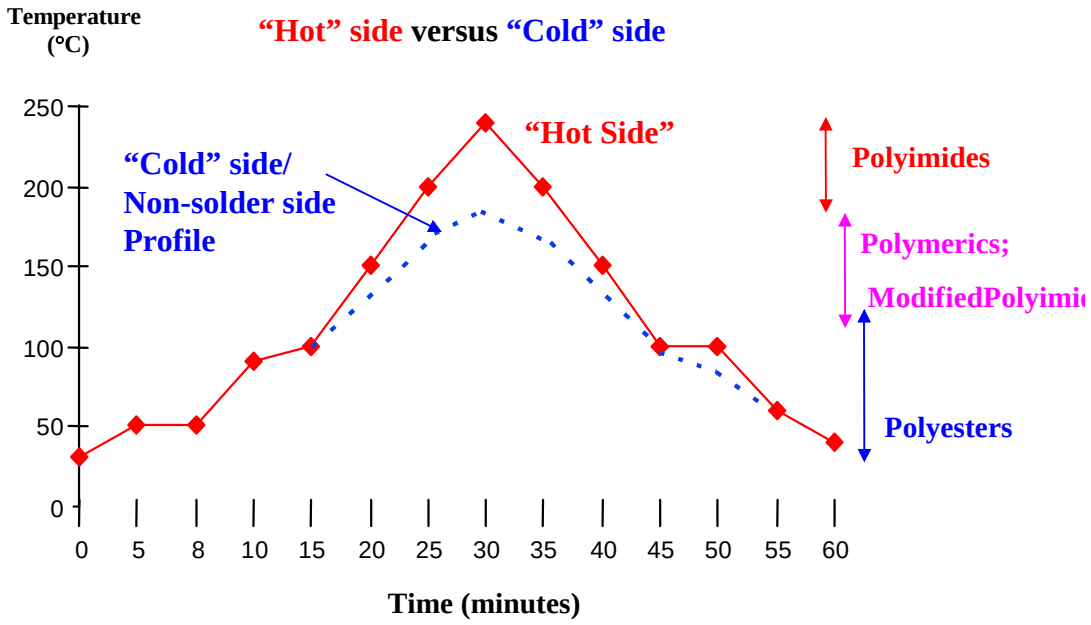
FIGURE 3. MANUFACTURING PROCESS ENVIRONMENTS



So, the challenge facing the bar code user is to define the process stepwise, in the face of multiple chemical exposures at varying temperatures. This process definition will dictate which label materials are appropriate to use, to provide the optimum performance at the lowest price.

Figure 4 depicts the same thermal profile as **Figure 3**, but suggests appropriate label materials for various process steps at the appropriate temperature ranges.

FIGURE 4. MATERIALS FOR “HOT” VS. “COLD” SIDES OF PCB’S



"Hot Side"

Wave solder: Polyimide
IR Reflow : Polyimide
Modified polyimide

"Cold" Side

Wave solder: Polymeric, HTPET
IR Reflow : HT Polyester, Polyester

The tradeoff the user must make is to satisfy the required function at the lowest price. If the functionality required is not achieved, then the bar codes will fail. Conversely, if the user overspecifies the label material needed for the required functionality, then excess costs will be incurred. There are very clear **PRICE/PERFORMANCE** tradeoffs, as shown in **Figure 5**.

FIGURE 5. RELATIVE MATERIALS COSTS FOR PCB LABEL MATERIALS

Label Material	Comment	Relative Cost
Paper	**Finished Goods**	**1**
Polyesters	**Excellent for WIP and non-solder side**	**10-15**
Polymerics	**IR Reflow**	**20-30**
Polyimide	**General Workhouse, Solder**	**40-60**

Although laminated labels historically were the only way by which a bar code could survive the rigorous PCB environment, a variety of thermal transfer ribbons, when printed on POLYONICS' **THERMOGARD®** polyimide materials, give superior performance through these same processes, at a significantly lower cost to the customer. Polyimide film is expensive, whether in the form of a label or of a laminating film. **A laminated polyimide label will cost almost TWICE AS MUCH as a non-laminated one.**

ISSUES: THERMAL TRANSFER PRINTING ON POLYIMIDE LABEL

MATERIALS WITHOUT LAMINATION.

Each manufacturer has a unique manufacturing process, combining proprietary thermal and soldering cycles in conjunction with the cleaners, saponifiers, fluxes, and other chemistries unique to that circuit board product. Unfortunately, there is no single combination of ribbon and label substrate that will withstand all of the chemicals in use today. Rather, with one or two label materials, and one or two thermal transfer ribbons, labels can be printed which will survive over 90% of the process environments encountered today.

What does all this mean for users of bar code labels on printed circuit boards? Some general rules can be extracted from actual experience:

1. Polyimide materials should be used for bar code labels that will be exposed directly to 500^{O}F, whether the solder process is direct wave solder, or, IR, hot air convection, or vapor matched to the thermal transfer printable polyimide label stock (see the Applications Note, "Not All Ribbons are Created Equal").
2. A variety of materials, (high temperature polyesters, specialty "polymerics", and modified polyimides) are available for use on the side of the board opposite the soldering process (see attachments "PRICE/PERFORMANCE TRADEOFFS" and "THERMOGARD® OVERVIEW").
3. If bar code labels will be used on circuit boards after the manufacturing process, but still be subject to vapor phase degreasing and prolonged burn-in, polyester label materials can be used, because the high temperatures of soldering will not be encountered.
4. Paper or vinyl labels can be used on boards that are finished and will be inventoried or used in a finished product. Direct Thermal paper labels should be used with caution if the bar code information is to be used over a long period of time. Thermal labels may lose contrast as a function of time, temperature, and exposure to ambient light.
5. If the process temperatures fall below 250°C, but above 200°C the user may want to evaluate modified polyimide (or PEI) label materials - not quite as resistant as Kapton®, but about half the price. Likewise, if regular polyester labels shrink excessively in the thermal processes, the user may want to evaluate high temperature polyester, or a polymeric alternative (known as PEN) which gives better thermal resistance.

THE KEY TO SUCCESS IS TO TEST, TEST, TEST !

OK, HOW DO I MATCH RIBBON WITH LABEL MATERIAL?

Each POLYONICS product is tested rigorously with up to twenty different ink ribbons, each on one of several printers. These labels are then subjected to a variety of chemicals, cleaners, fluxes, and solvents, under several different process environments. **Over 3500 individual tests have been performed on our THERMOGARD® product line.**

Call **POLYONICS** today to discuss **your requirements** and to request a catalog or samples of these high performance materials. Also available is a listing of recommended thermal transfer ribbons that have been evaluated with these **THERMOGARD®** Thermal Transfer materials.

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