Selective Plating Equipment for Tape Automated Bonding Film (TAB Film)

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Introduction

Tape Automated Bonding (TAB) is becoming an increasingly important alternative to wirebonding in the assembly of fine-pitch, high-density Integrated Circuits (IC). Using the traditional metal leadframes (Cu-alloys or FeNi), the chip and the inner leads are connected by thin gold wires. In contrast, the tape automated bonding technology makes use of the fine-line conductor patterns on the flexible copper/polyimide leadframe, on which the chip is directly bonded. To achieve the most reliable bond between the chip and the copper leads of the TAB film, these inner leads are preferably plated with 1-2 microns (40-80 microinches) of pure gold. For the later connection of the outer leads onto the Printed Circuit Board (PCB), a gold flash with a thickness of only 0.1 micron (4 microinches) is optimum. This paper describes the background and the working of a newly developed plating system that makes it possible to selectively plate the thick gold onto the inner leads, while masking off the remaining flash-plated portion of the frame, including the outer leads. A considerable gold savings is the result.

How is a TAB leadframe produced?

TAB-tape manufacturers work along different routes. A number of them make a three-layer "sandwich"--the copper foil, the polyimide and an adhesive to connect both foils. In contrast, others go for a two-layer film whereby either the copper layer is plated onto the polyimide foil or the polyimide is polymerized onto the copper foil. Both etchable and non-etchable polyimides are in use, resulting in different technologies (etching or stamping) to produce the holes and windows in the film.

The TAB-tape comes in standard widths up to 70 mm and is very much like photographic film. Precision sprocket holes along the edges allow for further reel-to-reel processing, both in etching and in selective plating equipment. Photomasking and etching provide the required pattern of copper lines, inner leads, outer leads, test pads, etc.

Advantages of TAB leadframes over the conventional metal frames

Originally, back in the 1970s, TAB offered a remarkable advantage over the slow, wirebonding technology, which was still totally operator-dependant. The TAB offered a much faster, simultaneous "gang-bonding" in a reel-to-reel, well-controlled, assembly process. In addition, it allowed for much thinner packages, ideal for use in calculators, watches and other consumer electronics.

The development of high-speed, automated wirebonders in the 1980s made many IC-producers withdraw from using the more expensive TAB. Furthermore, surface mount technology was the driving force for the development of smaller packages, still on the traditional metal frames. TAB did not disappear, but it was a long time before a real "comeback" could be noticed.

To date, the new interest originates from the following advantages (Source: Dr. Subash Khadpe):

* Very high lead counts (up to 1000) are easily achievable as a result of inner lead pitches of less than 0.1 mm (4 mils). Further reduction of the pitches and a growing number of leads have been announced.

* The photomasking/etching production technology gives few limitations in the design of the frame.

* The reel-to-reel assembly allows for a highly reliable, low-cost process.

* Better electrical and thermal performance of the TAB frames.

* No inductance risk, in contrast with high lead count, wirebonded packages.

* Ultra-light and thin packages.

The worldwide TAB applications are shown in table 1 (source: Semiconductor Technology). Growth rates of 25-40% per year have been realized recently and are predicted for the coming years as well.

The plating

Similar to conventional metal leadframes, TAB-tape frames require a plated deposit on both the inner and outer leads. The inner leads require a bondable deposit to create a reliable bond with the gold bumps on the chip. The outer leads will be soldered onto the printed circuit board, so a good solderable deposit is required.

As mentioned before, the production of TAB-tape is a reel-to-reel process. A very obvious step is to have the plating also done on reel-to-reel equipment. Because of the fact that the TAB film is relatively fragile (especially the inner leads), special pay-off and take-up equipment has been designed, as well as dedicated cathode contact systems. The rest of the plating equipment looks very similar to any other reel-to-reel plating line. The process steps are also very well-known; a cleaning, an activation of the copper, the (electro)plating cells, rinses, blow-offs and, finally, a drying oven. Until recently, a selective plating method designed around the special requirements for TAB-tape was not available. As a result, all plating on TAB-tape used to be simple, allover plating, with the same deposit thickness on the inner as well as the outer leads, but not limited to these functional areas (the leads). All copper interconnection lines are plated as well, although this has no function and is a waste of precious metal.

Typical deposits are:

1. Electroplated gold (1 micron)
2. Electroplated nickel (1 micron)
   and on top, electroplated gold (1 micron)
3. Electroless tin (0.7 micron)
4. Electroplated tin (1 micron)

Since bondability of the inner leads and solderability of the outer leads are such different technical requirements, it is easy to understand that whichever of the above-mentioned deposits is chosen, as long as the plated thickness cannot be influenced locally, it is always a compromise. Furthermore, in terms of precious metal, it is often a very expensive compromise.

We also have to keep in mind that investigations and tests have shown us that the 1 micron gold deposit on the inner leads guarantees the highest reliability for the bonding characteristics. Pull force tests, carried out in the Technical University of Berlin, clearly show that after thermal aging (an artificial aging process to determine shelf life), the gold-plated and the nickel/gold-plated frames show hardly any degradation, in contrast with the tin (electroless) deposit. (From the same investigations, we determined that the nickel underlayer had no influence on the shelf life and bondability.)

Since it may take 8-12 weeks from the production and plating of the leadframe to the final bonding and encapsulation, it is obvious that customers prefer gold-plated over tin-plated frames. However, because of the excessive gold usage, gold-plated frames are often too expensive.

For all these reasons, a clear demand for selective gold plating on the inner leads was frequently heard among TAB-tape producers and their customers.

Why not the well-established spot plating technology?

Because of its unique production technology by photomasking and etching, there are almost no limits in designing a TAB leadframe (and this makes the technology very attractive). However, it has resulted in the fact that hardly any standardization of frames is visible; on the contrary, many specific applications have asked for (and gotten) their own designs of TAB frames. So the variety is great and the quantities per series are relatively low.

The normal spot plating (of silver) on conventional leadframes is carried out with product-related spot tools--high-precision tools with relatively high costs. The traditional metal frames, especially the stamped frames, are usually produced in big quantities, so the influence on costs of a selective spot plating tool is negligible. Not so with TAB-tape frames! The clear message was: "Selective plating: great, but only with cheap and simple masks." We took the challenge.

The selective plating unit for gold

In general, the inner leads on a leadframe are a number of very thin metal pins, either situated around a metal pad (for the traditional die bonding) or around an opening (to accommodate the chip to be bonded in the tape automated bonding process).

As said before, the copper foil and the plastic film together form the TAB-tape. The only non-supported copper parts are the inner and outer leads--exactly the parts that require gold plating. However, the outer leads require a very thin 0.1 micron deposit. This deposit can, because of the thin thickness, be plated allover, leaving the inner leads the only spot to be plated with an additional 0.9 micron, selectively, on both sides. In preliminary laboratory tests--with a special anode setup and electrolyte agitation--it was discovered that when the film was supported on the plastic side by a solid plate, the backside of the leads could be plated very well. This means that a space of only the thickness of the polyimide foil (10-15 microns) is enough for good electrolyte refreshment underneath the leads. There the idea was born to press the TAB-tape with the plastic side against a solid roller to allow for continuous transport (wheel unit).

Another test established that the plastic tape itself (TAB-tape without the copper) could ideally be used as an outside masking belt, shielding off the TAB-tape totally, apart from where a window was created in the area of the inner leads.

This masking belt--which is cheaply and quickly produced by the TAB-tape supplier--can run on the above-mentioned wheel unit as an outer masking belt, thus creating a selective plating unit with an outside electrolyte sparging system (Figure 1)

This unit can either become a part of a new plating line or be incorporated in an existing line as a retrofit.

A typical plating speed for the unit is 3 m/min for 1 micron of gold.

Gold savings

When discussing selective plating of precious metals, the obvious consideration is the actual savings that can be achieved.

We have carried out plating tests with a commonly used TAB-tape design (see photograph). Gold usage figures have been established by the strip-and-weigh tests.

The first strip was plated all over 1 micron of gold, which in fact was the only available method until now.

The second strip was plated with 0.1 micron of gold, good for the outer lead solderability, but not enough for good bonding characteristics.

The third strip was plated all over with 0.1 micron, and selectively in the inner lead area, using the described plating cell and masking belt. It is remarkable how little gold is used for the inner leads and what enormous gold savings have been achieved. An important step forward in the reduction of costs to produce the highest quality TAB-tape.

References

1) Dr. Subash Khadpe

Developments in Tape Automated Bonding

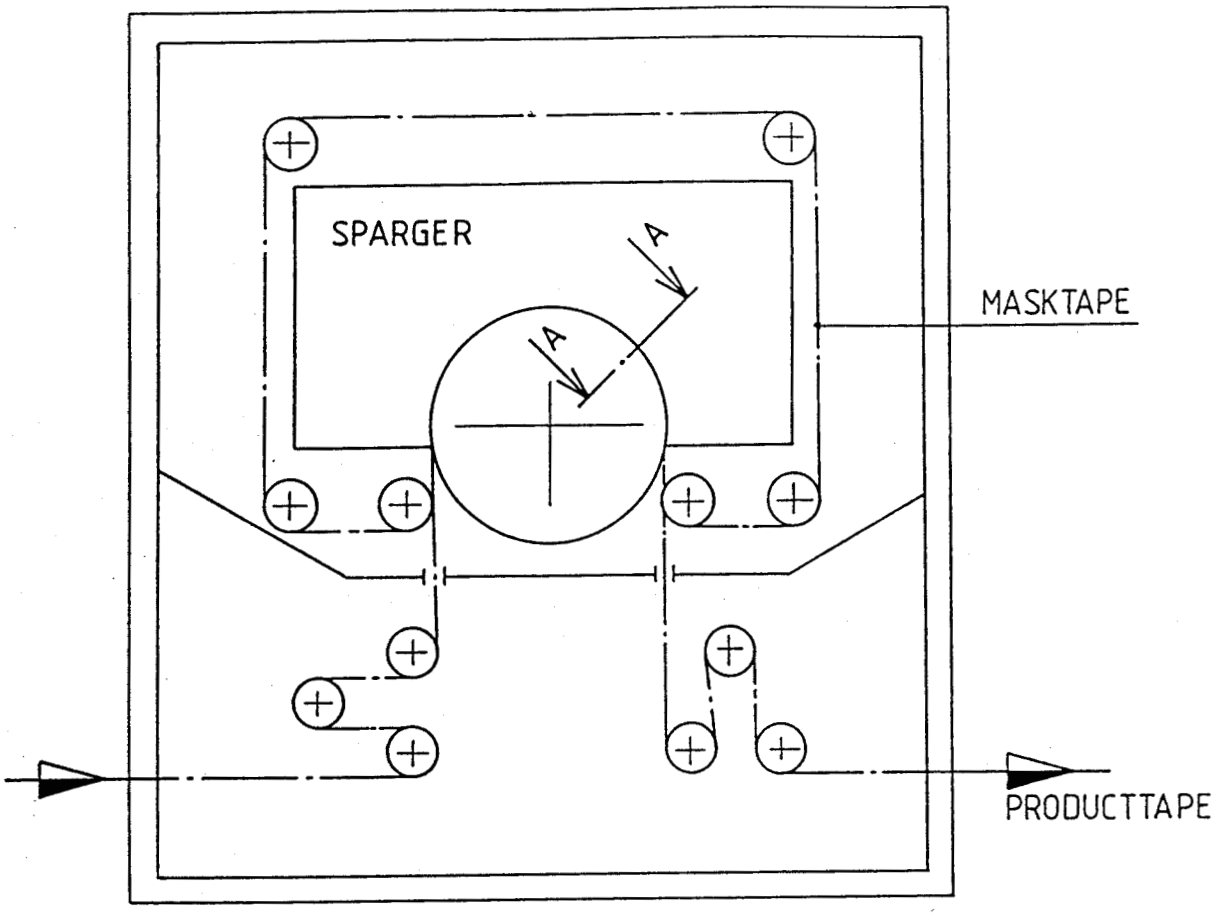
2) Dipl.-Ing. Elke Zakel
Dipl.-Ing. Rudolf Leutenbauer
Prof.Dr.-Ing. Herbert Reichl

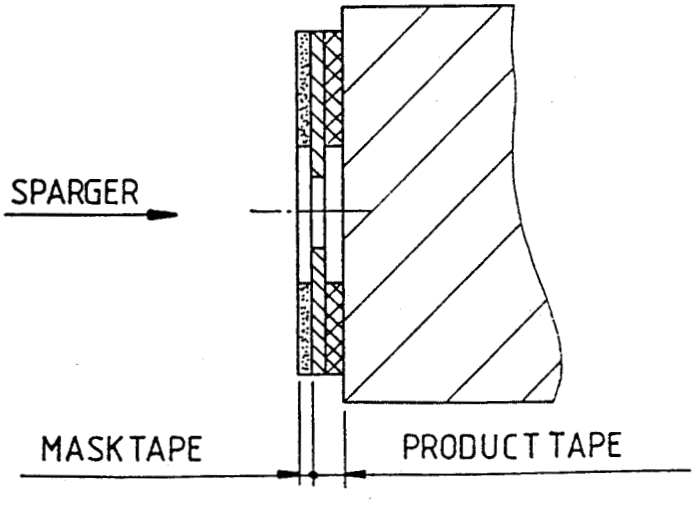
Investigations on the Cu-Sn and Cu-Au Tape metallurgy and of the bondability of TAB-innerlead contacts after thermal aging

3) Semiconductor Technology Center

FIGURE 1

SELECTIVE TAB-TAPE PLATINGUNIT

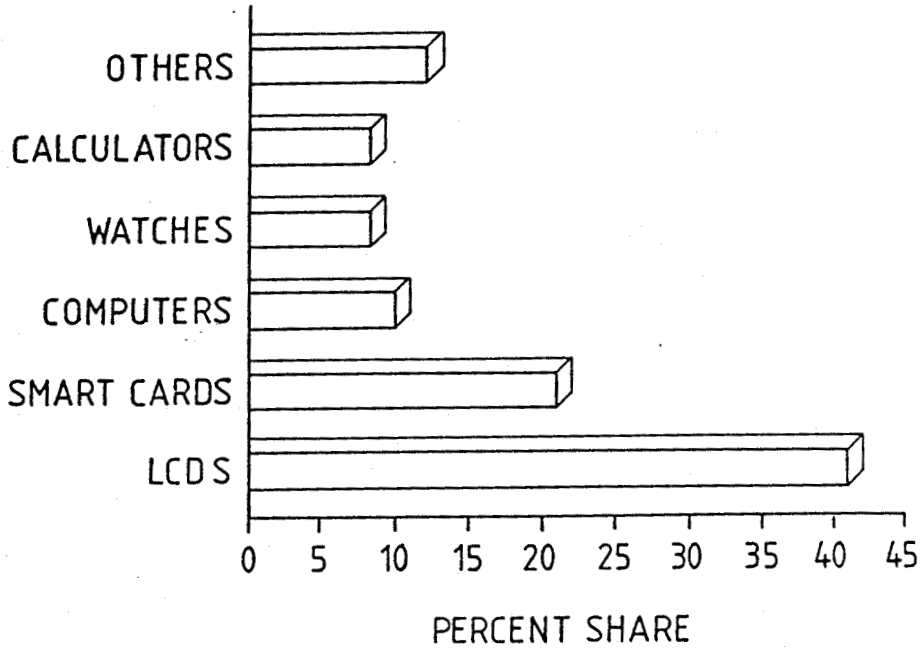




CROSS SECTION A-A

TABLE 1

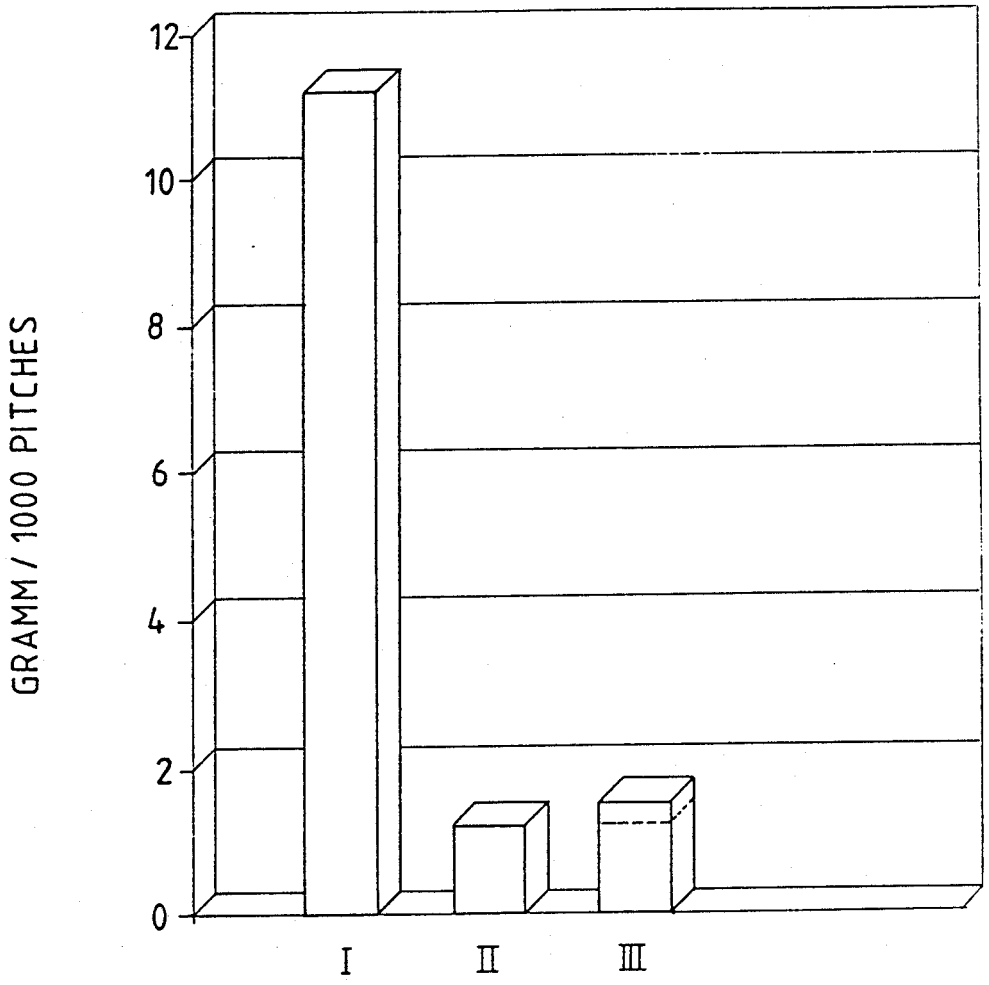
WORLDWIDE TAB APPLICATIONS IN 1990



SOURCE : SEMICONDUCTOR TECHNOLOGY CENTER

TABLE 2

GOLDCONSUMPTION



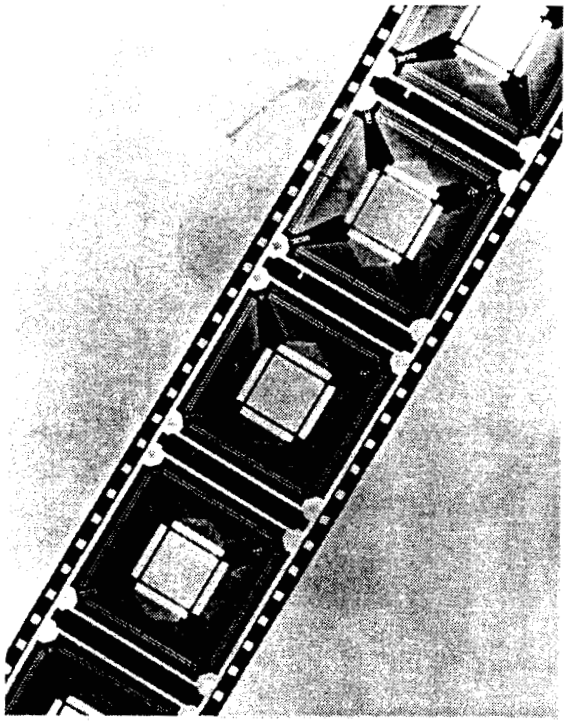
I = All over plated 1 micron

II = All over plated 0,1 micron

III = All over plated 0,1 micron
+ 0,9 micron selectively plated on the innerleads

FIGURE 2

TAB-tape leadframes



TAB-tape + maskingbelt

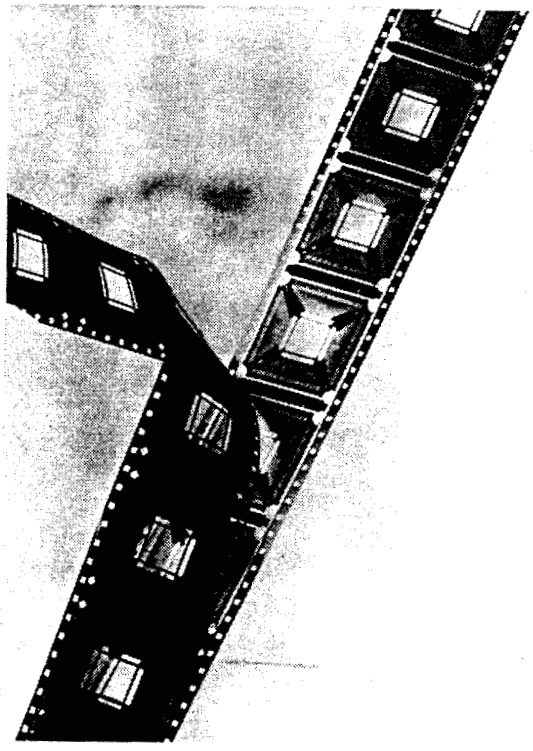
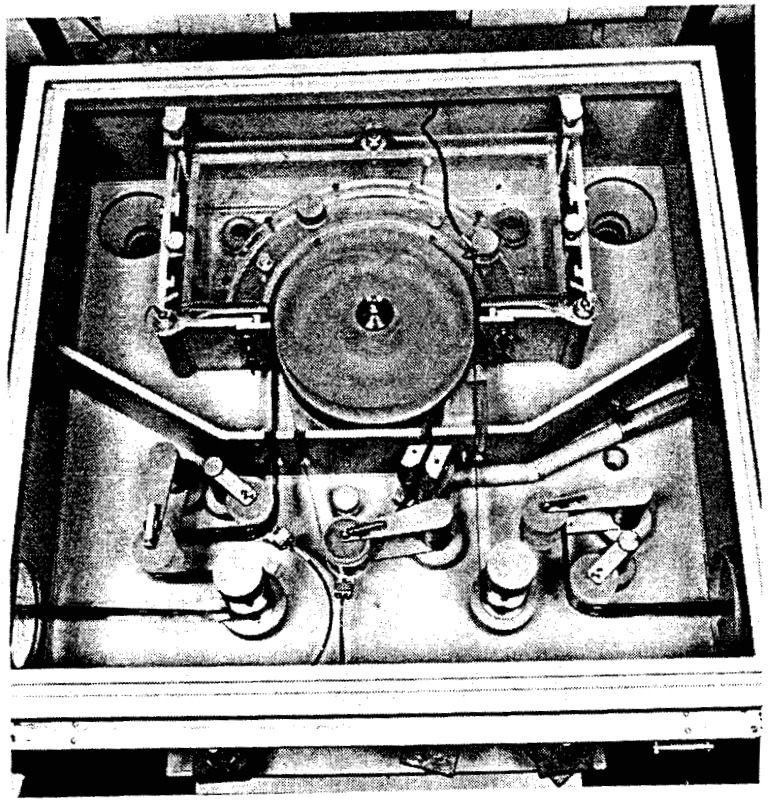


FIGURE 3



Selective TAB-tape plating unit