IMPACT
International Microsystems, Packaging, Assembly and Circuits Technology conference

EMAP
International Conference on Electronics Materials and Packaging

Temporary Non-Etching Adhesion Promotion System for Dry Film Applications

J. Huang, R Massey
Atotech (China) Chemicals
No 73, Xinzhuang 2-Lu,
Guangzhou, 511356
PRC

Dr. N. Lützow, C. Sparing, Dr. D. Tews, M. Thoms
Atotech Deutschland GmbH
Erasmusstrasse 20
10553 Berlin
Germany

Abstract

Within the Semi Additive Process (SAP) it is common for the Process's Copper seed layer to be only chemically cleaned before dry film lamination and imaging. While this has been historically acceptable, as imaging requirements increase, it is now beginning to reach its limitations. Two methods to resolve this exist; the one being pursued by dry film manufacturers is to increase the flow and adhesion properties of the dry films themselves, while the other solution is to treat the available Copper surface so that its own adhesive properties increase. Atotech's ResistAssist® IC process is a novel non-etching chemistry that actively increases dry film adhesion without any effect on track geometry or subsequent processing steps.

This paper discusses the development and latest results achieved with this process. Test methods centre on adhesion of fine line dry films to surfaces treated with the ResistAssist® IC chemistry, and then subjected to further tape testing. For comparison, the relative performance to surfaces treated with acid cleaning only is also reported.

The summary of this work is that this novel approach offers yield improvements over a current acid clean process, or potentially an increase in fine line capability with the same dry film.

Introduction

Historically, as imaged features have decreased in size, the Copper surface topography has been modified either mechanically or chemically in order to increase roughness. The resulting increase in surface area thus, providing improved mechanical adhesion of the dry film. For fine line applications below 100 µm L/S the ResistAssist® process was successfully introduced a number of years ago as a means of providing a unique Copper surface topography to improve dry film adhesion and thereby the first pass yield [1]

In recent years, developments in the IC chip industry have pushed the manufacturing process's to create new solutions. For the IC arena, 20 µm L/S are widely available, and roadmaps show a move towards 8 µm in the near future. At these high resolutions of ultra-fine lines, the traditional subtractive process routes cannot be used anymore, and this has led to increased use of the Semi-Additive Processing (SAP) In the SAP sequence, an electroless Copper seed layer is applied directly onto the insulator material. Dry film is then applied onto the process's Copper layer and the circuitry is pattern plated. After stripping of the dry film, the remaining seed layer is etched away, leaving behind the ultra-fine line circuitry [2]

Initially the process's Copper layer was a minimum of 1.5 µm in thickness, allowing the use of mild etching solutions to clean and roughen the Copper surface prior to dry film lamination. However, for the next generation of ultra-fine lines (below 20 µm) the process's Copper seed layer is reduced to approximately 0.5 - 1.0 µm. At such low Copper thickness's, due to the risk of damaging or fully removing the process's layer, etching as the dry film pre-treatment can not be used. Therefore it is becoming more common, that acid cleaning is used.

It is widely known that dry film materials get a small increase in adhesion when applied to acidic surfaces, but to rely on this mechanism as the means of adhesion promotion is still seen as a risk. [3r]

This paper discusses Atotech's development of non-etching adhesion promoter process's for dry film adhesion. The ResistAssist® IC process is a novel non-etching adhesion promoter process that improves the dry film adhesion through chemical bonding between dry film and Copper surface.

Process Description

The majority of dry films used in the PCB industry are acrylate based, subsequently; the goal of this programme was to develop a functional adhesion promoter capable of bonding to both a Copper surface and to the acrylate compounds of commonly used dry films.

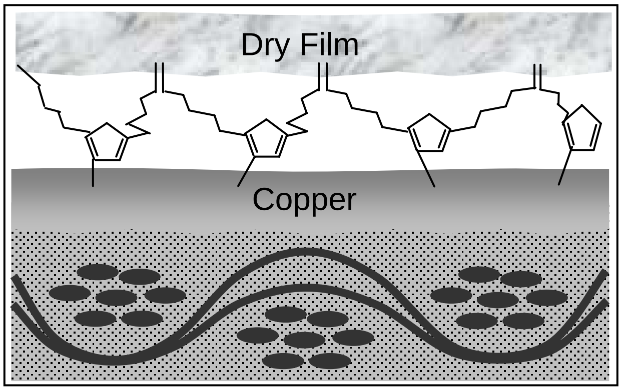

Figure 1.
Schematic of Functional Non - Etching
Adhesion Promoter

In the proposed system, we make use of two bi-functional components that act in combination to increase dry film adhesion. The first ingredient bonds well to the Copper surface, but has poor reactivity with the acrylates in dry films. The second ingredient has good adhesion to acrylates but is not so effective with metals. They do however bond well to each other, so the resulting two step process is a sequential operation, where the acrylate adhesion promoter is applied only after the Copper surface is suitably cleaned and activated.

Process	Temp	Time
ResistAssist® IC Activator	35 °C	30-35 sec
ResistAssist® IC Solution	45 °C	45-60 sec

Table 1.
Process Steps for Non-etching Adhesion Promoter

As this system is for temporary adhesion of dry films, it must not only be stable throughout exposure, developing, and the subsequent acid plating process. It must not interfere with any of these process chemistries or operations, yet also allow the dry film to be fully stripped when required.

In order to achieve this, the coating has been optimised so that the adhesion mechanism to the acrylate only occurs in those areas exposed to intense UV energy. The action of the UV light polymerizes the dry film, and thus creates the functional groups in the acrylate, which are required to bond with the adhesion promoter.

It is this methodology which gives enhanced dry film adhesion where needed, and fast, clean developing elsewhere. As the masked or un-exposed areas of the dry film remain un-polymerized, the underlying adhesion promoter also remains unchanged, and once in the developer solution readily forms soluble salts that are quickly removed leaving residue free areas of Copper. A similar mechanism operates during stripping, where the more aggressive stripper chemistry aids salt formation and fully cleaves the exposed dry film from the Copper surface. By making use of the exposure process, the geometry and accuracy of the adhesion promoter mimiks exactly that of the dry film, thus ensuring no undercut of the imaged lines, or residues in between the imaged traces.

Test Vehicles & Experimental Procedure

It is acknowledged that build-up type films are used in IC substrates, however, these materials tend to have heavy surface roughness and so offer high levels of mechanical adhesion for dry films, in view of this, test vehicles based on Copper Clad Laminate (CCL) were used. CCL parts exhibit much flatter surfaces relative to build-up films and so offer improved resolution for the effects of a chemical adhesion mechanism.

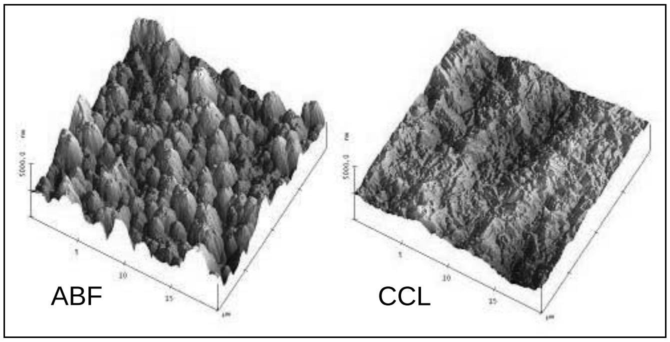

Figure 2.
Surface Topography of Ajinomoto GX13
and CCL Test Vehicle

CCL test vehicles were coated with 1µm of process's Copper using the Atotech Printoganth PV process. Pre treatment was carried out either with the ResistAssist® IC process, or the control treatment of 5-10% H_2SO_4. Hitachi RY3325SG dry film was laminated and exposed in accordance with the manufacturer's instructions and was selected as typical fine line capable material. The artwork was designed specifically for these tests and made use of 10, 12, 15, 20, 25 µm lines with spacing's of 50, 100, 150, 200 and 250 µm (Figure 3). After the recommend hold time, the image was developed in a 1% Na_2CO_3 solution (50% break point)

After development, the number of complete lines was determined for each line and space condition. Following the initial evaluation, tape testing of the dry film lines was performed and the number of complete lines re-measured.

The data shown throughout this report is the mean of repeat tests carried out over a number of months.

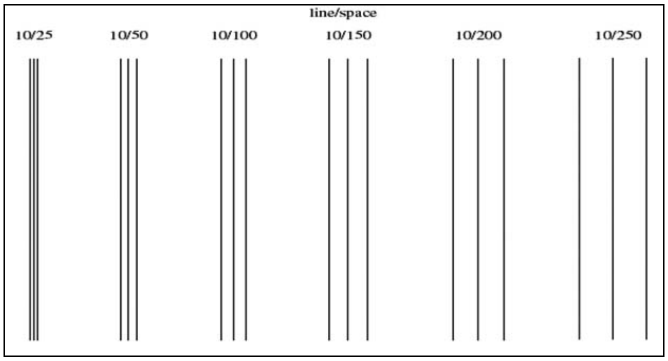

Figure 3.
Test Artwork Showing 10 µm Line Area

Performance

During the manufacture of the test vehicles, no impact was noted on any processing, specifically in the imaging and development areas. No adjustments to exposure energy were required in order to achieve the desired "Stouffer step" and the breakpoint within the developer was comparable to that seen with the control group samples.

Figure 4 shows the performance of surfaces treated with ResistAssist® IC ***relative*** to those treated with the simple acid cleaner, the greater the rating, the larger the improvement noted.

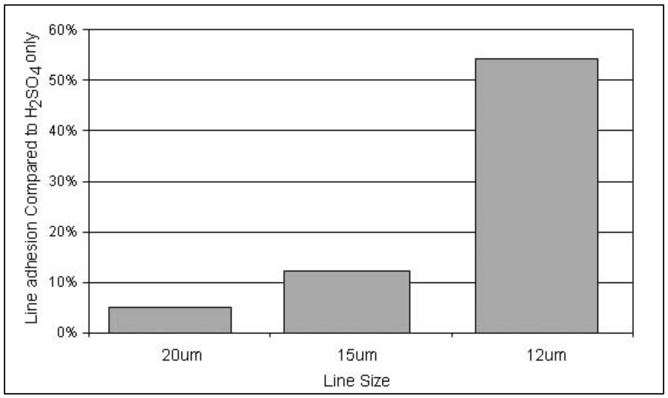

Figure 4.
Line Adhesion Data

As can be seen, at the larger line sizes, the adhesion properties of the dry film itself are sufficient to give excellent line adhesion, however as the feature size reduces, the properties of the dry film are no longer able to ensure good adhesion, and the impact of the pretreatment becomes apparent. At 15 µm lines, the surfaces treated with the non-etching chemistry have 10-15% more lines still attached compared to surfaces treated with Sulphuric acid, and this increased to 50-55% as the lines reduce to 12 µm.

From Figure 2, it is clear that the low surface roughness of the CCL parts is giving little mechanical adhesion to the dry film and it is offered that all the improvement over the acid cleaned parts arise from chemical bonding only.

Figure 5 shows an isolated dry film line on a surface treated with the ResistAssist® IC process. As shown, the dry film track shows no negative effects from the use of the non-etching adhesion system. There is no film lift or cavitation at the resist foot, and the track is well defined with no excessive foot that could be associated with problems whilst developing.

In order to determine the impact of the system on subsequent process's, some parts were continued through acid plating and resist stripping. Figure 6 shows no negative impact on acid Copper plating, and that complete removal of the dry film has occurred during stripping. Most importantly, here is no sign of "seepage" or under plating which could be associated with poor dry film adhesion.

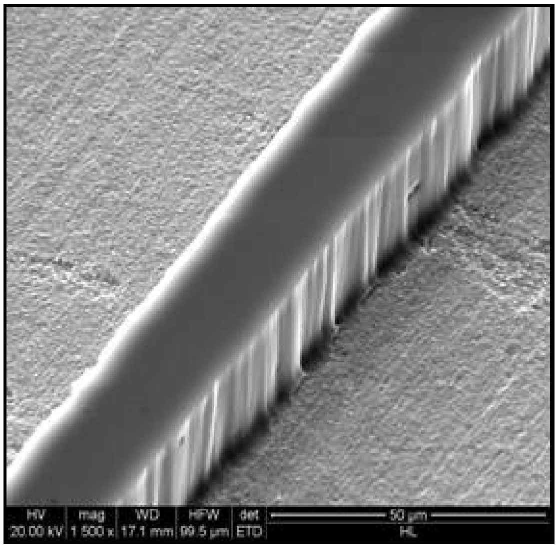

Figure 5.
12 µm Line, 25 µm Spaces. Dry Film on ResistAssist® IC Treated Surface

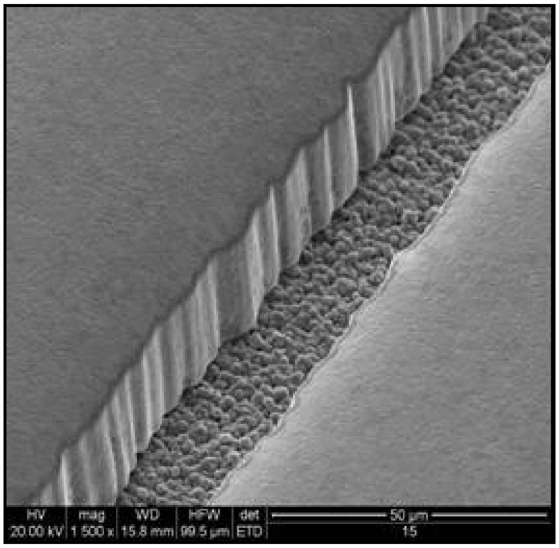

Figure 6.
12 µm Line, 25 µm Spaces. (Dry Film) After Acid Plating and Resist Strip

Summary and Conclusions

A non-etching adhesion promoter is offered that makes use of functional components to give enhanced adhesion between Process's Copper surfaces and acrylate based dry film materials.

The characterisation tests reported show that for dry film features smaller than 20 µm, the ResistAssist® IC process gives enhanced film adhesion and offers yield improvements over the existing acid clean process, with no impact on subsequent process's.

ResistAssist® IC is Atotech's a simple, low temperature process that makes use of non-etching adhesion promoters to increase the performance of fine line dry films. As such, the process is a viable alternative to the commonly used acid clean step prior to dry film application in SAP type products

References

[1] U. Hauf, H. Fuerhaupter, H. Roberts, *Process for Improved Photoresist Adhesion*, Circuitree 2001 (5) p.56-66

[2] CF. *Combs Printed Circuit Handbook Six Edition*, McGraw-Hill, 2008, Chapter 31, p 31.1 – 31.15

[3] K. Dietz, *DryFilm Photoresist Processing Technology*, Electrochemical Publications, 2001, p. 61-63