TECHNOLOGICAL ASPECTS OF AUTOMATED SELECTIVE SYSTEMS APPLICATION IN CONFORMAL COATING PROCESSING*

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The main function of conformal coating is protection of PCB from solvents, moisture, dust or other contamination. Coating also prevents dendrite growth or oxides formation and mitigates the risk of failure due to tin whisker growing on the surface of tin-rich alloys The coating could be applied with dipping, brushing, or spraying method. However, like most of the manufacturing processes, conformal coating application methods have been developed from manual to automated systems.
Cracow Division of Institute of Electron Technology is involved in implementation of Asymtek Selective Conformal Coating System C-341 equipped with SC-300 Swirl Coat applicator possessing three modes of operation: bead, monofilament and swirl, applying the lacquers in the form of atomized spray.
This article focuses on technological aspects of Automated Selective Coating Systems application in protection of electronic boards, especially in small-scale production. Preliminary tests carried on a series of analogue RSS-14 type charge regulators, protected with conformal coating, applied with SC-300 Swirl Coat applicator, showed no significant electric parameter deviations in comparison with the primary levels. Influence of applicator mode, lacquer data and curing system on the required coating quality will be also discussed.

Key words: conformal coating, protection, dispensing
Słowa kluczowe: powłoka konforemna, powłoka ochronna, nanoszenie

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1. INTRODUCTION

Conformal Coating is thin, transparent, polymeric coating that is applied to the surfaces of PCBs to provide protection from the end-use environment. It is used for the following reasons:
- current leakage and short circuit inhibition due to humidity and contamination,
- corrosion inhibition,
- fatigue life of solder joints to leadless packages inhibition,
- arcing, corona effect inhibition,
- providing of mechanical support for small parts to prevent damages due to mechanical shock and vibration,
- preventing of dendrite growth or oxides formation,
- mitigation of the risk of failure due to tin whisker growing on the surface of tin-rich alloys [1-2].

Obligatory implementation of RoHS Directive into industrial practice, especially concerning Pb elimination from solder joints, caused the growing interest of this subject. If the elimination of pure tin form electronic circuits is impossible, conformal coating are recommended for limitation tin whisker growth and restraint this forms under the coating. For this reason importance of implementation this kind of protection seems to be reasonable [3].

Conformal Coating is especially used in:
- automotive applications (under hood and inside cabin)
- aerospace and military applications
- telecommunications
- commercial applications
- heavy equipment (construction, agricultural and railroad)
- industrial applications (general controls).

On the world market, many companies offer wide range of conformal coating lacquers, generally classified as acrylic, epoxy, urethane, silicone or parylene. Recently UV cured conformal coating lacquers become widespread [1].

Methods for applying conformal coating to Printed Circuit Boards (PCBs) have evolved from the simple dip, brush and spray processes to selective coating. Major improvements in conformal coating can be realized through the use of automated systems that selectively apply coating. A dispenser mounted to a robot is programmed to move and dispense material in designated locations on the PCB. The system can be manually loaded or equipped with conveyors for in-line board processing. The coating material, dispenser type, and robot speed determine the coverage and film build. Selective conformal coating machines provide consistent application of material, higher throughput, material savings, closed fluid systems and, given the proper dispenser and PCB layout, do not require custom tooling or board masking.

In comparison to other method, the main disadvantage is the cost of a selective conformal coating machine. The Conformal Coating process has benefited from increased automation in recent years. Conveyors and board handling equipment have been added to reduce operator errors and reduce (or eliminate) board damage before and after coating. Improved fluid delivery methods increase both product quality and system flexibility. Graphical, user-friendly software developed specifically for selective conformal coating simplifies process development and operator interface. Quality improvement, ease of use, and operator safety should be carefully considered when procuring a conformal coating system [4-5].

Main advantages of Automated Selective Coating are following:

- repeatable results
- improving material utilization
- reducing labor costs
- closed Fluid System
- increasing productivity
- improving quality
- in-line processing
- batch processing

2.COATING DEVICE

The C-341 Conformal Coating System (Fig. 1A) is a cost-effective, automated batch system for selectively applying conformal coating materials.

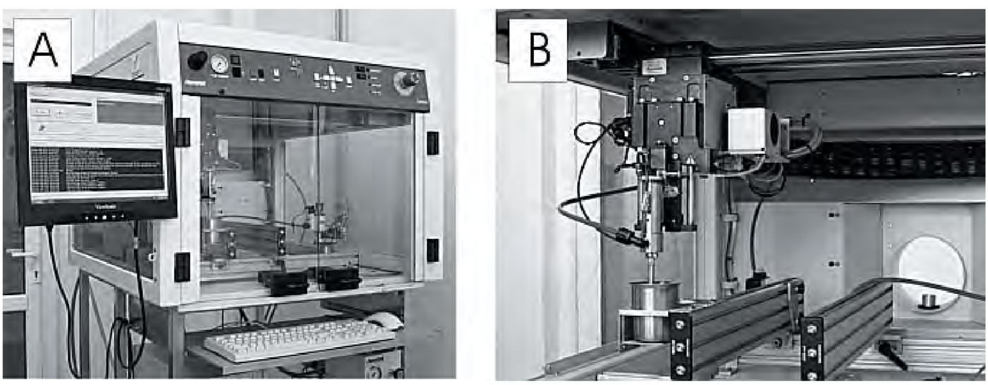

Fig. 1. A - C-341 Asymtek selective conformal coating system. B - SC-300 swirl coat applicator.

Rys. 1. A – System C-341 firmy Asymtek do selektywnego nakładania powłok konforemnych; B – głowica SC-300 Swirl Coat.

The C-341 system is equipped with Easy Coat for Windows XP (ECXP) software, which is uniquely designed for conformal coating applications, and offers coating flexibility beyond generic motion control and dispensing packages. Within a familiar Windows environment, multiple coating commands can be edited simultaneously, minimizing the time required to make programming and pattern changes. Conformal coating log files are configurable, allowing users to record system events and parameters for process improvement and analysis.

Coating System C-341 equipped with SC-300 Swirl Coat applicator (Fig. 1B) possessing three modes of operation: bead, monofilament and swirl (Fig. 2 A-C). Applicator handles a wide range of materials, varying in viscosity from 30 to 3500 mPa*sec (30 to 3500 centipoises).

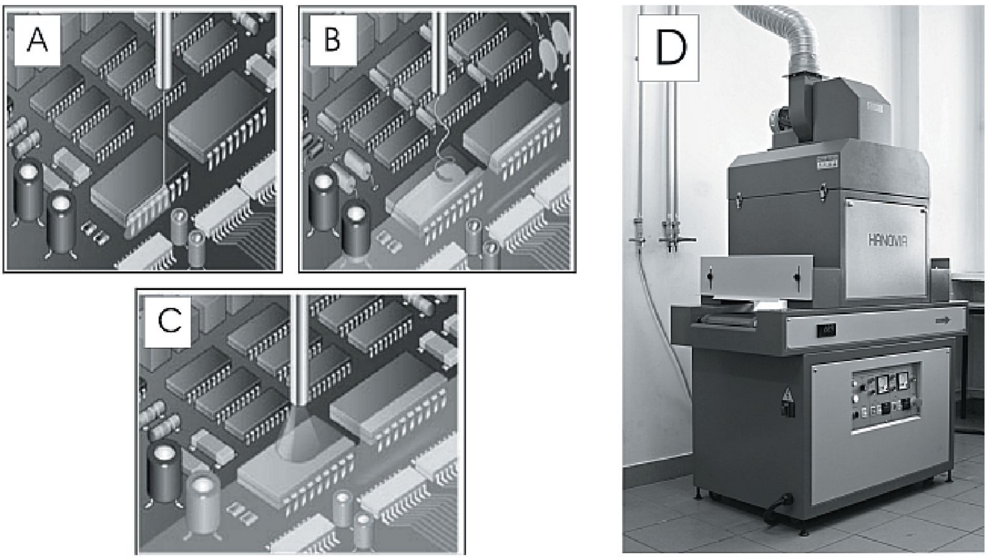

Fig. 2. A - bead mode; B - monofilament swirl mode; C – swirl mode (the pictures reproduced upon permission from Asymtek Company [6]); D - UV-12-2 Hanovia Conveyorized Ultraviolet Curing System.

Rys. 2. Tryby pracy głowicy SC-300. A – linia; B – spirala; C – spirala z natryskiem (zdjęcia wykorzystane za zgodą firmy Asymtek); D – system Hanovia do utwardzania powłok konforemnych za pomocą UV.

Bead mode is a single stream of material dispensed through a nozzle and applied to the board in areas where components are very close to non-coating or keep-out areas. This mode provides excellent edge definition and thick film build. Bead mode is typically used to apply extra material along a component or connector edge, or to build a dam around an area of coating. In both, monofilament and swirl modes lacquers are applying in the form of atomized spray. Controlling the fluid pressure and material flow passing through the nozzle creates monofilament pattern. Auxiliary air circulating through the air passage strikes the material at a precise angle, causing it to spin on its axis and form a conical, looping pattern. Increasing air pressure and lowering flow settings achieve the swirl pattern. Angled jets impinge air upon the pressurized material exiting the nozzle creating a conical, swirling pattern. The swirling action helps maintain pattern shape resulting in excellent width control. Because the air jets cause slight atomization of the material, extremely thin film builds are possible [4-6].

EXPERIMENTAL

For preliminary tests of C-341 Asymtek System Humiseal UV40 dual cure acrylated urethane coating was used. Viscosity of UV40 lacquer - 800 cps is, in comparison to another conformal coatings, relatively high. The lacquer is tack free after exposure to UV light and the secondary moisture cure mechanism will cure lacquer film within 2-3 days at ambient conditions. The secondary cure can be accelerated by baking of protected PCBs at +60 -800°C. Samples, after UV40 protection, were cured in UV-12-2 Hanovia Conveyorized Ultraviolet Curing System (Fig. 2D.)

Preliminary tests were made on paper, pattern sheet using bead, monofilament and swirl applicator modes. After UV curing and baking, samples were subjected to visual inspection with UV lamp usage. Surface quality and pattern thickness were evaluated.

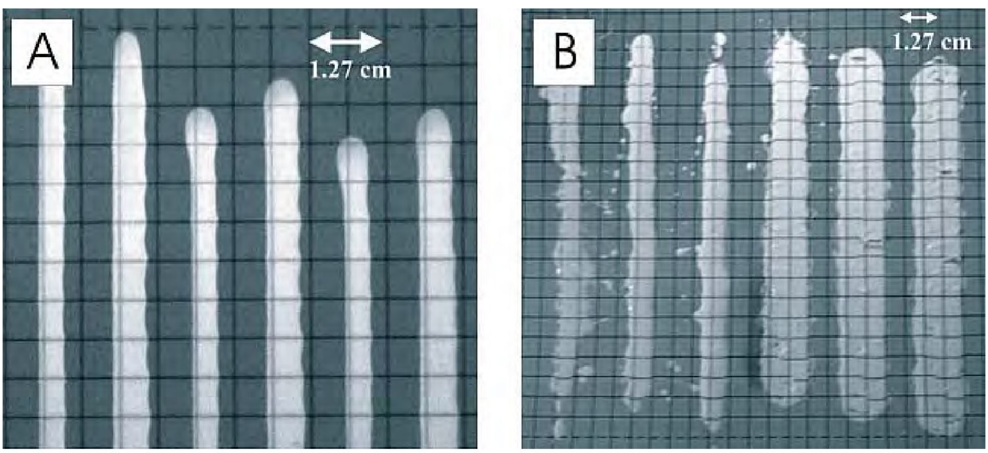

Fig. 3. A - bead patterns. The mode ensured the best uniformity of the lines; B - monofilament swirl patterns. On the edge of the lines many splashes were observed.
Rys. 3. A – Tryb liniowy, zapewniający najlepszą ciągłość linii; B – tryb spiralny. Tendencja do powstawania rozprysków na krawędzi linii.

The best surface and edge quality for bead mode was observed (Fig. 3A, Fig. 4B), however the pattern thickness exceeded 300 μm. Both, monofilament (Fig. 3B) and swirl (Fig. 4A) modes brought worse results especially at the edge uniform line. The pattern thickness for monofilament mode exceeded 300 μm, properly not exceeded 50 μm for swirl mode. In case of swirl mode with dispense speed 225 mm/s the lines were discontinuous (left side of Fig. 4A). Much better results were obtained with speed decrease to 100 mm/s (right side of Fig. 4A). Especially for monofilament and swirl mode drops of the lacquer around patterns were visible.

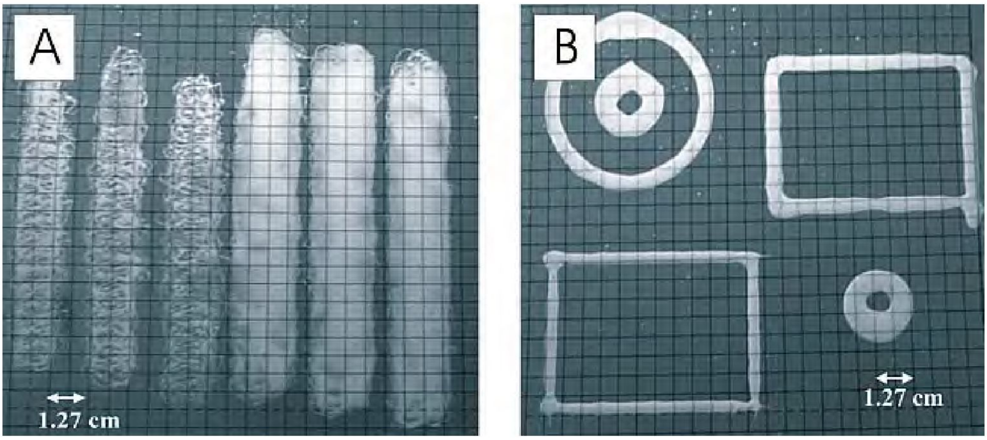

Fig. 4. A - Swirl patterns. Discontinuity of the lines on the left side of the picture was caused by too high dispensing speed; B - bead patterns – different.
Rys. 4. A – Tryb spiralny z natryskiem. Nieciągłość linii po lewej stronie zdjęcia spowodowana była zbyt dużą szybkością przesuwu głowicy nakładającej; B – tryb liniowy.

For estimation the influence of coating on certain parameters of electronic circuits, charge regulator RSS-14 (Fig. 5, [7]) were protected with UV-cured urethane coating, applied with Automated Selective Coating System. Regulators were manufactured in ITE in a small-scale production. This product could be generally exposed to moisture or dust so the coating protection in this case seems to be reasonable. The destructive influence of harsh environments on functioning of this circuit manifests oneself as changes of electrical parameters given in the Table 1.

For realization of the protective operation, ten regulator pieces were selected. All of them were previously precisely adjusted, without any protective coating, to the same values of their basic sore points i.e. the voltage level (Tab. 1).

Table 1. Electrical parameters of RSS-14 charge regulators.
Tabela 1. Elektryczne parametry regulatorów RSS-14.

Electrical parameter	Values	Remarks
Installation voltage	12 and /or 24 V	depending on version
Input/output max. current	5A	–
Basic battery voltage level*	13,7±0,1 V	at 25 °C
Momentary battery voltage level*	14,1±0,1V or 14,5±0,1 V	sealed conventional batteries at 25 °C
Output disable voltage level*	11,1±0,1 V	at 25°C
Resetting level*	12,5±0,2 V	at 25°C
Signaled voltage levels*	green≥12,6±0,2 red≤ 11,1±0,2	at 25°C

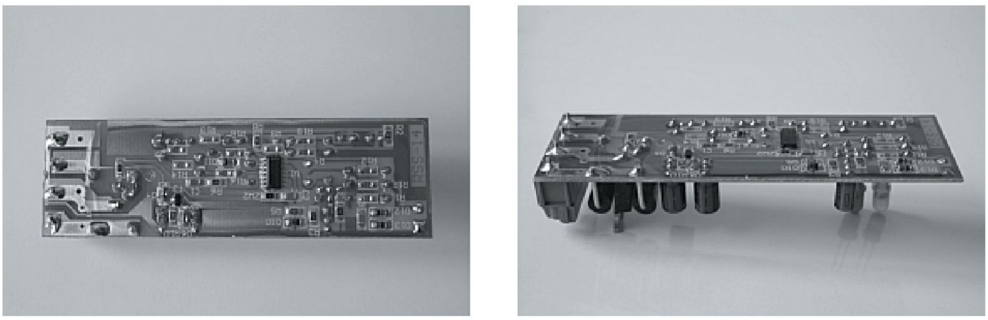

Fig. 5. RSS-14 battery charge regulator scheme.
Rys. 5. Schemat regulatora RSS-14.

The electrical parameters measured just after lacquering and UV curing showed an astonishing drop of parameter levels reaching, even 42%. As it was later explained - this effect was caused by the momentary presence of some conductive solvents in the lacquer. After 2 h drying at the temperature of +60°C the values of the electrical parameters were significantly much satisfactory.

The most important parameters i.e. basic voltage and momentary voltage have changed not more than 20 mV i.e. less than 0.15%. Quite similar or even smaller changes were observed in case of other parameters. Such results were much better than satisfactory, so no additional tests were acknowledged as necessary.

CONCLUSIONS

- The flexibility, cost savings and process controls are main benefits of the Selective Conformal Coating Systems introduction.
- Preliminary tests performed with using of different applicator modes showed better surface and edge quality, as well as much higher pattern thickness for bead mode.
- The cost of coating machine compared to other methods, relatively high lacquers losses especially during cleaning, relatively long time of lacquers replacement and machine cleaning determine using Selective Systems rather for medium and high production volume.
- The machine settings should be individually determined for every conformal coating lacquer.
- No significant influence of UV cured, selective applied, conformal coating lacquer on RSS-14 regulator parameters was observed, and although fully curing of the film seems to be substantial.
- Practical use of UV cured, a conformal coating lacquer is good, technological solution, but relatively its high price need to be considered.

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TECHNOLOGICZNE KONSEKWENCJE WPROWADZENIA AUTOMATYCZNYCH SYSTEMÓW DO SELEKTYWNEGO NAKŁADANIA POWŁOK KONFOREMNYCH

Główną funkcją powłok konforemnych jest zabezpieczenie układów elektronicznych przed niekorzystnym działaniem rozpuszczalników, wilgoci, pyłów czy innych zanieczyszczeń. Powłoki te zapobiegają również zjawisku powstawania dendrytów i ograniczają ryzyko zwarć powstałych w wyniku wiskersów rosnących na powierzchniach wysokocynowych stopów, szeroko używanych w elektronice. Powłoki konforemne mogą być nanoszone metodą zanurzeniową, z użyciem pędzla lub natrysku. Jednakże, jak większość procesów, technologia nakładania powłok konforemnych rozwija się w kierunku systemów zautomatyzowanych.

Krakowski Oddział Instytutu Technologii Elektronowej bierze udział we wprowadzeniu do produkcji urządzenia do selektywnego nakładania powłok konforemnych firmy Asymtek (model C-341), w którym głowica rozprowadzająca posiada trzy tryby pracy: liniowy, spiralny i spiralny z natryskiem.

W artykule zostały opisane technologiczne aspekty wprowadzenia automatycznego systemu do selektywnego nakładania powłok konforemnych, w szczególności do produkcji małoseryjnej. Testy przeprowadzone na serii regulatorów RSS-14= pokrytych powłokami konforemnymi, wykazały brak statystycznie istotnych różnic parametrów elektrycznych w porównaniu z próbkami niezabezpieczonymi. Przeprowadzona została również dyskusja wpływu wyboru trybu pracy głowicy, rodzaju lakieru i procesu utwardzania na jakość zabezpieczenia z użyciem powłok konforemnych.