Journal of Engineering Research and Reports

20(4): 147-152, 2021; Article no.JERR.66887
ISSN: 2582-2926

Die Attach Curing Program Automation of N_2 Parameter for Process Robustness

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Authors' contributions

This work was carried out in collaboration among the authors. All authors read, reviewed, and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2021/v20i417304
Editor(s):
(1) Dr. Neha Munjal, Lovely Professional University, India.
Reviewers:
(1) Kamil Kaszyca, Institute of Microelectronics and Photonics, Poland.
(2) Tagreed M. Al-Saadi, University of Baghdad, Iraq.
Complete Peer review History: http://www.sdiarticle4.com/review-history/66887

Original Research Article

Received 17 January 2021
Accepted 26 March 2021
Published 31 March 2021

ABSTRACT

In the world of semiconductor industry, automation plays a big role on every manufacturing plants to improve efficiency, prevent product yield losses, and making sure that top quality products will be delivered on end user. On die attach curing process of manufacturing semiconductor integrated circuits (IC) devices, certain problems occur like wrong Nitrogen (N2) parameter setting on the oven curing machine, with human intervention during setup, causing leadframe oxidation related defects. The paper discussed the importance of automation system on processing semiconductor IC products on die attach curing process, eliminating mostly human intervention on setting up machine parameters, storing and managing programs, restrict unauthorize users from accessing, provide friendly user procedures to prevent human errors and prevent oxidation related defects.

Keywords: Automation; die attach process; error-proofing; oven curing.

1. INTRODUCTION

Die attach is the process of attaching a semiconductor die from a silicon wafer to a package through leadframes or substrates with the help of a die attach machine and adhesive. The die attach process is fundamental to multiple types of packaging. After die attach, the package needs to subject at a specific temperature to cure the epoxy properly. There are certain requirements needed to set on the oven curing machine, including curing temperature, time and

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required Nitrogen (N_2) or Oxygen (O_2). These curing parameters were managed and controlled by giving a curing program name to be set on the curing machine and must be set correctly. The program has the following oven curing parameters:

- Die attach material type: the type of material used during die attach. (epoxy, film, etc.)
- Ramp up time – the time spent from ambient temperature to desired dwell temperature.
- Ramp up temperature – the temperature set from ambient temperature to desired dwell temperature.
- Dwell time – the time spent on curing within the desired dwell temperature.
- Dwell temperature – the temperature set for curing of die attached parts within the set dwell time.
- Nitrogen/oxygen setting – the setting of nitrogen/oxygen flow required during oven curing.

All these requirements are being embedded on a specific curing program number and will be selected manually on the curing machine by the technician during setup. Selection of program depends on the material requirement, so there are different curing programs stored on the oven machine which will be set manually. Nitrogen flow per product requirement will be set also separately on the knob of N2 gauge meter manually. This is to set the gas flow needed by the product with bare Copper (Cu) leadframe, which is susceptible to oxidation. Oxidation has been proven by different studies to cause package delamination during molding process. Thus, wastage on the manufacturing process will likely happen. To avoid this phenomenon, improvement on the current system must be performed to address the flaw of its structure and introduce a robust approach for manufacturing benefit.

2. REVIEW OF RELATED LITERATURE

Oxidations are one of the issues manufacturing engineers trying to resolve to have robust and quality products using Cu leadframes. One study emphasized the effects of oxidation on copper leadframes. The presence of a Copper Oxide (CuO/Cu_2O) layer on the leadframe of plastic IC packages was found to cause delamination at the diepad-to-mold compound interface as shown in Fig. 1 and the failure mechanism seemed to be the presence of micro-voids at the oxide-to-metal interface, which increased as the degree of oxidation was increased [1]. Assembly manufacturing of semiconductor devices in general have certain challenges encountered and determined at die attach process [2-4].

Fig. 1. Delamination between the diepad and mold compound interface [1]

Other studies introduced automation on their processes to improve productivity, prevent yield loss, and innovate to achieve robust manufacturing processes. Works in [5] provided a smart dashboard and console applications to improve the quality, provide higher productivity and deliver less cost. Another study with N2 improvement to minimize the occurrence of excessive oxidation for bare Cu leadframe is shared in [6]. Note that the excessing oxidation rate of bare Cu leadframe during package assembly manufacturing would cause reliability issues such as delamination.

3. METHODOLOGY

On die attach curing process, the existing procedure starts with preparing the products to be processed and checking the right curing program to be used with the help of visual aids. Oven curing programs was loaded up by the equipment technician to the oven curing system linked on the oven curing machine as seen in Fig. 2 by reading the product traveler card barcodes. Inside this barcode contains its required oven curing parameters including ramp up time and temperature, dwell time and temperature, cool down time and temperature, oven machine interlock temperature, and temperature overshoot control limits.

For the N2 setup, the technician will adjust the knob of the gauge meter manually to set required N2 flow during oven curing as shown in Fig. 3. There are indicators on the gauge seen as green marks that serves as the control limits indicator to maintain N2 flow rate. After setting up the oven curing machine and passes all the requirements, it can now go to production mode.

This oven curing machine setup however will not guarantee the compliance of the product, especially for setting up other curing parameters manually. Technician who will perform it might overlook the required parameter or even forgot to set it. Thus, the product will be vulnerable to defects and abnormalities during processing.

4. RESULTS AND DISCUSSION

To prevent the event of mis-operation caused by human errors and wrong parameter set, an innovation for the said flaw was made and applied. Machine technicians and engineers gather around to conduct experiments and simulations on the oven curing machine and the system to integrate the automation principle during setup of parameters especially the N2 flow setting.

This integration involves installation of the digital gas flow controller that was linked on the N2 gauge meter, which was activated also by the program controller of the oven curing system that reads the barcode and load all required parameters of the product. As illustrated in Fig. 4 after barcode reading, the program controller will load the parameters of the product including the N2 requirement and gives signal to the digital gas flow controller. The gas flow controller therefore will provide the required amount of gas flow during production run and will be displayed by the N2 gauge meter.

This N2 controller integration on the oven curing machine system provides multiple benefits that can help improve the manufacturing process.

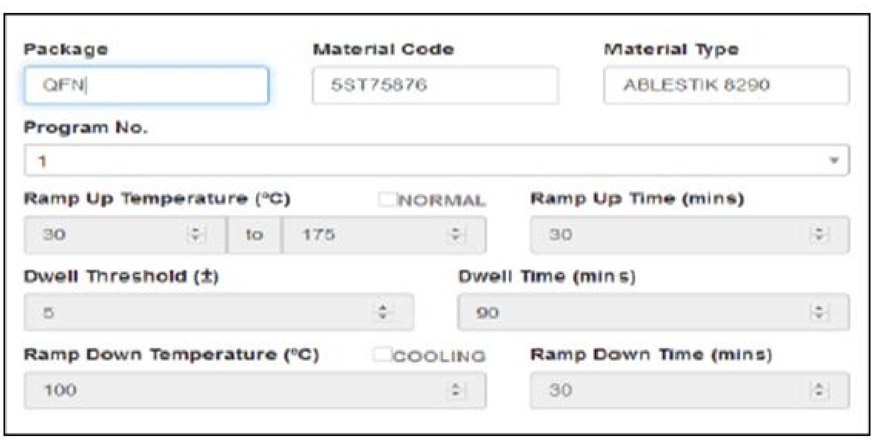

Fig. 2. Snapshot of oven curing system interface

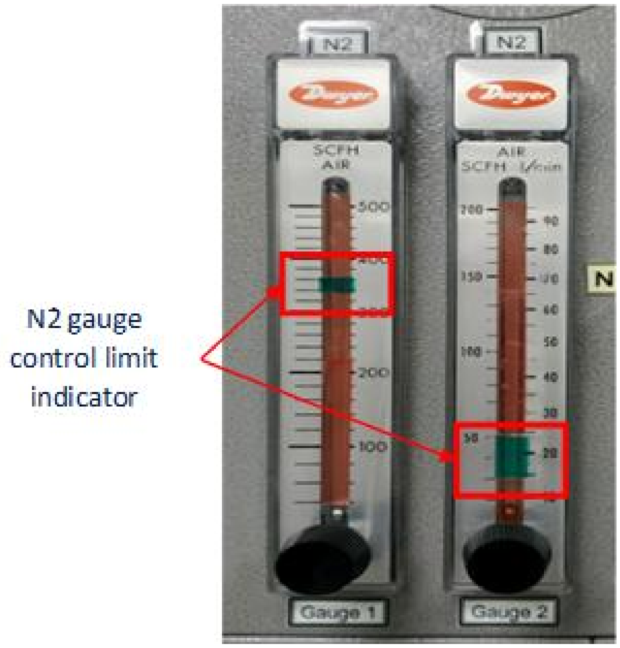

Fig. 3. N2 gauge meter with manual knob adjustment

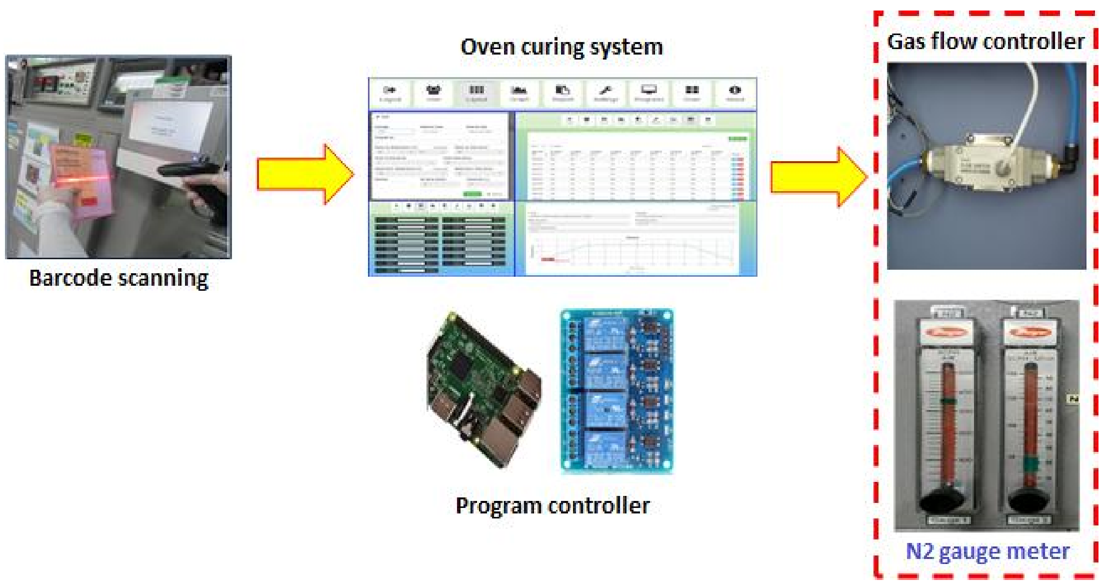

Fig. 4. Oven curing system flow

First, it can eliminate the risk of human errors caused by manual intervention and wrong parameter setup. Second, using this digital gas flow controller maintains and controls the required amount of N2 flow, avoiding wastages and unnecessary use of it. And third, the integration introduces and efficient and robust process by applying the automation principle that helps the user to work at ease.

As seen on the results of the 2-proportion test in Fig. 5, the system integrated with N2 automation has significant difference compared with the old system without N2 automation. In addition, based on the Mosaic plot system with N2 automation is statistically favorable at more than 95% confidence level and showed drastic results on the experiment done.

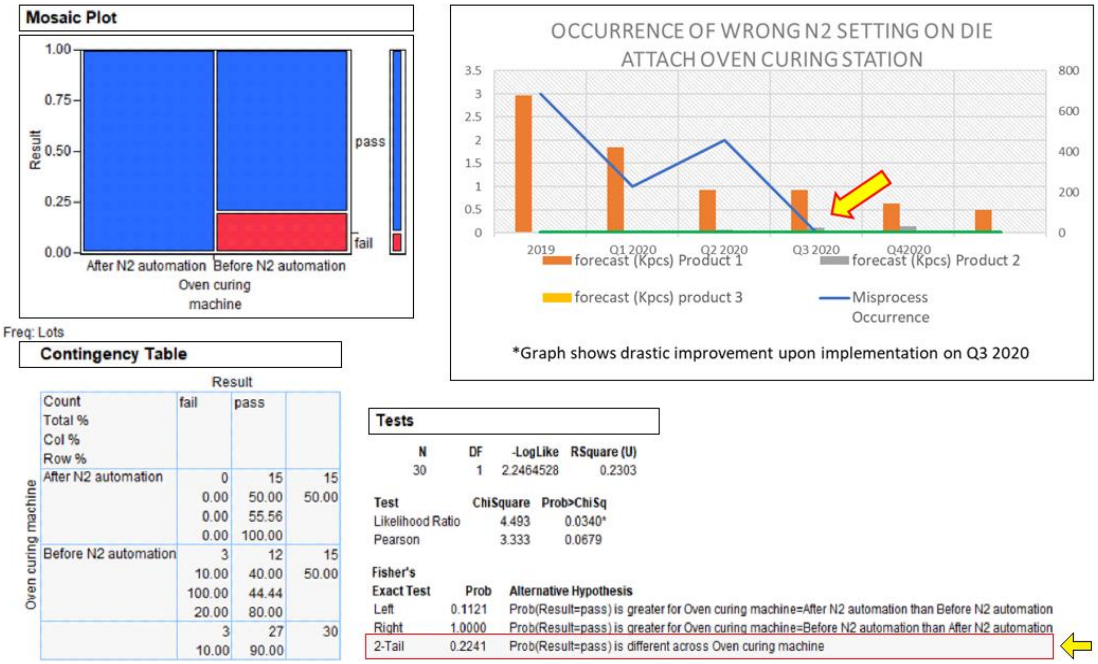

Fig. 5. Statistical analysis and implementation result of N2 automation

5. CONCLUSION AND RECOMMENDATIONS

The N2 parameter automation is the most innovative and efficient way to prevent unwanted losses and improve process robustness. It ensures the process to use the required parameters of the product and introduces process automation that can error-proof the usage of the system by the users. It is recommended applying the same automation principle on other manufacturing plants that need error-proof design, wastage prevention, and process efficiency improvement. Worthy to note that continuous process improvement is vital to sustain the high-quality performance of semiconductor products and the assembly manufacturing. Aside from the related studies earlier shared, works and learnings discussed in [7-12] would help reinforce the robustness and optimization of die attach assembly process.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/66887