

# Digital Exhaust Controller for Pressure Detection on Die Attach Oven Curing Machine

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## Authors' contributions

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

## Article Information

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## ABSTRACT

Innovation on die attach curing process on semiconductor industry play a big role to have a robust process eliminating unwanted gross unit rejection. Resolving failures and hardware breakdowns on the exhaust system of oven curing process are the focus of this paper. Discoloration and contamination due to outgas and fumes that cannot exit the oven chamber are the effects of a failed exhaust system. Addressing the said phenomenon showing simulations, trial runs will be discussed on this paper. Promoting an innovative approach that includes real time monitoring of the system performance, and detection of its failure to prevent continuous operation with failed exhaust system are performed to have an appropriate resolution.

**Keywords:** Digital controller; discoloration; leadframe; outgassing; oven curing process.

## 1. INTRODUCTION

Continuous innovation and modernization on manufacturing plants of semiconductor industry are some of the drivers that make us what we

have and what we achieve on this modern world. Every personnel that contributes to the improvement fuels the population on their environment to continue to work hard and strive further. Different experiments and evaluations

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are considered and performed, considering all inputs from different experts to achieve manufacturing Process robustness and eliminate potential material wastage. We cannot deny that technology enhances and develops fast like the speed of light, and always being considered by many consumers to improve their lifestyle and enjoy the benefits of efficiency. That is the reason we must come up with the technology and innovation as we are stepping into the internet age of our generation.

Integrated circuits (IC) on semiconductor manufacturing are also applied by this modern technology through the process flow of its assembly. Starting with the wafer sawing of Silicon (Si) type of material, going to die attach and wire bond process that put the active die on a leadframe (LF), cured and interconnected by industry grade wires. Then it will be encapsulated by mold resin that will be singulated and tested to check its specified function. During die attach curing process which will be the focus of the paper, certain struggles and phenomenon are encountered during processing. Some of these struggles are leadframe discoloration and die contamination respectively that is observed and detected after the oven curing process has been

completed. Variables on the process like die attach material outgassing and exhaust contaminants are considered and must be eliminated. Detection and preventive actions to address the phenomenon are formulated in resolving the said occurrence that resulting to gross unit rejection and low process yield.

## 2. REVIEW OF RELATED LITERATURE

Discoloration and contamination on both die and leadframe are some of the common issues on die attach curing process. It can be caused by oxidation of Copper (Cu) LF material, or due to contaminants like foreign material present on the oven curing chamber that can cause gross rejection of processed units and product's malfunction. As seen in Fig. 1, different modes of contamination are manifested on leadframe, and Silicon die that propagates overtime and affecting other process downstream. Some studies in [1-4] emphasizes that some contaminants can introduce corrosion on the active metallic part of the Silicon die resulting to wirebond anomalies and molding process delamination or in Cu-based leadframes as shown in both Figs. 1 and 2.

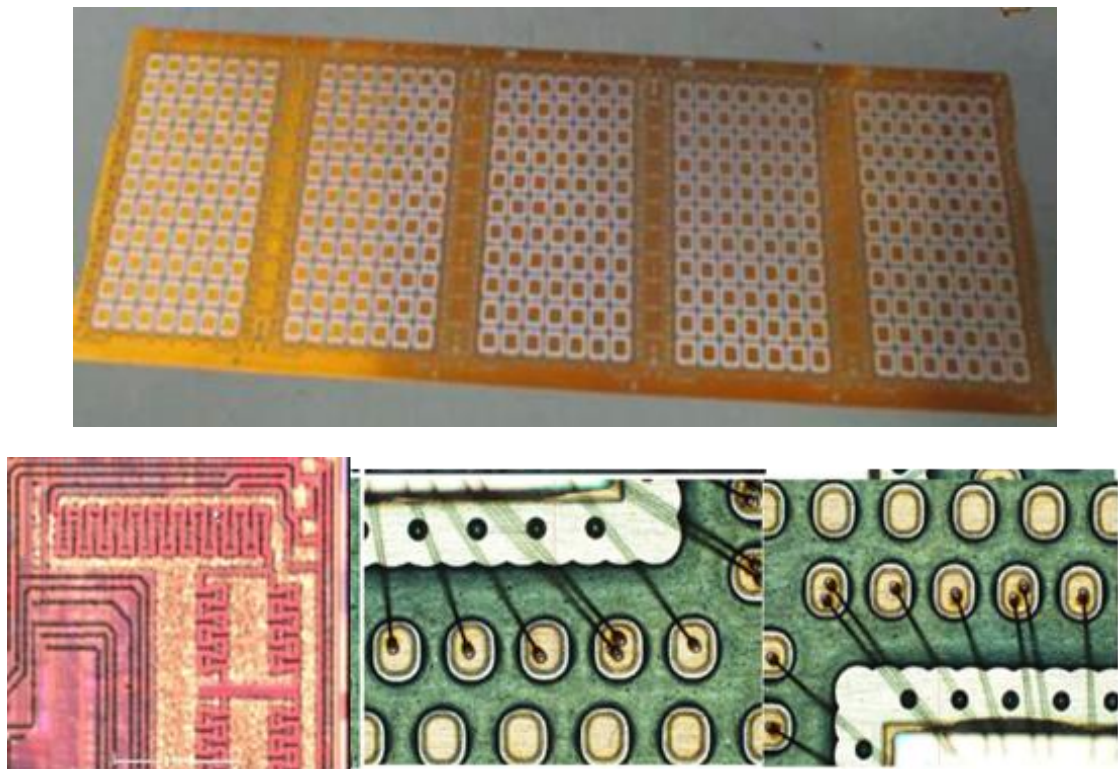
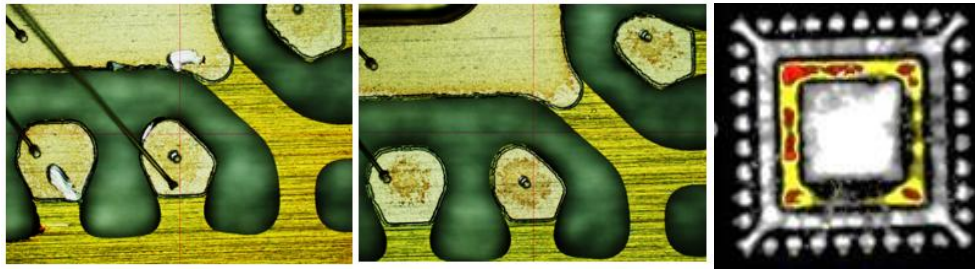


Fig. 1. LF discoloration and unit contamination observed after die attach curing



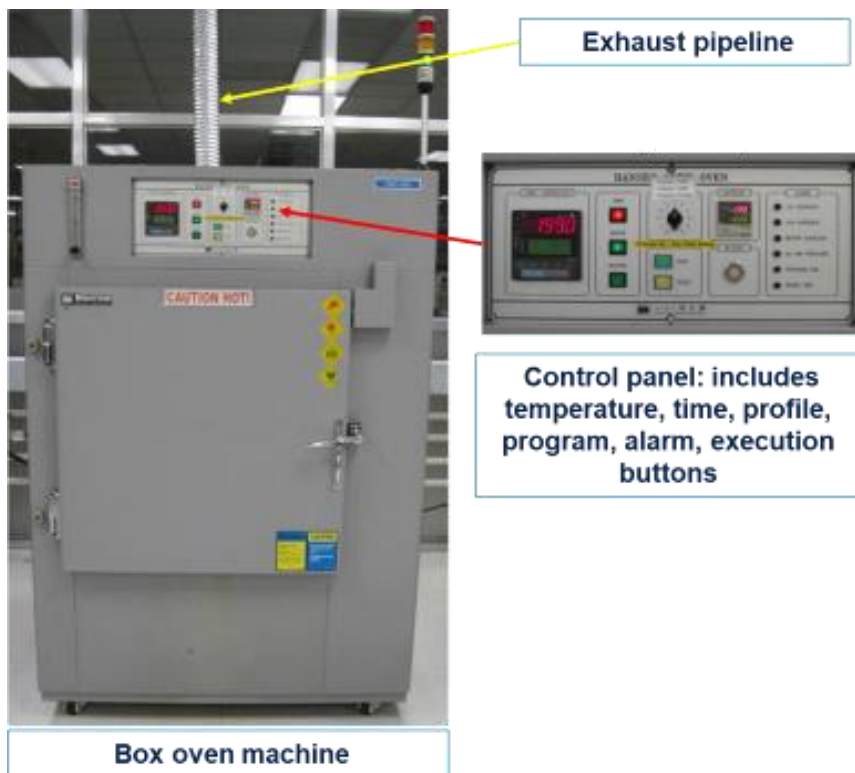
**Fig. 2. Wirebond and molding process defects caused by contamination**

Worthy to note that assembly manufacturing of semiconductor IC devices experiences a handful of challenges particularly at die attach process [5-8]. For this study, resolving the unwanted event of LF discoloration and unit contamination had been the focus, having different options and sequence considered, and finalizing the appropriate actions to eliminate the occurrence of the said phenomenon.

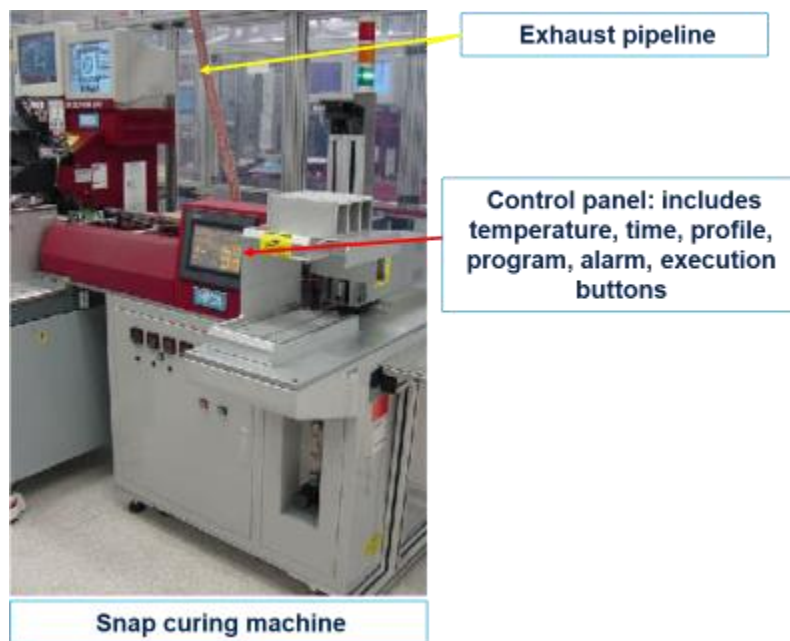
### 3. METHODOLOGY

Exhaust system on oven curing machine plays a significant part in die attach curing process, whether using box oven or snap curing machine.

box oven curing uses the conventional box oven machine and process the die attached units in a specific oven profile that includes defined temperature and time required by the product. Snap curing machine is another type wherein the machine has curing zones with different temperature, and the unit to be cured will pass through the zones by means of conveyor in a short span of time. From the word itself “snap curing” curing time required on this machine takes only a minute or two in processing die attached units. Figs. 3 and 4 show the example of box type oven machine and a snap curing machine respectively with exhaust pipeline connected on top.



**Fig. 3. Box curing machine**



**Fig. 4. Snap curing machine with exhaust pipeline connected**

Exhaust pipeline is interconnected on the oven curing machine as a standalone system to purge out epoxy die attach fumes and outgas from the processed units. The blower of the exhaust system “sucks out” these residues to prevent it from sticking and settling on the units inside the machine and goes straight on the manufacturing plant’s air treatment facility before dispersion. Eventually, exhaust system failure is inevitable for a continuous operation on manufacturing plants even though preventive maintenance and repeated inspections are performed. If this system fails, residue inside the oven curing machine will not exit, and go into the processed units contaminating all that is inside the chamber. Oven curing machine cannot detect the failure of the exhaust, thus, unwanted rejection of processed units and unscheduled downtime to repair the exhaust failure will take place. To prevent the wastages caused by discoloration and contamination, exhaust system failure must be detected and curing process must stop upon the detection of failed exhaust system. To have this kind of action, an integration of controller that detects the failure has been introduced.

#### 4. RESULTS AND DISCUSSION

Since die attach curing machines in default have no capability to detect exhaust pressure failures, this digital exhaust controller has been

introduced as the absolute improvement for the said phenomenon. The electronic instrument that was invented is composed of different instruments designed and built together to serve as a controller and shows real time performance of the oven curing machine’s exhaust system. It also detects system anomalies and failures (i.e., low to no pressure, pressure leak) and give signals to the machine to prevent continuous operation with failed exhaust system. With this system, gross rejection of the curing process with failed exhaust system can be prevented. Fig. 5 illustrates the basic schematic diagram of the controller in which it is integrated on the curing machine (in this case, snap curing machine).


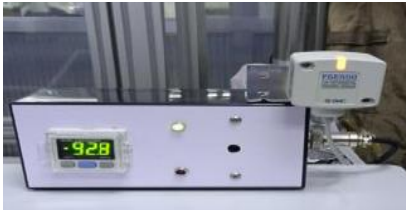


The controller composed of:

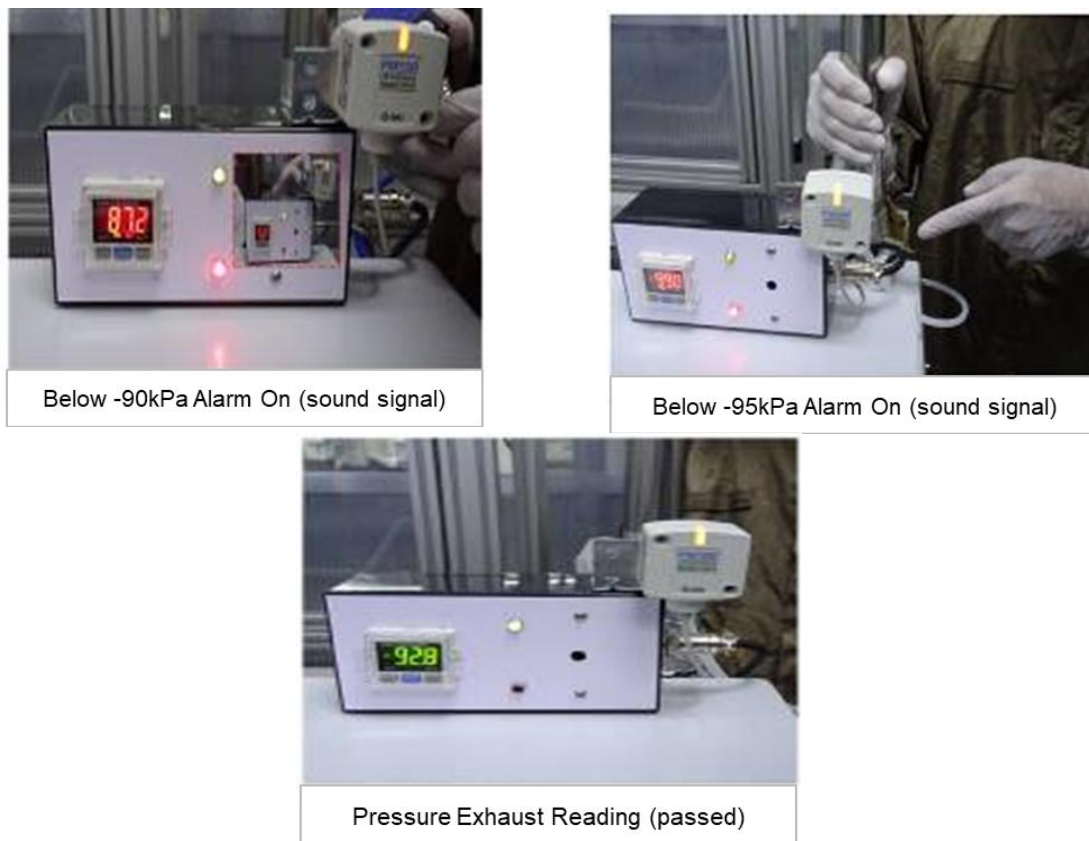
- A. Amplifier - the main controller with real-time pressure display indicator. Required pressure setting and limit is set in this instrument.
- B. Visual and Audio alarm – provides alert on the curing system for any abnormalities by means of light and sound.
- C. Pressure sensor – detects the actual pressure of the exhaust system and sends it on the amplifier.
- D. Relay output – the component inside the digital exhaust controller that give signals and commands to the machine.



Fig. 5. Digital exhaust controller

Table 1. Simulation of pass/fail reading on digital exhaust controller

Machine #	Pressure exhaust standard setup (kPa)	Actual pressure exhaust (kPa)	Actual photo	Remarks	Status
1	-90 to -95	-93.0		For validation, Pass as of workweek 2117	Operational
		-92.8		For validation, Pass as of workweek 2118	Operational
		-92.8		For validation, Pass as of workweek 2119	Operational
		-92.6		For validation, Pass as of workweek 2120	Operational



**Fig. 6. Actual simulation of pass/fail reading on digital exhaust controller**

To test the effectivity of the controller, simulation and test run was performed on one of the snap cure oven machines for a specific period as shared in Table 1. This simulation showed and monitored its performance comparing to normal oven curing machine with no digital exhaust controller installed. Included also on the simulation was the exhaust pressure checking that determines the effectivity of the exhaust system. As seen in Fig. 6, red number displays failed pressure reading, while green numbers show passing pressure reading. Machine alarm will activate also and stop the processing upon detection of failure reading.

## 5. CONCLUSION AND RECOMMENDATIONS

Having the digital exhaust controller on die attach curing machine makes an advantage to have a robust manufacturing process. Its detection capability to prevent the event of gross rejection and unwanted wastages caused by failed exhaust system innovates the current process and concluded to be a significant breakthrough on semiconductor industry. Further studies and

experiments to the hardware can be also considered to expand the scope of improvement for different products or the same. It is highly recommended to be applied and considered integrating on different curing machine with different or same application of process. Learnings from this manuscript combined with other ideas mentioned in the literature and in [8-12] would help reinforce and promote a lean and robust manufacturing on all branches of industry.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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