MECHANICAL DEVICES

New Era in Testing DUT over Temperature

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The process of manufacturing and qualifying IC's consists of many steps while Temperature forcing systems play a crucial role in the final testing process. These environmental tests assure quality and reliability by stressing the device on one hand as well as helping to characterize and validate it on the other hand (making sure manufacturing outcome meets the design requirements). At later stages the temperature testing can support failure analysis effort and root cause analysis. AS common practice we are dealing with few different kinds of temperature forcing systems: Chambers, Thermal Stream systems and Direct Thermal Head systems. In this article I would like to focus on the practical aspects of utilizing Thermal Stream systems and Direct Thermal Head systems.

Temperature Forcing Systems

Introduction

As integral part of the qualification and characterization process the Validation, Test and Product engineers need to verify that IC is functioning in different environmental conditions such as extreme temperature. In order to do so, extreme temperature conditions ought to be simulated and controlled first at the test lab and later on at the test house facility. This can be achieved by utilizing tools such as Thermal Stream systems and Direct Thermal Head systems.

What are they good for?

The great benefit of both systems is in the fact that they are relatively small and portable which makes it easy to move and share between test stations. The systems are versatile and are capable of simulating low temperature as well as high temperature. These qualities give them the ability to serve well the Product and Test Engineer at early stages of designing the IC and going forward while validating and performing full characterization of it. In some cases these systems can also come in handy post production for failure analysis efforts.

What are the limitations we face?

Unlike chambers, the Temperature Forcing System induce a small area and therefore are limited to test a single device. In addition, these systems are designed to work for limited period of time and not for many days/weeks as chambers. Both those factors should take part in test strategy consideration and affect the nature of tests which temperature forcing systems should be used for.

Thermal Stream System vs. Direct Thermal Head System

What are the system components?

Thermal Stream System: The system consists of compressed air, cooling system such as refrigeration and heating system to control the temperature of the air stream. The system also includes sensors to monitor the temperature surrounding the DUT (Device Under Test) and screen panel for controlling the system operation.

Direct Thermal Head System: The system contains cooling and heating capability and uses Plunger to transmit the temperature to the DUT. The Plunger itself contain thermal sensor to monitor the temperature. Addition of screen panel allows controlling the system operation.

Figure 2. Example of Direct Thermal Head Systems – the MaxTC from Mechanical Devices

What is the best location?

Most of Thermal Stream Systems are relatively big and aren't fit to work in small labs or offices. Their weight is more than 200KG (around 500lb) however there is an option to easily fold them therefore they are portable and mobile and can be transported from one test station to another while at the test floor. Though there are smaller and lighter systems available in the market (may weight as low as 14.5KG/32lb) and might be more suitable for small work spaces there is still major concern which is the noise level.

Due to the use of air flow, these systems are considered noisy and noise level can reach up to 70dBA. Not a good idea to use in the office…

Direct Thermal Head Systems are compact and very suitable for usage in small work spaces like small labs and offices. Its weight is about 22KG (~48lb) which makes it's easy to hand carry from one location to the other.

These systems don't rely on air flow which makes them significantly quieter. The measured noise level is around 40 to 45dBA.

What is the complexity of use and infrastructure setup?

Most of the Thermal Stream Systems require high power, 200 – 250 VAC (230V nominal) and about 30Amp. For countries which don't use these power levels as a standard such as U.S, CANDA and JAPAN special power outlet is necessary to ensure adequate functionality, in addition it is essential to install air supply at the test area. Often there will be a need to install more than one pair of power and air supply to support multiple test stations (one pair for each test station). Compared to that, the power requirements for Direct Thermal Head system are lower and designed to operate with 100 – 120VAC or 220 – 240 VAC and 10 – 15Amp. As a result, no special power outlet is required and on top of that it doesn't use air supply, which eases the deployment and makes it easier to port.

What are the considerations while planning thermal test?

Thermal Stream Systems use air convection to control the temperature of the DUT. It is well known that air is a poor conductor and it needs sufficient flow of air to move a thermal mass, as a result it takes more time to transfer the temperature to the IC case. In addition, the Thermal head (referred to as "elephant") is bigger than the DUT itself and might impact the temperature of components surrounding the DUT which would influence the test results. Impact might be minimized by using shroud kit (see figure 3) or silicon rubber to isolate the DUT. Thermal head, on the other

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hand, involves no special preparation before connecting to the board / socket.

Figure 3. Example for shroud kit

Direct Thermal Head System brings into play direct conduction and as such the temperature is transferred within seconds from the device plunger to the DUT. There is little to no influence to the surrounding components, which might improve the results and insure result integrity. However, we do need to keep in mind that in order to use the Direct Thermal Head some preparations are prerequisite to usage. Mechanical adapter plate needs to be attached to the socket or board before using the Direct Thermal Head, the adapter plate could be custom made or universal. In some cases, the customized adapter plate can be used only for one project/configuration and it can't be leveraged for other projects/ configurations.

Figure 4. Universal Adapter Plate.

What is the system accuracy?

Both systems show good temperature accuracy, about ±1.0˚C, which in most cases would be enough for IC testing. However, in some cases, such as testing thermal sensors, this accuracy level is not sufficient enough. In this case, the Direct Thermal Head system allows better resolution, with temperature accuracy of ±0.2˚C.

So how much will it cost?

Since the Thermal Stream Systems are more complex and include compressed air, cooling system and heating system, they require greater maintenance, which make it more expensive over time.

As no compressed air is needed for the Direct Thermal Head systems and required maintenance is straightforward, the overall price level is lower both while buying and while maintaining.

Summary

Comparison of thermal solutions

Item	Thermal Stream	Direct Thermal Head
Price	$20,000+	$12,500-19,500
Temp. Stability	±1.0˚C	±0.2˚C
Soak Time	~120sec	~30sec
System Size	Small unit: 40.1cm (15.8 inches) WIDE x 14.8cm (5.8 inches) HIGH x 48.9cm (19.2 inches) DEEP Large unit: Width: 61.0 cm (24 in.), Depth: 72.4 cm (28.5 in.)Height: 108 cm (42.5 in.)	High Power unit: L620mm (24.4in) x W480mm (18.9in) x H360mm (14.1in) Compact Unit: L420 (16.5") x W320 (12.5") x H 220 (8.5")
Footprint	>200mm	<80mm
Noise	up to 70dBA	40 to 45dBA
Stand-alone unit	Essential to install air supply. In some cases, special power outlet is necessary.	Real Plug & Play unit, ideal for IC design center where infrastructure is not available.
Maintenance	Need to maintain the Chiller & compressed air.	No need to maintain the chiller and compressed air. Calibration once a year.
Test condition	Thermal head is big and might impact the components surrounding the DUT	Temp. is conducted right where needed. Therefore, no overstress of peripheral components.

Both Thermal Stream Systems and Direct Thermal Head systems are capable and bring similar performance for temperature environmental testing. Nevertheless when we look closer at the differences between the systems and especially focus on size, noise level, complexity of use and pricing- it seems that the Direct Thermal Head systems give a more accessible and valuable solution.

It seems we are facing a new era in IC temperature testing.