Control Chip Temperature During VLSI Device Burn-in

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The display also shows global temperature settings for the burn-in board as well as actual minimum, maximum, and average temperatures and heater duty cycles. Burn-in-with-test systems can provide information about each DUT on a burn-in board. Here, green indicates satisfactory temperature performance; red indicates a temperature anomaly; and blue indicates a disabled device.

Burn-in Strategies

Burn-in strategies include static, dynamic, and burn-in with test. Static burn-in systems apply extremes of voltage and temperature to each device but do not exercise the device. Thus, static burn-in—in the least expensive of the burn-in strategies—does not stress all the potential failure mechanisms.

Dynamic burn-in systems exercise the device inputs and properly terminate the outputs in addition to applying extremes of voltage and temperature. With dynamic systems, electron charge transfers occurring at the exercised device’s circuit nodes initiate failure mechanisms that would escape static burn-in.

Burn-in-with-test test strategies stress devices while stressing them. They provide test vectors to a device and compare actual device outputs with expected outputs while the device under test (DUT) operates at its voltage and temperature limits. Burn-in-with-test systems can identify devices that fail to meet specification regarding either condition that would pass a post-burn-in in more rigorous test.

Burn-in-with-test systems also verify that a device under test gets exercised—that is, the device is powered up and test vectors are applied. Keep in mind that burn-in is testing—fragile high-pin-count components subjected to the repeated stress-and-recovery cycles of production burn-in—so devices are prone to failure. Just a few bad socket pins could prevent test vectors or supply voltages from reaching the device undergoing burn-in, resulting in your dropping or snagging parts that haven’t been electrically stressed. Therefore, it’s important to minimize handling and contact stress on devices being burned in.

An operator plugs devices into sockets on one side of a burn-in board (Fig. 2). A clamshell or other press fixture then brings a heat-sink assembly (Fig. 3) into contact with each device.

The heat-sink assembly contains a spring, temperature-sensor, and heater. The spring holds the temperature-sensor tightly against the device package to ensure good thermal contact. The control circuitry monitors the device temperature and applies the proper heater power to the device in order to maintain the required temperature.

Material Time Temperature

The conceptual model assumes that the package temperature is most important. The high-power burn-in system monitors and controls the package temperature, which is in turn determined by the die temperature in accordance with thermal impedances between the die, package, and heat sink. This thermal impedance is typically less than 0.5°C/W, depending on package, die, and die mounting method. Although the thermal impedance varies by device type, it’s usually uniform for a given part number.

You can calculate the package temperature (TP) required to maintain a specific die temperature (TD) from the thermal impedance (q) and the DUT heat dissipation (P):

\[ T_P = T_D - q \times P \]

For example, the package temperature required to provide a die temperature of 150°C for a device with the thermal impedance equal to 0.25°C/W and a heat dissipation of 10 W is as follows:

\[ T_P = 150°C - (0.25°C/W) \times 10 W = 147.5°C \]

Thus, controlling the package temperature to 147.5°C will maintain the die temperature at 150°C at 10 W dissipation.

Air Temperature and Velocity

A heat-sink chamber accommodates multiple burn-in-board heat-sink-assembly combinations and provides a uniform airflow. The optimum air temperature and velocity are functions of device power, the thermal characteristics of the heat-sink-assembly, and the required package temperature.

The quantity of heat transferred to the package is a function of the heat-sink-assembly temperature over the full potential range of heat dissipation. If the air stream carries away too much heat from the heat-sink assembly, the heater will not be able to maintain the package at the desired temperature. On the other hand, if the air stream carries away too little heat, the device will become too hot even with the heater turned off.

The heat-sink-assembly temperature is a function of the air stream temperature and velocity. The temperature of the air stream is proportional to \( T_{Ai} = T_{Ri} \times (V_{Ai} - V_{Rs}) \), where \( T_{Ai} \) is the air-stream temperature, \( T_{Ri} \) is the air-stream temperature, \( V_{Ai} \) is air velocity. Figure 4 illustrates airflow rates and air-stream temperatures for three rates of heat flow out of a heat-sink-assembly.

Figure 4. Many combinations of air temperature and velocity will remove a given amount of heat. Each of the three lines here represents the various combinations of air temperature and velocity that will provide the required heat flow from a heat-sink-assembly.

Air temperature and velocity are generally set so that the heater runs at half power (30%-duty cycle) when the device is operating at nominal power. This choice centers the heater output relative to the device power range. As the heat goes off the device increases, the control circuitry senses the temperature increase and reduces the heater power, allowing the package temperature to settle back to the setpoint temperature. Similarly, as the device dissipates less heat, the heater will dissipate more.

The total heat dissipation of the heat-sink-assembly is nearly constant as the power dissipation of the device varies under test. Thus, the air temperature and velocity, once appropriately set, need not be changed during testing. If a device under test needs a high or low temperature, this is provided by adjusting the air stream temperature and velocity at a particular device in the test chamber. For example, slightly warmer air at one device location would result in slightly less power to the heater for the corresponding device.

Control Software

A high-power burn-in system’s software can provide individual device temperature control and monitoring. In the Figure 5 example, the display provides color-coded information about each device; test codes provide details. The display also shows global temperature settings for the burn-in board as well as actual minimum, maximum, and average temperatures and heater duty cycles. TD/HP

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