Study on Calibration Method for Testing During Burn In equipment of integrated circuits

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Abstract. In order to implement Method 1015 of GJB 548B, TDBI(Testing During Burn In) technology of integrated circuit is widely used in the aging process of core VLSI(Very Large Scale Integration) which is included of FPGA, DSP, CPU and dedicated chips. Many models of TDBI equipment at home or abroad have been come into use. It is an important task to calibrate TDBI equipment in system level and ensure the traceability of its measurement value. At present, the calibration device of TDBI equipment has been successfully finalized and put into production, which has the advantages of convenient use and high cost performance. This paper mainly introduces the calibration method for TDBI equipment of integrated circuit from the aspects of the overall architecture design, signal adaptation design and calibration software design.

1. Introduction
TDBI equipment refers to a comprehensive aging test equipment that organically combines traditional aging with electrical performance test. The equipment can ensure the aging effect of integrated circuit, optimize aging time, detect the fault to the unit level and detect the "recoverable" fault (i.e. the fault that fails during high-temperature dynamic aging and returns to normal after recovering to normal temperature). TDBI equipment is widely used in high-end manufacturing fields such as weaponry, precision manufacturing, aerospace industry. Due to the different internal composition, measurement parameters and interface forms, calibration methods for TDBI equipment are different from conventional aging test equipment, especially under actual working conditions, the aging test chamber needs to be used to provide specific temperature and unconventional gas content in the measurement process. Hundreds of test channels are adapted and measured in each test area, which will bring greater difficulty and workload of actual operation.

This paper studies the calibration method of system level operability, and designs the hardware scheme and software scheme of the calibration device.

2. Principle and parameter of calibration

2.1. Principle of TDBI equipment
TDBI equipment is mainly composed of system controller, software platform, aging test chamber, and six subsystems (aging test, power supply, data process, temperature control, gas control and monitor)as shown in Figure 1. TDBI equipment works under certain temperature, nitrogen content and other environmental conditions, by implanting a variety of complex signals and test patterns, it can
measure the signal of each output pin, truly ensure the aging effect and eliminate the devices with quality defects[1-3].

2.2. Parameter analysis of calibration
The Parameters mainly involved in the calibration of TDBI equipment include:

1. The aging test subsystem mainly involves digital channel driver, rise time, PMU (precision measurement unit), rise time and test rate.

2. The power supply subsystem mainly involves program-controlled voltage and current drive and load adjustment rate.

3. The temperature control subsystem mainly provides the specified temperature conditions for the aging test chamber, involving temperature setting and temperature fluctuation.

4. The gas control subsystem fills nitrogen to reduce the oxidation degree of IC pins during the aging test, which involves the nitrogen content.

5. The monitoring subsystem is used to monitor and protect functions of temperature, power supply and gas environment conditions.

2.3. Calibration method of TDBI equipment
The calibration method of TDBI equipment is shown in Figure 2, that is, under certain temperature and gas environment conditions, for the calibration of DC parameters, the special DC calibration interface is connected to the outside of aging test chamber, the matrix switch is used to realize the switching between multiple channels, and the standard resistance can be installed in the calibration interface adaptation box, programmable resistance module can also be used; For the calibration of AC parameters, the special AC calibration interface with high temperature resistance shall be connected to the outside of the aging test chamber; For the temperature and gas environment conditions, special calibration interfaces are respectively connected to the outside of the aging test chamber. Finally, external instruments are used to calibrate each calibration parameter[4-5].

Figure 1. Schematic diagram of TDBI equipment
3. Implementation of calibration method

Calibration device is designed according to the calibration method. By configuring reasonable external instruments and meters, various calibration interface adapters are connected to the aging test chamber, and the parameters are detected at the slot end of the corresponding test area.

In order to reduce the volume of equipment, this paper adopts the calibration device based on PXI and virtual instrument technology. Through the reasonable layout and overall architecture design between instruments, the network interface is used to realize the communication between TDBI equipment and computer, so as to realize the automatic or semi-automatic calibration process.

In addition, the calibration interface and connecting cable outside the aging test chamber are designed in a universal way, so that the adaptation and connection of each set of TDBI equipment follow certain standards, reducing the complexity of developing calibration interface and connecting cable for specific TDBI equipment[6-8].

3.1. Selection of PXI

The external instruments and meters of the calibration device are composed of PXI, which are installed in the peripheral modules slot of PXI controller through PXI bus. As the main control module of the calibration device, the PXI controller is installed in the system controller module slot. Ethernet and other communication bus to complete the control of the calibration device.

The PXI selected include: 1) PXI controller: pxie-8840; 2) digital multi-meter: pxie-4071; 3) programmable resistance: Pickering 40-297-050; 4) matrix switch: Pickering 40-535-021; 6) DC power supply: pxi-4132; 7) oscilloscope: pxie-5185[9-10].

3.2. Adaptation design

The adaptation mode of the calibration device is shown in Figure 3. The function of the calibration interface is to realize the connection between the calibration device and various measured resources, connect the output signal of the calibration device to the calibration channel of the calibrated system, or transfer the output signal of the corresponding resources of the calibrated system to the measurement channel of the calibration device. The calibration interface adaptation is mainly divided into DC parameter calibration interface, AC parameter calibration interface, temperature and nitrogen content calibration interface. The DC parameter calibration interface is composed of aging adaptation...
board, signal interface adapter, high temperature resistant cable and supporting cable at the calibration end; AC parameter calibration interface is composed of aging adapter board and high temperature resistant RF cable; The temperature and nitrogen content calibration interface can be composed of sensor and high temperature resistant lead.

Figure 3. Schematic diagram of adaptation mode of TDBI equipment

The signal interface adapter board inside the aging test chamber is installed on the slot of the aging test chamber. The signal interface adapter board adopts the same size and connection mode as the aging test board according to the manufacturer's resource definition, and adapts to the definition and line sequence of high-temperature resistant cables. Therefore, the signal interface adapter chamber does not need to be redesigned and can realize the universal adaptation between the calibration device and the calibrated object. When designing the signal interface adapter board, materials with excellent heat resistance, high mechanical strength, good dimensional stability and low z-axis expansion coefficient, such as FR5 or polyimide (PI), are selected as the plate of the signal interface adapter board. At the same time, AC and DC connectors and cables with temperature resistance above 150 °C are selected to lead the calibrated signal out of the test chamber through the signal interface adapter board, Connect the calibration instrument so that the calibration instrument and other components of the calibration device that are not resistant to high temperature are not affected by the high temperature working condition of the aging test chamber.

As shown in Figure 4, the signal interface adapter board designed in this paper is designed with four groups of 90pin sockets connected with the slots of the aging test chamber. The signal interface adapter board is designed with high current terminals for the calibration of high current single channel, and high temperature resistant connectors for the connection with high temperature resistant cables. The signal interface adapter chamber is connected to the signal interface adapter board in the aging test chamber through 80pin high temperature resistant cable, and connected to the corresponding source table of the calibration device through banana plug cable. Finally, all resources are connected to the matrix switch of the calibration device through 100pin standard flat cable, so as to realize the dot matrix connection between multi-channel test equipment and matrix switch in IC aging.
3.3. Calibration software design
In order to conveniently realize the control, signal acquisition, signal processing and analysis, file input and output, real-time process control and display of various external instruments and meters of the calibration device, the calibration software is used to realize the above functions. The calibration software is composed of the general calibration software in the PXI controller and the special calibration program module in the aging test equipment. The control command and data transmission between the general calibration software and the special calibration program are realized through Ethernet (TCP/IP Protocol). The general calibration software runs on the PXI. The calibration instrument and the general calibration software can pass through the PXI bus GPIB bus, LAN bus and serial port realize communication.

The work flow of the calibration software includes: 1) start each hardware module of the calibration device, initialize itself, control the calibration device through the communication bus to complete the hardware configuration and parameter initialization, and establish a communication connection with the TDBI equipment; 2) Select the parameters and channels to be calibrated according to the needs, first control the test equipment in the aging process under the actual working conditions, and generate the parameters to be calibrated in the slot of the aging test chamber, then control the PXI at the end of the calibration device for measurement and channel switching, and return the measurement results of each calibration channel to the calibration software; 3) After all parameters are calibrated, the calibration software saves the measurement results as corresponding files.

4. Summary Conclusion
By analyzing the structure and working principle of TDBI equipment, this paper studies a field calibration method of multi-parameter and multi-channel TDBI equipment based on general test interface under actual working conditions, and finally designs a calibration device based on virtual instrument technology. The design and construction of calibration device is an important way to realize the full test area and full parameter calibration of TDBI equipment, and ensures the high efficiency and reliability of calibration of the IC aging equipment. The calibration device unifies and standardizes the calibration interface and connecting cable by reusing the hardware and modularizing the software, so as to minimize the workload of repeated development of test equipment in the later aging of specific integrated circuits, and has a broad application prospect.

The next step of the calibration method is to minimize the workload of repeated development for specific model test systems in the later stage, and implement the calibration operation of TDBI
equipment by developing a calibration device compatible with GPIB, PXI, USB and LAN bus interface instruments.

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