Research and development of public service platform for integrated circuit test

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Abstract. Integrated circuit (IC) test is a key technical part of IC chain, which works through the entire life cycle of IC design, manufacturing, packaging, and application. Based on the increasing requirements of IC test, this paper analyzes the breakthrough point to promote the development of IC test and puts forward an accurate and feasible programme of public test platform construction so as to achieve long-term sustainable development of IC industry.

Keywords: Integrated circuit, Public service platform, IC test.

1 Introduction

Integrated circuit (IC) is the foundation stone of the modern information society, which are used in several large and important applications such as ac/dc conversion, LED lighting, gate drivers for power modules and so on. The diverse market includes consumer electronics, household appliances, industrial electronics communications systems, and lighting. IC test has been a center of focus for many years. The development of IC design, process and package technology has presented challenges to IC test, which leads engineers to face new quality requirements [1]. In this paper, the first objective is to demonstrate the test requirements of IC industry types of IC test. The second objective is to propose a possible program of public service platform for IC test.

2 Contents of IC test

IC is typically tested with a test flow consisting of three test instances [2]: (1) wafer sort for the bare chip, (2) intermediate test for the partially complete stacks, and (3) package test for the packaged IC. IC manufacturing is extremely complex, which increases the risk of defects. Thus, each and every IC should be carefully tested [3]. The typical test flow is drawn in figure 1.

The test cost[4] of ICs depend on a large number of factors, such as the hardware manufacturing cost that includes wafer fabrication, packaging, DfT (design for test), fault coverage, and test equipment, the test time and yield. Minimizing the time spent on testing implies reducing defects in the manufacturing process by upgrading production

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technologies.

Table 1. The main products and execution standards - classified by signal processing mode.

Type of products	Execution standards
Digital circuits	IEC 60747 Semiconductor devices
	IEC 60748-1 Semiconductor devices. Integrated circuits. Part 1:General
	IEC 60748-2 Semiconductor devices. Integrated circuits. Part 2:Digital integrated circuits
	MIL-STD-750F Test Methods For Semiconductor Devices
	GB/T 16464 Semiconductor devices. Integrated circuits. Part 1:General
	GB/T 17574 Semiconductor devices. Integrated circuits. Part 2:Digital integrated circuits
Analog circuits	IEC 60747 Semiconductor devices
	IEC 60748-1 Semiconductor devices. Integrated circuits. Part 1:General
	IEC 60748-3 Semiconductor devices. Integrated circuits. Part 3:Analogue integrated circuits
	MIL-STD-750F Test Methods For Semiconductor Devices
	GB/T 16464 Semiconductor devices. Integrated circuits. Part 1:General
	GB/T 17940 Semiconductor devices. Integrated circuits. Part 3:Analogue integrated circuits
Mixed-signal circuits	IEC 60747 Semiconductor devices
	IEC 60748-1 Semiconductor devices. Integrated circuits. Part 1:General
	IEC 60748-23 Semiconductor devices. Integrated circuits. Hybrid integrated circuits and film structures. Manufacturing line certification
	MIL-STD-750F Test methods for semiconductor devices
	GB/T 16464 Semiconductor devices. Integrated circuits. Part 1:General
	GB/T 15138 Case outlines for film integrated circuits and hybrid integrated circuits
Interface circuits	IEC 60747 Semiconductor devices
	IEC 60748-1 Semiconductor devices. Integrated circuits. Part 1:General
	IEC 60748-4 Semiconductor devices. Integrated circuits. Part 4:Interface integrated circuits
	MIL-STD-750F Test methods for semiconductor devices
	GB/T 16464 Semiconductor devices. Integrated circuits. Part 1:General
	GB/T 18500 Semiconductor devices. Integrated circuits. Part 4:Interface integrated circuits

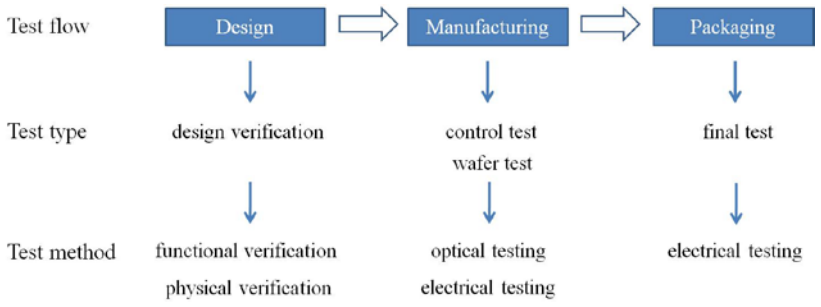

Fig. 1. Test parts in IC chain.

Table 2. Typical test items in IC industry.

Test service	Items	Test standards
RA	HAST	JESD22-A110E Highly accelerated temperature and humidity stress test (HAST)
	UHAST	JESD22-A118 Accelerated moisture resistance unbiased HAST
	HTOL	JESD22-A108 Temperature, bias, and operating life
	HTSL	JESD22-A103E High temperature storage life
	PCT	JESD22-A102-C Accelerated moisture resistance - unbiased autoclave
	IR-reflow	JEDEC J-STD-020E Moisture/reflow sensitivity classification for nonhermetic surface mount devices
	SD	JESD22-B102E Solderability
	ESD-HBM	JEDEC JESD22-A114E Electrostatic discharge (ESD) sensitivity testing human body model (HBM)
	ESD-CDM	JEDEC JESD22-A115-A Electrostatic discharge (ESD) sensitivity testing machine model (MM)
	ESD-MM	JESD22-A115C Electrostatic discharge (ESD) sensitivity testing machine model (MM)
	LATCH UP	JEDEC JESD78D IC Latch-up test
FA	C-SAM	/
	X-RAY	/
	DECAP	/
	SEM	/
	FIB	/
	EMMI	/
	OBIRCH	/
DPA	Visual inspection	MIL-STD-750D Test method standard for semiconductor devices MIL-STD-883H Test method standard for microcircuits MIL-STD-1580B Test method standard for destructive physical analysis for electronic, electromagnetic, and electromechanical parts
	X-ray inspection	
	PIND	
	Physical Check	
	Airproof Check	
	Decap	
	SEM/EDAX	
	C-SAM	
	Terminal strength	
	Pull Test	
	Attachment's strength	
	Integrality inspection for glass passivation	
	Bonding strength	
	Contact Check	
MA	TEM	/
	SIMS	/
	IR	/
	Raman	/
	AFM	/
	XRF	/
	ICP-MS	/
	XPS	/
	RoHS	IEC 62321 Determination of certain substances in electrotechnical products; GB/T 26572 Requirements of concentration limits for certain restricted substances in electrical and electronic products

Due to the obvious trend of vertical division in IC chain and the huge investment in the manufacturing equipments, the companies which could independently complete professional test are rare. However, the demand for verification analysis and industrialization test of many design companies is very huge, and the relationship between supply and demand of IC test resources is extremely unbalanced. On one hand, small and medium enterprises, which could not afford expensive test equipments, are always confused with finding the right test equipments for rent. On the other hand, test equipments of companies with independent test capabilities often lie in an idle state for a long time due to the long cycle of IC manufacturing. For that reason, test has increasingly become a key factor restricting the development of IC industry.

3 Construction of public service platform

IC industry, which is capital intensive, technology intensive and talent intensive, has the characteristics of large investment, long income time and high investment risk. The demand for public services is very urgent. Firstly, the existing resources should be fully integrated. Secondly, the idle resources of manufacturing factories might be opened up in an orderly manner. And finally the needed capacity of the industry should be improved to realize the coordinated development of platform construction and enterprise manufacturing. The public platform should be able to carry out appraisal inspection, quality consistency inspection, single inspection, failure analysis, standard formulation and so on.

The platform aims at serving IC industry, which includes digital IC, analog IC, mixed-signal IC, and so on. The main products and execution standards are listed in table 1.

The test service includes reliability analysis (RA), failure analysis (FA), destructive physics analysis (DPA) and material analysis (MA). RA is the measurement of the product durability. FA is the post-hoc inspection of a failed device. DPA is to verify that the design, structure, materials, process conditions and manufacturing quality of the components meet the requirements of the intended purpose or relevant specifications. And MA includes three parts: element analysis, structure analysis and morphology analysis. The test items are listed in table 2 in detail.

4 Conclusion

It is extremely necessary and urgent to develop public service platforms for IC test, which could significantly reduce the entrepreneurial threshold and R&D costs for IC enterprises, especially small and medium-sized ones. Meanwhile, related talents could be concentrated and provide feasible advices for formulating industrial policies, which promote the leapfrog development of IC industry.

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