Material Issue

Product Quality

Quality Culture Enhancement
- Enhance internal quality culture by promoting continual improvement programs
- Enhance local supply chain's quality culture and competitiveness by promoting their participation in National Quality Control Circle competition

Quality Capability Enhancement
- Increase employees' productivity by establishing 12-inch wafer outgoing visual inspection defect automatic classification system with machine learning methodology
- Ensure employees' health and safety by establishing chemical lab's capability for hazardous substance analysis

Quality Application Realization
Complete reliability qualification for leading technologies and specialty technologies at design and development stage according to the technology roadmap

Strategies

TSMC 2020/2025 Goals

- Create NT$10 billion benefit from continual improvement programs annually
- 90% local suppliers participate in the National Quality Control Circle competition (original goal "80%" is planned to be achieved in 2018)
- Increase visual inspector's monthly productivity for 12-inch wafers to 5,670 pieces
- Establish 100% (813) materials' analysis capability for carcinogenic, mutagenic, or toxic for reproduction (CMR) substances
- Complete reliability qualification for 5nm technology and characterize the process window
2017 Achievements

42,056 Suggestions were issued from basic level
Target: Issue 38,000 suggestions

2,020 Continual improvement cases were completed
Target: Complete 1,850 continual improvement cases

10.1 billion Benefit created from suggestions and continual improvement cases
Target: Create NT$10 billion benefit

4,747 Increased visual inspector’s monthly productivity for 12-inch wafers to 4,747 pieces
Target: 4,500 pieces 12-inch wafer

74% Established 23% (183) materials’ analysis capability for carcinogenic, mutagenic, or toxic for reproduction (CMR) substances
Target: Established 18% (146) materials’ analysis capability

2018 Targets

Completed reliability qualification for 7nm technology and characterized the process window
Target: Complete reliability qualification for 7nm technology and specialty technologies

Completed the second generation Integrated Fan-Out (InFO) assembly technology and reliability qualification for application processor with integrated passive device

Completed the Chip on Wafer on Substrate (CoWoS) assembly technology and reliability qualification for advanced silicon technology chip with High Bandwidth Memory

Completed the Diffractive Optical Element (DOE) process development and reliability qualification to support mobile phone with 3D sensing and facial recognition application

Issue 41,228 suggestions from basic level

Complete 1,957 continual improvement cases

Create NT$10 billion benefit from suggestions and continual improvement cases

80% of local suppliers participate in the National Quality Control Circle competition

Increase visual inspector’s monthly productivity for 12-inch wafers to 4,860 pieces

Establish 49% (396) materials’ analysis capability for carcinogenic, mutagenic, or toxic for reproduction (CMR) substances

Completed reliability qualification for leading technology and specialty technologies according to R&D’s goal
Quality is the critical factor for TSMC’s sustainable development. To continuously provide excellent product quality while providing a green, healthy, safe and enjoyable working environment, and also establish a customer-oriented approach to quality – these are what the Quality and Reliability Organization have always insisted upon.

The sciences and technologies change with each passing day. In addition to traditional 3C (Computer, Communication, Consumer) products, with the increasing popularity of new electronic products – Mobile Device, Internet of Things (IoT), Smart Car, Virtual Reality (VR) and Artificial Intelligence (AI) – our safety and convenience are closely linked with the quality and reliability of electronic products. Semiconductors are the soul of electronic products, and TSMC is the world’s largest integrated circuit technology and services provider. We lead in technology development, achieving our commitment to our customers to provide them with the quality and reliability they count on, along with low power and high performance.

To ensure sustainable development with excellent product quality, the Quality and Reliability organization promotes continual improvement activities for TSMC’s quality culture enhancement and deploys them to supply chains for management consideration, introduces new methods for quality capabilities enhancement, and collaborates with other organizations to have strict reliability qualifications for ensuring each product application.

Quality Culture Enhancement

In TSMC, quality is the basis for all work and services. All employees are dedicated to increasing quality in all aspects of our business. The benefits are not only product quality improvement but customer satisfaction enhancement.

To enhance corporate quality culture with continual improvements on product quality, production efficiency, cost reduction and customer satisfaction, TSMC fully promoted the "Suggestion" in basic levels and the activities of "Continual Improvement Team (CIT)". TSMC also held a corporate-level "Total Quality Excellence and Innovation Conference." With the public rewards and praises, we expect to provide a cross-department communication and study platform with continual improvement cases sharing. It aims to enhance employees’ problem solving and innovation capabilities for achieving the win-win goal of TSMC’s competitiveness and customer satisfaction. In 2017, there were 42,056 suggestions issued by the basic levels and a total of 2020 continual improvement team activities were registered and implemented. The benefits from these improvement cases were NT$10.1 billion. Among them, 45% (915 cases) of continual improvement team activities were related to product quality enhancement.

Note 1: Suggestion – Employee identifies ways to improve routine jobs and initiates action with the manager. The scope of suggestion includes Quality, Cost, Transportation, Production Process, Service, Safety, Facility and Equipment.

Note 2: Continual Improvement Team (CIT) – A cross-functional task force formed with three to 10 members solves the same work-related problems. The improvement targets are related to Quality, Cost, Delivery, Service, Productivity, Process Technology and Safety.
In addition to internal cross-department communication and study, TSMC also participates in the ‘National Quality Control Circle’ competition to share and learn continual improvement methods in a cross-industry communication and study setting. Other local industries can adopt improvements learned from TSMC’s sharing, and TSMC employees can also enhance capabilities of problem solving and innovation with the learning from others’ sharing. In 2017, TSMC secured six gold and two silver medals in the National Quality Control Circle competition and Fab 6 was the team with the most gold medals since the inception of these awards. With their perfect mechanisms for continual improvement, TSMC also won first prize for ‘Excellent Promotion for Continual Improvement Activities in Taiwan’ over the past 30 years.

Examples in 2017 Total Quality Excellence and Innovation Conference

<table>
<thead>
<tr>
<th>Group</th>
<th>Cases</th>
<th>Benefit</th>
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<tbody>
<tr>
<td>Quality Enhancement</td>
<td>To improve the methods in Lithography processes</td>
<td>99.7% Enhanced product yield to 99.7%</td>
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<td></td>
<td>To improve the methods in Integrated Fan-Out (InFO) clean process</td>
<td>88% Improved test reject rate 88%</td>
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<td></td>
<td>To improve the methods in Furnace process</td>
<td>75% Reduced specific product defect rate 75%</td>
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<td></td>
<td>To improve the methods in 3D image sensor Etching process</td>
<td>50% Enhanced image resolution 50%</td>
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<tr>
<td>Customer Satisfaction</td>
<td>To develop 40nm Ultra Low Power technology</td>
<td>80% Improved customer product standby power performance 80%</td>
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<tr>
<td></td>
<td>To establish innovative design service platform for stacked CMOS image sensors</td>
<td>70% Shortened customer product development schedule for image analysis and test 70%</td>
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<tr>
<td>Environment, Safety, Health</td>
<td>To reduce 6-inch Fab carbon emissions and save energy</td>
<td>63,500 metric tons Reduced CO₂ emission 63,500 metric tons and saved the use of electricity 60,290,000 kWh annually</td>
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Note 1: In Taiwan, the National Quality Control Circle competition is held by Corporate Synergy Development (CSD) Center which is commissioned by the Industrial Development Bureau of the Ministry of Economics. The purpose of the National Quality Control Circle competition is to promote the continual improvement team activity to public and private organizations for their enhancement. With the competition, organizations among different industries have a communication and study platform to learn improvement methods from others and enhance their international competitiveness.

To strive for a win-win between TSMC and local suppliers, the Quality and Reliability organization not only enhances TSMC’s corporate quality culture, but also coaches local suppliers to participate in the National Quality Control Circle competition for suppliers’ quality culture and capability enhancement by applying the practices of continual improvement. In 2017, local suppliers’ participation rate in National Quality Control Circle competition was 74% and suppliers secured two Silver Medals and seven Bronze Medals.

Quality Capability Enhancement

The failure analysis capability plays an important role to support advanced and specialty technology development, reliability qualification and mass production timing. To help customers meet their time-to-market requirements, the Quality and Reliability organization collaborates with academics, suppliers and customers to develop failure analysis techniques, enrich advanced material and chemical analysis capabilities and enhance fault isolation methods. TSMC continually enhances its manufacturing capabilities. To reduce product defects, enhance process controls, detect abnormalities early and prevent quality events affecting customers, the Quality and Reliability organization and Operation organization collaborate to establish real-time defense systems by applying advanced statistical methods and quality tools. In 2017, the deep machine learning methodology had successfully been applied for advanced spectral analysis to detect differences among processes and equipment, and triggered improvement actions. With machine learning methodology, an automatic defect classification system for 12-inch wafers outgoing visual inspection was also established to enhance the consistency of visual inspection and enrich a visual inspector’s monthly productivity to 4,747 pieces.

Highlights in 2017

- Enhanced 35% resolution of fault isolation equipment
- Completed fault isolation capability buildup for 7nm, extendable to support 5nm
- Established scanning and transmission electron microscopy laboratory in Nanjing site and executed failure analysis since Nov. 2017
- Enhanced trace metal impurity analysis capabilities to Part Per Trillion (PPT) level for 10 chemicals
- Established organic impurity analysis capabilities for 10 chemicals
- Coached suppliers to enhance their analysis capabilities for trace metal impurity in chemicals to Part Per Trillion (PPT) level
- Coached suppliers to establish organic impurity analysis capabilities for chemicals
On the other hand, to prevent carcinogenic, mutagenic and reprotoxic (CMR) substances in materials affecting employees' health and safety, Quality and Reliability organization enhanced the chemical laboratory's ability to detect and analyze hazardous substances. With risk assessment, the Quality and Reliability organization collaborated with the Environmental Safety and Health organization to establish a sampling plan for analyzing suspicious materials used in TSMC. For new material control, suppliers were also required to declare their compliance and a sampling inspection was executed by TSMC to validate suppliers' declarations. In 2017, the Quality and Reliability organization established 23% (183) suspicious materials' analysis capability for CMR substances.

In addition to meeting customers' requirements, striving for customers' satisfaction and creating customers' value, product quality must be balanced with environmental sustainability to ensure environmental and ecological stability, and sustainable development. To comply with the European Union's regulations and the customer's green product requirements, TSMC integrated the IECQ QC 080000 hazardous substance process management system developed by the International Electrotechnical Commission Quality Assessment System with automotive quality management system IATF 16949. The hazardous substance management requirements were built-in the operations of process design and development, material procurement, supply chain management and process controls. In 2017, suppliers were required to provide materials with non-PF0A (Perfluorooctanoic acid) derivatives for replacement of existing materials with PF0A derivatives. Additionally, a third-party audit verified the effectiveness of TSMC's hazardous substance process management system and quality management systems in compliance with IECQ QC 080000 and IATF 16949. Equally important, the products made by TSMC complied with European Union regulations and customer requirements with the sampling validation by a third-party external laboratory.

Quality Application Realization

To provide excellent and reliable product quality for customers' requiring timely delivery, ensuring users' safety and product applications, and preventing post-production recalls, the Quality and Reliability organization assists customers in the technology developmental stages and product design stages to design-in superior product reliability. An automotive quality improvement program is in place to meet automotive customers' low Defect Parts Per Million (DPPM) requirements.

In 2017, the Quality and Reliability organization collaborated with R&D to complete reliability qualifications for leading-edge 7nm technology (the third FinFET generation), the second generation Integrated Fan-Out (InFO) assembly technology for application processors with integrated passive devices, the Chip on Wafer on Substrate (CoWoS®) assembly technology for advanced silicon technology solutions with High Bandwidth Memory, and the Diffractive Optical Element (DOE) supporting mobile phone with a 3D sensing and facial recognition application. In addition, the design rules for automotive products were also enhanced and the Automotive Quality System migrated to version 2.0 which enhanced Fab in-line and Wafer Acceptance Test process capability and strengthened maverick wafers handling. TSMC also provided dedicated resources for customer return analysis and timely physical failure analysis (PFA) for process improvement. With these efforts, TSMC did not have any product recalls in 2017.

For more details, please refer to TSMC’s 2017 Annual Report "5.3.5 Quality and Reliability".