Quality Handbook

November, 2022
Device Solutions
Samsung Electronics Co., Ltd.

SAMSUNG

Rev. 06

Disclaimer:

SAMSUNG ELECTRONICS CO., LTD. AND ITS AFFILIATES (COLLECTIVELY, “SAMSUNG”) ASSUMES NO LIABILITY WHATSOEVER, AND SAMSUNG DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY,

ARISING OUT OF OR RELATED TO THE INFOMRATION CONTAINED HEREIN AND YOUR PURCHASE, APPLICATION AND/OR USE OF SAMSUNG PRODUCTS INCLUDING WARRANTIES RELATED TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR NON-INFRINGEMENT.

THIS DOCUMENT IS PROVIDED FOR REFERENCE PURPOSES ONLY, AND ALL INFORMATION DISCUSSED HEREIN IS PROVIDED ON AN "AS IS" BASIS, WITHOUT WARRANTIES OF ANY KIND. SAMSUNG ASSUMES NO RESPONSIBILITY FOR POSSIBLE ERRORS OR OMISSIONS, OR FOR ANY CONSEQUENCES FROM THE USE OF THIS DOCUMENT.

This document and all information discussed herein remain the sole and exclusive property of Samsung. Except your limited right to use this document for internal evaluation purpose, no license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document. Samsung makes no commitment to update the information contained in this document, and Samsung reserves the right to change this document at any time without notice.

All brand names, trademarks and registered trademarks belong to their respective owners.

Table of contents

Figures

Tables

1. The Samsung Quality Policy

Samsung Device Solutions ("Samsung") has been continuously enhancing the quality management system to achieve the best quality in all products and services.

Samsung's Quality Policy statement:
"We deliver, on the basis of an efficient quality system, the best products and services which conform to our customer requirements and expectations."

The quality objectives of Samsung's are measurable and consistent with quality policies. Quality objectives include key performance indicators by processes and joint quality improvement projects with customers and suppliers.

2. Samsung's Quality Management System (QMS)

2.1 Quality Management System Framework

Samsung has the world's best QMS based on ISO9001/IATF16949. Samsung's QMS has been constantly evolving to satisfy various needs. Samsung meets requirements from our customers as well as international standards such as ISO9001/IATF16949.

For Samsung's international standard certification history, see
https://www.samsung.com/semiconductor/support/quality-management/.

Requirements from ISO9001/IATF16949 and customer are served as the baseline for Samsung's QMS. Samsung's QMS implements Plan-Do-Check-Action (PDCA) cycle into the system to provide sufficient resources for the process and improve overall performance continually.

Figure 2-1. QMS Model-PDCA Cycle

2.2 Audit Program

There are three types of audit program: third-party audit (certification audit), second-party audit (supplier audit) and first-party audit (internal audit).
Samsung has obtained international standard QMS certifications such as ISO9001/IATF16949 and has been maintaining this through annual audit from an accredited certification body. Supplier audits are conducted for monitoring of supplier to maintain stable sourcing quality of materials and to improve quality of them as well.
Internal audits are performed on a regular basis to ensure compliance of QMS requirements by using checklist which encompasses all processes. In case any nonconformity is found, relevant department quickly investigates and analyzes the potential cause(s), takes corrective actions and establishes preventive measures. These multiple approaches to quality audits enable us to prevent, detect, and take containment actions for important quality issues properly in a timely manner.

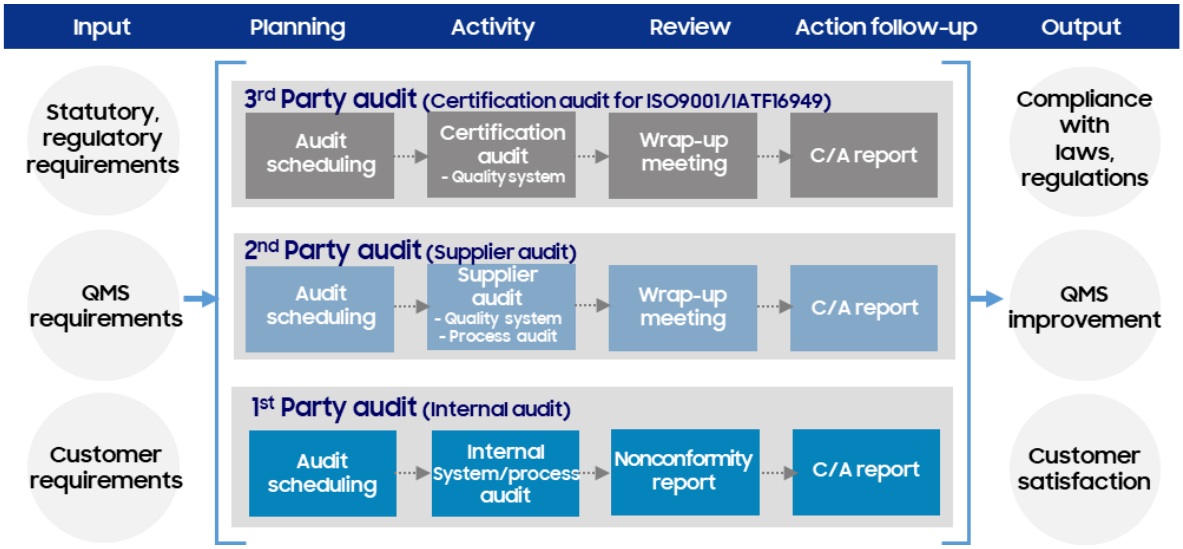

Figure 2-2. Samsung's Audit Program

2.3 Quality Documentation System

One of the objectives of Samsung's QMS is to establish and maintain a documented quality system which is defined to ensure that the products and processes conform to their specification and to meet ISO9001/IATF16949 requirements as well.
All employees are committed to the concept of "NO SPEC NO WORK" (we don't work without standards) and perform all applicable quality activities for improvement of QMS. Samsung's quality documentation system is comprised of a document structure hierarchy as shown in the figure2-3.

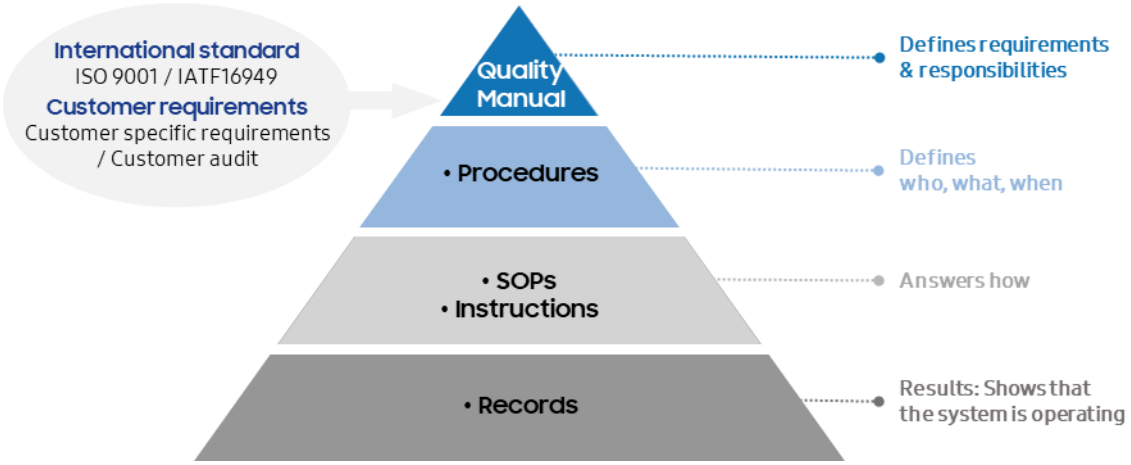

Figure 2-3. Quality Document Hierarchy

Quality Manual is the top level document that defines Samsung's QMS. It represents major contents such as quality policy, quality goals, and organizational roles and responsibilities. The objective of the Quality Manual is to specify the requirements for Samsung's QMS in order to satisfy the ISO9001/IATF 16949, statutory and regulatory requirements as well as customer's needs; and to ensure that all employees are involved in implementation of the quality policy.

Procedures describe order of work processes, relevant standards, roles and responsibilities in practicing the core elements of Samsung's QMS.

SOPs/Instructions describe detailed procedure of works, criteria, and technical methodologies to carry out specific operation or function.

Records include all kinds of data and documents for from processes. Samsung's document management system provides efficient environment through sharing, collaborating and managing the records. Proper retention records ensures traceability of process and product data (Chapter 5.6).

3. Product Development & Qualification *(This part is not applicable to the Foundry business)*

3.1 Product development & Qualification stage

Increasing complexity of product design and performance demands translate into key challenges to product development and certification. Samsung has been constantly improved test capability and capacity in development phase to meet these challenges. Samsung assures product's quality and reliability performance with structured qualification and validation process throughout the product life cycle. The Samsung's Product Life Cycle (PLC) is defined in four phases as shown in Figure 3-1.

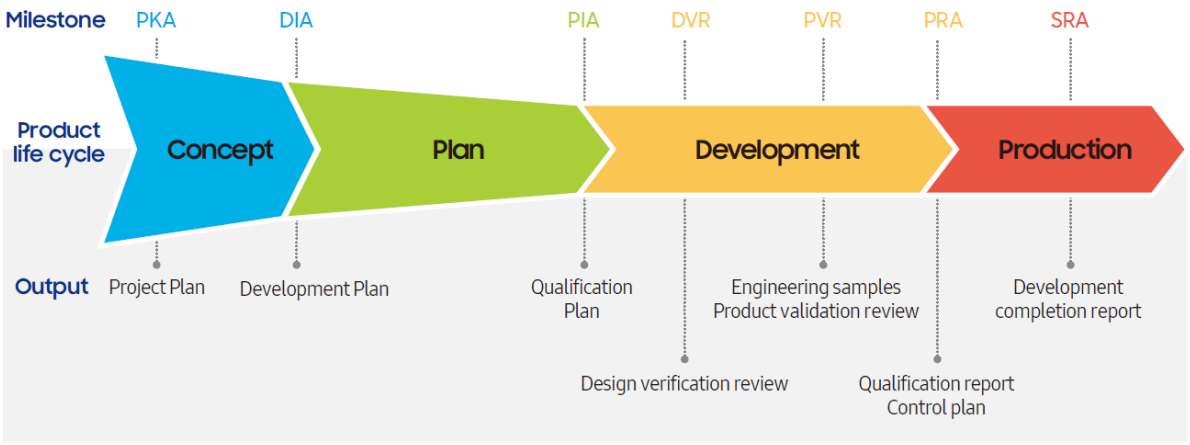

Figure 3-1. Samsung's Product Life Cycle and Product Qualification Milestones

Concept stage

New product requirements and business opportunities are evaluated based on the project proposal and market needs.

Plan stage

Product design guidance and qualification plans are specified for use in Development stage. To meet these product development objectives, the resources (such as money, human and machine) are also planned and allocated.

Development stage

Products are developed to satisfy its requirements. Performance, reliability and mass-producibility for products are verified at this step.

Production stage

Product's launch is decided after product validation and manufacturability evaluation of mass production. This stage ranges from mass production to product discontinuance that have completed its life cycle.

3.2 Software Quality *(This part only describes software quality management processes of Memory business)*

Software Quality Management

Recently, software is used in various fields (mobile, PC/server, automobile, drone, etc.), and software development with features and performance that customers can satisfy within a limited period of time is required. While software requirements are getting more complicated, small errors in software cause fatal problems, so the importance of software quality is getting bigger. Therefore, Samsung has continuously made various efforts to achieve the best software quality in development and maintenance process. In addition, Samsung pursues high product completion by applying development process based on international software quality standard such as ISO / IEC 25000 (SQuaRE: Systems and software Quality Requirements and Evaluation)

Software Development Life Cycle

Samsung follows the development process as shown in Figure 3-2 to develop and validate software that satisfies customer requirements. Samsung assures software quality through efforts to define and follow procedures to improve quality at each development stage throughout software development life cycle.

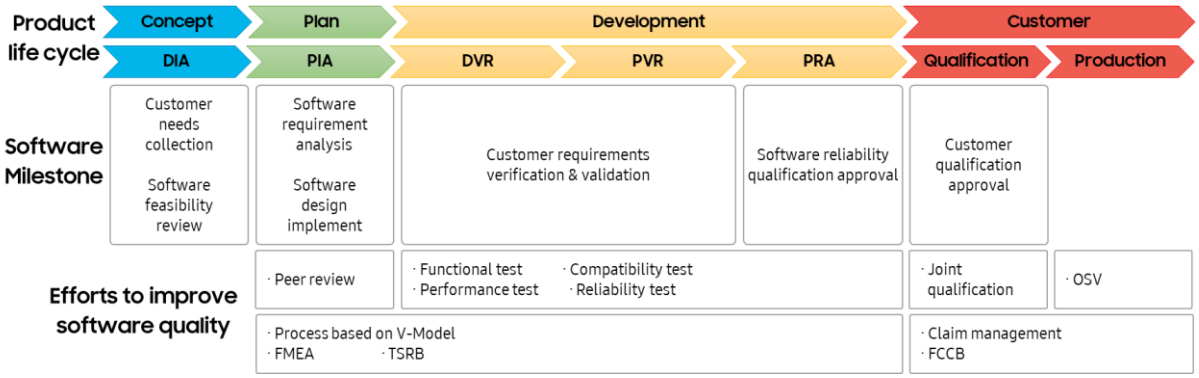

Figure 3-2. Software Development Life Cycle

4. Materials and Outsourcing Quality System

To be successful in satisfying business expectation, Samsung selects and develops reliable suppliers/ subcontractors (hereinafter referred to as ”suppliers”) . Each supplier’s performance is assessed periodically (normally once a year) by in-depth audit in terms of technology, quality, delivery, cost, and finance. Suppliers are notified of the evaluation results and their improvement activities are driven systematically.

4.1 Materials Quality Control

Samsung ensures materials with stable quality and supply capability by following the certification procedure. The procedure is designed to validate product conformity, supply risk assessment and production capability through supplier self-checklist and manufacturing site audit.
Process for new supplier/material qualification is shown in Figure 4-1.

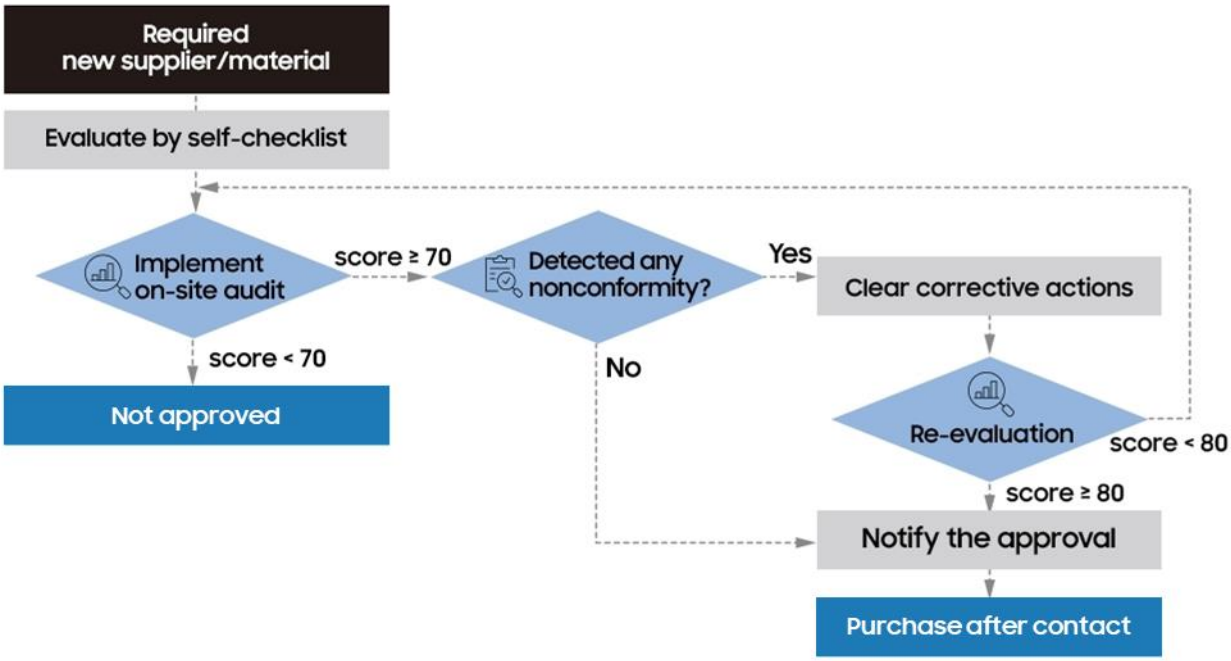

Figure 4-1. Procedure of New Supplier/Material Qualification

Samsung has various management tools to maintain material quality and to address any material-related issues.

Table 4-1. Material management system elements

Prevention	• Change Control Board • Failure Mode & Effect Analysis (FMEA) • Audits • Technical Review Meeting (TRM)
Detection	• Supplier Statistical Process Control (SPC) • Supplier Outgoing Quality Control (OQC) • Samsung Incoming Quality Control (IQC) • Material Quality Monitoring
Reaction	• Supplier Corrective Action Request (CAR) • Material Review Board (MRB)

Prevention: Samsung operates several preventive measures against any material-related quality issues. The Material Change Control Board (MCCB) controls and evaluates any changes in suppliers. The Failure Mode and Effect Analysis (FMEA) can be used as a tool to define potential causes of quality issues and to design effective counterplans in advance. At this point, Samsung performs audits on each supplier's quality management system and manufacturing processes, including but not limited to Supply Chain Management (SCM) capacity, procurement, and storage management.

Detection: To detect and take control of excursions, Samsung uses detection tools such as the material inspection based on the statistical process control and the advanced metrology system. Suppliers should comply with the process control actions in any excursions, and, if necessary,

Samsung offers consulting and/or training program that supports their technology development and utilization.

Reaction: Suppliers are responsible for performing corrective actions following material-related issues. Samsung runs the Material Review Board (MRB) to identify the root causes of the detected issues and implements corrective actions to prevent reoccurrence of the same issue.

4.2 Outsourcing Quality Control

Samsung follows the subcontractor qualification procedure whenever package, equipment, process or materials are newly added and/or changed. The subcontractors' conformity to mass production process is validated by technical reviews and evaluations.

Nonconformity Product Handling (Subcontractor's duty): This procedure is designed for taking corrective actions for the lots with below-standard-yield due to the device's characteristics issues. Tests are conducted at Onyang Plant after the subcontractor's semi-finished products are assembled. Product's characteristics that may affect the reliability and quality due to the detected defects are evaluated.

Subcontractor Rating & Ranking (S.R.R) (This system aims to conduct a periodic and objective evaluation of all activities of subcontractors in relation to the quality to ensure an efficient and systematic control of Samsung's subcontractors, thereby improving the quality level of subcontractors.

5. Manufacturing Quality Systems

Samsung's commitment to quality enables us to sustain world-class competitiveness in semiconductor industry. All employees take responsibilities to improve product quality and share best practices across factories. In addition, fully automated production facilities and highly specialized continuous monitoring systems allow us to ensure consistent quality and reliability of products.

5.1 Factory Overview *(This part covers all Device Solution business including memory, S.LSI and Foundry)*

Samsung Semiconductor has five manufacturing sites in Korea (at Giheung / Hwaseong / Onyang / Cheonan and Pyeongtaek campuses) as well as sites in the United States of America and China.

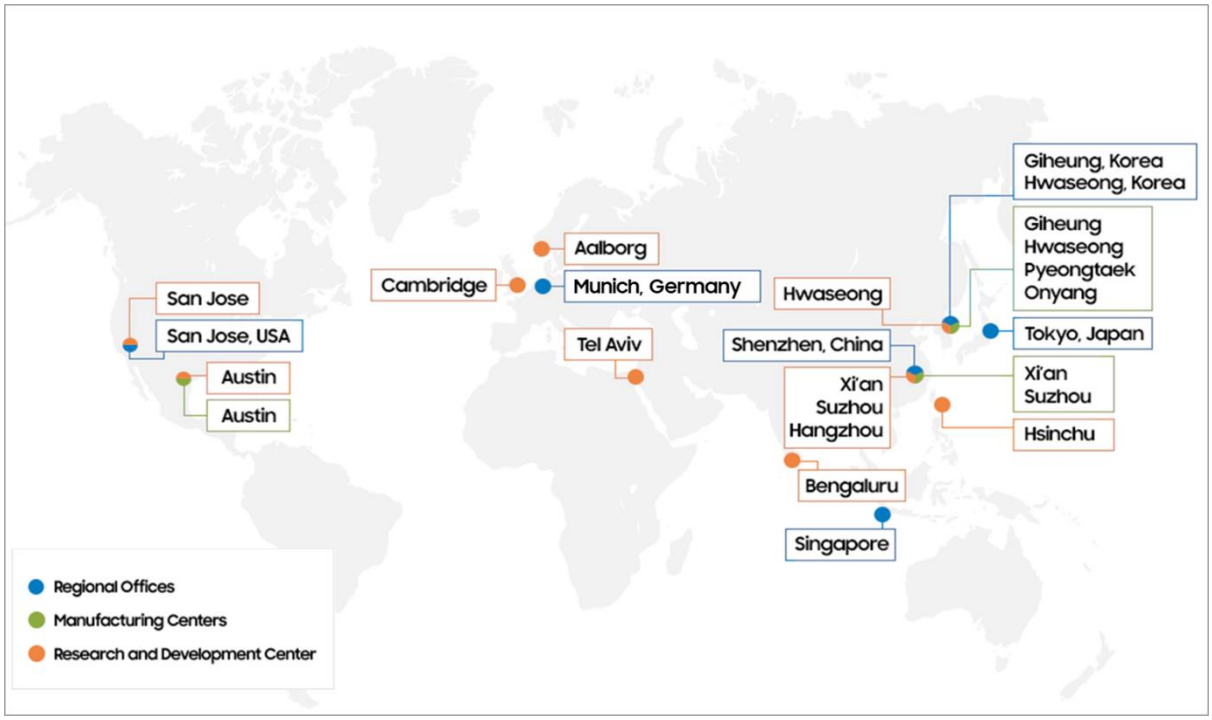

Figure 5-1. Samsung Semiconductor Global Network

5.2 Process Change Management

There are many changes in products and the production processes for a variety of reasons including enhancing performance of products, adding manufacturing capacity, and changing suppliers. Changes in product and process are inevitable and necessary for improvements, and, without proper evaluation and verification, it may lead to unexpected failures.

The Process Change Control Board (PCCB) is a tool for controlling process changes in Samsung factories including materials and facilities. The PCCB requires clear implementation and verification plans to prevent the risk and verify the benefits following the changes. PCCB's objectives are to a) ensure an effective management of process changes, b) lead process improvement and product enhancements and c) maximize the accumulated technologies.

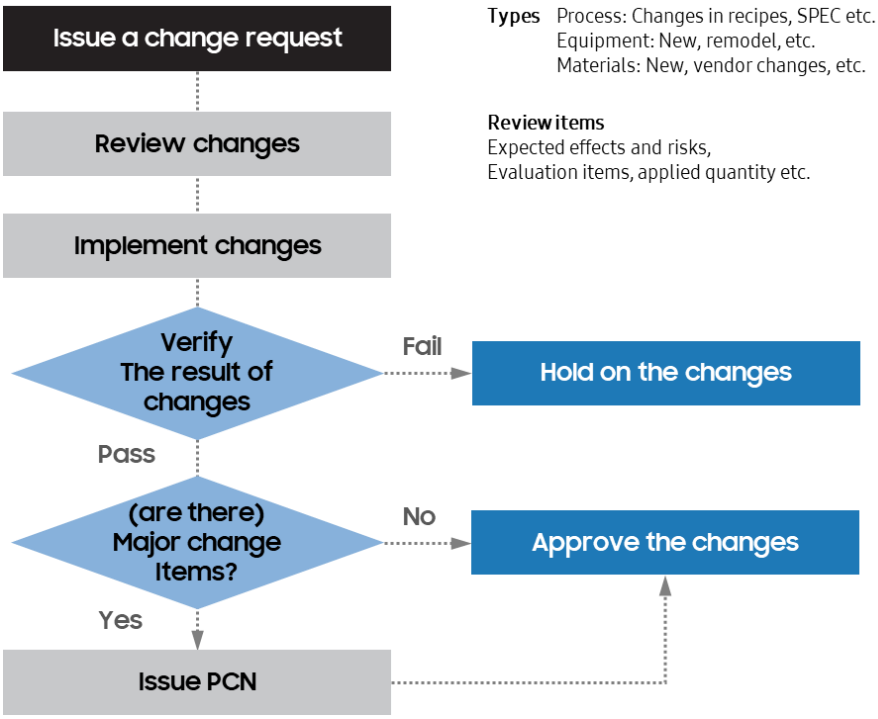

Figure 5-2. Procedure of Process Change Control

Once a change request has been made, the PCCB review and create an application plans with limited schedule that can minimize the impact on manufacturing process. After Implementation of such change, the results are verified. The PCCB tracks any in-line parameters that may affect the product's performance and finished products parameters such as yield and reliability. Final approval is granted only when all members of the PCCB reach a mutual agreement.

Samsung communicate critical changes that may affect a product's performance to customers through Product Change Notification (PCN). PCN is linked in the PCCB for any major changes. Please refer to PCN in Section 6.2 for details.

5.3 Manufacturing systems

As technology of semiconductor advances, the size of the product decreases while the complexity increases. Samsung's monitoring system has been continuously evolved to detect abnormalities, maintain quality, and reduce variability of key parameters.

Process & Production Monitoring

Samsung's monitoring program detects any unpredictable and subtle variations. It allows engineers to identify problems early and prevent excursions.

Interlock System: Throughout the manufacturing process, critical parameters are monitored and tracked by interlock systems. The critical parameters may include machine input(Equipment Control)/output(Fault Detection Control) and process input(Recipe) / output(CD, thickness, etc.). In wafer fabrication process, a three-stage protection system is operated as shown in Figure 5-3.

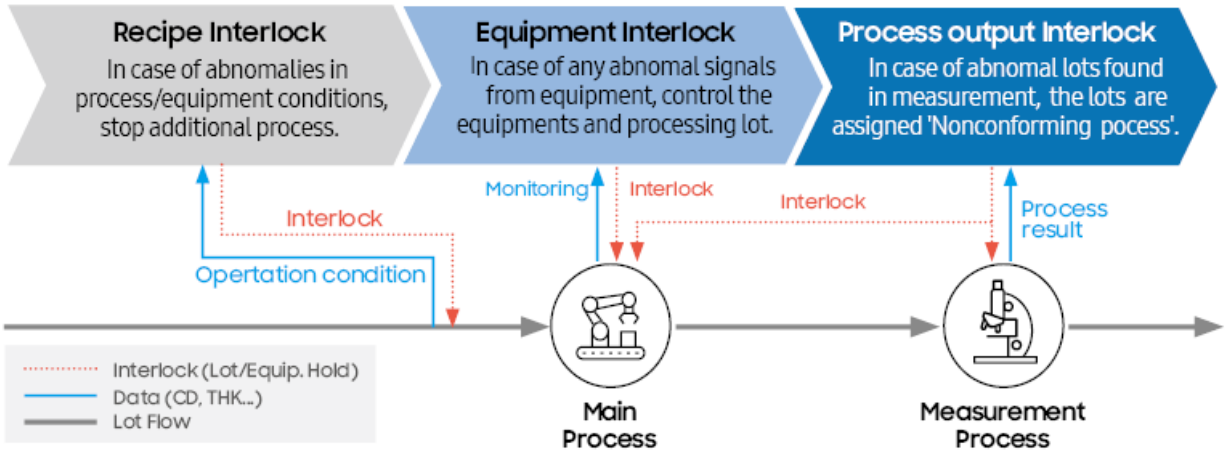

Figure 5-3. Samsung's interlock system

Statistical Process Control (SPC) and Advanced Process Control (APC) : SPC system allows to detect abnormalities in process and to take corrective actions before the quality failures. Samsung has highly advanced SPC program which is suitable for semiconductor manufacturing technologies. It includes small-change detection which is called EWMA (Exponentially Weighted Moving Average). Also APC system performs real-time, and controls equipment's inputs automatically by run-to-run variation.

Continual Improvement

Manufacturing engineers continually focus on variation reduction and process improvement. We believe that eliminating sources of variation may lead to product enhancements.

FAB Equivalency - "Copy Intelligently": The Samsung Equivalence Test checks the equivalency at all levels of physical inputs and outputs. It is derived from "Copy Intelligently" activities. The Samsung Equivalence Test enables consistency of product's performance between different manufacturing sites, lines, and(or) equipment.
Samsung's equivalency methodologies are applied to facility, materials, process input/output criteria, and product performance criteria. Both central tendency and variations of the parameters are statistically matched. It is possible to control deviation of process and pre-check the stability of process for any changes in Samsung factories.

Statistical Post Processing: Statistical comparisons of wafer test data to final product's quality allow not only to optimize test condition but also to predict product performance. With advanced statistical methods, wafers and(or) dies with potential risks can be effectively screened.

FMEA (Failure Mode and Effects Analysis): The Failure Mode and Effect Analysis (FMEA) is a methodology for identifying potential failure modes, determining their risks and defining preventive actions in the product design and the manufacturing process. Based on FMEA, manufacturing process and control factors are divided into small units, and all possible failure modes are clearly defined and listed by each item. The effect on the product performance and the root cause of each failure are also identified. Then, corrective and preventive actions are implemented.

5.4 Control of monitoring/measurement equipment

Samsung continuously endeavors to guarantee reliable monitoring and measurement results by

minimizing variation caused by measurement equipment.
Measurement System Analysis (MSA) is performed to quantify the uncertainty of the measurement system (component elements including the measurement environment and sample as well as mechanical devices) statistically analyzing measuring methods and people. This is for stability and integrity of measurements of process parameters in terms of product characteristics from both the short and long-term perspectives.

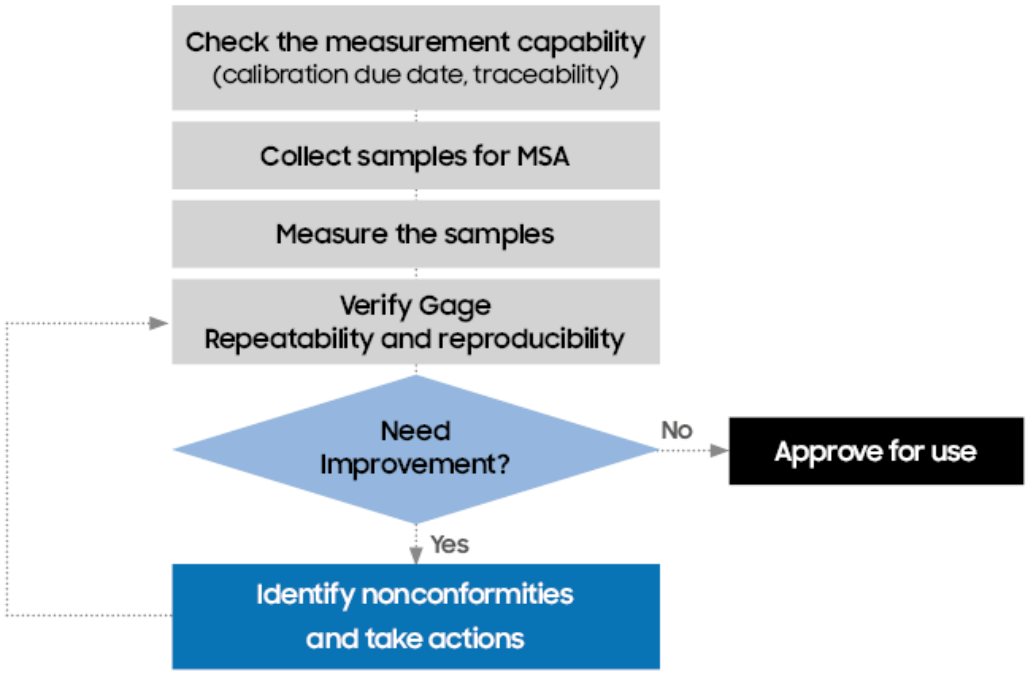

Figure 5-4. Procedure of Samsung's Measurement System Analysis (MSA)

5.5 Control of Nonconforming Product

Samsung identifies and controls nonconforming products, which do not conform to the specification and criteria. All nonconforming products are identified and segregated from normal products.
The Abnormal Lots Processing System (ALPS) and Quality Management (QM) system are used to manage the nonconforming products.

Control of nonconforming product process has 4 stages:
- Stage 1: Notification of nonconforming product occurrence
- Stage 2: Identification of the root cause and establishment of permanent corrective and preventive action
- Stage 3: Disposition of affected products
- Stage 4: Review and Approve

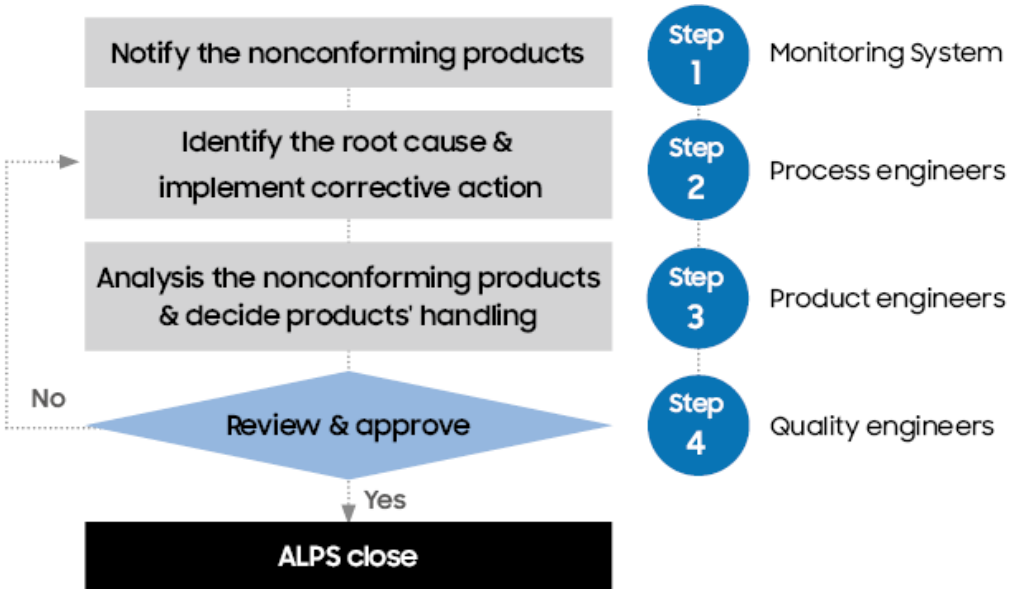

Figure 5-5. Procedure of Abnormal Lot Processing System (ALPS)

5.6 Product Identification and Traceability

Product is identified and tracked from raw materials through all manufacturing process to shipment to customers. The unique identifier is assigned to each material, equipment and product and managed by the Code Information System (CIS) according to the operation of master code. Process information (product code, lot number, manufacturing history, etc.) is systematically managed by identification process, So that nonconforming products are immediately isolated and scrapped.
Product information can be tracked when any abnormality is discovered or upon customer's specific requests. Samsung's traceability enables us to identify the source of any nonconformities, and determine products which might be affected.

6. Customer Support

Samsung has a comprehensive set of customer support system that encompasses technical support, quality issue resolution, return managements and quality cooperation.
The customer support system includes:

- Understanding customers' requirements on the quality and reliability of products
- Providing customer assistance by resolving customer quality issues
- Performing the periodic internal quality diagnosis to satisfy customer's quality needs
- Measuring and improving customer satisfaction

6.1. Customer Quality Support Network

Samsung has established a worldwide network in order to provide speedy customer support for inquiries and quality issues covering both consumer (B2C) products and business (B2B) products. In the case of the business products, we have assigned quality experts (failure analysis engineer, quality engineer) in Samsung's local site for in-depth customer support of quality issues. In the case

of the consumer products, specialized consultation/service centers work for troubleshooting of quality issues that are raised from customers.
For B2B products, the worldwide regional headquarters are specified at http://www.samsung.com/semiconductor/support/global-network/.
For consumer products, Internet access and customer Support Hotline phone numbers are specified at http://www.samsung.com/semiconductor/minisite/ssd/support/cs/.

6.2 Customer Quality Support System

Samsung provides a comprehensive set of customer quality support system including:

- PCN (Process Change Notification) Management
- Technical Support
- Claim Management
- RMA (Return Material Authorization)
- VOC Management (Voice Of Customers)
- Product Regulation Certification

Through above customer quality support systems provided by Samsung, customers can reduce cost of their business operation. Samsung is also continually improving and enhancing our services to provide customers with better products and services.

PCN (Process Change Notification) Management

Product and process changes allow Samsung to improve product quality and manufacturing efficiency as well as customers' flexibility. These changes include adopting new or different types of materials, designs or processes. Samsung has a PCN procedure for major or critical changes in processes. By following this procedure, customers can be notified before such changes.

Technical Support

Samsung provides various technical supports in order to maintain a stable service quality level for customers and to make continual improvements. Samsung's quality management system provides customers with a wide range of technical support. It enables Samsung to predict the expected quality level of the customers, provides sufficient human and material resources to resolve quality issues promptly.

Claim Management

Figure 6-1 demonstrates procedures of the failure analysis for the maximization of customer satisfaction which covers receiving quality claims, analyzing them, establishing countermeasures and taking corrective actions via the accurate identification of customer complaints about the product Thus, claims are effectively handled to prevent recurrence of same or similar issues and to ensure outstanding product quality and reliability.

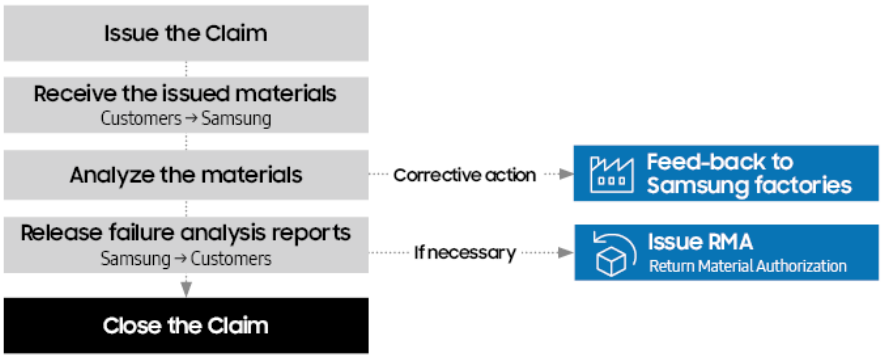

Figure 6-1. Procedure of Claim Management

RMA (Return Material Authorization)

This is a series of steps by which any quality issues with Samsung's products that have already been shipped to customers or warehoused for shipping are identified and handled promptly. The objective of RMA process is to minimize quality issues by responding to customers' quality-related requests quickly in a timely manner.

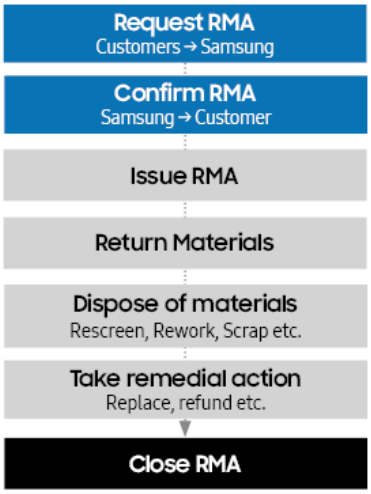

Figure 6-2. Procedure of RMA

VOC Management

Samsung actively listens to customer's voices through various channels and analyzes collected data to provide customers with quality products and services. The types of VOC management for customers include surveys or interviews for specific customers, Ranking & Rating, and periodic quality review meetings, etc.

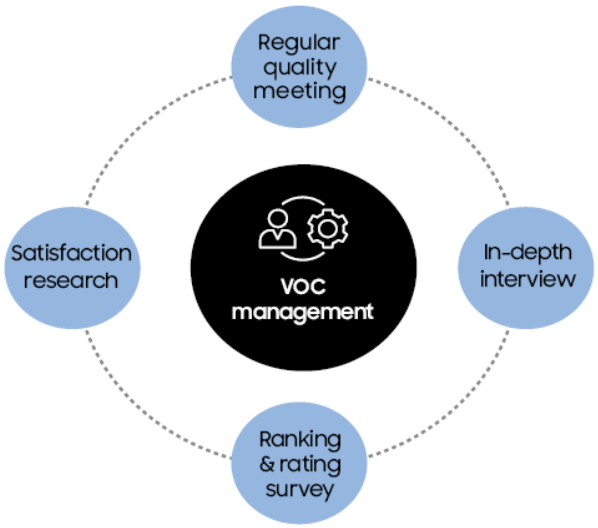

Figure 6-3. Elements of Samsung's VOC management

Product Regulation Certifications

Samsung complies with the relevant and applicable regulations for electromagnetic compatibility and safety. We comply with mandatory regulations by the global societies and endeavor to design and produce products that minimize their adverse impacts on the safety. Please visit the following website for additional regulatory information:
https://semiconductor.samsung.com/support/quality-support/regulatory-information/

Revision History

Date	Version	Revision Notes
22.11	06	1) Deletion of chapter 5.2 Environment, Health and Safety Management 2) Deletion of 'Order Fulfillment Quality' from Chapter '6.2 Customer Quality Support System' 3) Overall wording correction and update of links to web pages
21.11	05	1) Chapter 2 – modified Figure 3-1 2) Chapter 3 – added 3.2 Software Quality 3) Chapter 5 – added 5.1 Factory Overview 4) Overall minor wording correction
20.04	04	Updated chapter 2.2 & modified Figure 2-3
18.10	03	Added chapter 2~3, 4.1, 5.1, 5.2, 5.6 & updated other chapter with minor revision
17.06	02	Renewal semiconductor website and quality handbook
14.02	01	Updated Quality training curriculums
08.06	00	Initial release