IC Quality Assurance

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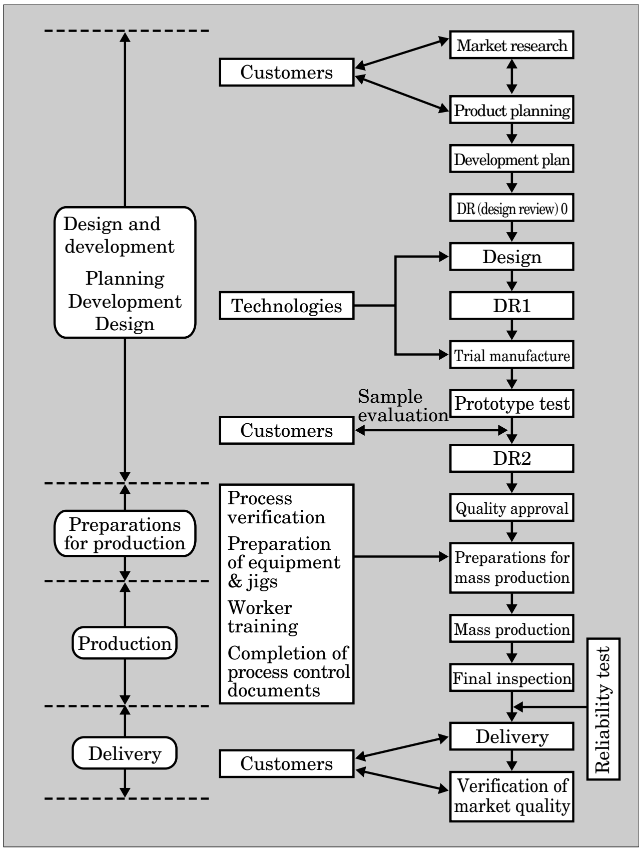
1. Introduction

The information and communication functions of recent electronics products have become complicated and advanced, and requirements for IC quality and reliability have become stricter. The development and mass production of new products requires establishing new technologies and materials within a short time, resulting in a harsh environment for products.

To meet this situation, Fuji Electric is aggressively pursuing analysis and research. This paper introduces a partial failure analysis of the quality assurance activities described in Chapter 2.

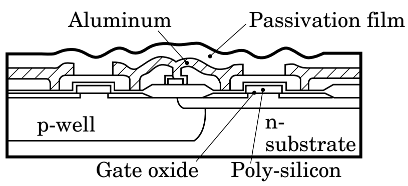
Fig.1 IC quality assurance system



2. Fuji Electric's Quality Assurance Activities

The Matsumoto factory of Fuji Electric received ISO9001 certification in February 1994 and has striv-

Table 1 Modes and causes of IC failures (for CMOSICs)

Defective element	Failure mode	Failure cause
Mold	Short Leak Deterioration Open	Moisture, ion impurities, excessive stress
Bonding (die, wire)	Short Leak Open	Migration, Au-Al alloy, mechanical stress
Passivation (surface protection film)	Leak Open	Pinhole, crack, scratch, contamination
Metallization	Short Leak Increase in resistance Malfunction	Scratch, step break, ill pattern, insufficient contact pressure, non-ohmic contact, electromigration, corrosion, thermal break (electrostatic discharge, surge)
Passivation (middle insulation)	Leak Short V_{th}-shift	Pinhole, contamination, electrostatic discharge, surge
Poly-silicon	Leak Short Malfunction	Shape, ill pattern
Gate oxide	Leak Short V_{th}-shift Deterioration	Pinhole, irregular thickness, contamination, electrostatic discharge, surge, hot electron injection
Silicon substrate	Leak Short	Crystal defect, diffusion fault, impurities, micro-crack
IC section		

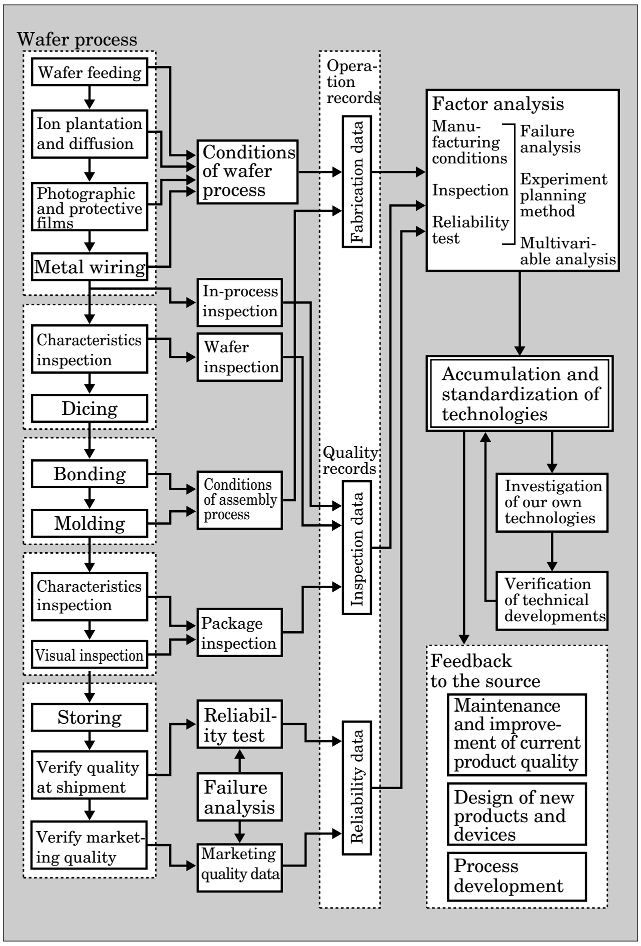


Fig.2 IC quality information

en to define and improve quality assurance systems. System based quality assurance activities, ranging from development to preparations for production, production, and delivery are described for each stage. The IC quality assurance system is shown in Fig. 1.

(1) Design and development

To achieve the quality and reliability goals of product plans based on market trend and user requirement data, quality requirements and quality information are accurately assessed and analyzed. This information is effectively utilized at every step of the design and development.

(2) Preparation for production

So that the quality goals of the development stage can be realized in the production stage, the process design is thoroughly examined, and the “initial quality” of the first completed products is checked. The relevant supply companies are provided with guidance for quality inspections, so that they can perform the same level of quality assurance as Fuji Electric based on the process design.

(3) Production

Reducing defects through process control (maintenance) and improving defect-free ratios through the continuous analysis of in-process defects (measures for improvement) ensures quality in the production stage. The measuring accuracy of testers and measuring instruments is verified and managed so as not to send a defect to the next process.

(4) Delivery

The assessment of product quality and reliability

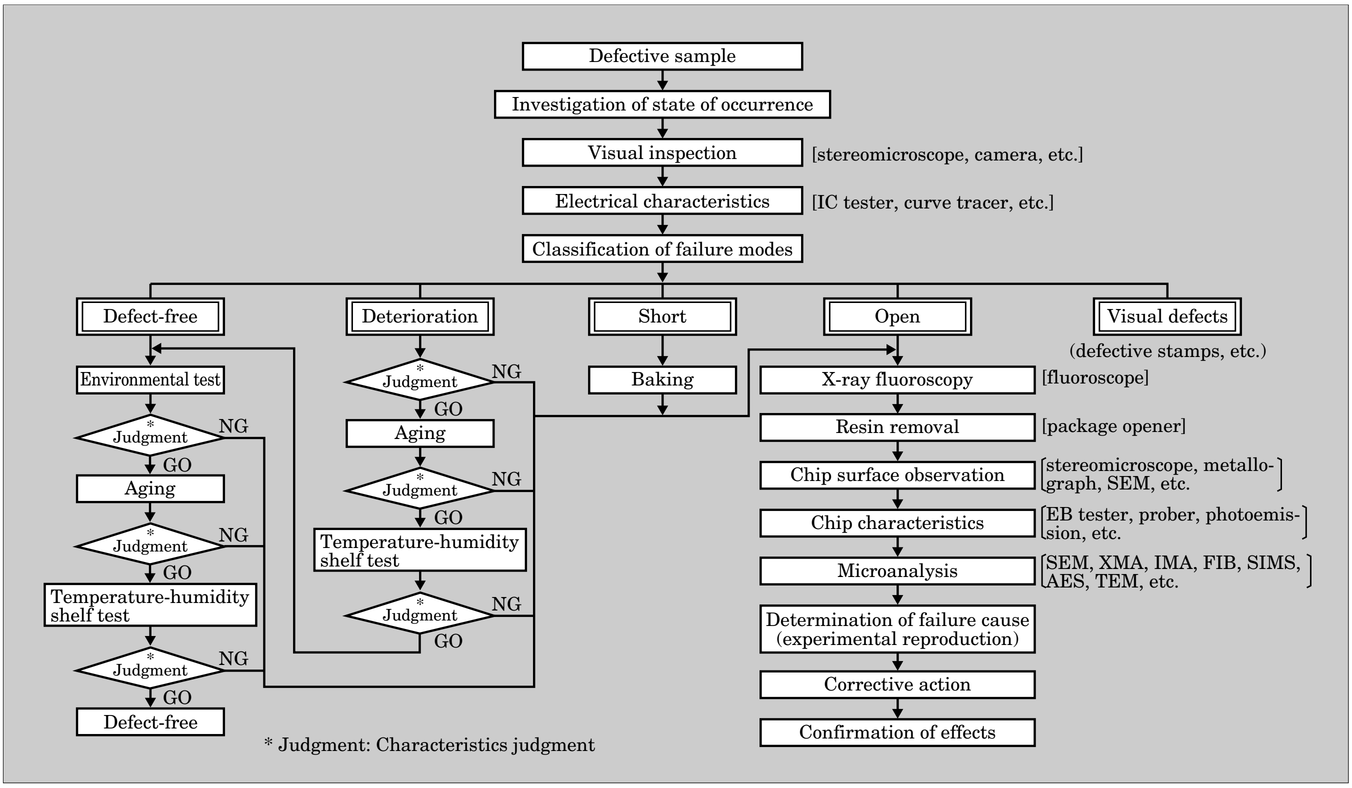


Fig.3 Flow chart of IC failure analysis

Fig.4 Example analysis with an EB tester

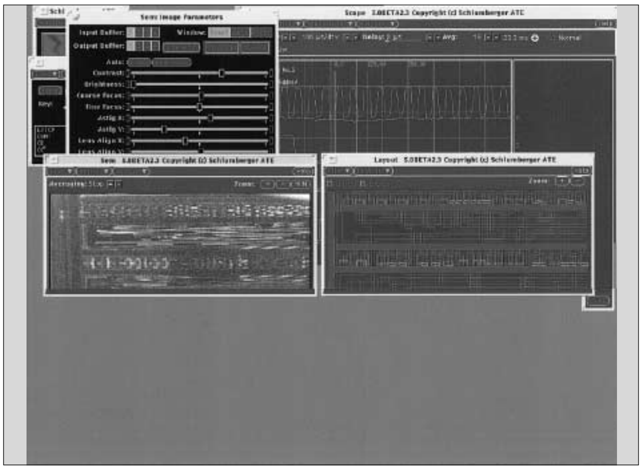


Fig.5 Example analysis with an FIB

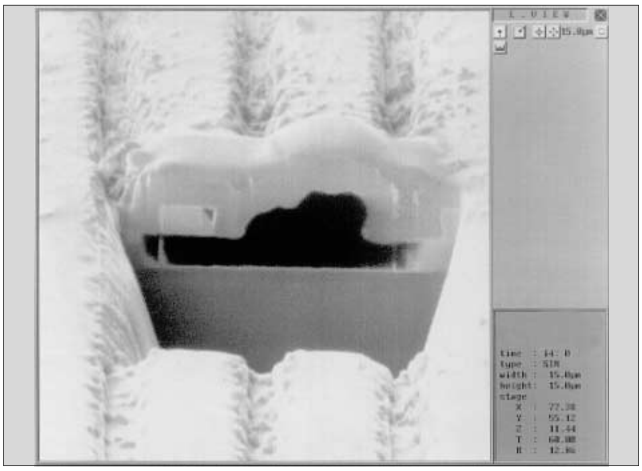
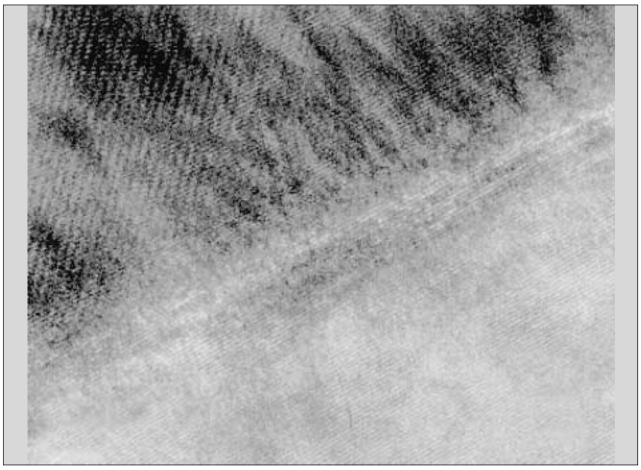


Fig.6 Example analysis with a TEM



and the failure analysis of defects that occur in the marketplace are important management items.

The four stages from design and development to delivery have been outlined above. A clear understanding of failure mechanisms is essential for reliable IC design. It is necessary to precisely analyze the failures of defects in the marketplace, to collect various data of in-process quality by model types, reliability tests, and marketing quality, and to quickly supply this information in an easy-to-use format. These results are fed back to the sources. This information is utilized for daily quality maintenance and fundamental improvement. We are also making efforts to link this information to new product design and process development.

3. IC Failure Analysis

Table 1 shows typical examples of failure modes and failure causes collected by Fuji Electric. Failure analysis describes the failure mechanisms. Fed back to the source, that information plays an important role in maintaining and improving quality and reliability. Figure 2 shows an example of quality information. Based on the results of failure analysis, manufacturing and inspection data are analyzed, and quality information is fed back to the source. Figure 3 shows a flow chart of IC failure analysis. Typical example analyses are shown in Figs. 4 through 6.

Figure 4 shows an example of analysis with an EB (electron beam) tester. This is a method of analyzing the IC operating state using SEM (scanning electron microscope) contrast images and waveforms. The required time to perform the analysis, and its precision, are improved by linking this with CAD (computer-aided design) data.

Figure 5 shows an example of analysis with an FIB (focused ion beam). This is a method of inspecting the condition of a cross-section of an IC. In this example, an abnormal form due to foreign matter buried under the metal wiring part is detected.

Figure 6 shows an example of analysis with a TEM (transmission electron microscope). This is a method of analyzing the atomic-level state of materials. In this example, the boundary condition between metals is analyzed.

4. Conclusion

Fuji Electric ICs, developed through close cooperation with the user, have gained in popularity. The trend has been toward high value added products, while the life cycle has become much shorter. Under these circumstances, with its reliable technology and management, Fuji Electric will continue to accumulate and standardize technology and supply high-quality, highly reliable ICs to customers.

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