CHAPTER 1

OVERVIEW

1.1 Introduction

Rapid growth in several key technological areas such as communications, transportation, computers, software and consumer electronics has been possible due to tremendous advances in the integrated circuit manufacturing technology. Increasing demand for more integrated circuits products have, however, attracted more manufacturers making very similar products resulting in a highly competitive market. At the same time, the continuous drive towards smaller features size on integrated circuits and larger die size has caused an increase in its cost. Tough competition and increasing cost have thus made semiconductor manufacturing a risky venture. Thus, improving productivity and cost effectiveness of a semiconductor industry has always been a high priority and is more so in the light of increasing complexity and competition in the market. To be competitive, the cost per die must be minimized while quickly increasing the manufacturing yield to an economically acceptable level. Bringing yields up rapidly allows a chipmaker to produce more parts when prices are high, generating profits it can plow into the next generation of technology.

To maintain a competitive edge, ICs must be precisely manufactured within tight tolerances. Thus, in order to keep the cost of manufacturing down one must ensure that no errors are made during any of the stages of producing ICs from design to packaging. Manufacturing ICs without any errors is a complex task. Whenever a new process or product is introduced, the manufacturing yield or the fraction of correctly manufactured ICs is usually low. One has to ensure not only processes and products are designed to be high-yielding but also that errors in manufacturing are eliminated as quickly as possible through continuous and timely improvements.

Success of an integrated circuit manufacturing process and its economic viability depends on its ability to produce fully functional circuits whose performance and reliability lie within a specified range while maintaining high yield. Despite continuing improvements in manufacturing tools such as hardware configuration and in assembly and test processes, there still exist random variations in each step of integrated circuit manufacturing. Moreover, as technology continues to advance towards smaller device geometries, it is increasingly difficult to scale the manufacturing variations in direct proportion to the device dimensions. As a result, the manufacturing of integrated circuits, particularly in the deep submicron regime, is becoming more and more challenging not only due to the increased complexity of the process, but also due to the tool capability and control requirements or customer specification which are becoming increasingly difficult to satisfy.

1.2 Objectives of the Study

To improve yield, and thus realize the financial benefits, all sources of yield loss must be analyzed and quantified, and root cause must be identified. In general, if the yield varies by value of an electrical parameter such as transistor parameters, resistance, or capacitor values while the said parameters are within their specification limits, a design issue is indicated. If the yield varies by electrical test values of leakage current between metal or poly lines, or current leakage between nodes of transistors, a process problem is indicated (Ross et al., 1999).

This study evaluates the effect of certain equipment and conditions on the manufacturing yield of a certain new product of a well-known IC manufacturer, company A. Identification of low yield at various stages of the manufacturing process is an essential first step to analyzing yield performance.

At a particular stage of the process, testing, devices are identified as having low yield and then are examined in some detail. The main thrusts of this study are listed as follow.

i) To analyze if there is any significant differences in the average yield by tester and by day at three stages of the production process of varying temperatures, the open short test (TOS), low temperature (TLO) and high temperature (THI) test processes.

ii) To examine the yield across these various tests inserts (TOS, TLO and THI) to identify the stage which results in most defects, and then identify the reject bin with most defects.

1.3 Profile of Company A

The company A was established in 1928, a global leader in communication, semiconductors and advanced electronic systems. These include:

a) Software-enhanced, wireless telephone, two-way radio, messaging and satellite communications products and systems, as well as networking and internet-access products for consumers, network operators, and for commercial, government and industrial customers.

b) Embedded semiconductor solutions for customers in the consumer, networking and computing, transportation, and wireless communications markets.

c) Electronic systems for automotive, communications, imaging, manufacturing systems, computer and consumer markets.

1.4 Semiconductor Industry

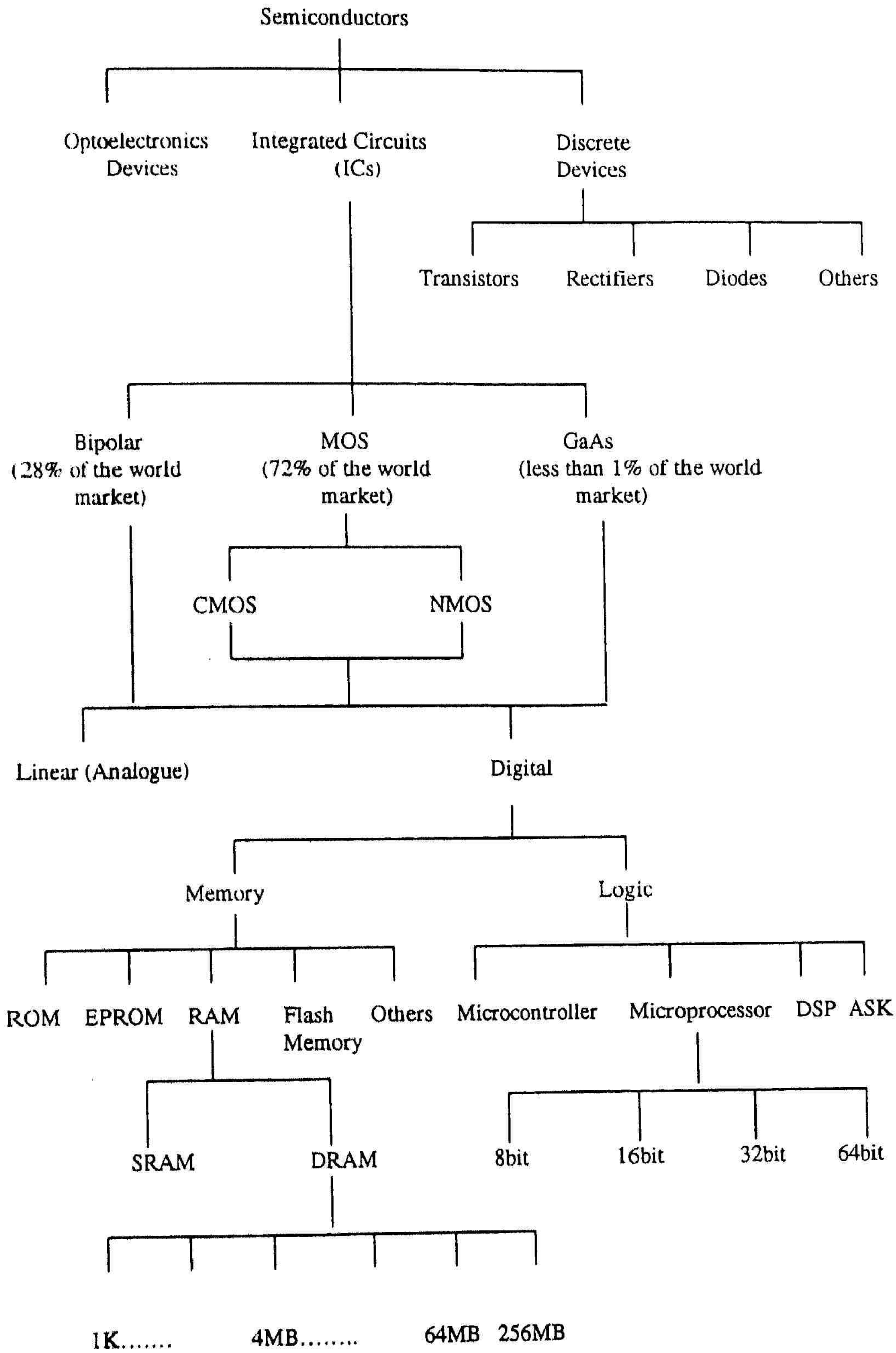
The semiconductor industry is the foundation of the electronics industry, the largest industry in the U.S., employing 2.7 million Americans. The semiconductor industry manufactures integrated circuits, or chips, for use in airplanes, computers, cars, televisions and other electronic equipment (Veronica Czitrom et al, 1998).

1.4.1 Definition of the Industry

The semiconductor industry is defined as all companies being involved in the production of integrated circuits (ICs). These companies can be divided into three categories: (1) Wafer manufacturing companies; (2) IC designers; (3) Companies being involved in the assembly and testing of semiconductors circuits (Elsevier Advanced Technology, 1997).

1.4.2 Major Types of Semiconductor Products and Their Usage

As shown in Figure 1.1, semiconductor products have three major categories: optoelectronics devices, discrete devices and integrated circuits (Elsevier Advanced Technology, 1997). ICs can be classified by three kinds of



Source: Profile of the worldwide semiconductor industry, 1997

Figure 1.1 **Semiconductor Products**

process technology employed in their production: Bipolar, MOS (Metal Oxide Semiconductor) and GaAs (Gallium Arsenide). Bipolar is the prevalent technology in linear ICs and is also used in digital ICs. MOS technology dominates in the production of digital memory, logic and ASIC (Application Specific Integrated Circuit) chips. GaAs is a complementary semiconductor material to silicon and is also used in digital and analogue ICs. As the principal advantage of Bipolar over MOS is its speed, one important application of Bipolar is for military high-speed computers. MOS has the advantages over Bipolar of lower cost, lower power consumption and greater attainable circuit density.

ICs can further be distinguished between linear (analogue) and digital. Linear ICs process electrical signals over a continuous voltage range and are therefore suited for consumer electronics goods such as televisions and radio. Digital ICs, on the other hand, process information only in binary digits corresponding to high and low voltage electrical impulses. This characteristic makes digital ICs most commonly used in computers and various other types of electronic equipment.

Digital ICs can then be classified into logic and memory circuits. Logic circuits perform arithmetic operations on data stored in the memory circuits. Logic circuits include microprocessor, microcontroller, DSP (Digital Signal Processor) and ASIC. Microprocessors are mainly used in information processing equipment and they are the "brains" of computers. Microcontrollers also have many applications such as consumer electronics, automobiles, robotics and telecommunications. ASICs are standard ICs customized for specific functions, thus taking advantage of the inherently lower cost of standard parts and the higher performance of custom ICs. Uses of ASICs are broad because they are tailored for each user. They are used in cellular phones, HDTV (High Definition TV), music synthesizers, and medical equipment. DSPs are devices that can be coupled with analogue-to-digital converters to accept, compress, improve, and transmit or manipulate analog signals such as sound, light and radar. They are used in computer printers, electronic banking system, military radar and modems.

Memory circuits are used in a wide range of electronic products such as computers, automobiles, telecommunication equipment and electronics. The ROM (Read-only Memory) is used in storage of standard arithmetic functions while the RAM (Random Access Memory) is used in storage of operating instructions. Information stored in a ROM can only be retrieved sequentially while that stored in a RAM can be retrieved at random. EPROM (Electronic Programmable Memory) and flash memory are non-volatile memories in the sense that they retain data even when the power is turned off. This is most suitable for portable computers and mobile communication equipment.

RAM can further be classified into SRAM (Static RAM) and DRAM (Dynamic RAM). SRAM is used in cache memory of the microprocessors for a computer while DRAM is used in a computer, an office equipment, telecommunication, or consumer electronic good. DRAMs are usually described by storage density. A 1MB DRAM has 1,048,576 storage cells (bits) while a 4MB DRAM can stored 4,194,304 bits of data. The higher the density, the more sophisticated technology is needed to fabricate the DRAMs.

1.5 Organization of The Report

The remainder of this thesis is organized as follows: general integrated circuit (ICs) process flow presented in Chapter 2. Several literature reviews presented in Chapter 3. A brief description on product background, type of defect and failure modes, methodology and data collection is presented in Chapter 4. Analysis and result will be presented in Chapter 5. Conclusion, shortcoming or limitation of analysis and future work are suggested in Chapter 6.