Introduction

Evolution Meets Revolution in Semiconductors

The evolutionary path the semiconductor industry has followed over the last several decades is being met today by revolutionary changes. On the one hand, Moore's law, forecasting the creation and manufacture of increasingly complex integrated circuits continues to evolve by shrinking the same basic transistor design and using increasingly purer and more sophisticated materials, Revolution is occurring in terms of the transformation to a truly global market. At the device level, there is a need for revolutionary advancements in new material adoption, process integration, and systems integration to allow sophisticated data management and computer integrated manufacturing. There is also a desire to implement revolutionary approaches to asset management to allow unprecedented levels of productivity.

Chip technology continues to advance at a staggering pace, yet is requiring new materials and process tools, better management of production flow, shorter time-to-market, and creative approaches to resource management. Current emphasis on short-term profitability, resulting in part from investors' interest in high technology stocks, is forcing corporate restructuring and better risk management. This occurs at a time of heightened global competition in most device markets, a need for increasing global support from semiconductor equipment and materials suppliers, and rising R&D and production cost. As a result, manufacturing cost effectiveness has become a central focus of all firms in the semiconductor industry.

Leading economists estimate that technology has accounted for at least one-half of the economic growth in advanced industrial nations over the last 50 years.[1] Global access to technology and scientific development means that any number of developing nations are capable of challenging traditional market leaders. These nations are gaining access to emerging technological markets previously owned by the most industrialized nations. Key emerging sectors include the information superhighway, wireless communication, and fabrication of advanced displays for computers, televisions, etc.

The capital-intensive nature of the semiconductor industry is illustrated given a few startling statistics:

- A typical fab costs over a billion dollars to build and equip
- Device development costs can exceed $2 billion per device
- The $150 billion semiconductor industry reinvests $40 billion for capital equipment and advanced facilities
- The market value of a typical fab's in-line inventory running 20,000 wafers per month (200mm) can be as high as $15M
- Each employee of semiconductor manufacturers is supported by $120,000 of net fixed assets

This book serves as an update to Cost Effective IC Manufacturing 1995, a publication dedicated specifically to providing cost-reduction strategies for new and existing fabs. This book examines the complex relationship between company profitability, capital expenditures, device yield, cycle time, time-to-market, and other factors. It also reviewed management strategies that allow higher productivity and continuous improvement in everyday fab operations.

Cost Effective IC Manufacturing 1998-1999 maintains the focus of the first edition, while expanding analysis in key areas including:

- factors influencing profitability
- cost per wafer,
- cost of ownership,
- overall equipment effectiveness,
- cycle time management,
- benchmarking of operations, and
- yield improvement.

In addition, this new publication analyses controversial issues including the move to 300mm wafers, changes in device lifecycles,

Changing Terminology

Much of the move to label our era in time — as the “Information Age,” the “Digital Age” and the “Gigabit Era” — is driven by the need to emphasize the enormous influence technology has on our world today. At the same time, as users become more knowledgeable, there is a need to describe technology in more accessible terms. For instance, semiconductors are becoming known as the building blocks of the information age. Microprocessors are the brains of personal computers. DSPs are described as the chips that makes toys talk.

Beyond such helpful descriptions, the increasing use of personal computers, networked computers and the Internet are driving the need for better descriptions of computing and data transfer capabilities. For instance, users rarely use the metric of baud rate in purchasing modems.

Part of the revolution involves the translation of complex integrated circuits and electronic devices into concepts that users can appreciate and utilize in making purchasing decisions.

Changing Business Strategies

The face of semiconductor business is changing more rapidly than ever. Within electronics companies cost structures are changing, management strategies are changing, and budgets are changing continuously. The semiconductor equipment and materials suppliers are changing time-to-market and scope of services — as well as cost structures. New business strategies continue to come “on-line” — from the fabless and foundry models of the early 1990’s to the latest “virtual” companies who neither design nor manufacture integrated circuits, they simply breathe life into them.

But the forces of change are occurring not only within the semiconductor companies themselves. Perhaps more notably, it is the consumers and the investors that are changing the way companies approach capital expenditures and manage risks.

Changing Priorities

Cost control is the single greatest challenge facing semiconductor companies today. For IC manufacturers, profitability is increasingly tied to time-to-market, manufacturing cost reduction, and asset utilization.

This book does not attempt to present all the cost-reduction strategies available to companies in the semiconductor industry, but rather reviews success stories and equipment-specific issues that most critically affect manufacturing costs and profitability. Importantly, the book addresses issues faced by engineers and managers in existing fabs that do not have the resources needed to invest in industry-leading equipment, which typically receives the most attention at industry conferences and in trade publications. As the industry continues to mature, the longevity of 200mm wafer processing systems will be extended as much as possible, and cost-reduction strategies for existing fabs will become even more important.

In addition, alliances designed to minimize the risks and share the investments in acquiring and developing new technology are starting to become commonplace. Examples are:

- Advanced Technology and Materials (ATMI) and IBM, TI and Micron said to have invested a total of $15M in a DRAM-related project aimed at reducing the number of process steps to make the basic cell capacitor, targeting 1G DRAM production in 2000

- TI, Hitachi and Mitsubishi join on 1G DRAM development, initially spending $82M sharing technology, cutting development costs and time to market by introducing the economy of shared resources

- 1300I is a consortium formed to develop 300MM wafer technologies. There are currently 13 member companies involved.

- DuPont, Motorola and others have invested in a facility in Round Rock, Texas to investigate new reticle technologies that will further extend the capability of optical lithography.

References

1. Mary Lowe Good, “The Globalization of Technology,” *Physics Today*, August 1996, p.23.