



# HANDBOOK OF THIN-FILM DEPOSITION PROCESSES AND TECHNIQUES

Principles, Methods, Equipment and  
Applications

Second Edition

Edited by

**Krishna Seshan**

Intel Corporation  
Santa Clara, California

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Page 3 of 49

# 6

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## The Role Of Metrology And Inspection In Semiconductor Processing

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*Mark Keefer, Rebecca Pinto, Cheri Dennison,  
and James Turlo*

### 1.0 OVERVIEW

As integrated circuits (IC) are incorporated into more and more products, the market demand for lower cost, higher performance devices continues to grow. In order to design and manufacture a high performance integrated circuit cost-effectively, the parameters of the manufacturing process need to be carefully controlled: film thicknesses and material properties must be accurate, uniform and controlled; linewidths and edge profiles must fall within tight limits, and the devices need to be free of defects that affect yield.

Thin film metrology and wafer inspection for defects are integral to controlling the semiconductor manufacturing process. Film properties, linewidths, and defect levels need to be measured, first to optimize the manufacturing process, then later to ensure that it is operating under control.

This chapter explores the subjects of metrology and inspection of integrated circuits. After the introduction, implementation strategies for metrology and inspection are examined from a historical perspective. Then, as we anticipate increasingly complex devices having critical dimensions of 0.18 and 0.13  $\mu\text{m}$ , manufactured on 300 mm wafers, we look at how metrology and inspection will evolve to meet these measurement challenges, while simultaneously meeting increasing pressure for automation, higher throughput and higher reliability. In the final section we provide a technology reference that discusses theory of operation, equipment design principles, main applications, and strengths and limitations of the metrology and inspection systems. The sections are organized as follows:

- 1.0 Overview
- 2.0 Introduction to Metrology and Inspection
- 3.0 Metrology and Inspection Trends: Past, Present and Future
- 4.0 Theory of Operation, Equipment Design Principles, Main Applications, and Strengths and Limitations of:
  - 4.1 Film thickness measurement systems
  - 4.2 Resistivity measurement systems
  - 4.3 Stress measurement systems
  - 4.4 Defect inspection systems
  - 4.5 Automatic defect classification
  - 4.6 Defect data analysis systems

## 2.0 INTRODUCTION TO METROLOGY AND INSPECTION

Metrology and inspection systems can be broadly separated into three main classifications by application: critical dimension (CD) and overlay measurements, particle and pattern defect detection, and thin film parameter measurement (such as resistivity, thickness and stress). The typical processing steps, and metrology and inspection equipment used to monitor and/or control them, are given in Table 1.

In the semiconductor industry, the continual demand for denser integrated circuits with higher performance and higher speeds drives technological advances in all facets of manufacturing. A key to the success of semiconductor processing is an understanding of the chemical, mechanical and kinetic properties of the wide range of materials used to make a typical circuit.

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