FEATURE ARTICLE

New Multisensor Platform for Advanced Process Control

Pascal Amary*, Eric Bluem*, Christian Louis*, Jean-Philippe Vassilakis*

*JOBIN YVON S.A.S.

Abstract

In the spirit of the Global HORIBA Group philosophy and strategy, the Thin Film Division of JOBIN YVON S.A.S., has developed in collaboration with a key semiconductor manufacturer a new generation of Multi sensor Platform for Advanced Process Control of complex processes. Based on innovative proprietary technology, and long relationship with end-users, the competitive edge of our products, originality of the architecture, smart sensor technology, analytical methodology, and unique signal processing will allows to satisfy the needs of in-situ process control.

1 Introduction

As the semiconductor industry experiences rapid technological changes, new products and processes are continuously developed while technology becomes ever more complicated and precise. These changes give rise to the growing need for in-situ process control and Advanced Process Control System (APC), since human intervention can no longer control the processes. Today, No more fabs will be built without APC strategy. Working groups are organized worldwide to create standards covering in situ and ex situ instrumentation methodologies.

Problems associated with implementation of APC solutions are manifold. How should relevant data be acquired and on what platform should data acquisition and matching take place and how should the results be used?

The Thin Film Division of JOBIN YVON (JY TFD), which primary activity consists of the study, development and manufacturing of instruments for in-situ thin film process control and analysis utilizing techniques such as Optical Emission Spectroscopy, Specular and Polarized Interferometry with Imaging capabilities, Ellipsometry, is now focusing its energy in the development of a universal APC platform in close collaboration with a key semiconductor device manufacturer. The goal of this platform is to perform data acquisition and data management and is based on a flexible and modular architecture which allows the user to tailor a solution to his needs .

The ability to synchronize different sensors on the same chamber, and coupled to a network based architecture allows a complete control of the process. The system provides a common data base to store information on runs from different chambers which is very useful for Advanced Process Control modeling.

2 Smart Sensors

A key part of the system is the availability of a variety of smart sensors (Fig.1) each designed to monitor specific process steps and critical parameters in the same or different chambers of a cluster tool. State of the art optical based sensors including optical emission spectrometer, laser or white light interferometers, and in-situ ellipsometer, can be easily interfaced with process chambers or analysis chamber in order to measure a wide variety of parameters for controlling processes and determining process characteristics. It is also important to allow third party sensors to be integrated (example coupling Bias signals).

Each sensor is described as a combination of a hardware embedded in a PC based controller which includes the acquisition and remote control board and is defined as a station. Each station performs such tasks as enhanced numerical filtering, acquisition, modeling and local data base management. For process control functions there is a remote control link from each station to the equipment.

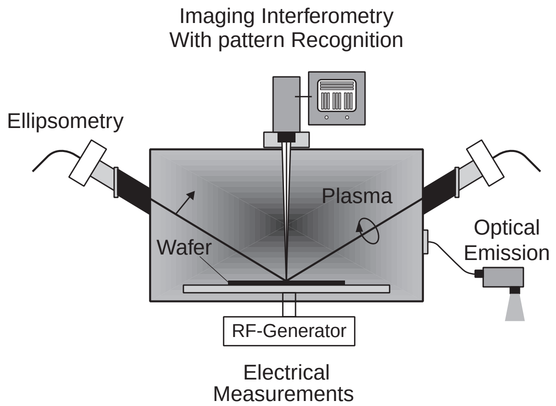

Fig 1. Multisensor Capabilities

2.1 Hardware

2.1.1 Optical Emission Spectroscopy (OES)

The plasma light provides a wealth of information about the etch state, chamber properties, and species reactivity. Usually, this information is easily exploitable. One way to use this information is in determining the endpoint of an etch process or monitoring the health of the chamber. It relies on the simple fact that when one etches through a layer and hits a chemically different under layer, the plasma composition, and therefore the emission spectrum, changes as the new layer is etched and appears in the plasma .

Our OES (Fig.2) systems are based on the use of a high sensitivity CCD array coupled to a high luminosity spectrograph. It covers the spectral range of 200-800nm with a resolution better than 1nm. Acquisition time from few millisecond to second can be easily achieved. For specific application where highly sensitive photo-multipliers are needed, a wide range of monochromataors is available . The flexibility of the system allows the ability to combine and synchronize multiple OES systems.

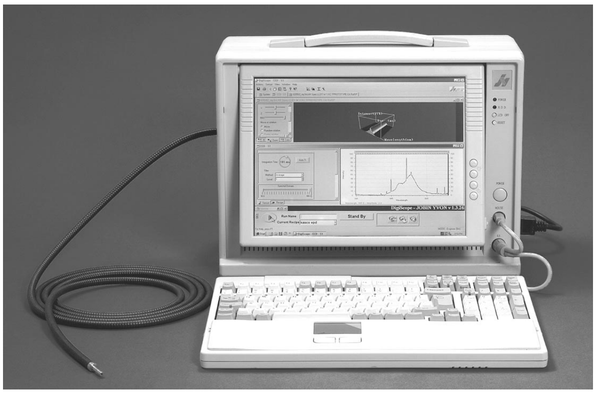

Fig 2. Fully Integrated Optical Emission Spectrometer

2.1.2 Interferometry and Imaging

Interferometry is a powerful technique consisting of illumination of the surface and measuring the reflected intensity from several layers. This sensor allows the determination of the etch or deposition rate, the thickness, and the selectivity. Both monochromatic, for differential measurements, and spectroscopic, for absolute measurements of the thickness are available.

For complex structure with small critical dimensions imaging capability is necessary. We provide a patented system based on the use an imaging camera. The system combines a compact interferometer and a CCD sensor for wafer observation and spot alignment. Attached to a motorized X-Y table, this system allows patterns recognition.

Several fitting methods were developed for the determination of etch/growth rate and film thickness .

2.1.3 Polarized Interferometry and Ellipsometry

Polarized interferometry and Spectroscopic ellipsometry (Fig.3) measures the change in the polarization state of probing light, introduced by its interaction through reflection with the sample under study, and as a function of wavelength. These techniques are very sensitive to the film thickness and optical properties of the material under study.

Several sensors based on single wavelength (HeNe laser), Spectrosocopic Phase Modulated Ellipsometer and Twin-Spot polarized interferometer are available. Sensitivity to mono layer and accurate measurement of refractive index In-Line are achieved. Sophisticated modeling capabilities for ultra thin layers were developed.

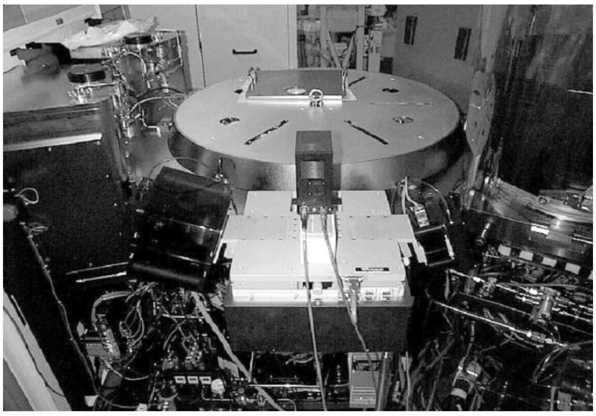

Fig.3 In-Line Monitoring by Spectroscopic Ellipsometry

3 Software

3.1 Data Acquisition and Signal Processing

Several trends in the semiconductor market are driving the need to improve signal processing : the need to increasing yields in wafer manufacturing, the need to produce small critical dimensions (which leads to a deterioration of the signal to noise ratio), and short process times (the system then has less data to fit the phenomenon with the suitable theory and detect the endpoint), the need to predict process evolution versus tool maintenance. With the constant development of new technologies, endpoint methods and collection of information are continuously updated to combine DSP numerical techniques, cross sampling methods, wafer to wafer variations, and improved detection sensitivity even inside noisy signals. Several endpoint methods can also be combined for enhanced endpoint detection.

3.2 Modeling Algorithms

Accurate measurement of thin film thickness and end-pointing represents a main customer goal. It consists of finding a special signal variation pattern during the run analysis using a defined model in order to immediately stop the process. This endpoint detection must be very reliable, must allow parameter tuning to eliminate bad patterns and to guarantee to meet the needs of manufacturing.

3.3 Communication

The communication interface with the tool is crucial for accurate process control, but now links to the Fab Information Servers are an obligation. Our software provides protocols to communicate with most of the equipment manufacturers present on the market. It consists on a SECI/II/HSMS integrated package which can mix also an RS and TCP/IP protocol.

In order to secure the production from sensor failure, a Pass Through Box with 3 levels of securities (Hardware watchdog , power supply , software activity) was developed . It allows to instantly restore the by-pass Tool to Fab link without needing an additional link for instrumentation.

Automatic monitoring of the process and the tool is available. In case of a problem, an automatic alarm is raised and an email can be sent to the process engineer or to the maintenance engineer.

3.4 Data Management

The data management is processed via an embedded SQL relational data-base which was designed and realized for redundancy and data portability. A new concept of unified Runs was built. All data and results (including statistics) related to a run are listed with a generic viewer. Additional actions and tracers, permit to rebuild a database, to merge databases, to move database to another tool.

In a full parallel way, performing Statistics through the Intranet LAN from the desk office even when the instruments are in the clean room and performing a process becomes an easy job.

3.5 Reprocessing Capability

Process application engineers are under enormous pressure to shorten time to production, in addition they must minimize the number of development wafers used. The reprocessing software embedded in the family of Digi JY TFD instruments permits the process engineers to replay all the previous run in an accelerated mode in order to simulate and verify all signal analysis and all parameter settings without processing additional wafers. It is even possible to do reprocessing analysis outside of the clean room and to utilize the knowledge of our customer support team.

Self statistics on reprocessing runs: take a finished production lot, then reprocess its runs, then do statistics on the reprocessed runs, then compare the statistics runs initial versus reprocessed, then recipe changes enhancing quality are validated for next lot is done with new scripting features.

3.6 Advanced Process Control Methodology

There are two major type of APC systems : SPC (Statistical Process Control) and MBPC (Model Based Process Control). Due to the limitations of these methodologies, and due to the absence of a reliable and unique solutions, our focus was to offer a complete and extremely versatile solution which allows the user to tailor a solution to his needs. In order to achieve this feature, a new proprietary concept of unified active recipe was developed. Easy and simple at creation , it can be used by process engineers and operators to perform diverse functions like endpoint, health monitoring , and statistics for fault detection. The “Lego” block style allows us to create the concept of Elastic Recipe (Fig.4).

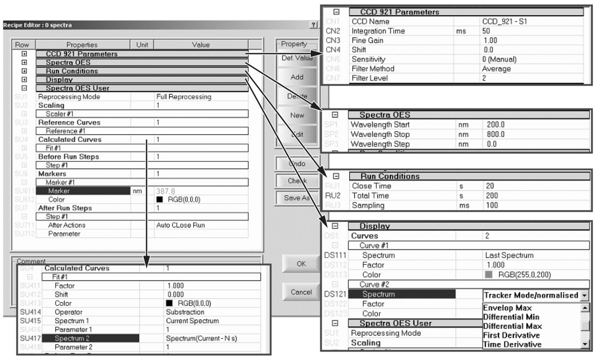

Fig.4 Lego Type Elastic Recipe Editor

A mathematical and logic formula editor allows the user to treat all the stored or acquired data in real time with a spreadsheet like technique and apply to this data a model. As an example, before a lot or between 2 wafers, a recipe can analyze first all the history of the chamber, perform statistics and do trend analysis and model a fault detection pattern. As each process and each wafer is traced in a lisible way, a full automated integration of customized APC or MBPC methods can be easily implemented.

4 Multisensor Supervisor

The supervisor unit control the overall system. This is necessary for complex multi-chamber and multi-sensor applications. In a stand-alone chamber application, user interface functions can be controlled directly at the station level. But in complex environments where several stations have to work together, a supervisor must exist to provide a common user interface and data base management for a group of stations. The supervisor is linked to the stations through a local area network. It also supports a direct Secs II communications link to the equipment.

The selection of a configuration, either a stand alone unit, (one station with up to two sensors), multichamber, or cluster tool configuration depends on the application.

5 Conclusion

The family of JY TFD products offers the customer state of the art instrumentation for semiconductor process control. We are unsurpassed in the flexibility and innovation in all aspects of our design. Whether it's the instruments, sensors, software, or the open architecture of multichamber control, our solutions represent the cutting edge of process control technology. Just as important as our products are the people of JY TFD and their commitment to being the best in the industry. We provide a level of customer support that consistently wins the appreciation of our customers. The passion of the people at JY TFD for being the best in the industry is experienced by every customer we serve.

Pascal Amary, Dr.

Technical Director (R&D)
Thin Film Division

JOBIN YVON S.A.S.

Eric Bluem, Dr.

Application Scientist
Thin Film Division

JOBIN YVON S.A.S.

Christian Louis, Dr.

Software Engineer
Thin Film Division

JOBIN YVON S.A.S.

Jean-Philippe Vassilakis

Manager (Software)
Thin Film Division

JOBIN YVON S.A.S.