PROJECT PROFILE

T304: Development initiative in advanced metrology and automation for new IC technologies (DIAMANT)

PROCESS EQUIPMENT

Partners:

Alcatel Vacuum Technology
ASMI
ATMEL
Canberra Semiconductor
ELDIM
FEI
Fraunhofer Institute
GeMeTec
H.P.E.
INCAM Solutions
Infineon
LETI
MEMC
Nanophotonics
PANalytical
Philips Semiconductors
RECIF
SI Automation
SOPRA
STMicroelectronics
University of Antwerp
University of Cambridge
Wacker

Project leader:

Laurens Kwakman,
Philips Semiconductors

Key project dates:

Start: January 2001
End: December 2004

Countries involved:

Belgium
France
Germany
Italy
The Netherlands
United Kingdom

European chipmakers require innovative physical characterisation and metrology techniques to support efforts to achieve extremely fast development cycles (time to market) and to ensure efficient volume production ramp-up (time to volume). The key objective of this project is to strengthen the position of European metrology suppliers in the global market by developing new tools and methods together with future European users of these tools. European chipmakers will benefit from this co-operation by early access to new analytical techniques and tools. DIAMANT will also strengthen the research community through intellectual property (IP), patents and international dissemination of project results.

New semiconductor technology characterisation requires development of improved analytical techniques, particularly automated in-line thin film metrology. In-line metrology is aimed primarily at process control and equipment monitoring, and is focused on measurements of film thickness, film conductivity, defects, device topography and metal contamination.

Transparent films can be measured by spectroscopic ellipsometry on product wafers but currently no techniques exist that allow opaque film measurements directly on product wafers.

Metrology and defect detection and characterisation techniques are important supportive measures during the development of new process steps and the debugging of new manufacturing processes. They also enable faster increase of yield – preventing loss of material and strengthening the competitive position of semiconductor manufacturers.

Shortening time to volume depends on having appropriate in-line techniques available to measure film properties accurately, reproducibly and rapidly. It is also clear that integrated metrology is a key factor in efficiency and shorter production cycle times in fully automated 300mm wafer fabrication environments.

Range of solutions

Various novel concepts are being investigated and developed in the MEDEA+ T304 DIAMANT project to make suitable metrology tools available at the next nodes on the International Technology Roadmap for Semiconductors (ITRS) in a timely manner. This will enable Europe to benefit from cheaper and more powerful devices, enabling faster yield ramp and higher final yields – resulting in less scrap and lower cost.

Project work includes the study of metrology techniques for integration at different levels in chip manufacture – ranging from stand-alone to fully *in situ* for automatic process control. As a part of the integrated metrology concept, special attention is being paid to clean wafer handling procedures and fabrication logistics.

The large consortium in this MEDEA+ project consists of a balanced mix of European metrology and process equipment suppliers, advanced research institutes and chipmakers, well positioned to realise its ambitious targets.

Three work packages

Work is divided into three independently managed but fully co-ordinated packages:

Work package 1

This key work package is developing and delivering novel techniques and equipment to enable quantitative physical and chemical analysis at chemical and spatial resolutions compatible with sub 0.1µm device technologies. Vapour phase decomposition and carrier lifetime techniques are being developed for in-film and bulk contamination control (less than 10^8 at/cm^2) – essential for assessment of front-end process cleanliness – while scanning/transmission electron microscope (S/TEM), electron energy loss spectroscopy (EELS) and energy dispersive X-ray (EDX) based techniques are being explored and developed to make semi-quantitative analysis possible in sub 0.1µm structures.

Work package 2

This work package targets the equipment and application developments needed for fast and accurate in-line metrology tools. The programme is directed towards techniques and equipment able to measure production wafers and that deliver fast, accurate and relevant material properties/process information for new technology processes. An IR-spectroscopic ellipsometry (IRSE) tool is being optimised for thickness measurements. Combining existing metrology techniques in a single tool helps extraction of film properties by forward feeding data and may help in making in-line metrology more efficient and cost effective. Two combined tools are being developed and applications will be tested in the field. Field-proven X-ray fluorescence (XRF) techniques are being expanded through focused X-ray source developments to enable XRF analyses in-line or expressed differently with regard to production wafers – this is not currently possible.

Work package 3

This package focuses entirely on various aspects of integrated metrology. Three realisations are envisaged: integrated product wafer ellipsometry in a batch, clustered furnace, spectroscopic ellipsometry in a real time protocol (RTP) cluster tool and, finally, an advanced integrated residual gas analyser (RGA) sensor in a chemical vapour deposition (CVD) cluster system. Technical developments are being conducted to:

- Develop compact but powerful metrology blocks as well as standardised equipment front-end modules (EFEMs) with integrated metrology blocks;
- Create an original and innovative stocker/sorter with integrated metrology for efficient monitor wafer management; and
- Develop a single wafer front-opening unified pod (FOUP) as a new standard for monitor and device wafer characterisation purposes, where clean wafer transport is essential.

Work package tasks are oriented to the realisation of various integration projects, including: particle and film thickness metrology tools in processing equipment or in the atmospheric front-end module, also developed and realised in this work package; the development of an efficient monitor wafer strategy (FOUP stocker with integrated metrology to sort and class monitor wafers automatically); appropriate wafer handling techniques; and the data management and control structures that form the heart of an integrated metrology architecture. Consortium members are working together in the latter activity to define standards and best practice.

Securing competitive position

This MEDEA+ project aims to secure the competitive position of the European microelectronics industry in areas of metrology equipment, IC process equipment, wafer fabrication automation and chip fabrication in the face of tough competition from US, Japanese and other Asia-Pacific semiconductor manufacturers. It builds on the results of the earlier MEDEA T618 and T601 projects and complements work in the MEDEA+ T301 0.1µm Fab project.

The current annual global market for thin film metrology is around € 500 million with a growth rate of some 25% a year. About 95% is currently stand-alone, but an important shift is forecast towards integrated metrology. Europe has a significant strength in metrology equipment and has the most advanced solutions in the field of integrated metrology. Major competition today on integrated metrology is from the USA and Japan.

Three of the world's top ten semiconductor manufacturers are based in Europe and have an interest in early access to the most novel metrology tools. The DIAMANT project should boost European employment possibilities in a competitive European semiconductor equipment industry, a competitive European semiconductor industry and high-level European research and development community.

This MEDEA+ project is also intended to influence future standards in the metrology field, particularly in data management and communications protocols for integrated metrology.

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