VO!CE

Edition 9

•••••• Spotlight ••••••

Wafer based metrology is becoming increasingly important for improved process control. The wireless sensor wafers of K-T Promesys allow temperature measurements of a wafer at such diverse process steps as bake, develop, wet clean, CMP, and ion implant. Other process parameters can also be measured at the wafer level. Please read about the smart capabilities of process monitoring that are available today.

Our partner **PSI** has broadened their offering of calibration standards and we are now able to supply standards for step height and metal thickness. The new standards feature two calibrated areas and additional diagnostic features. On page 4 we describe how you can benefit in calibrating your metrology tools faster and more reliably.

The photomasks required for exposure of test circuits and during pilot production contribute significantly to cost and often hamper rapid design improvements. Imagine how much faster and more flexible you could act if no mask was required for exposure! Our partner **Intelligent Micro Patterning** offers mask less pattern projection systems. Please read about it in more detail on page 2.

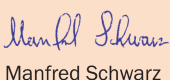
Model-based infrared reflectometry is able to successfully address a wealth of metrology challenges. Out of the numerous possible applications of the tools from **AMS**, we pick measurement of etched structures in silicon used in trench gates and super-junctions of power devices.

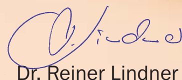
Other companies and products featured in this issue of our VO!CE letter are:

- **Foothill Instruments**
  Table top film thickness metrology tools
- **Nucent**
  Chemical probe card cleaning equipment
- **Sawatec**
  Hotplates and resist coating equipment
- **Syniad Systems**
  Equipment for wafer sorting and wafer handling

We hope you enjoy reading this new edition of the VO!CE of veonis.

Yours





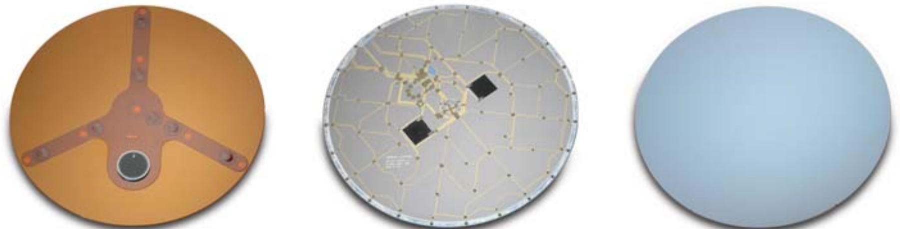
Manfred Schwarz Dr. Reiner Lindner

“In-situ“ process control

with wafer level metrology

Up to recent years, only wired sensor wafers have been known. Meanwhile, wireless versions of such wafer based process probes have become available. The wireless design has greatly simplified the handling of the wafers and improved monitoring capabilities within new process areas. Because sensors, electronic circuitry and memory are all placed on the wafer surface or are integrated into the wafer substrate the sensor wafer can run through diverse process steps like an ordinary product wafer.

Fig. 1: Different models of sensor wafers.



a) PlasmaVolt Wafer *b) Integrated Wafer* *c) Integral Wafer*

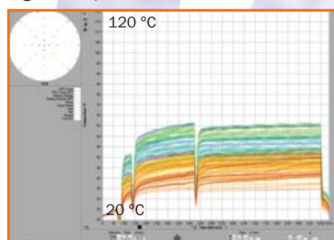
Temperature measurements during the bake of the photoresist before and after exposure were one of the main applications in the past. With the new generation of sensor wafers temperature profiles and transients can be measured at a variety of processes steps such as develop, wet clean, CMP, implant and plasma etch. Moreover, other important process parameters can be measured with new sensor technology. The PlasmaVolt wafer is a distinct example. It allows measurement of electrical properties of an etch plasma at the wafer surface with spatial resolution.

Figure 1 illustrates several versions of wireless sensor wafers. Sensors and additional electronics are either placed on top of the wafer surface (Fig. 1 a: PlasmaVolt Wafer) or they are completely embedded into the substrate and are covered with polyimide or silicon (Fig. 1 b: Integrated Wafer; Fig. 1 c: Integral Wafer).

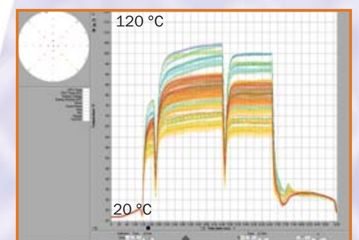
Sensor wafers are most commonly used in lithography tracks for matching of hotplates, adjustment to optimise the bake temperatures and periodic monitoring of temperature profiles. The use of the sensor wafers under plasma etch conditions is much less prevalent despite the huge benefit for this application. Measurements in plasma processes mainly focus on measuring the temperature rise due to the active plasma and to determine the influence of the helium pressure of the electrostatic chuck (ESC) on the wafer temperature.

Fig. 2 illustrates how helium pressure of the ESC affects the temperature level of the wafer (Fig. 2a and 2b) and how it contributes to the spatial temperature distribution over the wafer (Fig. 2 c through f, page 5). As expected there is a rise in peak temperature if the helium pressure is reduced. However, the drop in helium pressure did not have a uniform impact on the wafer temperature. The almost radially symmetric profile changes to a saddle shaped profile. Such asymmetric profiles are very difficult to cope with because they can hardly be compensated for by other measures.

Fig. 2: Temperature versus time for all sensors



a) at 45 Torr Helium pressure



b) at 25 Torr Helium pressure

>> continued page 5

veonis
MORE THAN SUPPLY

Metrology for power semiconductors

For many years veonis Technologies have been partners with Advanced Metrology Systems (AMS). The company has added applications for power semiconductor devices to its IR3000 metrology tool. The IR3000 uses Model-Based Infrared Reflectometry (MBIR) to measure etched and filled trench structures, in addition to film thickness and chemical composition. New applications for power semiconductor devices include measurements of trench depth and width, detection of profile defects and measurements of poly fill depth and recess etch.

Power device manufacturers now have a class of trench metrology problems similar to those faced in the advanced logic and memory areas, although the dimensions of power device structures are much larger.

Advancements in power semiconductor devices are being driven by several goals (such as decreasing cell size, lowering resistance, and raising breakdown voltages) which benefit from incorporating more vertical structure into the device. Recent developments include trench-gate power MOSFETs with vertical gate structures, the use of deep trench isolation (DTI) to isolate devices and the development of super-junction structures. These trends are similar to the parallel trends in advanced logic and memory devices, which have also become more vertically structured.

Trenches used in power devices may be from 1 to 2 µm deep for trench gates or 40 to 80 µm deep for DTI or super-junctions. Metrology and process control for this new class of deep trench structures is difficult using visible optical metrology. Narrow, deep trenches in silicon are not easily accessible with visible light due to optical absorption and diffraction effects.

However, using MBIR with infrared light, the optical wavelength (1.4 to 20 µm) is well suited to these large structures.

MBIR-based IR3000 tools are already widely deployed within fabs producing deep trench DRAM memory devices, which use high aspect ratio trenches formed in silicon. MBIR is used to measure etch depth and bottom area as the trenches are formed, to detect misprocessed die with abnormal trench profiles and to measure recess depths after each fill/etch cycle as the trenches are filled.

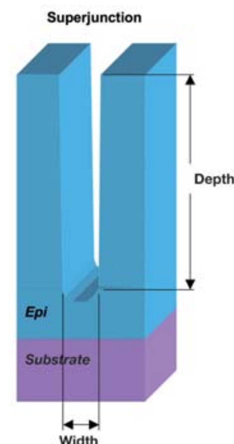
Similar metrology needs are encountered in the fabrication of power devices of various types: Initially high aspect ratio, deep trenches are etched into the silicon; then the trenches are filled and the fill is etched back to controlled recess values.

Advanced Metrology Systems has added metrology applications for these power semiconductor device processes. Applications include:

- Trench etch depth
- Trench bottom width
- Abnormal profile detection
- Poly fill depth
- Fill voids detection
- Recess measurement

By using MBIR technology chip manufacturers can reduce costly and time-consuming SEM analysis, get faster feedback on production problems, and improve yields and development time. The rapid measurement of the IR3000 tool enables routine and detailed process monitoring.

The IR3000 tool is fully automated and fab-ready, and has already been deployed in fabs worldwide.



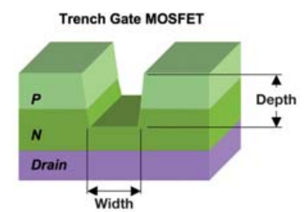


Fig. 1: Schematic diagrams of trench gate MOSFET and superjunction structures used in power semiconductor devices. The IR3000 from AMS uses infrared light to measure trench dimensions, fill, and recess.

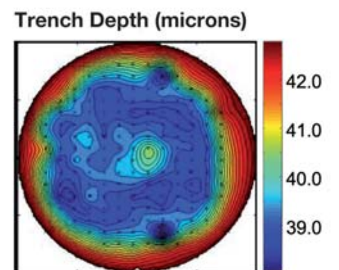


Fig. 2: Full-wafer uniformity map of etch depth on 40 µm deep trenches.

AMS focuses on unique metrology solutions and is based near Boston in the US. Established by Philips Electronics, the company became an independent business entity in October 2006.

Mask Less Patterning of Flat and Curved Substrates

Fast, simple, and low cost patterning of microstructures is important for many applications. Intelligent Micro Patterning's SF-100 (Fig. 1) uses direct pattern projection without the need for a photomask. This affords the user many benefits, such as significantly decreased development time, accelerated time to market, reduced prototype costs, and process versatility. The applications of the tool cover such diverse fields as MEMS devices, microwave devices, microfluidics, microgears, but also include medical stents and patterning of curved devices. As a result of its sophisticated optical design, the SF-100 is able to project complete images onto non-flat surfaces. This unique system capability is not available with traditional lithography systems. In combination with greyscale imaging technology (a standard feature of the tool) uniform exposures across an image over a curved surface become feasible. A sample of this capability is shown in Fig. 2. The sample illustrates successful image transfer to

Hotplates and Resist Coating Equipment

SAWATEC

Sawatec Solutions AG is a new partner of veonis Technologies. The company has specialized in the design and manufacture of products for research labs, universities and pilot production lines in the Semiconductor Industry. In addition, the products are also serving system integrators in the Replication Industry such as CD-R and DVD manufacturing. The product range covers hotplates and coolplates, spray coaters, spin coaters, resist developers, dispensing pumps and related products. The equipment excels due to its high quality design, stable performance and reliability. A multi-zone hot/coolplate is shown in Fig. 1. The equipment is loaded manually and allows programmable ramp up to a maximum temperature of 700°C and controlled cool down.

Other features such as loading and proximity pins, levelling of the hotplate, HMDS wafer prime and nitrogen flush are included as well. A protection glass for the hotplate is available as an option.

Resist coaters are offered in two versions, as spray coaters and spin coaters (Fig. 2). Both types of coaters are available for round substrates up to 300 mm in diameter or for quadratic samples with a maximum size of 8” x 8”. The manually loaded spray coater features a heated chuck up to 150°C, electrical swivel arm for static or dynamic dispense and a special spray nozzle from Sawatec. Chucks are mounted via snap-in and can be easily exchanged without the use of any tools.

Spin coaters use a servomotor for up to 12’000 rpm ± 1 rpm. Contamination of servomotors with photoresist is prevented by special protection measures. The substrates are fixed via a vacuum and protected with safety interlocks. The dispense pumps from Sawatec are able to handle viscosities up to 50’000 cps and offer suck back function. Other features include a cartridge dispense system and programmable process cycle with up to 24 pairs of speed/time values.

We would be pleased to introduce the products of Sawatec to you and to work with you on a technical solution specific to your requirements.

Hotplate/Coolplates

- Manual loaded
- Multiple zone hotplate/coolplate
- Max. temperature up to 700°C
- Programmable rump up as well as cool down
- Loading- and proximity pins
- Levelling of the hotplate
- HMDS wafer prime
- To be integrated into a vacuum chamber
- Nitrogen flush and protection glass

Fig. 1

Spin Coaters

- Manual loaded
- Substrate size up to 300 mm or 8” x 8”
- Substrate fixation via vacuum and safety interlock protection
- Dispense pumps from Sawatec for viscosities up to 50’000 cps and suck back function
- Cartridge dispense system
- Brushless AC servomotor for up to 12’000 rpm and accurate to ± 1 rpm
- Servomotor protection against contamination with photo resist
- Programmable process cycle with up to 24 pairs of speed/time values

Fig. 2

Fig. 1

the surface of a cone. The bottom diameter of the cone is 3 cm while the top diameter of the cone is 1 cm. Such imaging on an angled and curved surface is almost impossible with other techniques and demonstrates the power of the tool at other similar demanding applications. Curved surface patterning has been used to successfully pattern seamless embossing masters, stents, biomedical devices, and other cylindrical parts.

The standard image size of the tool is 16 x 13 mm^2 at a resolution of 20 µm. With optional reduction optics minimum features of 5 µm can be patterned. Exposure of large area substrates is possible by automated stitching of image fields. The tool utilizes standard G-line and I-line wavelengths and is compatible with current photoresists and polyimides, including SU-8. The capabilities of the equipment combined with its simplicity of operation and low cost make the SF-100 an ideal exposure tool for research and development labs and pilot production.

Fig. 2

Standards

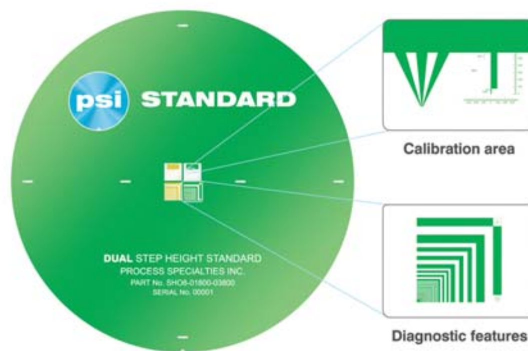
for calibrating profilometers and metal film thickness tools

Our partner Process Specialties has recently introduced two new standards. The new Dual Step Height Standards and Dual Thickness Metal Standards have in common that two NIST[1] traceable, calibrated thickness steps are located on one standard. This makes it easy to determine the linearity of metrology tools over a specific height range without the need to load and set-up a second standard.

Useful diagnostic features are also part of the design of both standards. They allow the user to check important parameters of the instrument. Special features on the step height standard allow stylus integrity, alignment and magnification to be examined. The diagnostic structures on the metal standards allow the user to determine the tool's useable spot size, verify actual beam position versus the electronic spot, plus monitor height and repeatability of stage movement. All of these parameters contribute to signal quality and measurement results and should be checked on a regular basis.

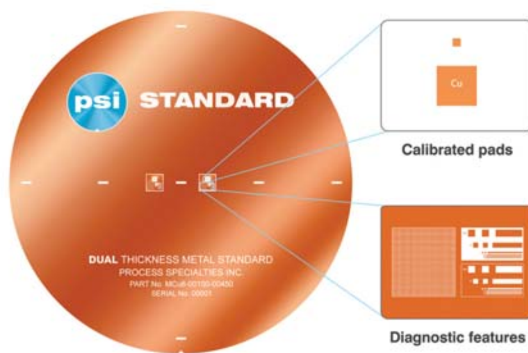
The new line of dual step height standards is offered over a wide range of nominal thicknesses. The precision SiO_2 design is suitable for all stylus based mechanical profilometers and AFM tools.

- New Dual Step Height Technology
- Suitable for Profilers and AFM Tools
- Diagnostic Features for Stylus Integrity, Alignment and Magnification
- NIST traceable



Process Specialties' new metal standards are the only NIST traceable metal thickness standards in the industry. The standards are available for Aluminium, Copper, Tantalum and Titanium. They allow the calibration and monitoring of widely used metal metrology tools on the most frequently used materials.

- New Dual Metal Thickness Technology
- Aluminium, Copper, Tantalum, Titanium
- Diagnostic Features for Spot Size, Spot Offset, and Stage Positioning
- NIST traceable



Automated use of both types of standards is simplified by pattern recognition alignment marks on the wafer. The marks support auto-loading and ensure exact positioning and repeatability of measurements.

In combination with the already available Silicon Dioxide and Silicon Nitride Film Thickness Standards veonis is able to offer you a complete suite of Standards for all film thickness metrology tools and step height measurement equipment.

[1] The National Institute of Standards and Technology, NIST, is a US agency comparable to the Physikalisch-Technischen Bundesanstalt in Braunschweig. Both agencies are responsible e.g. for industry standards and standardization of measurement procedures.

Film Thickness Metrology Tools

Our partner Foothill Instruments has specialized in design and manufacture of compact yet powerful tabletop thin film metrology equipment. The systems cover a wide range of film thickness and have special strengths in the measurement of very thick films (up to 500 µm) used in MEMS manufacturing. Any non- or weakly-absorbing material such as resists, oxides, nitrides, or poly-Si can be measured on any smooth substrate.

Fig. 1

Fig. 1 shows the KV-300 series of tools. Different thickness range configurations as well as a monochrome camera system and vacuum chuck are available. The equipment is simple to operate and extremely reliable. Key features and capabilities are:

- Compact footprint with highly reliable 300 mm R - Theta stage
- Generate thickness contour map in less than one minute
- Internal reference calibration standard to maintain accuracy
- Produces no stray white light
- Optical design eliminates need for focusing
- Simple maintenance: semi-annual lamp change done in minutes

Standards

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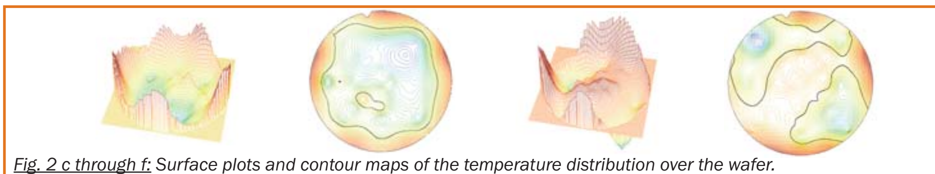

Fig. 2 c through f: Surface plots and contour maps of the temperature distribution over the wafer.

Chamber matching is another application for the sensor wafer products PlasmaTemp G4 or Integral Etch i3. Both types of wafer can be used in active plasma. The wafers differ in overall thickness, maximum permissible RF power and the number of sensors. Fig. 3 shows the difference in temperature as measured consecutively in four 'identical' etch process chambers. Despite running the same recipe the chambers display marked differences in actual performance delivered to the wafer. The mean temperature as well as temperature spread and distribution vary significantly over the four chambers.

This could be evidence of aging ESCs, clogged Helium, or disparate RF delivery.
Some process variations cannot be seen in the temperature profile. In some of these cases the Plasma Volt wafer can provide insight into the plasma process because the wafer is equipped with special sensors. The sensors are sensitive to the electrical properties of the plasma and respond to RF power from either source or bias. The data can be used to improve process control and to achieve better chamber matching. In addition, the PlasmaVolt wafer helps to diagnose RF subsystem problems quickly and thus reduce downtime.

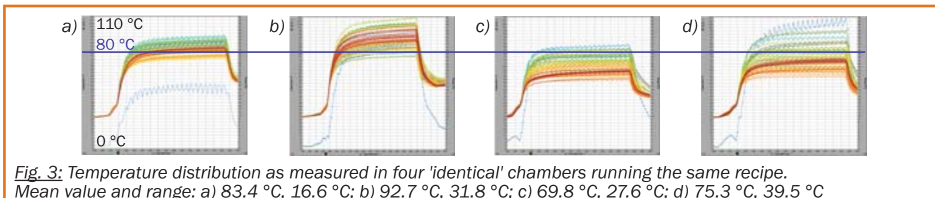

Fig. 3: Temperature distribution as measured in four 'identical' chambers running the same recipe.
Mean value and range: a) 83.4 °C, 16.6 °C; b) 92.7 °C, 31.8 °C; c) 69.8 °C, 27.6 °C; d) 75.3 °C, 39.5 °C

The sensor wafers of K-T Promesys have the following strengths and benefits:

- Process visualization
- Rapid engineering analysis and process optimization
- Tool installation and start up
- Troubleshooting assistance
- Chamber matching
- PM qualification
- Production monitoring
- Saving of etch rate test wafer

We would be happy to demonstrate the benefits the sensor wafers could bring to your process control. Please call us today!

In spring 2007 KLA-Tencor acquired the two companies SensArray and OnWafer and merged them into a new business unit called K-T Promesys (Process Metrology Systems). veonis Technologies is the exclusive distributor of K-T Promesys throughout Europe (with the exception of Italy).

„In-situ" process control

Contact less chemical probe card cleaning equipment

NUCENT Co., Ltd.

Fig. 1

Non-contact, non-abrasive cleaning of probe tips has been a challenge for quite some time. The CPCC-500 tool (Fig. 1) has been designed and developed to address the stringent demands of sophisticated probe cards.

Small probe tip geometries (15 to 25 µm) and low test voltages used today make the tips very sensitive to debris accumulation and mechanical stress. Probe cleanliness and probe integrity is of paramount importance to remove the burdens of re-test and to guarantee maximum device yields. Proper cleaning also increases probe card life and helps to reduce maintenance costs.

The CPCC-500 series of Chemical Probe Card Cleaners are designed to accommodate all probe card configurations and employ non-contact, non-abrasive cleaning of high density probe cards. The cleaning station uses an aqueous solution of a mild environmentally safe chemical cleaner – ProbeWash LC from RD Chemical Company. Probe card needle tips are immersed to a programmable depth in the cleaning solution with a Z axis accuracy of ± 1 µm. Depth control is via an electrical contact sensor driving a Z axis motor that controls the height of the cleaning tray.

Following the probe tip cleaning cycle the probe card needle tips are rinsed free of the cleaning solution by tip immersion in DI water. Finally the cleaned cards are dried using heated nitrogen gas. The entire cycle takes about 15 – 20 minutes to complete.

Fig. 2 shows a typical cleaning result. After one pass through the CPCC-500 tool the contact resistance of the probe needles has drastically decreased. The needles indicate no wear or other mechanical stress from the cleaning process. Key benefits of probe card cleaning in Nucent's CPCC-500 in combination with ProbeWash are:

- Increase of Probe Needle Life
- Increase of Probe Yield
- Removal of Oxide and Aluminium
- Reduction of Contact Resistance (Cres)

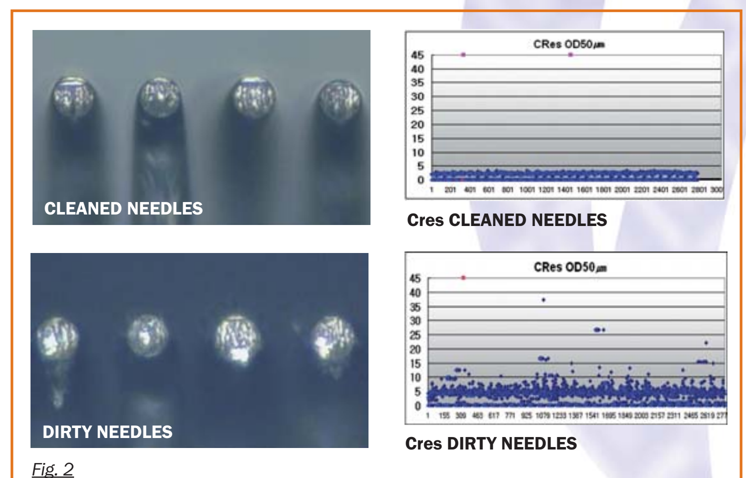

Fig. 2

WWW.PUR2.DE

Wafer sorters and micro loaders

Our partner Syniad Systems of South Wales in the UK has recently launched their Micro Loader ML1200. In combination with the Wafer Sorter WS4200 introduced in 2006 we are able to broaden our portfolio of automated wafer handling systems. Both types of equipment have already been installed at customer sites.

The Wafer Sorter WS4200 is State of the Art in design and incorporates the latest high speed wafer handling robots combined with precision wafer alignment for OCR and precise wafer placements into cassettes for thin or fragile wafers. The systems incorporate high level wafer safety sensing as standard including fast scanning of all cassettes on the system for wafers present and absent, and wafer misplacement sensing for wafers out of the cassette due to, for example, misloading by the operator. A unique light bar protects the whole sorter environment to provide safety for both the operator from moving parts and the wafers from operator intervention at incorrect times in the sorting cycle.

The system has 4 cassette stations by default and may have optional bright light inspection and other wafer measurement modules included for sorting according to particle density or wafer thickness for example. The system is available for wafer sizes up to 300 mm and can be configured as a bridge tool for 2 different wafer sizes.

The key benefit of this new system alongside its handling speed and wafer safety is the new Graphical User Interface. Written especially for the new tool, this includes the standard sorter applications of Sort, Split and Merge modes and in addition a Wand mode to simulate manual operator wafer moves. The unique Database Sort key is a software routine that allows data to be downloaded to the sorter from the MES system and the data used on the sorter to place the wafers to a particular position due to for example, their thickness or their OCR number.

Fig 1:
Syniad Systems Wafer Sorter WS4200™

The processes may be linked together to form sequences of steps which reduce operator interventions on the system and save time by reducing the need to rescan cassettes and program each part of the process. Dedicated keys on the sorter interface can then be assigned by the customer engineers to each of these processes and the remaining keys locked out to prevent mis-operation. All of these functions are protected by password and different access levels which are assignable by the user.

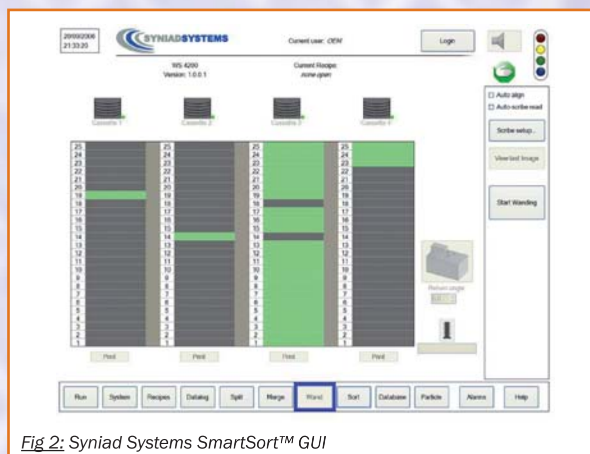

Fig 2: Syniad Systems SmartSort™ GUI

The new Micro Loader ML1200 is designed specifically for the use in combination with inspection microscopes. The equipment is very compact and offers cassette mapping as well as network integration via SECS/GEM. The intuitive software user interface SmartLoad™ allows easy configuration and operation of the loader.

Fig. 3:
Syniad Systems Micro Loader ML1200™

- Class 1 Cleanliness
- Cassette Mapping
- Autosize 100 mm – 200 mm Bridge Tool optional
- OCR (Optical Character Reading) optional
- Waferalignment optional
- SECS/GEM Interface optional

We look forward to demonstrate the user interface to you during a visit and to explain other features and benefits of the two tools.

EDITORIAL

Contact:
Dr. Reiner Lindner

veonis Technologies GmbH
Junkersstrasse 1,
D - 82178 Puchheim / Munich
Germany
Phone +49 - (0)89 - 800 85-0
Fax +49 - (0)89 - 800 52 68

veonis Technologies Ltd
United Kingdom
Phone +44 - (0) 145 28 86 349
Fax +44 - (0) 145 28 86 479

veonis Technologies Eurl
France
Phone +33 - (0) 476 63 49 14
Fax +33 - (0) 426 68 98 90

www.veonis.com