

PROCESSNEWS

A Newsletter from Oxford Instruments Plasma Technology (OIPT)



Welcome to PROCESSNEWS

As in previous editions, this issue of **PROCESSNEWS** explores some of the exciting work we are doing at OIPT both in process and tool development.

I was talking to our CEO the other day and he was asking what our key strengths were and why Oxford Instruments Plasma Technology (OIPT) was continuing to be successful despite the economic downturn. My instant response was "our world leading processes and process support", but on reflection, the real answer is our customers. We pride ourselves on the leading edge processes that we develop and continually refine at OIPT, but without the innovative research and demanding production requirements of our customers, these processes wouldn't be developed and we wouldn't be constantly challenged to improve them.

This leads me neatly on to this edition of **PROCESSNEWS** where I am pleased to report that we have two articles from our users with David Henry from Caltech and Francesca Iacopi from IMEC both contributing to this issue. I hope that these will be the first of many

contributions, so please don't be shy if there is something you would like us to include! We have also reported some of the exciting work we are doing at OIPT both in process development and tool development which I hope you will both enjoy and find informative.

Also in this edition, you will see that there are a number of new faces that have joined OIPT. All of these new roles are customer facing providing additional service and application support. This is a reflection of our continuing commitment to support our customers and to ensure that we provide the best possible service.

If you have any comments on any of our articles or ideas on how we can improve **PROCESSNEWS**, we would really like to hear from you. In the meantime, enjoy the read.

Mark Vosloo

Sales & Customer Support Director OIPT

Oxford Instruments Chairman's Awards for Innovation

OIPT were joint winners of the internal OI Technical Innovation prize, in the 4th Annual Chairman's Awards for Innovation. The winning entry was for High Density Plasma Source Innovation.

There were a record number of entries and the judges proclaimed the standard of entries was the highest yet!



Pictured are some of OIPT team, receiving their prize from Nigel Keen, OI's Chairman.

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Carbon Nanotubes and Semiconductor Nanowires for Microelectronics

Francesca Iacopi, PhD, *Senior Scientist*, on behalf of the Nano group, IMEC

The continuous downscaling of feature sizes in microelectronics according to Moore's law has already required the introduction of several "non-conventional" materials into the semiconductor manufacturing industry in recent years, such as Cu, high- and low- k dielectrics, etc.

For very advanced technology nodes (i.e. towards the 16nm node), bottom-up grown nanomaterials are also being considered for their potential as building blocks of devices and interconnections. Nanomaterials would not necessarily directly contribute to higher device

densities, but their unique properties may solve specific issues linked to downscaling and would certainly enable a number of new device concepts and architectures. Carbon Nanotubes (CNTs) and semiconductor Nanowires (NWs) are generally bottom-up grown in a catalysed chemical vapour deposition (CCVD) fashion, i.e. with the mediation of metal nanoparticles. The formation of such nanoparticles by breaking up a thin catalyst film on the substrate, and the particle pre-growth treatment are key steps of the global growth process, which would literally only start when the precursor

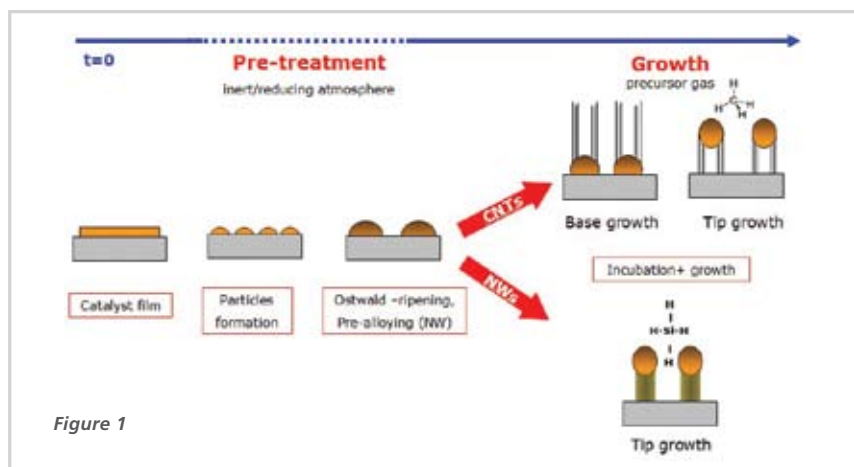


Figure 1

gases are brought into the chamber (Fig.1). For microelectronics applications, it is essential that the growth process stays compatible with Si technology in terms of materials, tools and processes used, and also that it can be realised on wafer –scale.

densities, but their unique properties may solve specific issues linked to downscaling and would certainly enable a number of new device concepts and architectures. Carbon Nanotubes (CNTs) and semiconductor Nanowires (NWs) are generally bottom-up grown in a catalysed chemical vapour deposition (CCVD) fashion, i.e. with the mediation of metal nanoparticles. The formation of such nanoparticles by breaking up a thin catalyst film on the substrate, and the particle pre-growth treatment are key steps of the global growth process, which would literally only start when the precursor

CNTs are mostly being considered as possible interconnects material, as replacement of Cu interconnects. The characteristic ballistic conduction of metallic CNTs, together with their high thermal conductivity (about 6000 W K^{-1} , compared to 400 W K^{-1} for Cu), makes them particularly interesting for vertical interconnects in small vias (10 nm diameter and below) with high aspect ratios. The most favourable configuration would be the growth of high density single wall carbon nanotubes, although also multi-wall nanotubes would lead to an improvement as compared to Cu.

As shown in Fig.2, a high density ($\sim 10^{12}$ CNTs/cm²) carpet of aligned CNTs with a few nm diameter was grown at 650°C in a **Plasmalab**System100, starting from a Fe/Ti bilayer catalyst. The plasma pre-treatment of the particles is key to such high density growth.

Semiconductor nanowires are ideal building blocks for both logics and memory devices. Their vertical wire geometry allows excellent control on the electrical field in the channel of a nanowire-based transistor thanks to the all-around gate. Also, the growth of segmented nanowires would enable the formation of high quality hetero-junctions of mismatched semiconductors, thanks to favourable elastic and plastic relaxation phenomena at the nanoscale. On the other hand, NWs are generally grown using Au catalyst particles. Au is a killer impurity in Si technology, and trials to use other metal catalysts have not been as successful. In Fig.3 we show the feasibility of Si NWs growth from indium nanoparticles, again in a **Plasmalab**System100. Indium is not an efficient chemical catalyst for the Si precursor dissociation, so the use of plasma-enhanced CVD growth, following a plasma-based particle pre-growth treatment of the In particles, is essential for a successful In-mediated nanowire growth.

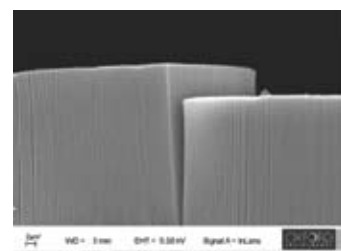


Figure 2

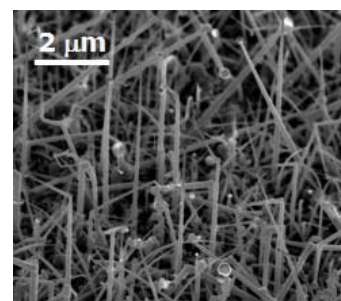


Figure 3

Conformal Coating of Carbon Nanotubes

Cigang Xu, PhD, *Development Scientist, OIPT*

There is great interest in the growth, functionalisation and application of carbon nanotubes. Growth and coating can be combined in a single tool.

Here we show that the growth and functionalisation of carbon nanotubes can be performed in a vacuum environment using OIPT's **Nanofab800Agile™** and **FlexAL** tools.

Carbon nanotubes were grown through thermal chemical vapour deposition (CVD) and plasma-enhanced chemical vapour deposition (PECVD) processes to give the dense carbon nanotubes and vertical carbon nanotubes respectively.

Atomic Layer Deposition (ALD) processes were then employed to coat the carbon nanotubes. Both the dense and vertical carbon nanotube samples survive the oxygen plasma steps of the ALD processes. After the ALD deposition of Al_2O_3 , there is no obvious change on the morphology of the carbon nanotubes, also no lump materials of Al_2O_3 can be observed through scanning electron microscope (SEM). The presence of Al_2O_3 on the treated carbon nanotube samples is verified through energy dispersive X-ray analysis (EDX). Fig.1 and Fig.2 show the SEM images and EDX spectrum from Al_2O_3 coated vertical carbon nanotubes and dense carbon nanotubes. These implied that the coating of Al_2O_3 was conformal.

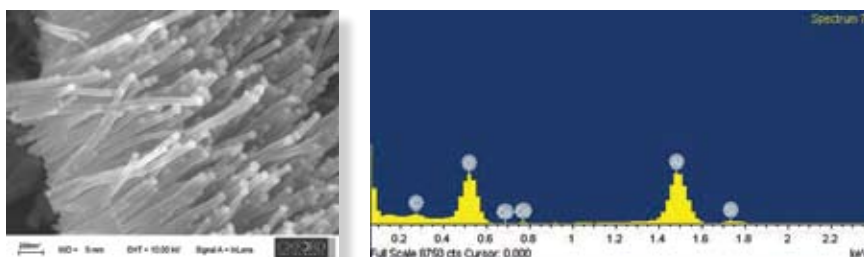


Fig 1. The SEM image and EDX spectrum of Al_2O_3 coated vertical carbon nanotubes (a) SEM image of Al_2O_3 -coated vertical carbon nanotubes (b) EDX spectrum shows the presence of Al and O (Co is the catalyst at the tip of carbon nanotubes, Si is from the substrate).

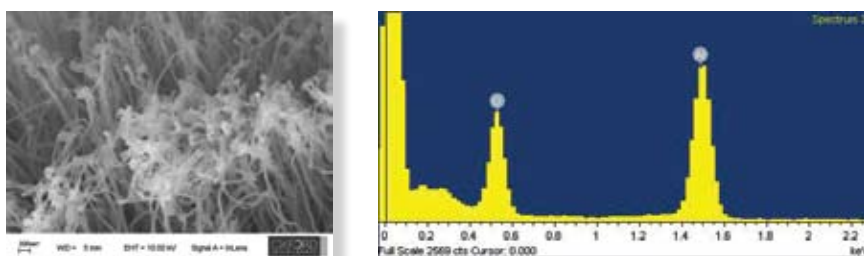


Fig 2. The SEM image and EDX spectrum of Al_2O_3 coated dense carbon nanotubes (a) SEM image of Al_2O_3 -coated dense carbon nanotubes (b) EDX spectrum shows the presence of Al and O (C is not indicated).

Control of the coating thickness may provide a non-destructive approach to functionalise carbon nanotubes, moreover the growth and coating step can in principle be performed in vacuum in a single tool, which is attractive to the semiconductor industry.

New OIPT Product Brochures

We have a number of new brochures available, both online and in hard copy. If you'd like us to send you copies of any of these new brochures, please email us at plasma@oxinst.com. You'll also find them on our website www.oxford-instruments.com/plasma



Selecting the Best Etch Chemistry and Etch Mask for Achieving Silicon Nanoscale Structures

M. David Henry*, Andrew Homyk, Sameer Walavalkar, & Axel Scherer
Applied Physics Department, California Institute of Technology

Achieving nanoscale features requires a plasma etch utilising passivation and a good etch mask determined by the etch chemistry selected.

Silicon etching at nanoscale dimensions requires quality and precision from both the etching system and the etch mask. The etching system must be clean and deliver a well tuned mixed-mode etch incorporating a continuous etch/passivate chemistry. Two such chemistries are the cryogenic silicon etch, utilising the SF_6 and O_2 chemistry, and the 'Waveguide Etch' referred to here as pseudo Bosch, utilising SF_6 and C_4F_8 chemistry. Both of these etches were performed here using **Plasmalab**System100 ICP-RIE 380s equipped with a cryogenic electrode. The cryogenic etch, performed typically at -120°C , provides high selectivity for most etch masks with vertical sidewall control capable of features with dimensions of hundreds of nanometers. However to achieve structures with lateral dimensions below 100 nanometers, a slower etch becomes more useful.

Using the pseudo Bosch etch at 15°C slows the etch rate down from microns per minute, (typical in cryogenic etching) to 200-300 nanometers per minute. The cost of slowing the etch rate down using this chemistry is that the etch mask selectivity also decreases. For example, where the cryogenic etch achieves selectivity values better than 75:1 for resist etch masks, pseudo Bosch achieves closer to 3:1.

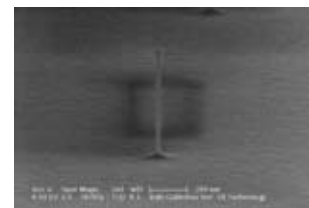
To compensate for the reduced selectivity, etch masks which do not significantly add to the complexity of patterning nanoscale features are required. Although metal masks, such as nickel, offer the increased selectivity desired, they also increase anisotropic undercutting directly below the masks due largely to electrostatic interactions. Thus, smaller scale structures are possible to define with such masks, but achieving deep silicon etches at low bias voltages is not. A good etch mask, then, needs

to be hard and chemically inert to the etch gas, like some metals are, yet electrically insulating as well. Insulating etch masks, such as silicon nitride and silicon dioxide do improve nanoscale etches using cryogenic chemistry by improving selectivity to around 200:1. For the Freon gas chemistry in pseudo Bosch etches, silicon dioxide and silicon nitride rapidly lose their selectivity and etch with rates closely resembling that of silicon etching.

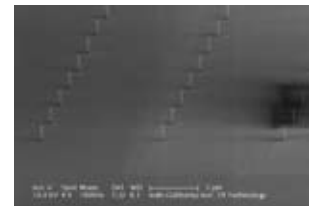
A less common etch mask is sputtered alumina. Thin alumina layers can achieve selectivity of greater than 65:1 for the pseudo Bosch and 5000:1 for cryogenic etching. Alumina etch masks are also easily removed without etching the silicon by using buffered hydrofluoric acid or RCA-1 cleaning chemistry, NH_4OH with H_2O_2 . Using this etch mask combined with the pseudo Bosch etch chemistry, we have etched silicon nanopillars with aspect ratios of 60:1 with diameters down to 20 nanometers.

Choosing the right mask depends on the required etch dimensions and etch chemistry. If the desired structures are hundreds of nanometers in dimensions, etch depths of microns, and a clean process is desired then choosing cryogenic etch chemistry with resist or silicon dioxide is ideal. If the desired structures are tens to hundreds of nanometers in dimensions, etch depths of a few hundred nanometers, and simple etch mask fabrication is desired, then using pseudo Bosch with organic resist is appropriate. But if etch dimensions are tens of nanometers or if extremely high aspect ratios are required, then using alumina etch masks and pseudo Bosch etch chemistry becomes the appropriate choice.

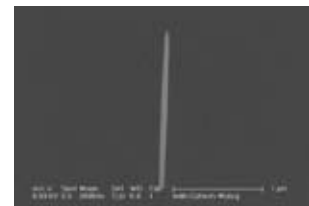
**MDH gratefully acknowledges the support of the John & Fannie Hertz Foundation.*



25 nanometer silicon pillar etched 650 nanometers using an alumina etch mask (still on) using Pseudo Bosch silicon etch in an Oxford Instruments **Plasmalab**System100 ICP-RIE 380.



Rows of 100, 75, and 50 nanometer silicon pillars (from left to right) etched 650 nanometers using an alumina etch mask (still on) using Pseudo Bosch silicon etch in an Oxford Instruments **Plasmalab**System100 ICP-RIE 380.



57 nanometer diameter silicon pillar 2.8 microns using an alumina etch mask using Pseudo Bosch silicon etch in an Oxford Instruments **Plasmalab**System100 ICP-RIE 380.



Tungsten probe contacting a 60 nanometer diameter silicon pillars, 2.5 microns tall. Etched using an alumina etch mask and Pseudo Bosch etch in an Oxford Instruments **Plasmalab**System100 ICP-RIE 380.

PLASMA

CCD1 Spectrometer for Plasmalab Systems

Andy Goodyear, *Principal Applications Specialist, OIPT*

A CCD spectrometer is an extremely useful addition to any plasma tool, since it can provide not only a process endpointing capability, but also a large amount of plasma spectroscopy information - used for monitoring the species within the plasma.

The newly introduced CCD1 spectrometer provides a cost-effective route to general purpose endpointing and spectroscopy, without compromising on resolution or signal strength.



Figure 1. Endpointing using the CCD1.

Process endpointing is achieved via OIPT's front-end software. An example endpoint trace is given in Figure 1. Either a single intensity or a ratio of two intensities can be used for the endpoint signal. The intensities of up to three user-selectable wavelengths can be displayed and datalogged. The intensity and smoothing parameters of the CCD signal can be adjusted via the integration time, number of samples to average, and boxcar width settings. Typical integration times are 5-100msecs for ICP plasmas, and 100msecs to 1sec for RIE or PECVD plasmas, depending on power levels used and assuming a clean window and an unobstructed view of the plasma.

A spectrometer captures the light emitted from the plasma via a viewport (usually on the rear of the chamber), and provides information on the light intensity at each emission wavelength. The CCD1 is a UV/VIS CCD spectrometer that can monitor a wide range of plasma emissions - between the wavelengths 200nm-880nm. This allows the user to monitor all common plasma emission peaks in the UV and visible wavelengths. The CCD1 unit provides good wavelength resolution (<2nm FWHM), hence allowing closely grouped emission lines to be individually identified. A window protector is provided in the CCD1 kit to minimise window fogging or coating and hence allow more repeatable endpointing and spectroscopy analysis in aggressive or depositing processes. The kit also includes a quartz viewport assembly (to allow UV detection), silica fibre optic cable, a spectroscopy software package, and integration of the CCD1 unit to OIPT's front-end software to allow process endpointing.

The CCD1 unit can be used in one of two ways:

Endpoint detection

Process endpointing is achieved via OIPT's front-end software. An example endpoint trace is given in Figure 1. Either a single intensity or a ratio of two intensities can be used for the endpoint signal. The intensities of up to three user-selectable wavelengths can be displayed and datalogged. The intensity and smoothing parameters of the CCD signal can be adjusted via the integration time, number of samples to average, and boxcar width settings.

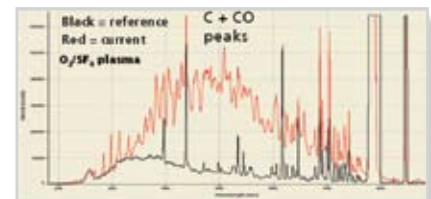


Figure 2. Effect of a contaminated chamber (polymer) on emission spectrum.

Viewing the emission spectrum

The plasma emission spectrum can be viewed and recorded using the provided spectroscopy software package. This allows the user to monitor the species present in the plasma, and hence to gain a greater understanding of the process and its performance. This can be very useful for process optimisation, chamber condition monitoring, and as a process/system health check.

The benefits of plasma spectroscopy can be most easily displayed by showing examples of potential causes of process fault conditions and their ease of detection via spectroscopy. In the following examples a reference spectrum was captured and then the process or system adjusted to simulate a process/system change (see Figures 2 and 3). In each case the change in spectra can be clearly seen and its cause determined.

The CCD1 spectrometer is now available as a system option on new **Plasmalab** tools, and can be offered as an upgrade to systems in the field, dependent on the system age, type, and configuration.

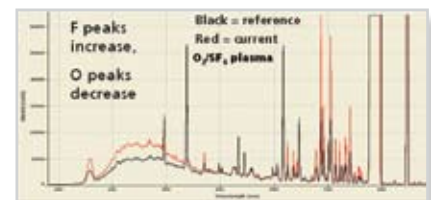


Figure 3. Effect of a gas flow error on emission spectrum.

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2009 Seminar Series Proves a Great Success



OIPT's series of collaborative seminars, with key partner Universities who kindly hosted the events, attracted around 60-70 delegates each.

Innovations in Processing at the Nanoscale at the University of Southampton, UK coincided with the opening of their new state of the art Mountbatten Cleanroom facility. **Prof Peter Ashburn, ECS & Prof James Wilkinson, ORC**, University of Southampton gave introductory talks, followed by tours of the new facility.

Guest speakers included:

Dr Francesca Iacopi, IMEC, Belgium *Carbon Nanotubes and Semiconductor Nanowires (See the article by Dr Iacopi in this issue)*

Prof Siyuan Yu, Bristol University, UK *Fabrication of photonic structures in Lithium Niobate and Lithium Tantalate*

Plasma Etch Tech 2009 – Pushing the Limits was held at the Molecular Foundry, LBNL, CA, USA. **Dr Deirdre Olynick** from LBNL introduced the Foundry Nanofab capabilities and spoke on *Limits in high resolution nanopatterning*.

Guest speakers included:

Dr. Axel Scherer & Dr. David Henry Caltech, USA *Alumina masking for silicon etches (See article in this issue)*

Steve Shannon NCSU, USA *Diagnostics for plasma characterisation and tool level control*

Sebastien Delprat, INRS, Canada *Nanodevice prototypes for testing new concepts in the domains of nanophotonics, nanoelectronics and biomedical devices*

Ivo Rangelow & Maik Hauguth, University of Ilmenau, Germany *Plasma Simulation*

Dr. David Graves, UC Berkeley, USA *Pushing the Limits of Plasma Etch to the Nanoscale*

David Bunzow, LBNL, USA *Intro to Molecular Foundry*

Dry processing for microelectronics, growth, deposition and etching at TUe Eindhoven, Netherlands included talks by TU Eindhoven (TUe), OIPT Process and Applications Experts, and key guest speakers. The workshop was opened by **Dr Erwin Kessels**, TU Eindhoven who also spoke on *ALD for crystalline Silicon photovoltaics*.

Guest speakers included:

Sandro Jatta, TU Darmstadt, NL *Deposition of dielectric films for micromechanical devices*

Boudewijn Docter, TUe, NL *Fabrication of advanced Photonic Integrated Circuits in InGaAsP*

Dr. Erik Langereis, TUe, NL *Monitoring ALD by spectroscopy ellipsometry, optical emission spectroscopy and mass spectrometry*

Maik Hauguth (Burkhard E. Volland, Valentyn Ishchuk, Ivo W. Rangelow, University of Ilmenau, Germany) *Integrated plasma processing simulation framework, linking tool scale plasma models with 2D feature scale etch simulator*

OIPT Applications and Process Specialists gave a range of talks at each event including:

Plasma etching: new features, new directions & ALD; Plasma process characterisation; Growth of Nanowires and Nanotubes; Materials and applications of ALD; Improvements in Ion Beam Processing incl SIMS EPD; Plasma Control/Diagnostics; Endpoint detection in plasma systems; ICP-PECVD, high quality deposition at low temperature; Cleaning of Plasma Systems...and many more

Also...one day ALD workshops were held at UCSB, USA and Cornell University, USA with talks by our ALD Product Manager, Chris Hodson who introduced the fundamentals of ALD.

We'll hold more seminars in 2010, so look out on our website and future issues of this newsletter for announcements.

Copies of several of these talks are available, and more will feature in future issues of **PROCESSNEWS**. To be kept up to date with seminar dates, or indeed to hold a seminar at your organisation or to receive the presentations, please email plasma@oxinst.com

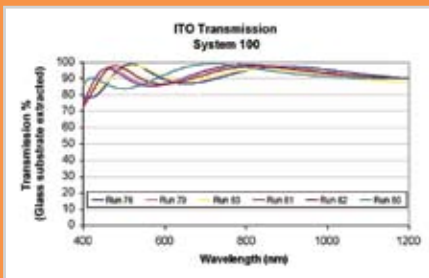


PLASMA

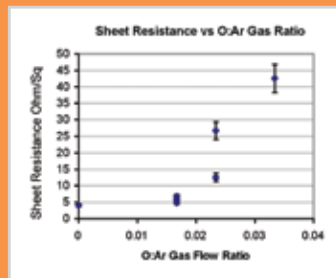


Photovoltaics: Sputtered TCO Process Development

Oxford Instrument Plasma Technology has introduced a single wafer sputtering system in addition to the **Plasmalab**System400 batch sputterer. The module has been designed to be integrated into a cluster configuration and used for PV applications such as TCO deposition using reactive DC magnetron sputtering. The system is available to process substrate sizes up to 156mm square at temperatures of up to 400°C. Processes for Indium Tin Oxide have been developed and show similar film properties to those achieved on the System400.



ITO transparency – all films < 10 Ω/Sq



ITO Sheet Resistance

New Faces at Oxford Instruments



Diane Stubbs

Customer Support
Sales Manager, UK



Dave Pearson

Ion Beam
Technologist, UK



Simon Morse

Customer Support
Engineer, UK



CY Liao

Applications
Engineer, China



Michael Qui

Customer Support
Engineer, China



Tobias Daiberl

Field Service
Engineer, Germany



Todd Komanetsky

Sales Manager,
Central South
America & Caribbean

Bright New Order from Bridgelux

Bridgelux, Inc., based in California, USA, has recently placed an order for a System800 Plus Batch PECVD and a System133 ICP 380 Batch Etch tool. Bridgelux is a leading manufacturer of energy saving light-emitting diode (LED)-based solid-state lighting solutions.

"We have been using OIPT etch and deposition tools for some time, and have successfully established our fabrication processes using these systems," commented Dr. Frank Hu, Ph.D., Bridgelux Director of Fab Operations. *"Bridgelux is focused on enabling mass adoption of LED-based solid-state lighting by reducing the cost of light in the general lighting market. Oxford Instruments has proven to be a reliable partner, delivering process performance and a high degree of flexibility with low cost of ownership to help us deliver a quality product with the high performance levels demanded by our customers."*



What are the Panels for?

Mike Cooke, PhD, *Chief Technology Officer, OIPT*

Why have panels to enclose a machine? Apart from style, we think there are good reasons to care about the panels, many of them affecting machine safety.

The law often distinguishes between an operator who uses a machine and a skilled or informed person who services or maintains that machine. In a work setting, the machine must be safe for everyone in that area. The operator, using the controls provided, with the panels fitted, must not be able to touch any hazardous live component. Anyone who gets inside the machine using a tool must be skilled, can understand the warnings posted on the tool and in the manual, and appreciate the hazards they find inside. Panels are an important contribution to the safe system of work of every machine user. Habitually leaving the panels off blurs the boundary between the usual machine users (who are often highly skilled) and others in the same room – including the cleaner.

A vacuum processing tool has several kinds of hazards inside, including:

- High voltage (3 phase power)
- Radio frequency (RF) sources (13.56MHz and other frequencies)
- Mechanical hazards (e.g. turbomolecular pump rotation)
- Toxic gases

It is a fundamental requirement that a machine is safe to operate, despite these hazards, and the panels play a role in assuring safety for all these hazard categories. Electric shock risks are clearly minimised by having the panels in place, especially if the panels are electrically grounded.

There are two principal levels of concern for RF:

1. RF can burn human tissue, so the radiation from the tool anywhere that can be touched is of the greatest importance
2. RF can interfere with other equipment. This is part of the 'electromagnetic compatibility' (EMC) issue.

OIPT products are designed to be safe against RF burns to nearby people, even with the outer panels removed. However, reaching inside the tool there could be some hot spots at internal panel joints where the level exceeds a power density of 1 mWcm^{-2} , which is a typical benchmark for RF safety. (Radiation from mobile phones is around this level). Skilled persons who appreciate the hazards associated with RF will be able to operate the tool with the outer panel removed (possibly

at reduced power level) without endangering themselves or those nearby, for example when setting up RF matching units.

OIPT products normally have two sets of panels between the source of RF energy and the operator. Never turn on RF power with both sets of panels removed: there will be a significant risk of RF burns.



Electromagnetic compatibility

The panels also play a role at the second level of RF safety – electromagnetic compatibility. The test data underpinning the 'CE' certification of OIPT products is taken with the panels in place, and no guarantee of compliance can be given if they are removed. There is nearly always an increase in measurable RF interference broadcast from plasma tools when panels are removed. There is also the potential for interference with the machine from outside RF sources, and (more often) disruption from static sparks when a charged person touches the machine. An outer case which conducts such sparks away to ground before the energy can get into the machine wiring is the best way to handle the susceptibility side of EMC compliance.



Mechanical Hazards

The major mechanical hazard inside the tool is the turbomolecular vacuum pump. When operating an etch machine, you are standing close to an aluminium alloy rotor of at least 1kg, spinning at 30,000rpm or higher. While rotor crashes are rare (especially if the tool is used as recommended), they do occasionally occur. Most such incidents destroy only the pump, but recent stress analysis at OIPT using data supplied by Adixen shows that a worst case incident with a large turbo pump has the potential to disrupt the vacuum envelope of the tool. Should this occur, the interlock system will immediately halt the flow of process gases, but the gases in the tool will begin to diffuse out, taking about one minute for concentrations to approach threshold limit values near the operator. It is clearly safer to the operator to have the outer panels installed to provide a physical barrier to the movement of both gases and broken parts.

The toxic gas hazard is most significant in the gas box, where the gases are piped in at pressures normally above atmospheric pressure, and are reduced to below atmospheric pressure before piping into the process chamber. The gas box is normally extracted if the gas hazard level is significant, and the panel plays an obvious role in maintaining local safety. This panel is normally interlocked, so that all gas valves are shut as the panel is opened.

Remember that there are always residual hazards in operating machinery. No-one can guarantee absolute safety, but as a responsible supplier OIPT keeps the risk of harm as low as reasonably possible. The panels are not just for the look of the machine; they are part of the safety and compliance design of the tool.

Information on RF safe levels is available at: http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

If you take the panels off...
PUT THEM BACK!



OpAL™ Tools Strengthen Liverpool University's ALD Research Project

OIPT recently received a second order from Liverpool University for its **OpAL** Open Load Atomic Layer Deposition tool. This compact system is a unique thermal ALD tool with a clear and easy upgrade route to plasma, allowing the combination of both plasma and thermal ALD in a single tool.

The first system was purchased as part of an EPSRC funded research project*, and the second **OpAL** was purchased as part of a joint industry/government funding initiative. Liverpool University continues to strengthen its links with industry, and is achieving this through its collaboration with OIPT and SAFC Hitech.

*"Our current **OpAL** system is being used to develop thermal ALD processes using ammonia and metal organic precursors for the deposition of hafnium-nitride and lanthanide nitrides / oxynitrides, these materials are of significant interest for gate stack applications in integrated circuits."*

*"The **OpAL** system is a solid research tool, which is well built and has a user friendly control system. As a research scientist with an interest in developing ALD processes, I especially like the fact that the **OpAL** shows plenty of scope for future expansions such as the plasma upgrade option and access ports for in-situ monitoring,"* comments Dr Richard Potter, University of Liverpool, Dept. of Engineering,

Prof. Paul Chalker, University of Liverpool, Dept. of Engineering adds, *"This additional **OpAL** system expands our R&D opportunities with plasma. We chose the **OpAL** because of its flexibility and its well established suitability for research applications both here and at other universities running similar projects."*

*EPIE0485601 - Atomic layer deposition of hafnium-nitride and lanthanide nitrides

Feature Tool System100 Range

Modular tools for wafer processing

OIPT's System100 Range is a flexible and well proven solution for plasma etching and deposition processes. The load-locked wafer entry allows fast wafer exchange, the widest range of process gases and particulate, and moisture control to exacting levels.

One of our most successful and popular tools due to its versatility and flexibility, the System100 Range has sold over 1000 systems worldwide. The range includes the System100 & System133, the pedigrees of which are well qualified and used successfully across the range of academia, R&D and production. The System100Pro Range offers single wafer production capability on a choice of 200mm and 300mm wafer platforms, offering excellent uniformity and high throughput on a range of applications.

Allowing maximum process flexibility for compound semiconductor, optoelectronics, photonics, MEMS and microfluidics applications, the System100 can have many configurations as detailed below.

Key features

- Options of single wafer/batch or cassette loading via the load-locked wafer entry. The System100 can be integrated into a cluster system with central robotic wafer handler and full cassette-to-cassette wafer handling for production processes
- Substrate temperature control is provided by a range of electrodes:
 - **Etch:** Heater/chiller fluid cooled electrode controlled to 150 °C and -150 °C to 400°C using cryo cooled technology. We also offer electrostatic clamping capabilities for silicon wafer and a range of other substrates
 - **Deposition:** temperature capabilities of +400°C, +700 °C and +800°C
- Endpoint detection by laser interferometry and/or optical emission spectroscopy can be fitted to the to enhance etch control

- Options of a 6- or 12-line gas pod provides flexibility in processes and process gases, and may be remotely sited in the service area, away from the main process tool
- Controlled liquid precursor delivery of TEOS, DEZ or TMB are well proven and readily available

Processes

Some examples of processes available using System100 plasma etch & deposition tool:

- Cryo Si etch, Bosch deep Si etch and SOI processes for MEMS, microfluidics and photonics
- III-V etch processes for laser facets, via holes, photonic crystals and many other applications in a wide range of materials (InP, InSb, InGaAsP, GaAs, AlGaAs, GaN, AlGaN, etc.)
- Full scale production and R&D process for GaN, AlGaN, AlGaInPN, AlGaN etching for HB LEDs
- High quality and high rate SiO₂ and SiN deposition for photonics applications
- Diamond like Carbon (DLC) deposition for power semiconductor applications
- Metal etch (Nb,W and Cu)

Process Techniques

Etch

- Inductively Coupled Plasma (ICP). The 200mm wafer source includes magnetic confinement and pulsed Rf control for added control
- Reactive Ion Etch (RIE)

Deposition

- Plasma Enhanced Chemical Vapour Deposition (PECVD) with a low frequency option
- 60 MHz PECVD of high quality films
- Inductively Coupled Plasma Chemical Vapour Deposition (ICP CVD)

We have a very active programme for innovating and developing our hardware and process offerings, working closely with our customers according to their application needs; please contact us for details.





New **FlexAL** Features

Listening to feedback from current **FlexAL** customers and following our own development roadmap a number of enhancements and new features are available for **FlexAL**.

These include:

- Increased number of rapid bubbled metal liquid or solid precursors from 4 to 8
- Increased precursor and operating temperatures
- Rapid delivery system for plasma and thermal gases
- Enhanced chamber liners, forming an inner chamber
- Ozone delivery
- Integrated mass spectrometry to complement the integrated ellipsometry
- Enhanced software interface for users new to ALD

Many of these features are available as upgrades for existing **FlexAL** customers. Contact your local OIPT Sales Manager for more details.

Customer Support Offering a Wide Range of Options

OIPT supplies bespoke equipment into many different types of customer, and so we need to be flexible to meet everyone's needs (from University and laboratories to 24/7 manufacturing).

We're just putting new packages together that mean our customers can pick and choose exactly the type of contract to suit them – if you'd like to know more about these new service and support packages please contact us: plasma@oxinst.com, or call your local OIPT Sales Manager directly.



Strengthening OIPT's Etch Capability for the HLED Market

Mark Dineen, PhD, Principal Applications Engineer, OIPT

Building on our established reputation for market leading etch hardware, the team at OIPT has developed an evolution of the System 133 RIE-ICP380 tool.

The new technology is an active spacer that improves the uniformity of the plasma across the electrode, giving excellent etch results both within wafer and cross batch. A key benefit is that it allows an increase in batch size from 20 x 2" GaN wafers to 27 x 2", or a mammoth 7 x 4" GaN and 18 x 2" Sapphire wafers.

OIPT's new spacer offers uniformity tuning at will, which simplifies the process. This allows enhanced process performance and higher throughput, which is essential for our production customers.

The spacer is retrofittable to our systems in the field.

OIPT's well proven System 133 Process Module is built on a 300mm platform, with multi-batch capability, and with processes guaranteed to ensure rapid start up during installation. It may be clustered to combine technologies and processes, offering maximum flexibility. With an installed base of over 2000 tools worldwide, OIPT tools boast over 90% uptime.

This new technology is being investigated for other process applications with promising results.



Celebrating 50 Years of Innovation

Oxford Instruments recently held a reception at Highclere Castle near Oxford, UK, to celebrate the company's 50 years. With speeches from Sir Martin and Audrey Wood – our founders – there was also a great line up of speakers who took us on a journey through the worlds of science and Oxford Instruments.



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EVENTS ROUNDUP

Oxford Instruments Plasma Technology will be exhibiting at the following events:

Semicon Taiwan	30 September – 2 October 2009	<i>Taipei, Taiwan</i>
MNE 2009	28 September – 1 October 2009	<i>Ghent, Belgium</i>
Semicon Europa	6 – 8 October 2009	<i>Dresden, Germany</i>
ICNS-8	18 – 23 October 2009	<i>Jeju, Korea</i>
Productronica	10 – 13 November 2009	<i>Munich, Germany</i>
Semicon Japan	2 – 4 December 2009	<i>Tokyo, Japan</i>
Semicon Korea	3 – 5 February 2010	<i>Seoul, Korea</i>

New White Papers now Available

The Applications Team at OIPT have produced two new White Papers recently

Comparison of etch processes for patterning high aspect ratio and nanoscale features in silicon

Robert Gunn, Dean Stephens, Colin Welch, Oxford Instruments Plasma Technology

We look at different aspects of silicon etching, the two leading techniques for deep etching of silicon, namely the "Bosch" process and a cryogenically cooled process. The paper updates the latest results for these techniques and looks at the growing importance of nanoscale etching of silicon, which can only be achieved consistently using the cryogenically cooled process. The benefits of using this technique against other processes are described.

Comparison of etch processes for etching SiO₂ dielectric films

Robert Gunn, Colin Welch, Dean Stephens, Ligang Deng, PhD, Oxford Instruments Plasma Technology

This paper compares different aspects of dielectric etching, namely diode RIE and high density based processes. The authors update the latest results for these techniques and also look at the growing importance of nanoscale etching of dielectric films.

If you'd like to receive a copy, email plasma@oxinst.com.



visit www.oxford-instruments.com for more information

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