

SEMICONDUCTORS

*High-Tech Instrumentation for
the Semiconductor Industry*

**Theta-SE Ellipsometer for
Semiconductors**

Raptor Photonics
Launches Camera for
PET Semiconductor
Inspection

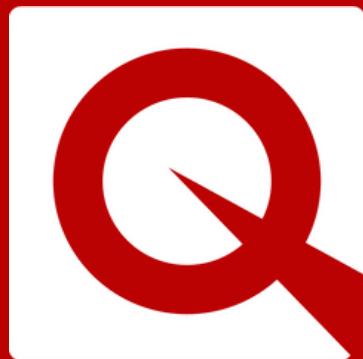
**Analyse Electronic
Components or
Semiconductor
Devices using Atomic
Force Microscopy**

**X-rays in
Semiconductors**

**SEMICONDUCTOR
METROLOGY**

Power Electronics:
Efficient Control of the
Futures Energy

**CASE STUDY:
STRUCTURE OF MAGNETIC
SEMICONDUCTORS**



WWW.QD-UKI.CO.UK

Quantum Design UK and Ireland is part of the Quantum Design International (QDI) group. QDI is a global laboratory equipment manufacturer. The company distributes scientific and industrial instrumentation through an international network, with subsidiaries in every major technological centre around the world.

**WITH CONTENT
CONTRIBUTIONS FROM
OUR PARTNERS:**



4D Technology

An Onto Innovation Subsidiary



HIGH-TECH INSTRUMENTATION FOR THE SEMICONDUCTOR INDUSTRY

A Magazine by QDUKI

Highlights

SEMICONDUCTOR RESEARCH USING THE QD PPMS VERSALAB

POWER ELECTRONICS: EFFICIENT CONTROL OF THE FUTURES ENERGY

X-rays in Semiconductors

SEMICONDUCTOR METROLOGY

Theta-SE Ellipsometer for Semiconductors

CASE STUDY: STRUCTURE OF MAGNETIC SEMICONDUCTORS

Contents

- 4 - Foreword
- 5 - ThetaSE Ellipsometer for Semiconductors
- 7 - Semiconductor Testing Solution - E-Lit
- 11 - X-rays in Semiconductors
- 12 - Metrology of Optics and Imaging systems
- 14 - Semiconductor Metrology
- 17 - Case Study: Structure of Magnetic Semiconductors
- 19 - Power Electronics – Efficient Control of the Futures Energy
- 22 - Published Semiconductor Research Using the Quantum Design PPMS VersaLab
- 23 - Raptor Photonics Launches Camera for PET Semiconductor Inspection
- 25 - Analyse Electronic Components or Semiconductor Devices using Atomic Force Microscopy
- 26 - Hard Coat Bandpass Filters for High Performance in Demanding Applications
- 28 - Further Reading
- 29 - Bespoke Ellipsometer Measurement for Semiconductor Industry
- 30 - Compound Semiconductors

FOREWORD

Quantum Design (QD) has been a leader in high-tech instrumentation for over 40 years with systems such as the MPMS and VersaLab. We have continually added to our product portfolio by acting as distributor for other market leaders who provide solutions for semiconductors, including J. A. Woollam, InfraTec, Sigray, 4D Technology and Lake Shore Cryotronics. This means we can provide our customers with the right solutions for their semiconductor applications.

Britain is already amongst the world leaders when it comes to researching and designing semiconductor technology. Semiconductors underpin the ambition to advance quantum, telecom, and AI technologies. QDUKI are proud to be part of that development, strengthening the position through new and innovative solutions.



The Quantum Design UK
and Ireland Sales Team



A handwritten signature of Dr. Shayz Ikram's name.

Dr. Shayz Ikram
TECHNICAL
DIRECTOR



A handwritten signature of Dr. Luke Nicholls' name.

Dr. Luke Nicholls
TECHNICAL
SALES MANAGER



A handwritten signature of Dr. Satyam Ladva's name.

Dr. Satyam Ladva
TECHNICAL
PRODUCT MANAGER



A handwritten signature of Dr. Alex Murphy's name.

Dr. Alex Murphy
TECHNICAL
SALES ENGINEER

RESULTS AT WAVELENGTHS OF INTEREST FOR A DESIRED APPLICATION

THETA-SE ELLIPSOMETER FOR SEMICONDUCTORS

Since the 1960s, as ellipsometry developed to provide the sensitivity necessary to measure nanometer-scale layers used in microelectronics, interest in ellipsometry has grown steadily. Today, the range of its applications has spread to the basic research in physical sciences, semiconductor and data storage solutions, flat panel display, communication, biosensor, and optical coating industries. Here we take a look specifically at the J A Woollam thetaSE ellipsometer and its uses for the semiconductor industry.



The theta-SE is a push-button spectroscopic ellipsometer for characterising thin film uniformity. It features advanced ellipsometry instrumentation in a compact package at an affordable price.



For many applications, optical properties are desired at specific wavelengths. For example, the semiconductor industry is interested in lithography which requires ellipsometry measurements in the UV region (157nm, 193nm, 248nm,...). The display industry is interested in the visible spectrum. Optical coatings require measurement at their design wavelengths, whether at visible, near infrared or even mid-infrared wavelengths. Woollam Spectroscopic Ellipsometers cover the spectral range from 33 microns to 140nm. This range offers an incredible flexibility that can meet almost any application requirement.



[Learn more about
Woollam thetaSE](#)



Want to discuss
Woollam and
semiconductor
applications?

Contact our Technical
Director
Dr. Shayz Ikram
Telephone: (01372) 378822
Email: shayz@qd-uki.co.uk

WHY THE THETA- SE?



FULLY INTEGRATED

The theta-SE comes equipped with 300 mm sample mapping, small-spot measurement beam, fast sample alignment, look-down camera and our latest Dual-Rotation ellipsometer technology. The theta-SE has everything you need to measure the spatial uniformity of your film thickness and optical properties.

HIGH SPEED

Sample throughput is optimised by using fast point-to-point translation, high-speed sample alignment and Dual-Rotation ellipsometer technology for continuous data collection.

COMPACT

The patented, Dual-Theta rotation stage enables full, 300 mm mapping in a small, table-top instrument. The instrument footprint is only slightly larger than a 300 mm wafer.

USER FRIENDLY

Automated data analysis and built-in reporting enables push-button operation and quick access to measurement results.

AFFORDABLE

The theta-SE delivers the power of spectroscopic ellipsometry and 300 mm uniformity mapping at a reasonable price.

PERFECT FOR:

- Dielectrics (oxides, nitrides, carbides)
- Polymers (Low-Dielectric constant)
- Polysilicon
- Multilayers (ONOPO, SOI,...)
- Lithography Applications
 - Photoresists
 - Antireflective coatings
 - Photomasks
- Compound Semiconductors

TECHNICAL PAPERS ON SEMICONDUCTORS

Ellipsometry Characterization of Bulk Acoustic Wave Filters

Authors: E. Nolot, A. Lefevre, J. Hilfiker
Phys. Stat. Sol. (c) 5, No.5, 17, (2008) 1168-1171.

Spectroscopic Ellipsometry (SE) for Materials Characterization at 193 and 157nm

Authors: J. Hilfiker, F. G. Celii, W. D. Kim, E. A. Joseph, C. Gross, T. Y. Tsui, R. B. Willecke, J. L. Large, and D. A. Miller
Semiconductor Fabtech, 17, (2002) 87-91.

Immersion Fluids for Lithography: Refractive Index Measurement Using Prism Minimum Deviation Techniques

Authors: R. Synowicki, G. Pribil, G. Cooney, C. Herzinger, S. Green, R. H. French, M. K. Yang, M. F. Lemon, J. H. Burnett, and S. Kaplan
Semiconductor Fabtech, 22, (2004) 55-58.

Spectroscopic Ellipsometry as a Potential In-Line Optical Metrology Tool for Relative Porosity Measurements of Low- K Dielectric Films

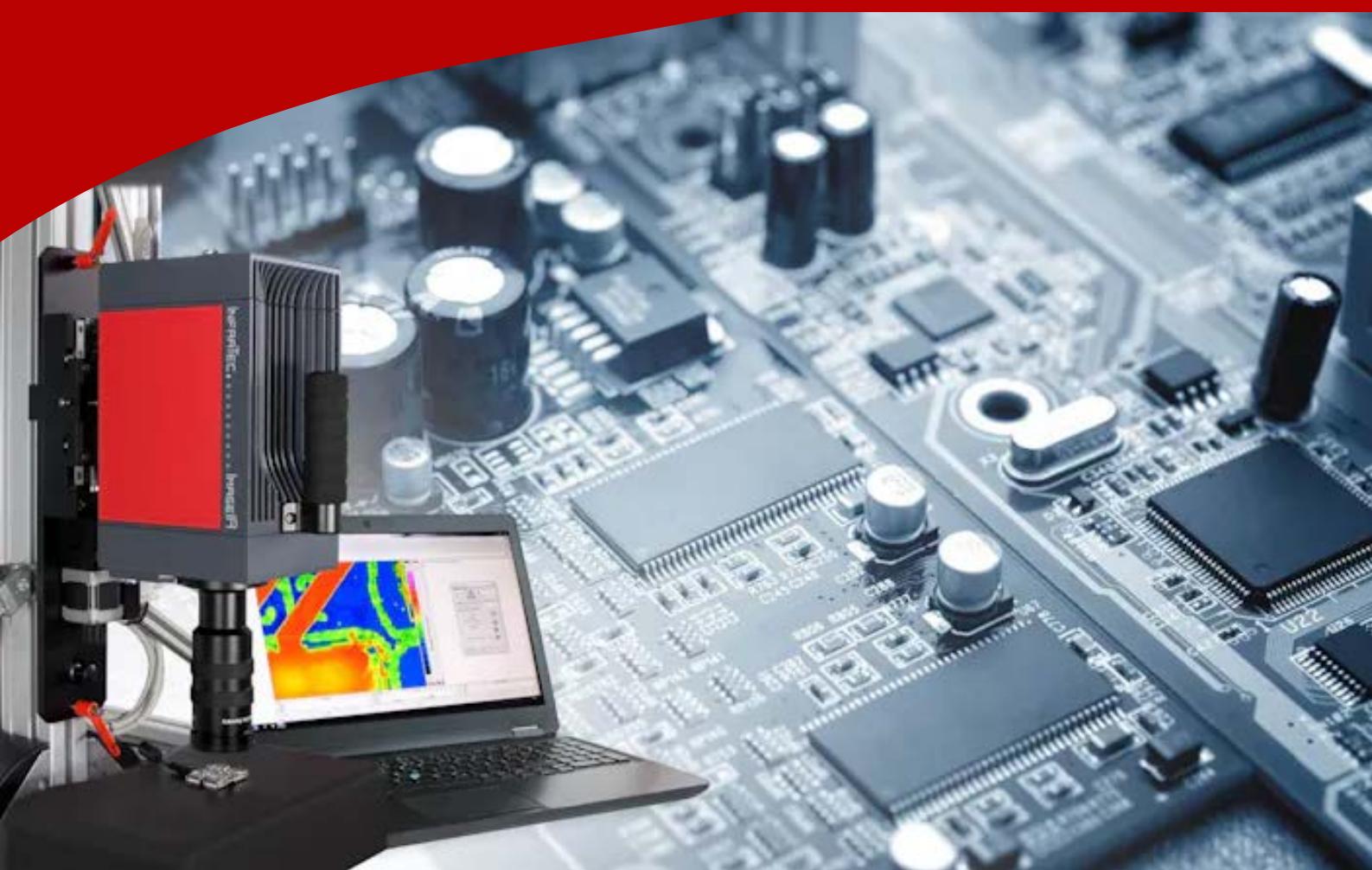
Authors: N. V. Edwards, J. Vella, Q. Xie, S. Zollner, D. Werho, I. Adhiketty, R. Liu, T. Tiwald, C. Russell, J. Vires, and K. H. Junkerd
Mat. Res. Soc. Symp. Proceedings, 697, (2002) P4.7.1-P4.7.6.

Spectroscopic Ellipsometry Analysis of InGaN/GaN and AlGaN/GaN Heterostructures Using a Parametric Dielectric Function Model

Authors: J. Wagner, A. Ranakrishnan, H. Obloh, M. Kunzer, K. Köhler, and B. Johs
MRS Internet J. Nitride Semicond. Res. XX, WY.Y, (2000).

Semiconductor Testing Solution

InfraTec's E-Lit



Modular Automated Test Bench

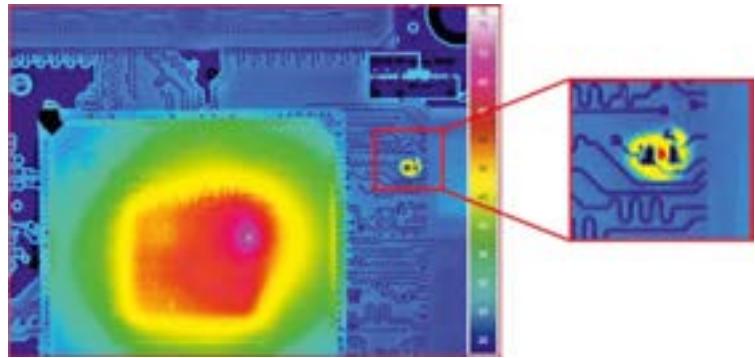
INFRATEC.
MADE IN GERMANY

- Thermal analysis of electronic and semiconductor devices
- Modular test bench for online lock-in measurement
- Reliable detection of thermal anomalies in the mK and μ K range
- Spatial location of defects in multilayer PCBs and multi-chip modules
- Use of thermographic systems with cooled and uncooled detectors
- Operational software IRBIS® 3 active with comprehensive analysis options in laboratory conditions

E-LIT - Lock-In Thermography for electronics is an automated testing solution system (as part of NDT techniques) which allows non-contact (electrical) failure analysis of semiconductor material during the manufacturing process. Inhomogeneous temperature distribution, local power loss, leakage currents, resistive vias, cold joints, latch-up effects and soldering issues can be measured with Lock-in Thermography. This is achieved by using the shortest measurement times combined with a high-performance thermographic camera and a specialised lock-in procedure.

The power supply for this process is clocked with a synchronisation module and failures that produce mK or even μ K temperature differences are reliably detected by the Lock-in Thermography system.

Smallest defects at electronic components like point and line shunts, issues from overheating, internal (ohmic) shorts, oxide defects, transistor and diode failures on a PCB surface, in integrated circuits (IC's), LED modules and battery cells can be detected and displayed in x and y positions. Additionally, it is possible to analyse stacked-die packages or multi-chip modules in z-direction with merely changing the lock-in frequency.



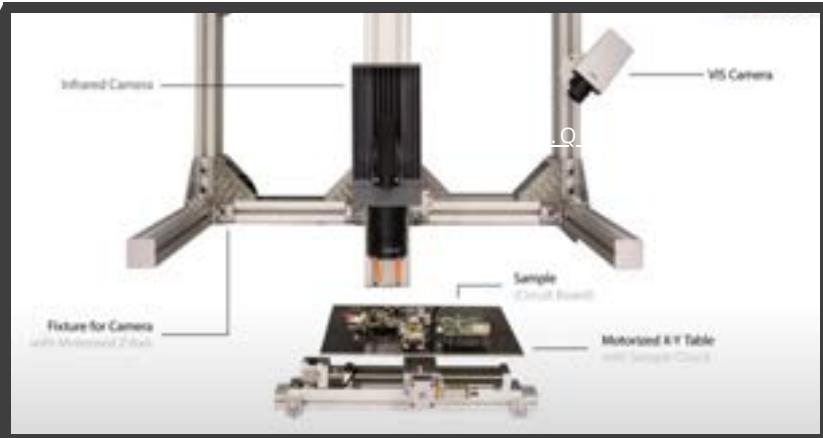
Automated Testing Solution ACTIVE-LIT Failure



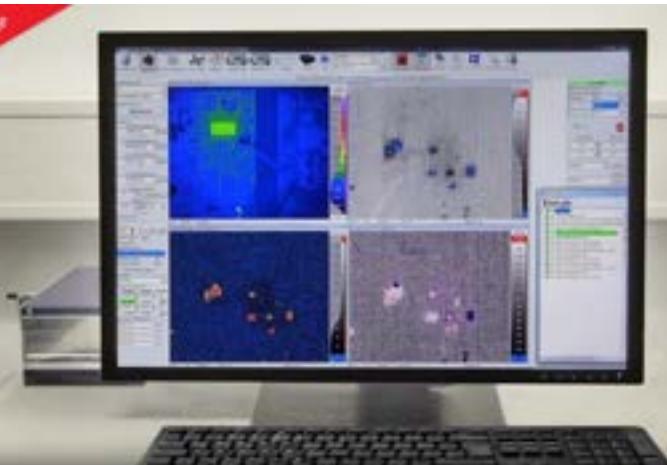
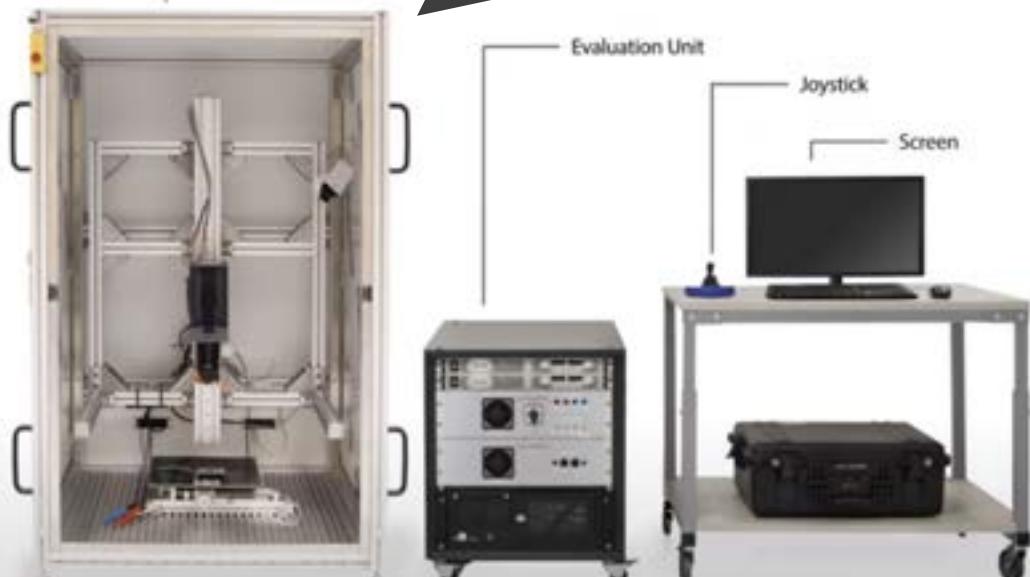
The powerful Lock-in Thermography software uses the latest algorithms and routines from most recent scientific publications.



Learn more about
InfraTec E-Lit



Measuring Chamber

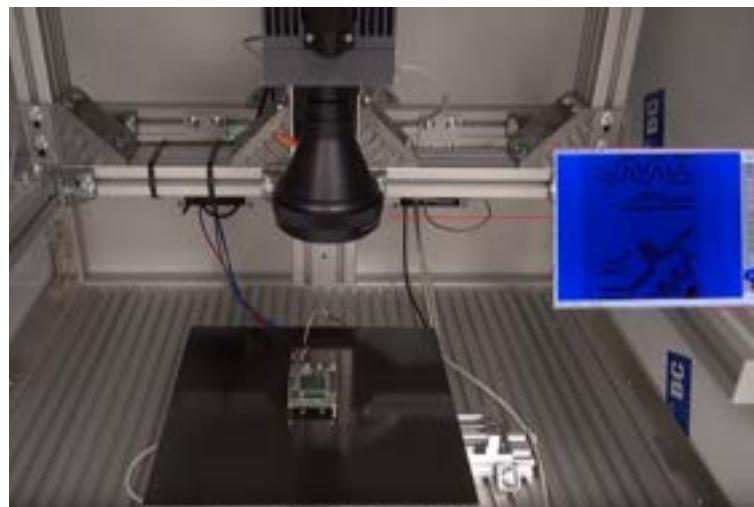


Detailed investigation with the help of Multiscanning

Variable parameter settings to analyse different layers and components on a single sample during one measurement run

Analyse your data in real-time with IRBIS® 3 active software

- Real-time calculation and visualisation of defect zones
- Continuous display of live, amplitude, phase and single phase image
- Batch mode / macro editor for automated analysis of sample surface on different layers below the surface
- Storage and charging of parameters for different samples



BENEFITS OF THE MODULAR TEST BENCH

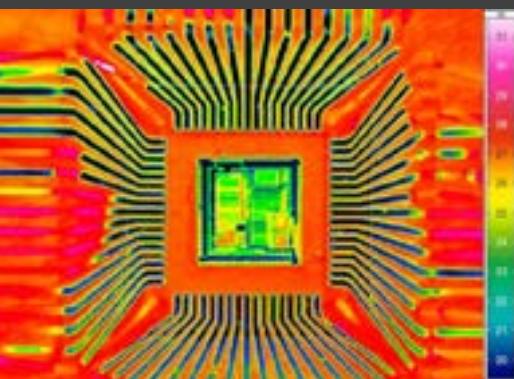
Measurement with one workstation - from the entire circuit board to the smallest detail.

- Customised modular measuring station, e.g. with X-Y table and Z-axis manually or motorised adjustable, for positioning and individual adjustment of the working distances, depending on the size of the measured object
- Flexibility through variable components, e.g. different optics, holding devices for the test specimen or contacting options,



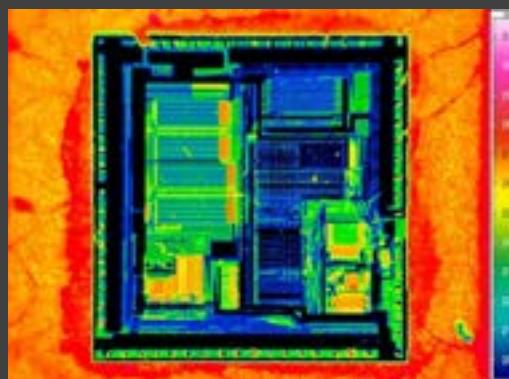
- Online lock-in measurement with the highest sensitivity
- Complete and detailed microscopy analysis
- Geometrical resolution up to 1.3 µm per pixel with microscope lenses
- Thermal resolution in the microkelvin range
- Multi-layer analysis
- Automatic scanning of larger samples due to precision mechanics

THERMOGRAPHIC IMAGES WITH DIFFERENT OPTICS



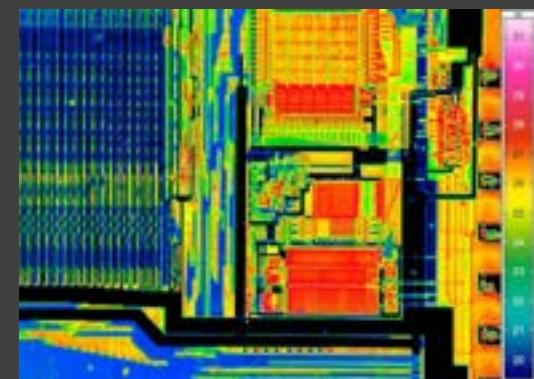
Telephoto Lens 100 mm

100 mm telephoto lens with 500 mm close-up; pixel resolution 75 µm



Microscopic Lens 1x

1x microscopic lens; pixel resolution 15 µm



Microscopic Lens 3x

3x microscopic lens; pixel resolution 5 µm

TALK TO US

Discuss your application and the InfraTec E-LIT Solution with our Technical Sales Manager, Dr. Luke Nicholls
 Call (01372) 378822
 Email luke@qd-uki.co.uk



X-RAYS IN SEMICONDUCTORS

Sigray's x-ray solutions include 3D x-ray microscopes and microXRF systems in vacuum environments. These systems are used for a range of semiconductor applications, including everything from inspection of wafer contamination and silicon-side process monitoring to failure analysis of packaging.

REVERSE ENGINEERING & TRUSTED CIRCUIT

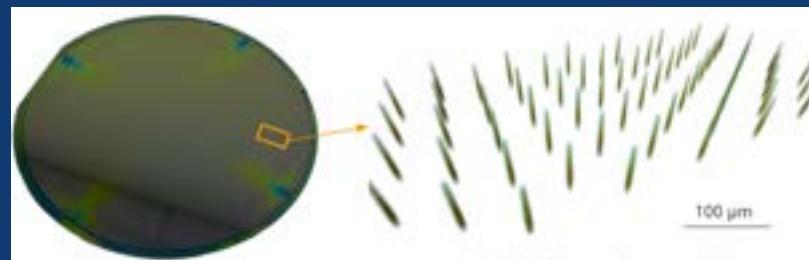
Sigray's Apex XCT-150 provides 0.5 μm resolution 3D imaging of large PCBs and packages within minutes for reverse engineering and trusted circuit applications. Complete montages of intact packages of 200 $\text{cm} \times$ 200 cm are possible at spatial resolutions down to 0.5 μm .

TI LaunchPad Evaluation Board
Sigray Apex XCT-100



WAFER LEVEL PACKAGING

Apex XCT-150 enables intact wafer imaging for next-generation packaging schemes. The system is successfully used for submicron failures such as voids, non-wets, cracks, etc. in TSVs, hybrid microbumps, and solder.



Voids clearly rendered in 5 μm TSVs within minutes. Imaged within an intact 300mm wafer on the Apex XCT.



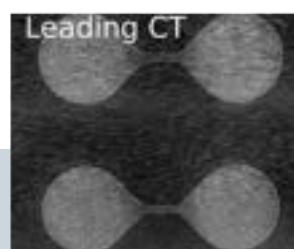
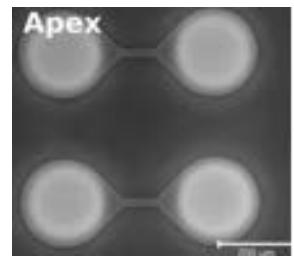
Sigray Apex XCT-150

Rethink Impossible
Sub-Micron 3D X-ray In Minutes
Advanced semiconductor packaging & FA

- 3D Imaging on Intact Samples Up to 300 mm Diameter
- 0.5 μm 3D Spatial Resolution in <15 Minutes
- No Beam Hardening Artifacts



[Learn more about
Sigray Apex XCT-150](#)



Metrology of Optics and Imaging systems

Supersmooth optical surfaces are required in applications such as lenses for semiconductor equipment

For UV, EUV, and X-ray wavelength applications, optics must be extremely smooth to avoid scattering, which affects image quality, signal-to-noise, and other critical optical performance properties. The typically high incident energy can also degrade optics quickly. Thus, manufacturers and end users require a reliable, reproducible method to verify smoothness to sub-nanometer levels.



Figure 1. UV, EUV, and X-ray optics, such as the mirrors in this ring laser gyro, require supersmooth surfaces to avoid scattering that can impact performance and degrade the optics. (Rogoway)

But, while newer manufacturing techniques have enabled production of supersmooth optics, the metrology to accurately measure these surfaces has lagged behind. To fill the void, the NanoCam HD optical profiler (Figure 1) has been proven to provide reliable, non-contact measurement of supersmooth surface texture, *in situ* on the shop floor.

"Because 4D's dynamic technology is the best way to obtain good measurements in extreme environments, we offer the best choices and the greatest experience in measuring in these circumstances."

4D Technology

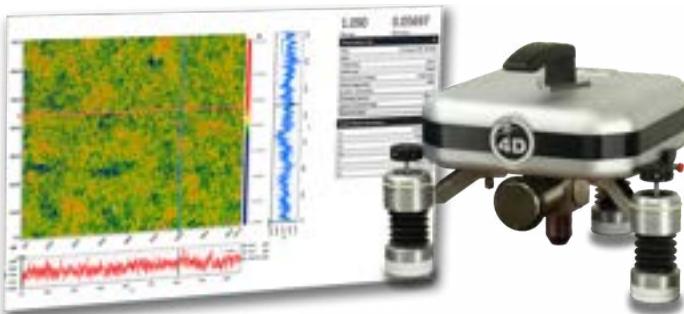
An Onto Innovation Subsidiary

THE CHALLENGE OF MEASURING SUPERSMOOTH OPTICS

"Supersmooth" surfaces typically have an RMS roughness (S_q) of less than 0.1 nm. Measuring such extremely smooth surfaces exceeds the capability of most measurement technologies.

To date, stylus-based instruments and atomic force microscopes have been used. However, these techniques are very slow, and the contacting probes can damage the surfaces. Additionally, the measurement systems require highly controlled environments because vibration, shop noise, and air turbulence will degrade measurements.

Non-contact, optical profiling is the preferred method for quickly acquiring 3D data of supersmooth surfaces. Scanning white light optical profilers are most common. But the noise floor of scanning systems is typically too high to measure sub-angstrom roughness, even using phase-shifting interferometry (PSI) mode.



NANOCAM HD MEASURES SUPERSMOOTH SURFACES

4D Technology's NanoCam HD is an enabling technology for controlling the production of supersmooth surfaces. The NanoCam HD (Figure 2) offers several benefits that make sub-angstrom measurement possible.

DYNAMIC INTERFEROMETRY

In recent years, vibration-immune "dynamic" interferometry has been adapted for roughness measurement. In dynamic instruments such as 4D Technology's NanoCam HD, all measurement data is acquired simultaneously, rather than sequentially as in scanning methods. Such fast acquisition enables the NanoCam HD to measure in shop floor environments without expensive vibration isolation.



[Learn more about
4D Technology](#)



**Discover more
and discuss your
application**

**Dr. Luke Nicholls, Technical
Sales Manager, QDUKI**

Tel: (01372) 378822

Email: luke@qd-uki.co.uk

4D Technology

An Onto Innovation Subsidiary

Semiconductor Metrology



Electronic components are everywhere in our modern world. These components must be reliable, as they control critical systems from everyday items to electronically controlled military equipment and various aerospace equipment.

To assure this reliability, components must go through a battery of tests. XRF analysis is an irreplaceable tool for the semiconductor industry to guarantee and certify their products.

Electrical or photonic circuits are one of these components that are the foundation for so many other products. These circuits begin their lives on silicon wafers. As the wafers and associated circuits and boards become more specialised, they require different types of testing.

IXRF Systems offers a 5 μ m spot size, the smallest on the market, allowing for extremely high resolution maps, analysis of small leads or pillars. Though SnPb solder has its place in technology, there is now a shift to use SnAg due to environmental, health and safety concerns. These solder points must also be tested.



TALK TO US

Discuss your application and the IXRF Systems range of products with our Technical Product Manager, Dr. Satyam Ladva
Call: (01372) 378822
Email: satyam@qd-uki.co.uk



[Learn more about IXRF Systems](#)





Current technologies include Pb-free bumps of SnAg, as well as Pb-free SnAg pillars on Cu seed. Current bump/pillar and seed sizes are about 50 to 150µm. However, next-generation technology is pushing towards smaller pillar/seed sizes of 20- 30µm.

Leads on electronic components cannot fail, less the whole system will fail. A well-known phenomenon known as 'whiskers' can cause these components to fail. The whiskers come from tin used in electronic component surfaces.

It has been found that adding lead to the tin can prevent the growth of whiskers. This addition of lead must be analytically measured to ensure expected and required concentrations. Most aerospace companies require a minimum of 3% Pb to prevent tin whiskers.

XRF is the preferred method for lead testing in tin. XRF is more accurate than EDS based on the larger area and depth of measurement.

IXRF Systems' powerful software can quickly identify, measure, and analyse multiple solder bumps on a board.

Quantitative analysis was done on one of the SnPb solder bumps in the centre trio section, a circled portion in the elemental map (fig. 2).

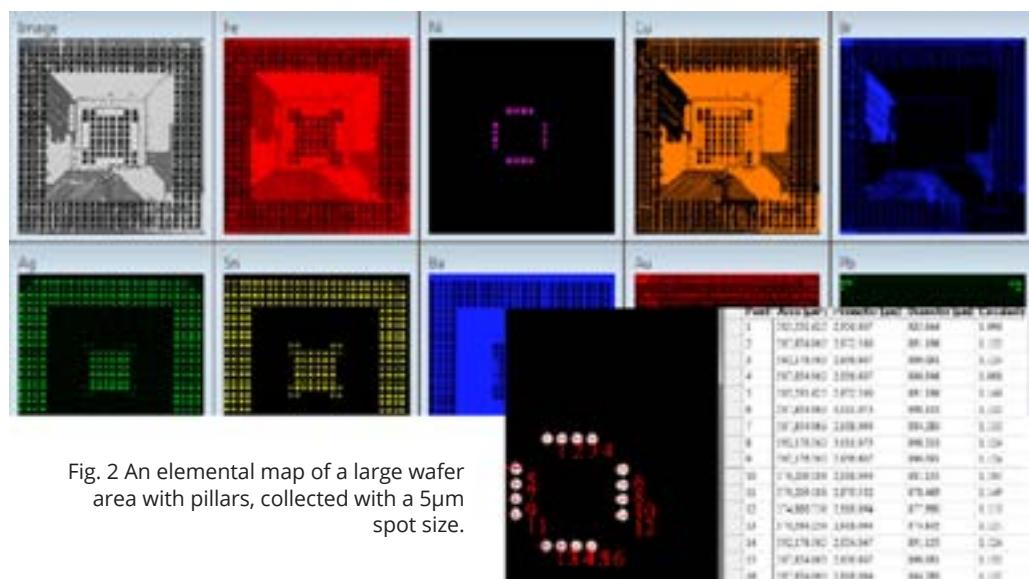


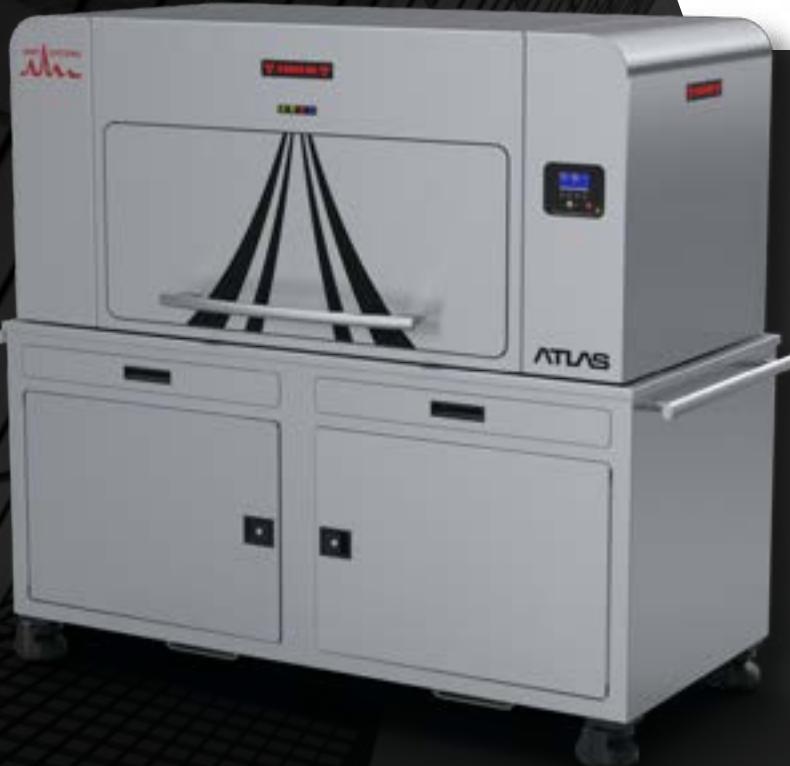
Fig. 2 An elemental map of a large wafer area with pillars, collected with a 5µm spot size.

IXRF Systems' ATLAS SEMI can analyse for:

- Bump inspection
- CMOS image sensors (CIS)
- Corrosion resistance coating
- Cu CMP control at BEOL
- Film stack
- Light elements
- Metal film stack composition such as CIGS
- Multi-stack structures
- Pb measurement for Whiskers
- Redistribution layer (RDL)
- Sn/Ag Bump/Pillar measurements

- Sputtering targets
- Thermal barrier coating
- Thick mono-layers
- Thickness and composition control
- Thin Film/Coating thickness measurements
- Ultra-thin films
- Under bump metallisation (UBM)
- Wafer-level packaging (WLP)

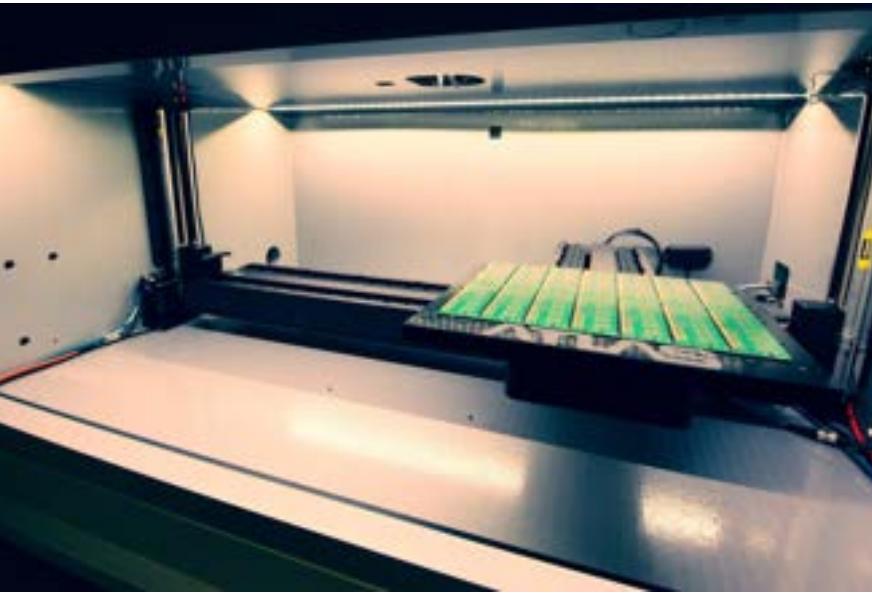




IXRF Systems' ATLAS SEMI is the very latest micro spot energy dispersive X-ray fluorescence (micro XRF) imaging spectrometer for **semiconductor metrology**

Biggest chamber

features the **industry's most voluminous** sample chamber, allowing for automation of more samples, larger area mapping capabilities, and wider variability of sample types



The 5 micron advantage

With the **smallest X-ray spot** in the industry at 5 microns, ATLAS SEMI is optimised for analysis speed without compromising accuracy.

Unmatched speed

Mix and match up to 4 Silicon Drift Detectors (SDD). For the largest possible solid angle collection efficiency. Up to 600 mm² active area. **Highest count rate** with the smallest spot for fast high-res images

CASE STUDY:

STRUCTURE OF MAGNETIC SEMICONDUCTORS

Housler et al

MC2011 Kiel Electron Microscopy Proceed

Magnetic semiconductor materials have attracted widespread attention in recent years due to their potential applications for the transport of information by exploiting both the intrinsic spin of the electron and its associated magnetic moment, in addition to its fundamental electronic charge. The new technology which emerged from discoveries in the 1980s concerning spin-dependent electron transport phenomena in solid-state devices was called Spintronics ('Spin Transport Electronics') also known as magnetoelectronics.



The material system (Mn,Ga)As on GaAs is of great interest for the development of such spintronic devices because the unstrained-bulk-MnAs is ferromagnetic at room temperature (α -MnAs, P6Jmmc). It undergoes a phase transition to paramagnetic phases at 40°C (β -MnAs, Pnma) and above 125°C (γ -MnAs, P6₃/mmc). "Surface contactable quasi-embedded" MnAs crystallite precipitates are formed in a [001] - oriented GaAs matrix during the cooling down stage of a MnAs layer that was deposited by metal-organic chemical vapour deposition (MOCVD) above 600 °C.

In order to obtain a thorough understanding of the (Mn,Ga)As crystallite formation process, the crystallographic phase and orientation of the precipitates with respect to the matrix have to be determined. The chemical composition of the precipitates was determined by quantitative EDXS analysis, their chemical composition was defined as $Mn_{0.75}Ga_{0.25}As$.

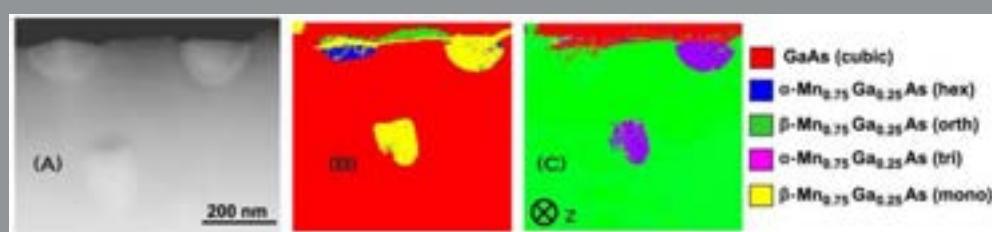
The Challenge:

Identify unknown phase of MnGaAs precipitates among 4 different crystal phases & establish orientation relation between GaAs matrix and precipitates

The Solution:

ASTAR technique coupled with precession electron diffraction

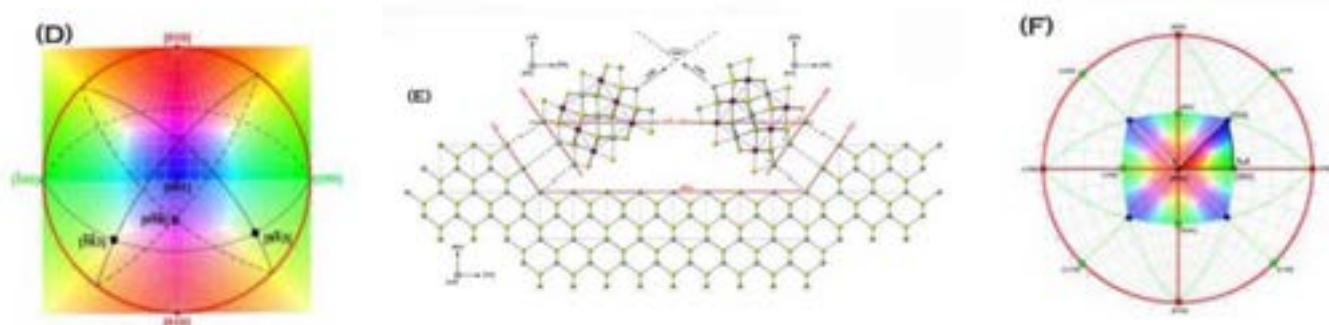
A careful inspection of the PED diagrams on the precipitates showed that there existed super structure reflections not consistent with MnAs bulk structure. ASTAR template matching analysis with all possible templates of 4 possible phases compatible with $Mn_{0.75}Ga_{0.25}As$ (total 38561 templates) shows a coexistence of precipitates with the monoclinic β -phase (space group $P2/m$) and of precipitates with the hexagonal α -phase ($P6/mmc$) at room temperature. An example of ASTAR phase and orientation analysis of the embedded (Mn, Ga)As-crystallite precipitates in GaAs is illustrated below.



Experimental Data:
TEM type: Jeol 2200
FS Map resolution: 1 nm
Scanned area: 2 x 2 μ m

(A) HAADF image of GaAs matrix and precipitates (B) corresponding ASTAR phase map
(C) ASTAR orientation matrix along z (D) stereographic projection of monoclinic phase
(E) orientation relation between GaAs-matrix and the completely embedded (Mn,Ga)As crystallite & (F) stereographic projection of cubic GaAs

Crystal Structure:
GaAs: Cubic, F43m
 $a = 5.56\text{\AA}$
 $Mn_{0.75}Ga_{0.25}As$: hexagonal, $P6/mmc$



SPINTRONIC DEVICE PROPERTIES STRONGLY DEPEND ON A NANOMETER SCALE STRUCTURE



[Learn more about the
Nanomegas A-Star TEM
Orientation Imaging](#)

TALK TO US

Discuss your application and the Nanomegas range of products with our Technical Director, Dr. Shayz Ikram
Call (01372) 378822
Email shayz@qd-uki.co.uk



Power Electronics – Efficient Control of the Future's Energy

Thermography in Electronics

THERMOGRAPHY IN USE FOR HIGH-PERFORMANCE ELECTRONIC SYSTEMS

The energy efficiency of electronic components is becoming increasingly important in numerous fields of application. And that is not all: in our electronic and high-tech age, the demand is for even faster active components, higher power densities of miniaturised systems as well as absolute reliability. Along with this, there is the request for environmentally conscious resource procurement and the requirement that the increase in performance of modules should run parallel to lower energy consumption. For this reason, the electronics industry has relied on silicon (Si) for more than 50 years. However, this is now reaching its physical limits.

The demands for more efficient and environmentally aware electronics, for example in data centres and in the development of electric cars, are growing steadily. Therefore, energy efficiency is becoming a strategic issue for wide areas of industry, and the semiconductor material gallium nitride (GaN) is becoming one of the key components in the field of renewable energies.

Fig. 1: Prof. Dr.-Ing. Marco Liserre, Head of the Chair of Power Electronics, and his team developed the prototype of an intelligent transformer that controls the current flow



Kiel University
 Christian-Albrechts-Universität zu Kiel,
 Faculty of Technology, Chair of Power Electronics
<https://www.uni-kiel.de/en/>
 M. Sc. Johannes Kuprat
 Prof. Dr.-Ing. Marco Liserre
 Thermal imaging system:
 ImageIR® 8300 infrared camera

Silicon-based microelectronics have repeatedly reached new performance peaks in recent years. The number of transistors on a chip doubled almost every two years and so did the computing power of processors. But the limits have almost been reached, which is why the Institute of Electrical Engineering and Information Technology (ET&IT) and the Institute of Materials Science are working on new semiconductor materials.

These are two of the three institutes of the Faculty of Technology at Christian-Albrechts-Universität zu Kiel (CAU Kiel). Research topics of this faculty include renewable energy, sensor technology and electromobility.

FUTURE SEMICONDUCTOR MATERIALS - NEW OPPORTUNITIES AND CHALLENGES

More powerful semiconductor materials are the prerequisite for the electronics market of the future in general and for power electronics in particular. Electronic systems should perform better and at the same time require less energy. This is a goal that manufacturers of electric cars, for example, have defined for themselves. The procurement of the resources used should be as environmentally friendly as possible and their use as efficient as possible.



What is required now are more powerful semiconductor materials for significantly smaller components. For this reason, power semiconductors such as gallium nitride (GaN) and silicon carbide (SiC) are overtaking silicon (Si), which has been used up to now. GaN transistors in particular enable a smaller size and potentially generate lower costs.



Fig. 2: Thermal setup with infrared camera and open semiconductor modules for thermal evaluation of the semiconductors during operation

They have a significantly lower conductive resistance for the same size of electronic components and achieve faster commutations, which in turn results in lower switching losses. The lack of reverse recovery charging also allows for higher frequency and power density. All of the above factors offer significantly higher energy efficiency than silicon-based technology.

THERMOGRAPHY IN USE FOR POWER ELECTRONICS

Since both the electronic components and the transistors are very small, the infrared camera to be used must meet certain requirements.

For this reason, a measurement set-up suitable for this purpose was designed for the CAU, in which a cooled thermography system of the ImageIR® infrared camera series from InfraTec is used. With its high thermal resolution, it detects even the smallest temperature changes and, due to its excellent geometric resolution, resolves structures of less than 50 µm in size in this application even with standard lenses. The ImageIR® infrared camera used has a cooled photon detector enabling the imaging of particularly fast processes. Switching peaks can thus be analysed without any problems. The non-contact measurement is non-destructive and enables the detection of several critical points, as the complete object is imaged. A further advantage is the non-complicated MATLAB interface via the IRBIS® Software Development Kit (SDK) from InfraTec.

Scientists at the Faculty of Technology at Christian Albrechts University (CAU) in Kiel are making use of these advantages. The changes and developments of temperatures and their distribution in various semiconductor materials in the field of power electronics are being researched here in order to optimise processes and techniques.



Fig. 3: Dr. Markus Andresen setting up the InfraTec infrared camera for tests to validate active thermal control

In particular, it is about U-Heart: a new concept of isolated DC-DC converters with multiple connections, which were developed to achieve the highest reliability together with high energy efficiency with minimal redundancy. It is equipped with a fault detection circuit that excludes a detected faulty cell from power transmission.

The ImageIR® infrared camera used has a cooled photon detector enabling the imaging of particularly fast processes. Switching peaks can thus be analysed without any problems. The non-contact measurement is non-destructive and enables the detection of several critical points, as the complete object is imaged. A further advantage is the non-complicated MATLAB interface via the IRBIS® Software Development Kit (SDK) from InfraTec.

Fig. 4: Measurement set-up for the analysis of different semiconductor materials in the laboratory of CAU Kiel



"Self-healing" approaches are actually under development to maintain the operation of all cells and to continue operating at full power: "self-healing" allows the inverter to continue operating at full power. Thus, U-Heart is a ERC grant for a proof of concept for a maintenance-friendly power converter and can be used as a multi-port converter connecting multiple voltage grids, e.g. energy storage systems (batteries, supercapacitors), renewable energy sources (solar PV modules, fuel cells, etc.) and DC loads. The development of this energy superstar also benefited from insights gained through thermography from the predecessor project Heart (ERC grant).

In general, it is reasonable to use thermographic cameras already in the development and creation process of new electronic components. Valid and meaningful data about the heat development in the components is obtained. This again allows, among other things, conclusions to be drawn about the performance and energy efficiency of a module, and faults are reliably detected at an early stage and can be rectified.

Want to learn more about InfraTec?

Contact our Technical Sales Manager:
Dr. Luke Nicholls
Telephone: (01372) 378822
Email: luke@qd-uki.co.uk

ImageIR® 8300 hp – The Flexible

- Large detector enables highest sensitivity
- (1,280 × 1,024) IR pixels by genuine camera hardware
- Analysis of extreme temperature changes and gradients in full frame
- Highly accurate and repeatable measurements
- High-speed, long-distance interference proof data transmission
- Flexible setting of temperature measurement ranges/integration times beyond calibration ranges
- Facilitates the analysis of objects with extreme temperature gradients

InfraTec Image IR Series Thermography Cameras

High-speed thermography systems
Precise radiometric calibration



[Learn more about the InfraTec ImageIR Series](#)

Published Semiconductor Research Using the Quantum Design PPMS VersaLab

Transport Anisotropy of Epitaxial VO₂ Films near the Metal-Semiconductor Transition

Kittiwatanakul, Salinporn and Lu, Jiwei and Wolf, Stuart A., *Applied Physics Express*, 4 (9), 1882-0786 (2011), DOI.

Abstract

We report a very large anisotropy in the dc conductivity of epitaxial VO₂ thin films deposited on a single-crystal (100) TiO₂ substrate. There was a large tensile strain along the c-axis and a compressive strain along the a-axis of rutile VO₂ due to the lattice mismatch between VO₂ and TiO₂. The in-plane conductivity was measured along <010> and <001> of VO₂, and it is found that the conductivity anisotropy ratio $\sigma_{<001>}/\sigma_{<010>}$ was 41.5 at 300 K, much larger than that of single-crystal VO₂.

 [READ HERE](#)

Thermoelectric transport and Hall measurements of low defect Sb₂Te₃ thin films grown by atomic layer deposition

Zastrow, S. and Gooth, J. and Boehnert, T. and Heiderich, S. and Toellner, W. and Heimann, S. and Schulz, S. and Nielsch, K., *Semiconductor Science and Technology*, 28(3), 035010 (2013), DOI.

Abstract

Sb₂Te₃ has recently been an object of intensive research since its promising applicability in thermoelectric, in phase-change memory devices and as a topological insulator. In this work, we report highly textured Sb₂Te₃ thin films, grown by atomic layer deposition on Si/SiO₂ wafers based on the reaction of SbCl₃ and (Et₃Si)₂Te.

The low deposition temperature at 80 °C allows the pre-patterning of the Sb₂Te₃ by standard lithography processes. A platform to characterise the Seebeck coefficient S, the electrical conductivity σ as well as the Hall coefficient RH on the same film has been developed. Comparing all temperature-dependent transport properties, three different conductive regions in the temperature range of 50–400 K are found. Room temperature values of $S = 146 \times 10^{-6}$ VK⁻¹, $\sigma = 10^4$ Sm⁻¹ and mobility $\mu = 270.5 \times 10^{-4}$ m² V⁻¹ s⁻¹ are determined. The low carrier concentration in the range of $n = 2.4 \times 10^{18}$ cm⁻³ at 300 K quantifies the low defect content of the Sb₂Te₃ thin films.

 [READ HERE](#)

Antiferromagnetic phase of the gapless semiconductor V₃Al

Jamer, M. E. and Assaf, B. A. and Sterbinsky, G. E. and Arena, D. and Lewis, L. H. and Sal'ul, A. A. and Radtke, G. and Heiman, D., *Phys. Rev. B*, 91(9), 094409 (2015), DOI.

Abstract

Discovering new antiferromagnetic (AF) compounds is at the forefront of developing future spintronic devices without fringing magnetic fields. The AF gapless semiconducting D0₃ phase of V₃Al was successfully synthesised via arc-melting and annealing...

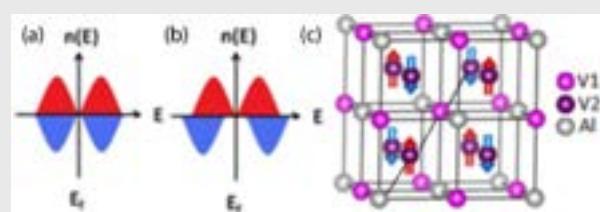


Figure 1. Illustrations of the DOS for (a) a gapless semiconductor and (b) a SGS. (c) The D0₃ structure of V₃Al has an Al-V2-V1-V2-Al configuration along the body diagonal and is an AF gapless semiconductor. The up (red) and down (blue) arrows correspond to atoms with positive and negative spins, respectively.

Quantum Design VersaLab™ Measurement System
3 Tesla Cryogen-free Physical Property Measurement System



Quantum Design VersaLab™ Measurement System
Cryogen-free Physical Property Measurement System
Contact our Technical Director: Dr. Shayz Ikram his 3
Telephone: (01372) 378822 Email: shayz@qd-uki.co.uk in a limited space.

 [READ HERE](#)

NEW UV OPTIMISED CMOS CAMERA

QDUKI's photonics partner, Raptor Photonics launches camera for PET semiconductor inspection

Raptor Photonics has launched the Hawk Indigo, using a next generation 2/3" CMOS sensor, enabling ultimate UV sensitivity and high QE of 36% at 250nm. With a pixel size of 2.74µm, the camera achieves a resolution of 8.1MP and offers global shutter, progressive scan technology to enables real time, lag-free images at 15Hz full-frame through a CameraLink interface.

The Hawk Indigo is extremely rugged and can be used in harsh environments, working from -20°C to +55°C, with more extreme temperatures on special request. It is ideal for integration into industrial applications offering greater precision in hyperspectral imaging, transparent materials (plastic and PET), semiconductor, wafer and mask inspection, material sorting, combustion imaging and high voltage technology.



Key features:

2/3" UV optimised CMOS Mono Camera

- **2848 x 2848, 2.74µm pitch CMOS technology**
 - Enables imaging from 0.2µm to 0.4µm
- **Latest Generation CMOS technology**
 - Enables ultimate sensitivity similar to EMCCD
- **Ultra compact and rugged**
 - Easy integration into any Electro-Optics platform
- **High UV QE: >36% @ 250nm**
 - Enables better quality image under low light conditions
- **Global shutter, progressive scan technology**
 - Enables real time, lag-free images at 15Hz full-frame



Discover the
Raptor Range

Contact our Technical
Sales Manager:
Dr. Luke Nicholls
Telephone: (01372) 378822
Email: luke@qd-uki.co.uk



You might also like...

the Raptor Ninox 640

*a cooled VIS-SWIR InGaAs camera
ideal for semiconductor inspection*



[Learn more about the Raptor
Ninox 640](#)

By combining the complementary strengths of **AFM** and **SEM**, FusionScope opens the door to a world of **new application possibilities**

fusion
scope[®]
by Quantum Design



[Learn more about the QD FusionScope](#)



FusionScope is an easy-to-use correlative microscopy platform designed from the ground up to add the benefits of SEM imaging to a wide range of AFM measurement techniques.

TALK TO US

Discuss your application and the QD FusionScope with our Technical Product Manager, Dr. Satyam Ladva
Call (01372) 378822
Email satyam@qd-uki.co.uk



ANALYSE ELECTRONIC COMPONENTS OR SEMICONDUCTOR DEVICES USING ATOMIC FORCE MICROSCOPY

Detailed location and analysis of nanometer-sized structures is a challenging and time-consuming task for all AFM operators. The size reduction in recent generations of transistors creates especially high demands on quality control and failure analysis.

With FusionScope and Profile View you can easily navigate the cantilever tip to the region of interest and perform high resolution AFM analysis of your sample. Measure the real 3D topography with sub-nanometer resolution or extract additional information using conductive AFM.

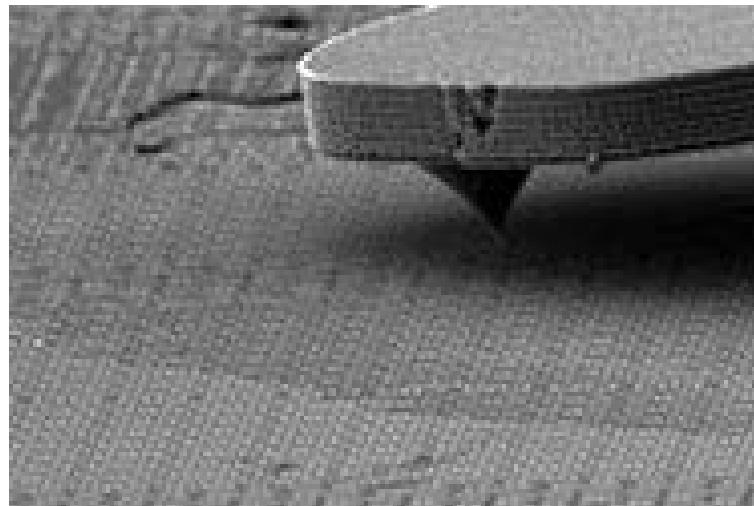


Figure 1. SEM image of CPU chip with cantilever tip positioned on the region of interest.

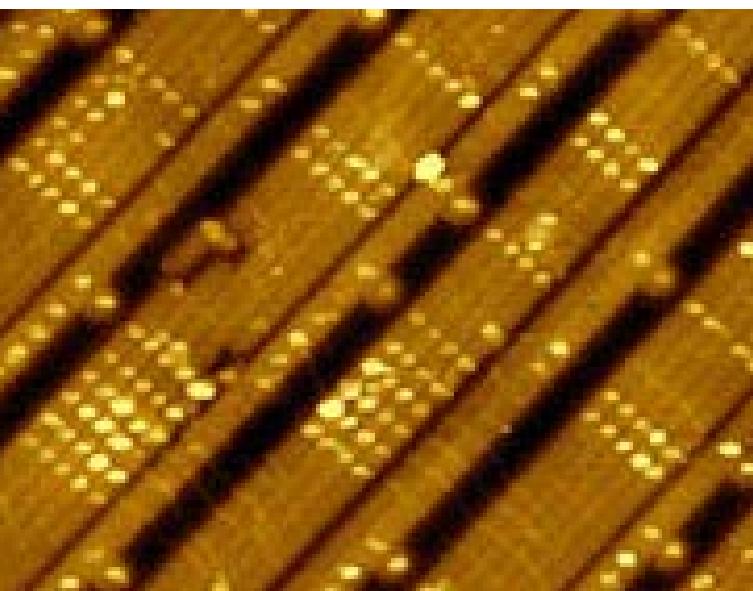


Figure 2. Correlative AFM image of specific area of transistor structures

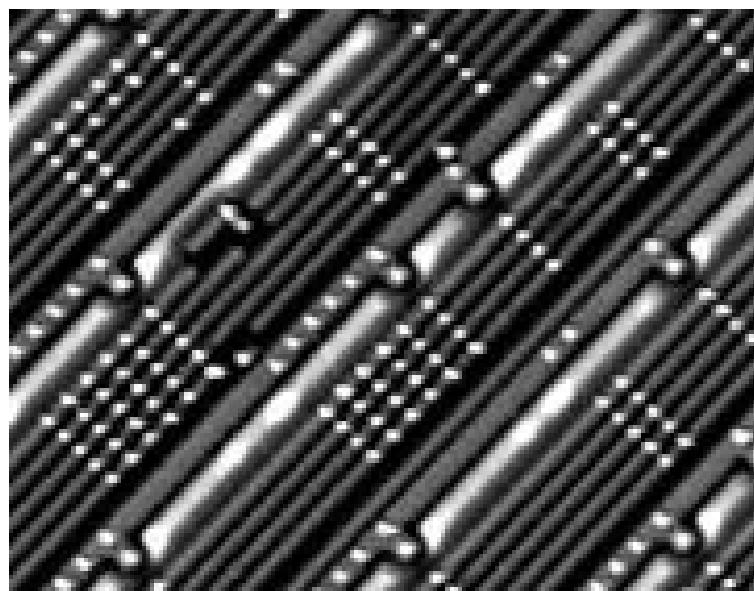


Figure 3. Correlative SEM image of specific area of transistor structures



[Learn more about the QD
FusionScope](#)

ANDOVER CORPORATION ADVANTECH™ LINE OF HARD COAT BANDPASS FILTERS FOR HIGH PERFORMANCE IN DEMANDING APPLICATIONS

Andover Corporation, a world leader in the design and manufacture of optical filters, has released its new line of ADVANTECH™ hard coat bandpass filters.



These state-of-the-art filters offer steep slopes, high light transmission, superior durability and long life for demanding applications, such as spectroscopy, fluorescence, imaging and sensing in the biomedical, machine vision and semiconductor industries.

ADVANTECH first surface bandpass filters provide transmission rates over 90% at wavelengths from 337-1200 nm.

These hard coat filters are manufactured using a magnetron-sputtered hard oxide coating precisely deposited without any absorbing filter glass. This coating produces optical filters that are thinner and lighter weight while providing greater resistance to extreme temperatures, humidity, scratching and other environmental hazards.



Additionally, hard oxide coatings are known to extend filter life to as long as 30 years. ADVANTECH hard coat filters are available in three standard sizes and mounted in an anodised aluminum ring.



[Learn more about
Andover Filters](#)

ADVANTECH thin films can be customised and applied to a wide range of substrate materials to achieve deep blocking and high transmission for various application requirements. With a staff of in-house engineers, advanced testing capabilities and custom fabrication options, Andover is uniquely qualified to meet and exceed customers' needs for high performance and exceptional value.



"Andover is well known for its commitment to high quality and world-class customer service. We are excited to add ADVANTECH to our ever-expanding line of hard coat and traditional optical filters so our customers can continue to excel at bringing cutting-edge technology to their markets."

Michael Tiner, COO of Andover Corporation



You might also like:

These specialised filters are custom parts mass ordered throughout the years. They're highly utilised in a wide range of industries and applications, including; semiconductor photoresist removal (ANDV4442, ANDV4565)



Want to learn more about Andover?

Contact our
Technical Director:
Dr. Shayz Ikram
Telephone: (01372) 378822
Email: shayz@qd-uki.co.uk





Dopant and Thin Film Analysis at Sub-Å Equivalent Thickness



[READ NOW](#)

ABSTRACT We describe a new technique for non-destructive, quantitative measurements of dopants and equivalent thicknesses using SIGRAY's ellipsometer. Dopant and equivalent measurements of over 100 samples were made in nanometres of PZ film. The results are compared to atomic layer deposition, ion implantation, ion scattering, secondary ion mass spectrometry, and Rutherford backscattering.

SIGRAY's ellipsometer provides ultrahigh sensitivity at high throughput. The measurements and features can complement atomic layer deposition, sputter, PECVD, CVD, and other chemical-based -OH measurement by the ellipsometer measured with 10 nm resolution.

FURTHER READING

Ellipsometers for Semiconductors

iSMART Research Group and J. A. Woollam IR-VASE II Case Study and Bespoke Ellipsometry Measurements for the Semiconductor Market

Antiferromagnetic Phase of the Gapless Semiconductor V₃Al

Abstract Compound semiconductors are the workhorses of modern technology. One class of compound semiconductors is the class of magnetic insulators. These materials exhibit magnetic properties such as magnetism and magnetoresistance, which are important for various applications.

Compound Semiconductors

Electronic Transport Characterisation of HEMT Structures



[READ NOW](#)



[READ NOW](#)



[READ NOW](#)



BESPOKE ONE-OFF ELLIPSOMETER MEASUREMENTS FOR THE SEMICONDUCTOR MARKET



Seeking to better understand the optical and electronic properties of materials or thin films for nanophotonic or electronic applications?

The partnership agreement between QDUKI and the Medical Technology Innovation Facility, affords customers the ability to view and utilise the [JA Woollam IR VASE II Spectroscopic Ellipsometer](#).

Indeed, this is only one of two such instruments in the UK and the only one now made available to customers in the UK in this way. The nature of Ellipsometry (relatively fast and non-destructive) makes it ideal for diagnostics in several sectors such as semiconductor devices, photovoltaics, nano-photonics, flat panel displays, optical coating stacks, construction materials, biological and medical coatings, protective layers as well as real-time quality control.



MTIF – with a strong academic pedigree and expertise in nanofabrication – can conduct such analysis on your behalf offering a bespoke and individualised service. Please [reach out to discuss your needs today](#).

"This partnership provides companies with a unique opportunity to use cutting edge Ellipsometry technology supported by renowned research expertise. These capabilities are usually unavailable to all but the largest organisations. This partnership allows organisations of every size the opportunity to accelerate their development programmes."

Professor Mike Hannay, Managing Director of the Medical Technologies Innovation Facility (MTIF).

A variety of assistive technologies for materials deposition, including physical and chemical deposition techniques, such as RF magnetron sputtering, atomic layer deposition and thermal evaporation of nano-engineered coatings and thin films. These are applicable across a broad range of industrial applications such as, optical coatings, plasmonic thin films, SERS sensors and large-area electronic devices.



J.A. Woollam



Want to learn more about Ellipsometry?

Contact our Technical Director:
Dr. Shayz Ikram
Telephone: (01372) 378822
Email: shayz@qd-uki.co.uk

Compound Semiconductors

Electronic Transport Characterisation of HEMT Structures



 **Lake Shore**
CRYOTRONICS
ADVANCING SCIENCE

 **Quantum Design**
UK AND IRELAND



[Read the article](#)

Our Other Magazines

Cryogenics

Highlights:

- Customisable Cryostats
- Focus on Temperature Sensors
- Lowest Temperature Measurements
- The Next Generation of Helium Recovery

[view here](#)



Space

Highlights:

- Imaging Venus with SWIR
- Temperature Sensors for Space
- Measurement of Space Optics/Structures
- Optical Filters for Astronomy

[view here](#)



Imaging Cameras

Highlights:

- Advancing Geology with Hyperspectral Imaging
- Avoiding Contamination in the Food Industry
- SWIR Cameras for Telecommunications Applications
- Streak Cameras in Action

[view here](#)



High Tech Instrumentation

Highlights:

- Customisable Cryostats
- Focus on Temperature Sensors
- The Next Generation of Helium Recovery

[view here](#)





Quantum Design
UK AND IRELAND

Further reading:

- *Upcoming Events*
- *Webinars*
- *Latest News*
- *Press Room*

Produced by:

Quantum Design UK and Ireland
Unit 1, Mole Business Park, Leatherhead, Surrey,
KT22 7BA
+44 (0)1372 378822
info@qd-uki.co.uk
www.qd-uki.co.uk

Follow us:

