Agate

Non-Destructive Inspection and Metrology for the Semiconductor and Micro-Electronic Industries

Hybrid Configuration:
- X-Ray Analysis
- Automated 3D Scanning
- 2D Microscope
NON-DESTRUCTIVE ANALYSIS

The Agate combines X-Ray, 2D microscope and 3D scanner, allowing significant advantages:

- Height and critical dimension (CD) monitoring
- Volume measurement
- 3D structure analysis such as misprocess, voids and surface defects
- Thin film multi-layer analysis
- Materials composition inspection

“The merging of our two core technologies, EDXRF and automated 3D imaging, results in a hybrid solution that is truly synergistic in that the sum is greater than the parts.”

We follow the ITRS (International Technology Roadmap for Semiconductors)

The advent of X-Ray technology for semiconductor metrology reduces the need for entrenched destructive methodologies requiring sample preparation.

XRF is capable of analyzing localized 3D structures and thus has an advantage over technologies which are surface sensitive only (including XRR, XRD and optics).
TECHNOLOGY- HYBRID SOLUTION

XwinSys has pioneered a hybrid approach to meet complex 3D structures in the Semiconductor industry. Combining 3D optics with XRF enables a single measurement to achieve full inspection. Furthermore the spot size of both analytical techniques is small enough to facilitate monitoring of localized features.

Energy Dispersive X-Ray Fluorescence
EDXRF spectroscopy is the most accurate and economical analytical method for determination of the elemental composition of many types of materials. This technique is non-destructive, requiring no sample preparation, and is suitable for almost all sample types and shapes. X-ray Fluorescence (XRF) spectrometric analysis can be employed to measure a wide range of atomic elements, from Carbon (6) through Fermium (100), with low detection limits and high precision.
No edge exclusion- EDXRF comprises a vertical top-down beam source. This combined with the small spot size of the beam ensure that there is no edge-exclusion zone for the tested material.

3D Scanner
This second core competency covers an optical metrology methodology. Supplement with dedicated algorithms and software packages that can be applied to specialized and automated machine-vision solutions for quality control and hands-free 2D and 3D geometrical measurements in industrial applications. Computerized image processing is an essential ingredient of this core competence and one that enables accurate and reliable automated inspection.

2D Microscope & Image Processing
The main importance of the 2D microscope is its advanced optical features, mainly used for efficient geometrical inspection purposes, as well as an accurate navigation tool. The high level of image processing and pattern recognition allow defect inspection, color inspection, feature dimension, centralization feature, contour extraction and more.
## AGATE SPECIFICATIONS

<table>
<thead>
<tr>
<th>Configuration</th>
<th>System Parameters</th>
<th>Specifications</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metrology type</td>
<td>Non-destructive ED-XRF and optical techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wafer size</td>
<td>Up to 300mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X/Y stages resolution</td>
<td>0.5µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z stage resolution</td>
<td>50nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back side camera</td>
<td>Easy calibration feature</td>
<td>Auto calibration mode</td>
<td></td>
</tr>
<tr>
<td>Sample handling</td>
<td>Manual loading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automation</td>
<td>Full wafer capability</td>
<td>300mm and smaller</td>
<td></td>
</tr>
<tr>
<td>Navigation</td>
<td>Precise stages complemented with image recognition algorithm</td>
<td>Sub-micron fast navigation to single feature center</td>
<td></td>
</tr>
<tr>
<td>SW user interface</td>
<td>Ease-of-use recipe creation and maintenance</td>
<td>Auto tool health monitoring and auto calibration</td>
<td></td>
</tr>
</tbody>
</table>
### XRF

<table>
<thead>
<tr>
<th><strong>XRF beam orientation</strong></th>
<th>Vertical incidence micro-spot XRF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X-ray tube energy</strong></td>
<td>50KV, 50W</td>
</tr>
<tr>
<td><strong>Detector type</strong></td>
<td>Silicon drift detectors (SDD)</td>
</tr>
<tr>
<td><strong>Detector resolution</strong></td>
<td>125eV +/- 5eV With large solid angle</td>
</tr>
<tr>
<td><strong>X-ray beam spot size (FWHM@8 KeV)</strong></td>
<td><code>&lt;10µm with poly-capillary optics Small / Regular capillary: Sn - 7µm / 17µm Cu - 10µm / 23µm</code> Small spot for high energy elements</td>
</tr>
<tr>
<td><strong>Detectable range of elements</strong></td>
<td>All elements down to C(6)</td>
</tr>
<tr>
<td><strong>Multi-channel analyzer (MCA)</strong></td>
<td>High efficiency Larger than 1 million photons per second</td>
</tr>
</tbody>
</table>

### 2D Microscope

| **2D Microscope** | Resolution: 5 Megapixel lateral 0.1 µm | Sub-micron navigation with pattern recognition |

### 3D Scanner

<table>
<thead>
<tr>
<th><strong>3D Scanner</strong></th>
<th>Ultra-fast 3D geometrical parameter extraction i.e. height, shape, structure Vertical resolution: 100 nm</th>
<th>Insensitive to material absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Magnification (optical microscope)</strong></td>
<td>X2, X10</td>
<td>Option: X20, X50 and other</td>
</tr>
<tr>
<td><strong>Working distance</strong></td>
<td>150µm / 300µm / 1400µm</td>
<td></td>
</tr>
</tbody>
</table>
APPLICATIONS HIGHLIGHTS

The XwinSys Agate is a high-end system serving the in-line semiconductor fab environment. It is a unique hybrid product that acts as a review station as well as serving the rapidly evolving 3D IC segment of the Semiconductor industry. The system combines high resolution elemental material composition analysis with 3D geometrical inspection of features exemplified by micro-bumps associated UBM and RDL features and TSV. Other Semiconductor applications are also relevant and include ultra-thin (sub nm) layer measurement and localized layer thickness measurement, and composition analysis associated with FinFET structures. An added advantage of the XwinSys Agate system is its proven ability to concentrate an X-ray beam down to 7 microns in diameter, crucial for inspection of micro-features of corresponding size.

The Agate is equipped with an array of 4 state-of-the-art silicon drift detectors (SDD) including a light-element SDD allowing for highest throughput and precision (2 axis symmetry) of an expanded range of elements detection from Carbon upwards. The integrated XRF and 2D/3D optical imaging technologies allow for the system to function as a Review Station for defect verification using 2D defect imaging, 3D defect structure rendering and XRF material composition of the defect. The highly accurate, automated feature location and indexing, enable fast and precise material analysis and 3D geometrical inspection of 300mm wafers and multi-feature arrays of specimens.

NMT: ULTRA-THIN FILMS MEASUREMENT

As thin films are becoming ultrathin and more localized, and material interactions move to smaller scales and with increased sensitivity to aberrations, XwinSys has developed a novel ED-XRF technology named NMT. This Noise-reduced, Multilayer, Thin-film measurement is a reliable multipurpose inspection, metrology and analysis of localized ultra-thin layers and features - down to 1Å.

Metal 1 Thickness = Total Height - Metal 3 - Metal 2
BUMP APPLICATION - COMPOSITION AND HEIGHT
The hybrid solution provides quick and reliable location of bump and wafer defects. The bump is a dome-like structure made of solderable material that is a crucial interconnecting element for connecting chips in a three dimensional stack and for connecting the stack to the printed circuit board.

REAL TIME REVIEW
Detection of defects and miss-processes complemented with in-depth metrology: reliable and quantitative analysis of voids, missing layers and features. Innovative image acquisition technology to achieve better detection capabilities.

UBM / RDL THICKNESS MONITORING
Multi-stack structures and thick mono-layers are analyzed efficiently by XRF for layer thickness and composition whereas optical metrology technologies are not capable of distinguishing separate layers simultaneously (necessitates measuring each layer before application of next layer). Other X-ray techniques such as XRR are not capable of measuring non-planar structures.

LIGHT ELEMENTS DETECTION CAPABILITY
Elemental analysis of low Z elements (such as Magnesium, Fluorine, Oxygen, Nitrogen and Carbon) is performed with state-of-the-art light elements detector. The mentioned elements represent the evolving trend of the organic elements penetrating the semiconductor industry, mainly suitable for applications such as glass substrate photo-resist, isolators and more.

ALLOY COMPOSITION
By using XRF, elemental composition can be determined for most of the existing alloys in the semiconductor industry. In some cases the accuracy of the chemical composition is highly important for performance; hence XRF enables fast and accurate measurement which facilitates yield improvement.
The Semiconductor industry including nano-devices is at an inflection point; two dimensional shrinkage, while still the holy grail of miniaturization, is giving way to 3D stacking in the race to achieve more condensed volume functionality at an affordable price. This has caused a profusion of changes to system architecture that expresses itself in a wealth of new and complex geometries and materials. Thin films are becoming ultrathin and more localized, and features comprise more materials and material interactions at smaller scales and with increased sensitivity to aberrations.

XwinSys has identified this trend and after investigating the disparities between existing solutions and evolving needs, has developed a novel technology designated as **NMT**: Noise-reduced, Multilayer, Thin-film measurement for multipurpose inspection, metrology and analysis of localized ultra-thin layers and features.

- Helium significantly reduces signal noise.
- Vertical incident X-ray beam enabling both high flux and small spot size
- Unique algorithm designed to remove background noise from the elemental signal.

**Case Study:**

**Calibration Curve - Thickness vs. Intensity**

![Graph showing calibration curve with thickness vs. intensity](image)
The hybrid solution provides quick and reliable location of bump and wafer defects. The bump is a dome-like structure made of solderable material, is a crucial interconnecting element for connecting chips in a three dimensional stack and for connecting the stack to the printed circuit board.

- Elemental composition analysis by optical analysis for geometrical parameters and XRF
- Vertical incident X-ray beam (spot down to 7µm on SnK line) using four independent detectors configured in a symmetric assembly
- Thickness / composition extraction using robust fundamental parameters (FP) algorithm
- Composition analysis using standardless fundamental parameter (SLFP) option

Bump Scan Imaging
Integrated 3D and 2D metrology and inspection in a single system obtains a precise, stable measurement of a wide range of shapes and materials. Innovative image acquisition technology to achieve better detection capabilities.

Detection of defects and miss-processes complemented with in-depth metrology: Reliable and quantitative analysis of voids, missing layers and features.

- Measurement of bump dimensions and precise location
- Inspection of surface defects for a wider range of configurations
- Detection of voids by obtaining 3D volume, elemental volume and composition
Multistack structures and thick mono-layers are analyzed efficiently by XRF for layer thickness and composition whereas optical metrology technologies are not capable of distinguishing separate layers simultaneously, necessitates measuring each layer before application of next layer. Other X-ray techniques such as XRR are not capable of measuring non-planar structures.

- Multi stack analysis in one shot
- CuNiPd / CiNiAu / CuNiZn
- High TPT performance
- Multi-element detection is discrete
- Robust fundamental parameter algorithm for thickness extraction
Elemental analysis of low Z elements is performed with state-of-the-art light elements detector. These elements represent the evolving trend of the organic elements penetrating the semiconductor industry, mainly suitable for applications such as glass substrate photo-resist, isolators and more.

These elements are invisible and/or overlapped with other elements in the sample, when analysed with other systems. This feature opens a wide range of capabilities, both inline and offline, for many semiconductors applications.

- Analysis of light (low energy) elements such as Magnesium, Fluorine, Oxygen, Nitrogen and Carbon
- Efficient analysis of dozens of other elements by detecting its low level readings
ALLOY COMPOSITION INSPECTION

By using XRF, elemental composition can be determined for most of the existing alloys in the semiconductor industry. In some cases, the accuracy of the chemical composition is highly important for performance. Thus XRF enables fast and accurate measurement which facilitates yield improvement.

Variety of composition inspection capabilities:
- Light element detection such as Carbon, Magnesium, Aluminum and Phosphorous is an important added value
- Elemental analysis of metals such as Ga, P, Co, Ni, Fe, Pt, Cr, Zn, Mn
- Identification of alloys such as NiFe, CoNi, NiP, NiPt, CrMn
XwinSys Technology Development Ltd., founded in 2012 and fully owned by Eurocontrol a Canadian company (TSXV, EUO), with headquarters located in the hi-tech industrial park at Migdal Haemek (north Israel). Company is led by an outstanding team of senior managers, board members and global advisers with vast accumulated experience.

XwinSys was founded by using the core competency of more than 30 years in the design, development, production and marketing of Energy-Dispersive X-Ray Fluorescence (ED-XRF) systems.

XwinSys is dedicated to the design, manufacture and marketing of novel solutions based on improved X-ray technology combined with automated optical 3D & 2D technologies, for the semiconductor and related industries.

The XwinSys product line is designed to offer an attractive and innovative technological solution for the rapidly growing semiconductors market. The company’s modular technological concept allows multiple application capabilities, cost-effective maintenance and budget oriented approach.

The XwinSys Integrated and improved X-Ray and optical (3D & 2D) analysis is a new approach to meet the challenges of roadmap requirements for inspection and metrology of 3D structures, thin-films, multi-stack and organic applications in the semiconductor industry.

3D-IC is the fastest growing segment of the semiconductor industry and leads the way to vertical stacking that is evolving as the disruptive force of the industry.
CONTACT US

XwinSys Technology Development Ltd.

E-mail: info@xwinsys.com
Website: www.xwinsys.com

Headquarters
Address: Ramat Gabriel Industrial Zone,
6 Hatikshoret St. Migdal Haemek 2310901, Israel
Tel: +972-4-9891313 | Fax: +972-4-9891323

USA Office
Address: P.O. Box 5693, Carefree, AZ 85377, USA
Tel: +01-602-460-4286 | Fax: +01-602-297-6563