Non-Destructive Inspection and Metrology Analysis for the Semiconductor

Hybrid Configuration of X-Ray Analysis, Automated 3D Microscope and 2D Image Processing
The advent of X-Ray Technology for semiconductor metrology reduces the need for entrenched destructive methodologies requiring sample preparation.

The Onyx combines X-Ray and optics, allowing significant advantages:

- Height and critical dimension (CD) monitoring
- Volume measurement
- 3D structure analysis
  - Misprocess
  - Voids
  - 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.”
Scaling can still drive cost down

Atoms still don’t scale

But it is exponentially more costly to develop

WE FOLLOW THE ITRS
(International Technology Roadmap for Semiconductors)
TECHNOLOGY

Energy dispersive X-RAY fluorescence (EDXRF) spectroscopy is the most accurate and economical analytical method for the 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.

Automated 3D Scanning
This second core competency covers a variety of optical based metrology methodologies including confocal, interferometry and triangulation. We supplement them 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 automated inspection.

2D 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 and more.
ED-XRF

HYBRID DESIGN MERGING X-RAY, 2D MICROSCOPE & 3D SCANNER

3D Scanner

Multi Channel Analyzer

X-Ray Source & Optics

Detector Assembly

Underside Calibration Camera

3D Optical Scanner

2D Microscope
# INTRODUCING THE ONYX SPECIFICATIONS

<table>
<thead>
<tr>
<th>System Parameters</th>
<th>Specifications</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metrology type</strong></td>
<td>Non-destructive EDXRF and 3D optical techniques</td>
<td></td>
</tr>
<tr>
<td><strong>Wafer size</strong></td>
<td>Up to 300 mm</td>
<td></td>
</tr>
<tr>
<td><strong>X/Y stages resolution</strong></td>
<td>1µm</td>
<td></td>
</tr>
<tr>
<td><strong>Z stage resolution</strong></td>
<td>50nm</td>
<td></td>
</tr>
<tr>
<td><strong>Magnification (optical microscope)</strong></td>
<td>X2, X10, X20, Option: X50</td>
<td>Auto calibration mode</td>
</tr>
<tr>
<td><strong>Back side camera</strong></td>
<td>Easy calibration feature</td>
<td></td>
</tr>
<tr>
<td><strong>3D methods - resolution:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth-of-Focus</td>
<td>0.15µm</td>
<td></td>
</tr>
<tr>
<td>Triangulation (optional)</td>
<td>1µm</td>
<td></td>
</tr>
<tr>
<td>Interferometer (optional)</td>
<td>0.2µm</td>
<td></td>
</tr>
<tr>
<td><strong>Throughput</strong></td>
<td>1-150 sec. per site (bump or void)</td>
<td>Application dependant</td>
</tr>
<tr>
<td><strong>Sample handling</strong></td>
<td>Manual loading</td>
<td></td>
</tr>
</tbody>
</table>
## XRF

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XRF beam orientation</td>
<td>Vertical incidence micro-spot XRF</td>
</tr>
<tr>
<td>X-ray tube energy</td>
<td>50KV, 50W</td>
</tr>
<tr>
<td>Detector type</td>
<td>Silicon drift detectors (SDD) with large solid angle</td>
</tr>
<tr>
<td>Detector resolution</td>
<td>125eV +/- 5eV</td>
</tr>
<tr>
<td>X-ray beam spot size (FWHM@8 KeV)</td>
<td>&lt;20µm with poly-capillary optics</td>
</tr>
<tr>
<td>Detectable range of elements</td>
<td>all element range down to C(6)</td>
</tr>
<tr>
<td>Multi channel analyzer (MCA)</td>
<td>High efficiency</td>
</tr>
<tr>
<td>Automation</td>
<td>Full wafer capabilities</td>
</tr>
<tr>
<td>Navigation</td>
<td>Precise stages complimented by final image recognition algorithm</td>
</tr>
<tr>
<td>SW user interface</td>
<td>Ease of use recipe creation and maintenance</td>
</tr>
</tbody>
</table>

## Optics

<table>
<thead>
<tr>
<th>Microscope</th>
<th>Resolution: 2448 x 2048</th>
<th>Sub micron navigation with pattern recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High resolution Microscope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D Microscope (3DM)</td>
<td>Ultra-fast 3D geometrical parameter extraction i.e. height, CD</td>
<td>Insensitive to material absorption</td>
</tr>
</tbody>
</table>
HYBRID SOLUTION

XwinSys has developed a novel non-destructive hybrid system, featuring both inspection and metrology analysis capabilities, to simultaneously monitor geometries and elemental composition. This unique combination of advanced optics and XRF technologies, together with its automatic features, enables accurate and precise analysis of applications in the micro-electronic industries.

N.M.T: ULTRA-THIN FILMS MEASUREMENT

As thin films are becoming ultrathin and more localized, and material interactions gets into smaller scales and with increased sensitivity to aberrations, XwinSys has developed a novel EDXRF technology named NMT: Noise-reduced, Multilayer, Thin-film measurement for reliable multipurpose inspection, metrology and analysis of localized ultra-thin layers and features - down to 1Å.
BUMP APPLICATION - COMPOSITION AND HEIGHT

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.

TSV VOID DETECTION - USING NON-DESTRUCTIVE SOLUTION

Advanced interconnect technologies such as through silicon vias (TSV) have become an integral part of 3-D integration. The International Technology Roadmap for Semiconductors (ITRS) has identified a need for metrology solution for characterizing voids in TSV structures.

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

For analysis of light (low energy) elements such as Magnesium, Fluorine, Oxygen, Nitrogen and Carbon. Elemental analysis of low Z elements 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 the performance; hence XRF enables fast and accurate measurement which facilitates yield improvement.
APPLICATIONS FEATURES & CONFIGURATION

3D LOCALIZED STRUCTURES
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). This trend of increased localized 3D structures will only increase in the future and highlight the distinct advantage of the XwinSys volume sensitive capabilities.

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
High resolution, high precision
Any type of sample (transparent/opaque, polished/rough)
All materials (metal, glass, semiconductor, plastic...)
No preparation of the sample required

HIGH RESOLUTION 2D MICROSCOPE
Sensor Technology: CCD Color
Resolution: 2448 x 2048
Lenses: X2, X10 (X20 X50 optional)
Image processing capabilities
Accurate navigation system incorporating pattern recognition
Centralization feature
Contour extraction

MICRO X-RAY FLUORESCENCE
Vertical spot (FWHM @8KeV-35µm, 25KeV-17µm)
4 SDD detectors around the capillary (symmetrical assembly)
XRF filters assembly – to improve performance
State of the art Multi Channel Analyzer (MCA)

EASE OF USE
Unique calibration features
Backside camera for calibration
Accurate stage down to 1 µm
Auto calibration features
Excellent navigation on micro features
Feature centralization
Feature contour
Self test monitoring system
Single to dual automatic loader
User-friendly interface
With the advent of complex 3D structures in the Semiconductor industry inspection and metrology face a challenge to adapt to 3D structures and to be able to simultaneously monitor both geometries and elemental composition. Moreover this needs to be accomplished for small areas and specific localized features.

XwinSys has pioneered a hybrid approach to meet these challenges. 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.
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 - **N.M.T: Noise-reduced, Multilayer, Thin-film measurement for multipurpose inspection, metrology and analysis of localized ultra-thin layers and features.**
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. Optical analysis for geometrical parameters and XRF for elemental composition analysis. Vertical incident X-ray beam (spot down to 17µm on SnK line).

Four independent detectors configured in a symmetric assembly. Robust fundamental parameters (FP) algorithm for thickness / composition extraction. Standardless fundamental parameter (SLFP) option for composition analysis.
Advanced interconnect technologies such as through silicon vias (TSV) have become an integral part of 3-D integration. The International Technology Roadmap for Semiconductors (ITRS) has identified a need for metrology solution for characterizing voids in TSV structures.

Reliable, accurate and precise voids detection - down to 5% of volume.

The International Technology Roadmap for Semiconductors (ITRS) has identified a need for metrology for characterizing voids in TSV structures.
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):

- Multi stack analysis – one shot!
- CuNiPd / CiNiAu / CuNiZn
- High TPT performance
- Multi element detection is discrete
- Robust fundamental parameter algorithm for thickness extraction

Other X-ray techniques such as XRR are not capable of measuring non-planar structures.
Analysis of light (low energy) elements such as Magnesium, Fluorine, Oxygen, Nitrogen and Carbon. Elemental analysis of low Z elements 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.

The unique Light Element Detector capabilities also allows efficient analysis of dozens of other elements by detecting its low level readings. These elements will be invisible and/or overlapped with other elements in the sample, when analysed with other XRF systems. This feature opens a wide range of application capabilities, both inline and offline, for many semiconductors and other processes.
By using XRF, elemental composition can be determined for most of the existing alloys in the semi-conductor industry. In some cases, the accuracy of the chemical composition is highly important for the performance; hence XRF enables fast and accurate measurement which facilitates yield improvement.

Capabilities of light element detection such as Carbon, Magnesium, Aluminum, Phosphorous and more, is an important added value.

Full composition inspection capability variety:
- Elemental analysis of metals like; Ga, P, Co, Ni, Fe, Pt, Cr, Zn, Mn and more.
- Easily identification alloy like NiFe, CoNi, NiP, NiPt, CrMn and more.
COMPANY PROFILE

XwinSys Technology Development Ltd., founded at 2012 and fully owned by the Canadian company ‘Eurocontrol’ (TSXV, EUO), and headquartered 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 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 was designed to offer an attractive and innovative technological solution to the rapid-growing semiconductors market, allowing multiple application capabilities, modular technological concept, cost-effective maintenance and budget oriented approach.

It’s 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 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.