Extending ArFi immersion scanner capability in support of 1xnm production nodes

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Contents

• Lithography requirements & immersion roadmap

• New ArFi technology introduced in HVM
  • Productivity
  • Focus control
  • Imaging
  • Overlay

• Future developments & Summary
TWINSCAN ArFi roadmap supports future nodes including overlay & focus requirements for multiple patterning

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>On Product Overlay</td>
<td>6.5 nm</td>
<td>5-3.5 nm</td>
<td>3.5-2.5 nm</td>
</tr>
<tr>
<td>CD Uniformity iso</td>
<td>1.8 nm</td>
<td>1.4 nm</td>
<td>1.1 nm</td>
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<tr>
<td>Total Focus Budget</td>
<td>80 nm</td>
<td>60-55nm</td>
<td>55-50 nm</td>
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### Node extension package

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Timing</td>
<td>Q1 2013</td>
<td>1H 2014</td>
<td>1H 2014</td>
</tr>
<tr>
<td>DCO / MMO</td>
<td>2.5 / 4.5*nm</td>
<td>2.0* / 3.5*nm</td>
<td>&lt;1.5* / &lt;2.5*nm</td>
</tr>
<tr>
<td>Full Wafer Focus Unif</td>
<td>22nm</td>
<td>20nm</td>
<td>15nm</td>
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<tr>
<td>Full Wafer CDU (iso)</td>
<td>2.0nm</td>
<td>1.3nm</td>
<td>1.0nm</td>
</tr>
<tr>
<td>Throughput (96 shots)</td>
<td>230 WpH</td>
<td>250 WpH</td>
<td>250 WpH</td>
</tr>
<tr>
<td>Defects/Wafer</td>
<td>10</td>
<td>&lt;7</td>
<td>&lt;7</td>
</tr>
</tbody>
</table>

* *Full Wafer to reference*
NXT: 1960Bi systems show high productivity
Up to > 4000 WpD quarter average, > 5000 WpD best week average

NXT: 1960Bi installed base systems with utilization > 50%, max per segment
NXT:1970Ci is in use in HVM
TWINSAN NXT:1970Ci design improvements to support down to 10 nm node requirements

**Legend:**
- **Overlay**
- **Imaging/Focus**
- **Productivity**

**Wafer Stage:**
*Higher throughput*
*Tighter focus & overlay*
*Improved thermal stability*

**UV Level sensor:**
*Process independent leveling*
*Improved edge focus control*

**Lens:**
*Reduced non-correctable errors*
*Improved Matching*

**Parallel lens interferometer:**
*Improved Lens heating & Reticle heating control*

**Immiscion hood:**
*Higher productivity*
New NXT:1970Ci ramping to HVM productivity in days
in use for Logic, MPU, NAND & DRAM applications

>10 NXT:1970Ci systems in field by Q1 2014
5 systems already in use

NXT:1970Ci system ramping to HVM at memory chip maker

Wafers per Day
TWINSCAN NXT:1970Ci design improvements
to support down to 1x nm node requirements

- **Wafer Stage:**
  - Higher throughput
  - Tighter focus & overlay
  - Improved thermal stability

- **UV Level sensor:**
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- **Parallel lens interferometer:**
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- **Immersion hood:**
  - Higher productivity

- **Lens:**
  - Reduced non-correctable errors
  - Improved Matching

Legend:
- Overlay
- Imaging/Focus
- Productivity

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Slide 8
250 WpH NXT:1970Ci wafer throughput proven with robust immersion defect control

New wafer stage & immersion hood support 800mm/s scan speed

NXT:1970Ci systems

NXT:1960Bi throughput

0.6 scanner defects/ wfr
(10wfr average. No post-soak, Resist: AIM5484 80°)

Resist contact angle 60° - 75 °
(customer wafer stacks)
NXT: 1970Ci wafer stage improved dynamics
at high productivity with consistent performance from centre-to-edge

1960Bi 0.7 m/s  Overlay  1970Ci 0.8 m/s

40%  40%  75%

MA X  MA Y  MA Z
NXT:1970Ci shows down to 10nm focus uniformity consistent for all systems & center-to-edge.

Results have been corrected for Offset & tilt per field to illustrate Imaging Optimizer capability.
NXT:1970Ci wafer table heater minimizes fingerprints

NXT:1960Ci segmented wafer table heater

NXT:1970Ci multi-segment wafer table heater
TWINS\textsuperscript{C}AN N\textsuperscript{X}:1970Ci design improvements
to support down to 1x nm node requirements

**Legend:**
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**Lens:**
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- Improved Matching

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- Higher productivity

**Wafer Stage:**
- Higher throughput
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- Improved Lens heating & Reticle heating control
Improved NXT:1970Ci projection lens aberration control proven at multiple systems
TWINSCAN NXT:1970Ci design improvements to support down to 1x nm node requirements

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**Legend:**
- Overlay
- Imaging/Focus
- Productivity

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Parallel Image sensor enables minimized reticle heating
PARIS sensor allows for accurate higher order corrections

NXT:1960Bi

NXT:1970Ci with PARIS sensor

Reticle heating residuals after correction
(max over 15 wafers, 50 mJ/cm2)

2x7 points capture actual barrel shape
Lens correction using scanning lens element
Faster & more accurate measurement using Parallel Lens Interferometer (PARIS)
Automatic wafer-by-wafer lens heating corrections

New ultra-fast Paris sensor measures lens heating in between every wafer.

Lens heating causes field distortion offsets.

New multifunctional sensor detects lens heating …

And corrects it with aberration manipulator.
NXT:1970Ci lens heating corrections result in stable through-lot overlay

Lot-by-lot feed forward correction only

Overlay drift mainly due to low order aberration drift (Z2/3)

1st layer: Annular illumination | low reticle transmission
2nd layer: Dipole illumination | high reticle transmission
TWINS CAN NXT:1970Ci design improvements
to support down to 1x nm node requirements

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Public
Slide 19
Reduced process dependency by leveling with UV LS
More and smaller detection spots for more accurate edge measurement

Example: NAND product wafer

Previous level sensor
600 nm ~ 1 μm

Reduced process & product sensitivity

accurate edge roll-off measurement

New level sensor (UV-LS)
200 nm ~ 425 nm

Example: NAND product wafer

Note: AGILE airgauge sensor is used to calibrate intrafield effect
NXT: 1970Ci UV Level Sensor works for all applications

Previous Level Sensor
600 nm ~ 1 µm

UV Level Sensor
200 nm ~ 425 nm

No air gauge sensor based intra-field fingerprint compensation applied.
NXT:1970Ci system
Imaging performance
NXT:1970Ci shows stable CDU through lot

40nm isolated lines - full wafer

40nm dense lines - full wafer
NXT:1970Ci system
Overlay performance
NXT:1970Ci design shows improved machine overlay to well below 1 nm

NXT:1960Bi at 230 WpH & 700mm/s (SPIE 2013)

NXT:1970Ci at 250 WpH & 800mm/s (2014)

0.90/0.79 nm (99.7% of all data)

>25% overlay improvement

0.65/0.56 nm (99.7% of all data)

For HVM usability chip manufacturers need...

• stable & robust overlay (heating, lot settings)
• matching to ArFi & EUV
• seamless integration with holistic lithography
• consistent performance for multiple scanners

…without productivity compromise
NXT:1970Ci minimizes heating and lot transition effects resulting in <2 nm machine overlay through lot.

Paris in-line lens heating correction

Paris in-line reticle heating correction

Multi-segment wafer table heating correction

Reticle heating

Dense Lines
Mode = Quasar
NA = 1.35, Sigma = 0.98/0.90
Transmission: ~40%

Lens heating

Cuts/Via’s
Mode = Annular
NA = 1.35, Sigma = 0.94/0.79
Transmission: ~80%

Wafer heating

Varying lot sizes

Machine overlay [nm]

(1.94 nm, 1.97 nm)
NXT:1970Ci shows <2.5 nm matched overlay capability consistently for all systems.

Results have been corrected for higher order wafer & field fingerprint.

NXT:1970Ci supports correction of higher order wafer & field fingerprints by holistic lithography.
NXT:1970Ci ArFi supports EUV insertion
overlay matching at 2.6nm demonstrated

Matched Overlay EUV to ArFi
X: 2.6 nm     Y: 2.5 nm

1st layer
NXE:3300

2nd layer
NXT:1970Ci

YieldStar overlay metrology
Future developments
Future improvements will be driven by Overlay & Focus control

Several improvement areas under investigation

**Alignment improvements**
- Improved robustness
- Improved accuracy

**Wafer stage & wafer table**
- Improved focus performance
- Improved temperature control

**Reticle stage**
*Further reticle heating improvements*

**Lens**
- Improved temperature control
- Reduced non-correctable errors

**Grid calibration improvements**
- Reduction of grid calibration errors

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Summary
TWINSJCAN NXT ArFi supports overlay & focus requirements for 1x nm nodes at high productivity

- NXT:1960Bi systems at chipmakers show up to > 5000 WpD productivity

- New NXT:1970Ci ramping to HVM productivity
  - 250 WpH wafer throughput at 800mm/s with robust immersion defect control
  - New parallel image sensor minimizes lens & reticle heating effects
  - Reduced process effects & accurate edge detection by UV Level Sensor
  - Intrinsic machine overlay as low as 0.65nm
  - Matched overlay to ArFi capability <2.5 nm shown on all systems
  - Overlay matching to EUV at 2.6nm demonstrated
Acknowledgements to: