SCREEN Equipment Manufacturer: Full participation within the SOI Consortium

June 1, 2017
SCREEN Semiconductor Solutions Co., Ltd.
1. SCREEN as a product line-up

2. SOI and Alternate Application solution: test case of Laser anneal

3. All about uniformity nm control and process control

4. How to integrate SOI product solutions within our own tools

5. Conclusion

Why are equipment manufacturer interested in participating in the SOI Consortium?
1. SCREEN as a product line-up

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Why are equipment manufacturer interested in participating in the SOI Consortium?
### Top growth rate of tool sales between major SPE manufacturers

[CY2015 → CY2016: +34.2% US$ basis]

### Number 6 Worldwide Wafer Fab Equipment

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Revenue 2015 (M$)</th>
<th>Revenue 2016 (M$)</th>
<th>'15-'16 Growth (%)</th>
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<tr>
<td>Applied Materials</td>
<td>7,737</td>
<td>7,819</td>
<td>1.0%</td>
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<tr>
<td>Lam Research</td>
<td>5,213</td>
<td>5,275</td>
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<td>ASML</td>
<td>5,091</td>
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<td>Tokyo Electron</td>
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<td>4,919</td>
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<tr>
<td>KLA-Tencor</td>
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<td>2,442</td>
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<td>Screen Semiconductor Solutions</td>
<td>1,375</td>
<td>1,434</td>
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<tr>
<td>Hitachi High-Technologies</td>
<td>980</td>
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<td>Nikon</td>
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<td>761</td>
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<td>Hitachi Kokusai Electric</td>
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<td>548</td>
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<td>ASM International</td>
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<td>Murata Machinery</td>
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<td>509</td>
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<tr>
<td>Disco</td>
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<tr>
<td>Others</td>
<td>4,634</td>
<td>4,840</td>
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<tr>
<td>Total Market</td>
<td>37,407</td>
<td>38,095</td>
<td>1.7%</td>
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</tbody>
</table>

Source: Gartner, April 2017
Semiconductor Equipment Solutions

**Product Line-up**

- **AQUASPIN**
  - SS-80EX
  - SS-3100
  - SS-3200

- **AQUASPIN**
  - SU-3200
  - SU-3300

- **60EX/80EX**

- **DT-3000**

- **LA-3000-F**

- **LT-3000/3100**

- **LA-830**

- **F-WET**
  - FC-3100
  - FC-821L

- **VM-1200/1300 Series**

- **VM-1020/1030 Series**

- **VM-2200/3200 Series**

- **RE-3100/3300 Series**

- **CW-1500**

- **CW-1500**

- **600mm**

**Scrubber**

**Wet Station**

**Measurement System**

**Frontier Project for 200mm**

**Coat/Develop Track**

**Annealing System**

**Direct Imaging System**

**SCREEN Semiconductor Solutions Co., Ltd.**
**Wafer Cleaning System**

**Single Wafer Cleaner**

**SU-3200**
- Nano process capability for 28nm and lower
- Provides throughput of up to 800 WPH
- Downtime reduction & maintenance capability improvement
- Flexible tool/chamber system
- ECO Friendly

**SU-3300**
- 24 chamber configuration
- 4 levels x 6 towers construction
- APAC2 super clean technology
- Nanodry7
- Nano Control Nozzle
- Nanocycle
- Single chamber servicing

**Scrubber**

**SS-3200**
- Installation of the latest cleaning tools achieves high cleaning capacity
- Provides throughput of up to 800 WPH
- Same processing capacity as the highly reliable and stable SS-3100
- Space-saving design

**Wet Station**

**FC-3100**
- Nano process capability for 45nm and lower
- Provides throughput of up to 650 WPH
- Short delivery time and fast setup
- Highly stable and reliable
- Flexible system configurations
Coat/Develop Track

DT-3000

- High-Throughput while Ensuring High Reliability
- Non-Stop Operation Delivers High Productivity
- Small Footprint & Flexible Configuration
- Advanced Lithography Technology

RF-310A

- Simple hardware and software enable high reliability
- High throughput designed for various process flows
- Features the latest technology for today’s cutting-edge, finer pattern processing
- Uses a modular design that is inherently flexible and expandable. The adaptable equipment design makes it possible to deliver and assemble the RF3 quickly

60EX/80EX

- Continuing the Reliability of the Long-Selling 60/80 Series
- Updated Control System for Easy Expandability
- Maintaining the Upward Compatibility of the 60/80 Series
- Flexibility to Process a Variety of Substrates
- Performance Leveraging Advanced Technology
Annealing System

Flash Lamp Annealer
LA-3000-F

- Precise thermal budget control
  - Flexible shape pulse and energy control
    - Ramp, Peak, Dwell, Soak timing and pulse height
- Confined atomic diffusion control
  - 0.1 msec pulse width control > 1 nm junction depth control
- High dopant activation and high heating rate
- High cooling rate to minimize deactivation
- Excellent R<br>uniformity (no scan overlap)
- Broad wavelength absorption to minimize pattern effect
- Supports many annealing applications as:
  - Well, S/D Extension, Contact, S/D USJ, HK Nitridation, HK PDA, Metal Gate Anneal

Laser Annealer
LT-3000/3100

- Ultra-low Thermal Budget
  Achieving the highest possible temperature gradient in sub-micro seconds, LT tools are able to anneal fragile substrates without damaging critical device structures.
- Full Device Exposure
  Annealing one die, a group of dies or only the desired region in a single shot, the LT makes it all possible by shaping the beam size to meet process and device requirements without stitching.
- Dopant Activation Control
  Obtaining unprecedented high line and parametric yield levels are only possible with the LT annealing process. By melt-annealing, the dopants are superactivated and the low resistance layer is defect free.
**Measurement System**

**Ellipsometric Film Thickness Measurement System**

**RE-3100/3300 series**

The ellipsometer is not affected by warping or bending of wafers, enabling highly accurate measurements.

- SiC/Si Power Device
- MEMS
- SAW Device
- Thin Wafer Transfer

**High-end model**

Φ150mm → Φ300mm

**Spectroscopic Film Thickness Measurement System**

**VM-2200/3200 series**

The VM-2200/3200 series offers high throughput of up to 160 wafers per hour in high-speed mode (during five-point measurement of SiO2 wafers).

- SiC/Si Power Device
- MEMS
- SAW Device
- Thin Wafer Transfer

**Multi-function model**

Φ100mm → Φ300mm

**VM-1200/1300 series**

A desktop model that can be incorporated into production lines.

- SiC/Si Power Device
- MEMS
- SAW Device
- Thin Wafer Transfer

**Desktop model**

Φ100mm → Φ300mm

**VM-1020/1030 series**

Microscope model that is ideal for R&D.

- SiC/Si Power Device
- MEMS
- SAW Device

**Desktop model**

Φ50mm → Φ300mm
Inspection System/Direct Imaging System

Wafer Pattern Inspection System

ZI-2000

Can be used in a wide variety of processes from in-process inspections in the frontend wafer process, where flexibility is demanded, to final visual inspections, where speed is of the essence.

Direct Imaging System for Advanced Packaging

DW-3000

- Equipped with Twin Drafting Head Utilizing Grating Light Valve (GLV™) and High-power YAG Lasers
- Handling of Warping and Non-linear Distortion Generated During Thinning and Attachment to Supporting Substrate
- Equipped with a Proprietary Optical System Designed for Thick Resist Processes

Direct Imaging System for Panel Level Packages

DW-3000 for PLP

- World-leading 2.0µm high-resolution imaging
- Automatic image correction function for the optimum exposure
- The world’s fastest* “Quad Head Concept”
- Suitable for large substrates for FOPLP
Agenda

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Why are equipment manufacturer interested in participating in the SOI Consortium?
Moving to 3D age...

3rd dimension became a fundamental design freedom in Advance logic, memory, IOT ...

In Power Electronics, vertical device optimized the 3rd dimension since more than 10 years

Infineon IGBT evolution

Need for process solution capable of surface localized annealing without affecting buried structure
LASSE LTA – Step & Repeat Process

LASSE LTA process
- Wavelength 308nm
- Pulse ~160ns
- Up to 9J per pulse
- Beam size up to 26x36mm²

- Ultra localized annealing
- Large temperature annealing capability
- Controllable melting process
Ultra localized annealing on top layer:
- Crystallization
- Activation
- Stress engineering

S. Kerdilès et al. in proceeding IWJT 2016
Laser integration supported by LASSE Innovation Booster

Simulating thermal, phases, diffusion dynamics during laser annealing

- Fully-owned Standalone software
- Native 3D
- Collaborating and developing with top academic experts
- Customer oriented
- Optimized for LT technology
Enable high temperature top layer annealing with BEOL temperature limitation (top layer bonded SOI or deposited):

- Stress Engineering
- Activation
- Mechanical properties engineering

LETI application:
a-Si to poly-Si Crystallization for resonator formation gas detectors

Pressor Sensor (IWJT 2014)

Planar Light Valve (PLV)
Need localize annealing for backside processing
Need melting process for defect free junction/contact
Need large temperature to integrate SiC substrate
Laser annealing for thin wafer Power Devices

- **Backside activation in Si IGBT (>1000°C)**
- **Backside contact formation in emerging SiC market**

*Implanted Si*

Ni deposited on thinned SiC

Contact formed after laser annealing


Complete Front Side Processing

Wafer Thinning

Backside processing

Junction formation

Contact formation

SCREEN UV laser annealing

BEOL < 450°C
Monolithic 3D integration of BSI CIS

- Enable high temperature for imagers (BSI-CIS ensuring) monolithically formed on CMOS technology
  - “EPI-like” recrystallization
  - High Activation Rate with Melt Process
  - No Damage to buried structure
1. SCREEN as a product line-up

2. SOI and Alternate Application solution: test case of Laser anneal

3. All about uniformity nm control and process control
   - Particle control
     - Process chamber technology
     - Physical cleaning
   - Etch uniformity control
   - Wafer drying technology
   - Customer acknowledgement: FDSOI HVM Enabled Atomic-Scale Uniformity

4. How to integrate SOI product solutions within our own tools

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Why are equipment manufacturer interested in participating in the SOI Consortium?
APAC (Advanced Process Atmosphere Control) technology

- Air-protect tech. for fine Drying process
- Small Chamber for quick refresh of the air
- Uniformed Exhaust for all Chem. Ports
- Clean process area can be maintained by ASP.
- Cup-window-velocity is boosted by the ASB.

Optimized Air-flow in Chamber

Chamber volume
290L
86L

Air Balance Guide
Particle control - Physical cleaning

<table>
<thead>
<tr>
<th>Technology node (nm)</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
<th>2015~</th>
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<tbody>
<tr>
<td>65</td>
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<tr>
<td>45</td>
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<tr>
<td>20/16</td>
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</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- **Softspray**: Inside mixing
- **Nanospray/Nanospray2**: Outside mixing

- Dual fluid (Liquid & N2)
- Further upgraded Nanospray2
- New concept of physical clean

Well-controlled droplet

Droplet velocity (m/sec) vs. Droplet diameter (um) graph

Further upgraded Nanospray2

SCREEN Semiconductor Solutions Co., Ltd.
**Nano control features**

1. Individual nozzle temperature control
2. Individual nozzle flow control
3. Adjustable dispense point

- Less chemical consumption
- Superior uniformity
- Unique etching curves

**Improved profile**

**Special etching curve**

*Graphs and charts showing improved profile and special etching curve.*
Customer acknowledgement

FDSOI HVM Enabled Atomic-Scale Uniformity

- 28nm node FDSOI products thickness uniformity < ±5 Å in HVM
- Using SCREEN’s leading edge HVM Single Wafer Clean technology
- JDP continues on advanced FDSOI products for 14nm/10nm node

Soitec FD-2D wafer

Silicon lattice: 5.43 Å
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Creating a Virtuous Cycle

- From **Process Equipment** which enables manufacturing of Advanced Electronics (IoT) including SOI technology . . .
- To utilizing **Advanced Electronics** to enhance the features and capabilities of Process Equipment.
What Does this Enable?

✧ **Combining SOI-based Advanced Electronics with Cloud Computing and Big Data**
  - Embedded Smart systems on Process Equipment
  - Interfaced to Factory Management System
  - Algorithms (expert systems, model-based, etc.) to
    - Extract knowledge from data, and
    - Take action (intervene automatically, adjust process within limits, or notification with recommendation)

✧ **New Capability to Enhance Manufacturing Effectiveness**
  - Real-time Data Collection and Monitoring of Process variables on-tool
  - Advanced Fault Detection and Classification
  - Adaptive Process Control
  - Preventive Predictive Maintenance
  - Process results matching across
    - Many chambers per tool
    - Tool to Tool in large fab installed base
Benefits

♦ Product Consistency and Control
  – Process results are maintained within tighter tolerances
    • Run to run of same device type
    • Device to Device on a common process flow
  – Achieve higher Yields

♦ Better Utilization of Fixed Assets
  – Reduce downtime
  – Streamline maintenance cycles
  – Advanced warning of impending failure
    • Schedule intervention instead of reacting to unplanned tool-down
    • Insure replacement part stocking and availability of resources to address
    • Eliminate jeopardizing product from failure in mid-process run

♦ Continuous Improvement of Best Known Methods
  – Root cause analysis
  – Training algorithms for better proactive detection of Process shifts
  – Development of most effective Corrective Action Plans
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Conclusion

Why are equipment manufacturer interested in participating in the SOI Consortium?

1. We need to understand the specific challenges for SOI technology

2. What are the key differentiating needs within the SOI ecosystem

3. FDSOI of course but also RFSOI, …

4. Let’s discuss how we could impact and support!
Fit your needs, Fit your future