Advances in Multi-Beam SEM Technology for High-Throughput Defect Inspection

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Why multi-beam SEM technology?

Defect inspection of a 300mm wafer with a single beam SEM:

~700cm² @ 10nm Pixel Size ➔ 700 terapixel

➔ ~ 13 months @ 20MHz

Advantages of multi-beam systems:

• Low data rate per beam
• Low Coulomb effects
• Total data rate

Advantages of multi-beam, *single column* systems:

• Small & variable beam pitch
• Established technology
• Superb scalability
How does it work?

High throughput data acquisition with a multi-beam SEM

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ABSTRACT

Conventional scanning electron microscopes are limited in their ultimate data acquisition rate at a given resolution due to statistical electron-electron interaction (so-called Coulomb interaction) as well as the limited area of detectors and deflect systems. We increased imaging speed dramatically by using multiple electron beams in a single column and parallel detection of the secondary electrons. The multi-beam SEM generates multiple overlapping images during a single scan, thereby covering a larger area in shorter time as compared to a single-beam SEM at the same pixel size. This addresses the upcoming need for high speed imaging at electron microscopic resolution to investigate larger and larger areas and volumes.

Keywords: Multi-beam, SEM, high speed imaging, beam splitter

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How does it work?

Multiple SE-Beams @ Detector

Multi-Beam Field of View

61 beams: up to 1.22Gpix/s

> 30,000 pix

> 100µm
How well does it work?
Key specifications

**Speed**
Fastest SEM in the world
- Imaging 61 beams in parallel
- Top speed 1.220 MPixel/s

**Resolution**
4 nm in current configuration

**Beam current**
570 pA per beam
35 nA total

**Automation**
Continuous high-throughput imaging

**Applications**
Ultra-high-throughput electron microscopy, initially tailored to academia market - brain mapping
Mouse brain section (Jeff Lichtman, Harvard)

Single hexagon imaged on MultiSEM
Semiconductor wafer sample: AMAG6L

Single hexagon imaged on multi-beam SEM
Semiconductor wafer sample: AMAG6L

Single-beam image

60 nm

1 µm
Intentional Defect Array Imaging I (1/2)
Intentional Defect Array Imaging I (2/2)
What if 61 beams is still too slow?

Scaling up a single column, multi beam system in 3 easy steps:

1. Add more electron beams
2. Add more detectors
3. Add *much* more storage capacity and/or post processing power
First 91-beam imaging results @ 10 nm resolution

91 beams: up to 1.82 GPix/s

> 35,000 pix

> 200µm
In summary …

- Multi-beam electron microscopy has arrived – 61 and 91 beam SEMs are working and available today
- Relevant defect structures can be imaged
- Technology is scalable to higher beam counts

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