Hitachi Hightech
-
Your Partner for Process Control and Metrology

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2. General Applications in photonics/microelectronics
3. Application Examples
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1. Hitachi Group Overview

Hitachi in numbers

1910
Founded

260k+
Employees*

€59,521 m
Revenues**

500+
Companies*

* As of March 31, 2024
** For information purpose only: 9,728.7 billions of yen (Result of FY2023 ended March 31, 2024)
converted at the rate of 163.45 JPY to 1 EUR (Euro Foreign Exchange Reference Rate of European Central Bank as of March 28, 2024)

Hitachi Group Expansion of Business Segments

HITACHI
Inspire the Next

1910

From a humble beginning

To over 100 years of social innovation

- Information & Telecommunication Systems
- Social Infrastructure & Industrial Systems
- Construction Machinery
- Automotive Systems
- Financial Services
- Power Systems
- Electronic Systems & Equipment
- High Functional Materials & Components
- Digital Media & Consumer Products
- Others

Hitachi High-Tech Overview

Hitachi High-Tech in numbers

1947
Founded

14k+
Employees*

€4,102 m
Revenues**

25
Countries
/regions***

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* As of March 31, 2024
** For information purpose only: 670.4 billions of yen (Result of FY2023 ended March 31, 2024)
converted at the rate of 163.45 JPY to 1 EUR (Euro Foreign Exchange Reference Rate of European Central Bank as of March 28, 2024)
***As of April 2024

Hitachi High-Tech in Europe: Company Profiles

Company Name: Hitachi High-Tech Europe GmbH

Management: Kazuyoshi Matsukaze,
Taiji Takano, Mark Marshall

Established: April 1964

Number of Employees: 153

Headquarters' Location: Krefeld, Germany

Company Name: Hitachi High-Tech Analytical Science

Management: Dawn Brooks, Ben Light,
Carsten Stumpf, David Credidio,
Adrian Smith, Teppo Henttonen,
Pirjo Remes, Jotaro Igarashi

Established: July 2017

Number of Employees: 400

*including other areas than Europe

Headquarters' Location: Abingdon, United Kingdom

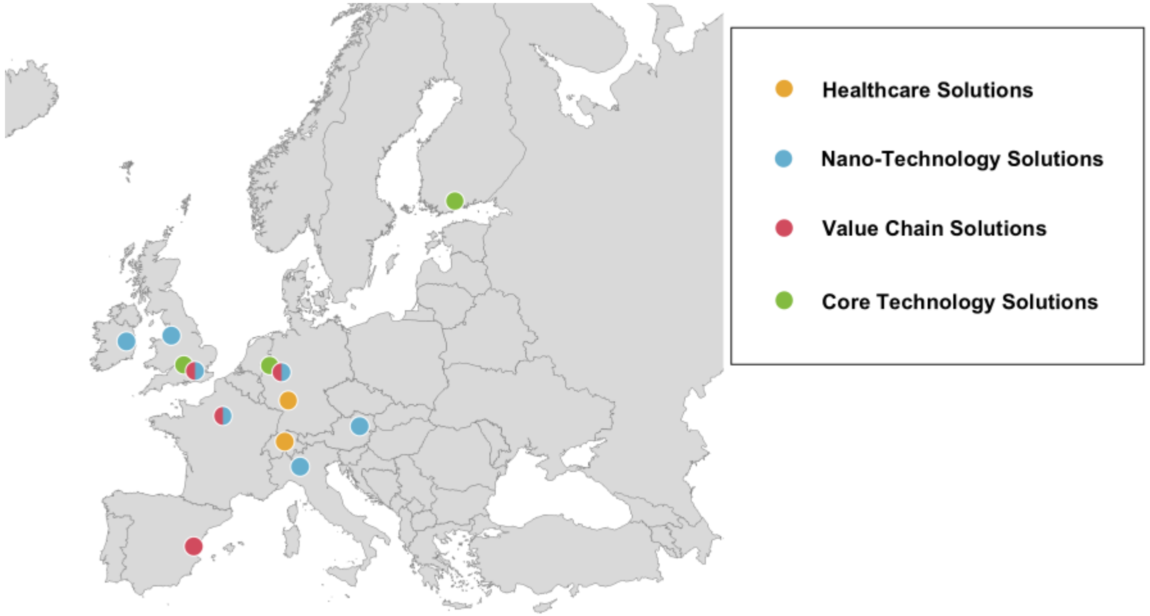
Company Name: VLC Photonics, S.L.

Management: Iñigo Artundo, David Doménech

Established: July 2011

Number of Employees: 27

Headquarters' Location: Valencia, Spain



Hitachi Hightech Business Segments

HITACHI
Inspire the Next

Healthcare Solutions

Healthcare and Biotechnology fields

Design, manufacturing and sale of Clinical chemistry and immunodiagnostic analyzers, Laboratory automation systems, Capillary electrophoresis sequencers, Particle therapy system and X-ray therapy system, etc., and engaging in Digital healthcare-related businesses

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Nano-Technology Solutions

Semiconductor fields

Design, manufacturing and sale of Etch systems, Measurement and inspection systems

Value Chain Solutions

Industrial fields

Providing solutions and selling materials and parts in industrial fields such as mobility, connected, environment and energy, etc.

Core Technology Solutions

Batteries, Advanced materials, Semiconductors, Biopharmaceuticals and other such fields

Design, manufacturing and sale of Electron microscopes, spectrophotometers, X-ray fluoresce analyzers, Thermal analyzers, Liquid chromatographs, etc.

Nano-Technology Solutions

Together with our customers we will create new value on the front lines of semiconductor device manufacturing, which underpins the evolution of digital technologies such as PCs, smartphones, and other electronic devices in addition to IoT, AI, 5G, remote networking and autonomous vehicles.

Business Vision

Create and grow together with our customers

Strengths

- Technological Capabilities (Core Technologies)
- Manufacturing Capabilities
- Co-creation with Customers and Partners

Main Products

- Etch systems
- Measurement and inspection systems

Conductor Etch System
9000 Series

High-Precision Electron Beam Metrology System
GT2000

Wafer Surface Inspection System
LS9300AD

Core Technology Solutions

Making the most of our strengths in our core technologies: beam and analysis technology, we will contribute to solving social issues such as environmental problems, resilience, and safety and security.

Business Vision

Create new businesses based on our core technologies

Strengths

- Technological Capabilities (Core Technologies)
- R&D
- Focused Solutions Development Capabilities
- Product Development Foundation and Manufacturing Capabilities

Main Products

- Electron microscopes (SEM, TEM, FIB)*
- X-ray fluoresce analyzers
- Thermal analyzers
- Liquid chromatographs

Field Emission Transmission Electron Microscope HF5000

Ultrahigh-Resolution Schottky Scanning Electron Microscope SU8700

X-ray (XRF) Coating Thickness Gauge FT230

*SEM : Scanning Electron Microscope,
TEM : Transmission Electron Microscope, FIB : Focused Ion Beam

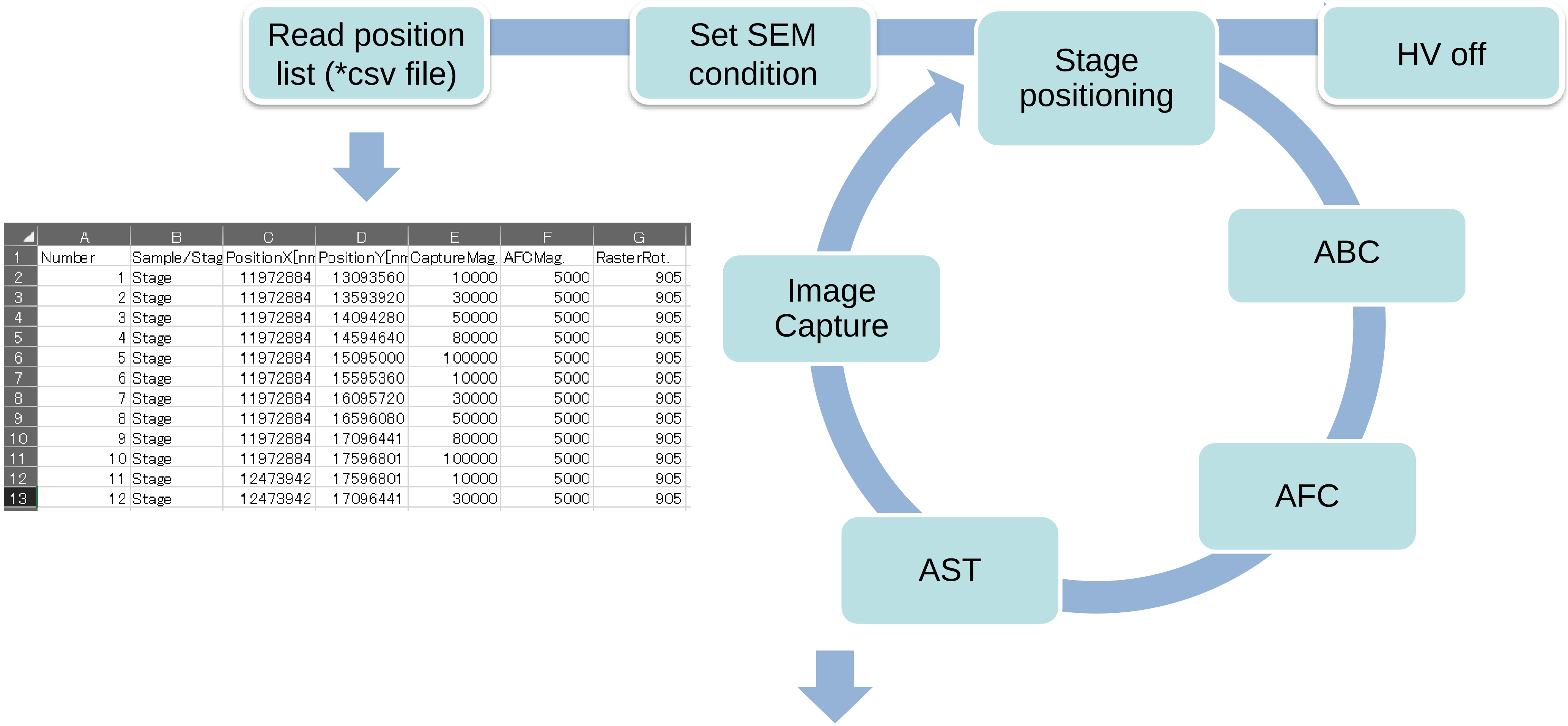
2. General Applications in photonics/microelectronics

- Sub-µm/sub-nm imaging and dimensional measurements in 1D / 2D / 3D
- Defect inspection and defect review, defect classification
- Analysis of material composition and molecular/crystal structure
- Focused and broad ion beam solutions for high quality sample-cut/preparation
- Fully automated, fab automation integrated, high throughput, inline metrology/defectivity-process control on (3“)/4“/6“/8“/12“ wafers

3. Applications examples

- SEM Automation and Offline Measurements
- CS4800 CDSEM for wafers smaller than 12“
- High resolution observation of insulating materials using low vacuum function
- Wide Area Three-dimensional image of Microlens
- Atomic Column Elemental Mapping with Large Solid Angle SDD of the HD-2700
- Cross-sectional observation of a blue light emitting diode

SEM automation concept: Acquire at pre-defined positions



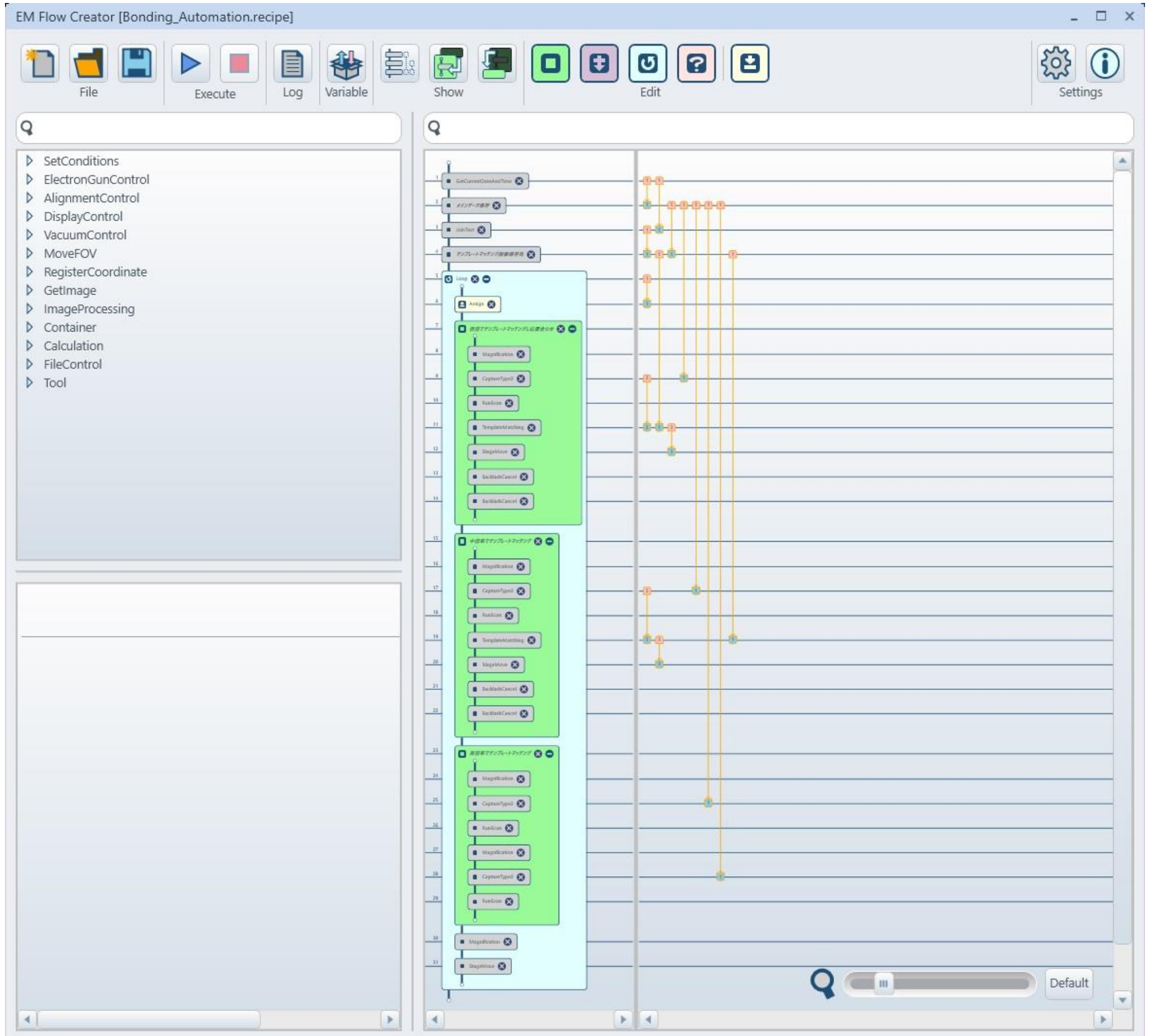
	A	B	C	D	E	F	G
1	Number	Sample/Stag	PositionX[nm	PositionY[nm	CaptureMag.	AFCMag.	RasterRot.
2	1	Stage	11972884	13093560	10000	5000	905
3	2	Stage	11972884	13593920	30000	5000	905
4	3	Stage	11972884	14094280	50000	5000	905
5	4	Stage	11972884	14594640	80000	5000	905
6	5	Stage	11972884	15095000	100000	5000	905
7	6	Stage	11972884	15595360	10000	5000	905
8	7	Stage	11972884	16095720	30000	5000	905
9	8	Stage	11972884	16596080	50000	5000	905
10	9	Stage	11972884	17096441	80000	5000	905
11	10	Stage	11972884	17596801	100000	5000	905
12	11	Stage	12473942	17596801	10000	5000	905
13	12	Stage	12473942	17096441	30000	5000	905

- Allows to acquire data at any stage position automatically
- Various processings available by using Python library or EM-Flow Creator

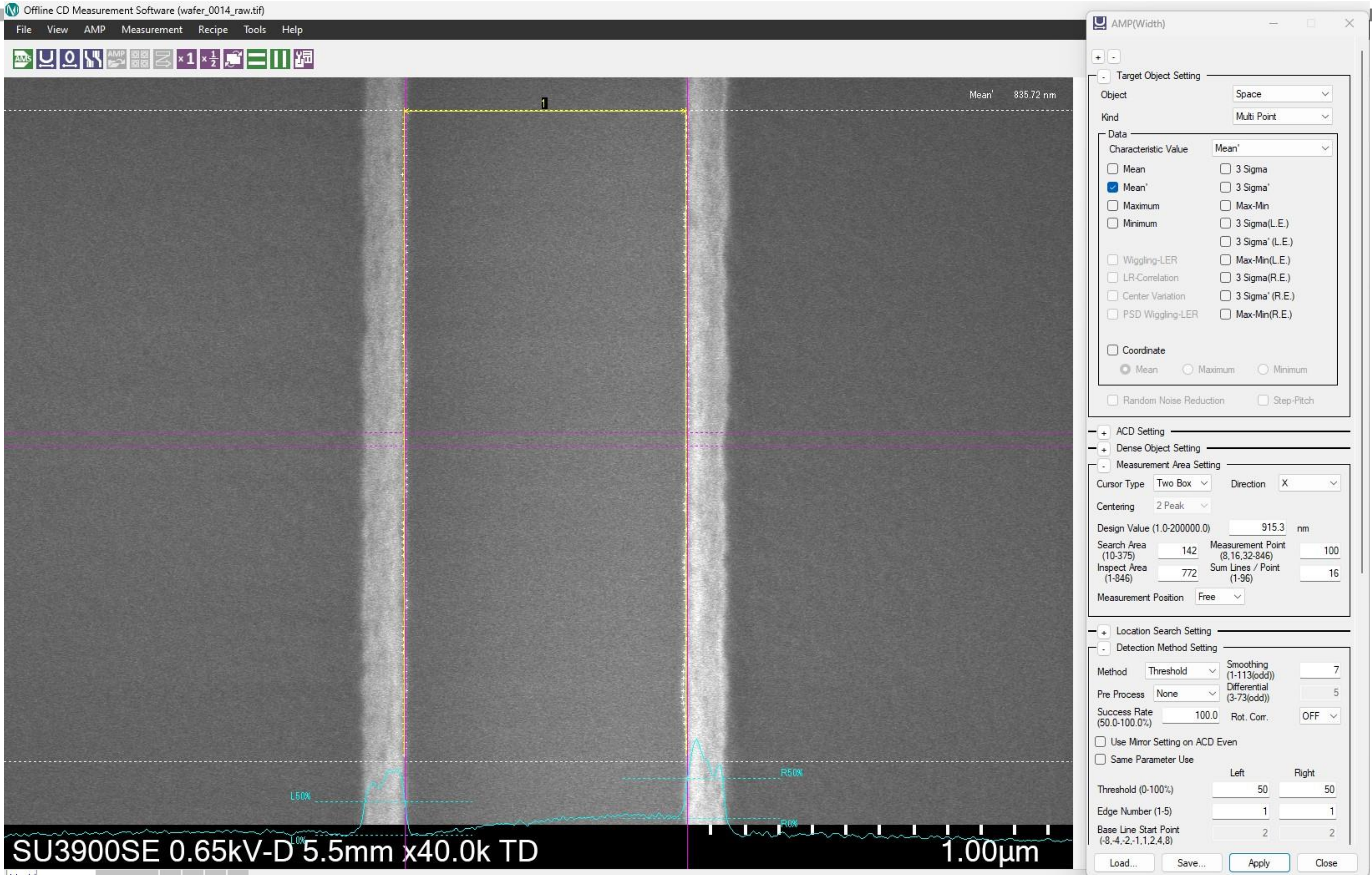
SEM automation with EM Flow Creator

EM Flow Creator for workflow automation

- Supports automation of operations such as continuous image acquisition including fine positioning by pattern-matching
- SEM functions such as magnification, stage position settings and focus/contrast adjustments… are defined as BLOCKS
- Recipes can be created by dragging and dropping blocks and arranging them like a flow
- Blocks can be linked, loops and conditions can be defined



Offline CD measurement using „Terminal-PC Measurement Software“



Mean' 835.72 nm

SU3900SE 0.65kV-D 5.5mm x40.0k TD 1.00µm

Target Object Setting

Object: Space

Kind: Multi Point

Data

Characteristic Value: Mean'

☐ Mean ☐ 3 Sigma

☑ Mean' ☐ 3 Sigma'

☐ Maximum ☐ Max-Min

☐ Minimum ☐ 3 Sigma(L.E.)

☐ 3 Sigma' (L.E.)

☐ Wiggling-LER ☐ Max-Min(L.E.)

☐ LR-Correlation ☐ 3 Sigma(R.E.)

☐ Center Variation ☐ 3 Sigma' (R.E.)

☐ PSD Wiggling-LER ☐ Max-Min(R.E.)

☐ Coordinate

● Mean ○ Maximum ○ Minimum

☐ Random Noise Reduction ☐ Step-Pitch

ACD Setting

Dense Object Setting

Measurement Area Setting

Cursor Type: Two Box Direction: X

Centering: 2 Peak

Design Value (1.0-200000.0): 915.3 nm

Search Area (10-375): 142 Measurement Point (8,16,32-846): 100

Inspect Area (1-846): 772 Sum Lines / Point (1-96): 16

Measurement Position: Free

Location Search Setting

Detection Method Setting

Method: Threshold Smoothing (1-113(odd)): 7

Pre Process: None Differential (3-73(odd)): 5

Success Rate (50.0-100.0%): 100.0 Rot. Corr.: OFF

☐ Use Mirror Setting on ACD Even

☐ Same Parameter Use

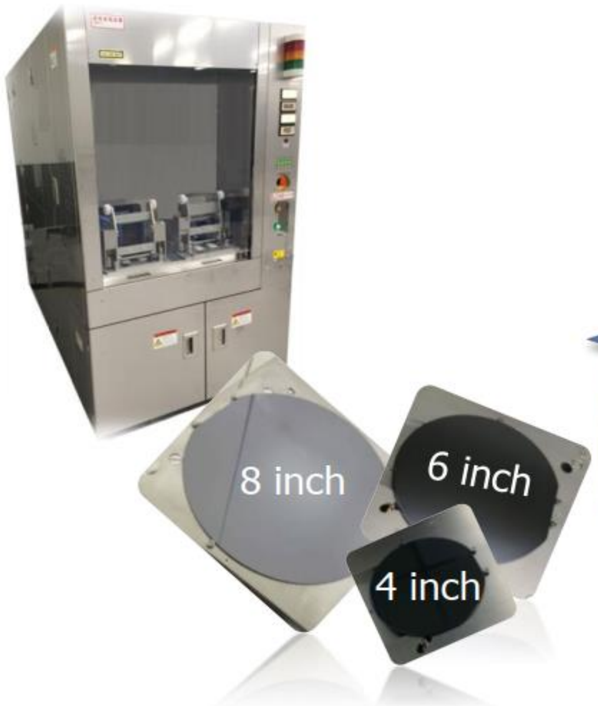
	Left	Right
Threshold (0-100%)	50	50
Edge Number (1-5)	1	1
Base Line Start Point (-8,-4,-2,-1,1,2,4,8)	2	2

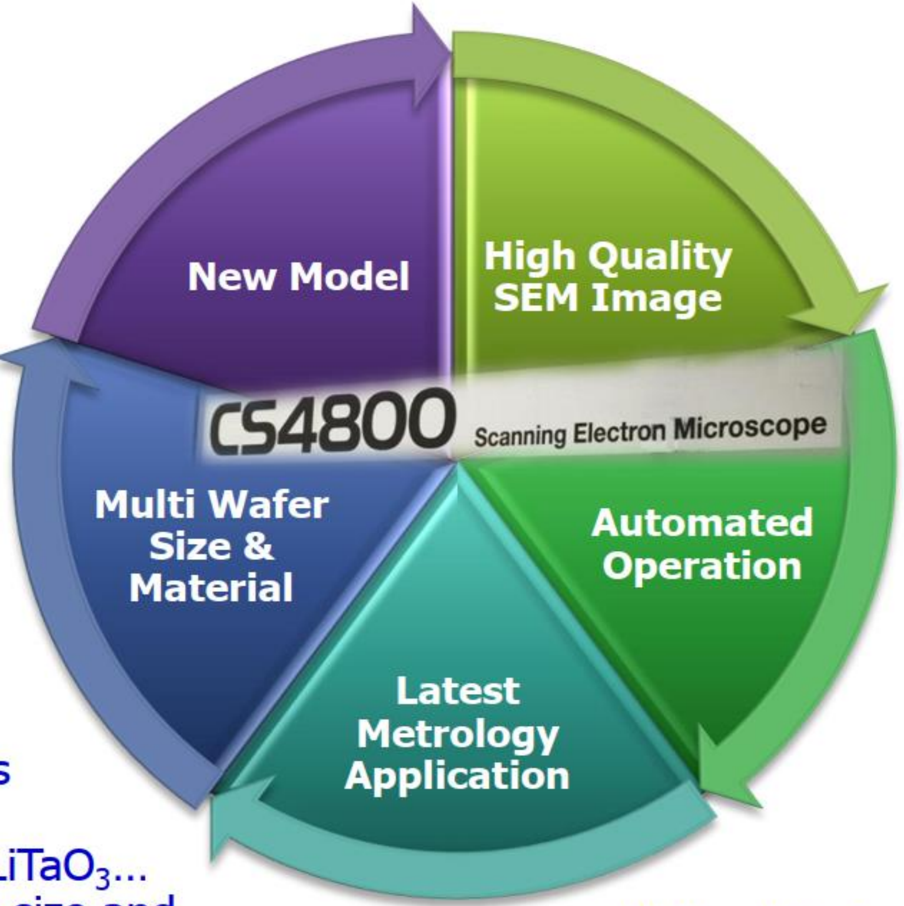
Space: 835.72nm

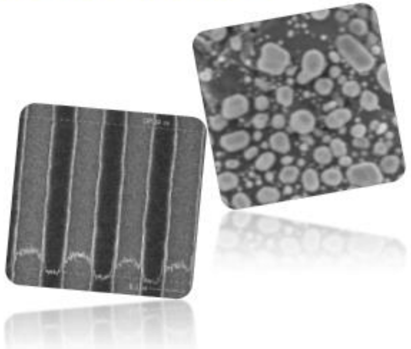
Advertising Break: CS4800 CDSEM

- ✓New Model for multi-wafer size 4”~8” CD-SEM
- ✓Competitive Performance
  with 7 years guaranteed parts availability

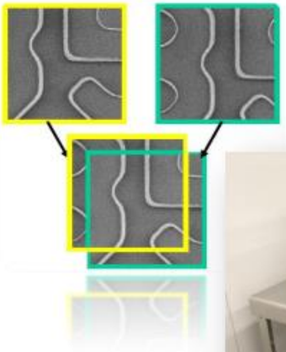
- ✓High Resolution & Clear SEM image
- ✓High Precision







- ✓Auto Beam Alignment
- ✓Robust Pattern Matching
- ✓Fast MAM time

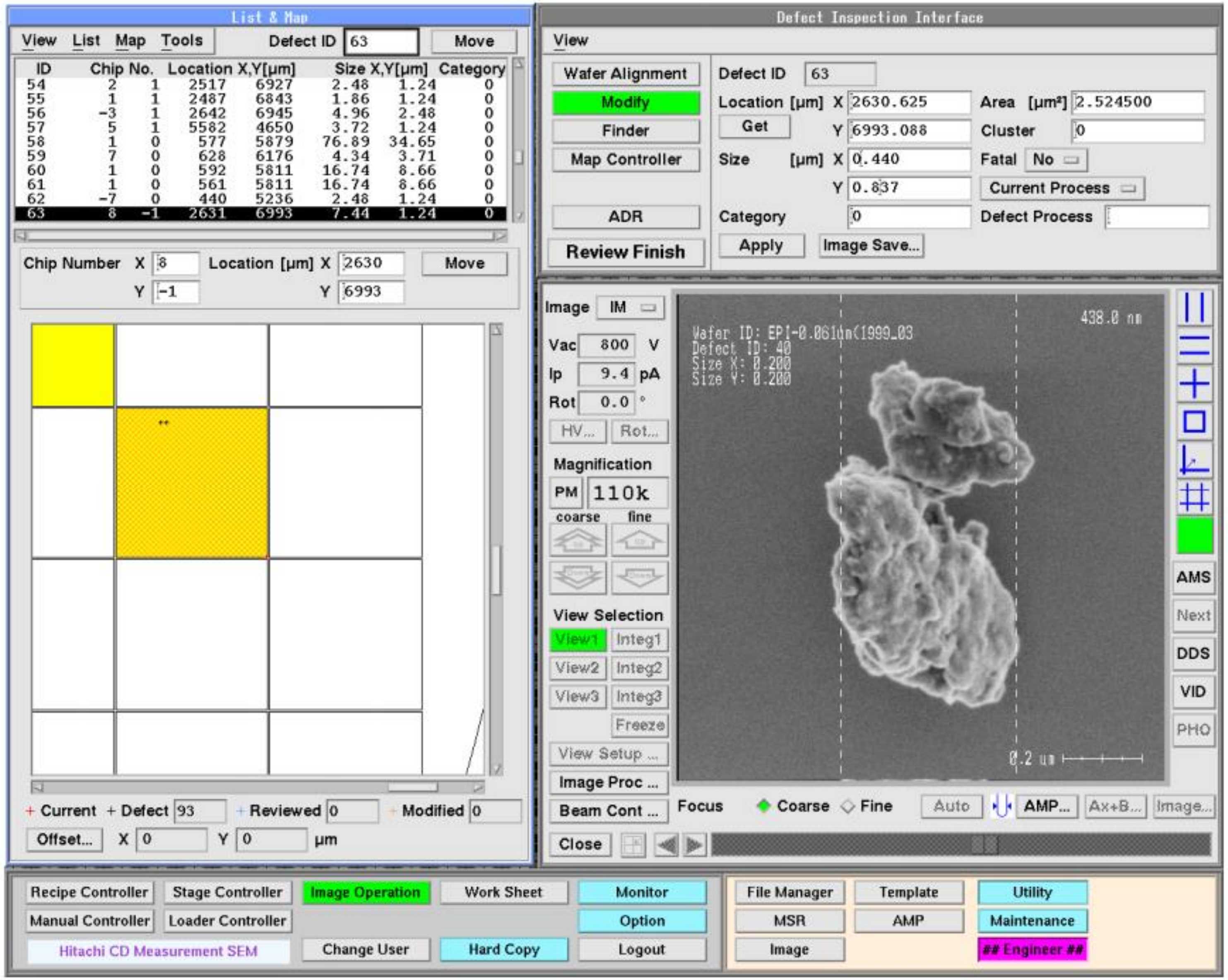


- ✓Accommodate various kinds
  of wafer size & material
  (ex) SiC GaN GaAs InP $LiTaO_3$…
- ✓Set up for 2 different wafer size and
  can be switched over by customers

- ✓Utilize latest metrology application
  developed for 12” CD-SEM

CS4800 is used by a wide variety of semi and photonics customers, including producers of glasses for VR/AR. Next generation successor will be anounced soon.

Advertising Break: CS4800 CDSEM Defect Review



Defect ID 63

ID	Chip No.		Location X,Y[µm]		Size X,Y[µm]		Category
54	2	1	2517	6927	2.48	1.24	0
55	1	1	2487	6843	1.86	1.24	0
56	-3	1	2642	6945	4.96	2.48	0
57	5	1	5582	4650	3.72	1.24	0
58	1	0	577	5879	76.89	34.65	0
59	7	0	628	6176	4.34	3.71	0
60	1	0	592	5811	16.74	8.66	0
61	1	0	561	5811	16.74	8.66	0
62	-7	0	440	5236	2.48	1.24	0
63	8	-1	2631	6993	7.44	1.24	0

Chip Number X 8 Y -1
Location [µm] X 2630 Y 6993

+ Current + Defect 93 + Reviewed 0 + Modified 0
Offset... X 0 Y 0 µm

Defect ID 63
Location [µm] X 2630.625 Y 6993.088
Size [µm] X 0.440 Y 0.837
Category 0
Area [µm²] 2.524500
Cluster 0
Fatal No
Current Process
Defect Process

Image IM
Vac 800 V
Ip 9.4 pA
Rot 0.0 °
Magnification PM 110k

Wafer ID: EPI-0.061um(1999_03
Defect ID: 40
Size X: 0.200
Size Y: 0.200

- Automatic Wafer Alignment on patterned and unpatterned wafers.
- Import of Defect Locations from KLARF/KRF files from customer server.
- Manual Defect Review with SEM images and re-classification in KLARF/KRF.
- No ADR, No EDX, No Beam Tilt supported, however, at least, manual top-down SEM review with high magnification and resolution is possible.

SHEET No.079

High resolution observation of insulating materials using low vacuum function

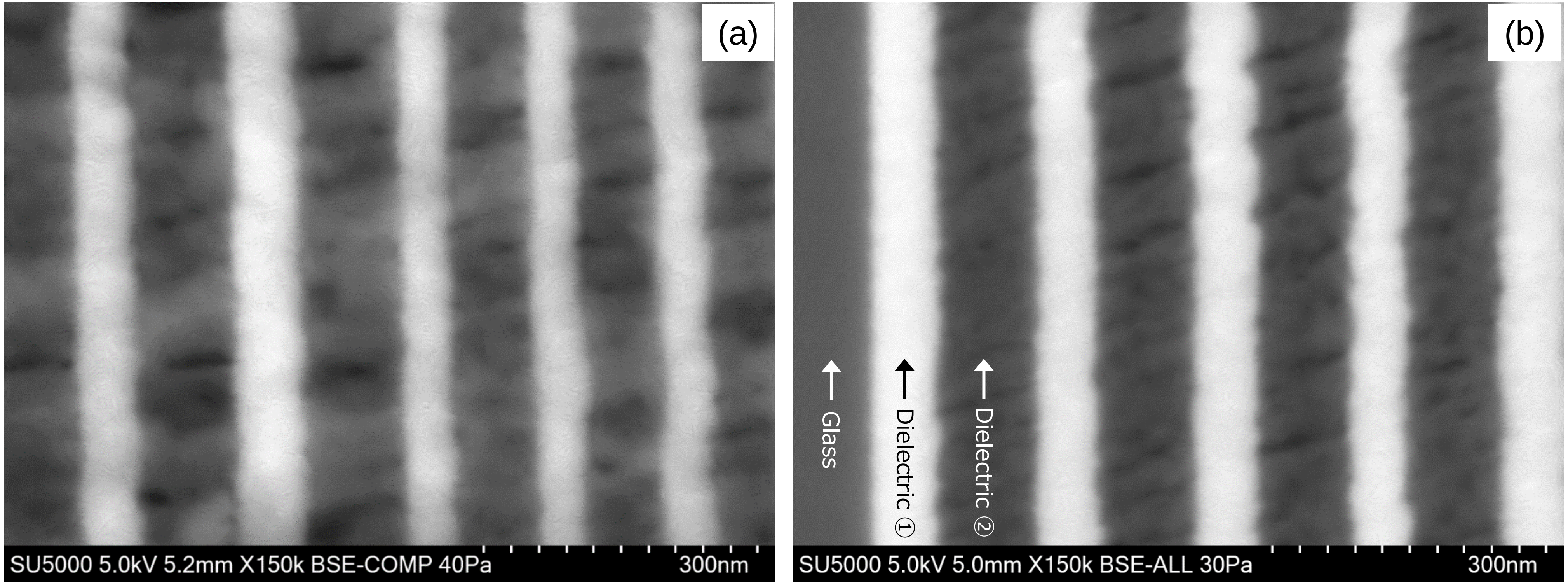


Fig.1 SEM images of a cross section of dielectric multi layers on a glass substrate
SEM : SU5000, Vacc : 5 kV, Magnification : ×150k, Vacuum : (a) 40Pa (b) 30Pa
(a) Cleaved cross section (b) Ion milling cross section(ArBlade5000, Vacc. : 6 kV, Irradiation time : 1 hour)

Figure 1 shows SEM images of a cross section of dielectric multi layers on a glass substrate. High resolution images can be obtained without charging phenomena using low vacuum function, even though the sample is composed of insulating materials. In Fig. 1 (a), interfaces between two different dielectric layers of a cleaved cross section are unclear. In Fig. 1 (b), the interfaces between the dielectric layers of a flat cross section made by ion milling can be observed clearly with high contrast and high resolution.

Shuichi Takeuchi, Maasa Yano, Yuki Inagi, Saori Miyoshi; Application development Dept.

SEM Application Data Sheet

High quality lamella preparation of InGaN/GaN using triplebeam system

SHEET No.029

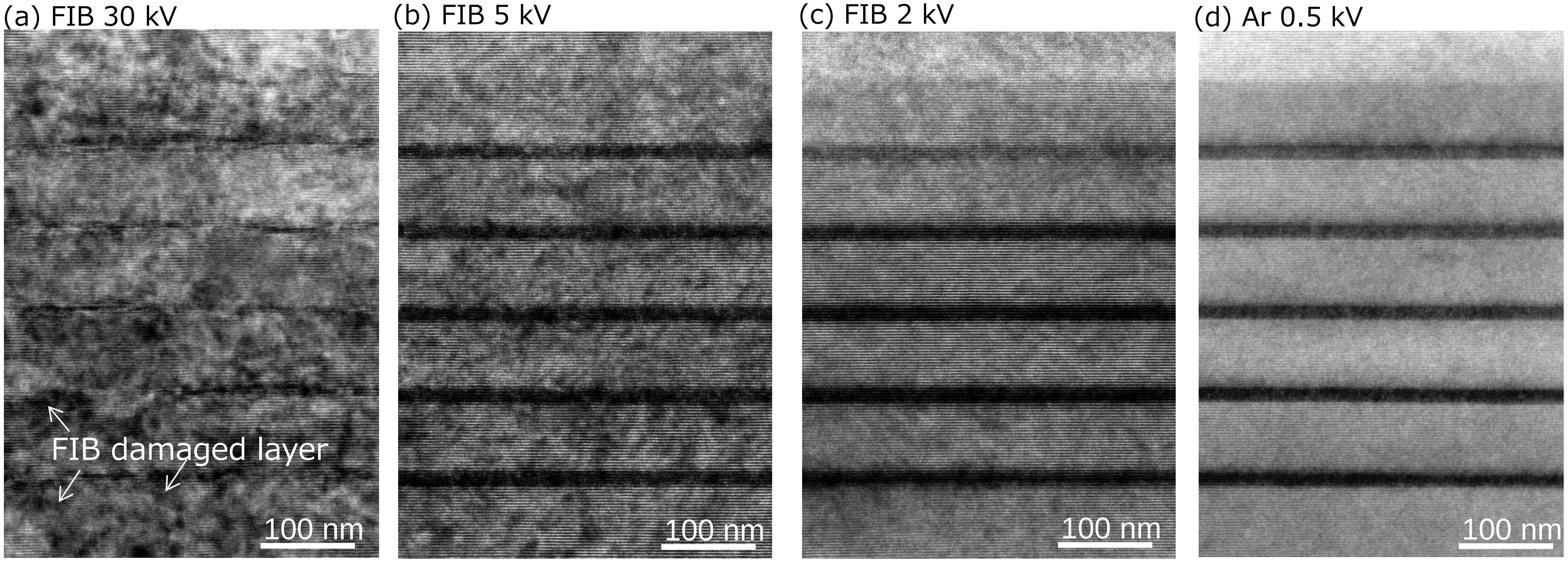


Figure1 TEM observation of InGaN/GaN preparation process

Specimen : InGaN/GaN multi quantum well, Preparation : NX2000, Observation : HF-3300, Electron incident direction : $[11\bar{2}0]$

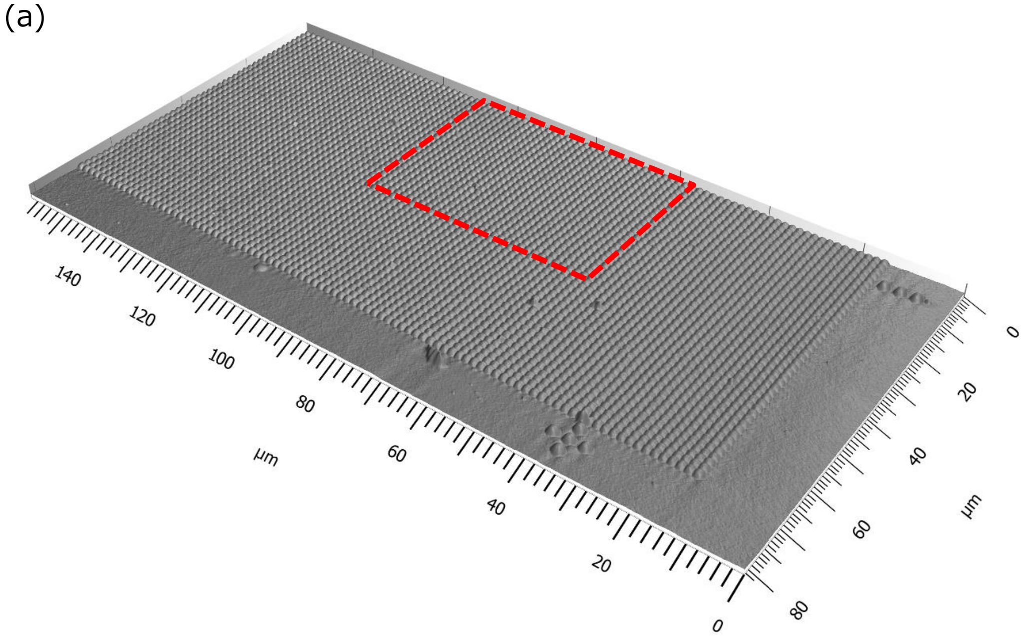
InGaN/GaN is one of the difficult materials to prepare lamella samples, because it suffers FIB damage easily. The NX2000 FIB-SEM-Ar triple beam was designed with FIB, SEM and Ar column axes to intersect at the same point, so that the FIB damaged layer can be removed by low energy Ar ion milling. Figure 1 shows the TEM images of InGaN/GaN multi quantum well (MQW). An NX2000 was used for sample preparation, and an HF-3300 for observation. Images show the results of 30 kV FIB preparation (a), and 5 kV (b), 2 kV(c) FIB, then Ar 0.5 kV (d) finishing. Bright and dark spots in TEM image (a) are damages and they degrade image quality. Though FIB finishing with declined acceleration voltage reduces damaged layer in (b), it still remains after 2 kV FIB (c). A high quality TEM image was obtained in (d) by removing damaged layer with low energy Ar ion milling. Performance of the NX2000 as a powerful tool to prepare the low damage and high quality lamellae of GaN compound semiconductors and related materials is demonstrated.

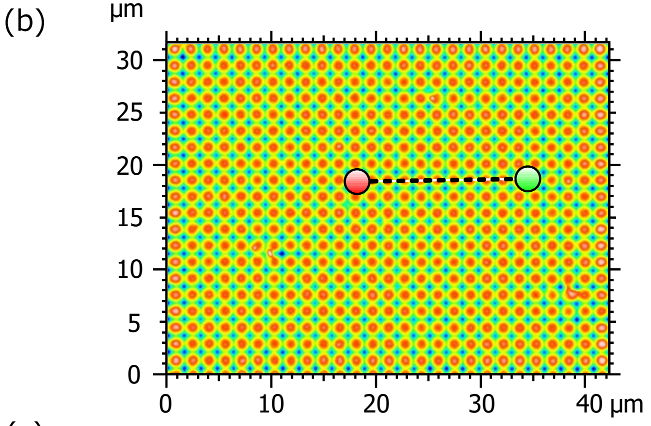
Sample courtesy of Prof. Satoshi Kamiyama, Faculty of Science and Technology, Meijo University

Authors : Takahiro Sato, Yuka II; Hitachi high-technologies corp., Ikuko Nakatani, Masahiro Kiyohara; Hitachi high-tech science corp.

SHEET No.082

Wide Area Three-dimensional image of Microlens





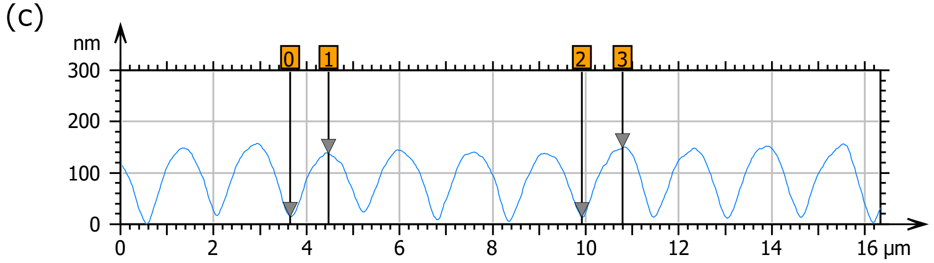


Fig 1. Microlens
(a)Stitched wide area 3D image(x2k), (b)Topography image(red frame)
(c)Cross section of line drawn in (b), (d)Measured Values of (c)

(d)

Parameters	0-1	2-3
Horizontal distance（nm）	826	875
Vertical Height （nm）	123	135
Angle(degrees)	8.47	8.74

Fig.1(a) shows a wide area 3D image of microlens. The wide area image is stitched from multiple 3Dimages obtained using the software ”Hitachi Map 3D”. Fig.1(b) shows a topography image of the area indicated by the red frame in (a). Height information is easily confirmed by referring to the color gradation. Fig.1(c)(d) show the cross section extraction results of the line drawn in Fig.1(b). The horizontal distance, vertical height and angle of the top and bottom of each lens (arrows 0-1, 2-3) are provided.

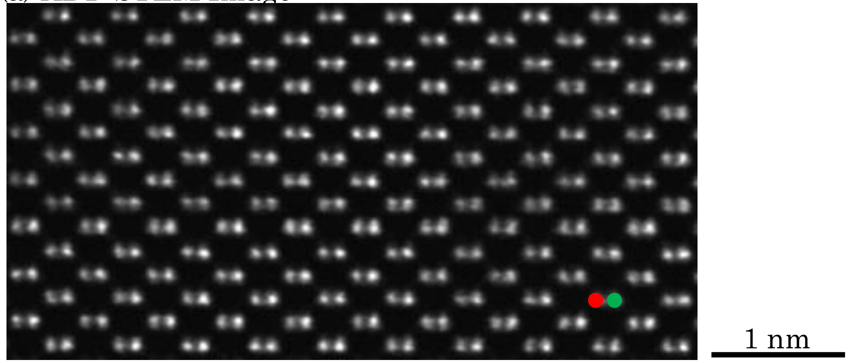
Obtaining wide area 3D images and section profiles is possible using Hitachi Map 3D.

Instrument : FlexSEM1000　Observation condition : 5 kV, x2k, 30Pa　Software : Hitachi Map 3D

Author : Mai Yoshihara, Application Development Dept.; Shinichi Hasegawa, Marketing Dept.

Fig. 4 shows the observation results for GaAs[110] crystal. Fig. 4(a) is an ADF-STEM image, Fig. 4(b) is its image intensity line profile, and Fig. 4(c) shows the GaAs crystal structure model. The somewhat brighter dots on the right side represent the positions of the As atom columns, and the dots on the left side show the Ga atom columns. The GaAs lattice spacing is narrower than that of $SrTiO_3$, and from the line profile, it can be identified that the Ga and As atom columns are arranged at intervals of 0.14 nm. Fig. 5 shows a filtered element map of GaAs, and corresponding to the 0.14 nm lattice spacing, the Ga and As atoms sites are clearly separated and observed.

(a) ADF-STEM Image



(b) Image Intensity Line Profile

(c) Crystal Structure Model

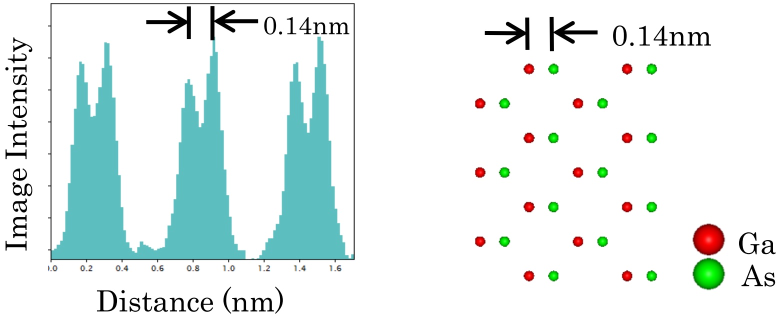


Fig. 4: GaAs[110] Crystal Structure
Accelerating Voltage: 200 kV, Observation Magnification: 10,000k time

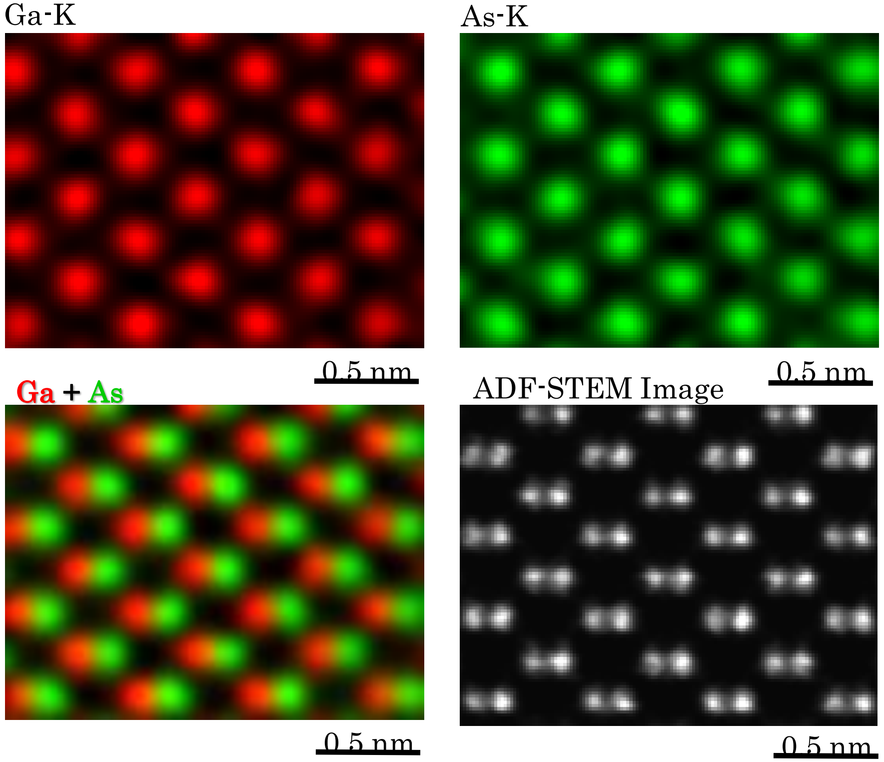


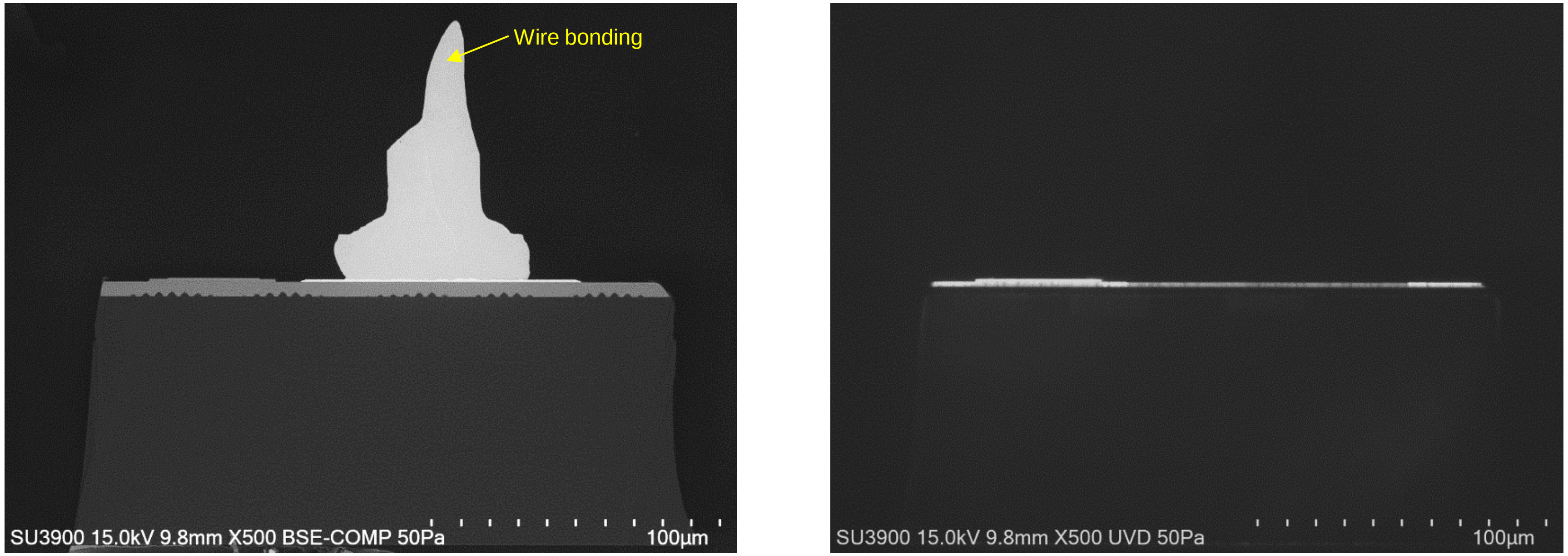
Fig. 5: GaAs [110] Atomic Column Element Map
Pixel Size: 128×96, Acquisition Time: 12 minutes

⑤ Summary

Using spherical aberration corrected HD-2700 and large solid angle SDD, atomic columns can be observed not only in ADF-STEM images, but also in EDX elemental mapping.

Authors: Yuya Suzuki and Takahiro Sato of the Application Development Department, and
Kuniyasu Nakamura of the Electron Microscope 1st Design Department.

Cross-sectional observation of a blue light emitting diode



(a) BSE image

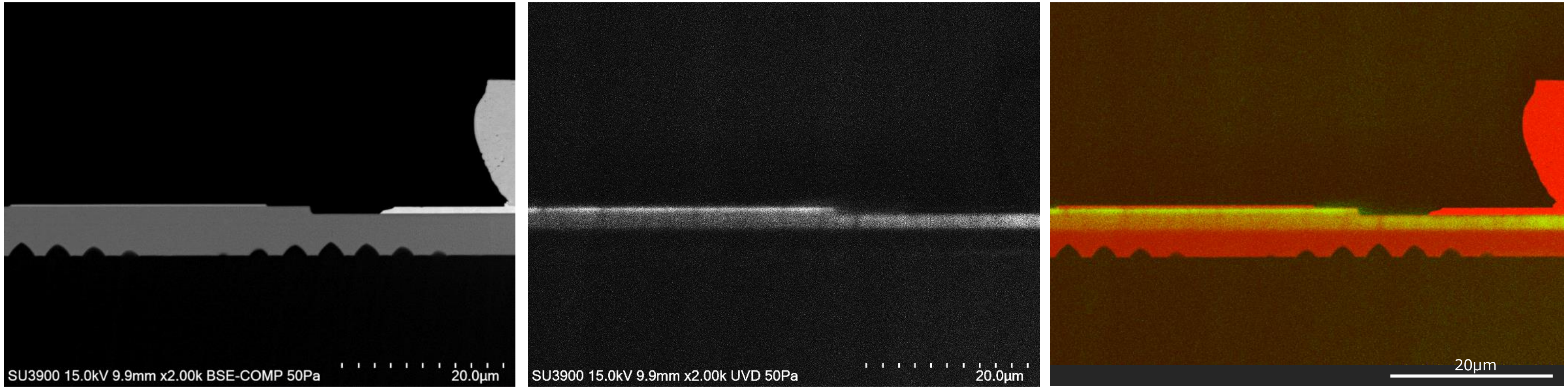
(b) UVD-CL image

Figure 1. Cross-sectional SEM images of a blue light emitting diode

Ion milling instrument : ArBlade5000
Acceleration voltage : 4 kV
Milling time : 3 h

SEM instrument : SU3900
Acceleration voltage : 15 kV
Magnification : x 500
Sample chamber pressure : 50 Pa

For identifying the light emitting part, cross section sample of a blue light emitting diode (LED) was prepared using an ion milling instrument and observed with an SEM. Figure 1 shows the cross-sectional observation results of the lead frame type blue LED. Backscattered electron image (a) shows entire cross-sectional structure of the LED elements by composition contrast, and UVD-CL image (b) acquired on the same field of view with the BSE image reveals that light is emitted from the immediate vicinity under the wire bonding part.



(a) BSE image

(b) UVD-CL image

(c) Color composition image
(Red: BSE image, Green: UVD-CL image)

Figure 2. Magnified images near the wire bonding

SEM instrument : SU3900
Acceleration voltage : 15 kV
Magnification : x 2000
Sample chamber pressure : 50 Pa

Figure 2 shows enlarged images of the wire bonding periphery. BSE image (a) and UVD-CL image (b) were acquired in the same field of view simultaneously. Although correlating the BSE image and the UVD-CL image may indicate the light emission location, superimposing them by the color composition function makes the localization easier and clearer as shown in (c).

Author : Saori Miyoshi, Application engineer, HHT

4. Contacts/Links/Ressources

- https://www.hitachi-hightech.com/ (global)
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