大学共同利用機関法人　自然科学研究機構
分子科学研究所

K Program
経済安全保障重要技術育成プログラム

マイクロ固体フォトニクス研究会
第５回 レーザー学会「小型集積レーザー(II)」専門委員会

半導体製造用EUV光源開発とその応用の現状

Development of EUV Source for Semiconductor Manufacturing and its Application

■ **概要**

- EUV光を使った日本発のリソグラフィ技術は、欧米主導で半導体量産工場への導入が進められている。日本では約10年遅れで、ラピダス社の工場に昨年複数台のEUV量産露光装置が導入された。
- 九州大学チームは「レーザーを使ったプラズマ生成・分析実験技術：九州大学」、「EUVプラズマの解析技術（Thomson 散乱計測）北海道大学」、「EUVプラズマ高効率化の可能性を予測するシミュレーション技術　大阪大学・Purdue大学」３つの技術の組み合わせで、今後の光源の改良の可能性とその実現の**新プロジェクト(Kプログラム)を他研究機関および九州大学より提案中**
- またEUVを利用するため不可欠な材料開発の支援を目的とした『EUVフォトン社』を立ち上げた。
本講演では、これらの活動の最新状況を報告する。

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EUV Photon

Agenda

- **Introduction:**
  DUV/EUV Semiconductor Lithography and light Source
- **New Company: EUV Photon**
  - Motivation
  - EUV Exposure Road map of EUVP
  - Observation tools of EUVP
  - New Material Investigation with Visualization of Phenomenon
- **K-Program: High Efficient LPP-EUV Source and Optics**
  - Investigation of Lithography technology related Security Export Control
  - K-Program: New program of EUV Source and Optics Research
  - EUV Plasma diagnostic technology & Simulation
  - Concept of SMET: Smart Laser and Mirror Evaluation Tool
- **Summary / Acknowledgement**

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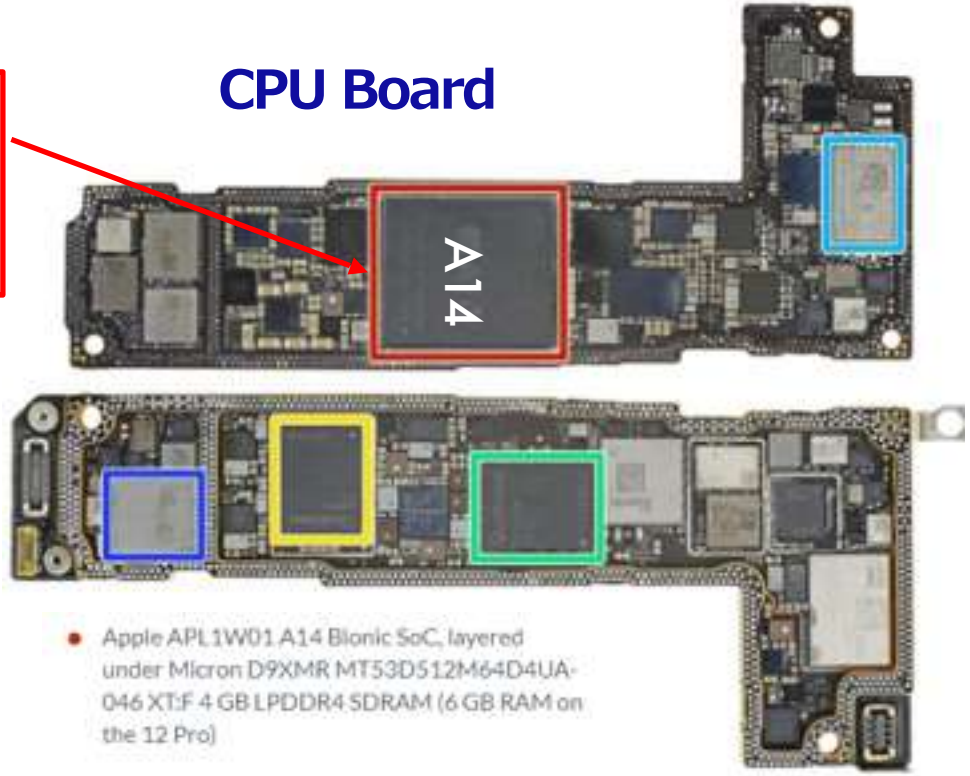
i-Phone-XII

EUV 5nm process is employed made by TSMC

CPU Board



- Apple APL1W01 A14 Bionic SoC, layered under Micron D9XMR MT53D512M64D4UA-046 XT:F 4 GB LPDDR4 SDRAM (6 GB RAM on the 12 Pro)
- KICM224AY4402TWNA12029, 64 GB of Kioxia NAND flash memory.
- Qualcomm SDR865 5G and LTE transceiver
- Qualcomm SDX55M 5G modem-RF system and SMR526 intermediate frequency IC
- USI/Apple U1 ultra-wideband chip
- Avago AFEM-8200 high/mid power amplifier with integrated duplexer
- Apple APL1094 343S00437 power management IC

EUV Photon

Manufacturing of Semiconductor

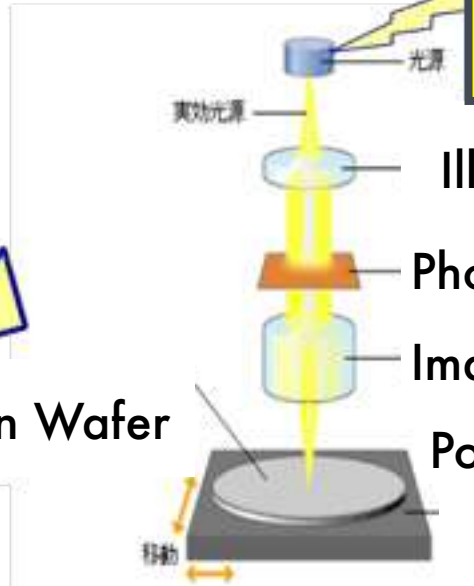
Silicon Ingot

Silicon Wafer

Silicon Wafer

Light Source

GIGAPHOTON The Future is Today

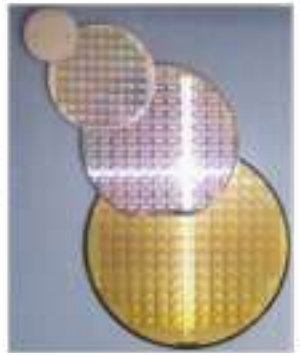


Illumination Optics

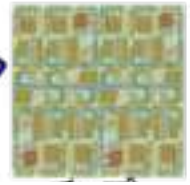
Photo Mask

Imaging Optics

Positioning Stage

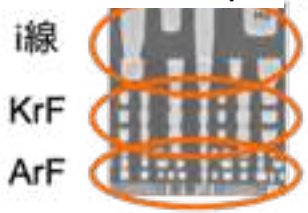


Silicon Wafer after Exposure



Silicon Chip

LSI



Cross section of pattern

Application Products

GIGAPHOTON

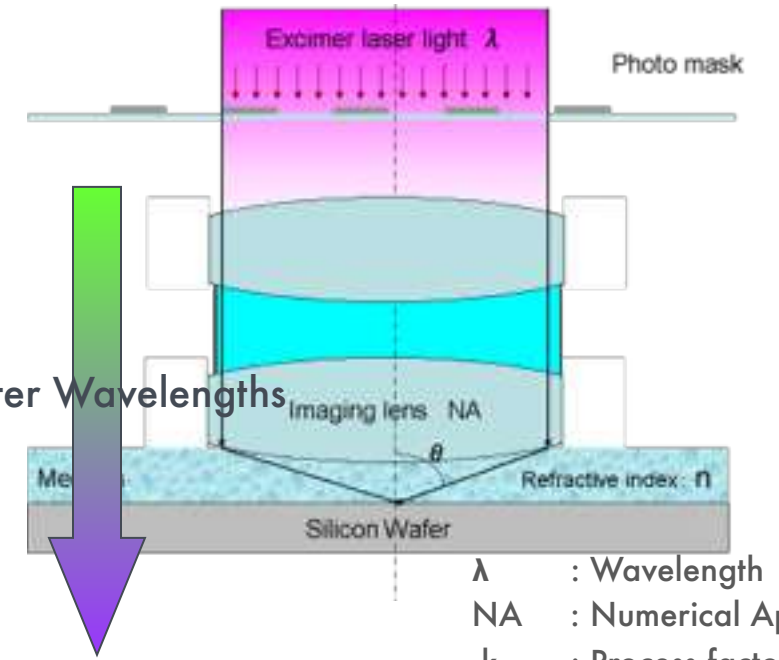
Optical Lithography and light source

Finer patterning is realized by shorter wavelength

$$R = K_1 \frac{\lambda/n}{NA}$$

(*Rayleigh Formula*)

Resolution at projection optic system *R*



λ : Wavelength
NA : Numerical Aperture (NA=sinθ)
k_1 : Process factor
n : Refractive index

DUV

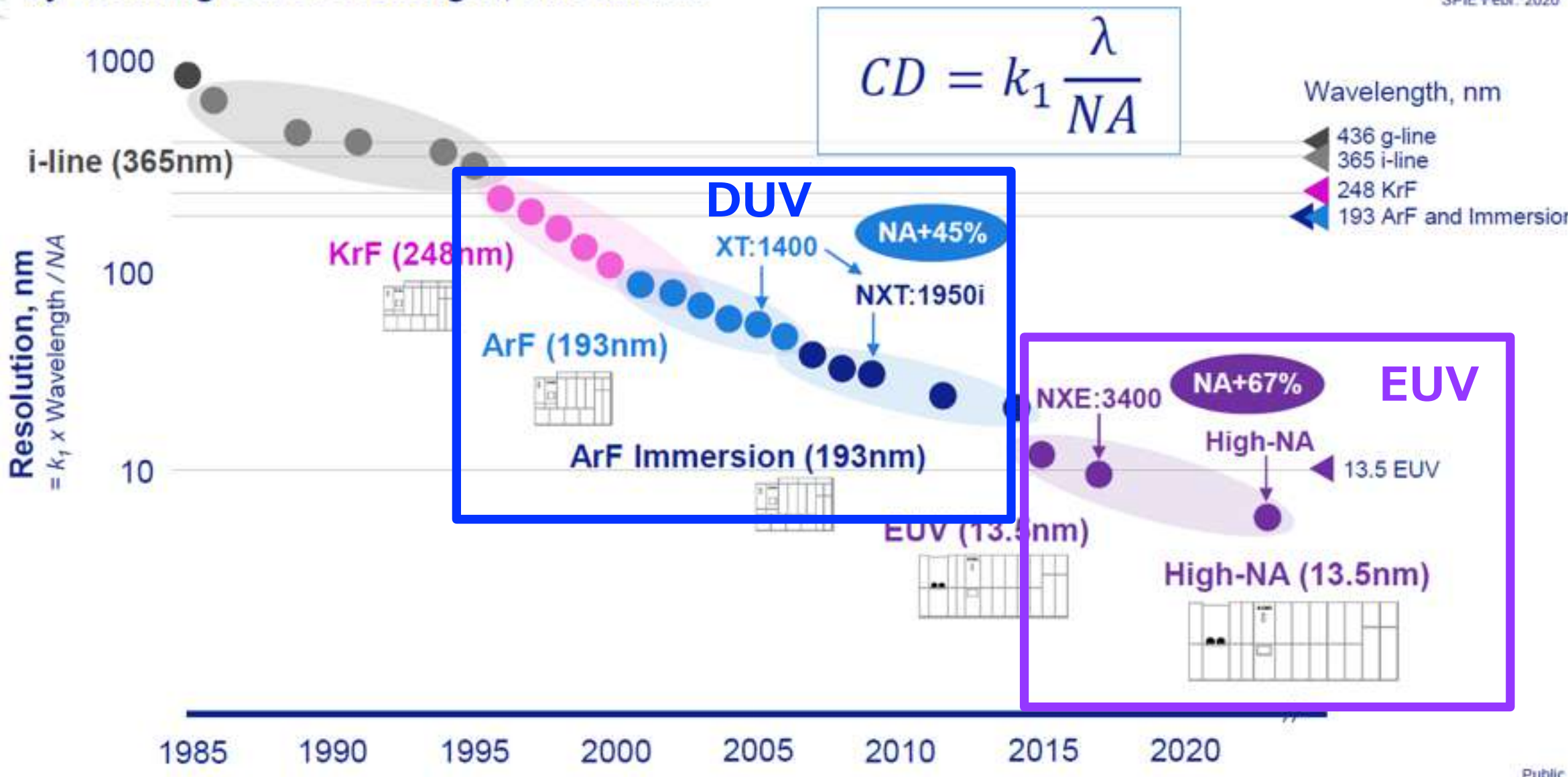
	R (K1=0.4) nm	n	medium	λ/n *nm*	NA	Power
KrF dry	124	1	Air	248	0.8	40
ArF dry	103	1	Air	193	0.75	45
F_2 dry	84	1	N_2	157	0.75	-
ArF immersion	40	1.44	H_2O	134	1.35	90
EUV (λ=13.6nm)	**18**	**1**	**Vacuum**	**13.6**	**0.3**	**>250**
EUV (λ=13.6nm)	**9**	**1**	**Vacuum**	**13.6**	**0.6**	**>500**
EUV (λ= 6.7nm)	**4.5**	1	**Vacuum**	**6.7**	**0.6**	**>1000**

EUV Photon

Over 35 years 2 orders of magnitude resolution reduction

by working on Wavelength, NA and k1

ASML



Public

DUV Excimer Lasers for Lithography (Gigaphoton Inc., Japan)

DUV Lithography

KrF

G60K

248nm wavelength

4kHz max repetition

40-60W output

Extends 150% Maximum Power

ArF

GT45A

193nm wavelength

6kHz max repetition

45W-90W output

Utilizes cutting-edge ArFi technology

ArFi

GT66A

193nm wavelength

6kHz max repetition

60-90W output

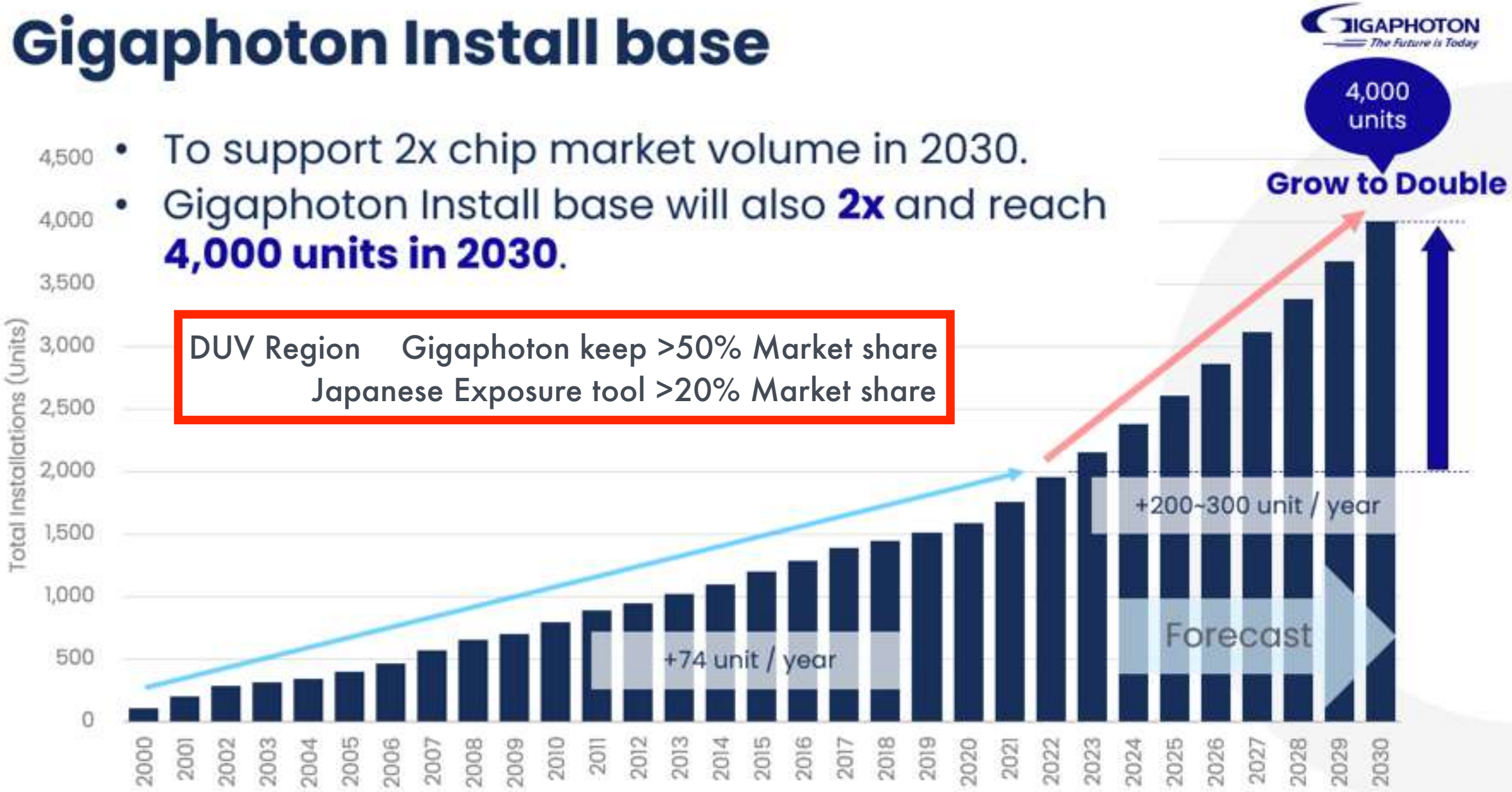
Improves up to 30% speckle reduction

GIGAPHOTON

Gigaphoton Install base

- To support 2x chip market volume in 2030.
- Gigaphoton Install base will also **2x** and reach **4,000 units in 2030**.

DUV Region Gigaphoton keep >50% Market share
Japanese Exposure tool >20% Market share



0.3 NA EUV Exposure tool

・Leading Edge Semiconductor factory install more than 300 unit in the world.
And RAPIDAS in Japan installed EUV Exposure tool (2024/12)

EUV product roadmap

Wavelength	NA, Half pitch	2022	2023	2024	2025	2026	≥ 2027
EUV	0.55NA, 8 nm			EXE:5000 1.1 nm | 150 wph	EXE:5200B <0.8 nm | 220 wph; EXE:5000 OFP&PEP <0.8 nm | 190 wph		NEXT
				Customer R&D	High Volume Manufacturing		
		Please see; 2023 EUVL Workshop Keynote presentation by Jan van Schoot					
	0.33 NA, 13 nm	NXE:3600D 1.1 nm | 160 wph; Alignment 12C option		NXE:3800E 0.9 nm | 220 wph		NXE:4000F <0.8 nm | 250 wph	NEXT
		3400C 1.5 nm 135 wph	PEP 145 wph	PEP 160 wph			
		3400B 1.5 nm	PEP 137 wph				

Product | Matched Machine Overlay (nm) | Throughput(wph)

Product status | Released | Development | Definition

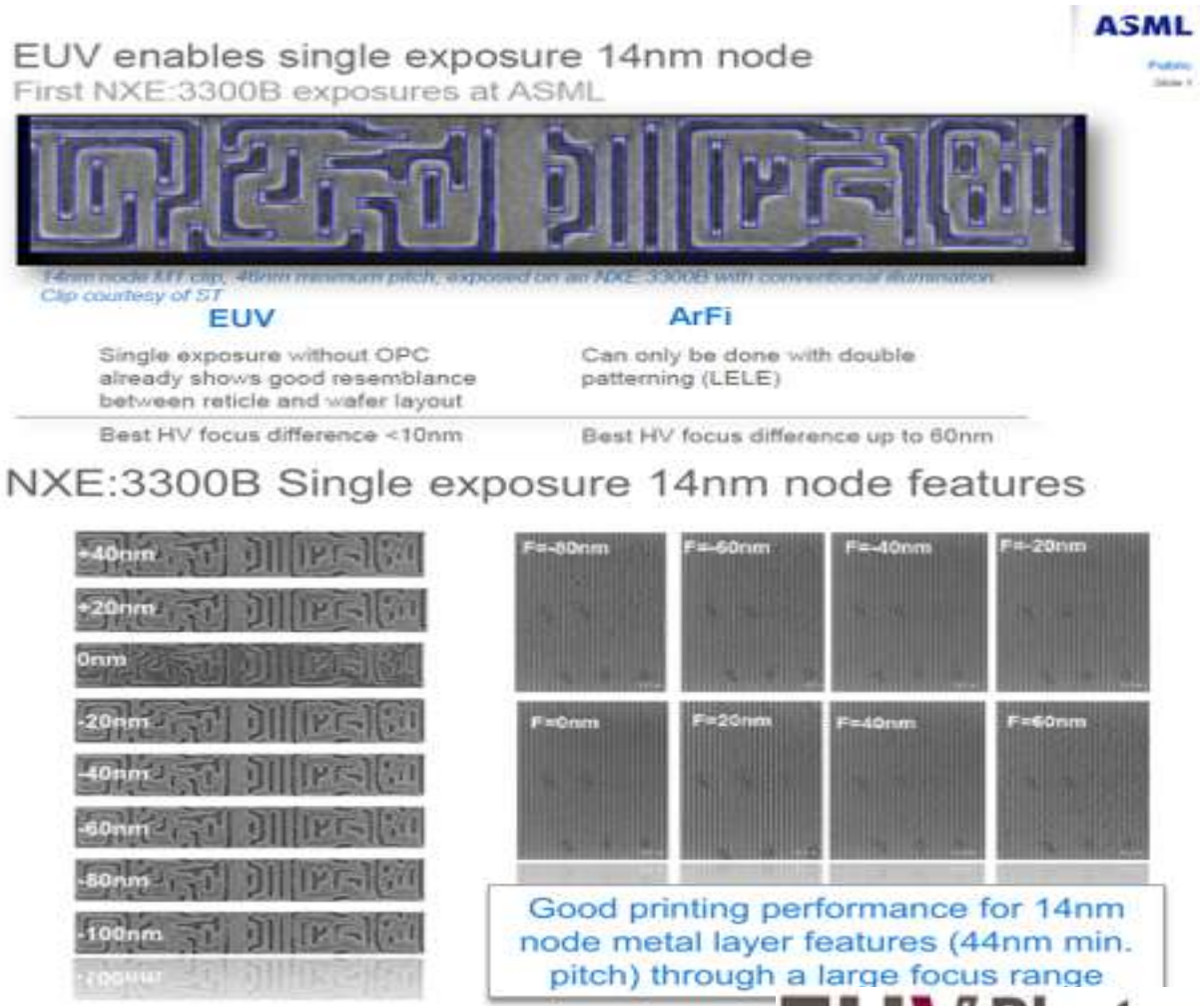
ASML

0.3 NA EUV Exposure System: ASML NXE3300B：First shipment in 2013

EUV

	NXE-3300B→3800D
Resolution	22nm
Optics NA	0.32
Through-put	125WPH
Source Power	50W

At present 500W



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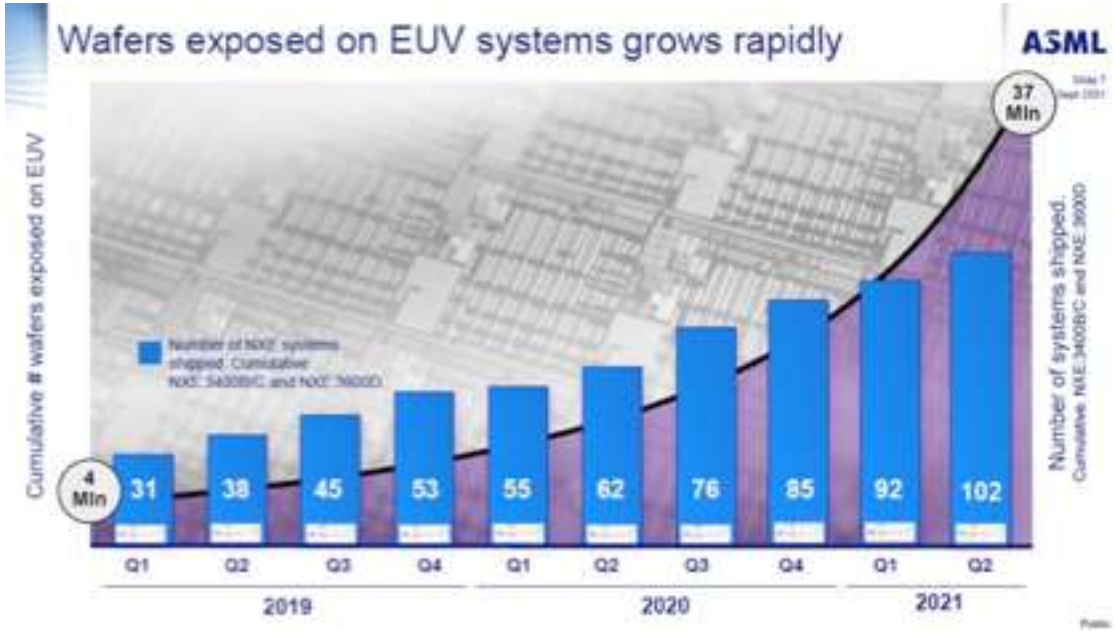
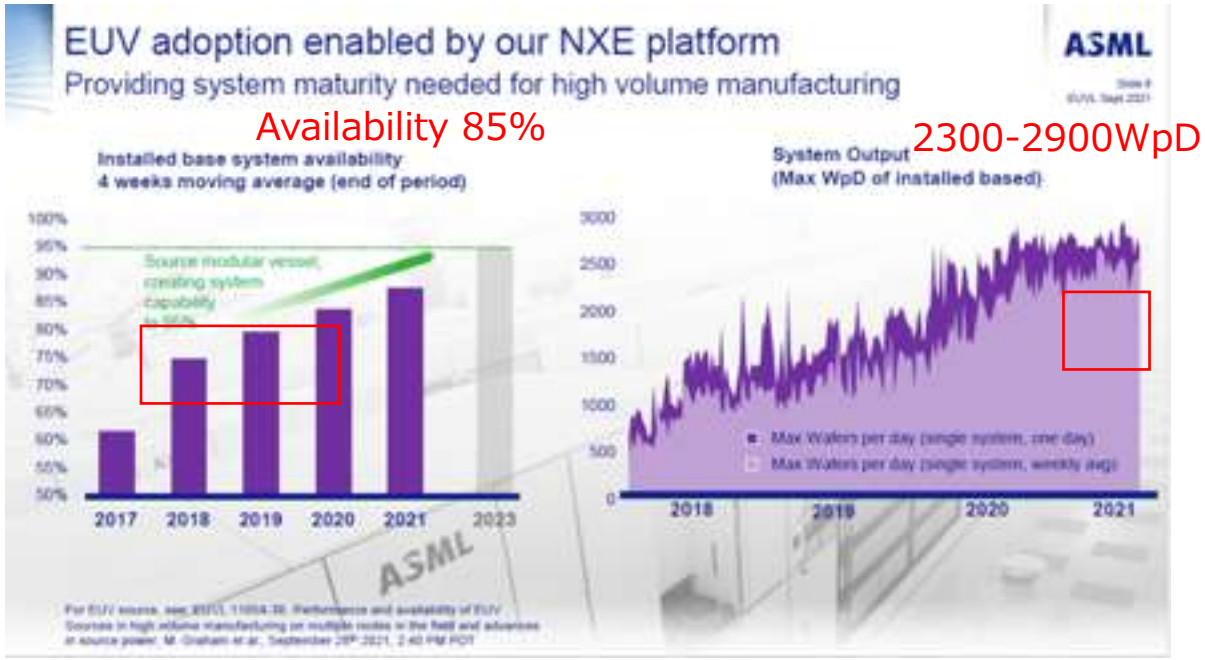
EUV Photon

Number of 0.3 NA Exposure Tool shipment, Availability, Throughput has been improved

- **Number of Exposure Tool shipment**
  2021Q3 117 Units（2021/10/21）
  2025Q2 >300 Units

- Availability >85% by improvement
- Max Throughput is 2300-2900WpD





EUV Photon

▸ *Hot Topics of EUV lithography*

0.3 NA EUV Exposure tool

・Leading Edge Semiconductor factory install more than 300 unit in the world. And RAPIDAS in Japan installed EUV Exposure tool (2024/12)

High-NA EUV Exposure Tool

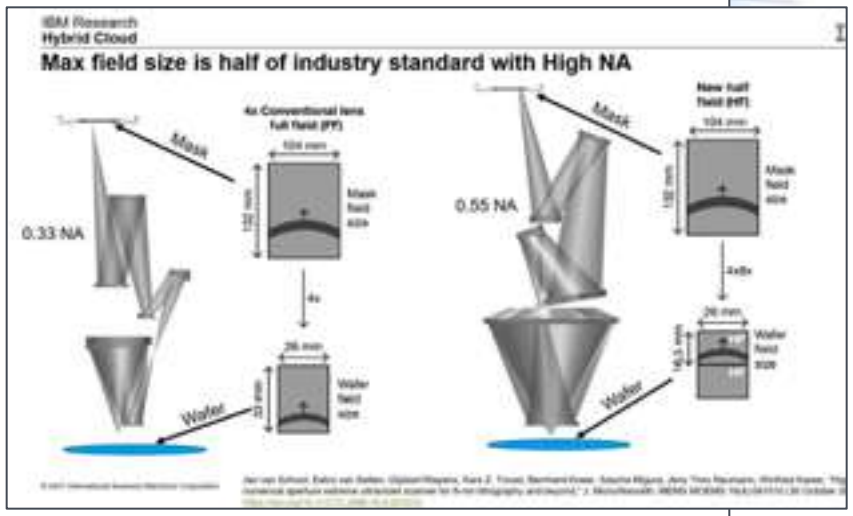
・First Machine of High-NA has been installed to INTEL Oregon factory. And started Operation (2023/12)

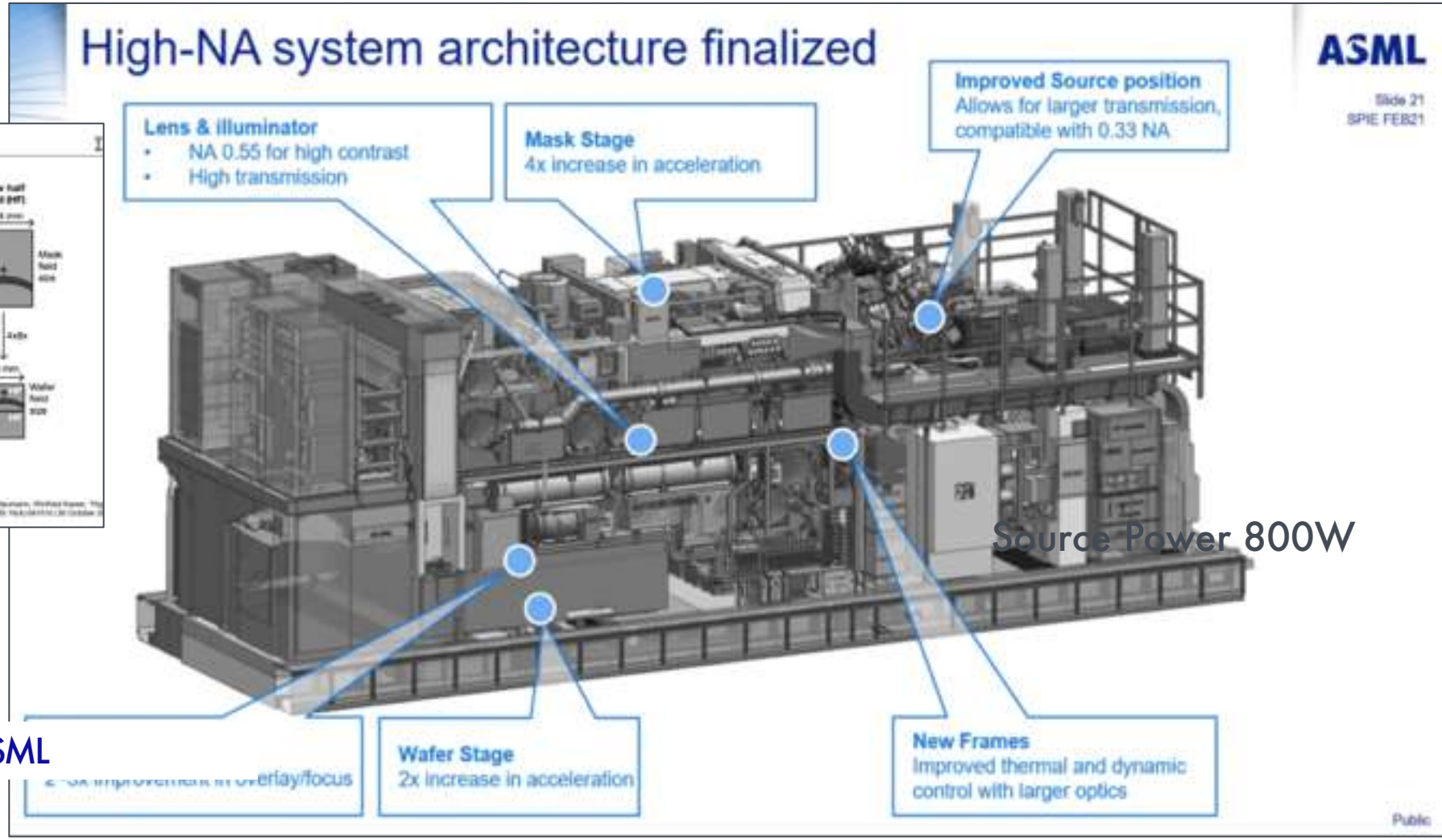
The next innovation in Lithography is here: High NA EUV

Delivery of cost-effective lithography scaling is an imperative

intel

High NA (=0.55 NA) system architecture





Ref. from SPIE AL-2021,ASML

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EUV Lithography Road Map

・Next Generation High NA 0.55 Exposure tool for Mass production

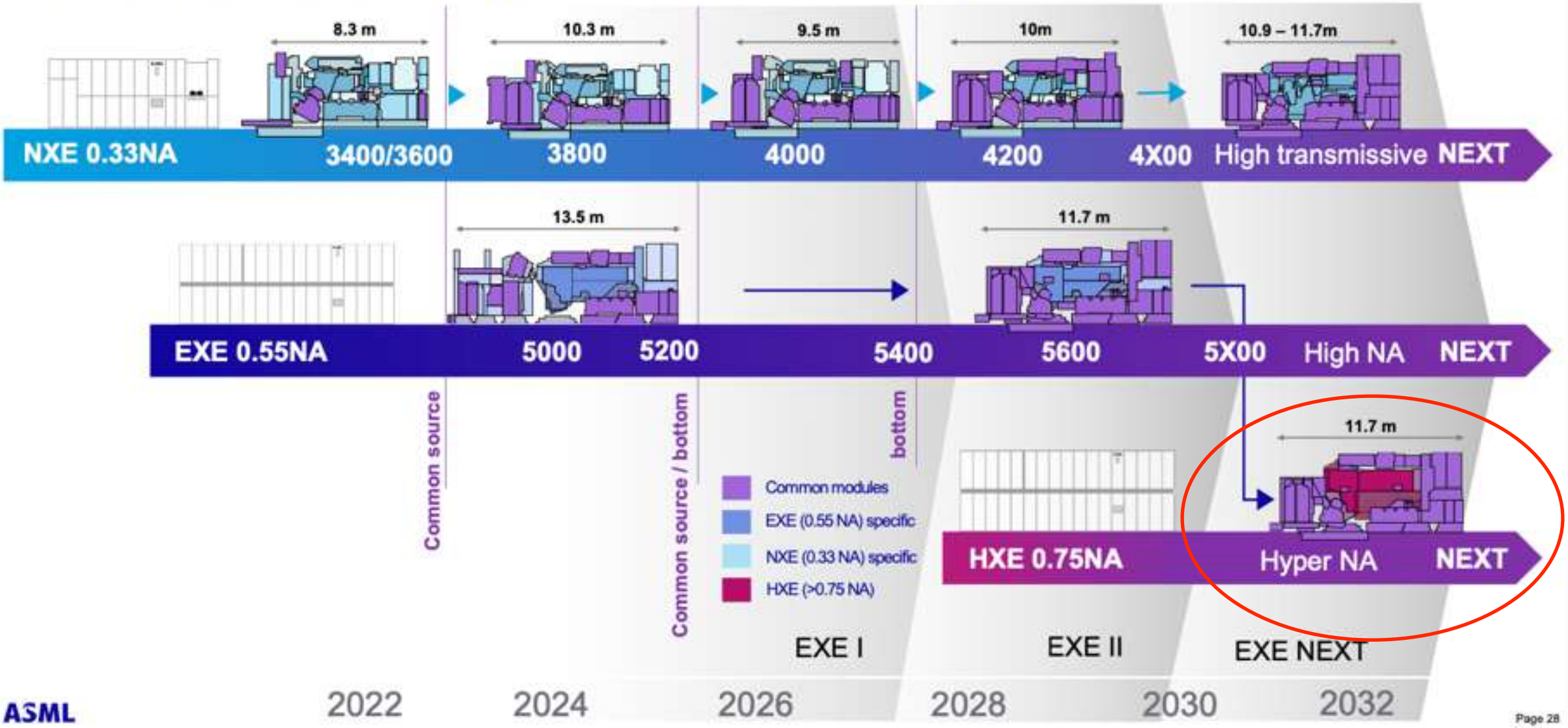
- Shipping target 2028
- High Throughput
- High NA Lab. Start

・After Next Generation Hyper NA 0 .75 machine （2032) is on the road map. Demand of higher power EUV source is still very strong.

EUV Photon

A common NEXT EUV holistic platform: the vision for the coming decade

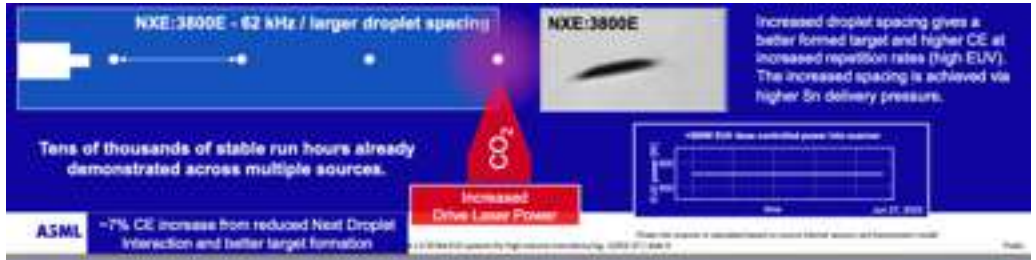
Supporting single expose patterning pitch down to < 10 nm using hyper NA EUV

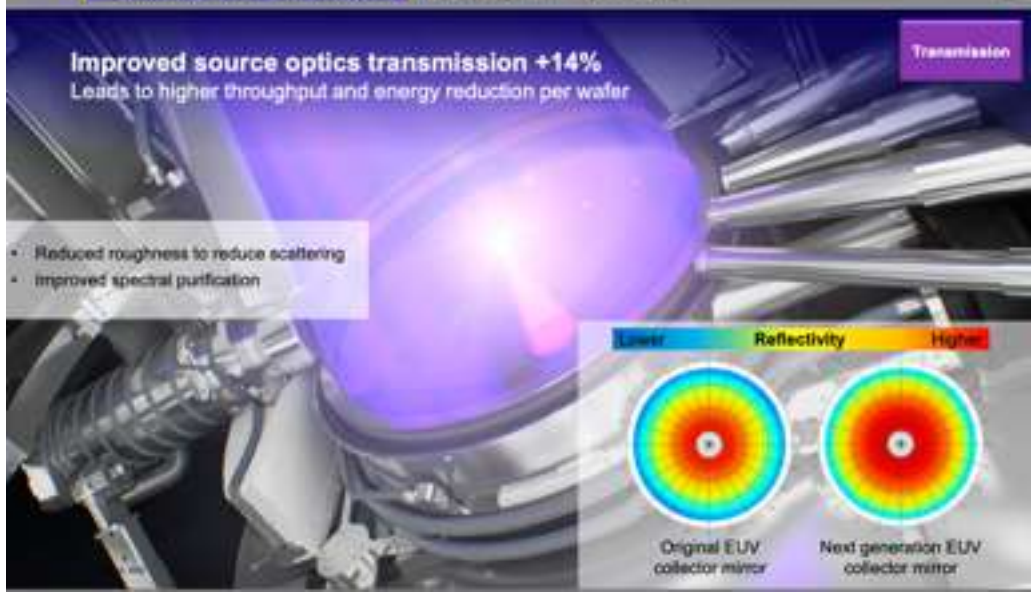


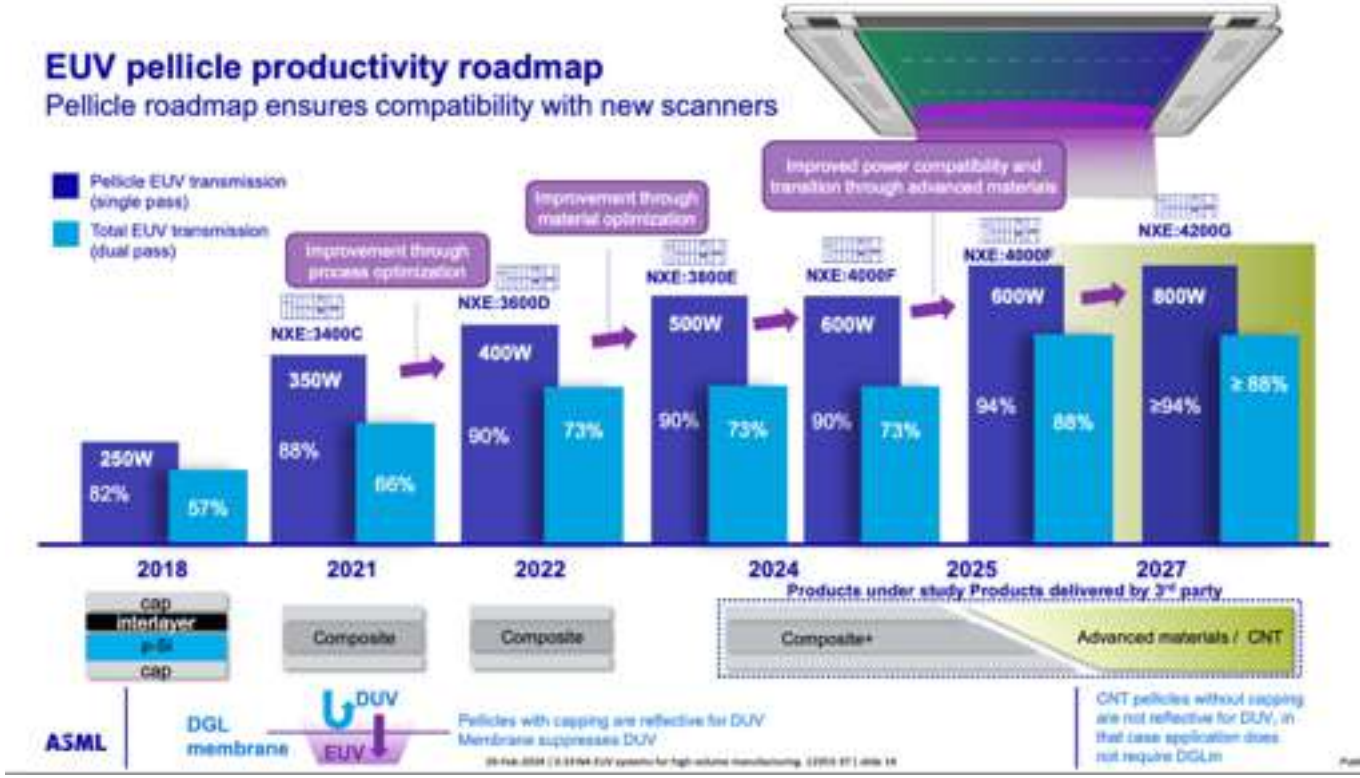
Trend of EUV Light Source for Lithography

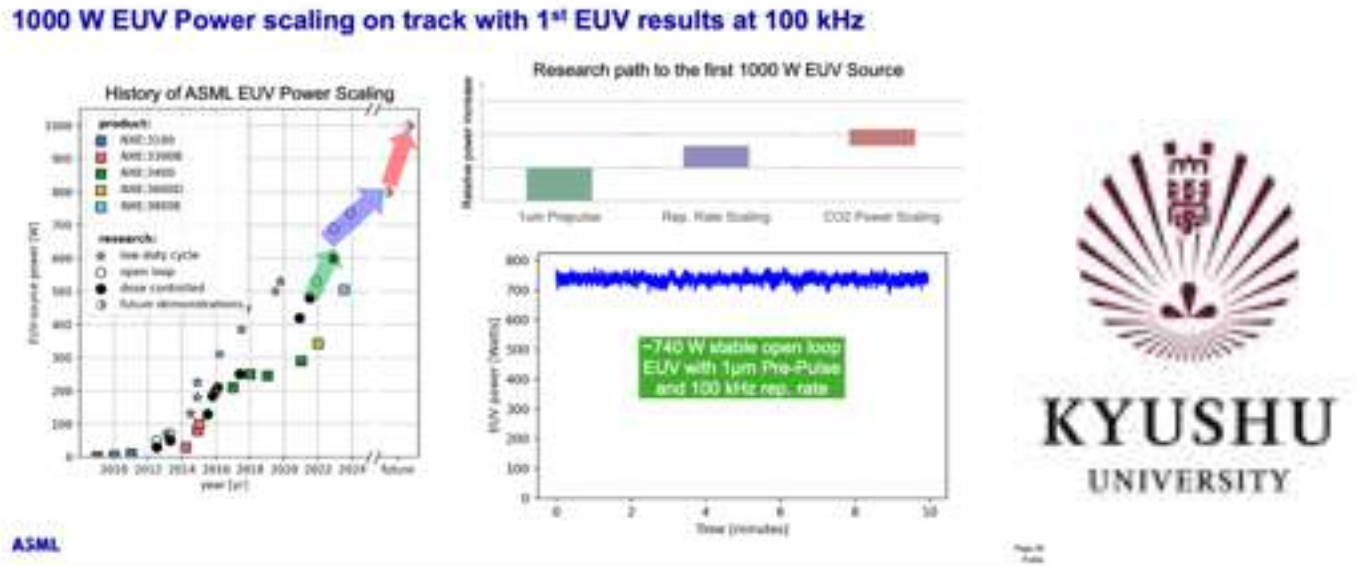
- Reflectance of Collector Mirror improved +14%
- 500W stability improved with higher speed of droplet
- Improvement of Pellicle reduce limit of Source power
- Source Power road map extended:

600W→800W→1000W









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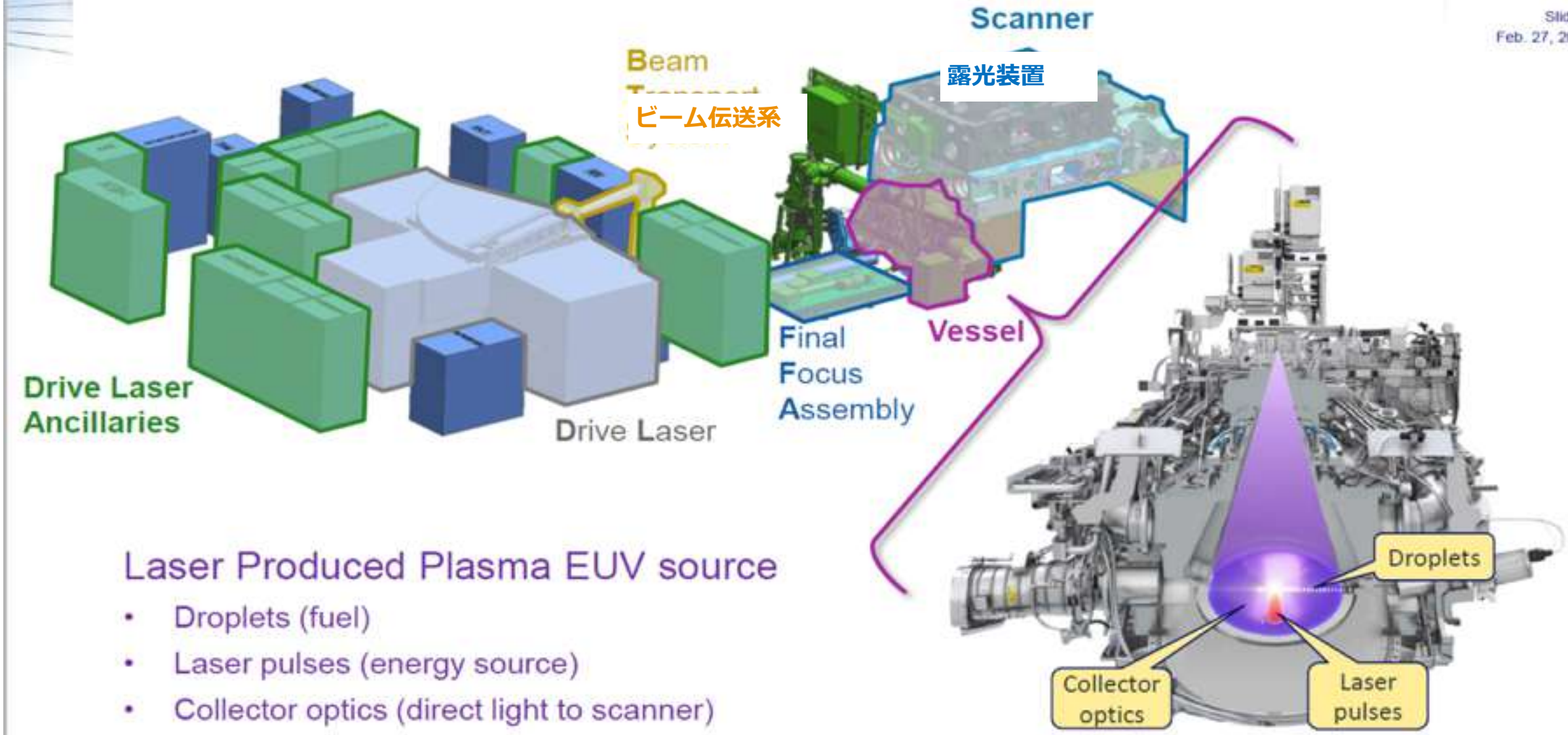
ASML EUV Source

Introduction to the NXE EUV source

ASML

Slide 3
Feb. 27, 2020



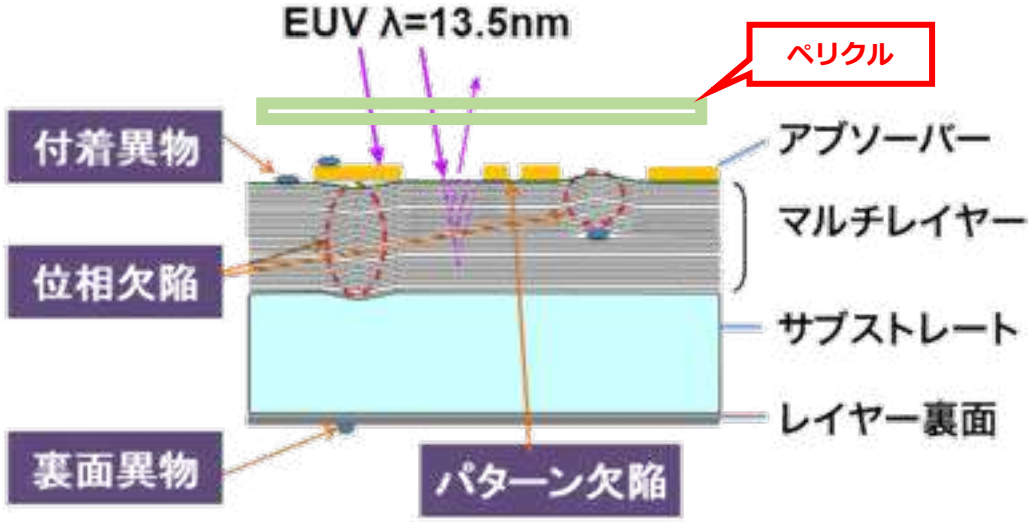
Laser Produced Plasma EUV source

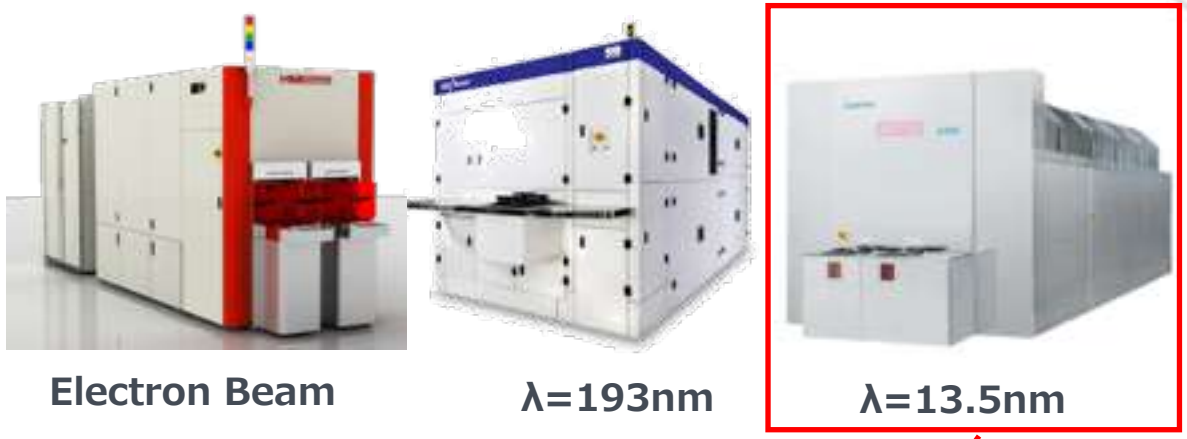
- Droplets (fuel)
- Laser pulses (energy source)
- Collector optics (direct light to scanner)

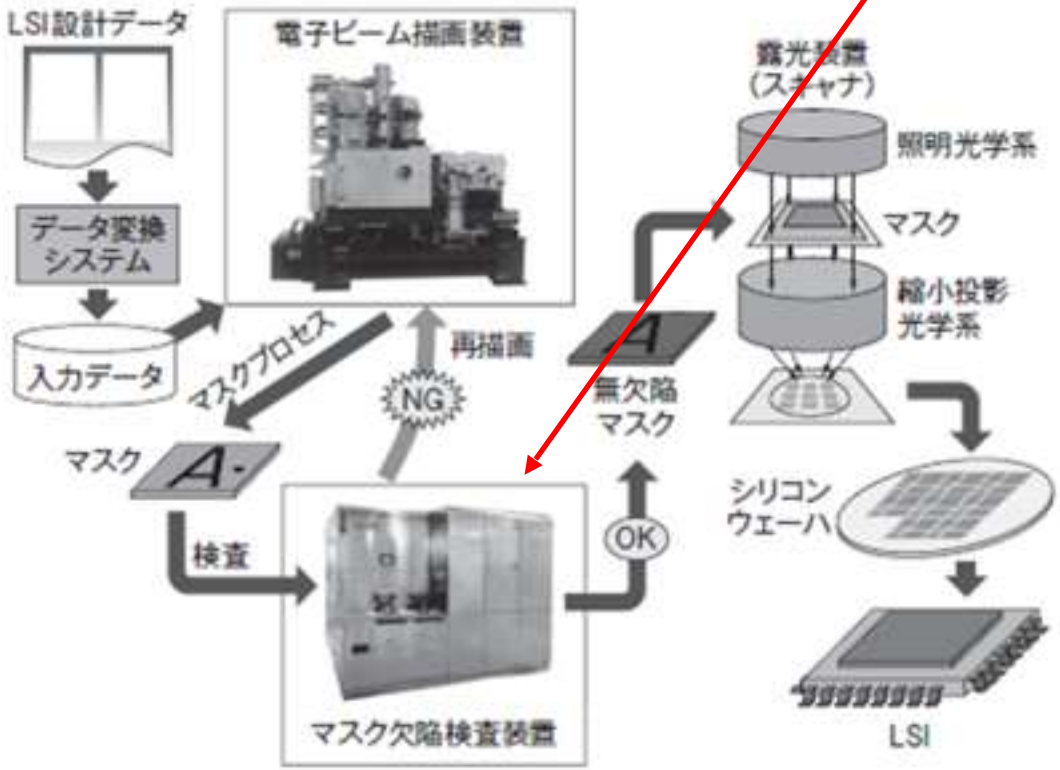
その他のEUV光源の動向

EUVマスク用検査装置

露光装置で使用されるマスク(原画)は電子線で描画されるが、マスクに欠陥があると歩留まりが下がる。
従来は、**電子線やArF (波長193nm)**を利用した検査装置で管理運用してきたが、EUV露光の本格量産と共にペリクルの使用が導入され、**従来機での運用は限界**にきている。検査装置業界では、**EUV光による検査装置、EUV光源**の開発ニーズが高まっている。







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Actinic EUV Patterned Mask Inspection System

ACTIS A150

World's first EUV patterned mask inspection system

- EUV light source (13.5nm) delivering significantly higher defect sensitivity compared with conventional DUV light source
- Actinic inspection with the same wavelength of EUV lithography enabling the detection of printable defects on wafer
- Through-pellicle EUV mask inspection

Lasertec レーザーテック株式会社

Background to the development

2003 … 2016 2017 2018 2019 … 2023 2024 Ready for High-NA

EUV mask blank inspection technology
Now with Actinic Blank Inspection (ABI)

// The world's first //

EUV

MAGICS M1350 MAGICS M9650 ABICS E120 ABI in HVM

Patterned mask inspection technology

MATRICS X800 MATRICS X8ULTRA

Actinic Patterned Mask Inspection (APMI)

// The world's first //

ACTIS A1XX
- ✓ EUV Light Source
- ✓ Production use in HVM

APMI
ACTIS A3XX

Superior light-source required

MATRICS X9ULTRA
- ✓ DUV Light Source
- ✓ Production use in HVM

Progress Report on Actinic Patterned Mask Inspection for EUVL
Satak Sayan (Intel)
No.2-2, Apr. 25-27, 2023, Photomask Japan

Actinic pattern mask inspection for high-NA EUV lithography
Toshiyuki Todoroki, et.al.,
12751-1, Oct. 2-5, 2023, SPIE PHOTOMASK TECHNOLOGY + EUV LITHOGRAPHY

LASER TEC :

ISTECからライセンスを受けたEUV光源URASHIMAを発表

Lasertec's In-house EUV light source: URASHIMA

Urashima is designed for actinic patterned mask inspection

Overview

- ✓ High brightness light source
- ✓ Stable EUV emission by laser-produced plasma
- ✓ Optimized illumination area to minimize heat load to pellicles

Inspection system verification

- ✓ Operating on site with multiple ACTIS
- ✓ Qualified by all customers

Actinic inspection technology enhancement for n3 node and beyond
Han-Ming Chang (TSMC), et.al.,
12751-1, Oct. 2-5, 2023, SPIE PHOTOMASK TECHNOLOGY + EUV LITHOGRAPHY

High-brightness Light Source Based on a New Concept of LPP for Actinic EUV Microscopy and Metrology Applications
Mikhail Krivokorytov, et.al.
534, Nov 5-7, 2018, Source workshop

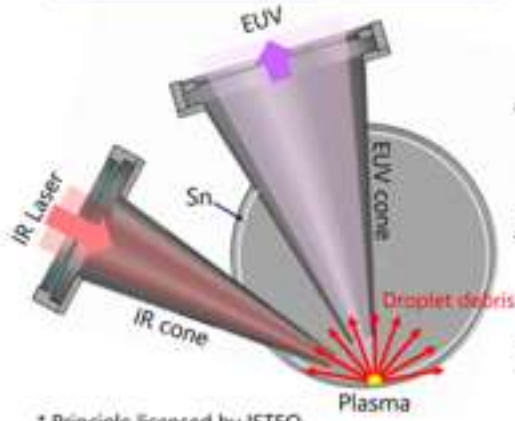
ACTIS system with URASHIMA light source

2023 Source workshop 7

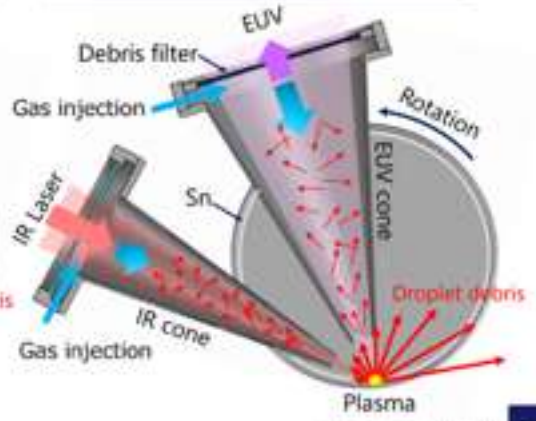
URASHIMA EUV light source: Debris mitigation techniques

Debris mitigation by a combination of fast rotating Sn, gas injection and debris filter

No rotation, no gas



Fast rotating Sn, gas injection, debris filter

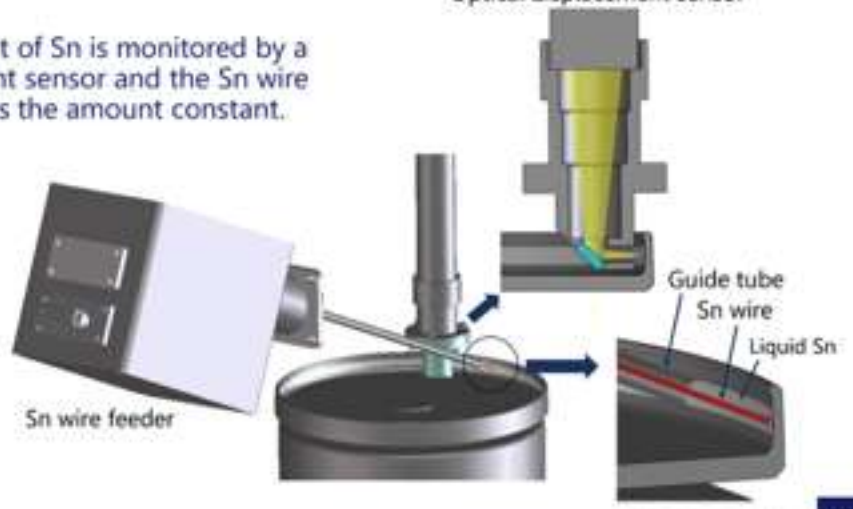


* Principle licensed by ISTEQ

2023 Source workshop 9

URASHIMA EUV light source: Automatic Sn supply mechanism

- The amount of Sn is monitored by a displacement sensor and the Sn wire feeder keeps the amount constant.



2023 Source workshop 10

Strengths of URASHIMA light source

URASHIMA is an EUV light source best suited for APMI.

		Strengths of "URASHIMA" source
High throughput Stable inspection	Configuration	Laser Produced Plasma
	Brightness	400 W/mm²/sr @ Plasma verified
	Power Fluctuation	σ 0.2 % @ 4msec average
Lower heat load on pellicles and masks	Etendue	0.001 mm²sr
	Pulse energy	~0.1 uJ
Eco-friendly	Sn consumption	~4 g/day
	Power consumption	~18 kW
	Footprint	~4 m²

2023 Source workshop

Gigaphoton:

高輝度のLPPプラズマEUV光源（検査用）を発表

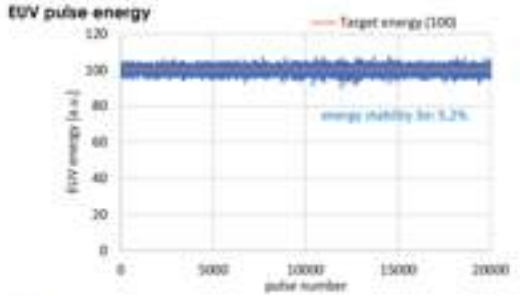
System overview and specification

EUV Light source overview

#	Item	Specification
1	Source assembly	SoCoMo (collector mirror included)
2	Method	Sn Droplet LPP
3	Center wavelength (2% Band)	13.5 nm
4	Repetition rate	20 kHz
6	Duty cycle	100 %
7	Plasma size	Φ 50 ~ 80 μm (depends on customer specification)
8	Rated brightness at plasma point	~ 120 W/mm²-sr
9	Brightness stability (1σ)	< 3 % (pulse to pulse)
10	Availability	>95%
11	Maintenance cycle	1 year
12	System dimensions	≦2.0 m(W)×2.6 m(D)×2.6 m(H)
13	Used Gas@fab	H_2, Ar, XCDA (Extreme Clean Dry Air)
14	Used Gas@sub fab	N_2, CH_4, O_2, CDA (Clean Dry Air)

* Brightness and Etendue at IF : Depends on customer specification

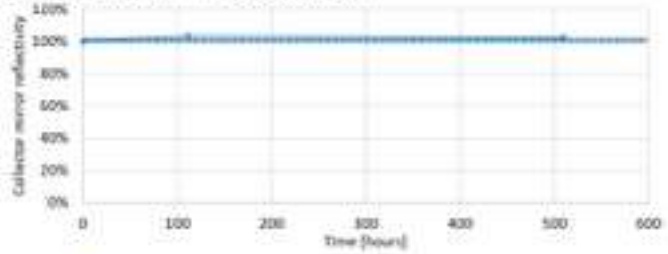
EUV energy stability (short term)



- Pulse to pulse energy stability 3σ
- Pulse number 20kHz)
- High-accuracy spatial position st enables a stable EUV emission.

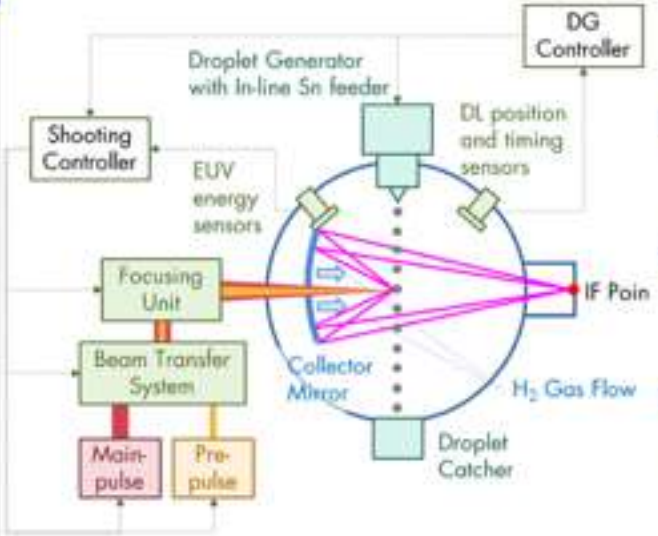
Collector mirror lifetime

Actual EUV collector mirror reflectivity trend



- No reflectivity degradation is observed after 500 hours of operation.
  - A much longer operation test is ongoing.

System configuration



- **Sn-droplet Generator (DG)**
  - ✓ Minimum-mass and high-speed droplet target to minimize debris.
  - ✓ In-line Sn fuel feed system to extend the DG lifetime and availability.
- **Dual Laser Pulse Irradiation**
  - ✓ A dual laser pulse irradiation optimizes Sn target condition and achieves high EUV conversion efficiency (CE) at low Sn ion energy.
- **Shooting Control**
  - ✓ High-accuracy spatial and temporal control between lasers and droplets to ensure high EUV energy stability and minimum fragmented Sn debris.
- **Debris Mitigation**
  - ✓ Optimized H_2 gas flow and chamber pressure to extend collector mirror lifetime.
  - ✓ Combination of H_2 gas, Droplet target, and high-accuracy laser irradiation control to enable a long collector mirror lifetime without filters.

Availability

Source Availability (Target, Estimation)

Item	Target	Current Estimation
Availability	> 95 % (< 438 hours)	> 99.0% (consider only Scheduled down)
Scheduled down time (SD)	< 3 % (< 263 hours)	< 1% (< 87 hours)
Unscheduled down time (USD)	< 2 % (< 175 hours)	0.7% during 700hours continuous operation Evaluation is ongoing.

Target lifetime and maintenance time (main modules)

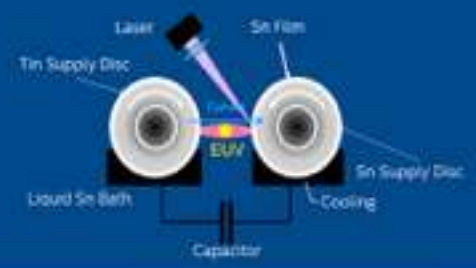
Module	Target Lifetime	Target Maintenance time
DG with Sn refill	1 year	3.0 hours
Droplet catcher	1 year	2.5 hours
Collector mirror	2 years	2.0 hours
Pre-pulse and Driver laser	2 years	4.0 hours
Laser focus optics	2 years	1.5 hours
Dry pump maintenance	3 years	8.0 hours
[illegible] maintenance	5 years	6.0 hours

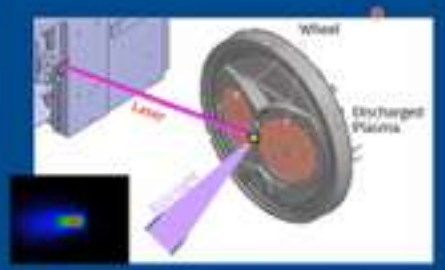
- The design concept of long lifetime and efficient maintenance ensures minimal downtime.

Concept of Sn-LDP (Ushio, Japan)

Laser-assisted Discharge-produced Plasma source

- ✓ High brightness
- ✓ Relatively small plasma size, high photon flux per pulse
- ✓ Stable: No spatial and timing synchronization needed
- ✓ Reliable: 24/7 operation
- ✓ Novel Debris Mitigation

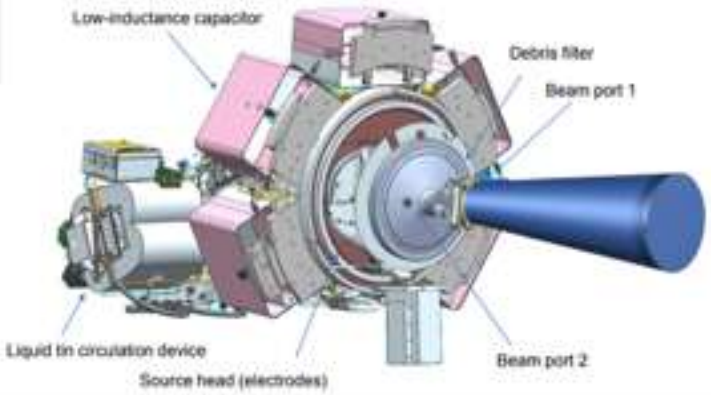




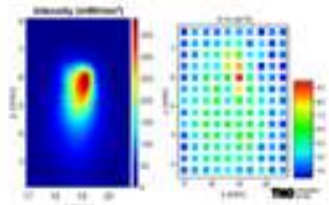
intel

LDP source for beamline and mask inspection

USHIO



EBL2 result example



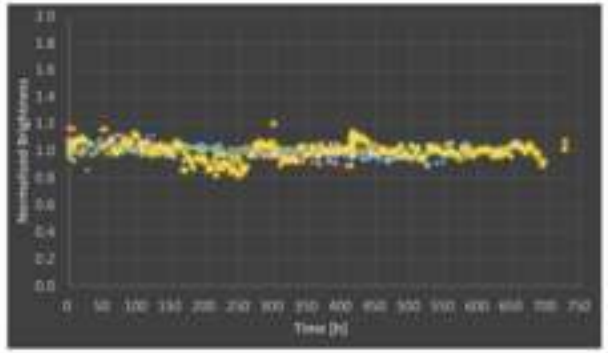
K. Barthelemy, et al., presented at the 41st International Conference on Vacuum Ultraviolet and X-ray Physics (VUVX 2023), July 3-7, Campinas-SP, Brazil.

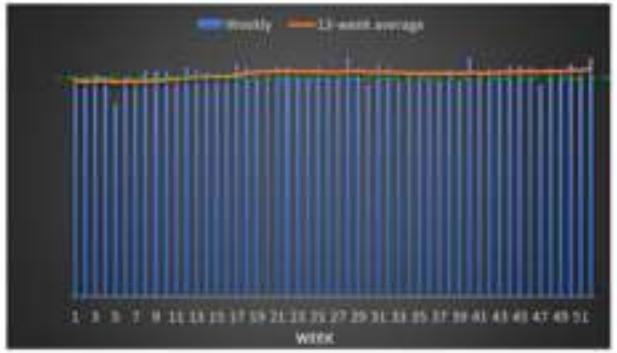
2023 Source Workshop, Aachen (Germany), October 24, 2023

Non-interrupted operation for >600 hours

USHIO

- Continuous operation for >4 weeks on 24/7 basis.
- Availability of all field sources >90 %.
- Extension of MTBM contributed to longer non-stop operation.
- System and component reliability improvement reduced unscheduled downtime.

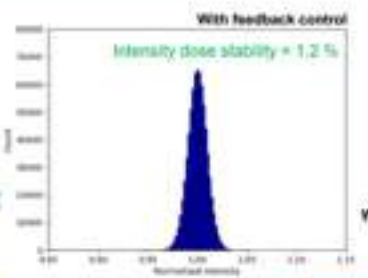




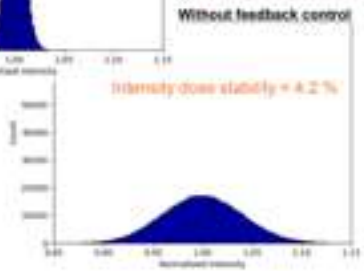
Feedback control for intensity stabilization

USHIO

Experiment on EBL2 at TNO



- Pulse-to-pulse energy feedback control (dose control) was applied to intensity control.
- The dose controller adjusted the charging voltage every pulse.
- The voltage margin was narrowed.
- Intensity dose stability was improved from 4.2 % to 1.2 %.



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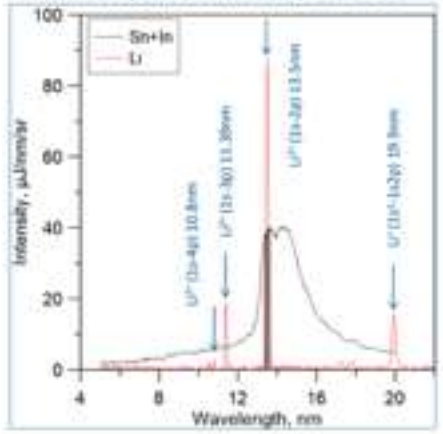
ISTEQ：

高輝度のLiターゲットのEUV光源を発表

Emission energy and spectra of laser produced plasmas

Laser parameters: pulse energy 3.3mJ, duration 1.5ns, spot size 60μm (1/e² level)

Emission spectra, resolution $\lambda/\delta\lambda \approx 100$



The emission energy is measured by an AXUV100 photodiode covered with SPF filters. In given laser irradiation conditions, measured conversion efficiency (CE) in 2π is:

- ~2.0% @ Sn+In for the in-band radiation, 13.5 ± 1%.
- ~2.3% @ Li for the Li^{2+} (1s-2p) line.

Under these conditions, comparable EUV energies inside 2% bandwidth can be generated for both materials. For Sn+In energy is distributed over all 13.5 ± 1% range, while for Li **energy is concentrated in a narrow spectral line.**

EUV light source TEUS - S100: today

Today, TEUS-S100 is a serial product that can be found in laboratories and factories around the world.

MAIN ADVANTAGES

- High brightness (means high throughput) along with excellent stability
- absolute minimum debris,
- extremely high uptime,
- high duty cycle and turnkey operation (user-friendly along with automated protocol to ensure the system runs smoothly with no risk and interruption).

APPLICATION FIELDS

- Mask and surface inspections
- Patterning Mask Inspection (PMI)
- Actinic Mask Inspection (AMI)
- Mask Blank Inspection (MBI)
- EUV optics (main in the EUV scanner inspection
- Material science
- Wafer inspection

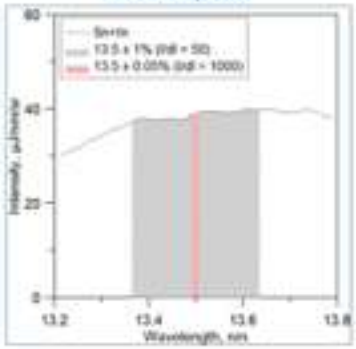
Please, **visit our poster #7-S114** "TEUS: high-brightness EUV LPP light source based on fast rotating target. Product overview and specifications"
and also please pay attention to
#48-S72 "Development of a laser-induced plasma EUV light source suitable for inspection tools" from Lasertec

LASER World of Photonics, Munich, 2022 & 2023

Increasing spectral brightness: motivation

Our goal is to help customers in need of monochromatic light by improving the efficiency of optical systems.

Emission spectra



Sn(+In)

An estimate "the effective" CE if it is necessary to use only a small part of the spectral range:

- If for the spectral interval $\lambda/\delta\lambda = 50$ $CE^{50} \approx 2\%$, then for $\lambda/\delta\lambda = 1000$, effective $CE^{1000} \approx 0.1\%$.
- Any technique for filtering a narrow line from a quasi-continuous spectrum (for example, using a spectrograph) leads to a significant decrease in the spectral brightness of the radiation by a factor of 5 to 10. Thus, we obtain estimates of the resulting CE for a narrow line in the case of the tin spectrum: effective CE $^{\sim1000} \approx (0.01\text{-}0.02)$ %. **Huge losses!**

Is it possible to concentrate the emission energy around 13.5nm?

Emission properties

Comparison between different focusing conditions & target materials

Drive laser: 100W, 1.5ns

Material	CE,% in 2π	E, mJ	Source size, μm	Brightness 13.5±1%[1], W/mm²/sr	λ/δλ	Spectral brightness @13.5 nm², W/sr*mm²/sr
Sn+In	2	4	60	100	50	170 (before filtering)
Li	2.3	4	90	52	1000	1800
Li	2.3	4	60	106	1000	7900
Li	1.1	4	120	14	1000	1000
Li	0.7	0.5	40	80	1000	5900

1 – brightness is indicated on the plasma, i.e. excluding losses in debris mitigation systems

Using Li as a target material results in an incredible increase in spectral brightness!

DPP source Energetic EQS-10

Current EQS-10 performance

Parameters	EQ-10	EQS-10
Power, W / 2π	20	41
Brightness, W/mm²/sr	8	11*
Plasma FWHM (µm)	450	450**
Pulse Frequency (kHz)	2.5	up to 5
Continuous Operation (days)	7	6*~7

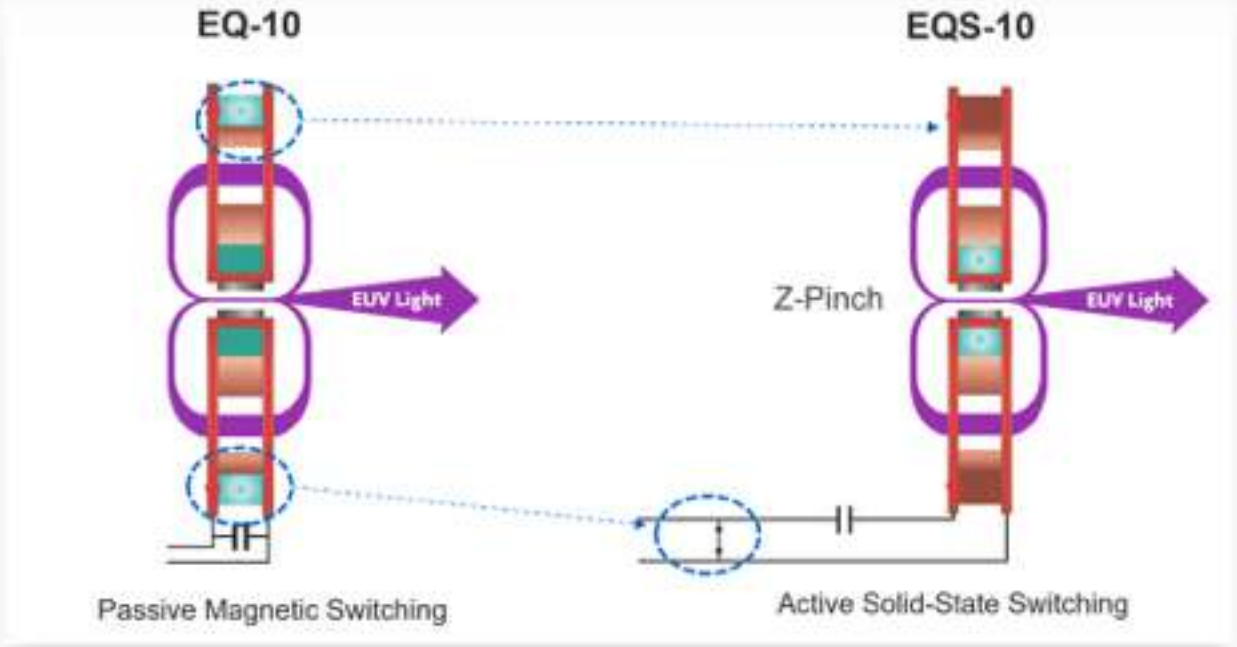
*Depending on application space

New for the EQS-10

Direct Fueling Technology

Our Direct Fueling system injects Xenon (Xe) directly into the Z-Pinch area, enhancing Xe density, ionization, and distribution for improved performance. This efficient method reduces Xe consumption while minimizing absorption, resulting in a more effective and sustainable use of resources.

- 60% reduction in gas usage by direct fueling
- 25% reduction in cost per watt



Agenda

- **Introduction:**
  DUV/EUV Semiconductor Lithography and light Source
- **New Company: EUV Photon**
  - Motivation
  - EUV Exposure Road map of EUVP
  - Observation tools of EUVP
  - New Material Investigation with Visualization of Phenomenon
- **K-Program: High Efficient LPP-EUV Source and Optics**
  - Investigation of Lithography technology related Security Export Control
  - K-Program: New program of EUV Source and Optics Research
  - EUV Plasma diagnostic technology & Simulation
  - Concept of SMET: Smart Laser and Mirror Evaluation Tool
- **Summary / Acknowledgement**

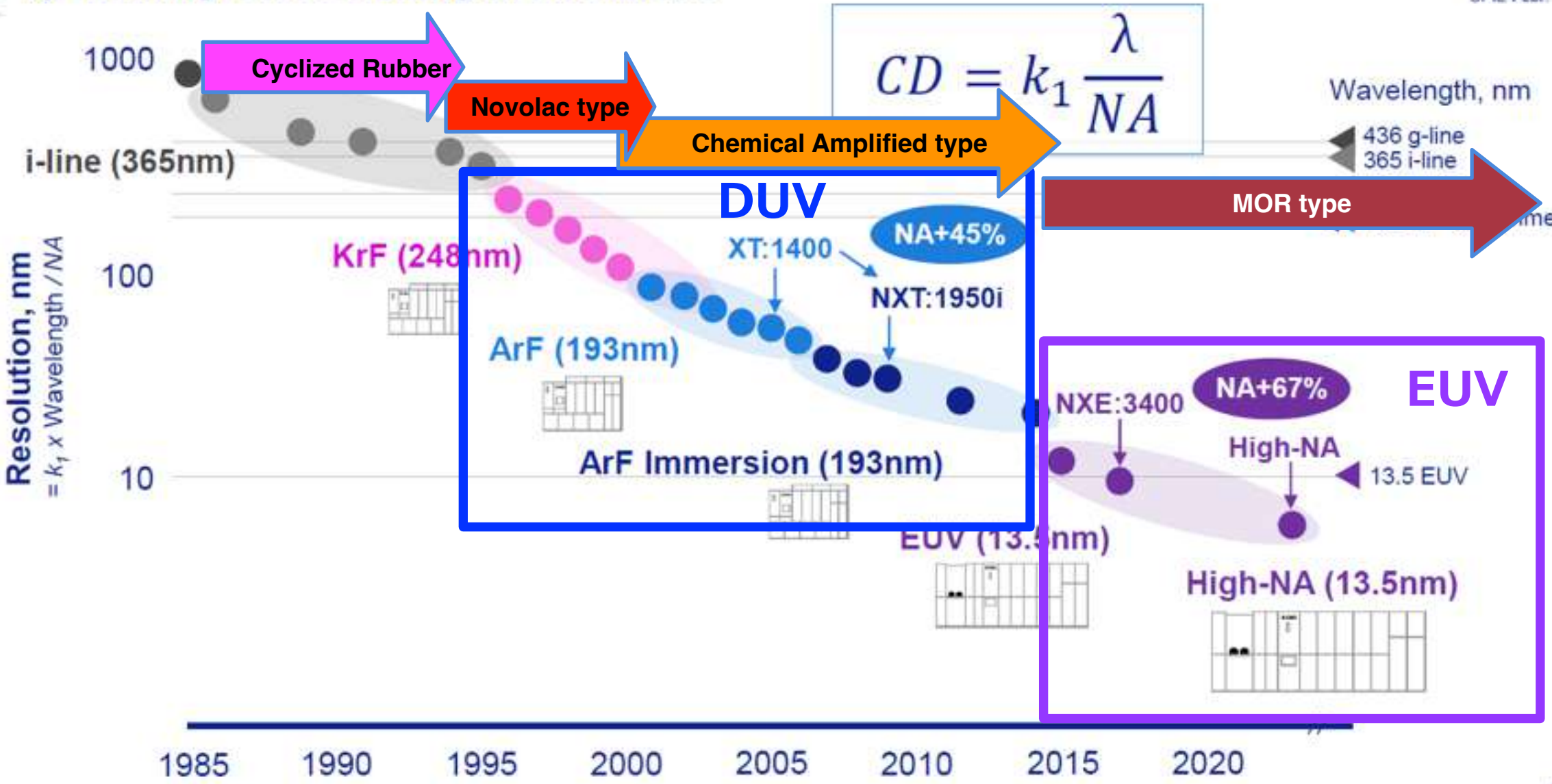
KYUSHU UNIVERSITY

Over 35 years 2 orders of magnitude resolution reduction

by working on Wavelength, NA and k1

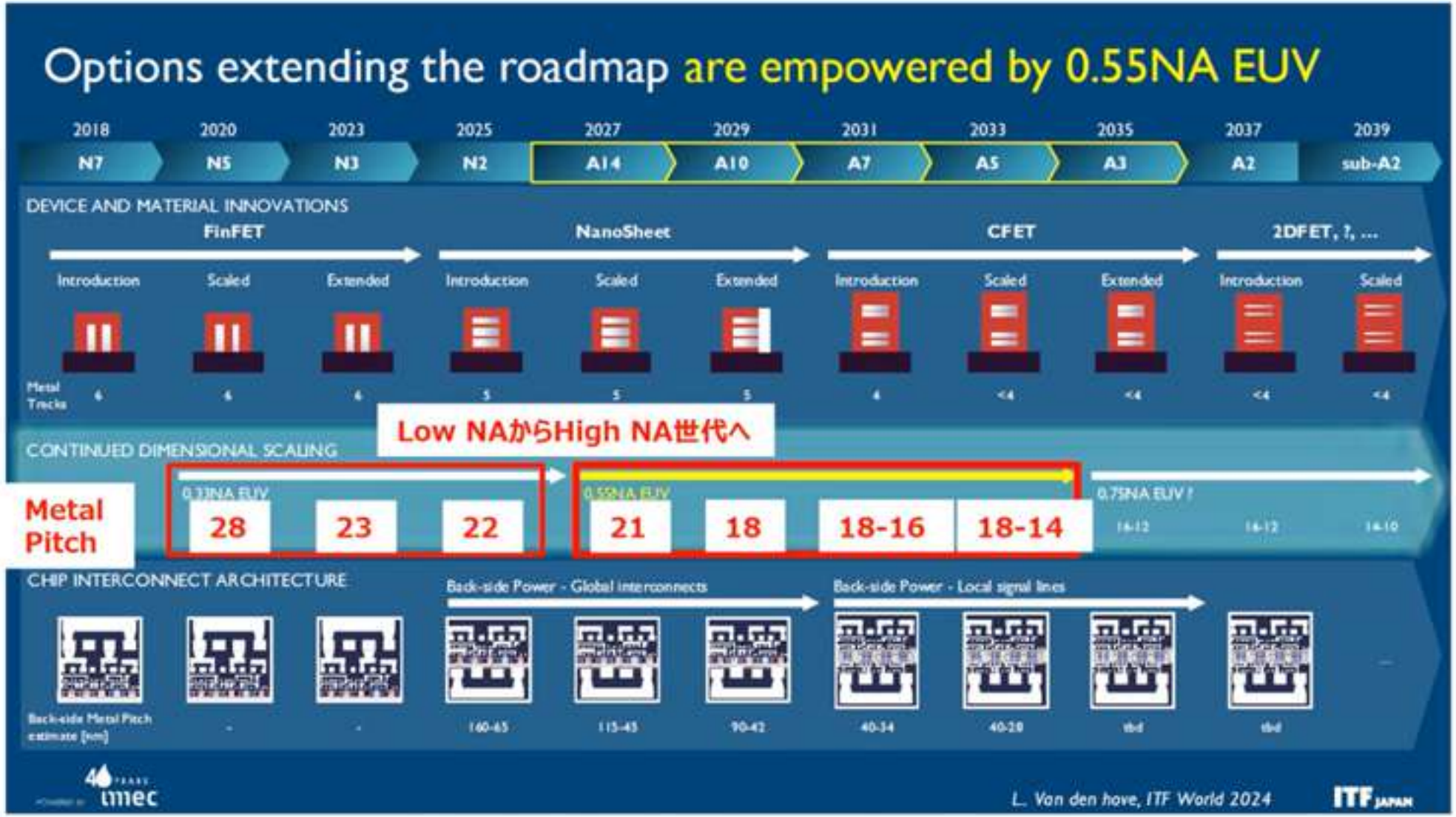
ASML

$$CD = k_1 \frac{\lambda}{NA}$$



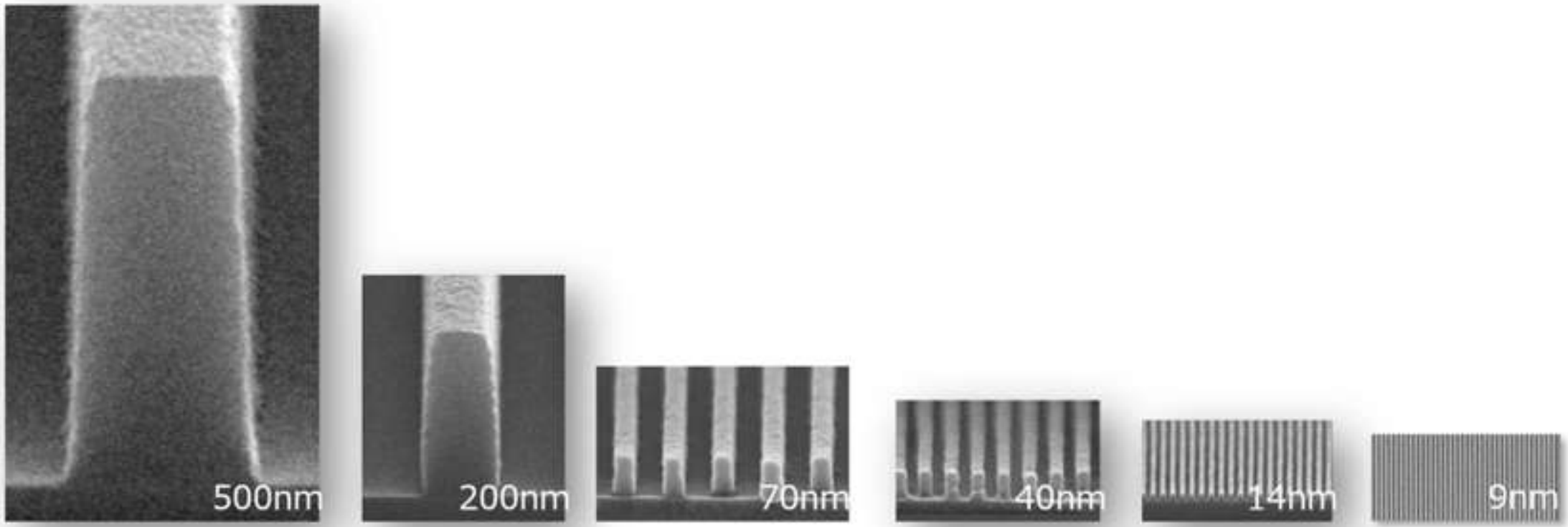
Public

微細化



Geert Vandenberghe, High NA EUV lithography: enabling logic and memory patterning breakthroughs, ITF Japan

History of Resist Minimization



Concept of EUV Photon Activate Supply Chain of Resist

Photo Mask Manufacture Process → Front Process Chip on Wafer → **Paint Photo Resist** → Patterning - Exposure - Develop Photo-resist → End Process Cut Chip on Wafer → **Semiconductor Manufacturing Process**

Toppan, DNP *Shinetsu, SUMCO*

Resonac, Ibiden, Tanaka Noble metal

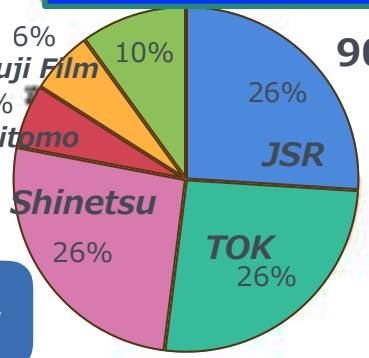
Material Development

Screening of New Material → Lithography Patterning

EUV Photon IrradiationTool

ASML Exposure Tool

Market share of Photo resist



90%of Market is Owned by Japanese company

Speed of development is very important to survive leading edge technology competition

ISSUE

- ***EUV irradiation is possible Only in Holland, Begium***
- ***Leading time is vely long Usually 6 monthes***
- ***Testing Fee is vely Expensive Usually $200/Job monthes***
- ***Optical property is Different between DPP and LPP***

Worst case: Additional 10 monthes

Our Solution

Start EUV Irradiation Center in Kyushu University

EUV Photon

Shorten Waiting Time
Max 1/10 from present
Around 1-2 monthes

Cheaper Fee
Max 1/4 from present
Around $50/Job

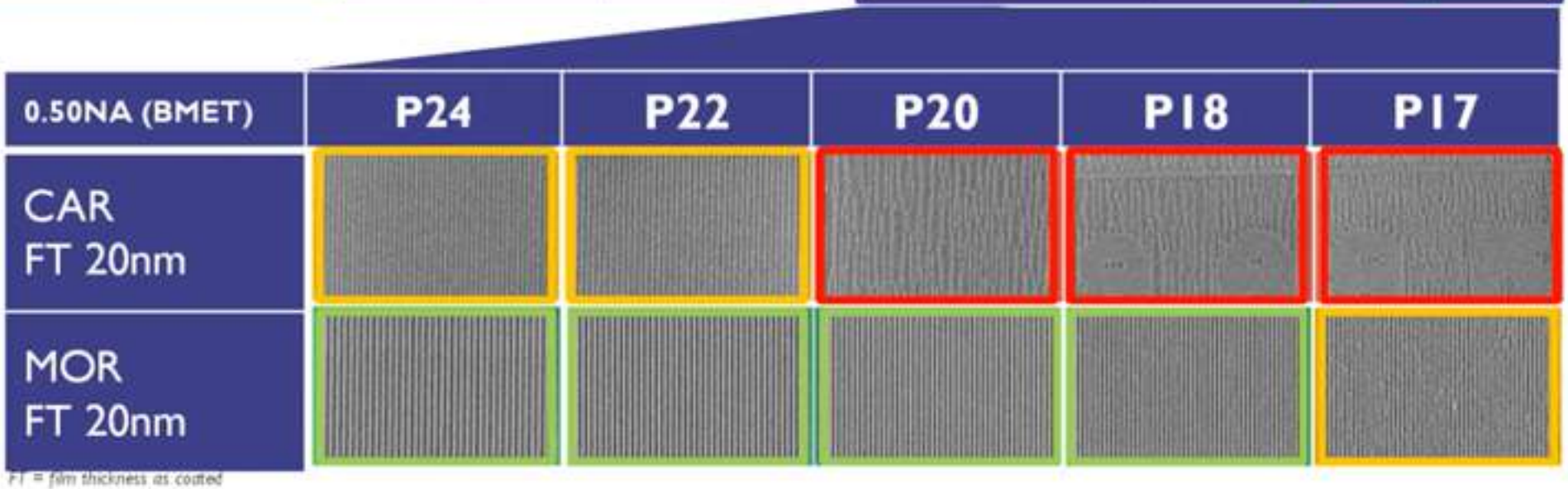
Why Kyushu University?

First LPP Source Innovation was started from Kyushu University
Top level ” Center of Plasma Nano - Interface Engineering
Top level Analysis technology and instruments

KYUSHU UNIVERSITY

CARとMOR

Design M2 Pitch	P32	P30	P28	P26	P24	P22	P20	P18	P17
k1 at 0.33NA: Performance are imaging driven	0.39	0.37	0.34	0.32	0.29				
k1 at 0.50NA (BMET5): Performance are materials driven	0.59	0.56	0.52	0.48	0.44	0.41	0.37	0.33	0.31
CAR ultimate resolution LS @ 0.5NA									
MOR ultimate resolution LS @ 0.5NA									



Danilo De Simone, The EUV materials at the angstrom era of Moore's low, ICPST-40, A5-3-4 (2023)

各国の軟X線・EUV光源センター状況

	X線光学センター CXRO	Imec imec embracing a better life	オランダ応用科学研究機構 TNO innovation for life	パウルシェラー研究所 PSI	フランフォファー Fraunhofer ILT
国・場所	アメリカ合衆国 カリフォルニア州	ベルギー ルーヴェン	オランダ Delft	スイス Villigen	ドイツ アーヘン
大学・機関	ローレンスバークレー国立研究所 内	フランダース政府 大学院大学として	TNO デルフト工科大学	スイス連邦工科大学	
研究テーマ	X-Ray Database Zone Plate Education Nanomagnetism X-Ray Microscopy LDJIM EUV Lithography EUV Mask Imaging Reflectometry Zone Plates/Nanofab Coherent Optics Optical Coatings Engineering Education 	ASML、JSRなど 半導体の開発拠点 	オランダの独立した研究機関。受託研究を実施し専門家によるコンサルティングサービスの提供、特許およびソフトウェアのライセンス付与 	Paul Scherrer Instituteは、スイス連邦工科大学に属する学際的な研究機関であり、ETHチューリッヒとEPFLもカバーしています。 1988年にEIRとSINの合併により設立 	Fraunhofer ILT. ウシオの光源開発 Xtream

Kyushu-Univ.
CONFIDENTIAL

EUV Photon

New Company EUV Photon was Established July 2024 as second generation subsidiary of Kyushu University

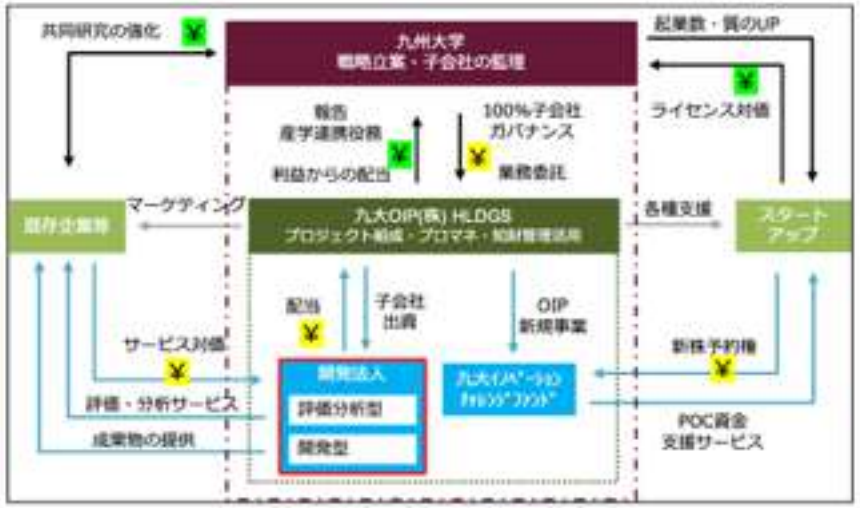
日本経済新聞
https://www.nikkei.com/article/DGXZQOJC265LA0W4A720C2000000/

九州大学、先端半導体の露光技術「EUV」で新会社設立

シリコンアイランド

記者会見する九大OIP傘下の新会社「EUVフォトン」の社長に就任する九州大学の浅野種正名誉教授（中）ら（26日、福岡市）

九州大学は26日、最先端の半導体製造に欠かせない極端紫外線（EUV）の技術を持つ新会社、EUVフォトン（福岡市）を設立すると発表した。企業が先端半導体向けの新素材などを開発するにあたり、EUVの照射から解析までをワンストップで提供することで技術を蓄積、半導体供給網の強化につなげる。



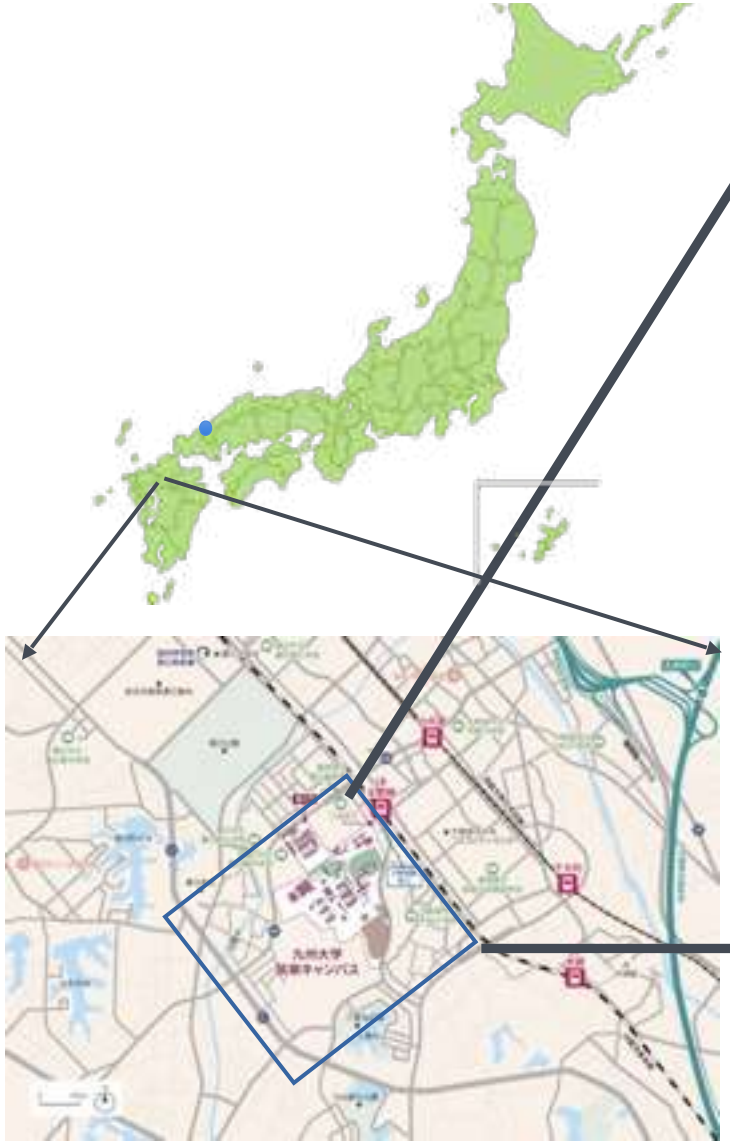
設立は29日付で、産学連携の加速を目的に4月に設立した九大OIP（同）の傘下企業第1号となる。社長には半導体の研究・教育に長く携わってきた浅野種正・同大名誉教授が就任する。資本金は当初100万円だが外部からの出資受け入れも視野にいれる。

EUVフォトンでは半導体の回路を形成する際に使われるフォトレジストなどを手掛ける素材メーカーから発注を受け、EUVの照射や解析、評価を担う。解析や評価のノウハウは九大からも提供を受ける。EUVの光源など設備の発注や人材の採用を学外から進め、2025年度中のサービス提供を予定する。

現状、EUV向け素材などの研究開発は海外に委託するケースが多く、高額な料金などが課題になっている。国内で試作を受注することで技術を蓄積するほか、人材も育てる。九大の石橋達朗学長は「半導体がブームとなるなか、九大も率先して産業に貢献

KYUSHU UNIVERSITY

Our Organization



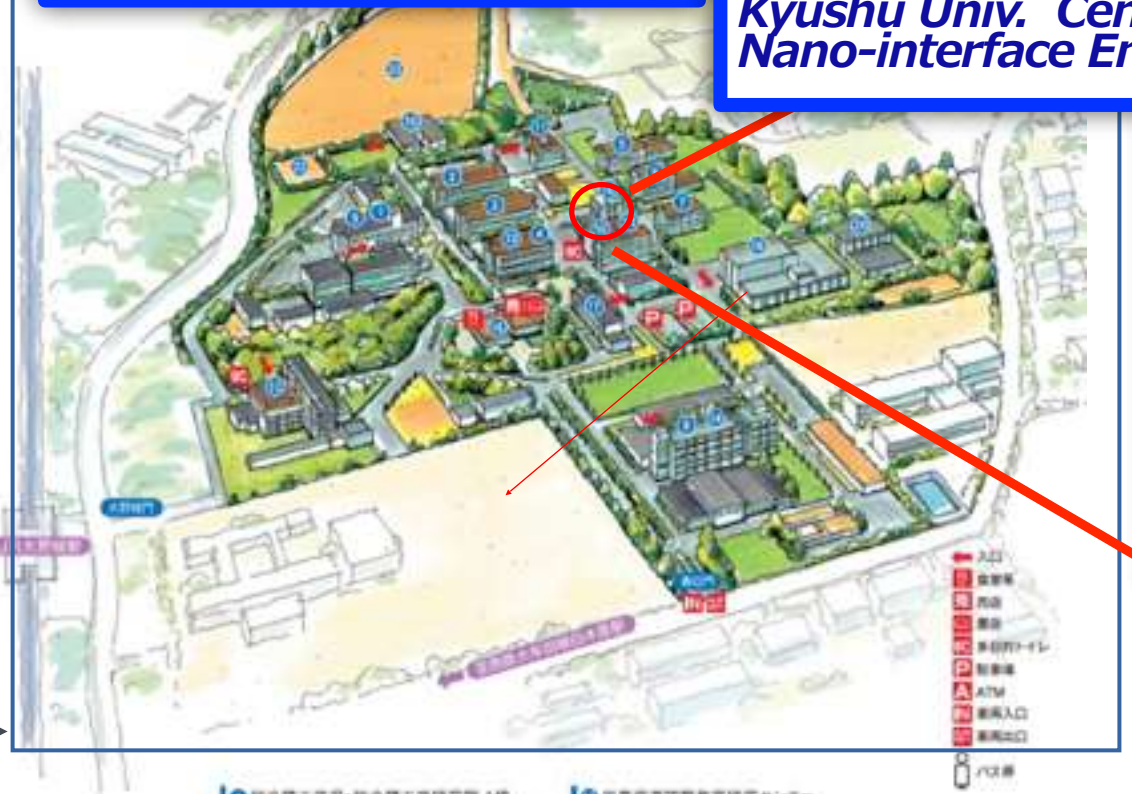
New Company EUV Exposure Service

EUV Photon

EUV Source Technology Research & Development

Kyushu-Univ. CPNE

Kyushu Univ. Center of Plasma Nano-interface Engineering



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EUV Photon

Planed Space Lab.#21

New Material Investigation with Visualization of Structural Fluctuation and Defect Mechanism

EUV Photon

■ New Material Prospect Numerical Simulation

- ■ Material Informatics (NIMS)
- ■ Quantum Chemical Calculation (AIST Quantum AI Center)

■ Structure Analysis

- ■ Vertical Distribution
  HardX-ray Photo-electron Spectroscopy
  > Spring-8
- ■ **Horizontal 2D Distribution**
  > AFM-IR (Kyushu Leading Edge Technology institute)

■ Material Synthesis

- ■ Synthesis
- ■ CVD Test

■ EUV Exposure

- ■ EUV Exposure tool
- ■ Light Source
  - ■ Synchrotron ■ DPP ■ LPP

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  - Concept of SMET: Smart Laser and Mirror Evaluation Tool
- **Summary / Acknowledgement**

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EUV irradiation road map of EUV Photon

EUV Source

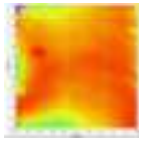
Evaluation

1st Stage of EUV Exposure

Small Power

DPP Source &Synchrotron

Semiconductor Material Evaluation



- Transmittance of EUV
- Outgassing
- Measurement and Analysis

?

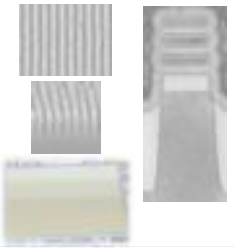
MiddlePower

LPP Source & Patterning

+

?

Leading Edge (<2nm) Semiconductor Material Development



- EUV patterning
- Resist Material Evaluation
- Pellicle Material Evaluation
- Anti-reflection Coating Evaluation

EUV Power

10W

100W

1KW

EUV Photon

EUV Exposure Tool (1)

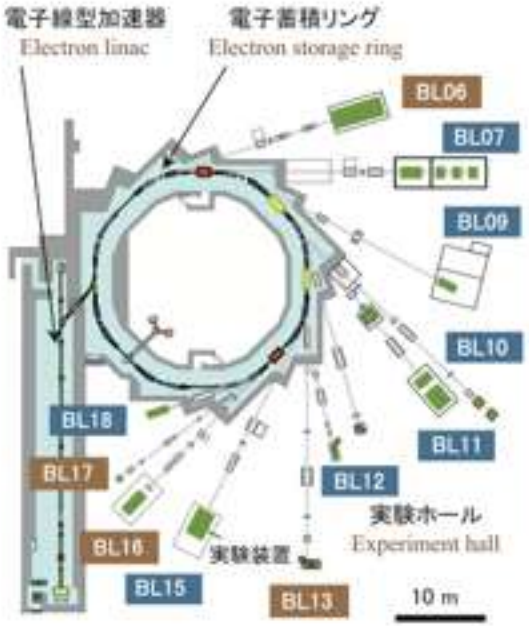
Synchrotron: SAGA SOR

佐賀県立
九州シンクロトロン光研究センター
SAGA Light Source

実験ホールとビームライン *Experiment Hall and Beamlines*

実験ホールには、放射光を同時に利用できる複数のビームラインと実験装置が配置されています。現在7本の県有ビームラインと4本の他機関ビームラインが稼働しています。

Multiple beamlines equipped with experimental apparatus are placed in an experiment hall where scientists can perform experiments using synchrotron radiation. Seven prefectural beamlines and four other agency beamlines are now in operation.



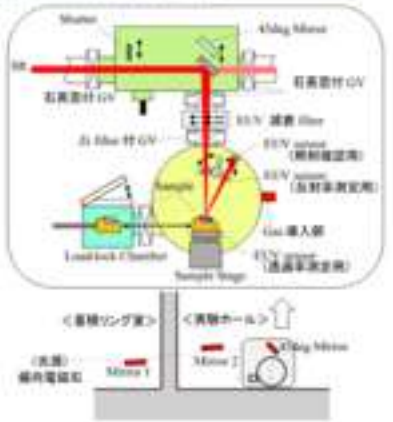
県有ビームライン（共用） *Prefectural beamlines (common use)*

名称	光源	光子エネルギー	実験手段
BL07 バイオ・イメージング	ウイグラー （4T超伝導磁石）	5 keV～35 keV 白色（ピーク8 keV）	X線イメージング（CT）、X線回折 XAFS、照射（加工、放射線効果）
BL09 照射・結晶構造	偏向電磁石	5 keV～20 keV 白色（ピーク5 keV）	単色・白色X線トポグラフィ 照射（加工、放射線効果）
BL10 ナノサイエンス	アンジュレータ （偏向可変）	40 eV～900 eV	軟X線XAFS、光電子顕微鏡 角度分解光電子分光
BL11 局所構造	偏向電磁石	2.1 keV～23 keV	XAFS、X線小角散乱 蛍光X線分析
BL12 表面界面	偏向電磁石	40 eV～1500 eV	軟X線XAFS X線光電子分光
BL15 物質科学	偏向電磁石	3.5 keV～23 keV	X線回折（薄膜、粉末）、XAFS 単色X線トポグラフィ、反射率
BL18 EUV光照射	偏向電磁石	92 eV	EUV光反射 反射率計測

*）16keV～23keVのX線を使用する場合はBL調整が必要です。事前にご相談下さい。

他機関ビームライン *Other agency beamlines*

名称	光源	光子エネルギー	実験手段
BL06 九州大学	偏向電磁石	2.1 keV～23 keV	XAFS X線小角散乱



EUV Exposure Tool (2)

DPP EUV Source

EUV Source by Energetic

EQ-10HP
High-Brightness
20Watt EUV Source
for Metrology and
Testing

EUV Exposure system by Litho Tech Japan

Agenda

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- **Summary / Acknowledgement**

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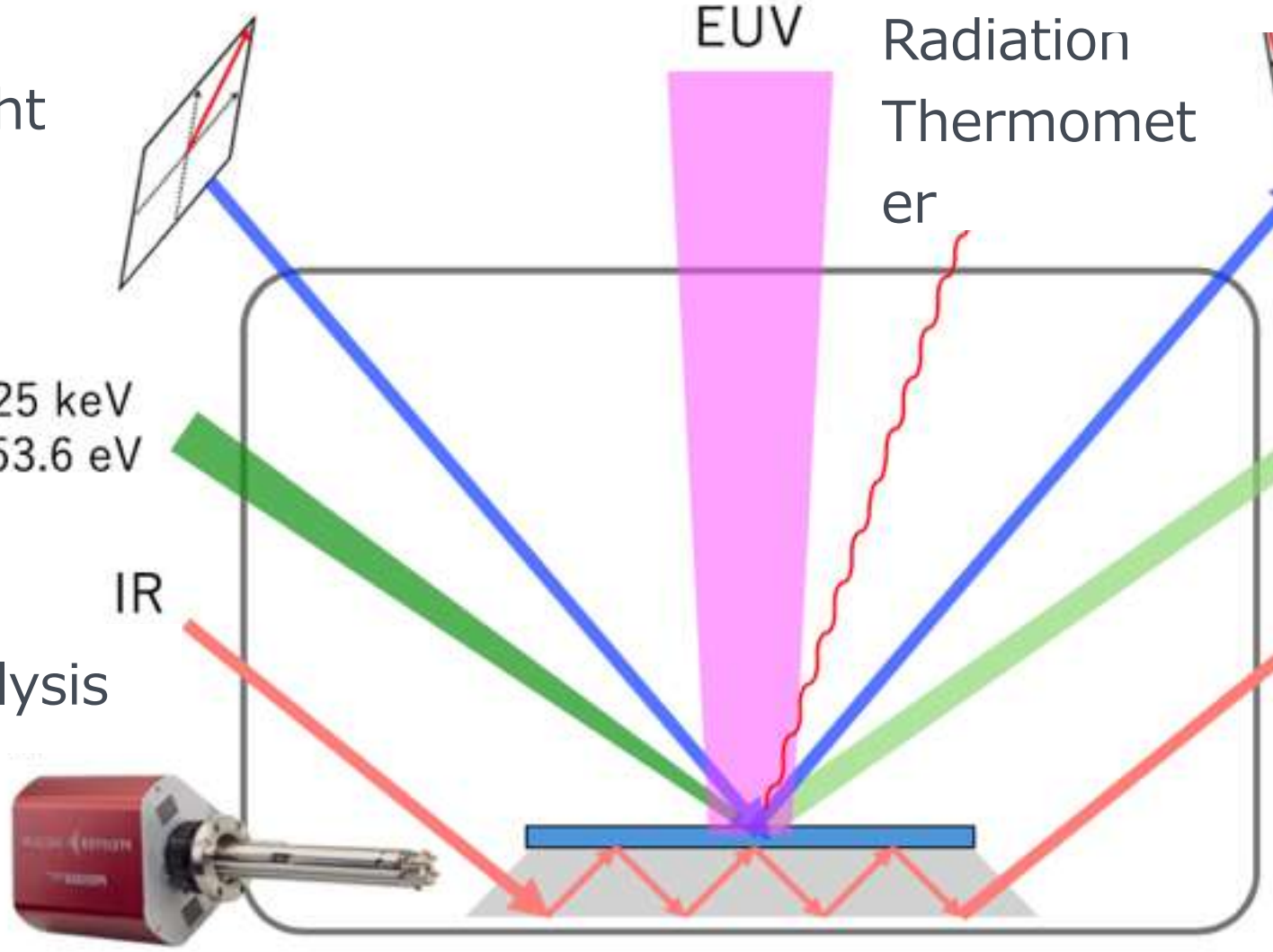
Observation tools of EUV Photon (planed)

■ Enhance In-situ Analysis



Elipsometry
(Thickness,Optical Property)

Polarized Light
(Visible)

Radiation
Thermomet
er

Photo-Electron
Analysis
Thermometer

X-ray:
GaKα : 9.25 keV
AlKα : 1253.6 eV

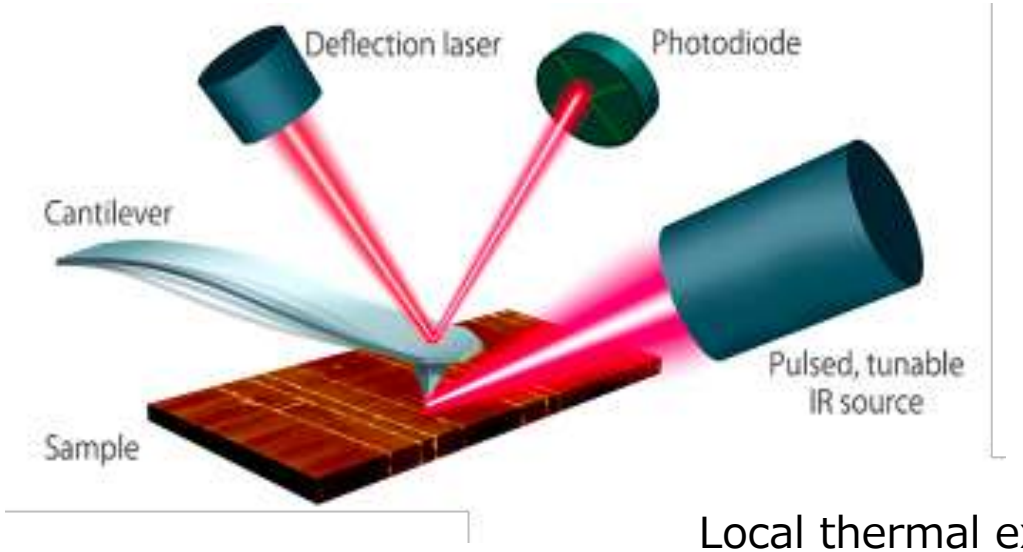
FT-IR/ATR
(Chemical bond)

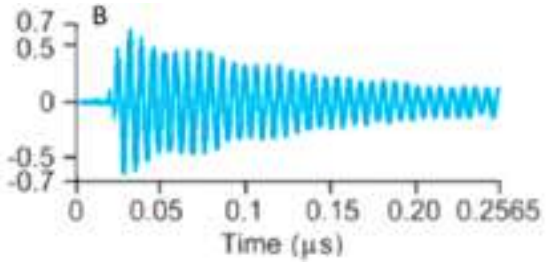
IR

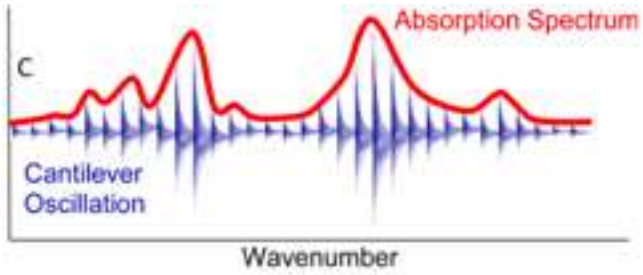
Outgas Analysis

Ex-situ Analysis
Sensitivity, Optical Property
AFM-IR・XPS・
SEM, etc.

nanoIR (AFM-IR)





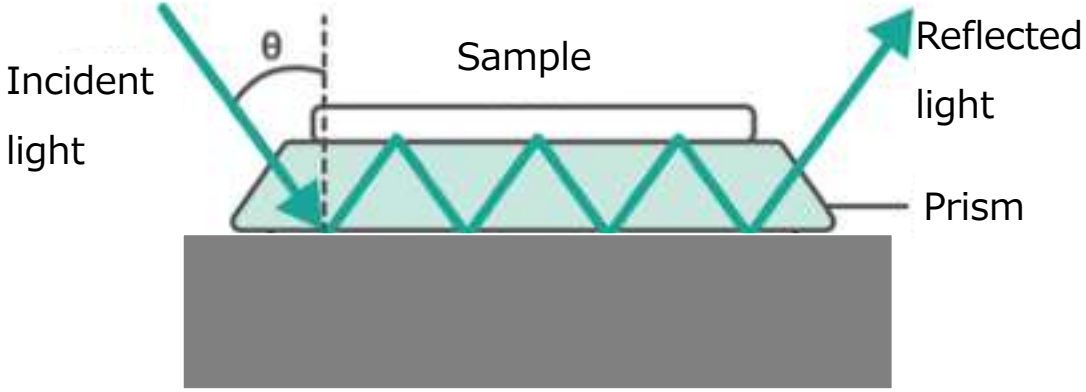


Local thermal expansion:

Vibration Amplitude

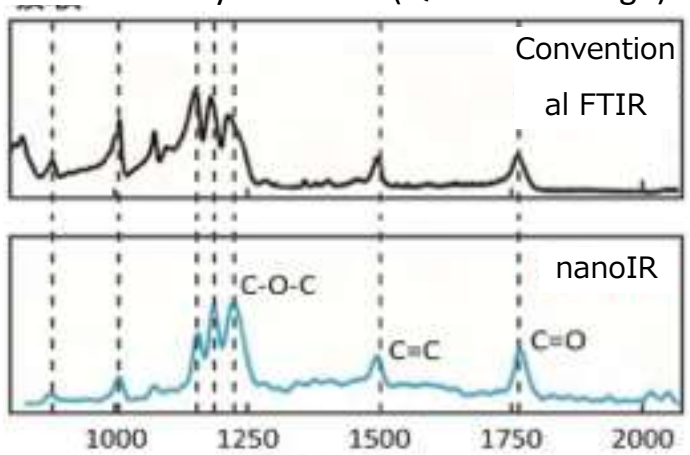
∝ Absorption rate

- Fourier Transform Infrared Spectroscopy (FT-IR)



Absorption

Polycarbonate (Quantum Design)

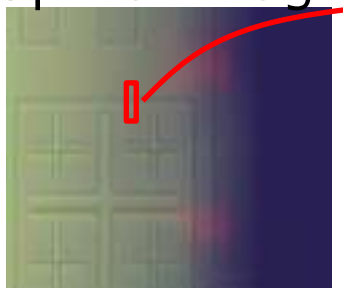


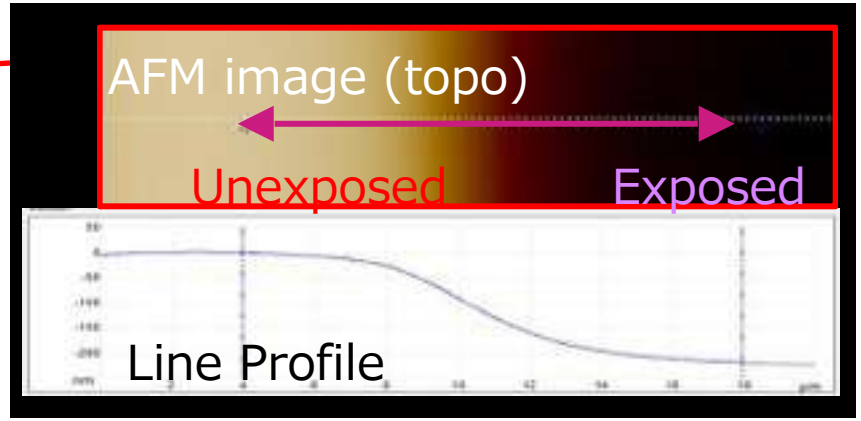
Wave number (cm^{-1})

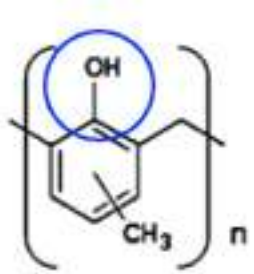
Molecular structure in photoresist latent image

- ✓ IR spectra were obtained locally near the boundary region between exposed and unexposed areas, and structural changes were analyzed.

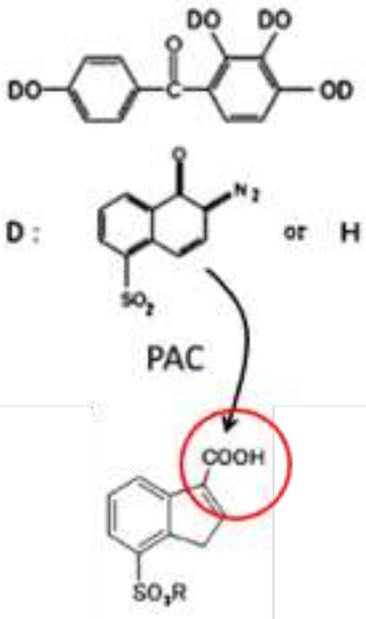
Optical image

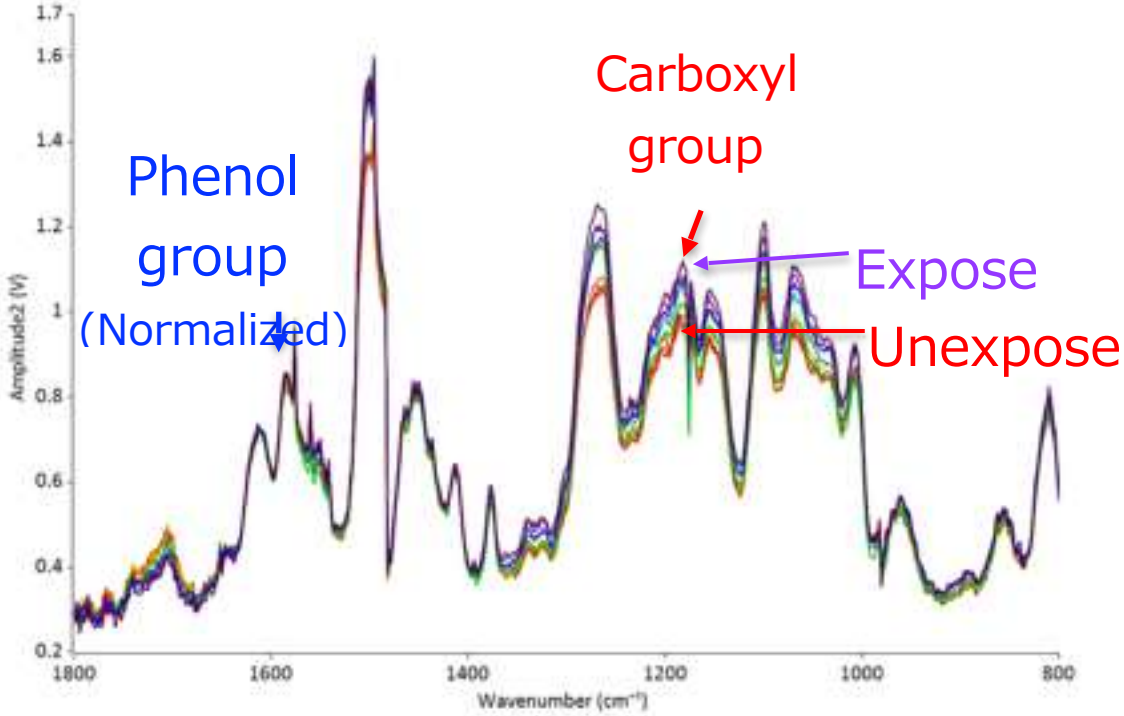






Novolak resin





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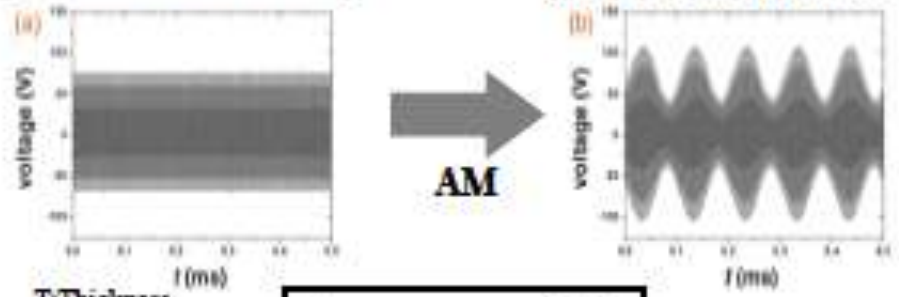
Plasma Applied Surface Conditioning

Previous Research:

CW discharge
(Continuous Waveform)

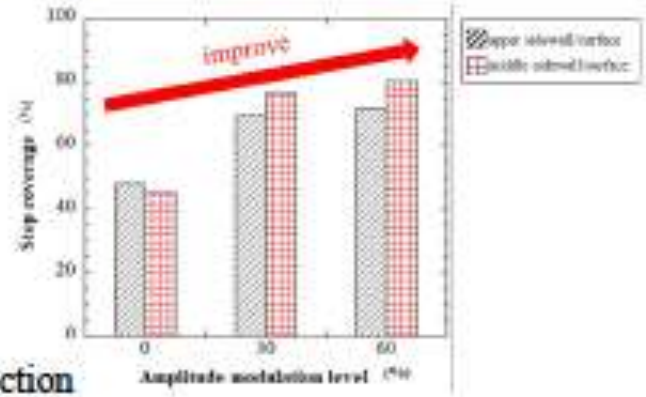
AM discharge
(Amplitude Modulation)



T:Thickness
(surface)

step coverage: S/T

S:Thickness
(sidewall)

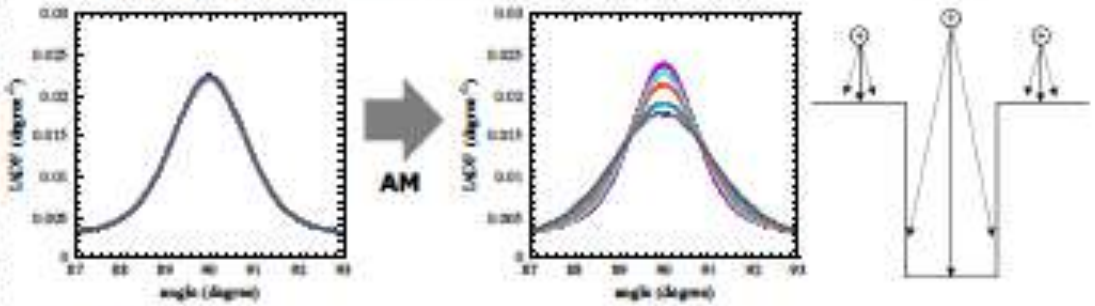


Schematic of trench cross-section

Improvement of step-coverage of trench sidewall by Sinusoidal Amplitude Modulation discharge in TEOS-PECVD[7]

Ion Angular Control by Sinusoidal AM[8,9]:

Ion Angular Distribution Function(IADF)



AM discharge can realise temporal variations in plasma parameters, such as electron density, electron temperature.

Next Step:
Investigation of the effects of other AM waveforms on capacitively coupled plasma(CCP)

This research:
Investigation of Rectangular AM in CCP by PIC-MCC Simulation

[7] K. Kamataki, *et al.*, Proc. of 42nd International Symposium on Dry Process (DPS) G1 (2021).
[8] K. Abe, *et al.*, Jpn. J. Appl. Phys. 60, 106003 (2022).

Semicon Japan 2024 出展

2024/12/11-13

EUV Photon

EUVフォトン株式会社
代表取締役 浦野 健正
CSO 小川 直
CTO 鏡口 計

プロジェクトアドバイザー
九州大学教授 白谷 正治

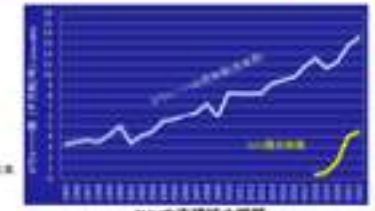
半導体サプライチェーンの国内集約に向けた「EUV照射センター」

背景

設計・作成 → 前工程（ウェハーの上に半導体チップを作成） → 後工程（チップを切り分け製品化）

フォトレジスト塗布 → 露光・現像（回路パターンの焼付）

フォトレジストの世界シェア


EUVの市場拡大期待
（半導体生産量の3分の1がEUV用）

EUV露光イメージ

フォトレジストの世界シェアのうち**9割**を**日本メーカー**が占めている。
EUVリソグラフィの台頭に伴い新素材の研究が必要となる。

課題

- EUV照射はできる国は**オランダ・ベルギー**のみ（国内では不可）
- 待ち時間が長い 通常 **10ヶ月** 程度
- 試験費用が高額 1回 **2,000万円** 程度
- 量産LPPと照射DPPは光源の性質が異なる

ソリューション

- 試験費用を大幅減額 最大 **4分の1** 程度（約500万円～）
- 待ち時間を大幅短縮 最大 **10分の1** 程度（約1～2か月）
- 独自の解析技術を用いたコンサルティングサービス

国内におけるEUV照射機会を提供
佐賀シンクロトロンを用いた
EUV照射サービス開始

EUV Photon
- 国内トップのEUV照射ノウハウを保有
- 国内有数の解析機器を保有
- 高電圧に耐えうる施設を保有

連絡先

九大OIP株式会社（福岡市西区九大新町5番5 研究開発棟111号室）
contact@euvphoton.jp
https://www.kyushu-u.ac.jp/ja/notices/view/7730/

OIP

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KYUSHU UNIVERSITY

Investigation of EUV Lithography technology related Security Export Control in Kyushu Univ. (2023-2024)

EUV Project Team

EUV-Litho Group

Director
Dr. Shiratani

Dr. Suzuki
Exposure System
(Formerly N)

Dr. Mizoguchi
Light Source
(Formerly G)

EUV Source Group

- Dr. Suzuki Optical System (Formerly C)
- Stage Mr. C (S)
- Metrology Dr. Usami (G)
- EUV chamber Dr. Yamagata (Q)
- Driver CO2 Laser Dr.Nakamura (Q)
- Solid State Laser Prof. Kobayashi Dr. Midorikawa (R)
- B-EUV Dr Higashiguchi(U)

Quantum and Photonics technology Research Center in Kyushu University

Collaboration

- Tokyo Univ. Dr. Mimura (TBD)
- Company S (TBD)
- AIST (TBD)
- EUV chamber Team (TBD)
- Dr.Tomita Hokkaido Univ.
- EUV Driver Laser Team (TBD)
- ISSP Tokyo Univ.
- RIKEN
- Utsunomiya UNIV.

Manufacturer

- Company A
- Company B
- Company C
- Company D

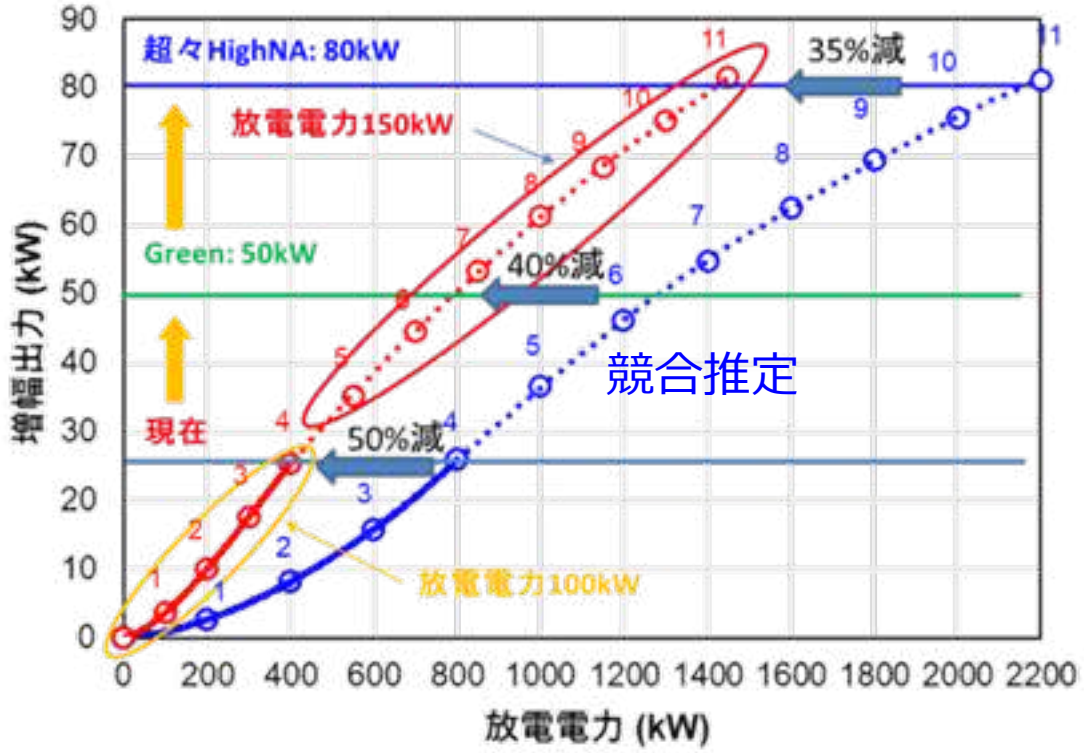
国産EUV光源開発の課題（１）　CO2レーザパワーアップ

■ ポイント

- 5段目以降の放電電力を150kWに高出力化
- 1000W：11段増幅、600W：７段増幅　にて実現。
- 競合に対して約35%の電力削減（推定）

MITSUBISHI ELECTRIC Changes for the Better

放電電力と増幅出力

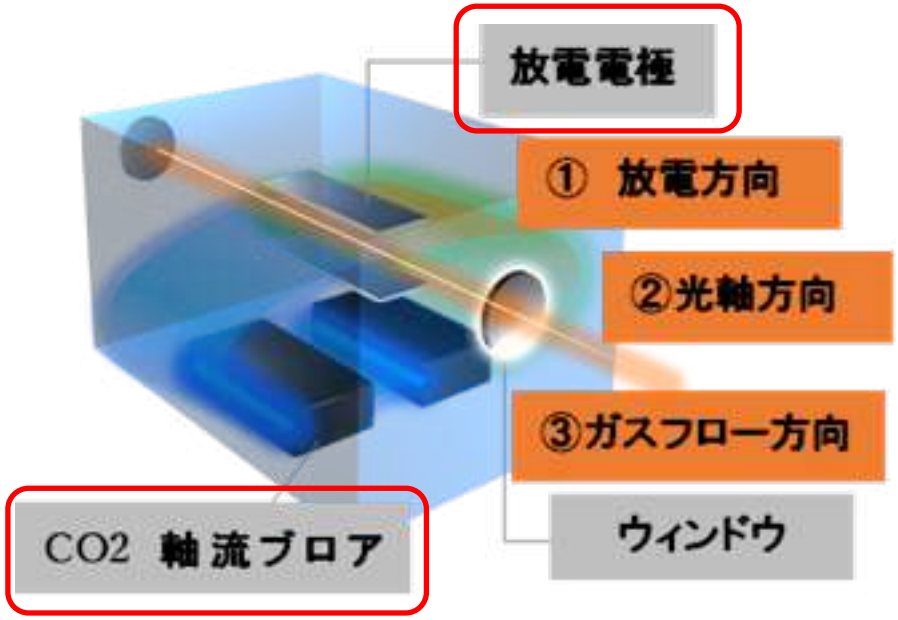


■ メンテンナンス間隔延長

- 放電電極、ブロアの長寿命化により、ランニングコストを低減

MITSUBISHI ELECTRIC Changes for the Better

3軸直交方式CO2レーザ増幅器

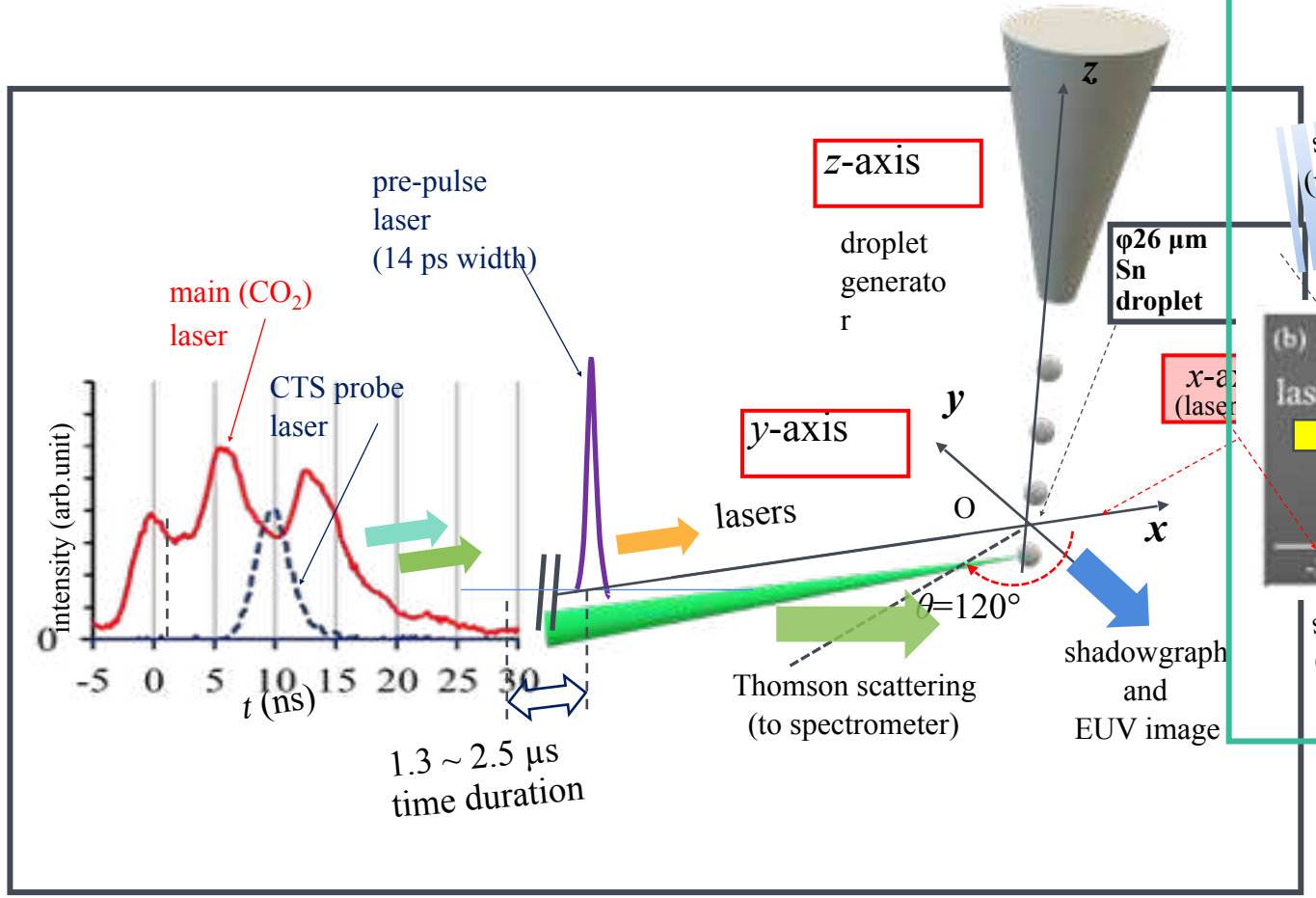


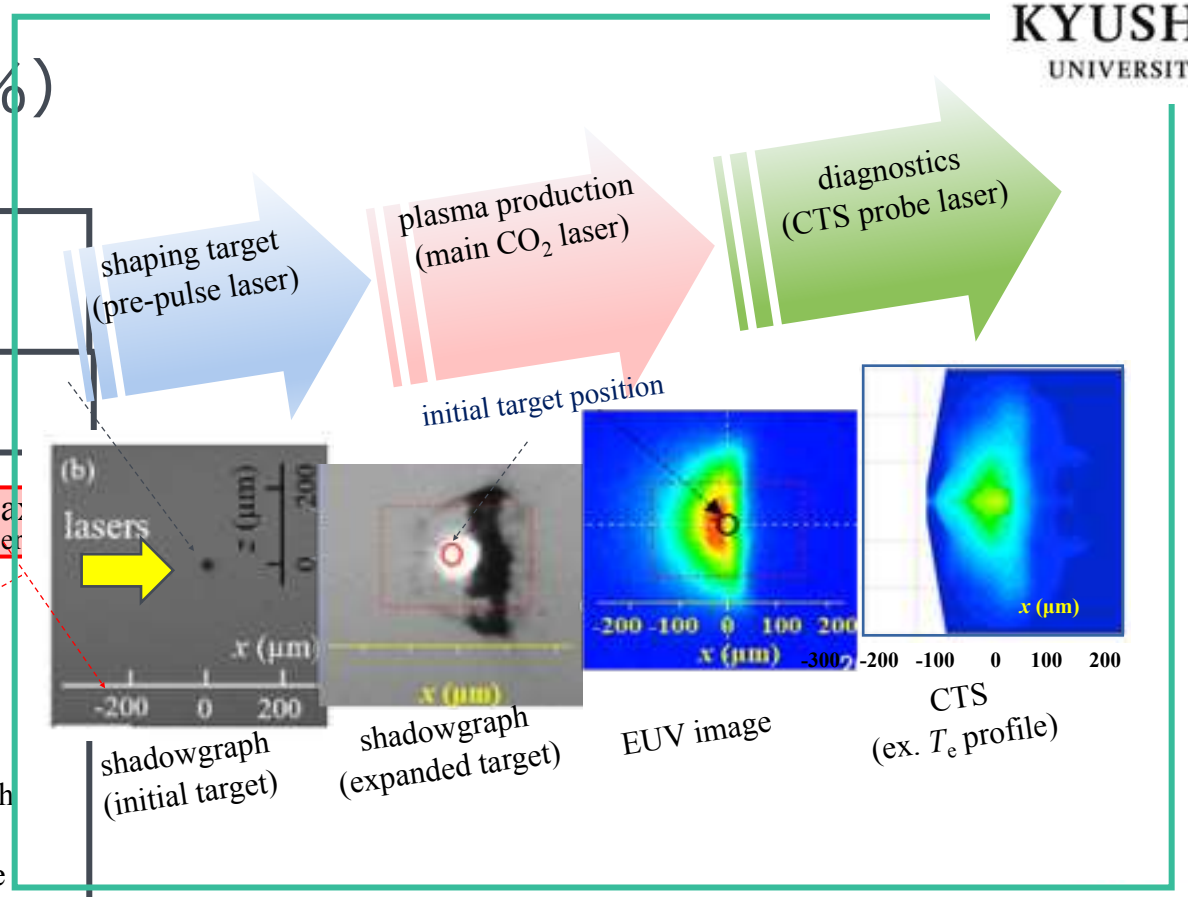
EUV Photon

国産EUV光源開発の課題（２）　EUVプラズマ発光効率の改善

KYUSHU UNIVERSITY

理論的には10%超可能（現状製品４～６%）





CTS: Collective Thomson Scattering

Tomita, K., Pan, Y., Sunahara, A., Kouge, K., Mizoguchi, H., & Nishihara, K. (2023). Observation of plasma inflows in laser-produced Sn plasma and their contribution to extreme-ultraviolet light output enhancement. Scientific Reports, 13(1), 1825.

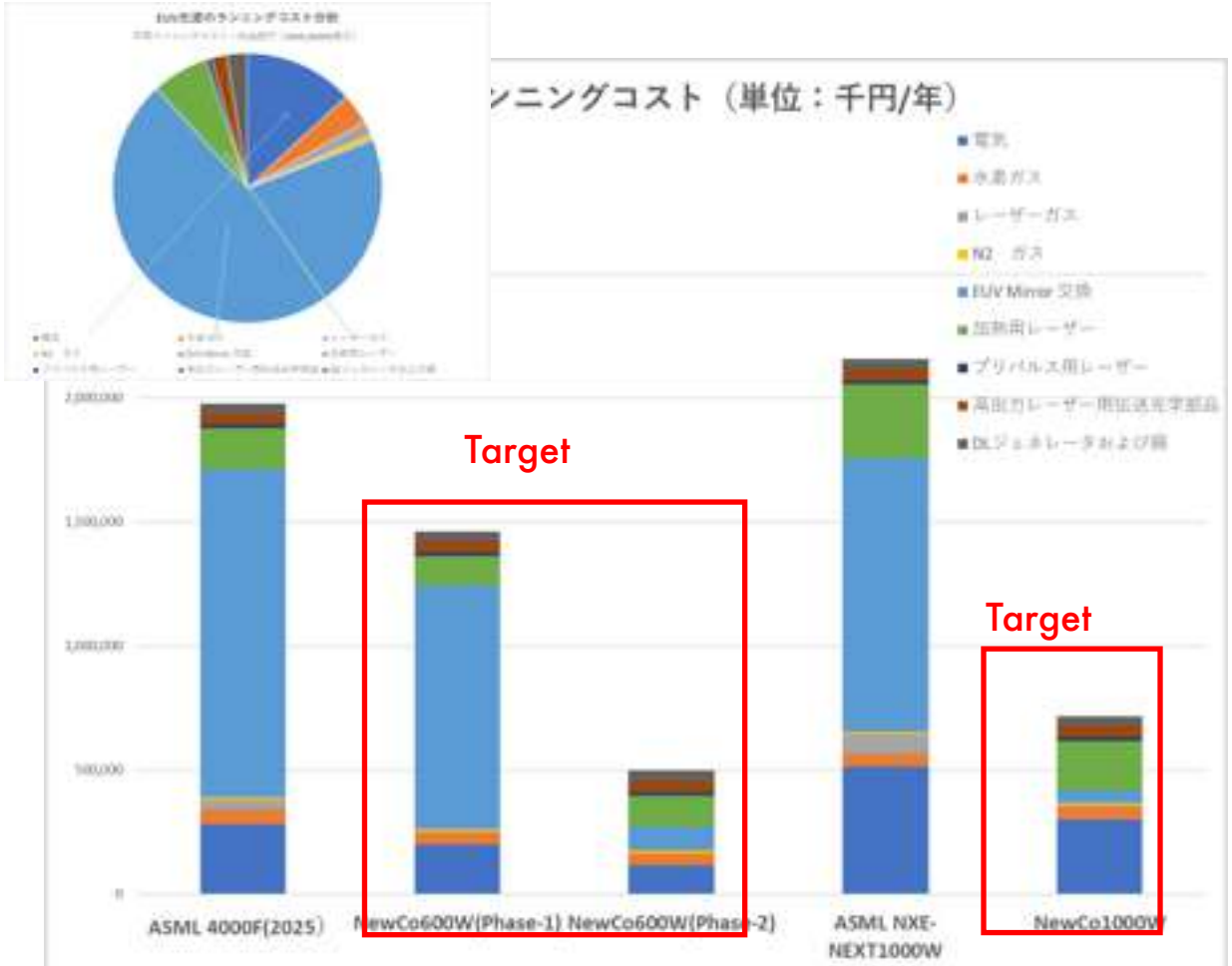
北海道大学 EUV Photon

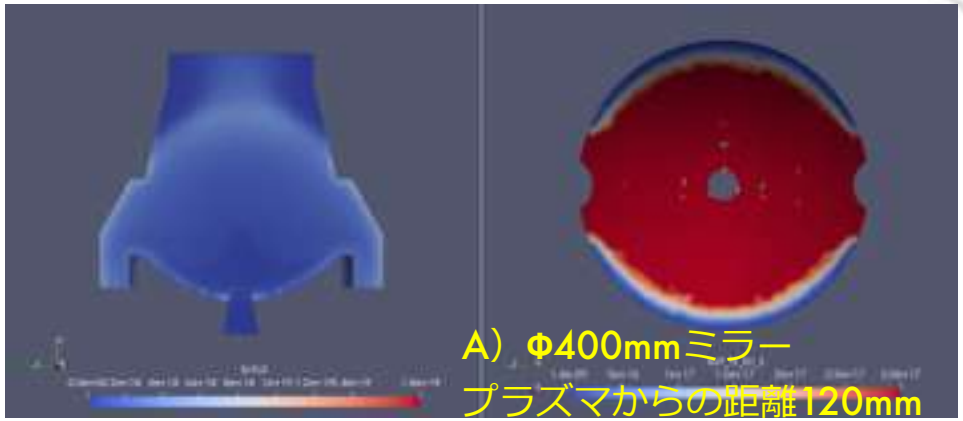
日本応用物理学会

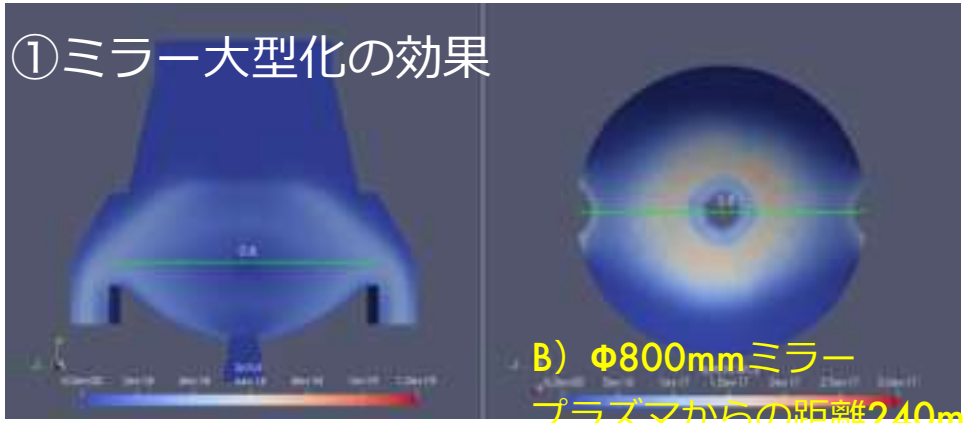
国産EUV光源開発の課題（3）

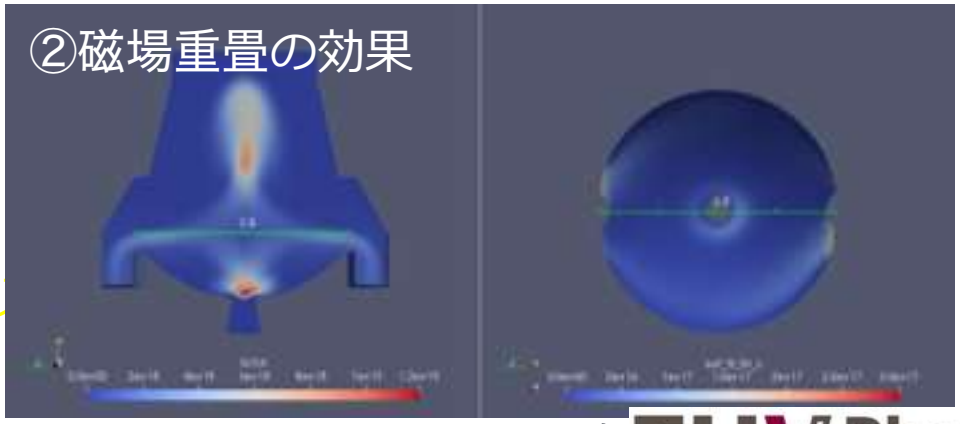
集光鏡メンテナンスコスト低減

- ミラー大型化、スマート磁場で、スズ付着レート低減。長寿命化が期待される。
- 目標：　集光鏡交換　　１回／年
  反射率低下速度　< 0.01%/Gpls









チャンバ断面　　コレク

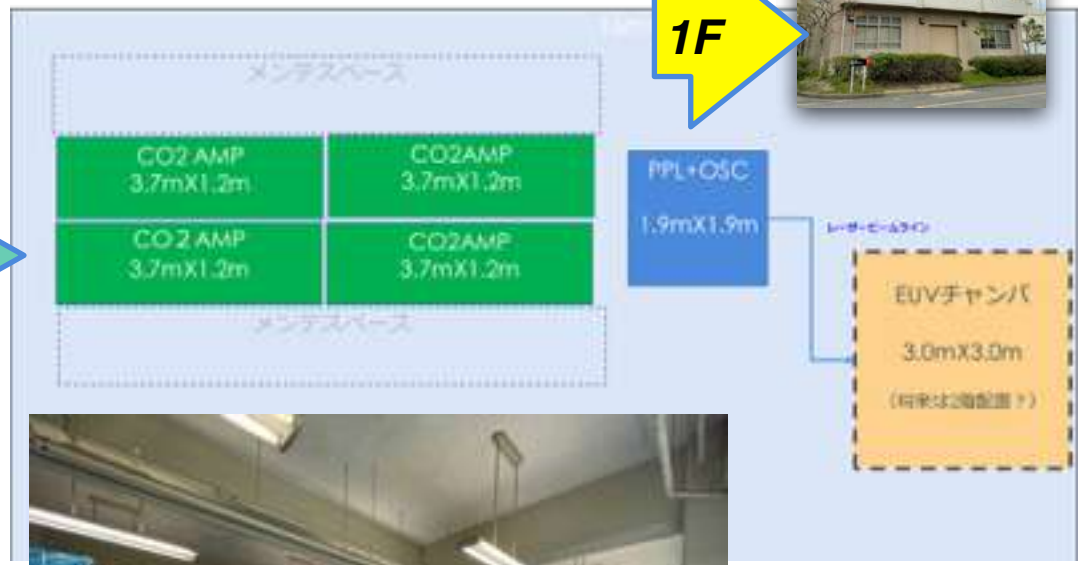
EUV Photon

Kyushu-Univ. CPNE

Kyushu Univ. Center of Plasma Nano-interface Engineering

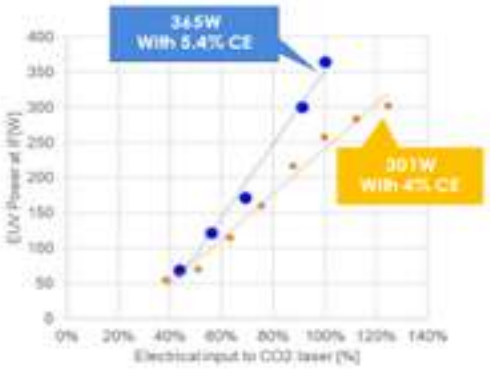
Kyushu Univ. 25kW CO2 Driver Laser System

・Driver Laser system is donated by Gigaphoton Inc. in July 2022.
・We already fix design for higher power operation

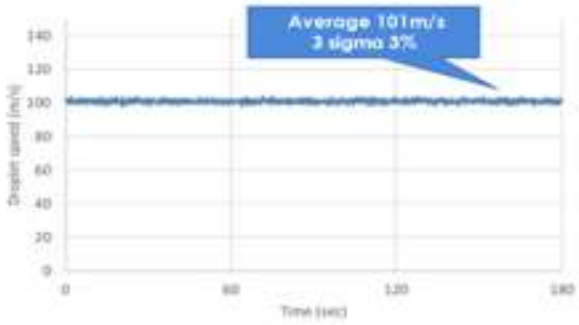


GIGAPHOTON

■ >360W with >5% CE at 100kHz operation is demonstrated at Pilot#1 (short term)



■ Higher Droplet speed(>100m/s) realized 1mm spacing and demonstrated more stable EUV generation



NGLR研究会：2021年第3回定例会(WEB) 2021.11.9

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次世代半導体微細加工プロセス技術　最大135億円程度】

- **半導体**は、5G・ビッグデータ・AI・IoT・DX等のデジタル社会を支える重要基盤であり、経済施策を一体的に講ずることによる安全保障の確保の推進に関する法律」（経済安全保障推進法）に基づく**特定重要物資**としても指定されている。
- 日本の半導体産業の地位は、1990年代以降、徐々に低下しており、国内の半導体製造基盤を確保・強化していくことが戦略的に重要。とりわけ、デジタル技術の利用が拡大する中では、**電子機器の更なる高性能化に必要不可欠な半導体微細加工プロセス技術を強化**していくことが必要。
- そのため、本構想では、現在、半導体関連企業が共通して認識している技術課題の延長線上には無いような、最先端のEUV（Extreme Ultra Violet）露光技術を超える全く新しい技術や、半導体製造以外の用途の可能性を開拓することも視野に、革新的なレーザー技術・ミラー作成技術の開発、及びその周辺技術の高度化を図り、**よりエネルギー効率が高く省エネ・省スペースを実現する技術を獲得**することを目指す。また、実用化に向けた要素技術の検討などの企業導入に向けた方策の検討を進める。

1 EUV露光励起用レーザーの開発

- EUV光を発生させるレーザー（ドライブレーザー）の開発、特にレーザー発振器や前置増幅器、増幅器、エネルギー伝搬計測 制御技術などの開発を行う。

2 EUV露光に用いるミラー開発

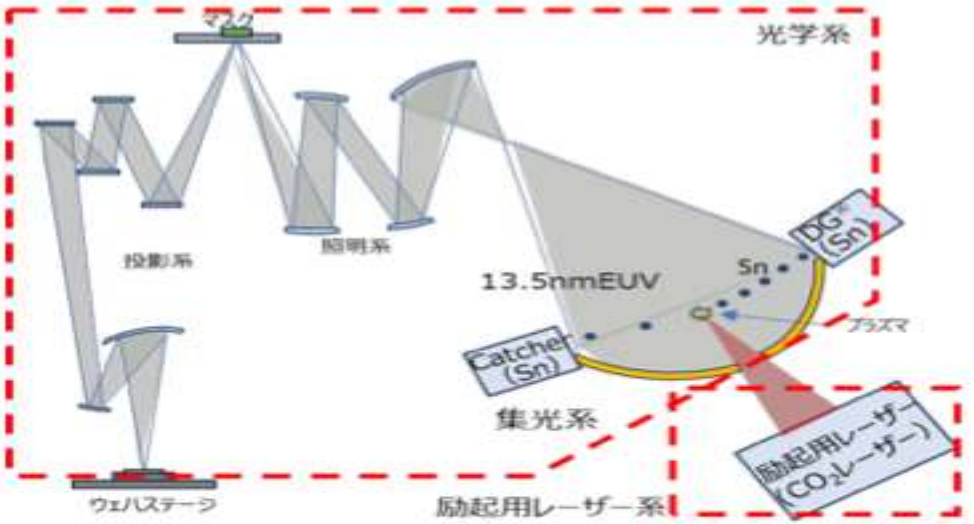
- EUV用の大型ミラーの作成に必要な超微細研磨技術、膜技術、超精密ミラーの特性計測技術などの開発を行う。

3 半導体チップを実装する工程での次世代微細加工プロセスの開発

- 様々な種類のチップに柔軟に対応可能となるよう、マルチスケールの微細加工に関するデータベースの整備、高速条件出しのためのAI技術開発等を行う。

4 最先端露光技術の更に先を見据えたBeyond EUV実現も念頭に入れた革新的基盤技術の開発

- EUV露光用の新規高性能光源の開発に向けた要素技術開発（低消費電力で高出力を実現できる技術開発等）や、既存のEUV露光技術の更にその先を指向した光源、光学系、材料系、計測技術等の要素技術開発（フィージビリティスタディ）を行う。



※ Droplet Generator

現在のEUV露光システムのイメージ図

支援対象とする技術

▶次世代半導体微細加工プロセス技術

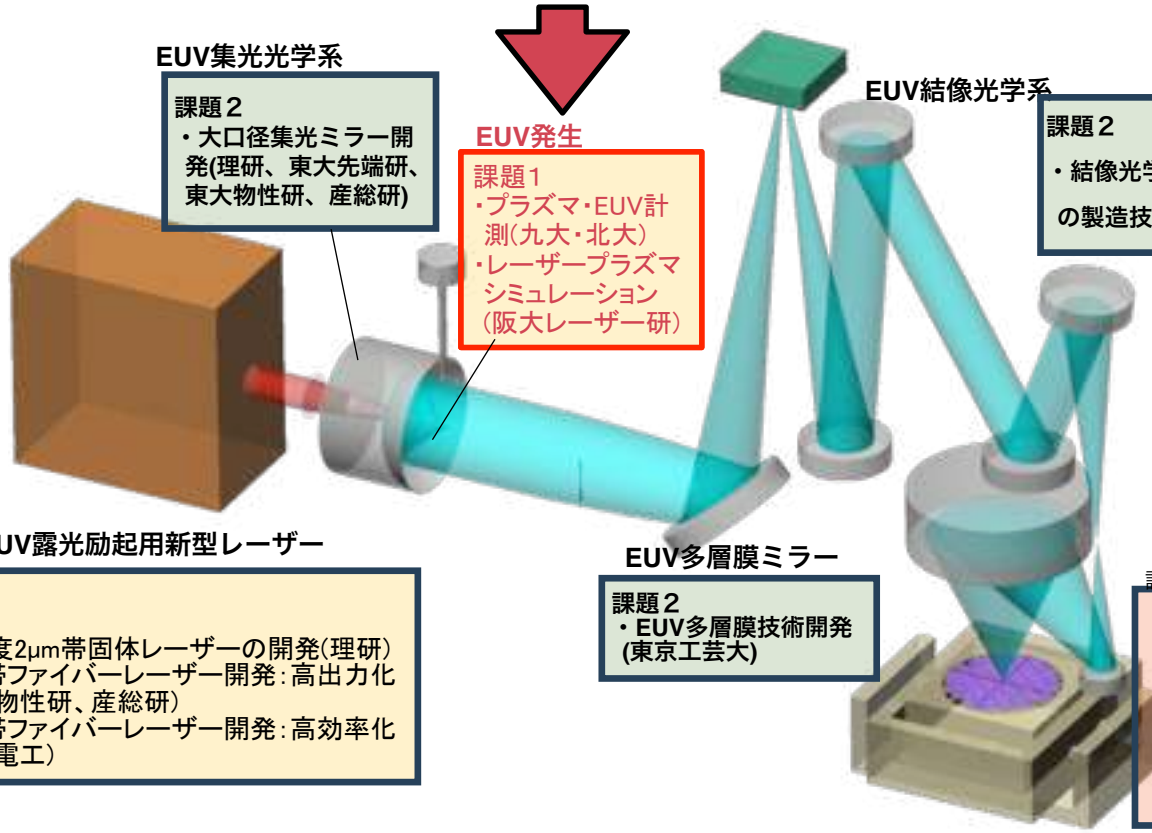
K Program
経済安全保障重要技術育成プログラム

次世代半導体微細加工プロセス技術　概要

本提案では、我が国においてEUV露光に関連する最先端の技術を有する機関と人材を糾合し、次世代半導体技術の更なる発展に不可欠とされる革新的基盤技術の研究開発を推進する。具体的には、将来のEUV光源に必要な高出力で高効率な新しいレーザー光源と大口径で高精度なミラーの加工と成膜技術、そして後工程に必要とされるレーザー微細加工において、これまでの技術を大きく凌駕し将来キーテクノロジーとなり得る革新的技術の確立を目的とする。計画の推進にあたっては、各テーマにおいて従来の技術に捕らわれず科学的知見をもとに基礎から見直すことにより、広く当該分野の新たな発展と価値の創出に資することを念頭に、我が国の半導体微細加工の国際的地位の向上に貢献することを目指す。

「次世代半導体微細加工プロセス技術」 研究総括(Headquarters)：代表 理化学研究所 緑川克美

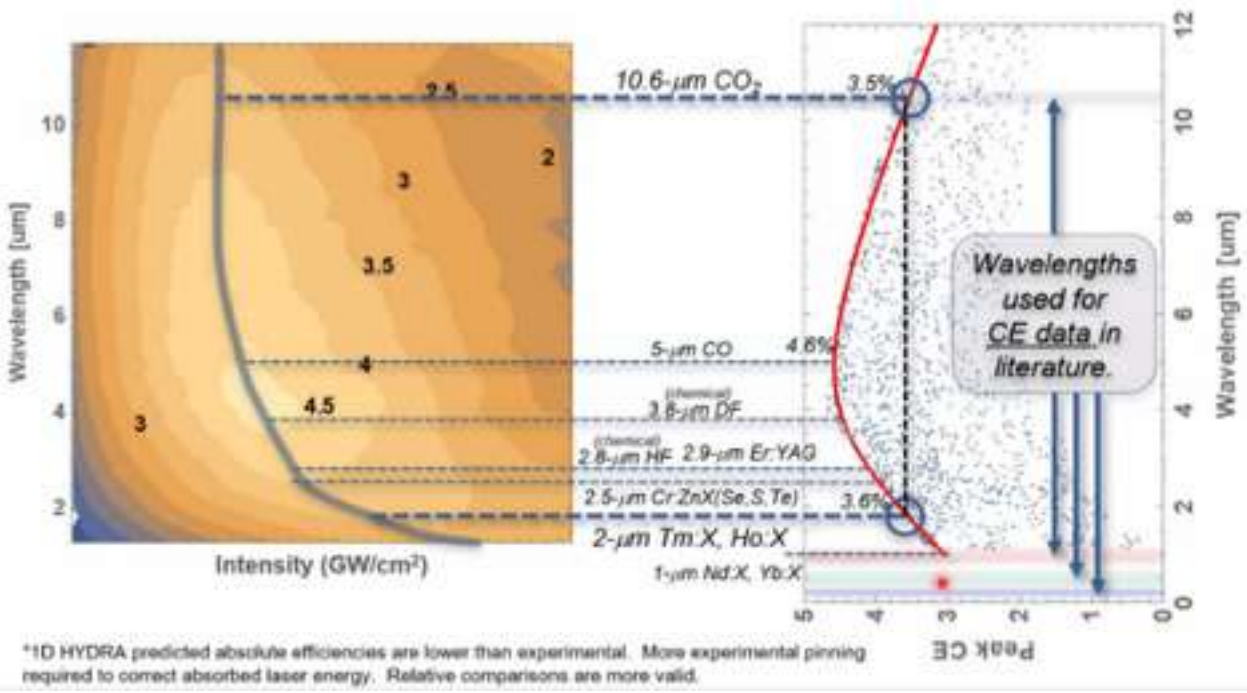
- 課題１：EUV露光励起用新型レーザーの開発：代表　理化学研究所 高橋栄治
- 課題２：EUV露光に用いるミラー開発：代表　理化学研究所 山形豊
- 課題３：半導体チップを実装する工程での次世代微細加工プロセス：代表　東京大学 小林洋平



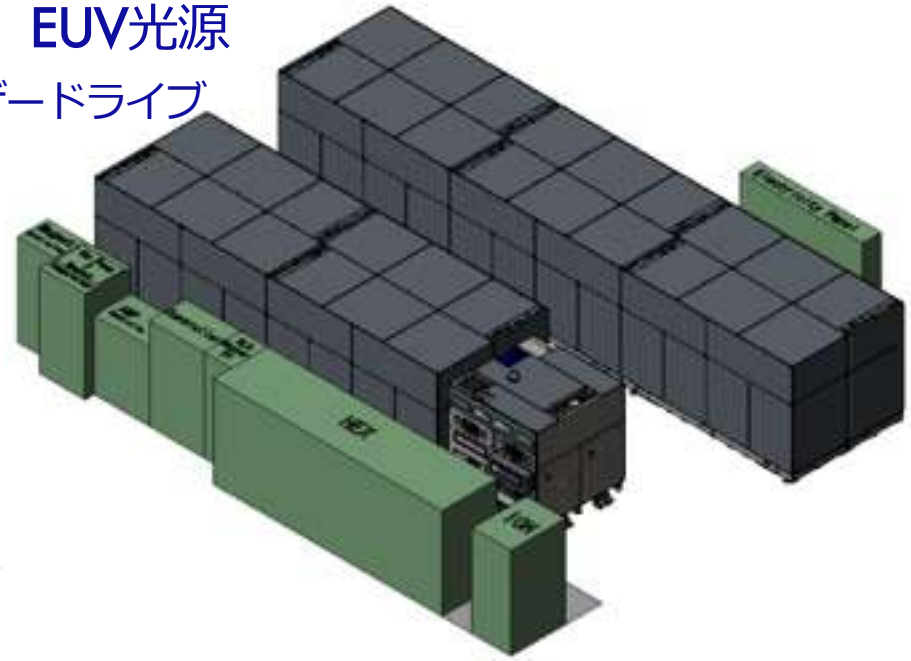
国産EUV光源開発のポイント　2μm固体レーザ駆動

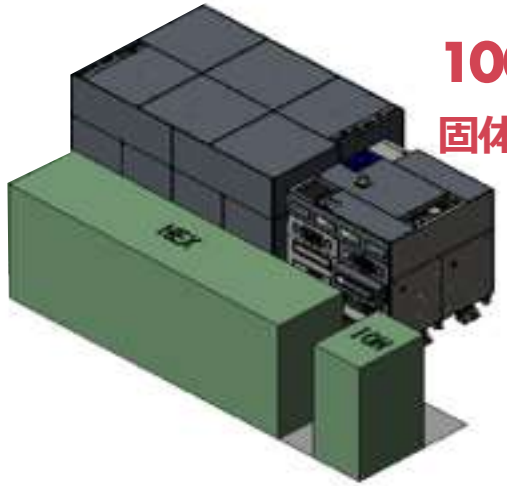
K Program
経済安全保障重要技術育成プログラム

＜経緯・コンセプト＞
ＥＵＶＡ、Leading ProjectでＣＯ2レーザー／錫の組み合わせが
高効率となることを九州大学で実験的に発見（2007年）
↓
ＣＯ２レーザードライブ＋錫ターゲットが主流に。**更に高出力化**
求められ、レーザーシステムが巨大化（現在）
↓
近年の進歩著しい中赤外域の固体レーザの利用を検討（2030年以降？）
・高プラグイン効率　CO2：5%以下　→ 固体：～20%以上
・コンパクト化



1000W　EUV光源
CO_2レーザードライブ





1000W　EUV光源
固体レーザードライブ

EUV Photon

Agenda

- **Introduction:**
  DUV/EUV Semiconductor Lithography and light Source
- **New Company: EUV Photon**
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- **Summary / Acknowledgement**

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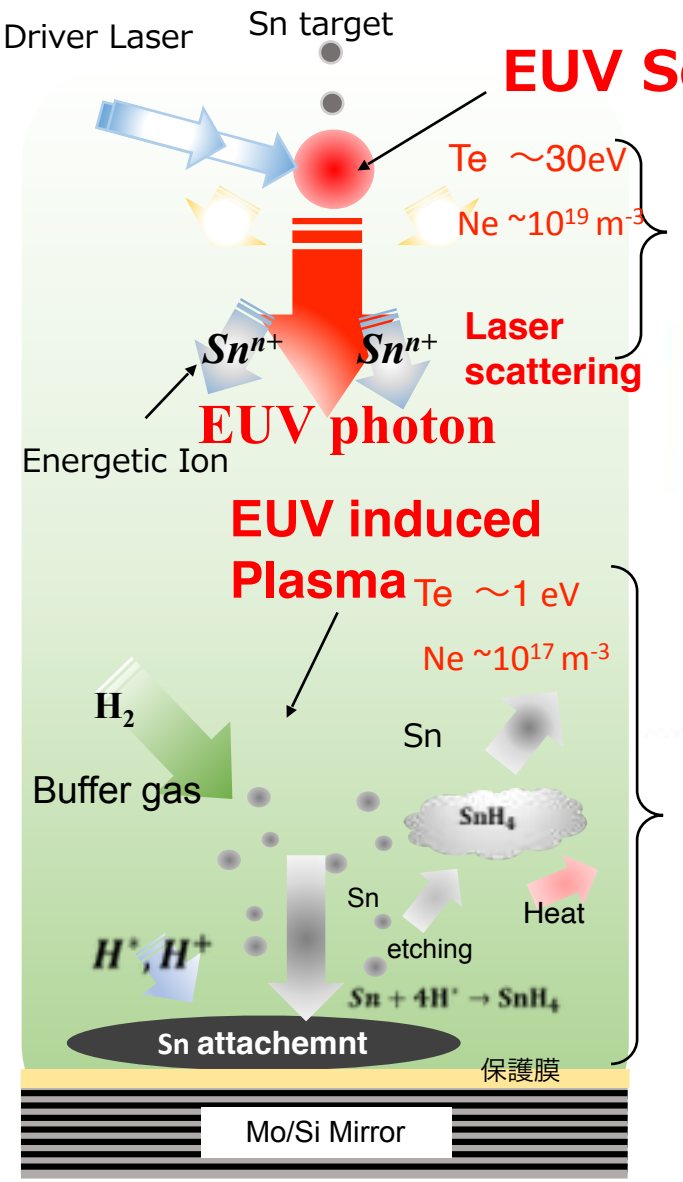
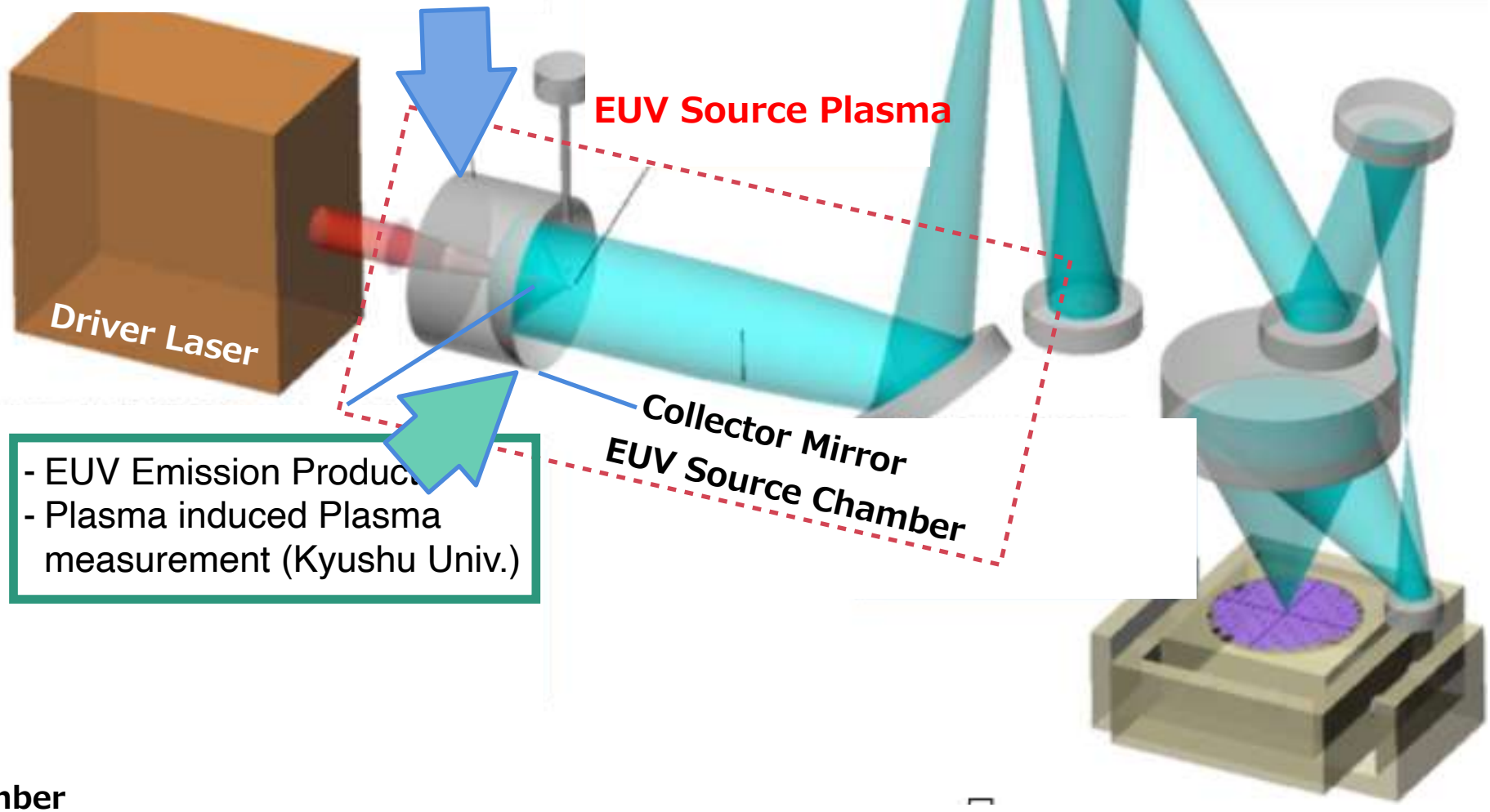
Image of EUV Source Research in Kyushu-Univ.

K Program
経済安全保障重要技術育成プログラム



Plasma Dynamics in the EUV Chamber

・Source Plasma Measurement (Hokkaido Univ.)



- EUV Emission Product
- Plasma induced Plasma measurement (Kyushu Univ.)

EUV Source Plasma Group

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大阪大学 THE UNIVERSITY OF OSAKA
Yoshimura

北海道大学 HOKKAIDO UNIVERSITY
Tomita

KYUSHU UNIVERSITY
Yamagata

KYUSHU UNIVERSITY
Nakamura

KYUSHU UNIVERSITY
Mizoguchi

EUV Plasma Simulation G

シミュレーション開発

- スズデータベースの高精度化
- 長パルス照射への対応
- 実験との比較ツール構築

EUVプラズマデザイン

- レーザー条件最適化
- ターゲット条件最適化

連携

EUV Plasma MeasurementG

シミュレーション検証用プラズマ生成・計測

- 長パルスレーザープラズマ実験
- 多段レーザー照射実験

プラズマ計測器開発

- プラズマ温度・密度等計測器
- EUV光強度・瞬間イメージング

開発→移設

EUV Induced plasma G

EUV光学系（理研）評価

周辺プラズマ計測系

計測器開発用チャンバ

Driver Laser G

チャンバ仕様

シューティングシステム構築

プリパルスレーザ

2μmレーザ（理研）評価

SMET G

ターゲットチャンバ動作システム

制御ソフト構築
国内ソフトウェア会社

EUV光源ターゲットチャンバー
国内メーカー

ターゲット供給装置
国内メーカー

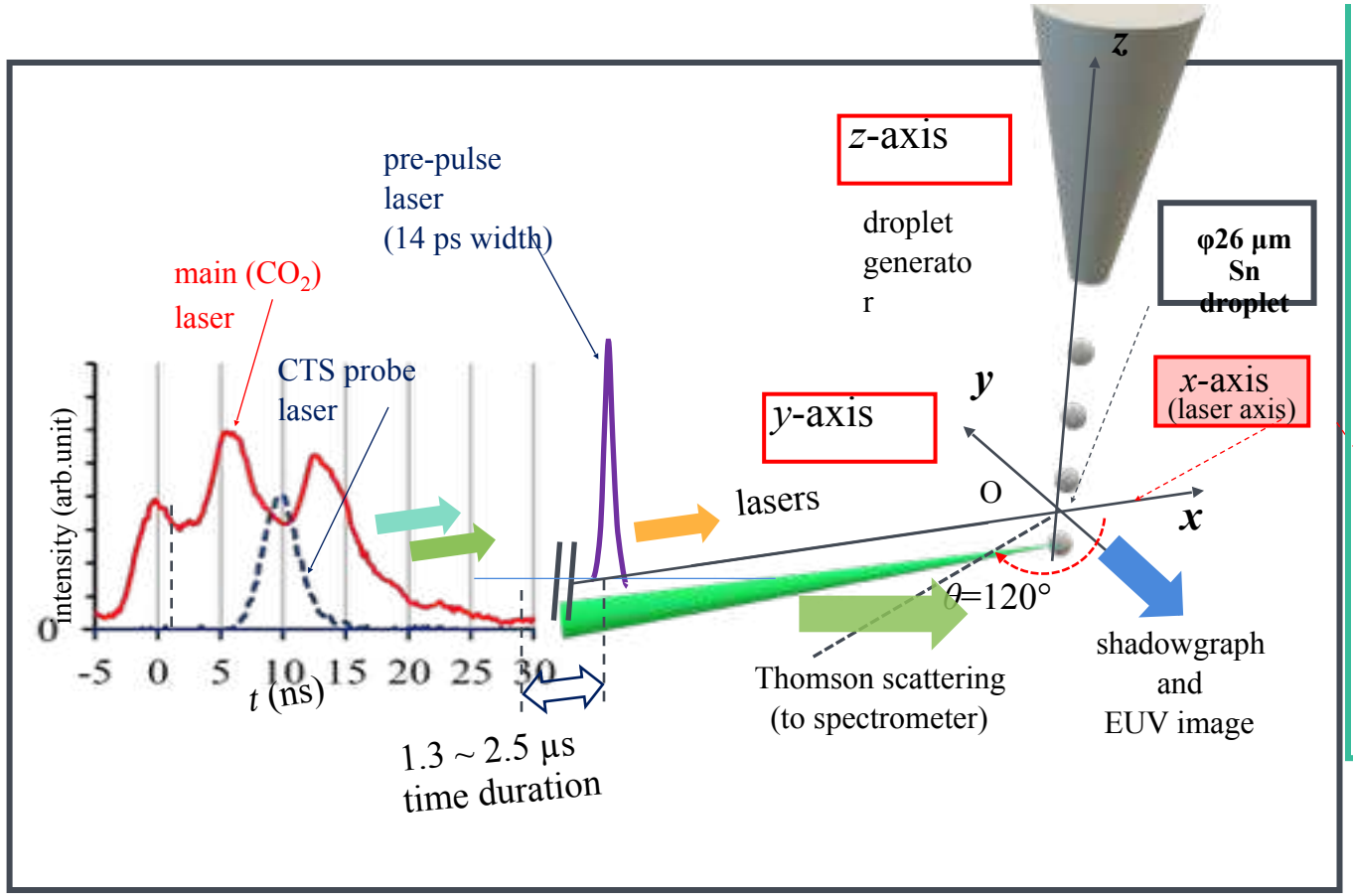
立上→移設

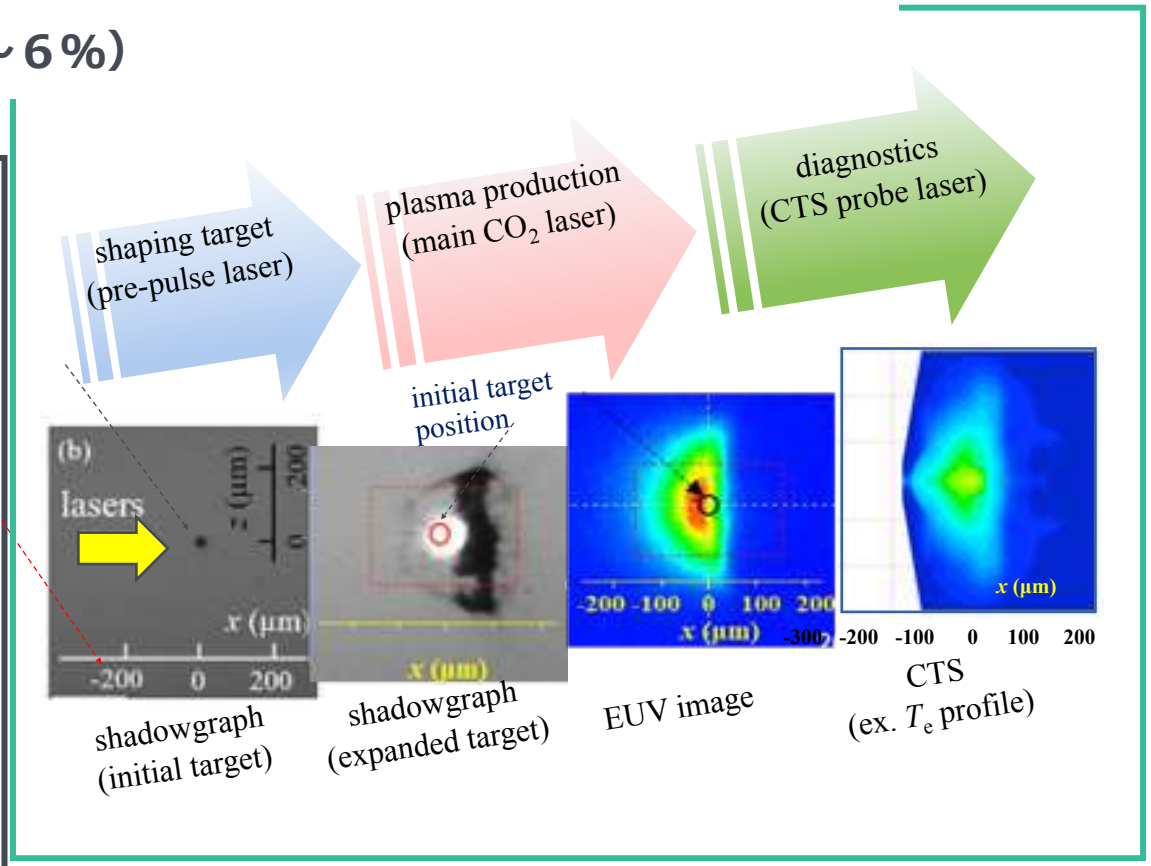
SMET

EUV Plasma diagnostic technology

Key for higher efficiency EUV Source

Target conversion efficiency >10%（at present 4～6%）





CTS: Collective Thomson Scattering

Tomita, K., Pan, Y., Sunahara, A., Kouge, K., Mizoguchi, H., & Nishihara, K. (2023). Observation of plasma inflows in laser-produced Sn plasma and their contribution to extreme-ultraviolet light output enhancement. Scientific Reports, 13(1), 1825.

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北海道大学 HOKKAIDO UNIVERSITY

(1) Plasma Dynamics of EUV Plasma by Thomson Scattering

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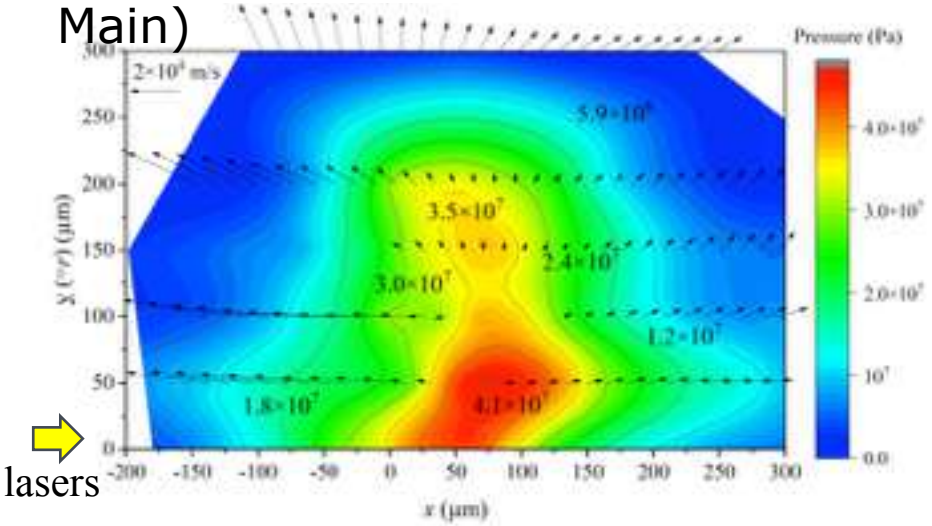
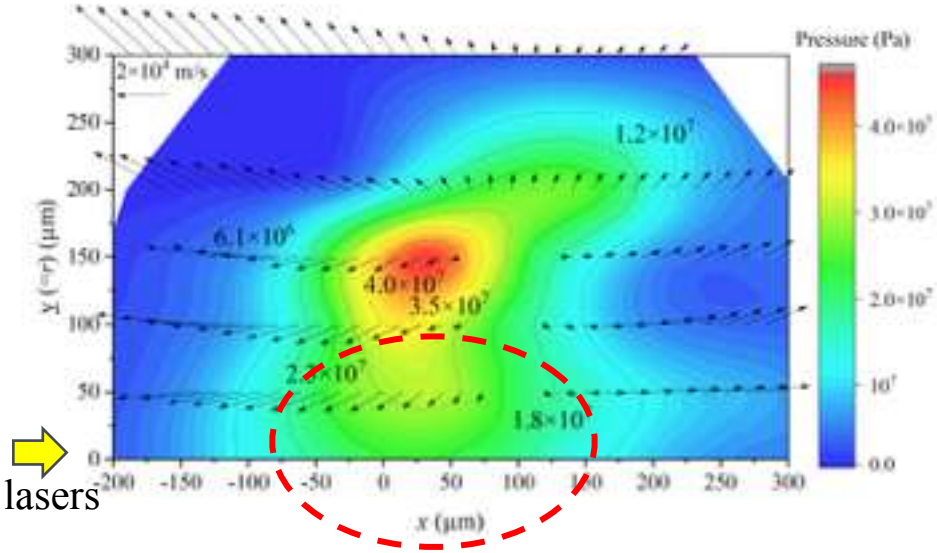
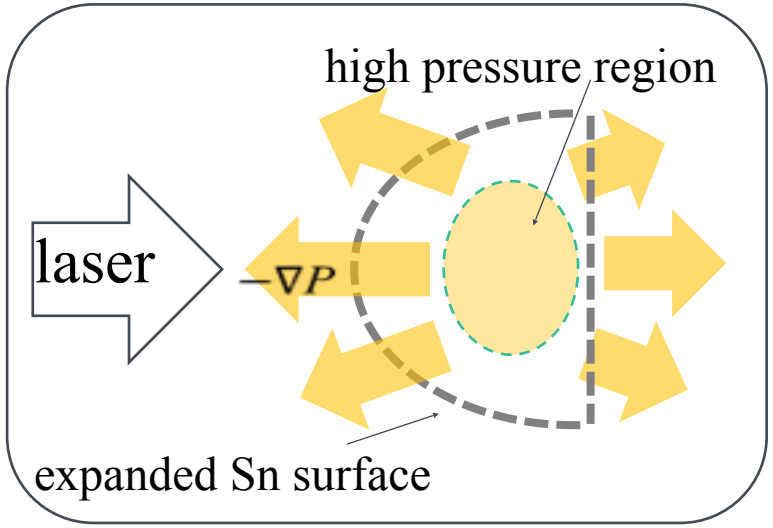
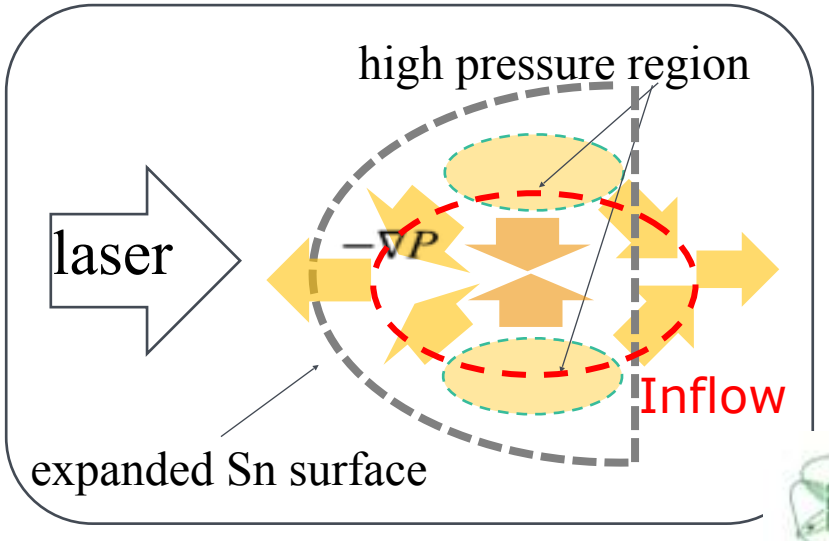
1.3 μs delay (pre-pulse to Main)



2.0 μs delay







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(2) Plasma Dynamics of EUV Plasma by Simulation

Simultaneously with experiment, Numerical simulation expect >10% conversion efficiency (Purdue Univ.)

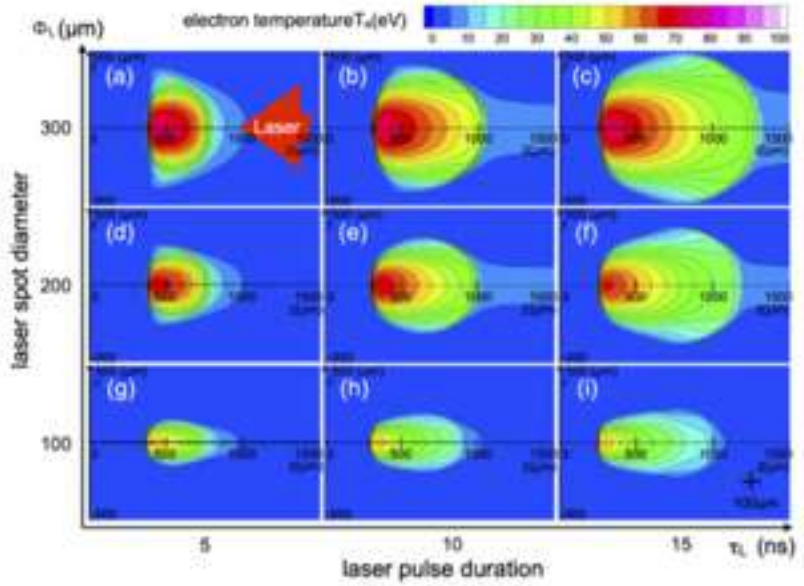

Fig. 2. Electron temperature profiles $T_e(r,z)$ at the laser peak timing on the (τ_L, ϕ_L) plane for L_{vol} = 100 μm. The horizontal axis represents the laser pulse duration τ_L : (a), (d), and (g) correspond to 5 ns, (b), (e), and (h) to 10 ns, and (c), (f), and (i) to 15 ns, respectively. The vertical axis represents the laser spot diameter ϕ_L : (g)-(i) correspond to 100 μm, (d)-(f) to 200 μm, and (a)-(c) to 300 μm, respectively.

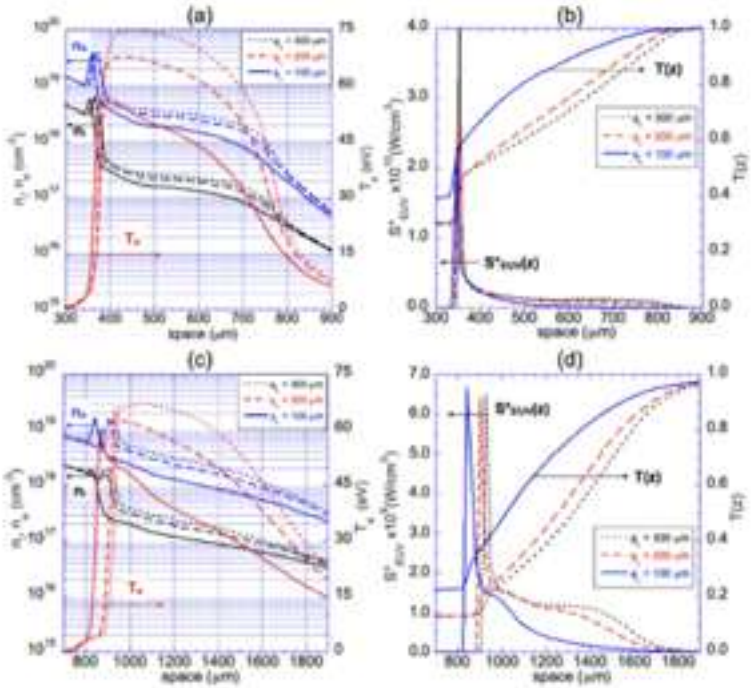

Fig. 7. (a) and (c) Plasma profiles of n_i, n_e, T_e at the radiation peak timing with τ_L of 5 ns and various ϕ_L for L_{vol} of (a) 100 μm, (c) 300 μm, respectively. (b) and (d) are corresponding EUV properties of $S^*(z)$ and $T(z)$ to (a) and (c), respectively. Solid, dashed, and dotted lines indicate ϕ_L of 100, 200, and 300 μm, respectively.

Sunahara, A., Hassanein, A., Tomita, K., Namba, S., & Higashiguchi, T. (2023). Optimization of extreme ultra-violet light emitted from the CO 2 laser-irradiated tin plasmas using 2D radiation hydrodynamic simulations . Optics Express, 31(20), 31780.

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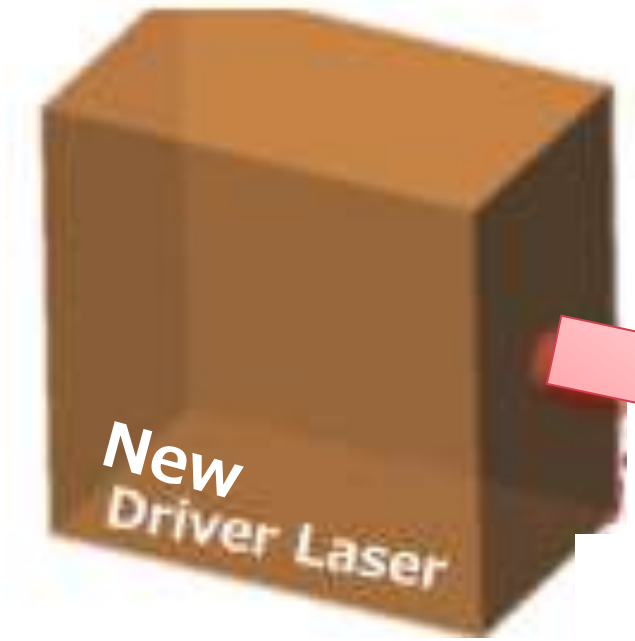
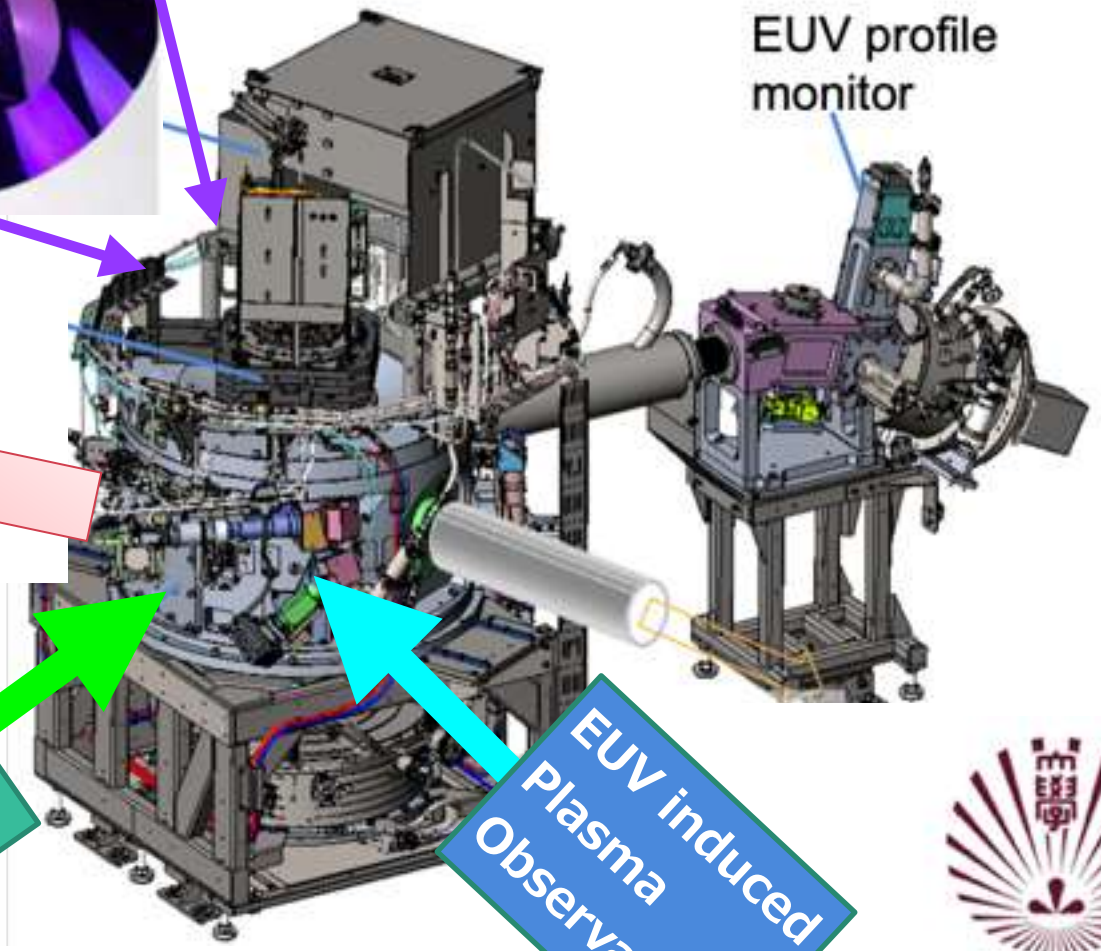
SMET: Smart laser and Mirror Evaluation Tool

K Program
経済安全保障重要技術育成プログラム

New
EUV Mirror

EUV profile
monitor





Plasma
Observation

EUV induced
Plasma
Observation

Kyushu-Univ. CPNE

Kyushu Univ. Center of Plasma Nano-interface Engineering

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Kyushu-Univ. CPNE

Kyushu Univ. Center of Plasma Nano-interface Engineering

K Program
経済安全保障重要技術育成プログラム

Planed Space for S-MET Source Chamber

2F

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Summary / Acknowledgement

EUV Photon

■ EUVリソグラフィ実用化の進展

- DUV光源はギガフォトン社の国産エキシマ光源が世界の50%シェアを獲得。市場の累積露光機台数は4000台を超える。
- ASML社のNA0.3の露光装置を中心に量産ラインへの導入進み市場稼働台数は200台を超え300台に迫る。日本のラピダスにも2024年複数台導入。
- NA0.5の露光装置１号機が2023年12月にインテル社に導入。High NA時代が始まった。
- NA0.75のHyperN -NAリソグラフィ装置の開発もスタート。
- ペリクル、マスクの開発と軌を一にして、リソグラフィ用光源の開発は1kWを目指して進んでいる。

■ EUVフォトン社が発足

- EUV関連材料の照射インフラの提供による国内材料開発のサポートを企画。九州大学を親会社として2024年に発足。
- 資金、人材・インフラ整備を準備中であるが、研究会、展示会への出品で活動開始。

■ EUVリソグラフィ光源・露光関連の調査研究を実施（2022-23）、新プロジェクト提案中

- G社露光機用光源事業撤退にともなって、CO2ドライバシステムを九大に寄贈
- 次期EUV露光技術・光源の調査を実施。日本独自の「EUVプラズマの解析技術（Thomson 散乱計測）北海道大学」「EUVプラズマ高効率化の可能性を予測するシミュレーション技術（変換効率10%超の可能性示唆）Purdue大学」「レーザーを使ったプラズマ生成・分析実験技術」などを統合し次期研究開発プログラムの提案活動中。

■ 謝辞

- 本プログラムを研究面から支えてくださった、北海道大学富田研究室、Padue大学砂原氏、大阪大学西原氏に感謝します。
- また、EUVリソグラフィ関連調査のキッカケをくださった経済産業省の関係者に感謝します。

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Future Vision of EUV Photon & CPNE in Kyushu Univ.

Material Industry

- Resist
- Pellicle
- Layer

Metrology Industry

Semiconductor Industry

IBM

Rapidus

tsmc

SAMSUNG

Component Industry

Tool Industry

key components

ASML

New Private Company

EUV Photon

Kyushu-Univ. CPNE

Kyushu Univ. Center of Plasma Nano-interface Engineering

Academia

Fraunhofer ILT

imec

embracing a better life

TNO

BERKELEY LAB

CXRO

THE CENTER FOR X-RAY OPTICS

Collaboration

Thank you for your Attention

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Project Adviser, EUV Photon

Senior Vice President of Kyushu-University
Director of Center of Plasma Nano-Interface Engineering
and Quantum & Photonics T.R.C.

Prof. Tanemasa Asano asano.tanemasa@euvphoton.jp

President and CEO, EUV Photon

Professor Emeritus, AiRIMaQ Advisor

Dr. Hakaru Mizoguchi mizoguchi.hakaru@euvphoton.jp

Director, CTO, Head of Technology Div., EUV Photon

Guest Professor, Quantum & photonics T.R.C. Kyushu-Univ.
SPIE Fellow, former CTO of Gigaphoton

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Director, CRO, General Manager of Analysis Division, EUV Photon

Professor, Quantum & photonics T.R.C. Kyushu-Univ.

Prof. Kentaro Tomita tomita.kentaro@eng.hokudai.ac.jp

***Assistant Professor**, Graduate School of Engineering, Hokkaido Univ.*
Guest Researcher of Kyushu-Univ.,

大学共同利用機関法人 自然科学研究機構
分子科学研究所

EUV Photon

EUV Photon URL

EUV PHOTON EUV PHOTON EUV PHOTON EUV PHOTON

EUV Photon Contact
contact@euvphoton.jp

マイクロ固体フォトニクス研究会
第５回 レーザー学会「小型集積レーザー(II)」専門委員会

END

マイクロ固体フォトニクス研究会
第5回 レーザー学会「小型集積レーザー(II)」専門委員会
開催案内

１．日時：令和７年（2025年）7月2日（水）

２．場所：自然科学研究機構 分子科学研究所 研究棟 201室（中継場所）

アクセス（http://www.ims.ac.jp/about/campus/access.html）

施設マップ（http://www.ims.ac.jp/about/campus/shonai.html）

オンラインとのハイブリッド会議

別途通知

連絡先：平等研究室秘書 ono@ims.ac.jp, norie-okuhara@ims.ac.jp

共催： 自然科学研究機構 分子科学研究所 社会連携研究部門

自然科学研究機構 分子科学研究所 小型集積レーザー（TILA）コンソーシアム

理化学研究所 放射光科学研究センター レーザー駆動電子加速技術開発グループ

レーザー学会「小型集積レーザー」専門委員会

科学技術振興機構（JST） 未来社会創造事業

３．内容：主題「先端レーザーと半導体プロセス」

13:10〜13:40

◇ 座長挨拶

平等 拓範（理化学研究所/分子科学研所）

13:40〜14:40（講演 50分，質疑応答 10分）

◇ 講演「半導体素子製造におけるレーザープロセシングの現状と未来」

池上 浩（高知工科大）

https://www.kochi-tech.ac.jp/profile/ja/ikenoue-hiroshi.html
14:40〜15:00 休憩

15:00〜16:00（講演 50分，質疑応答 10分）

◇ 講演「半導体製造用EUV光源開発とその応用の現状」

溝口 計（九州大学）

https://plasma.ed.kyushu-u.ac.jp/cpne/
16:00〜16:30

◇ 企業紹介「ハイティラ株式会社活動紹介」

平野 嘉仁（ハイティラ株式会社）

https://www.hytila.com/
16:30〜17:00

◇ 講演「小型集積レーザーに関する特許説明」

平等 拓範（理化学研究所/分子科学研所）

17:00〜18:00 社会連携研究部門平等研究室見学（希望者のみ）

18:15〜20:15

名刺交換会 場所：British Pub QUARTERS（東岡崎駅より徒歩3分）

https://quarters1999.com/party/plan/
会費「2,000円〜3,000円」

４． 研究会予定：

・第6回：2025年9月３日（水） 於：分子研 ハイブリッド
・第7回：2025年12月17日（水） 於：分子研 ハイブリッド
・第8回：2026年2月18日（水） 於：分子研 ハイブリッド

国際会議

・Optica Laser CongressÄb0：2025年10月19日（日）〜23日（木）
於：Prague Congress Center, Prague, Czech Republic

大学共同利用機関法人 自然科学研究機構
分子科学研究所