

New Combination of Damage Control Techniques

Using SEN's Single-wafer Implanters

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Michiro Sugitani

SEN Corporation

Sumitomo group



☆Philosophy

Prime importance on integrity and sound management in the conduct of its business.

*** Total group turnover: JPY 60 Trillion, 10 % of Japanese GDP**

*** 350 years history**

Heavy Industries

Electric
Industries

Trading company

Realty &
Development

Insurance

Metal Industries

Chemical

Cement, Etc.

Bank

Construction

Forestry

**19 Prime
Companies**

Sumitomo Heavy Industries Ltd.

Founded	November 20, 1888 (more than 120 years history) launched as a machinery production and repair shop for the Besshi Copper Mine of SUMITOMO Group
Capital	JPY 30,871, 650,000 (as of March 31, 2010)
Employees	15,463 (as of March 31, 2010)
Revenue	Consolidated 516,165,000,000 (for the 2009 Fiscal Year)
Products	Plasma Coating system, Semiconductor Packaging machines, Power Transmission & Controls, Laser Processing system, Plastic Machinery etc.

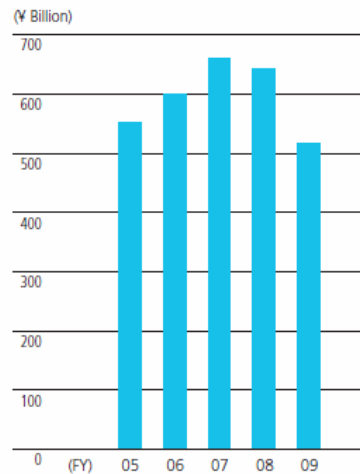
“Creation of value for customers.”

Prime importance on integrity and sound
management in the conduct of its business.

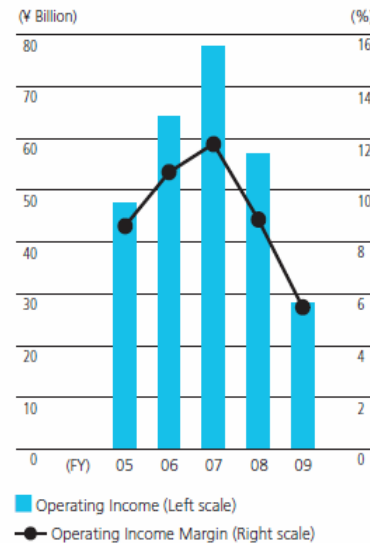


Technological innovation in a broad range of business areas

Net Sales



Operating Income and Operating Income Margin



Product Introduction

Plastics Machinery



Ultra-Precise Molding Machines
for Producing Optical Disks SD40E

Semiconductor & FPD Manufacturing Equipment



Single-wafer
Ion Implanter
SHX-III

Medical Systems Quantum Equipment



Proton Therapy
System

Laser Processing Systems



Laser Drill SLR-210T

230MeV
Cyclotron



Power Transmission & Controls



Precision Control
Speed Reducer
New IB Series

Key Components

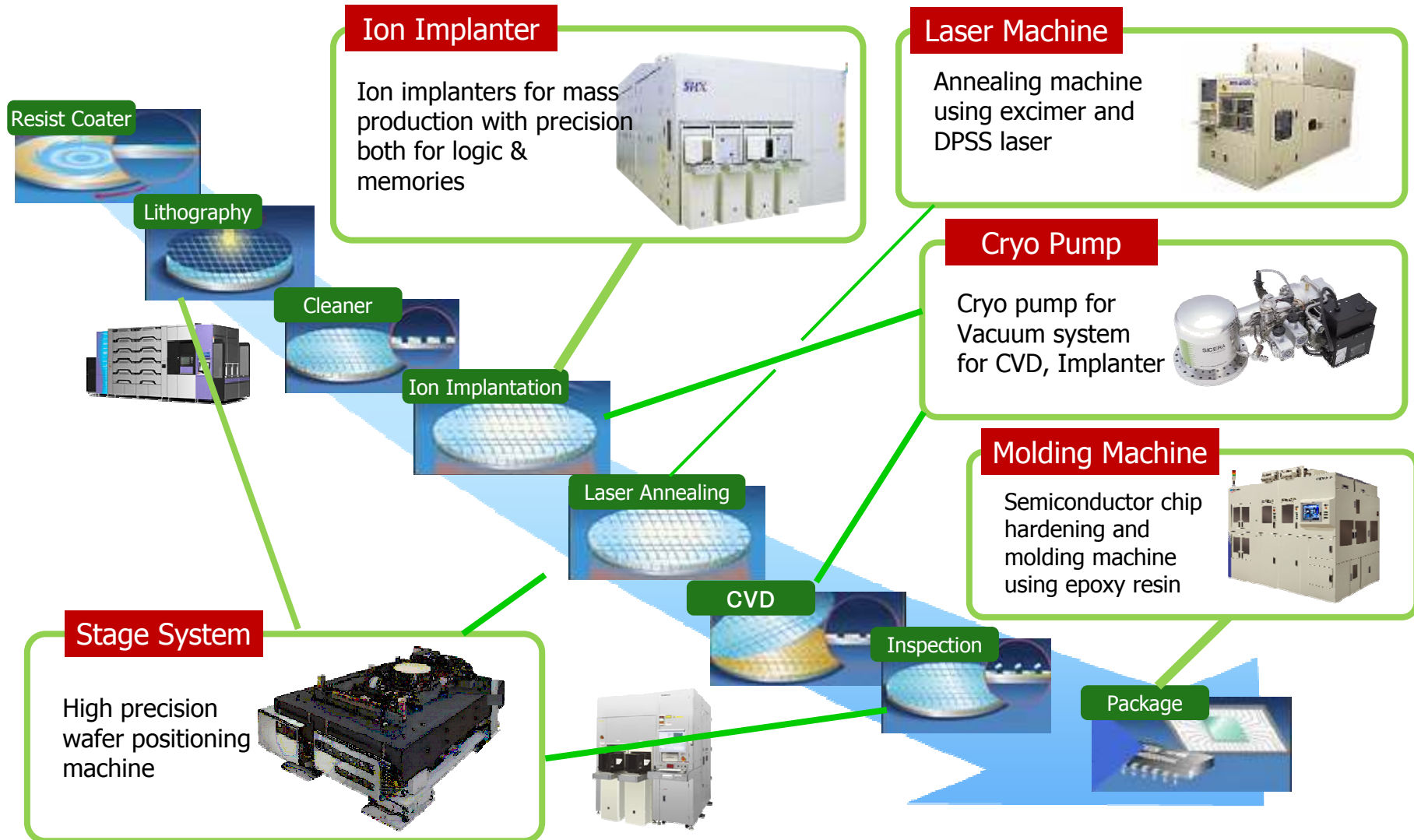


Linear motor
controllers



4K Cryocoolers

Activities for Semiconductor manufacturing



Contents

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- Background
- Damage Control
- **WBS (Wideband Beam Scan) Implant**

II. Performance of the New Damage Control Technique

- Amorphous Layer thickness
- Damage layer analysis by Boron Channeling
- Fluorine accumulation profile

III. Summary

Background of Damage Control Requirement

■ **Transistor Characteristics Improvement**

- **Reduction of Junction Leakage**
 - ✓ **Reduction of EOR defects**
- **Diffusion Suppression**
- **Reduction of Contact resistant**

■ **Process Matching**

- **Batch implanter vs Single-wafer implanter**
- **Spot beam vs Ribbon beam**

Damage Control

Damage Control of Ion Implantation

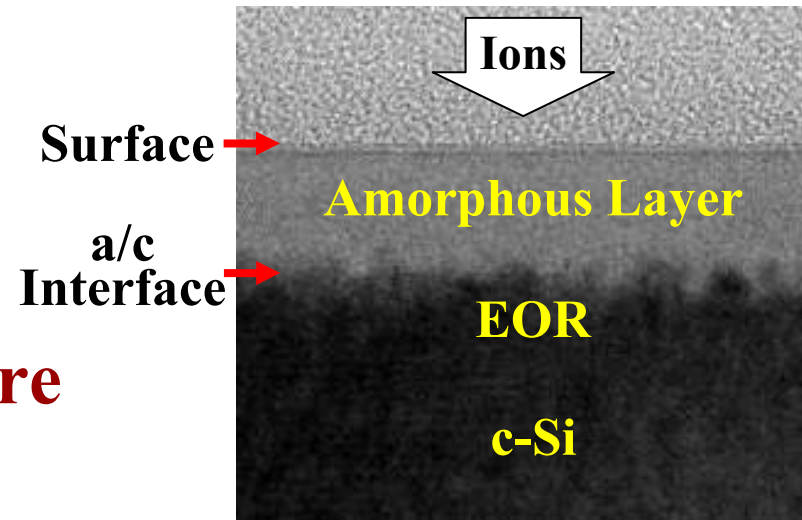
- Dose
- Ion Mass
- Energy
- Substrate Temperature

- Dose Rate

- ✓ Beam Size
- ✓ Beam Current

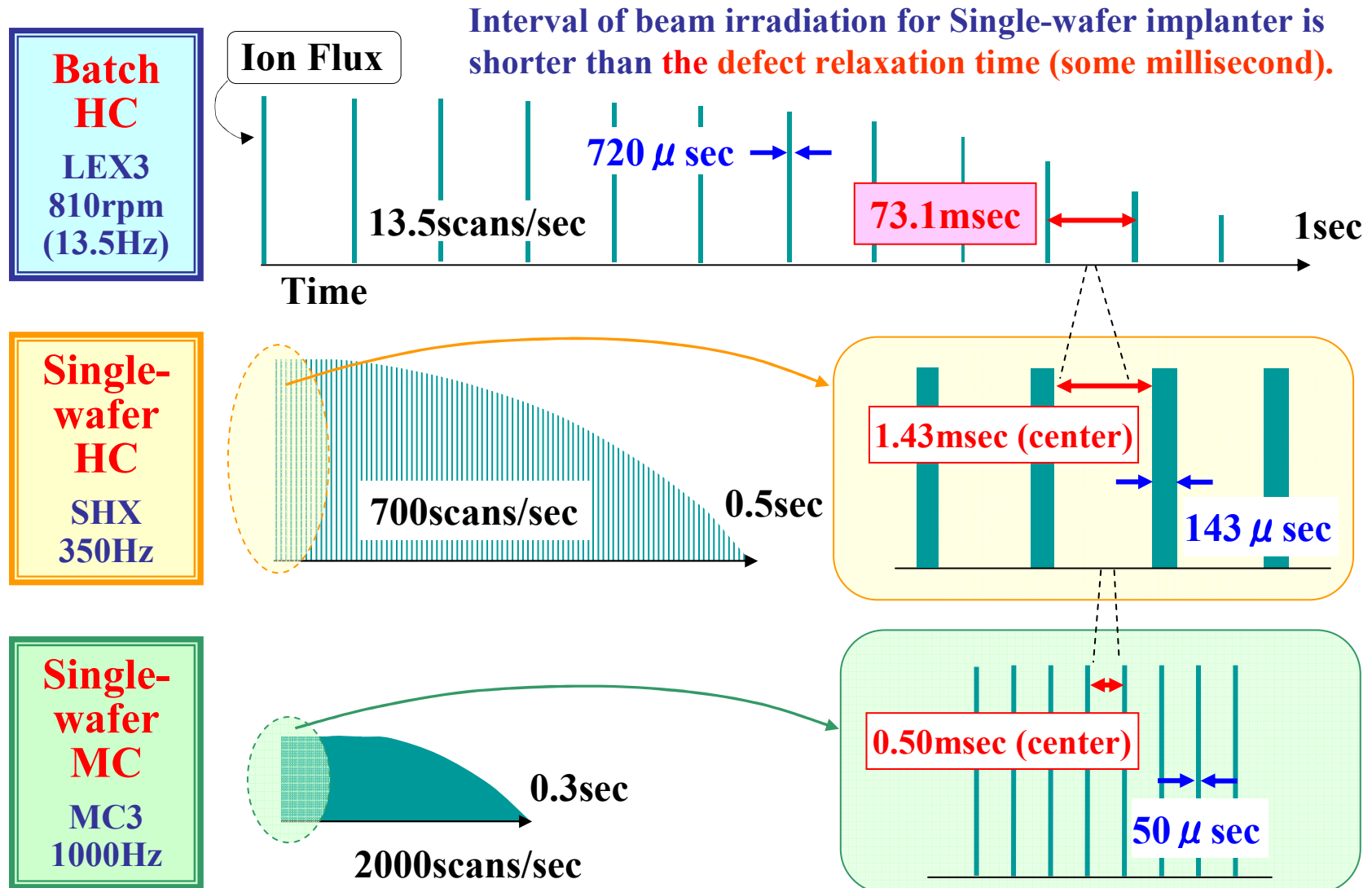
- ✓ Beam Scan Area
- ✓ Beam Scan Velocity

- ✓ Mechanical Scan (Wafer Scan) Velocity

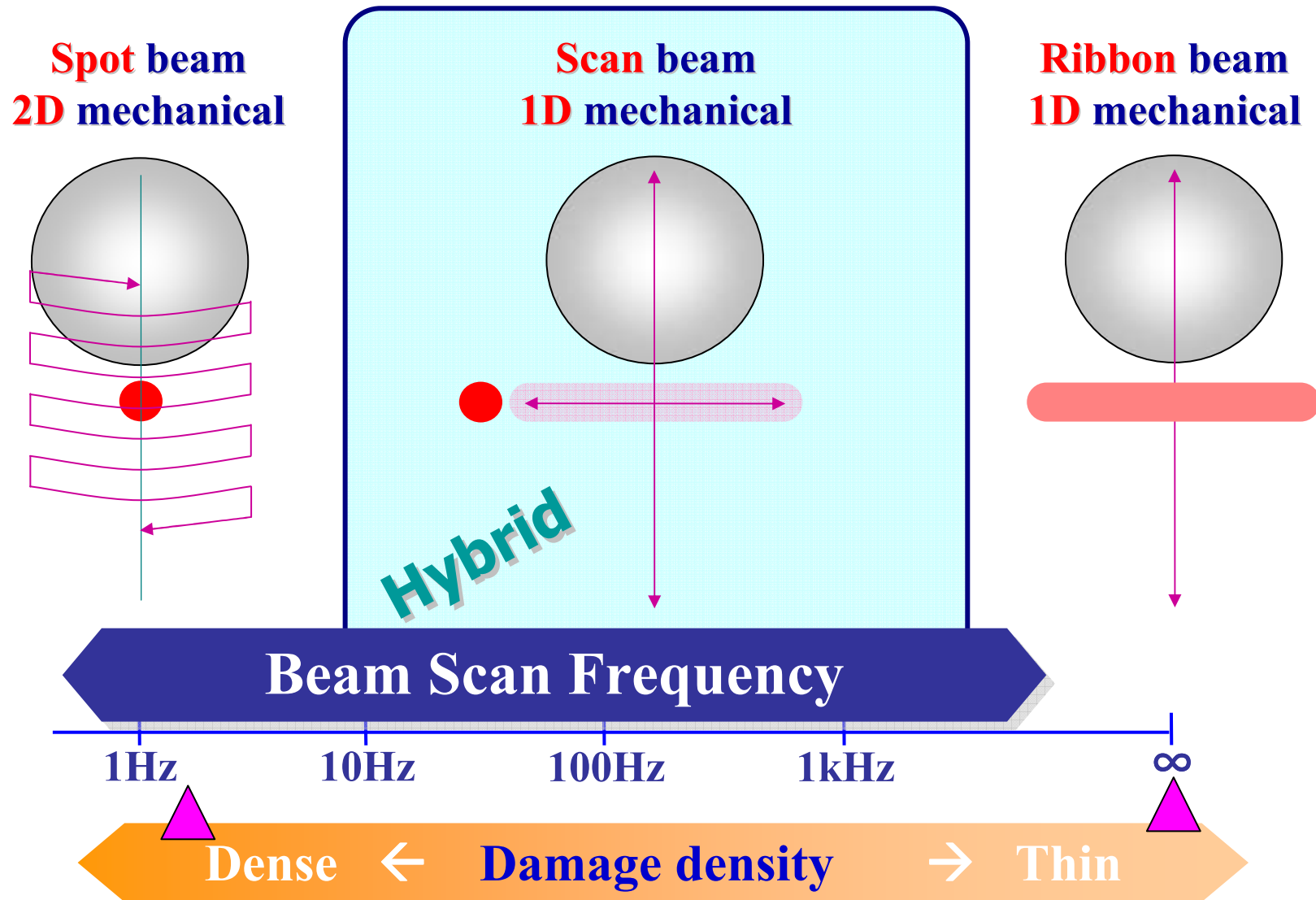


Increase of Amorphous layer and
Reduction of End of Range (EOR) defects

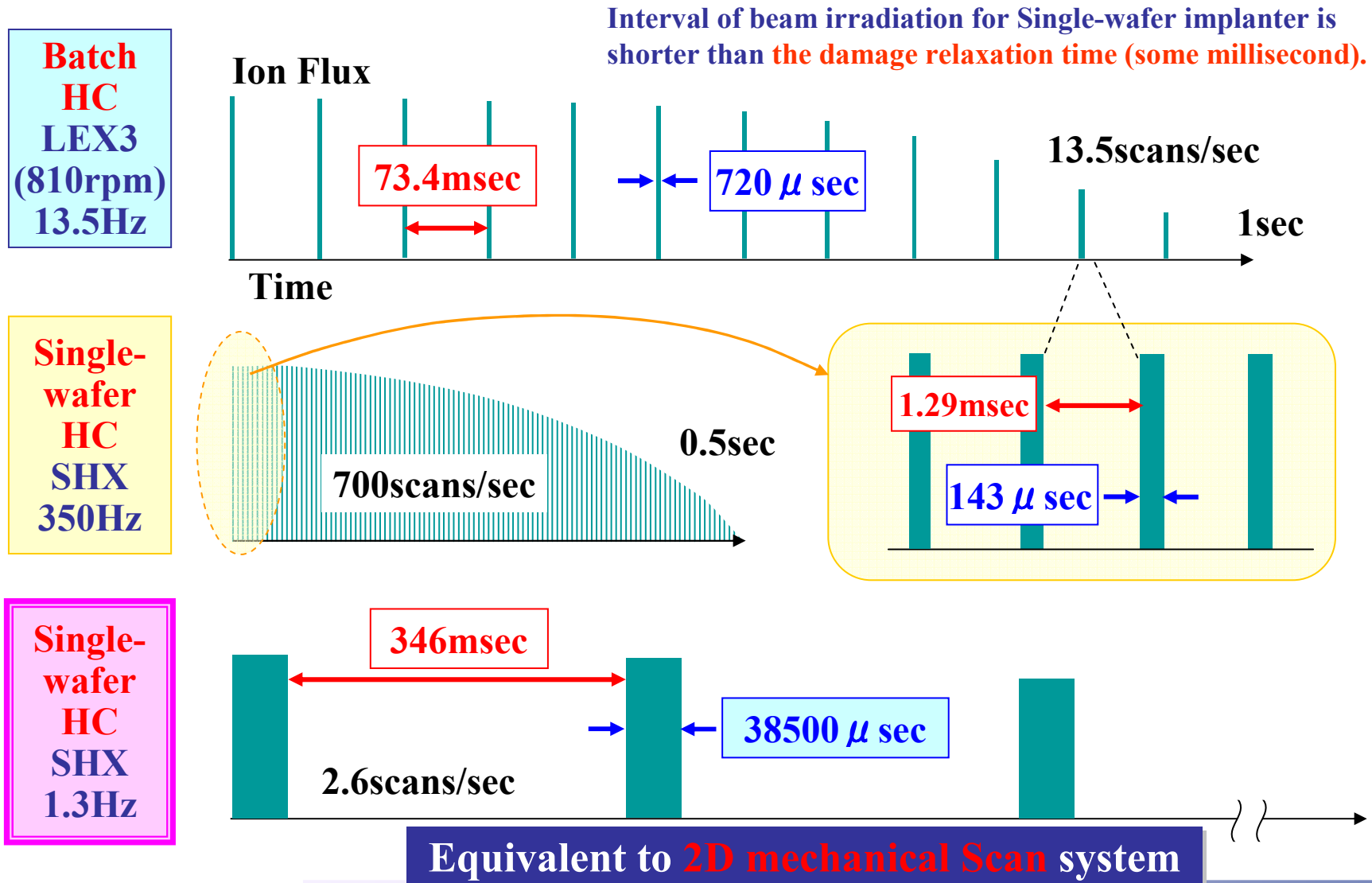
Time Structure of Beam Irradiation



Beam Scan Frequency Control



Time Structure of Beam Irradiation



SHX-III Features

- Single-wafer HC Ion Implanter

- Hybrid Scan System

(Scanning Beam /1D Mechanical Wafer Scan)

- ✓ Good Implant Uniformity

- ✓ High Throughput

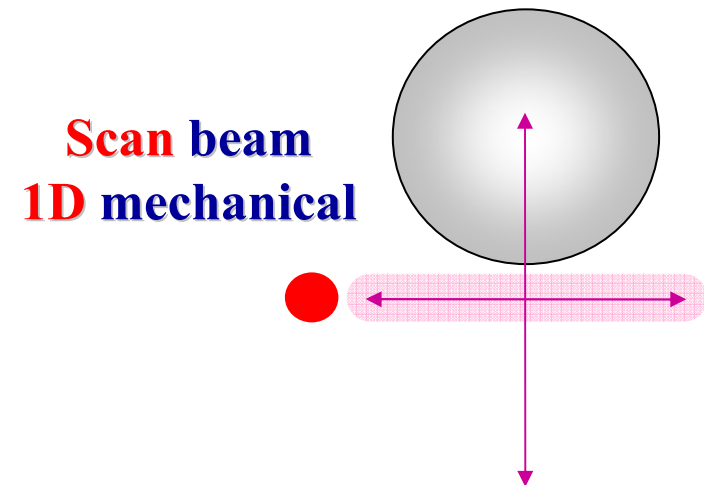
- ✓ “MIND(+)” System

- ✓ **Damage Control**

- Cryo Implant

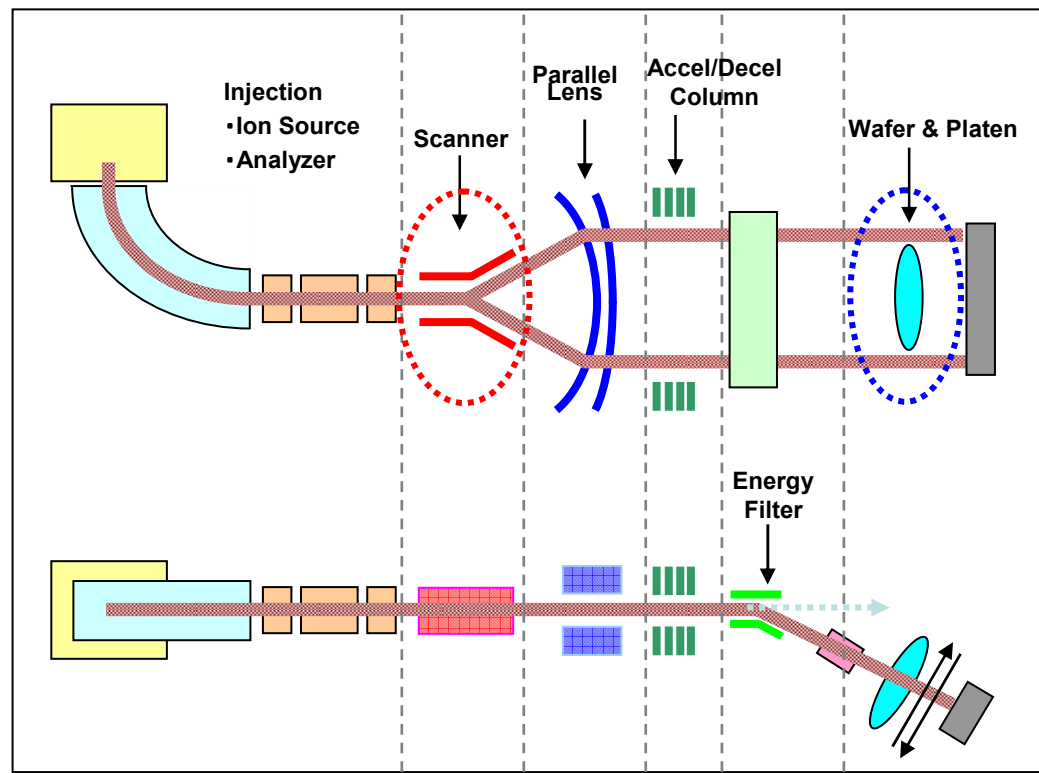
- Beam Scan Frequency Control

=>WBS (Wideband Beam Scan) Implant

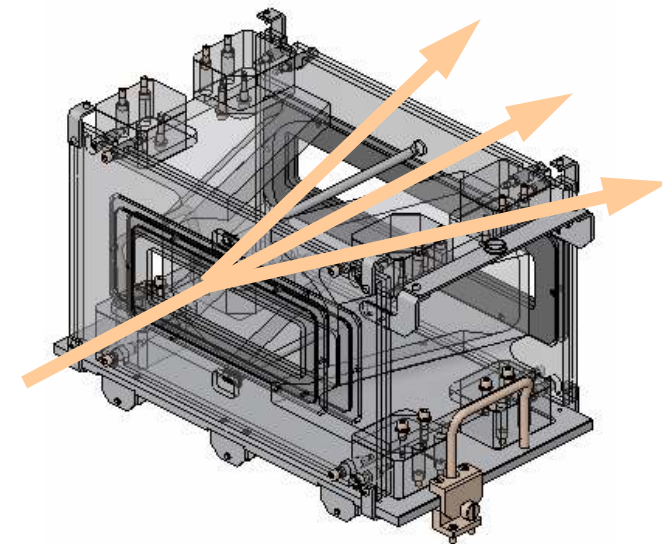


SHX-III Features

- Wafer Cooling Temperature : $-60^{\circ}\text{C} \sim 15^{\circ}\text{C}$
- Beam Scan Frequency : $0.3\text{Hz} \sim 1.35\text{kHz}$, 13points

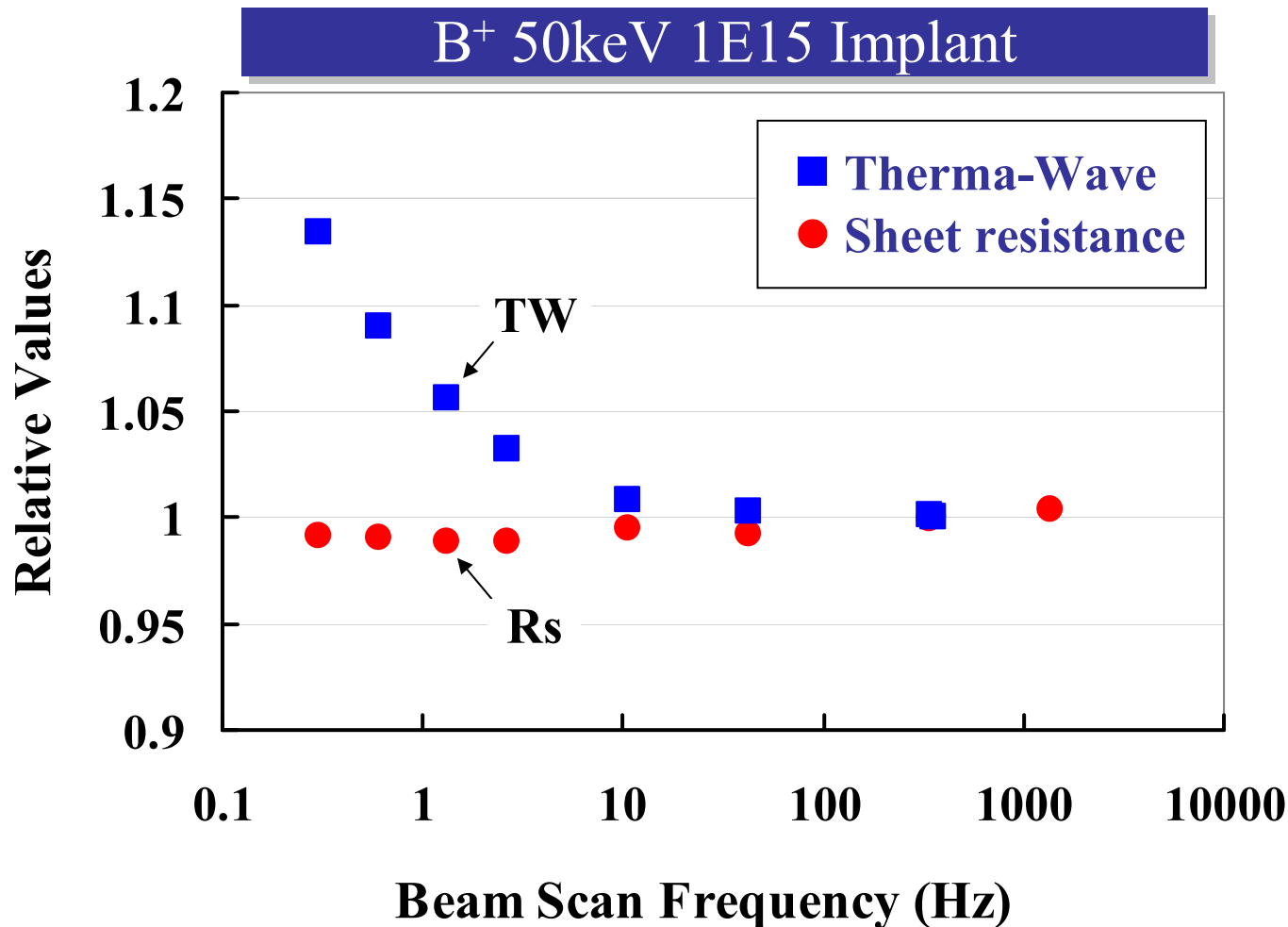


SHX-III beam-line



**Electrostatic
Beam Scanner**

WBS Implantation

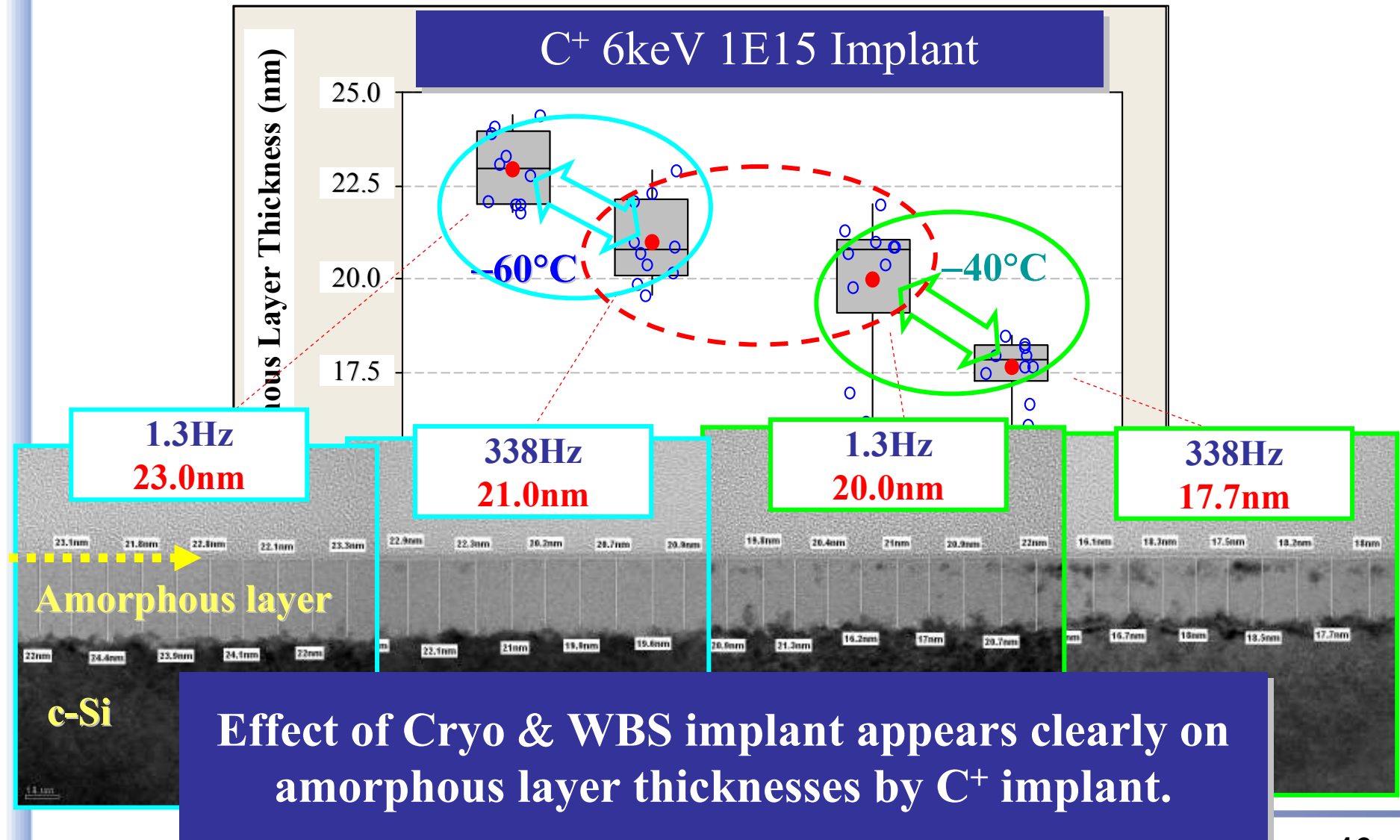


- Low beam scan frequency implant generates more damages.

Performance of Cryo & WBS Implant

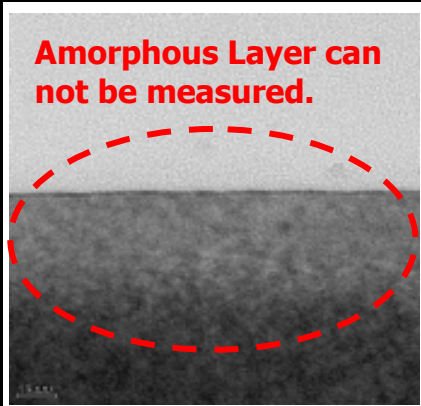
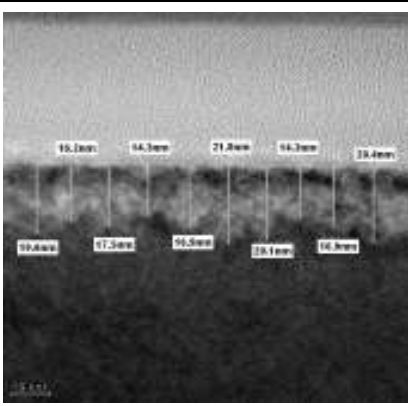
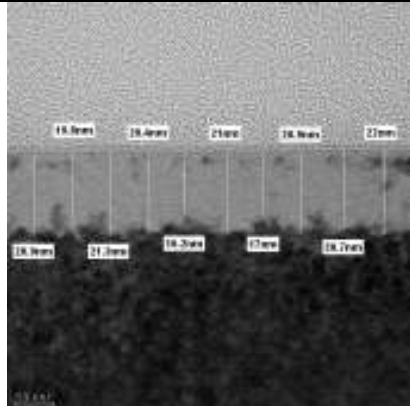
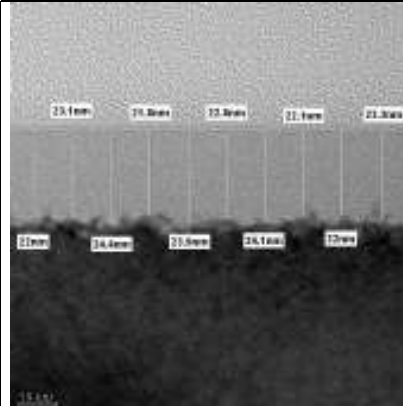
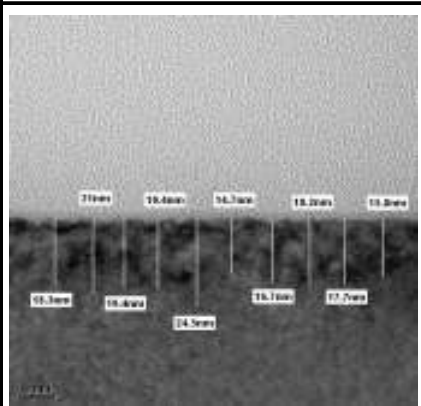
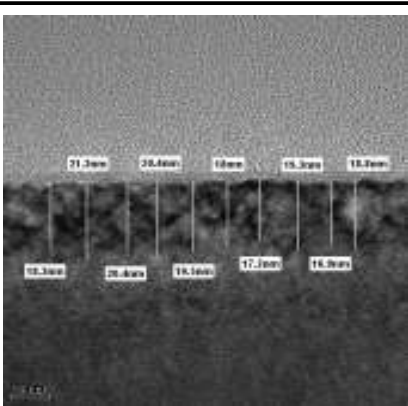
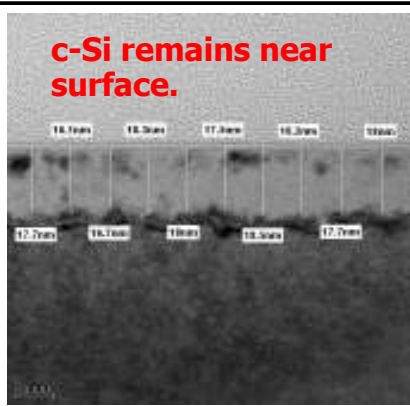
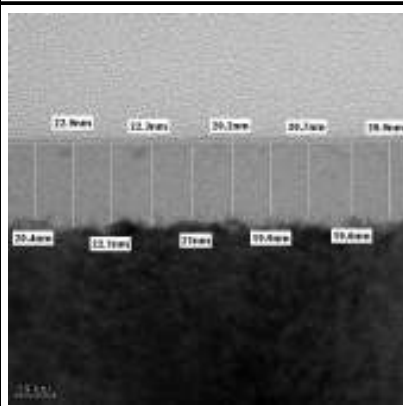
- **Amorphous layer thickness and it's quality evaluation of C⁺ implant**
- **Amorphous layer thickness of Ge⁺ implant**
- **Fluorine accumulation profile in BF₂ implant**

Carbon Implant



Carbon Implant

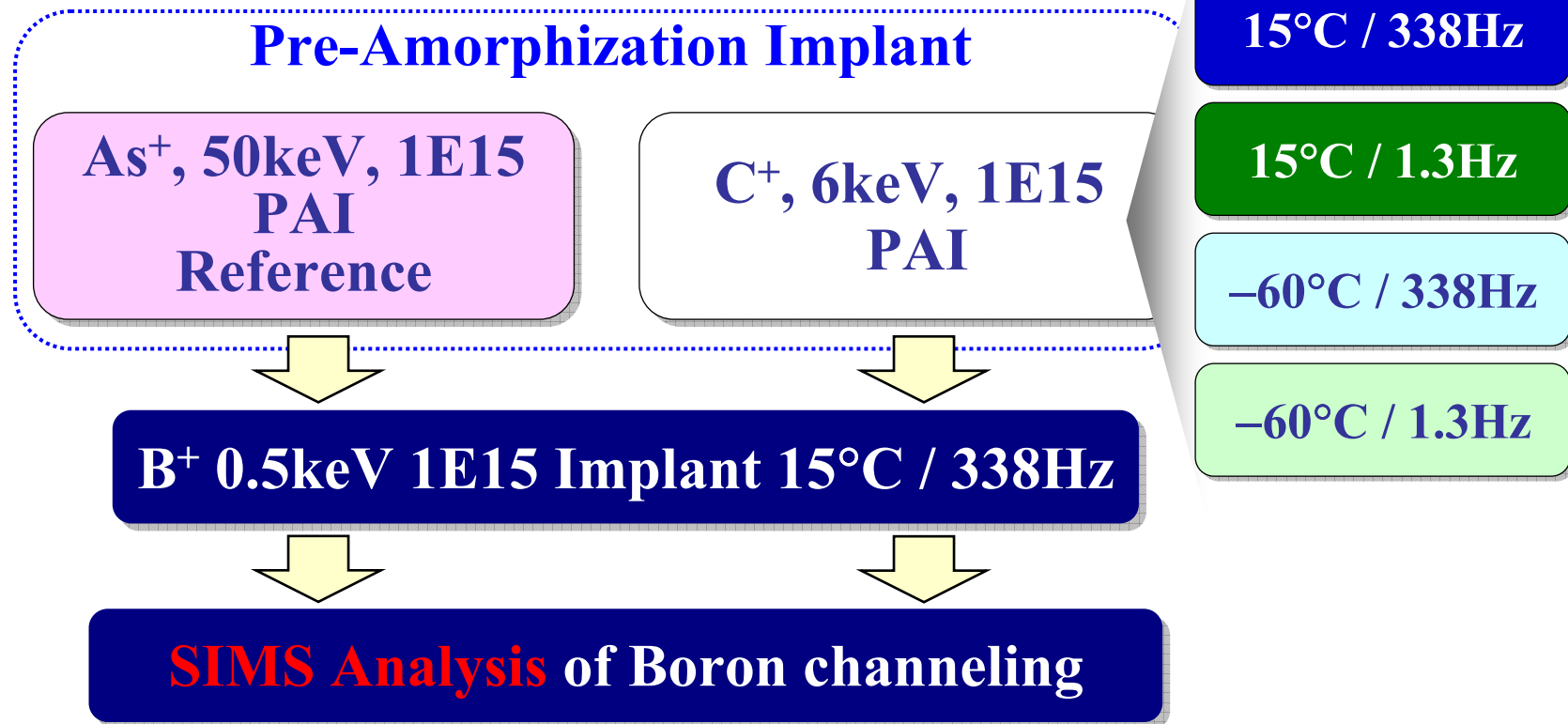
C⁺ 6keV 1E15 Implant

	15°C	5°C	-40°C	-60°C
1.3Hz	<p>Amorphous Layer can not be measured.</p> 			
	N/A	17.8nm	20.0nm	23.0nm
338Hz			<p>c-Si remains near surface.</p> 	
	18.6nm	19.0nm	17.7nm	21.0nm

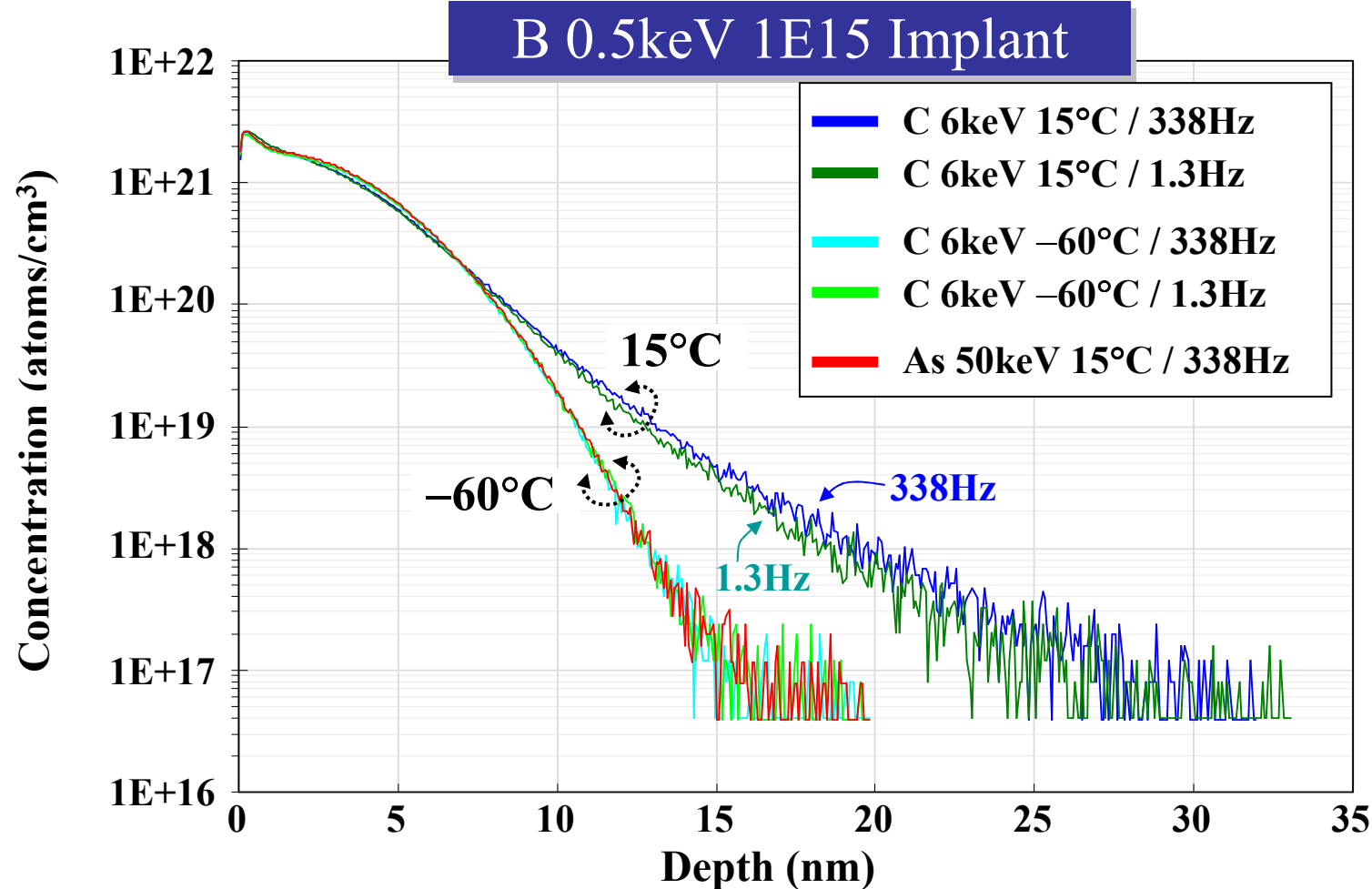
Damage Layer Analysis by SIMS

- Damaged layer quality was evaluated with Boron channeling profiles by SIMS.

< Experimental Procedure >

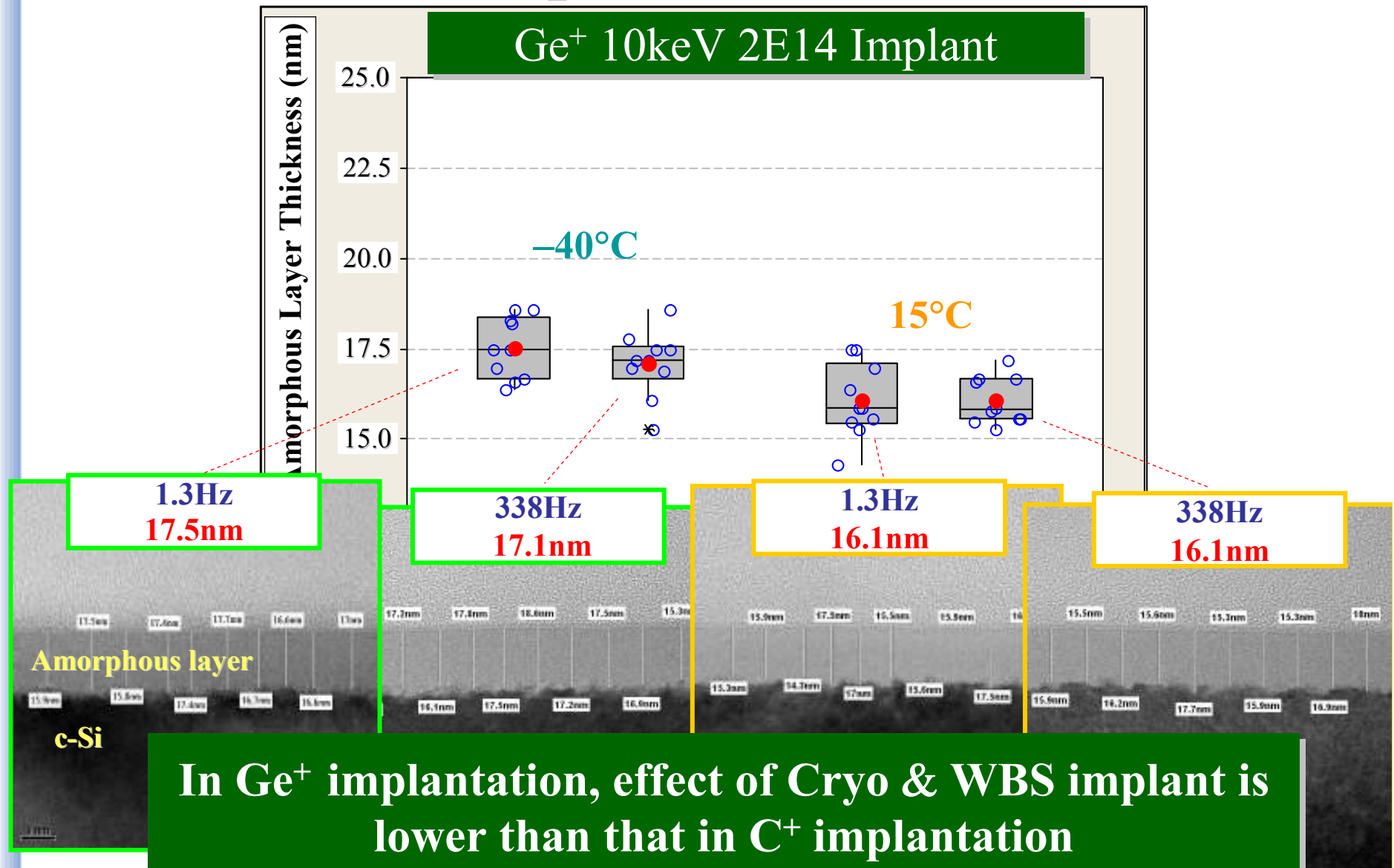


Damage Layer Analysis by SIMS



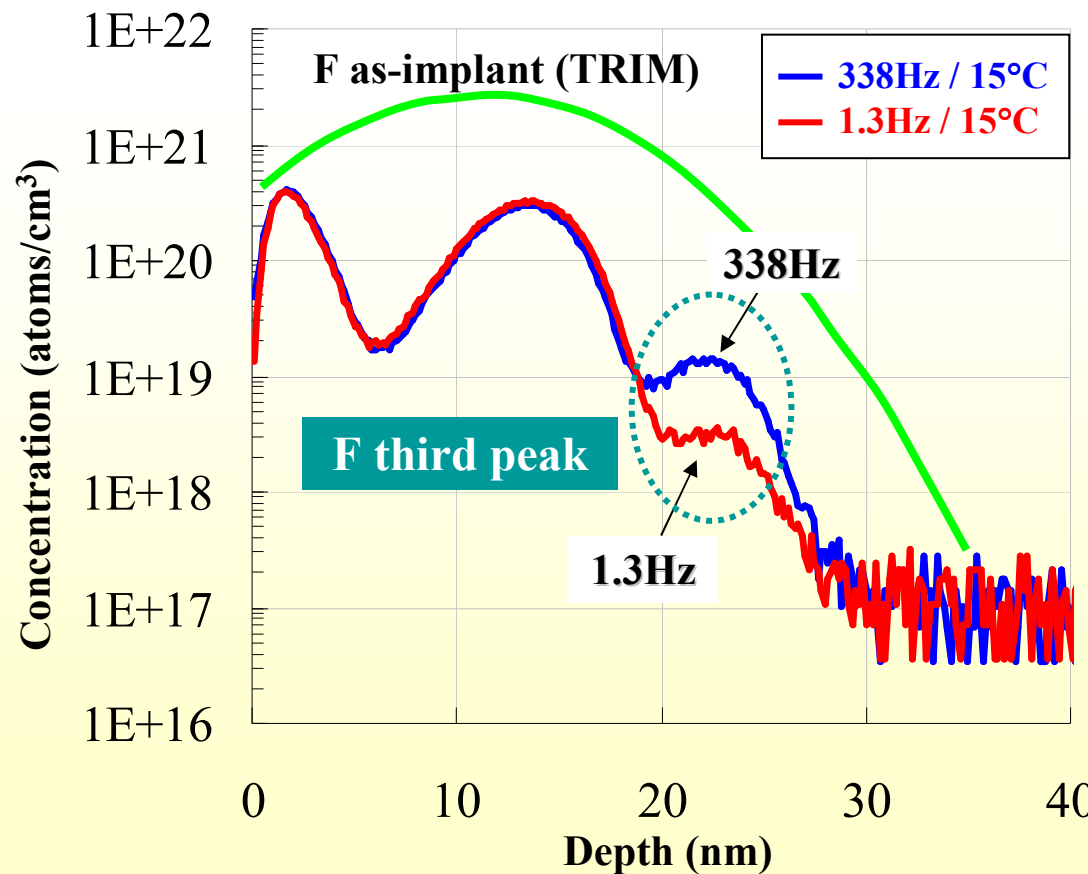
- Boron channeling decreases by PAI of low scan frequency at 15°C.
- No difference are seen with Boron channeling profiles at -60°C.

Germanium Implant



Fluorine Accumulation Profile

^{19}F profile was analyzed by SIMS to check the density of EOR defect.



- Implantation:
BF₂, 10keV, 2E15
- Annealing:
900°C, 120sec

- Fluorine third peak became lower by LOW frequency condition

Summary

- **New damage control techniques**, Cryo-Implant and WBS Implant, are installed to SHX-III and capability is demonstrated
- **WBS implant** covers wide-range damage region from Spot beam to Ribbon beam
 - ✓ WBS is expected to be useful for process matching among single-wafer HC implanters
- **Reduction of scan frequency** shows the same effect on damage creation as the low temperature implantation
- **Combination of Cryo and WBS implants** provides wide controllability on damage creation

Thank you for your attention!